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ABSTRACT

The 106 conference papers in this collection contain the thoughts and concerns of telecommunications carriers, suppliers, users, researchers, and government and professional groups. These papers were presented at a conference organized by the Pacific Telecommunications Council, an independent, voluntary-membership organization dedicated to the beneficial development and use of telecommunications in the Pacific Ocean Region, an area with enormous diversity of language and culture. Papers are categorized by 28 topic areas: computer communication analysis, geographic isolation, evolving trends in communication networks, regulatory and spectrum issues, information retrieval in the home, satellite communications, packet switched networks, telecommunications policy in developed countries, Hawaii's electronics industries, examples of computer communications networks, the 1979 World Administration Radio Conference (WARC), the evolution of information delivery systems for home and business, issues in open systems architecture, legal issues, Pacific telecommunications, computers in scientific networks, telecommunications and economic development in developing countries, communications systems, fiber optic systems, satellites for the Pacific, new telecommunications services, telecommunications planning, social and technical telecommunications futures, United States international telecommunications policy making, educational telecommunications, and pricing telecommunications services. Most papers include abstracts and references. (LMM)

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Papers and Proceedings of a Conference held January 7–9, 1980, at the Ilikai Hotel, Honolulu, Hawaii

Edited by
DAN J. WEDEMEYER

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FOREWORD

It is with great pleasure that I present this PTC '80 volume of papers that address many of the key problems and promises of telecommunication in the Pacific.

PTC '80 is, we hope, an improved version of PTC '79. Last year's conference attracted more than 300 telecommunication professionals from 18 nations and 23 U.S. States. During that two-day conference twenty workshops were convened to address topics ranging from highly technical digital systems to social telecommunication policy. This year more than thirty workshops will address equally broad and interesting topics over a three-day period.

The purpose of PTC '80 is to continue the open dialog established by PTC '79. It is only by maintaining an open and non-political discussion that diverse cultural and human needs and rights can be served by emerging telecommunication services.

This volume contains the thoughts and concerns of telecommunication carriers, suppliers, users, researchers, as well as government and professional groups. We have published the proceedings prior to the conference in order to facilitate previewing of written materials prior to session presentations.

The materials in this volume have been arranged to parallel the chronological format of the conference. The first day sessions are indicated by the number one followed by a letter denoting each individual topic area — second day sessions are indicated by the number two, etc. In order to facilitate interaction we have provided a "question/notes" section for the keynote addresses and each session.

On behalf of the PTC '80 Conference organizers and sponsors, I wish to express heartiest thanks and warmest aloha to all who have contributed to this volume.

Dan J. Wedemeyer
Editor, PTC '80

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A NEW DECADE FOR INTELSAT AND THE PACIFIC

Santiago Astrain
International Telecommunications Satellite Organization
Washington, D.C.

The diversity of language and culture in the Pacific Ocean Region is enormous. In fact, it is so diverse that the most common tendency is to speak of subregions of the Pacific, such as Southeast Asia, North Asia, the South Sea islands, Micronesia, Australasia, the Americas, etc. Perhaps the most critical issue facing telecommunications in the Pacific Ocean Region is whether and when these subregions will achieve a more cohesive identity.

Longer-term trends in this regard will likely hinge on future patterns of trade, communications and transportation, and regional processes and institutions. For example, new trade relations between Japan and South America have tended to shift from a traditional single-ocean perspective in South America to a two-ocean perspective.

Communications and transportation are, of course, closely related to trade links. However, technical innovations in the communications and transportation industries can themselves lead to new trade opportunities. Advanced communications satellites, new submarine technology, long-distance jets (such as the 747-SP), and supersonic transports (such as the Concorde), have all served in recent years to shrink the vast dimensions of the Pacific Ocean Region. It is now possible to fly non-stop from Sydney, Australia, to Los Angeles -- nearly 8,000 miles -- in 13½ hours. The World Cup Soccer matches last year were broadcast "live" from Argentina to 14 countries in the Pacific Ocean Region. Clearly, these new technologies are not only shrinking the great distances of the Pacific, but also affording new cultural and economic opportunities in ways simply not possible over a decade ago.

Perhaps in recognition of new trading relationships and new technological opportunities, there has been a dynamic trend toward actively pursuing new opportunities for regional cooperation. Just in the field of telecommunications alone, we have seen developments, such as:

A. Agreement, in principle, on the Asia/Pacific Telecommunity, reached in Bangkok in June of 1979;

B. The ASEAN regional organization, which has served as the coordinative mechanism for the creation of an extensive Southeast Asian submarine cable network, and has helped to coordinate regional satellite communications services to remote rural locations in Southeast Asia, using the Indonesian PALAPA satellite system;

C. The University of the South Pacific and the University of Hawaii have been instrumental in organizing tests and demonstrations with NASA's ATS experimental satellites, with a view to eventually establishing an operational telecommunications network that could link most of the island countries of the South Pacific (a subject I will return to in a few minutes);

D. The Energy Resources Institute of the East-West Center, here in Hawaii, is planning to establish a telecommunications network to link most of the energy research organizations in the Pacific Ocean Region;

E. Thanks to the leadership of a number of individuals who are here today, the Pacific Telecommunications Council is now a reality.

While I could cite additional examples in telecommunications, as well as in other areas of increasing regionalism, I believe these instances illustrate the dynamic path of cooperation that seems to be gathering momentum in the Pacific Ocean Region.

INTELSAT has certainly been encouraged by the results of our most recent Global Traffic Meeting, held in Washington at mid-year 1979. At that meeting 106 user countries met to project traffic for the next five years. The Pacific Ocean Region, which in recent years has shown a relatively small rate of growth in comparison to the other two ocean regions that INTELSAT serves, has shown definite signs of resurgence. The most recent forecast, for example, projects a near doubling of full-time telephone circuits in service by 1983. We at INTELSAT believe that events in the Pacific Ocean Region will greatly influence INTELSAT's future and, to a certain extent, hope that the reverse process will also be true. Namely, to the extent INTELSAT's planning can anticipate the needs of the countries of the Pacific Ocean Region, we can help prospective development to occur in a timely manner.

Since those of you here at this conference are the experts on the Pacific Ocean Region, I would like to focus my remarks primarily on trends within the INTELSAT System and in the field of telecommunications. I will try to show the more important relationships between these trends and the specific needs and opportunities that the Pacific Ocean Region poses. To do this, however, some background on INTELSAT is necessary.

First of all, it is important to be aware of the dynamic, flexible and evolutionary nature of the INTELSAT Organization. Many of the facts about INTELSAT that you learned a few years ago may no longer hold true.

Many of you may be aware that INTELSAT was created in 1964 with an initial membership of only 11 countries. Further, you may know that Comsat and the U.S. Government played an important and leading role in the creation of our organization. What may not be as well known is the fact that INTELSAT has now grown to a membership of over 100 countries, of which 27 countries are in Europe and North America, with the remaining 75 being from the rest of the world. Asian and Pacific Ocean countries compose the largest region in terms of numbers of members in the INTELSAT Organization.

In the last five years INTELSAT has grown and diversified in many important ways. Whereas five years ago Comsat acted as Management Services Contractor, the INTELSAT System is now managed by INTELSAT. Domestic services, provided on available spare capacity, are now provided to over 15 countries and constitute some 10 percent of INTELSAT's total revenues. During the last few years, the first and third most largely populated countries in the world, the People's Republic of China and the Soviet Union (both Pacific Ocean Area countries), have become users of the INTELSAT System. In fact, in August of 1977, the People's Republic of China became a full-fledged member of INTELSAT.

In order to keep pace with the rapid growth in telecommunications on a global basis, INTELSAT has invested heavily in research and development and has consistently sought the most advanced technology in its satellite system, consistent with reliability of service.

In keeping with INTELSAT's own pattern of rapid growth, this year we will initiate service in the Atlantic Ocean Region through our new INTELSAT V satellite. This satellite, with a capacity of 12,000 voice circuits plus two color television channels, will help INTELSAT meet the growing demand for telecommunications services in all regions of the world.

A number of factors can be expected to stimulate telecommunications growth in all parts of the world:

1. The global energy crisis will help convince businessmen and others of the need to substitute telecommunications applications for transportation.

2. There will be increased demand for new point-to-point telecommunications services, such as electronic mail; international teletext and computer data base access; videotelephone and teleconferencing services; dedicated, specialized business telecommunications networks; and international specialized carriers to provide packet-switched data networks.

3. There will also be new demand for mobile services. The INTELSAT space segment, beginning with the INTELSAT V (F-5) satellite, will be equipped to provide maritime mobile services. It is planned that the INTELSAT space segment for this service will be provided on a lease basis to the new INMARSAT Organization. Other types of international mobile telecommunications services, such as aeronautical communications, will also be in increasing demand in the 1980's. With hundreds of thousands of international airline passengers flying each day, this type of service (which Lufthansa has recently begun experimentally with HF radio technology), appears to be long overdue.

4. Increasing demand for domestic and regional satellite services should provide a very significant growth potential for the INTELSAT System.

There are, of course, a number of countervailing influences that could limit INTELSAT's continued expansive growth. These factors include: the future deployment of advanced submarine cables; a number of high-capacity cables, which are planned for the 1980's. Beyond these, it is likely that extremely high capacity submarine cables using optical fiber and laser modulation techniques may well be deployed along high-density communications routes. Given the high cost of both communications satellites and large-capacity cable systems, there is a greater need than ever before of close coordination in the planning of such facilities.

Another extremely important factor involves decisions by individual countries, as well as regional groups of countries, concerning the provision of domestic and regional telecommunications services either on INTELSAT or on separate satellite facilities. To the extent that these countries wish to deploy and operate separate satellite systems, there will be ever increasing demands on the radio frequency for all providers of satellite communications systems services. Furthermore, the growth of regional satellite systems, in particular, could serve to erode the economies of scale that the INTELSAT System has been designed to provide.

It is not INTELSAT's philosophy, nor will it be its practice, to obstruct the provision of telecommunications services wherever they are needed in the world -- domestically, regionally or internationally. Our approach, which derives from our international character and our well established record of dynamic growth, will be one of seeking innovative solutions. At the present time, INTELSA is actively exploring means whereby it can provide low-cost domestic satellite services on a planned basis, rather than relying exclusively on spare capacity. We feel confident that there are good technical solutions that would allow INTELSAT to make available expanded capacity in the 1980's in order to provide a wide range of services domestically and internationally at competitive costs. Such solutions include a switchable INTELSAT V satellite, which, on command from the ground, could be automatically reconfigured in whole or in part from an international operational mode to a domestic or regional configuration. Another possible approach is a smaller class "hybrid" satellite, which could be used either for domestic service or for international routes with less heavy traffic requirements, such as the Atlantic Ocean Region Major Path 2. It is possible that by mid-year 1980 the INTELSAT Board of Governors and the INTELSAT Meeting of Signatories will have taken the actions necessary to choose from among these the advanced satellite concepts and make available the needed satellite facilities in the early 1980's.

Assuming that positive decisions are reached, here are some of the results that INTELSAT may expect to attain by the end of the twentieth century:

1. Traffic volume for international service may have grown to a quarter of a million voice circuits.

2. International videoconferencing and videophone service may have grown to comprise a meaningful percentage of INTELSAT's business.

3. Domestic and regional television distribution satellite services provided by the INTELSAT System may exceed 25 systems and over 100 transponders. Significant new Pacific Ocean customers in the early 1980's are expected to include satellite networks for Australia and the People's Republic of China. For some countries INTELSAT will serve as a starter system until they evolve into a fully independent system; but for others, INTELSAT will be able to accommodate their long-term growth as well.

4. It is possible that, by the 1990's, the necessary technology, coupled with a need for greater interconnection

of various separate satellite systems, may even lead to the provision by INTELSAT of space platforms that would not only meet INTELSAT's primary telecommunications purposes, but serve as host to a variety of telecommunications, meteorological and earth resource packages that would be interconnected by hardwired "switchable" links. Special packages of this type, installed on the space platform, could be augmented or maintenanced at regular intervals by manned space stations. These platforms would of course not be manned on a continuous basis. A network of five or seven such platforms could meet virtually all needs in space applications except for tactical military communications. Truly gigantic manned space stations for industrial activity or energy production are beyond the scope of INTELSAT's planning in terms of size and cost.

If I may return to the present and less grandiose, I would just like to note that the key to the future is as much the small detail as is the grand design. INTELSAT's success stems from its preoccupation with the small and medium users, as well as the large. We are pleased that our new 11-meter Standard B antenna has proved to be a worthy answer to the international telecommunications needs of many of the South Pacific island countries. The introduction of Standard B operations in Tonga some months ago, for instance, has reportedly brought dramatic changes in the local economy. By means of "telephonic shopping" through the INTELSAT global network, much more competitive prices for import commodities have been obtained -- thus dropping the cost of imports for Tongans by 20 percent.

We are hopeful that some of the new satellite concepts for domestic services we are considering for the 1980's can provide the right power and coverage to allow much lower cost terminals in the 4 to 5-meter range. Finally, we hope that tests and demonstrations to be conducted through the INTELSAT System for the University of the South Pacific will be successful and that we can play a meaningful role in the future success of this ambitious, farflung educational enterprise.

This week we begin a new year, a new decade and a new future for the Pacific and for INTELSAT, and we have high hopes and aspirations for the evolving partnership between the Pacific Ocean countries and INTELSAT. My very best wishes to you and to your efforts on the Pacific Telecommunications Council.

High Speed Digital and Analog Parallel Transmission Technique over Single Telephone Channel

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Abstract

Adaptive equalization technique and carrier phase control technique in parallel transmission of digital and analog signals using a quadrature amplitude modulation are presented. In this transmission, a two-dimensional error signal necessary for dicision directed method in adaptive equalization and carrier phase control can not be measured due to analog signal undetectability. New decision directed schemes are derived so that the adaptive equalization and carrier phase control are satisfactorily achieved under the disturbance of correlated analog signal.

1. Introduction

Transmitting digital and analog information in parallel produces interesting applications, such as multiplexed transmission of digital and analog information sources, high fidelity analog signal transmission etc. In the field of information transmission over a single telephone channel, such a high speed parallel transmission has not been realized, although data transmission up to 9.6 kbps is well established by using adaptive techniques, such as adaptive equalization and carrier phase control. One promising parallel transmission method is to use quadrature amplitude modulation, where digital and sampled analog signals are mapped on inphase and quadrature components, respectively[1]. The adaptive receiver for this mapping scheme, called Hybrid Analog-and-Digital Modulation(HADM), is described in this paper.

Since the received signal through the telephone channel is often highly distorted due to filter system impairment and disturbed by carrier phase jitter, adaptive equalization and carrier phase control are significant demodulation functions in HADM modem implementation.

The adaptive equalizer implemented in a two-dimensional transversal filter is well known for digital data transmission based on double sideband modulation. The major problems of applying this technique to HADM are related to the treatment of analog information, namely;

(1) *Analog information is ordinarily correlated. No scrambling and descrambling techniques have been developed for sampled analog sequences.*

(2) Analog information can not be estimated accurately in the receiver, while digital information can be restored using a threshold scheme. The estimated error which is necessary for equalizer adjustment, can not be obtained due to the undetectability of analog information.

Most of the discussion is devoted to adaptive equalization and carrier phase control techniques. Using these techniques, parallel transmission of 4.8 kbps digital and 2.4 kHz sampled analog information can be realized over a single telephone channel. Computer simulation is achieved, demonstrating the feasibility of such a receiver scheme presuming the use of an actual channel system.

2. System model

A transmission system, based on HADM, is depicted in Fig.1. This system can be equivalently reduced to baseband and time discrete model, as shown in Fig.2.

The received signal X_n in Fig.2 is written as

$$X_n = \sum_{i=-\infty}^{+\infty} A_i P_{n-i} - V_n \qquad (1)$$

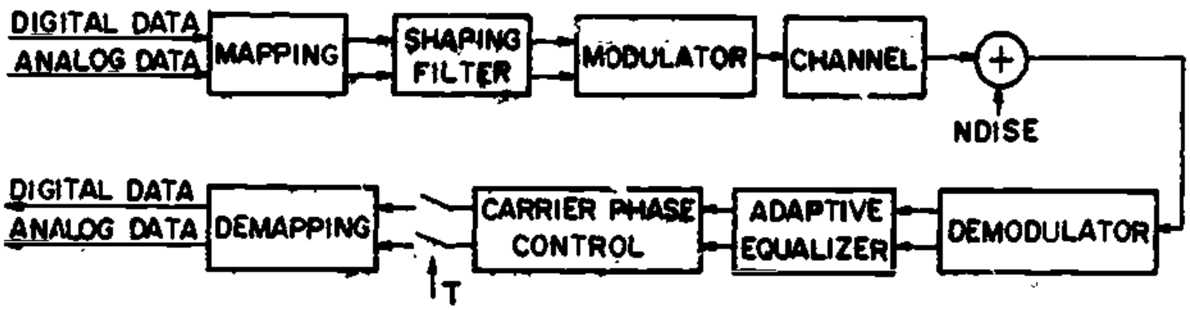
DIGITAL DATA
ANALOG DATA
MAPPING
SHAPING FILTER
MODULATOR
CHANNEL
+
NOISE
DIGITAL DATA
ANALOG DATA
DEMAPPING
T
CARRIER PHASE CONTROL
ADAPTIVE EQUALIZER
DEMODULATOR

Figure 1. System model

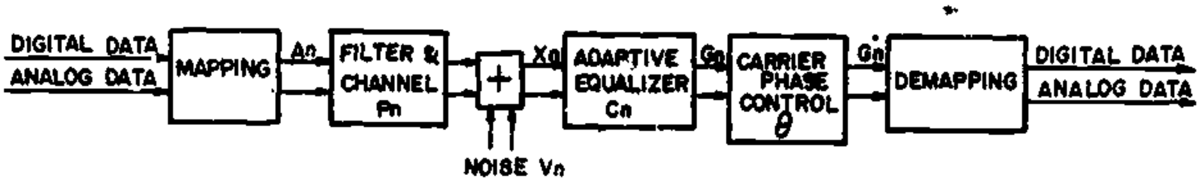
DIGITAL DATA
ANALOG DATA
MAPPING
An
FILTER & CHANNEL Pn
+
NOISE Vn
Xn
ADAPTIVE EQUALIZER Cn
Gn
CARRIER PHASE CONTROL θ
Gn
DEMAPPING
DIGITAL DATA
ANALOG DATA

Figure 2. Simplified system model

where A_n is transmitted data, P_n is a sampled impulse response for the overall filter system, and V_n is noise signal assumed to be white Gaussian. When digital signal a_n and analog signal b_n are mapped on inphase and quadrature axes of a two-dimensional plane, as shown in Fig.3, transmitted data A_n is expressed as

$$A_n = a_n + jb_n .$$

Equalized output G_n is given by

$$G_n = \sum_{\ell=-L}^{L} C_\ell X_{n-\ell} , \qquad (2)$$

where C_ℓ is complex valued tap coefficient for the transversal equalizer.

When the carrier phase control loop is provided after equalizer, output G'_n is given by

$$G'_n = e^{j\theta_n} G_n , \qquad (3)$$

where θ_n is the controlled carrier phase.

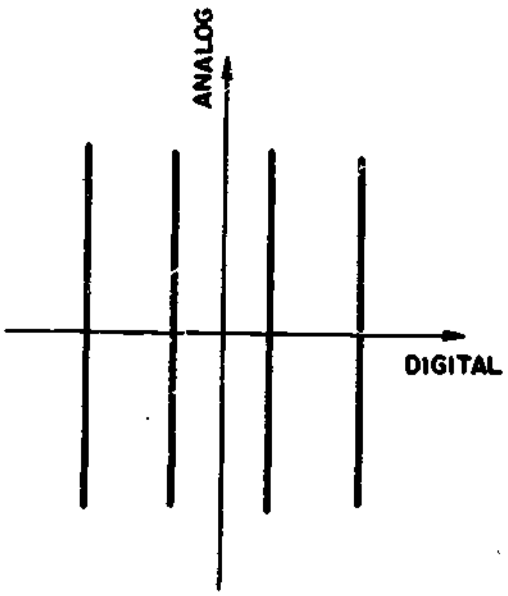

Figure 3. Mapping methods

Output G_n' is demapped to obtain the transmitted digital and analog information.

3. Adaptive receiver configuration

Automatic gain control and timing phase control are usually carried out directly by referring to a received passband signal. In the HADM system, they can be applied in the same way. On the other hand, adaptive equalization and carrier phase control must be carried out by decision directed method, using an accurate error signal $G_n' - A_n$. The difficulties in application of such a decision directed method to HADM are as follow:

(1) A_n estimation cannot be uniquely determined. Especially, there is no strategy to estimate accurate analog part b_n from distorted signal G_n'.

(2) Analog part of A_n is ordinarily correlated. No scrambling-descrambling technique has been developed for the sampled analog sequences.

3-1 Adaptive equalization

Adaptive equalizer tap coefficient should be adjusted so as to reduce error signal E_n:

$$E_n = G_n - A_n \qquad (4)$$

Since error signal E_n is a function of both channel characteristics and transmitted data, adjusted tap coefficients are determined not only by channel characteristics, but also by autocorrelation of the transmitted data sequence. If the transmitted data is uncorrelated, the channel distortion can be equalized in the sense of flat frequency characteristics. The whitening technique for correlated digital data sequence is well established in a scrambler and descrambler. However, there is no whitening technique for analog signals. Thus, one of the major problems in regard to adaptive equalization in HADM is to find tap adjustment algorithms so that the channel distortion is equalized, while not being disturbed by the strong analog part correlation.

From this view-point, the zero-forcing algorithm seems to be preferable to the mean square error algorithm. The zero-forcing algorithm optimizes tap coefficients so as to satisfy the following equations;

$$\sum_{\ell} C_{\ell} P_{k-\ell} = \delta_K \quad (K=-L\ldots+L), \qquad (5)$$

where

$\delta_K = 0$ $(K \neq 0)$ and $\delta_K = \text{Const}$ $(K=0)$.

Equation(5) is obtained from the crosscorrelation between error signal and transmitted digital data a_n, i.e.,

$$\langle a_{n-k} E_n \rangle = 0 \quad (k=-L\ldots L) \qquad (6)$$

under the conditions

$$\langle a_k a_\ell \rangle = 0 \quad (k \neq \ell) \text{ and } \langle a_k b_\ell \rangle = 0, \qquad (7)$$

where $\langle\ \rangle$ denotes the expectation [Appendix I]. Since Eq. (7) can be satisfied when only digital data a_n is whitened, this algorithm is free from the correlated analog signal disturbing force.

On the other hand, tap coefficients in the mean square error algorithm satisfy the following equations.

$$A \sum_{\ell} C_{\ell} \sum_{i} P_{i-\ell} P^*_{i-k} + NC_k = AP^*_{-k} \quad (K=-L\ldots+L), \qquad (8)$$

where A and N denote signal and noise powers, respectively. Equation (8) is obtained by crosscorrelation between received signal X_n and error signal E_n as

$$\langle X^*_{n-k} E_n \rangle = 0 \quad (k=-N\ldots N), \qquad (9)$$

when

$$\langle A^*_k A_\ell \rangle = 0 \quad (k \neq \ell). \qquad (10)$$

In Eqs. (9) and (10), * denotes complex conjugate. It should be noted that Eq. (10) is not satisfied, if transmitted analog signal is correlated. [Appendix II]

As a result of the above discussion, the zero-forcing algorithm is preferable for HADM equalization. However, it should be remarked that the zero-forcing algorithm has two disadvantageous aspects. One is that Eqs. (5) lack a random noise term. Therefore, optimized tap coefficients often have large noise enhancement. The other is that the zero-forcing tap adjustment fails for channels having a large initial distortion.

Another adaptive equalization problem in HADM is that true analog data cannot be obtained by the same threshold detection method, as used for digital data. Consequently, correct error signal given by Eq. (4) is unable to be found by any detection method. Other definitions of error signal in place of Eq. (4) must be satisfactorily applied to adaptive equalization algorithms. An idea to introduce new error signal definition is as follows.

For the zero-forcing algorithm, the real part of transmitted data, a_n, is used instead of A_n. Then, error $\tilde{E}_n$ is given by

$$\tilde{E}_n = G_n - a_n. \qquad (11)$$

Equation (5) is still obtained from the following equation using the cross-correlation between this error signal and transmitted digital data a_k, as

$$\langle a_{n-k} \tilde{E}_n \rangle = 0 \qquad (k=-N\ldots N) \qquad [\text{Appendix I}]. \qquad (12)$$

Therefore, iterative tap coefficient adjustment, based on the gradient method, is derived as

$$C_k^{n+1} = C_k^n - \alpha \left\{ a_{n-k} \tilde{E}_n \right\} \qquad (k=-N\ldots N). \qquad (13)$$

For the mean square error algorithm, the real part of Eq. (4) is employed, i.e.,

$$e_n = \text{Real}\left\{ E_n \right\} = g_n - a_n \quad , \qquad (14)$$

where g_n is the real part of G_n. In this case, Eq. (9) can be replaced equivalently by the following relation.

$$\langle X^*_{n-k}\, e_n \rangle = 0 \qquad (k=-N \ldots N), \qquad (15)$$

to obtain Eq. (8) [Appendix II].
Therefore, the mean square error adaptive equalization is obtained as

$$C_k^{n+1} = C_k^n - \alpha \left\{ X^*_{n-k} \; e_n \right\} \qquad (k=-N \ldots N) . \qquad (16)$$

3-2 Carrier phase control

The carrier phase jitter in telephone channels, which originates in leakage from AC power-supplying equipment, is one of the major impairments in high quality information transmission. Phase error ϕ_n, caused by carrier phase jitter, can be measured by detecting the angular deviation between the phase control output singal and transmitted signal A_n. In the data modem, phase error ϕ_n is easily approximated as

$$\phi_n \simeq \mathrm{Imag}\,[G_n'/A_n]. \tag{17}$$

Where the intersymbol interference is assumed to be eliminated by locating the adaptive equalizer before the carrier phase control loop. In HADM, however, such a phase measurement can not be exactly achieved, since no transmitted analog signal can be detected. One possible strategy to measure the carrier phase error is to regard h_n' as the detected imaginary part. This phase error measurement ψ_n is expressed as

$$\begin{aligned}\psi_n &\simeq \mathrm{Imag}[(g_n' + jh_n')/(a_n + jh_n')]\\ &= h_n'(a_n-g_n')/(a_n^2 + h'^2_n)\\ &= \sin\eta_n \sin\xi_n(\sin\xi_n + \sin\eta_n \cos\xi_n)/ 1+ \sin\eta_n\cos\xi_n (\cos\xi_n\\ &\quad + 2\sin\xi_n) .\end{aligned} \tag{18}$$

where ξ_n is the angular coordinate of A_n, and η_n is the difference between angular coordinates of G_n' and A_n.

Measured angular deviation ψ_n vanishes when analog part h_n' tends to zero. Hence, jitter measurement reliability depends on analog part amplitude distribution.

Thus, the carrier phase control can be carried out using this phase measurement scheme.

3-3 Joint system using adaptive equalizer and carrier phase control loop

The adaptive receiver, which provides carrier phase control loop after the adaptive equalizer, shows high performance[2]. Such a system is controlled jointly in a decision directed manner, referring to the estimated data. In this case, error signals for an adaptive equalizer involved in Eq. (11) or Eq. (14) must be replaced by the error signal after carrier phase control loop.

In the mean square algorithm, the mean square error magnitude gradient is expressed as $X_{k-n}e^{-j\theta_n}e_n$. Accordingly, the tap adjustment formula is given by

$$c_k^{n+1} = c_k^{n} - \alpha X_{n-k} e^{-j\theta_n} e_n . \tag{19}$$

In the zero-forcing algorithm, Eq. (12) can be expressed as

$$e^{j(\theta_n-\theta_n')} \sum_{\ell} c_\ell\, p_{k-\ell} = \delta_k , \tag{20}$$

where θ_n' denotes the carrier phase jitter. Equation (20) becomes equal to

Eq. (5) when the carrier phase jitter is completely controlled. In this case, tap adjusting Eq. (13) is not affected by the carrier phase control loop.

Initialization of this joint system is another significant problem. Initial training can not be achieved by sending an HADM signal. Therefore, a special training sequence must be sent before HADM signal information transmission. Such a training sequence may be the same one as is employed in conventional data modem.

4. Computer simulation

The computer simulation is achieved for highly distorted voiceband channel. Transmission conditions employed in the computer simulation are listed below.

(1) Modulation method: Double sideband
(2) Modulation rate: 2400 baud
(3) Shaping filter: 15% cosine roll off
(4) Carrier frequency: 1700 Hz
(5) Mapping method: 4 level raster mapping

The 35 tap adaptive equalizer is simulated under the condition that the analog signal is correlated. For visible understanding of the equalizer's fluctuation effect affected by the correlated analog signal, analog signal b_n *is chosen as periodic binary. The scatter diagrams shown in Fig.4 and 5 are for the zero-forcing and mean square error algorithms, respectively. The scattering magnitude for the zero-forcing equalization is larger than that of mean square error equalization. The reason is that the error signal in zero-forcing equalization does not tend to zero. In order to reduce the scatering magnitude, in zero-forcing equalization, the coefficient must be small to smooth out such a non-decreasing error signal. Scattering magnitudes along inphase and quadrature axes are the same in Fig. 4, but are different in Fig. 5. These factors imply that the mean square error equalization is not free from analog part correlation.*

Figure 6 shows the performance curves of two equalization schemes, when the analog signal is uncorrelated. Very small coefficient must be chosen for the zero-forcing equalization in order to get the same performance as obtained by mean square error equalization.

The mean square error equalizer performance, when operated jointly with the carrier phase control, is shown in Fig. 7. A second order filter with loop gain γ *is employed in the carrier phase control loop. It is seen that the carrier phase jitter is satisfactorily cancelled by carrier phase control loop.*

From curve (c) in Fig. 7, which is for the practical situation for an existing 25 dB signal to noise ratio, it is concluded that the resultant SNR at carrier phase control loop is better than 22 dB and guarantees a 10^{6} *error rate for digital information. This error rate performance is almost the same*

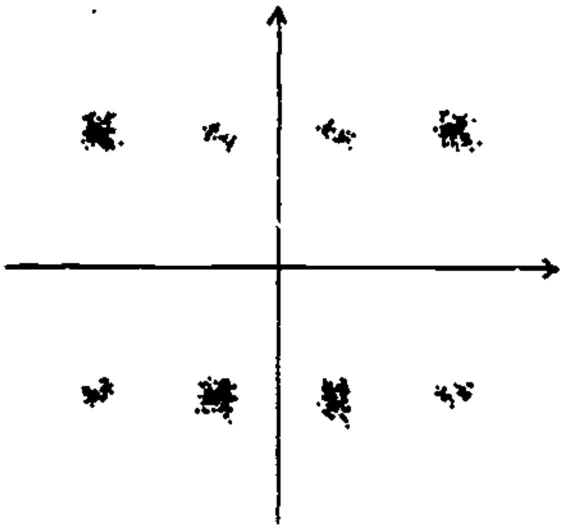

Figure 4. Scattering diagram for correlated analog data [Zero-forcing algorithm]

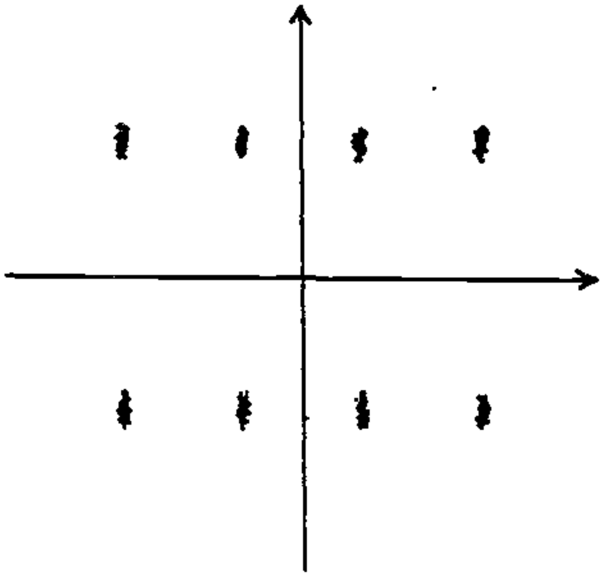

Figure 5. Scattering diagram for correlated analog data [mean square algorithm]

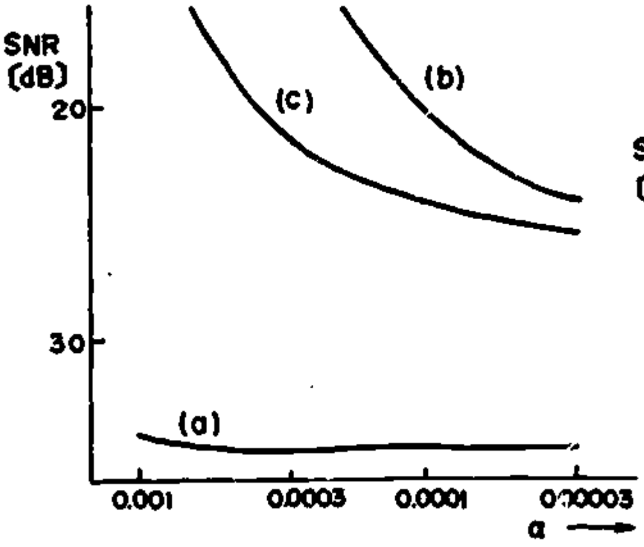

Figure 6. SNR for analog signal
(a) Mean square algorithm with phase control (γ=1.0)
(b) Zero-forcing algorithm with phase control (γ=1.0)
(c) Zero-forcing algorithm without phase control

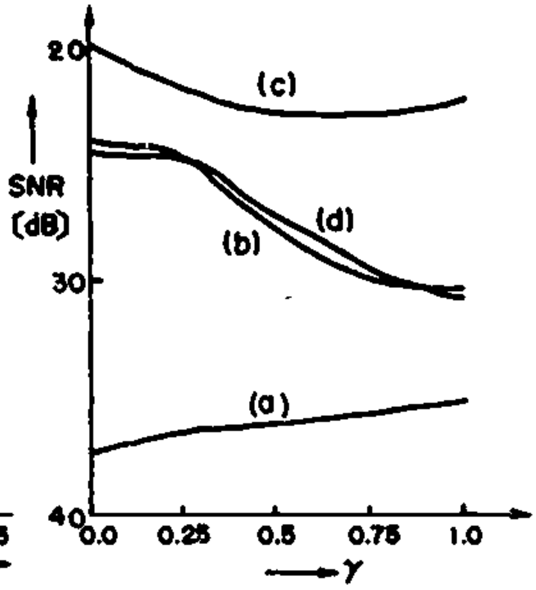

Figure 7. SNR for analog signal
(a) Uniform distribution without jitter
(b) Uniform distribution with 50Hz 10° p-p phase jitter
(c) Uniform distribution with 50Hz 10° p-p phase jitter and SNR 25 dB random noise
(d) Gaussian distribution with 50Hz 10° p-p phase jitter

as realized in the conventional 9.6 kbps data modem.

From a practical view-point, the transmission of a single 2.4 kHz sampled analog signal is interesting. Uniformly distributed sampled analog signal is divided into four parts and mapped on four different raster loci, as shown in Fig.8. A 12 dB SNR improvement can be obtained by this four level quantization. Therefore, the total SNR is 34 dB. When analog data is transmitted with the conventional 9.6 kbps data modem, 4 bit quantization must be applied to the analog data. Then, SNR is 24 dB, at best.

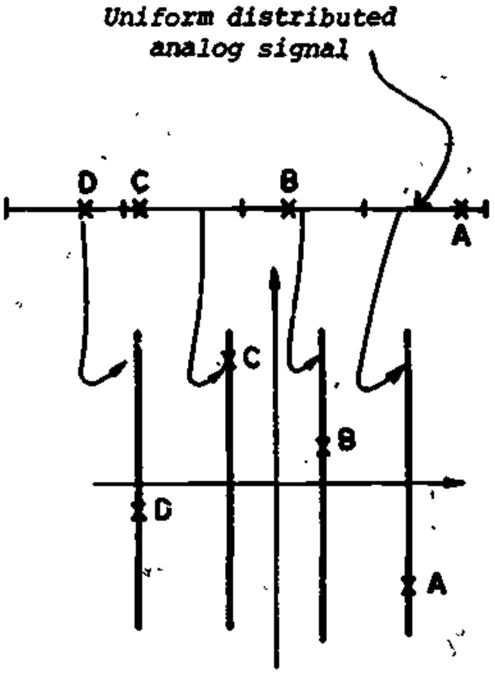

Figure 8. Mapping diagram when analog Signal is transmitted.

5. Conclusion

The adaptive equalization methods and corresponding carrier phase control methods, which are suitable for HADM transmission, were developed.

The computer simulation for the parallel transmission of 4.8 kbps digital and 2.4 kHz sampled analog sequences was performed for an actual telephone channel. Simulation results show that the parallel transmission technique improves the 10 dB SNR from a conventional 9.6 kbps data transmission, when 2.4 kHz sampled analog information is transmitted over a telephone channel.

The authors would like to thank Messrs. Y. Kato, M. Sugiyama, K. Murayama and Y. Marumo for their encouragement.

Appendix

I. The zero-forcing algorithm for HADM

In the zero-forcing algorithm, equalizer output peak distortion, which is defined by using impulse response samples after equalizer as

$$D_G = \sum_{i=-\infty\ i=0}^{+\infty} \left|\sum_{\ell} C_\ell P_{i-\ell}\right| / \left|\sum_{\ell} C_\ell P_{-\ell}\right| \qquad (21)$$

is minimized.

It is known that the peak distortion can be minimized by setting tap gains as to satisfy Eqs. (5), under the sufficient condition that equalizer input peak distortion is less than 1 [3]. Impulse response samples after equalizer can be estimated by the crosscorrelation between transmitted data and error signal as

$$\langle a_{n-k} E_n \rangle = \langle a_{n-k} \{ \sum_{\ell} C_\ell (\sum_{i} A_i P_{n-i-\ell} - V_n) - A_n \} \rangle$$

$$= \sum_{\ell} C_{\ell}\, P_{n-i-\ell} \langle a_{n-k}\, A_i \rangle - \langle a_{n-k}\, A_n \rangle$$

$$= A \left\{ \sum_{\ell} C_{\ell}\, P_{k-\ell} - \delta_k \right\} \quad (k = -L \ldots +L) \qquad (22)$$

under the conditions in Eqs. (7). Therfore, the zero-forcing equalization can be achieved by forcing Eqs. (6) zero.

From Eq. (22), it is seen that the transmitted data An in En can be replaced by its digital part a_n. Then Eq. (12), in which all signals are observable at the receiver, is also applicable.

II. The mean square algorithm for HADM

The mean square error

$$\mathcal{E} = \langle |E_n^2| \rangle \qquad (23)$$

can be minimized by setting tap gains to satisfy following equations.

$$\langle \partial\mathcal{E}/\partial c_k \rangle + j \langle \partial\mathcal{E}/\partial d_k \rangle = \langle X_{n-k}^{*}\;\; E_k \rangle = 0 \quad (k=-L \ldots +L) \qquad (24)$$

The left hand side of Eq. (24) can be rewritten as

$$\langle X_{n-k}^{*}\, E_k \rangle = \Big\langle \big(\sum_i A_i^{*} P_{n-k-i}^{*} + V_n^{*}\big) \Big\{ \sum_{\ell} C_{\ell} \big(\sum_i A_i\, P_{n-\ell-i} + V_n\big) - A_n \Big\} \Big\rangle$$

$$= \sum_{\ell} C_{\ell} \Big\{ \sum_i \sum_{i'} \langle A_i^{*} A_{i'} \rangle P_{n-k-i}^{*}\, P_{n-\ell-i'} + \langle |V_n|^2 \rangle \Big\} - \sum \langle A_i^{*} A_n \rangle P_{n-k-i}^{*}$$

$$= \sum_{\ell} C_{\ell} \big(A \sum P_{i-k} P_{i-\ell}^{*} + N\big) - A P_{-k}^{*} \qquad (25)$$

under the condition in Eq. (10).

If real part mean square error $\mathcal{E}'$ can be used instead of $\mathcal{E}$, it would be applicable to HADM in which only digital part error can be measured. When $\mathcal{E}'$ is used, the partial derivative of $\mathcal{E}'$ is written as

$$\langle X_{n-k}^{*} e_k \rangle$$

$$= \Big\langle \big(\sum_i A_i^{*} P_{n-k-i}^{*} + V_n\big) \Big\{ \sum_i a_i \mathrm{Re}\big(\sum_{\ell} c_{\ell} P_{n-i-\ell}\big) - \sum_i b_i \mathrm{Im}\big(\sum_{\ell} d_{\ell}\, P_{n-i-\ell}\big) + v_n - a_n \Big\} \Big\rangle$$

$$= \frac{\langle a_i^2 \rangle}{2} \sum_i P_{i-k}^{*} \mathrm{Re}\big(\sum_{\ell} C_{\ell} P_{i-\ell}\big) - j \frac{\langle b_i^2 \rangle}{2} \sum_i P_{i-k}^{*} \mathrm{Im}\big(\sum_{\ell} C_{\ell}\, P_{i-\ell}\big) + \frac{N}{2} C_k - \frac{\langle a_i^2 \rangle}{2} P_{-k}^{*}$$

$$= \frac{1}{2} \Big\{ \sum_{\ell} C_{\ell}\; \big(A \sum P_{i-k}^{*} P_{i-\ell} + N\big) - A P_{-k}^{*} \Big\} \qquad (26)$$

under the additional condition $\langle a_i^2 \rangle = \langle b_i^2 \rangle$.

Since Eqs. (26) is the same as Eqs. (25), the mean square algorithm for HADM can be achived by forcing Eq. (15) zero.

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A NEW ALGORITHM FOR SYMBOLIC RELIABILITY ANALYSIS OF COMPUTER - COMMUNICATION NETWORKS*

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ABSTRACT

A new algorithm for symbolic network analysis is presented. The algorithm is based on the application of a newly defined \$-operation on the set of all simple paths.

Comparisons with existing algorithms on the basis of terms that must be evaluated during the derivation, the number of operations required, and the execution time in several represented benchmarks show that the proposed algorithm is considerably more efficient than currently available solutions.

I. INTRODUCTION

The symbolic analysis of reliability networks has been the subject of considerable research. The symbolic terminal reliability algorithms available in the literature are based on path enumeration [1-13], cut-set enumeration [4,8] and on the acyclic subgraphs of the given probabilistic graph [14].

The most efficient path enumeration algorithms use reduction to mutually exclusive events by Boolean algebra. However, common drawbacks of these algorithms are that they generate a large number of terms [3, 13]; that they cannot efficiently handle systems of medium to large size (i.e., system graphs having more than 20 paths between input-output node pairs) [4]; and that they cannot easily determine the resulting symbolic function when the number of elements in the network is large [8]. The same drawbacks affect the algorithms based on the cut-set enumeration [4].

A more efficient algorithm based on the acyclic subgraphs of the given probabilistic graph was recently proposed by Satyanarayana and Prabhakar [14]. The examples indicate that this algorithm is appreciable faster than existing methods and can handle larger networks.

In this paper a new algorithm for the symbolic terminal reliability computation is presented. The algorithm belongs to the class of path enumeration algorithms (which use Boolean algebra) It is based on the application of a newly defined \$-operation on the set of all simple paths. A simple path is represented by a binary string (path identifier); thus only logical operations are required. The algorithm does not suffer from the drawbacks of path or cut-set enumeration algorithms.

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**Dr Grnarov is currently on leave from the Electrical Engineering Department, University of Skopje, Yugoslavia.

The algorithm was coded in FORTRAN IV and run on a DEC-10 timesharing computer system. Execution times confirm the advantages of the proposed algorithm over existing path and cut-set enumeration algorithms. The execution times are considerably shorter than the times shown for the network examples in [14] (these results, of course, provide only a qualitative comparison of computational efficiency since the programs were run on different computers).

II. DERIVATION OF THE ALGORITHM

For a network consisting of N nodes and E links, the path identifier is introduced by the following:

Definition 1: The path identifier IP_k for the path π_k is defined as a string of n binary variables

$$IP_k = x_1 x_2 \cdots x_i \cdots x_n$$

where

$x_i = 1$ if the i^{th} element of the network (node or link) is included in the path π_k

$x_i = x$ otherwise

and n = number of network elements that can fail, i.e.:

n = N in the case of perfect links and imperfect nodes

n = E in the case of perfect nodes and imperfect links

n = N + E in the case of imperfect links and imperfect nodes

As an example let us consider a 4 node, 5 link network, given in Figure 1, in which nodes are perfectly reliable and links are subject to failures. The path (s,x_1,a,x_5,b,x_4,t) is then represented by the string: IP = 1xx11.

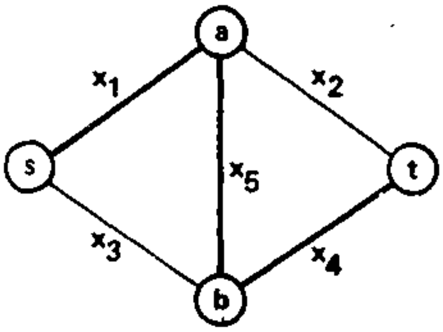

Figure I. Path Identifier String

According to *Definition 1*, it can be seen that a path identifier has the form of the cube in Boolean algebra. Hence, by applying the #-operation ("sharp" operation) ([15], page 173) between two path identifiers, denoted by $IP_k \# IP_j$, we obtain all subcubes (events) of IP_k not included in IP_j. Unfortunately, the generated subcubes are not mutually disjoint. The #-operation should be repeated

Since the proposed algorithm SYMB does not produce cancelling terms. the obtained result for the example given in Figure 1. has four terms in comparison with [4]and [3] which have five and six terms respectively.

For the second example of a network. shown in Figure 2 (also Figures 1, 10 and 3 in [8]. [4] and [14] respectively), we obtain a reliability expression which has 16 terms. The results in [8]a and [4] have 22 and 61 terms respectively, and the symbolic expression in [14] upon expansion yields 123 terms.

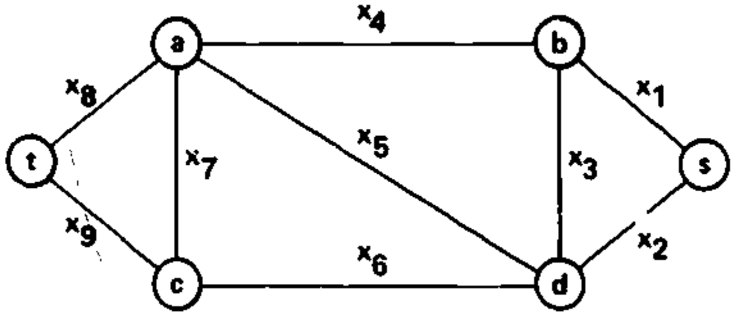

Figure 2. Modified Graph of ARPA Network

The third example, given in Figure 3, was also used in [3], [13] and [12]. The reliability expression has 38 terms while the result in [13] has 72 terms. For the determination of S_{23}, The algorithm SYMB requires 34 comparisons while the algorithms reported in [13] and [12] require 54 and 173 comparisons respectively For finding S_{24} these values are 26, 45 and 159 respectively.

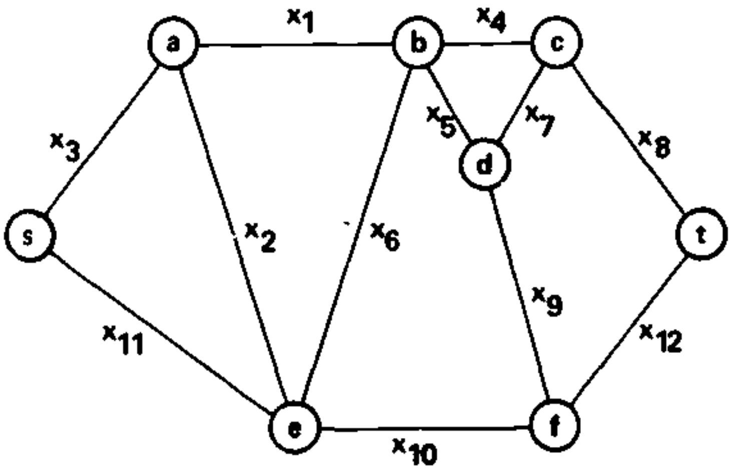

Figure 3. Example Network

A program based on the proposed algorithm was written in FORTRAN IV and run on a DEC-10 timesharing computer system. The program was applied to a number of network examples found in the literature. The execution times for examples given in Figures 2 through 6 are presented in Table 3 and are compared with the execution times of some of the existing algorithms. The results confirm the efficiency of the proposed algorithm.

on the set of subcubes again and again until a set of disjoint subcubes is obtained.

In the case when the paths π_j, $j = 1, 2, \cdots, m-1$, have been examined, the determination of the set of subcubes S_m of the path π_m, which are not included in the previous paths, can be performed as

$$S_m = (\ldots((IP_m \# IP_1) \# IP_2) \# \ldots \# IP_j) \# \ldots) \# IP_{m-1} \tag{1}$$

Since the #-operation is performed using the largest possible cubes (path identifiers), the generation of S_m is faster as compared with [3] and [8]; also there is no need for storing the new terms. The drawbacks of operation (1) are the generation of the repeated subcubes and the need for the repeated application of the #-operation between the subcubes in S_m. To avoid these drawbacks, a new \$-operation is introduced in *Definition 4* below.

Before the presentation of *Definition 4* it is useful to make the following consideration. Since the path identifiers contain only symbols 1 and x, the #-operation can produce as a new symbol, only 0. The 0's generated in step j are designated as 0^j. If in the cube generated by #-operation there is only one 0^j, we call this a unique 0. Next we quote the definition of the coordinate #-operation from [15] (the definition of #-operation between two cubes is given in [15] on page 173) and we introduce the definitions of the $@_j$-operation and the \$-operation.

Definition 2. The coordinate #-operation is defined as given in Table 1.

Table 1

b_i a_i	0	1	x
0	z	y	z
1	y	z	z
x	1	0	z

Definition 3. The $@_j$-operation between two cubes, say $C^r = a_1 a_2 \cdots a_i \cdots a_n$ and $C^s = b_1 b_2 \cdots b_i \cdots b_n$, is defined as

$$C^r @_j C^s = \begin{cases} C^r & \text{if } a_i \# b_i = y \text{ for any unique 0 or} \\ & \text{if } a_i \# b_i = y \text{ for all } a_i = 0^v \text{ for any v} \\ C_1^r \# C^s \bigcup C_0^r & \text{otherwise} \end{cases}$$

where

C_1^r is a cube obtained from C^r substituting all $a_i = 0^j$, for which $a_i \# b_i = y$, by 1.

and

C_0^r is a cube obtained from C^r substituting all $a_i = 0^j$, for which $a_i \# b_i \neq y$, by x.

Definition 4. The \$-operation between two cubes C^r and C^s is defined as

$$C^r \,\$\, C^s = \begin{cases} \Phi & \text{if } a_i \# b_i = z \text{ for all i} \\ S_k & \text{if } a_i \# b_i = y \text{ for any i} \\ C^r & \text{otherwise} \end{cases}$$

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where Φ is the empty set, $S_j = S_{j-1} @_j C^s$, $S_1 = C^t @_1 C^s$ and $j = 2, 3, \cdots k$ (k is the number of steps in which any symbol(s) $\mathbf{0}$ is generated), $C^t = c_1 c_2 \cdots c_i \cdots c_n$ and $c_i = a_i \# b_i$.

According to *Definition 4* it follows that if we substitute the #-operation in (1) by the \$-operation, the resulting set S_m will consist of disjoint cubes only. The symbolic expression, corresponding to a cube C in S_m, is given by

$$T(C) = P \cdot Q \prod_{j=2}^{k} (1 - P_j)$$

where

$P = \Pi\, p_i$	for all i satisfying $c_i = 1$
$Q = \Pi\, q_i$	for all i satisfying $c_i =$ unique 0
$P_j = \Pi\, p_i$	for all i satisfying $c_i = 0^j$
p_i	is symbol representing probability that the i^{th} element is up
$q_i = 1 - p_i$	

and Π and $\cdot$ are the product and concatenation operators in the string algebra.

We can now introduce the algorithm SYMB for the derivation of symbolic expression for terminal reliability:

ALGORITHM SYMB:

step 1.	Find path identifiers for all simple paths between node s and node t
step 2.	Sort them according to increasing number of symbols 1 (i.e., increasing path length).
step 3.	Set $T_{11} = T(IP_1)$
step 4. (loop)	For $m = 2, 3, \cdots, k$ determine $S_m = (\cdots((IP_m \,\$\, IP_1)\$IP_2 \cdots)\$IP_{m-1}$ Form $T_{mi} = T(C_m^i)$, $i = 1, 2, \cdots, l$
step 5.	END

In the algorithm, C_m^i is a cube in the set S_m and l is the number of cubes in S_m.

As an example, the SYMB algorithm is applied to the simple bridge network given in Figure 1. (This same example was used in [3]and [4].)

steps 1,2. Table 2 presents the set of all simple paths and their path identifiers (for simplicity we consider the case with perfect nodes and imperfect links).

Table 2

m	π_m	IP_m
1	x_1x_2	11xxx
2	x_3x_4	xx11x
3	$x_1x_5x_4$	1xx11
4	$x_3x_5x_2$	x11x1

step 3. $T_{11} = p_1p_2$

step 4. $m = 2$:

$$\begin{array}{lll} & \text{xx11x} & \\ & \underline{\text{11xxx}} & \\ S_2 = & \text{0011x} & j = 1 \end{array}$$

$$T_{21} = p_3p_4(1 - p_1p_2)$$

$m = 3$:

$$\begin{array}{lll} & \text{1xx11} & \\ & \underline{\text{11xxx}} & \\ & \text{10x11} & \text{unique 0, } j = 1 \\ & \underline{\text{xx11x}} & \\ S_3 = & \text{10011} & \text{unique 0, } j = 2 \end{array}$$

$$T_{31} = p_1p_4p_5q_2q_3$$

$m = 4$:

$$\begin{array}{lll} & \text{x11x1} & \\ & \underline{\text{11xxx}} & \\ & \text{011x1} & \text{unique 0, } j = 1 \\ & \underline{\text{xx11x}} & \\ & \text{01101} & \text{unique 0, } j = 2 \\ & \underline{\text{1xx11}} & \\ S_4 = & \text{01101} & \end{array}$$

$$T_{41} = p_2p_3p_5q_1q_4$$

step 5. END

The symbolic expression for terminal reliability is

$$T_{st} = p_1p_2 + p_3p_4(1 - p_1p_2) + p_1p_4p_5q_2q_3 + p_2p_3p_5q_1q_4$$

III. COMPUTATIONAL RESULTS

Two common criteria for the evaluation of symbolic reliability algorithms are: (1) the number of terms in the reliability expression; and (2) the number of comparisons of an intermediate product term with the term represented by a simple path [13].

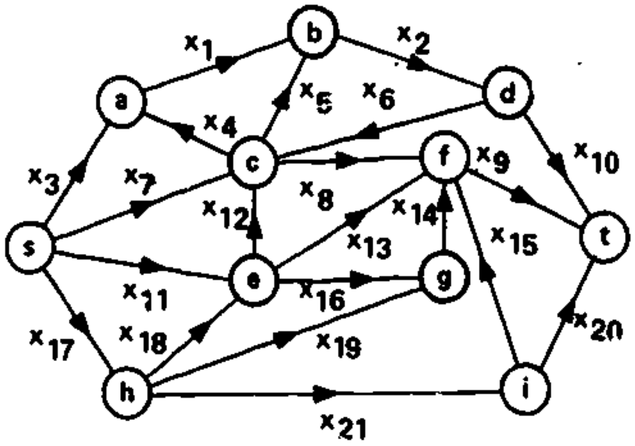

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Figure 4. Topology of a Highly Connected Network

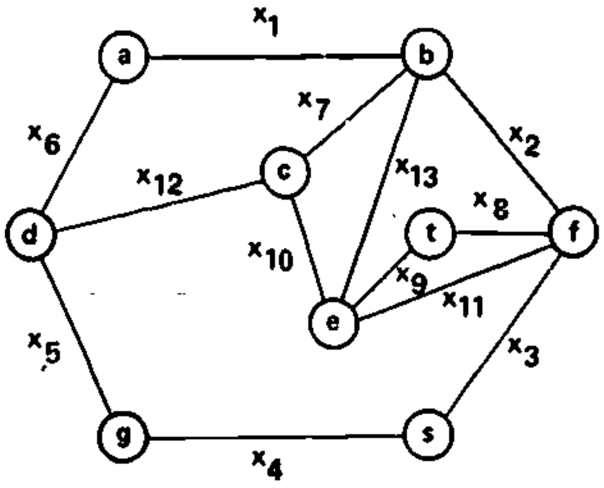

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Figure 5. A Long Line Telephone Network Example

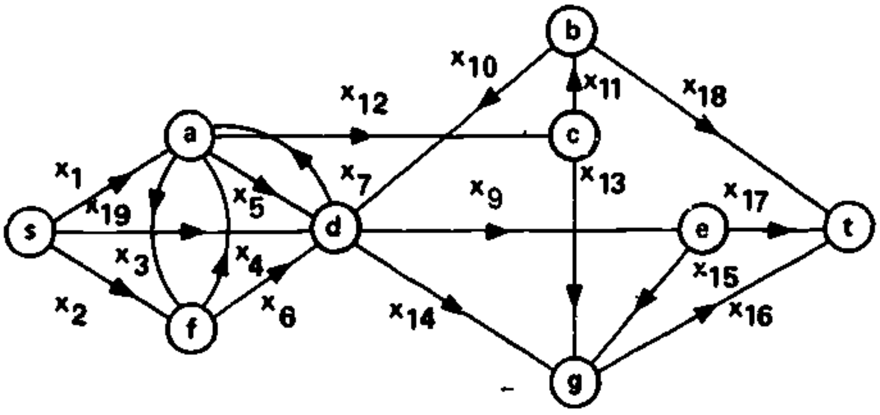

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Figure 6. Network Example Which Allows for Both Nodes and Links Failures

Table 3

Algorithm	Computer system/language	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 6
Fratta, Montanari [3]	IBM 360/67 FORTRAN		112 s.	> 10 min.		
Lin, Leon, Huang [4]	CDC 6500 FORTRAN	9 s.			75 s.	
Abraham [13]	DEC-10 SAIL		6 s.	19 s.		
Satyanarayana, Prabhakar [14]	PDP 11/45 FORTRAN	1.2 s			5.7 s.	43 s.
SYMB	DEC-10 FORTRAN	0.8 s.	1.5 s.	3.3 s.	1.1 s.	7.4 s.

IV. CONCLUDING REMARKS

The paper presents a new algorithm for symbolic network analysis. The proposed algorithm is based on the implementation of a newly defined \$-operation on the set of path identifiers. Applying the \$-operations, only the disjoint subcubes are generated and therefore the reliability expression can be obtained in a straightforward manner. The algorithm is efficient since it does not generate a large number of terms and does not require the generation and storage of intermediate terms beside the path identifiers.

The comparisons with the existing algorithms in the number of terms, number of comparisons and execution times of the realized program confirm the efficiency of the proposed algorithm.

Due to the improved computational efficiency, the SYMB algorithm permits us to analyze and derive symbolic reliability expressions for networks of considerably larger size than was possible using the previous techniques.

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BUFFER BEHAVIOUR FOR
BINOMIAL INPUT AND RANDOM SERVER INTERRUPTION

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Abstract

The main objective of this paper is to study the buffer behaviour for binomial input and random server interruption. Analytical expressions are obtained for parameters of interest and numerical results are discussed.

INTRODUCTION

Design of buffer is one of the important problem in data communication. The non uniform random nature of message generation in a data communication system is frequently occuring reality. More efficient data transmission system can be obtained by combining the needs of many random users in such a way that the flow of information becomes more continous. The rapid rate of growth of telecommunication particularly in connection with time shared computer has resulted in a rapid and intensive interest in this area. The solution of inefficient use of communication channels and equipment is the use of a synchronous multiplexor. These devices sample the various message sources, store detected messages in buffer memory and then transmitt the stored message over the communication link or channel. Thus it becomes necessary to find out that how long the storing of message will delay the performance. Moreover, the size of the buffer storage memory is finite and hence there will be probability of buffer overflow and consequent message loss. Given the buffer input statistics, the problem is to find the storage requirement such that the overflow probability and expected queuing delay due to buffering is less than their given specific value. In this paper a queuing model with finite buffer size for binomial input and random server interruptions is studied. It is assumed that there are only a small number of terminals. The receipt of messages in a specified time interval alters the probability that additional messages will be received in the same specified time interval.

ANALYSIS

Let the following specifications be given

Output rate (when serving) = r_o characters/sec.

Buffer length = N characters

Steady state probability of the switch in state 1 = p_{s1}

Steady state probability of the switch in state 0 = p_{s0} (1)

Service interval T_s = $(1/r_o)s$

Average output/service interval = p_{s1} characters

Average input/service interval, $\lambda = \rho\, p_{s1}$ characters (2)

where ρ (<1) is the traffic intensity.

The probability θ_k, of k characters arriving during a service interval is given by Binomial distribution

$$\theta_k = \begin{cases} \binom{N}{k} \lambda^k (1-\lambda)^{N-k} & , k = 0,1,2,\dots,N \\ 0 & , k < 0,\ k > N \end{cases} \tag{3}$$

Let the probability $p_i(j)$ of the buffer occupancy $B(j) = i$ at the end of j th service interval be defined as

$$p_i(j) = \text{prob} \quad B(j) = i \quad , i = 0,1,\dots,N \tag{4}$$

Equations for the buffer content process can be written as

$$p_o(j+1) = \theta_o\, p_{s1}\, p_o(j) + \theta_o\, p_{s1}(j) p_1(j) + \theta_o p_{so}\, p_o(j) \tag{5}$$

or in original

$$p_1(j+1) = \theta_1\, p_{s1}\, p_o(j) + \sum_{k=o}^{i} \theta_{i-k}\, p_{s1}\, p_{k+1}(j)$$
$$+ \sum_{k=o}^{i} \theta_{i-k}\, p_{so}\, p_k(j), \quad i = 0,1,\dots,N-1 \tag{6}$$

and

$$p_N(j+1) = \Big[1 - \sum_{i=o}^{N-1} \theta_i\Big] p_{s1}\, p_o(j) + \sum_{k=1}^{N} \Big[1 - \sum_{i=o}^{N-k} \theta_i\Big] p_{s1}\, p_k(j)$$
$$+ \sum_{k=o}^{N-1} \Big[1 - \sum_{i=o}^{N-k-1} \theta_i\Big] p_{so} p_k(j) + p_{so} p_N(j) \tag{7}$$

Equations (5) and (7) can be conveniently written matrix form as

$$p(j+1) = p_{s1}\ G\ p(j) + p_{so}\ H\ p(j) \tag{8}$$

where p(j) is the (N-1) dimensional vector

$$p(j) = \begin{bmatrix} p_o(j) \\ p_1(j) \\ \vdots \\ p_N(j) \end{bmatrix} \qquad (9)$$

and G and H are (N+1) x (N+1) matrices defined as

$$G = \begin{bmatrix} \theta_o & \theta_o & 0 & \cdots & 0 & 0 \\ \theta_1 & \theta_1 & \theta_o & \cdots & 0 & 0 \\ \vdots & & & & & \\ \theta_{N-1} & \theta_{N-1} & \theta_{N-2} & \cdots & \theta_1 & \theta_o \\ 1-\sum_{i=o}^{N-1}\theta_i & 1-\sum_{i=o}^{N-1}\theta_i & 1-\sum_{i=o}^{N-2}\theta_i & \cdots & 1-\sum_{i=o}^{1}\theta_i & 1-\theta_o \end{bmatrix} \qquad (10)$$

$$H = \begin{bmatrix} \theta_o & 0 & 0 & \cdots & 0 & 0 \\ \theta_1 & \theta_o & 0 & \cdots & 0 & 0 \\ \vdots & & & & & \\ \theta_{N-1} & \theta_{N-2} & \theta_{N-3} & \cdots & \theta_o & 0 \\ \vdots & & & & & \\ 1-\sum_{i=o}^{N-1}\theta_i & 1-\sum_{i=o}^{N-2}\theta_i & 1-\sum_{i=o}^{N-3}\theta_i & \cdots & 1-\theta_o & 0 \end{bmatrix} \qquad (11)$$

Stationary State Probabilities: When $j \to \infty$, $p(j+1) = p(j) = p$, equation (8) reduces to

$$p = p_{s1} G_p + p_{so} Hp \qquad (12)$$

or

$$Rp = 0 \qquad (13)$$

where, $R = I - p_{s1} G - p_{so} H$ (14)

It is obvious that matrix R will be of the form of

$$R = \begin{bmatrix} r_{oo} & r_{o1} & 0 & \cdots & 0 & 0 \\ r_{10} & r_{11} & r_{12} & \cdots & 0 & 0 \\ \vdots & & & & & \\ r_{N-1,o} & r_{N-1,1} & r_{N-1,2} & \cdots & r_{N-1,N-1} & r_{N-1,N} \\ r_{N,o} & r_{N,1} & r_{N,2} & \cdots & r_{N,N-1} & r_{N,N} \end{bmatrix} \quad (15)$$

Since (N+1) component equations obtained from equation (13) are not linearly independent, first N component equations from equation (13) are solved together with normalizing conditions

$$U^T p = 1 \quad (16)$$

where U is (N+1) dimensional unit vector (N+1) components of p can now be obtained using a recursion method by defining an (N+1) dimensional vector s as

$$S_i = p_i/p_o \quad (17)$$

so that

$$S_o = p_o/p_o = 1 \quad (18)$$

In general

$$S_k = p_k/p_o = \frac{\sum_{i=o}^{k-1} r_{k-1,i} S_i}{r_{k-1,k}}, \; k = 1,2,\ldots N \quad (19)$$

Equation (19) will give $p_k (k = 1,2,\ldots,N)$ in terms of S_k and p_o, where p_o is given by

$$p_o = 1/\sum_{i=o}^{N} S_i \quad (20)$$

Thus all values of $p_k (k = 1,2,\ldots,N)$ are evaluated through equations (19) and (20).

Overflow Probability : The probability, β of a character being transmitted during each service interval is given by

$$\beta = p_{s1}(1-p_o) \quad (21)$$

Therefore, the expected load carried during each service interval is β. The average load offered during each service interval is given by equation (2). The overflow probability p_{of} is defined as

$$p_{of} = (\alpha-\beta)/\alpha \text{ , where } \alpha = \text{average offered load} \quad (22)$$

Queueing Delay: The expected queue length at the end of a service interval is given as

$$Q_e = \sum_{i=o}^{N} i\, p_i \qquad (23)$$

Average number of characters that arrive during a service interval is given by equation (2). Hence the average queue length at the start of a service is given by

$$Q_e = \sum_{i=o}^{N} i\, p_i - \alpha(1-p_{of}) \qquad (24)$$

Overall average queue length is obtained by taking the time average of Q_e and Q_s. Thus the average queue length Q_L is given by

$$Q_L = \sum_{i=o}^{N} i\, p_i = \frac{\alpha}{2}(1-p_{of}) \qquad (25)$$

The expected queuing delay D is defined as

$$D = Q_L/\beta \text{ units of service interval} \qquad (26)$$

The values p_{of} and D are computed using the equations (22) and (26) for different values of ρ. The computed values are plotted in graphs as shown in Figures 1 and 2.

CONCLUSION

For fixed value of traffic intensity ρ the overflow probability p_{of} decreases as the traffic intensity N increases and for fixed value of N the p_{of} decreases as ρ increases. It is also observed that for a given value of λ the D increases as N increases and for fixed value of N the D increases as ρ increases upto $\rho = 0.5$ and on further increase of ρ from 0.5 to 1.0 D will nearly remain constant. This type of model is very useful where the number of users are less and the data should be transmitted through the existing telephone lines whenever there is speech interruption in the telephone line.

ON THE CAPACITY OF ONE-HOP ALOHA PACKET RADIO NETWORKS WITH ADJUSTABLE TRANSMISSION POWER *

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ABSTRACT

In this paper we investigate two possible policies for realizing an arbitrary traffic matrix in a Slotted ALOHA broadcast packet radio network: full connectivity and limited transmission power. The performance for the fully connected (point-to point) network is the same as the known result for a centralized network and allows a maximum throughput of $1/e$. The other approach, wherein we give each node sufficient power to just reach his destination, allows a maximum throughput proportional to the logarithm of the number of (active) nodes in the network. These results, which are derived analytically, are then verified by simulation, showing excellent agreement.

1. Introduction

One of the major problems in the effective utilization of computer resources is the distribution of those resources to the user. This problem has been greatly alleviated by the advent of communication networks but communication among these users in a local environment still remains a problem. The concept of broadcast packet radio for local access was first utilized in the ALOHA system [ABRA 70] and more recently, the Advanced Research Projects Agency of the Department of Defense has undertaken a project to investigate the use of more general broadcast packet radio systems [KAHN 77, KAHN 78]. A packet radio network consists of many packet radio units (PRUs)** sharing a common radio channel such that when one unit transmits, many other units will hear the packet, even though it is addressed to only one of them. This feature, inherent in broadcast systems, in conjunction with the fact that channel access control is neither automatic nor free, results in destructive interference when several packets are received simultaneously.

Many studies have been conducted to evaluate the capacity (maximum achievable throughput) of one-hop centralized communication networks using broadcast radio as the communication medium. In [ABRA 70] the capacity of fully-connected one-hop centralized pure ALOHA was found to be $1/2e$ and in [ROBE 75] the corresponding result for Slotted ALOHA networks was found to be $1/e$. In [LAM 74] we find an extensive analysis for the fully connected one-hop centralized slotted ALOHA access scheme and in [TOBA 74, KLEI 75] we find similar results for Carrier Sense Multiple Access (CSMA). Local access networks usually have centralized traffic requirements (the central node often being a gateway to the main network).

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** All components of the packet radio network (i.e., stations, repeaters and terminals) use a common device for channel access. This device is called the Packet Radio Unit.

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In [GITM 75, TOBA 78b] we find some capacity results for two-hop Slotted ALOHA centralized nets and these results are extended to CSMA in [TOBA 78a].

On the other hand, some applications of broadcast radio nets, (such as ship-to-ship communication or remote sensing networks) have arbitrary point-to-point traffic requirements. This kind of broadcast network has received little attention in the literature. In [KLEI 78] we derive the capacity for a *random* network (i.e., the nodes are randomly located in space, giving rise to random connectivity) using multi-hop Slotted ALOHA and find that we can achieve throughput proportional to the square root of the number of nodes in the network by restricting the transmission range. In fact, we find that the optimum number of nodes to have in range (i.e., the nodal degree) is about six. In [SILV 79b] we derive similar results for *regular* networks (i.e, nodes are regularly located and connected to a fixed number of neighbors), again finding a square root behavior and also that the nodal degrees should be minimized (subject to a connectivity constraint). The performance of any network will depend on the traffic requirements and in [SILV 79a] we derive bounds on the capacity of a single hop point-to-point network, for an 'optimal' traffic matrix, showing that we can achieve a throughput proportional to the number of nodes in the network.

In this paper we consider point-to-point networks, satisfying *arbitrary* traffic matrices, in which the nodes are sufficiently close that they can communicate in one hop. We investigate whether the nodes should transmit at full power or restrict their power to just allow communication to their intended destination. By restricting the range we expect higher performance since the interference will be reduced. This is the phenomemon that we have observed in other studies [KLEI 78, SILV 79a, SILV 79b].

2. The Network Model

The networks that we study in this paper have a random topology, which may be thought of as either representatives of the set of all possible networks or as snapshots of a mobile network. In order to model the requirement that the network should be able to handle an arbitrary traffic pattern, we assume a uniform traffic matrix. Our traffic model is, then, of the (instantaneous) communication requirement between some active subset of the total number of nodes in the network (non-active nodes are ignored).

A network is a set of n (active) nodes (with n even to allow pairing) randomly located in a unit hypersphere. These nodes are then randomly paired to represent communicating pairs of nodes. Having generated the network and the traffic matrix, we satisfy the communication requirement by suitable choice of transmission power. We consider two approaches that will allow this paired communication to be reallized: i) give every node sufficient power to be able to reach *every* other node in the network; or ii) give each node sufficient power to just reach his communication partner.

Once the network is established we have one additional parameter to specify - the probability that a node will transmit in any slot. (This corresponds to the offered channel traffic, randomized so that Slotted ALOHA will operate correctly and resolve previous conflicts caused by to simultaneous transmissions.) In order to compute the throughput we use the 'heavy traffic model', which corresponds to assuming that all (active) nodes are always busy, but which transmit in any given slot depending on this transmission probability. We denote the transmission probability for node i as p_i.

Nodal Throughput: Consider an arbitrary node (say node i) in the network. The probability that this node correctly receives a packet from his partner (say node j) in any slot, is given by:

$$s_i = Pr\{j \textit{ transmits}\}\, Pr\{i \textit{ does not transmit}\}\, Pr\{\textit{none of } i\textit{'s neighbors transmits}\}$$

$$= p_j\,(1-p_i) \prod_{k\in N_i} (1-p_k) \qquad (1)$$

where N_i is the set of nodes that i can hear (excluding his partner j). We are assuming here that a node either hears a transmission or hears nothing. (In a real network the reception process is not discrete but depends on noise levels etc.)

For the heavy traffic model, s_i corresponds to the (received) throughput γ_i for this node. Thus the total network throughput, γ, is given by:

$$\gamma = \sum_{i=1}^{n} \gamma_i = \sum_{i=1}^{n} s_i \qquad (2)$$

3. Completely Connected Topologies

One approach to satisfying an arbitrary random traffic matrix is to give every node sufficient transmission power so that all the nodes in the network hear when any one transmits. This corresponds to the model of [ROBE 75, ABRA 77] and the total network throughput will therefore be $1/e$. We proceed to show that our approach gives the same result.

Since the environment for each node is identical, we assume $p_i = p$. The number of nodes that can interfere with a given transmission is $n-2$, so the throughput for each node is:

$$\gamma_i = p\,(1-p)\,(1-p)^{n-2} \qquad (3)$$

In order to set the offered traffic in any environment to be the optimum value of one packet per slot [ABRA 70, LAM 74, YEMI 78], we use a transmission probability of $p = 1/n$. We then have:

$$\gamma_i = \frac{1}{n}\left(1 - \frac{1}{n}\right)^{n-1} \qquad (4)$$

As the throughput for each node is identically distributed, the network throughput, γ, is simply:

$$\gamma = \left(1 - \frac{1}{n}\right)^{n-1} \qquad (5)$$

which has the expected asymptotic behavior of $1/e$ for large networks.

4. Limited Transmitter Power

Another approach for arbitrary traffic matrices is to limit the power of each transmitter so that it exactly reaches its destination (we are assuming that reception is a two-state process, either you can or cannot hear a transmission). In Figure 1 we show a two-dimensional network of 10 nodes generated in this manner by the simulation program described in section 5; the lines joining pairs of nodes represent the traffic matrix and hence the transmission radii.

Since the networks we consider are homogeneous, the throughput for all nodes is identically distributed; we, therefore, drop the subscripts corresponding to the particular node under investigation. We set the offered traffic in any environment to unity, by selecting the transmission probability to be $1/k$ for a node that interferes with k others when he transmits, including himself and his transmission partner. In [SILV 79b] we studied other transmission policies and found that the scheme used here had the highest throughputs. Using the notation $\gamma(k)$ to represent the throughput for a node which interferes with k nodes and making the assumption that both nodes of a partnership hit the same number of nodes*, we obtain the following expression for the throughput:

$$\gamma(k) = I \frac{1}{k} \left(1 - \frac{1}{k} \right) \tag{6}$$

where I, the interference factor, is the interference contribution from nodes other than the node itself. We can think of this factor as background interference. If we assume that the interference encountered at any node is independent of the degree of that node, then the expected thoughput for any node in the network, γ_{node}, is given by:

$$\gamma_{node} = I \sum_{k=2}^{n} h_k \, \gamma(k) \tag{7}$$

where h_k is the probability that a node hits (interferes with) k other nodes when he transmits (note that he always hits himself and his partner).

We now proceed to find this hitting distribution. Consider an arbitrary node, P, in the network and rank the $n-1$ other nodes in order of their distance from P. If P is paired with his kth neighbor, he will interfere with (hit) exactly $k+1$ nodes when he transmits. As P is equally likely to be paired with any of the nodes, the hitting distribution is given by:

$$h_k = \frac{1}{n-1} \qquad k=2,3,\ldots,n \tag{8}$$

We can now compute the throughput.

$$\gamma_{node} = I \sum_{k=2}^{n} h_k \frac{1}{k} \left(1 - \frac{1}{k} \right)$$

$$= \frac{I}{n-1} \left[\sum_{k=2}^{n} \frac{1}{k} \left(1 - \frac{1}{k} \right) \right] \tag{9}$$

In [SILV 79b] we show that the interference factor, I, for networks where the interference heard by a node is independent of the degree of that node and the transmission probability is $1/k$, is given by:

$$I = \prod_{k=3}^{n} \left(1 - \frac{k-2}{n-2} \, \frac{h_k}{k} \right)^{n-2} \tag{10}$$

Thus the nodal throughput is given by:

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* As both nodes are transmitting at the same range, certainly the *expected* number hit by a transmission will be the same.

$$\gamma_{node} = \frac{1}{n-1}\left[\prod_{k=3}^{n}\left(1-\frac{k-2}{n-2}\,\frac{1}{k}\,\frac{1}{n-1}\right)^{n-2}\right]\left[\sum_{k=2}^{n}\frac{1}{k}\left(1-\frac{1}{k}\right)\right] \tag{11}$$

Since the throughput for each node is identically distributed, the total network throughput, γ, will be given by $n\gamma_{node}$.

$$\gamma = \frac{n}{n-1}\left[\prod_{k=3}^{n}\left(1-\frac{k-2}{n-2}\,\frac{1}{k}\,\frac{1}{n-1}\right)^{n-2}\right]\left[\sum_{k=2}^{n}\frac{1}{k}\left(1-\frac{1}{k}\right)\right] \tag{12}$$

With some manipulation, we find that the asymptotic behavior for large networks is given by:

$$\lim_{n\to\infty}\gamma = \frac{\log(n) + C - \frac{\pi^2}{6}}{e} \tag{13}$$

where C is Euler's constant. This can be approximated by:

$$\gamma \approx \frac{\log(n) - 1}{e} \tag{14}$$

The above results were derived with no reference to the dimensionality of the network. We can therefore achieve a throughput *logarithmically* proportional to the network size for all networks satisfying an arbitrary traffic pattern by exact adjustment of transmission range. It must be pointed out, however, that the throughput for all pairs of nodes in the network is not the same. Nodes that are close together (and thus have high transmission probabilities since they do not interfere with many other nodes) will achieve higher throughputs than those that are far apart (recall that the background interference is uniform for all nodes in the network). Even the node with the smallest throughput (in the worst case this node will hit $n-2$ other nodes) will have a throughput of:

$$\gamma(n-2) = \frac{1}{ne} \tag{15}$$

for large networks, which is the same as that for the fully connected case (in which *every* node achieves a throughput of $1/ne$). Thus the node experiencing the worst performance will be doing no worse than for the fully connected case, whereas nodes close together will far exceed this throughput. We are currently investigating the capacity of the network if some 'fairness' requirement is imposed.

5. Simulation

In order to check the validity of this model, we developed a simulation program to compute the throughputs for these networks. This program operates as follows (described for a two-dimensional network).

A randomly generated network is located inside the unit circle and pairs of nodes are then randomly matched. With this pairing, the transmission radii are determined so that communication can take place, and the adjacency matrix is computed. We then determine the transmission probabilities, based on the number of nodes within range of the node. From this we compute the success probabilities for each node and hence the network throughput. This process is repeated many times and the throughput, averaged over several networks, is computed.

In Figure 2 we have plotted throughput against network size, showing analytical and simulation results for a two-dimensional network averaged over 50 networks. Notice the excellent agreement between the model and simulation.

6. Conclusions

We have investigated two possible policies for supporting an arbitrary traffic matrix in a point-to-point broadcast packet radio network: full connectivity and limited transmission power. The performance for the fully connected network is the same as the known result for a centralized network and allows a maximum throughput of $1/e$. The other approach, wherein we give each node power sufficient to just reach his destination, allows a maximum throughput proportional to the logarithm of the number of (active) nodes in the network. This behavior was determined by use of an analytical model which was then verified by simulation.

One problem with this approach is that the network throughput is not allocated 'fairly' in that those nodes which are close together (and thus with higher transmission probabilities), will achieve higher throughputs than those which are more distant. In fact, it can be shown that we cannot increase the throughput of these high interference nodes without reducing the overall performance.

The traffic matrix considered in this paper is, in some sense, a 'worst case' as it shows no locality. (In fact the worst case would be if every node wished to talk to a node at the other extreme of the network, forcing the fully connected case.) If, as would probably be the case in reality, the traffic matrix exhibited some degree of locality, the capacity would exceed that shown here. In [SILV 79a] we investigated the case of extreme locality and attempted to find the 'best' possible traffic matrix. We were able to bound the performance from above and below by linear functions of the number of nodes in the network and found a traffic matrix that achieved a capacity between these bounds.

In a *real* one-hop point-to-point packet broadcast network we would therefore expect that we could obtain a capacity which grows somewhere between logarithmically and linearly with respect to the number of nodes in the network, depending on the traffic characteristics.

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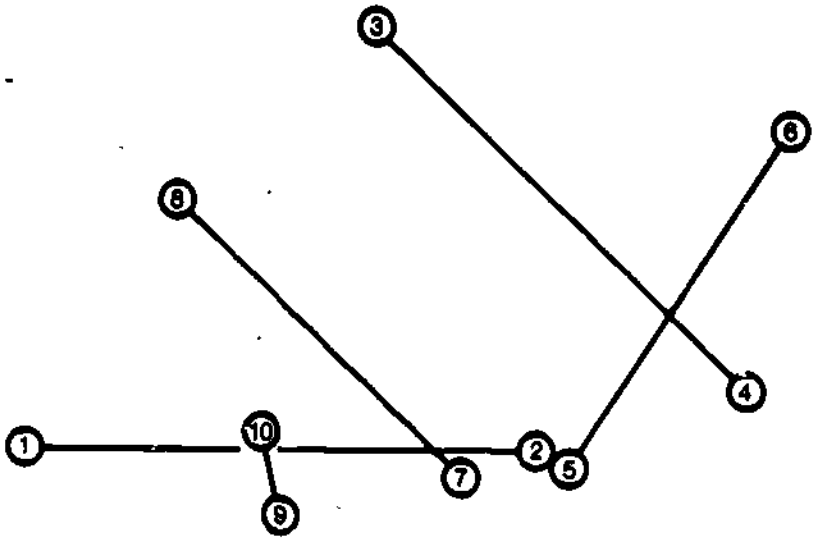

Figure 1. 10 Node Network Showing (Adjusted) Transmission Radii

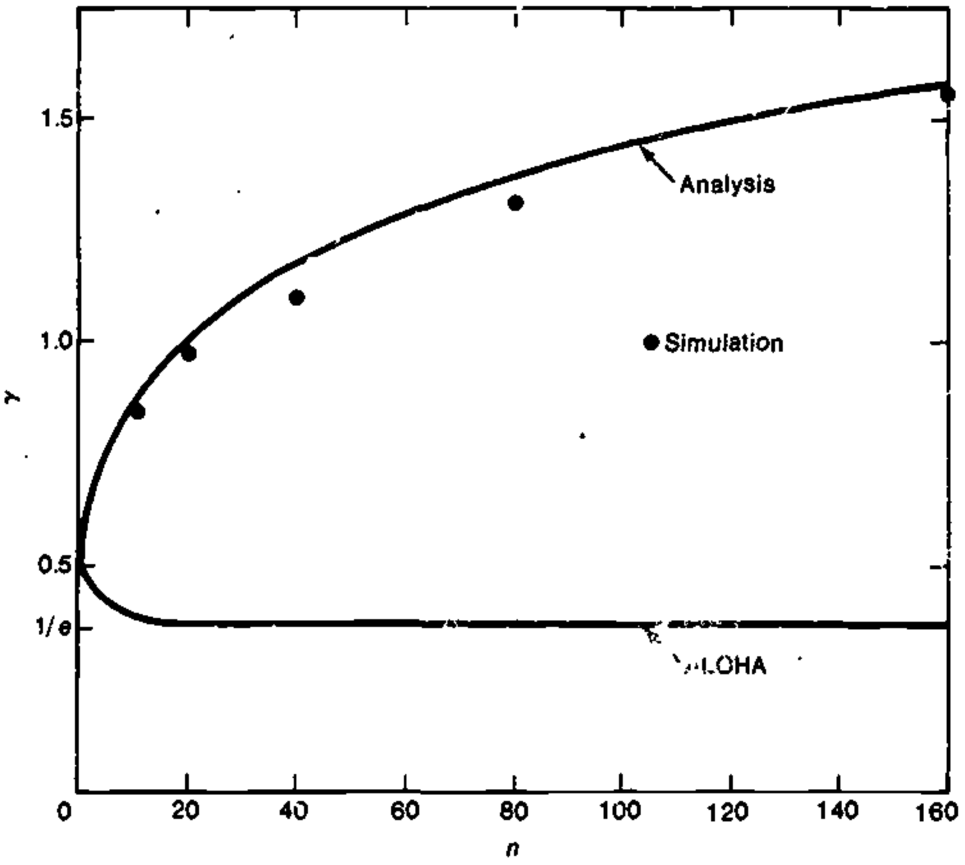

Figure 2. Analytical and Simulation Results for 2-dimensional Networks

MESSAGE-BASED PRIORITY FUNCTIONS IN MULTIACCESS/BROADCAST COMMUNICATION SYSTEMS WITH A CARRIER SENSE CAPABILITY*

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Abstract

We consider in this paper packet communication systems of the multiaccess/broadcast type exemplified by ETHERNET and single-hop ground radio networks, and describe a simple distributed algorithm which can support message-based priority functions using carrier sensing. The scheme is based on the principle that access right to the channel be exclusively granted to ready messages of the current highest priority level. It is suitable for fully-connected broadcast networks with or without the collision detection feature and can be made preemptive or non-preemptive.

I. INTRODUCTION

New multiaccess schemes in packet broadcasting have been abundant in recent years. The advent of these schemes is primarily due to the desire to share expensive communication resources (particularly the communication bandwidth), and to provide a high degree of connectivity among the communicating devices without the burden of complex topological structures.

In general, multiaccess schemes consist of algorithms which determine the users' right of access to the shared bandwidth. These algorithms differ by several aspects such as the degree of control exercised over the users' access, the centralized or distributed nature of the decision making process, and the degree of adaptivity of the algorithm to the changing demand paced on the channel.

The need for priority functions in multiaccess environments is a clear matter. Having multiplexed traffic from several users and different applications on the same bandwidth-limited channel in order to achieve a higher utilization of the latter, we require that a multiaccess scheme be responsive to the particular specifications of each. Priority functions in multiaccess environments constitute the subject matter of this paper.

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In a typical centrally controlled system, a central scheduler assumes the responsibility of granting access right to the users. Provided that it has at each instant complete knowledge of the activity on the channel and of the demand placed on the channel up to that instant, the central scheduler can make optimal scheduling decisions and thus easily support priority functions. The real problem however is how to provide the correct information regarding the demand from the distributed population of users to the central scheduler.

In distributed systems, users make their own decisions regarding access to the channel. Coordination in this decision making process can be accomplished by having all users execute a common distributed algorithm driven by control information to be exchanged among them.

In this paper, we consider packet communication systems of the multiaccess/broadcast type exemplified by ETHERNET (1) and fully-connected ground packet-radio networks (2). In these systems all users share a common transmission medium over which they broadcast their packets. Each subscriber is connected to the common communication medium through an interface which listens to all transmissions and absorbs packets addressed to it. We describe here a simple distributed algorithm which can support message-based priority functions using carrier sensing. The scheme is suitable for fully-connected broadcast networks with or without the collision detection feature and can be made preemptive or non-preemptive.

II. MULTIACCESS PROTOCOLS

The simplest multiaccess techniques are obtained when the bandwidth is assigned to the users in a static predetermined fashion. Time division multiple access (TDMA), frequency division multiple access (FDMA) and code division multiple access (CDMA) are typical examples. Unfortunately these fixed assignment schemes are nonadaptive to time-varying demand, and can be wasteful of capacity if small-delay constraints are to be met.

Adaptive and more efficient multiaccess schemes can be obtained by providing the entire bandwidth as a single high-speed channel to be shared by all users in some fashion. The sharing of a common channel by many geographically distributed users has been the subject of many investigations in recent years. The difficulty in controlling access to the channel from users who can only communicate via the channel has given rise to what is known as random access techniques. In the ALOHA random scheme, users transmit any time they desire (3). When conflicts occur, the conflicting users reschedule transmission of their packets to some later time. In carrier sense multiple access (CSMA), the risk of a collision is decreased by having users sense the channel prior to transmission (4). If the channel is sensed busy, then transmission is inhibited. CSMA performs well only if the propagation delay is short compared to the transmission time of a packet (a situation encountered in local area networks and ground radio systems) and if all users can hear all transmissions on the channel (i.e., the system is physically fully-connected). Many CSMA protocols exist which differ by the action taken by a ready terminal which finds the channel busy. In the nonpersistent CSMA, the terminal simply schedules the retransmission of the packet to some later time. In the 1-persistent

CSMA, the terminal monitors the channel, waits until the channel does idle (persisting on transmitting), and then transmits the packet with probability one. In the p-persistent CSMA, the terminal monitors the channel as in 1-persistent, but when the channel does idle, it transmits the packet only with probability p, and with probability 1-p it waits the maximum propagation delay and then repeats the process provided that the channel is still sensed idle.

These schemes can be used to access a ground radio channel, or a single coaxial cable as is the case with ETHERNET. The difference however is that in a broadcast bus environment, in addition to carrier sensing, it is possible for transceivers to detect collisions in real tim and thus abort the transmission of all colliding packets (5). This produces a variation of CSMA referred to as CSMA with collision detection (CSMA-CD).

In random access schemes no control is exercised over the users' right of access. A certain level of coordination or cooperation however may be achieved by gaining information regarding the status of just the channel (busy or idle) as is the case with CSMA. Higher levels of coordination are achievable by the means of distributed control algorithms which are driven by an increased volume of control information exchanged among the users. Clearly these algorithms are particularly feasible if the multiaccess/broadcast environment is physically fully connected (i.e., if all users are in line-of-sight and within range of each other). Such distributed algorithms are considered out of the scope of this paper.

III. ON PRIORITY FUNCTIONS IN MULTIACCESS ENVIRONMENTS

A) Illustrating the need for priority functions

To illustrate the need for priority functions in multiaccess environments we consider the following scenario on a broadcast bus using the nonpersistent CSMA-CD protocol (5). Assume that the channel is required to support interactive traffic at some low throughput level S_1, (e.g. 5% to 20% of the available bandwidth). Clearly a large portion of the channel is unused, and can be recovered if we allow traffic from other applications, say file transfer programs, to be simultaneously transmitted on the channel. File transfer traffic typically consists of packets which are "long" compared to those encountered in interactive traffic. Analysis of CSMA-CD with variable packet size has shown that higher channel utilization is indeed achieved by the introduction of file transfer packets, but to the detriment of the short interactive packets which incur increasingly high delays. Numerical results are displayed in Figs. 1 and 2. Denoting by $1-\alpha$ the fraction of long packets introduced in the mix, and by τ the one-way propagation delay, Fig. 1 shows a plot of packet delays D_1 and D_2 (as incurred by short packets of size $L_1=10\tau$, and long packets of size $L_2=100\tau$ respectively) versus $1-\alpha$, the fraction of long packets introduced in the mix. Fig. 2 shows a plot of the total channel utilization achieved versus $1-\alpha$. (The parameter T_c represents the collision detection and recovery period.) In order to recover the available excess capacity while maintaining an acceptable performance for interactive traffic we need to implement a priority scheme which gives priority to all interactive messages over file transfer messages.

B) *General specifications required of priority schemes*

Little work has been done in attempting to incorporate priority functions to multiaccess protocols. The distributed nature of the problem has been a major obstacle. Priority functions here are viewed in their most general sense; that is, priority is defined as a function of the message to be transmitted and not just the host transmitting the message. Before we proceed with a description of the priority scheme, we briefly discuss here the target requirements for a priority scheme to be acceptable.

(i) The performance of the scheme as seen by messages of a given priority class should be insensitive to the load exercised on the channel by lower priority classes. Increasing loads from lower classes should not degrade the performance of higher priority classes.

(ii) Several messages of the same priority class may be simultaneously present in the system. These should be able to contend on the communication bandwidth with equal right (fairness within each priority class).

(iii) A priority scheme must be robust in that its proper operation and performance should be insensitive to errors in status information.

(iv) The volume of control information to be exchanged among the contending users, as required by the scheme, and the overhead required to implement the priority scheme must both be kept minimal.

IV. A PRIORITY SCHEME USING CARRIER SENSE

To satisfy property (i) above, a priority scheme must be based on the principle that access right "at any instant" be exclusively given to ready messages of the highest current priority level. When in presence of a nondistributed environment such as a single server queueing system, one has knowledge of all events occurring in the system; the use of a preemptive priority discipline, whereby the assessment of the highest priority level is performed at each arrival time, guarantees that at any instant customers of the highest priority level occupy the server; the use of a nonpreemptive discipline, whereby assessment of the highest non-empty priority class is done only at the end of each service period, introduces some delay in the higher levels. In a distributed environment, there are three basic problems that we need to address in designing a multiaccess protocol with a message-based priority function: (i) to indentify the instants at which to assess the highest current priority class with ready messages; (ii) to design a mechanism by which to assess the highest non-empty priority class; and (iii) to design a mechanism which assigns the channel to the various ready users within a class. The priority scheme introduced in this paper consists of resolving the first two problems by the means of the carrier sensing capability, while the third is resolved by any of the above mentioned multiaccess protocols.

A) Basic mechanism for priority assessment (a nonpreemptive discipline)

With the broadcast nature of transmission, users can monitor the activity on the channel at all times. The assessment of the highest priority class with ready messages is done, at least (as is the case in the nonpreemptive discipline), at the end of each transmission period, whether successful or not, i.e., every time the carrier on the channel goes idle. When detected at a host, end of carrier (EOC) establishes a time reference for that host. Following EOC, the channel time is considered to be slotted with the slot size equal to $2\tau+\gamma$, where τ denotes the maximum one-way propagation delay between pairs of hosts, and γ is a period of time sufficiently long to detect a short burst of unmodulated carrier. Within each host, messages are ordered according to their priority. The priority of a host at any time is the highest priority class with messages present in its queue.

Let h denote an arbitrary host, and EOC(h) denote the time of end of carrier at host h. Let p(h) denote the priority level of host h at time EOC(h). The priority resolution algorithm consists of having host h operate as follows:

(i) If, following EOC(h), carrier is detected in slot i, with $i<p(h)$, (thus meaning that some host(s) has priority i higher than p(h) and access right must be granted to class i), then host h awaits the following end of carrier (at the end of the next transmission period) at which time it reevaluates its priority and repeats the algorithm.

(ii) If no carrier is detected prior to the j-th slot, where $j=p(h)$, then host h transmits a short burst of unmodulated carrier at the beginning of slot j (thus reserving channel access to priority class p(h)) and, immediately following this slot, operates according to the contention resolution algorithm decided upon within class p(h) (such as p-persistent CSMA, for example). At the next end of carrier, host h reevalutates its priority level and repeats the algorithm.

Thus, by the means of short burst reservations following EOC, the highest non-empty priority class is granted exclusive access right, and messages within that class can access the channel according to any contention algorithm. If the contention algorithm is CSMA, then we refer to the scheme as prioritized CSMA (P-CSMA).

Note that the above algorithm corresponds to a nonpreemptive discipline, since a host which has been denied access does not reevaluate its priority until the next end of carrier. However, note that by assessing the highest priority level at the end of each transmission period, whether successful or not, the scheme allows higher priority messages to regain the access right without incurring substantial delays.

We illustrate this procedure in Fig. 3 by displaying a snapshot of the activity on the channel. (For simplicity and without loss of generality we consider that, in this and all subsequent figures, there are only two possible priority levels in the system. We denote by n_1 and n_2 the number of active hosts in class 1 (C1) and class 2 (C2) respectively. We adopt the convention that C1 has priority over C2. We also show a reservation burst as occupying the entire slot in which it is transmitted. Finally we represent by a vertical upward arrow the arrival of a new message to the system; the label C1 or C2 indicates the priority class to which the message belongs.) We assume in Fig. 3 that at the first EOC we have $n_1=0$ and $n_2>0$. Following EOC a reservation burst is transmitted in the second slot. The priority resolution period, also called priority assessment period (PAP), is in this case equal to two slots. Following the reservation, we observe a channel access period (CAP) which consists of the idle time until the channel is accessed by some user(s) in class 2. Clearly CAP is a function of the channel access procedure employed by class 2. Following CAP we observe the transmission period (TP) itself, the end of which establishes the new EOC time reference. (A crosshatched TT signifies a collision.) The time period between a reservation and the following EOC, called the contention period and equal to CAP+TP, is the time period during which exclusive access right is given to the class which succeeded in reserving the channel. In this nonpreemptive case message arrival C1, although of higher priority, is not granted access right until the EOC following its arrival, at which time it reserves the channel. Fig. 4 displays channel activity similar to Fig. 3 with the exception that here we assume a collision detection feature to be in effect. In this case unsuccessful TP's are of length T_c, smaller than a full message transmission period.

Since the priority resolution period is of non-zero length, one may envision each host continuously updating its priority during the priority resolution period. Clearly, unless we allow messages to change priority levels, the priority of a host may only change at the generation times of new messages. As a result, given that we are in slot k of the reservation period, indicating that no priority class higher than k reserved access to the channel, a host may still make reservation for its most current priority as long as this priority is lower than priority class k, and no reservation burst is detected before its corresponding slot. However, if following EOC no reservation burst is detected for K consecutive slots, where K is the total number of priority classes available in the system, then the channel becomes free to be accessed by any host regardless of its priority, until a new EOC is detected.

A variant of this nonpreemptive P=CSMA algorithm is to require that each host record at the end of the priority assessment period the priority level that is granted access (say i), so that i-level messages generated during the period of time when access right is granted to level i may also contend on the channel.

Note that the overhead incurred in a reservation period following EOC is a function of the currently highest priority level. The higher this class is the smaller the overhead is and the smaller is the delay to gain access.

The scheme is robust since no precise information regarding the demand placed on the channel is exchanged among the users. Information regarding the existing classes of priority is implied from the position of the burst of unmodulated carrier following EOC. Note also that there is no need to synchronize all users to a universal time reference. By choosing the slot size to be $2\tau+Y$ we guarantee that a burst emitted by a transceiver in its k^{th} slot is received within the k^{th} slot of all other hosts.

B) 1-persistent versus p-persistent P-CSMA

Immediately following a reservation burst for class i, the p-persistent CSMA scheme consists of having each host with priority i do the following: (i) with probability p it transmits the message, (ii) with probability 1-p it delays the transmission by one slot and repeats the procedure if the channel is still sensed idle. This is equivalent to having each host with priority i transmit its message following a geometrically distributed delay with mean 1/p slots, provided that no carrier is detected prior to that time. When EOC is detected, a new time reference is established and a new reservation period is undertaken.

In a 1-persistent CSMA mode, instead of sending a short burst to indicate a reservation, hosts with ready messages simply start transmission of their highest priority messages in the corresponding slot following EOC, of course, provided that no carrier is detected in previous slots. If a single host is transmitting then its transmission is successful and its termination establishes a new EOC time reference. On the other hand, if two or more hosts overlap in transmission, a collision results; all users become aware of the collision and will consider it in lieu of a reservation. (That is, the end of this first transmission does not constitute a new time reference and no new reservation period is started.) All hosts involved in the collision reschedule the transmission of their respective messages incurring a random delay, say geometrically distributed with mean 1/p slots, and transmit their messages at the scheduled time provided that no carrier is detected prior to that time. The end of this new transmission period constitutes a new time reference and the procedure is repeated. (See Fig. 5.)

In general, 1-persistent CSMA is known to be inferior to p-persistent, since p=1 is certainly not optimum if the likelihood of having several hosts with ready messages of the same priority level is high. However, if the load placed on the channel by some priority class is known to be low (as it would most probably be the case for high priority levels in order to guarantee their performance) then 1-persistent CSMA used within that class may present some benefit.

In environments where a collision detection feature is available and the collision detection and recovery period T_c is small (on the order of $2\tau+\gamma$, as is the case with ETHERNET), 1-persistent CSMA is clearly superior to p-persistent CSMA.

C) A semi-preemptive P-CSMA scheme

Consider that after the reservation process has taken place, the channel has been assigned to class j. Assume that before a transmission takes place a message of level i, i<j, is generated at some host h. The nonpreemptive scheme dictates that host h awaits the next time reference before it can ascertain its (higher) level i. The semi-preemptive scheme allows host h to preempt access right to class j, as long as no transmission from class j has yet taken place, by simply transmitting the message. If the generation of the message of level i takes place after a transmission period is initiated, then host h waits

until end of carrier is detected. Both nonpreemptive and semi-preemptive schemes are applicable whether collision detection is in effect or not.

D) A preemptive P-CSMA scheme

The difference between this and the semi-preemptive P-CSMA scheme is that here a host with a newly generated packet may also preempt an on-going transmission of a lower priority level by intentionally causing a collision. Clearly this scheme is only appropriate if collision detection is in effect! It can offer some benefit if lower priority classes have long messages. One may also envision an adaptive preemption scheme whereby an on-going transmission is preempted only if the already elapsed transmission time is short.

E) Notes on reservation overhead

a) Hierarchical reservations: If the number of priority levels is large, then the overhead incurred in the reservation process may be high, especially if it is expected that the bulk of traffic will be in the lower levels of priority. This overhead can be decreased if a hierarchical reservation scheme (i.e., a tree priority resolution algorithm) is used. A burst in the first slot designates that messages in the highest group of priority levels are present. Following that, each level in the group is assigned its own slot for reservations, etc..

b) Message delay performance versus protocol overhead: In the above described schemes, the higher the priority is the smaller is the delay in gaining access right to the channel; and thus the better is the delay performance. Such a property is important if message delay for high priority classes is a critical performance measure. On the other hand, to guarantee a low delay performance for high priority classes, it is important to limit their load on the channel; as a result, it is expected that the bulk of traffic falls into the lower classes incurring high overhead at each priority resolution period. This in turn limits the overall achievable channel capacity. An alternative to the above scheme consists of having all ready hosts start transmitting the unmodulated carrier in view of a reservation immediately following EOC, but such that the higher the priority is the longer is the number of slots in which carrier is transmitted. As a result, the highest priority class present gains access by persisting the longest.

V. ON THE PERFORMANCE ANALYSIS OF P-CSMA

The difficulty which arises in analyzing multiaccess schemes such as CSMA is mainly due to the fact that the statistical evolution of the system is dependent on the system state; in particular the time required to successfully transmit a message is a function of the number of active hosts in the system. The same difficulty arises in P-CSMA and prevents us from using conventional priority queuing results to analyze its performance. However, using the "linear feedback model" (5,6) with a finite number M of hosts and two priority levels, analysis of the nonpreemptive p-persistent P-CSMA-CD has been carried out. In this model each host is assumed to have at any time at most one message of each priority class. A new message of a given priority class is not generated at the host until the previous one has been successfully transmitted. Thus with respect to each priority class, a host can be in one of two states: backlogged or thinking. In the thinking state, a host generates (and transmits, according to the P-CSMA access right acquisition procedure) a new message in a slot with probability $\sigma_i (i=1,2)$. (For simplicity in analysis, it is assumed here that the channel time axis is slotted and users are synchronized to begin tranmission at a slot boundary.) A host is said to be backlogged if it has a message awaiting transmission. It remains in that state until it completes successful transmission of the message, at which time it switches to the thinking state. At end of carrier EOC, the number of hosts with messages of class 1 and class 2 is denoted by n_1(EOC) and n_2(EOC) respectively. These two processes are shown to be two interactive imbedded Markov chains. The analysis based on semi-Markov processes and delay-cycle analysis provides us with the stationary throughput-delay performance of each priority class. The analysis and numerical results will be reported upon in a forthcoming paper.

VI. CONCLUSION

Multiaccess protocols suffer from the inability to satisfy performance requirements specific to each application. This problem becomes crucial when traffic from real-time application is multiplexed on the same channel with other traffic. In this paper we described a simple prioritized multiaccess scheme based on the carrier sense capability, called P-CSMA. The scheme is robust, efficient, fair to messages within each priority class, and requires low overhead to implement.

VII. ACKNOWLEDGEMENT

The author wishes to acknowledge Dr. Raphael Rom of SRI-International for the fruitful discussions on this subject.

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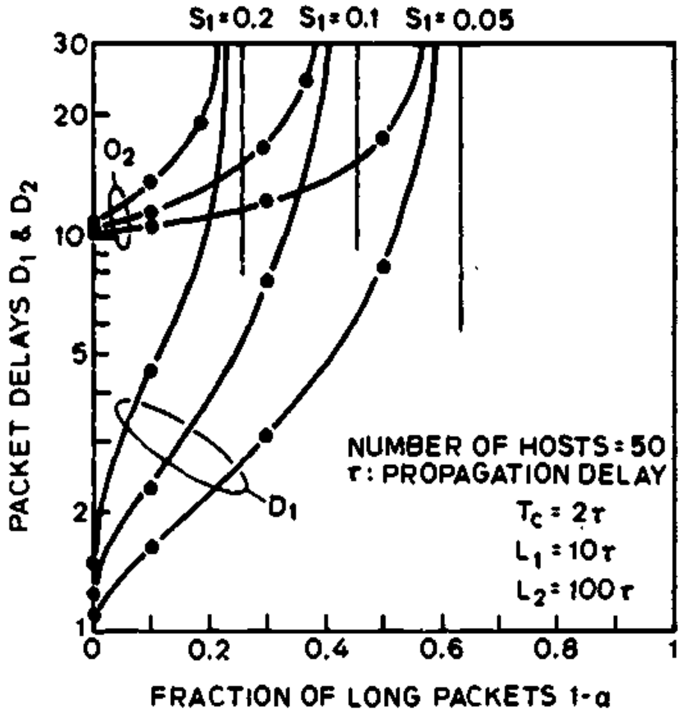

Fig. 1. Packet delays D_1 and D_2 versus $1-\alpha$ for constant S_1, normalized to the transmission time of short packets.

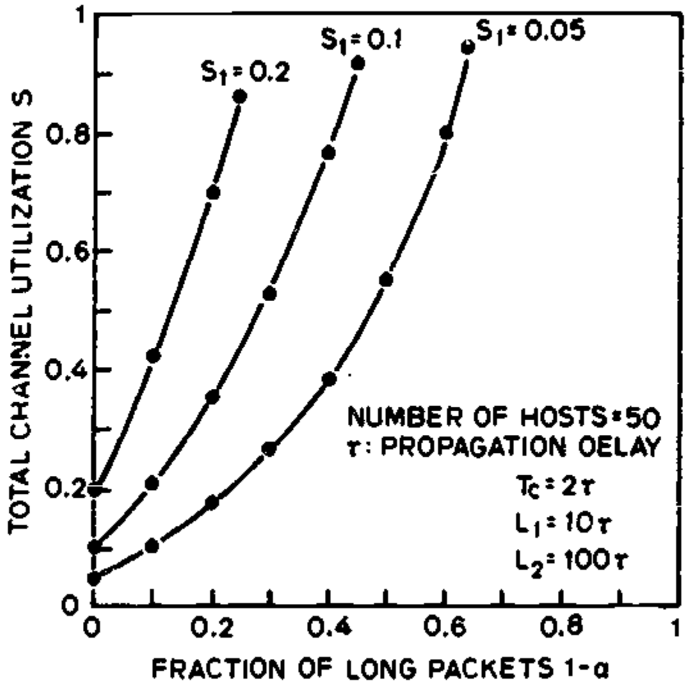

Fig. 2. Channel utilization S versus $1-\alpha$ for constant S_1.

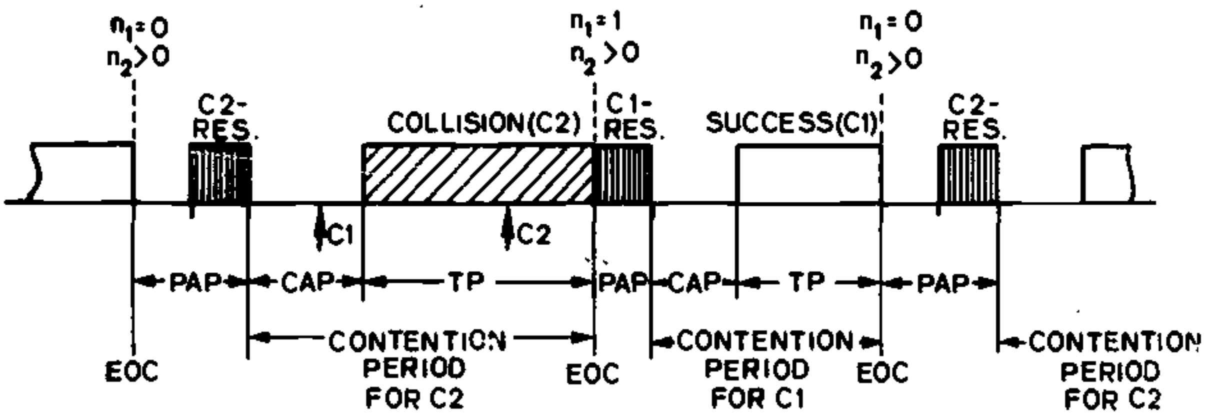
$n_1 = 0$
$n_2 > 0$
C2-RES.
COLLISION(C2)
$n_1 = 1$
$n_2 > 0$
C1-RES.
SUCCESS(C1)
$n_1 = 0$
$n_2 > 0$
C2-RES.
C1
C2
PAP
CAP
TP
PAP
CAP
TP
PAP
EOC
CONTENTION PERIOD FOR C2
EOC
CONTENTION PERIOD FOR C1
EOC
CONTENTION PERIOD FOR C2

Fig. 3. Nonpreemptive p-persistent P-CSMA

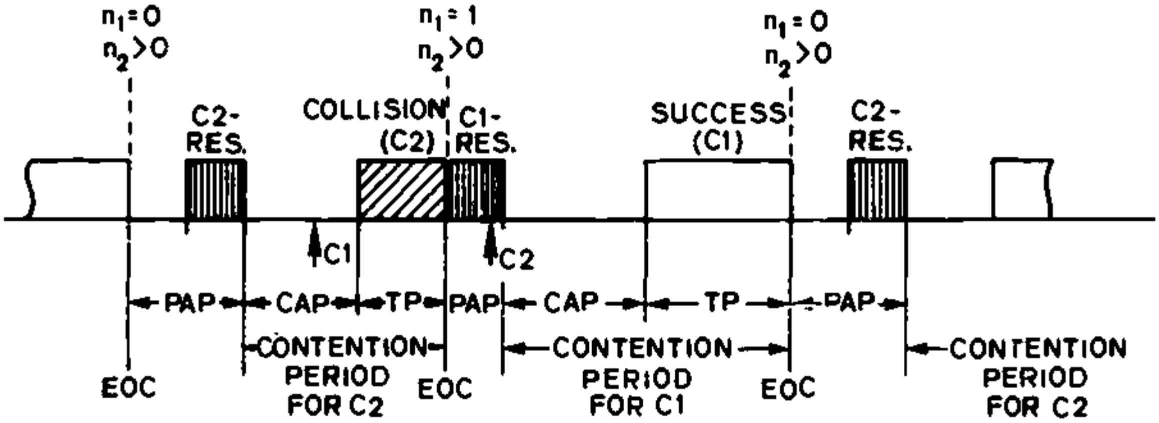
$n_1 = 0$
$n_2 > 0$
C2-RES.
COLLISION (C2)
$n_1 = 1$
$n_2 > 0$
C1-RES.
SUCCESS (C1)
$n_1 = 0$
$n_2 > 0$
C2-RES.
C1
C2
PAP
CAP
TP
PAP
CAP
TP
PAP
EOC
CONTENTION PERIOD FOR C2
EOC
CONTENTION PERIOD FOR C1
EOC
CONTENTION PERIOD FOR C2

Fig. 4. Nonpreemptive p-persistent P-CSMA-CD

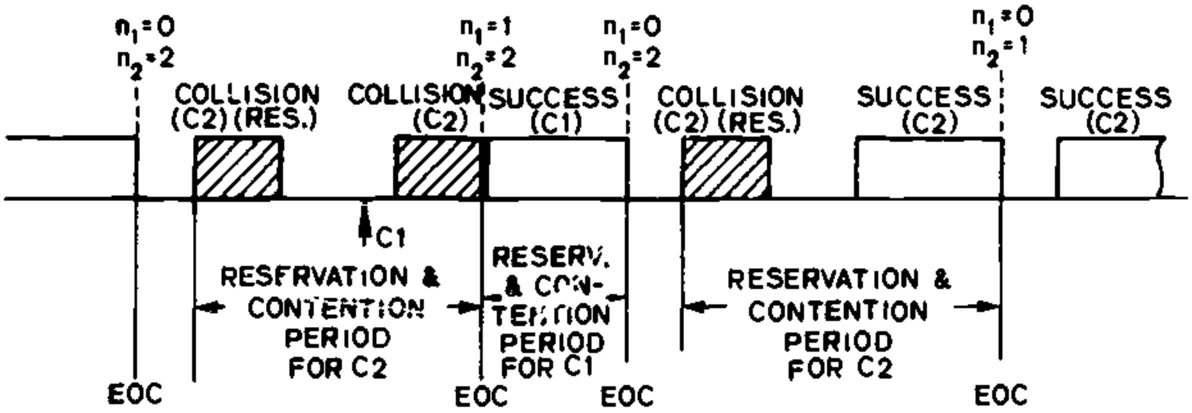
$n_1 = 0$
$n_2 = 2$
COLLISION (C2) (RES.)
COLLISION (C2)
$n_1 = 1$
$n_2 = 2$
SUCCESS (C1)
$n_1 = 0$
$n_2 = 2$
COLLISION (C2) (RES.)
SUCCESS (C2)
$n_1 = 0$
$n_2 = 1$
SUCCESS (C2)
C1
RESERVATION & CONTENTION PERIOD FOR C2
RESERV. & CON-TENTION PERIOD FOR C1
RESERVATION & CONTENTION PERIOD FOR C2
EOC
EOC
EOC
EOC

Fig. 5. Nonpreemptive 1-persistent P-CSMA-CD

SATELLITE COMMUNICATION IN THE PACIFIC ISLANDS: STATUS AND STRATEGIES

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Abstract

The purpose of this paper is to provide a framework for addressing the telecommunication requirements of the Pacific Islands. It presents the current status of public satellite telecommunications in the Pacific, summarizes the requirements for public telecommunications, identifies some of the issues that must be faced in planning for this region, suggests steps toward implementation of operational services. The focus is on satellite systems as the most viable means of providing reliable links between and among the widely scattered islands.

I. THE PACIFIC AS A DEVELOPING REGION

The Pacific islands share many characteristics with other regions of the developing world. These emerging nations are still heavily dependent on expatriates and on colonial or quasicolonial institutions that may not meet their new needs. Economic development may be dependent on one resource such as phosphates, or an agricultural crop such as copra, or on a climate favorable for tourism. Infrastructure is limited: transportation may be primarily by infrequent supply boat, with commercial air service only between major centers on international routes. Telecommunications are also limited, with several nations now having a reliable international link but still very limited and relatively unreliable domestic communication.

However, unlike many developing regions, the Pacific has several characteristics that compound the difficulties of telecommunications planning:

-- the population is relatively small, numbering a total of only about four million;

-- this population is spread over an immense area of approximately one third of the earth's surface:

-- the population is divided into a multitude of separate nations and semi-autonomous political units.

II. AN OVERVIEW OF THE FUNCTIONS OF TELECOMMUNICATIONS IN THE PACIFIC

A. Social Services

Telecommunications can help to extend the range of social services by providing for consultations between rural paraprofessionals and regionally based professionals and by providing information and education to rural residents. It can improve the quality of rural social services through in-service training and community campaigns, and improve the efficiency of rural services through improved administration of field activities.

1. Health Care

In several parts of the world two-way communication is used in support of health services. In Alaska the US Public Health Service has a specially designed health care network using the RCA SATCOM satellite. Earth stations in the smaller villages are usually equipped with two circuits: a conventional message telephone circuit, and a special circuit for emergency/ medical service.

The design of the health communication network was based on results from the ATS-1 satellite experiment. It was found that the single shared audio channel had the advantage of allowing the health aides to listen in and learn from medical consultations. Group participation is intended to reduce the sense of isolation, and the shared channel can also be used as a "broadcast system" to provide information and in-service training to all locations. Each channel is shared by two regional hospitals and their surrounding villages. Every day during a scheduled "doctor call", the doctor at the regional hospital talks to each village health aide in turn about her patients. These consultations can be heard by all health aides in the network. The system is also used for field administration, contact between villages and relatives in hospital, and arrangements for evacuation. It is available 24 hours per day for emergency use.

Communication systems can be used to mobilize assistance and coordinate activities in disasters and epidemics. The World Health Organization (WHO) used the ATS-1 satellite network in the Pacific to coordinate emergency relief during an outbreak of cholera in the Gilbert Islands (now Kiribati). NASA satellites have also been used in the US for disaster relief activities. The ITU has made available a specially designed portable earth station for disaster relief communications using the Symphonie satellite.

2. Education

Telecommunications can play many roles in rural education. Radio broadcasting has been used to bring quality instruction to rural primary children who have difficulty learning because of overcrowded classrooms, poorly trained teachers and lack of learning materials.

A major project in radio education is the Radio Mathematics project in Nicaragua sponsored by USAID. Initiated in 1973, the project has combined radio and print media--evaluated their educational and cost-effectiveness--

in teaching primary school mathematics. If failure and repetition rates can be reduced through use of this system, total education costs may actually decrease. Both teachers and students have responded favorably to the Radio Mathematics project. Radio has been used in several other countries for adult education and in support of development campaigns.

As with health services, telecommunications can also be used for administration to improve the efficiency of education services, and to provide links between scattered students and teachers.

The University of the South Pacific (USP) has a regional mandate to serve the newly independent nations of the South Pacific. USP augments the facilities of its main campus in Suva, Fiji, and an agricultural college in Western Samoa, with extension centers in six island groups. These centers offer USP correspondence courses and local cultural and educational activities. Since 1974, USP has used NASA's ATS-1 satellite (shared with Alaska and other experimenters) to link the Fiji campus with the extension centers. USP has found the shared conference channel to be an extremely important administrative link between the centers for coordination of Extension Service activities. It is also used for tutorials for students studying by correspondence and for seminars. This USP project is continuing and expanding with AID support.

3. Project Management

The major difficulty in most rural development and social service delivery projects is management and coordination. There will never be sufficient funds and trained personnel to enable trained professionals to work in all rural communities (even if urban-trained professionals could be induced to work there). Therefore, relatively undertrained paraprofessionals and virtually untrained rural community residents must carry out many of the development activities. Otherwise, many rural communities will be left unserved. Given the inevitable training deficiencies, communication links can be essential to provide supervision and continuing education (e.g., through supervised on-the-job-training). The costs of such management supervision are likely to be prohibitive if extensive travel by professionals or middle-level managers is required. Regular voice communication can maintain an effective network for management supervision and continuing education.

4. Improved Agricultural Techniques

From time to time, farmers may need advice on crop problems. Developing regions often lack agricultural specialists such as soil scientists, agronomists, and veterinarians. These resource people can extend their services through telecommunications. For example, in the South Pacific, American Samoan farmers had problems with their papaya and taro crops. The local government had no agronomist and called on the University of South Pacific's College of Agriculture in Western Samoa. A soil specialist was sent to examine the crops and took soil and crop samples. The specialist took the samples back to the lab for analysis, and was then able to report the results and recommend remedial action via telephone.

B. Economic Development

Telecommunications can support rural economic activities in several ways:

1. Marketing Information

A farmer may stand to lose much of his potential profit unless he can take advantage of changes in market conditions. Up-to-date information on prices for farm products can be critical. A small farmer needs to know what price he will get for his crop from the village trader, from a middleman in a nearby town, and from a cooperative marketing organization. Such information may be available through radio broadcasts, telephone service to government agencies or entrepreneurs, or through extension workers who in turn use telecommunications for up-to-date information.

2. Logistics

Some crops must reach market or processing centers very quickly before they spoil or their value will be lost. In northern Canada, lake fishermen use two-way radios to call float planes when they have a catch to go to market. Telecommunications can also be used to arrange timely transportation of perishable fruits and vegetables.

3. Consumers

The rural consumer is often at a disadvantage because of limited access to information about availability of goods and alternate suppliers, resulting in use of a few known suppliers and heavy reliance on middlemen. The effect is excessive markup to the rural consumer. Using the telephone, consumers can compare prices from distant suppliers as well as local merchants. For example, in Tonga, the new INTELSAT earth station installed in 1978 has provided a reliable link to the outside world for the first time. The Tongan government is now able to ask for several bids on jobs. Retailers can check market prices from several suppliers before making commitments. It has been suggested that this access to timely information has helped to reduce the local inflation rate significantly.

4. Suppliers

Voice and telecommunications links can be very important to remote suppliers who need to know price and demand for their products. For example, Pacific fishermen need to know market prices for various types of fish.

5. Tourism

Tourism is a major industry in the Pacific which is heavily dependent on telecommunications for hotel and aircraft bookings. Telecommunications is one of the first requirements for opening tourist facilities in a new area.

III. PUBLIC TELECOMMUNICATIONS REQUIREMENTS IN THE PACIFIC

The following is a summary of the major public telecommunications requirements in the Pacific.

1. International/Intercapital Communications: Reliable communication between each national/territorial capital or major center, and between these centers and other major world centers--particularly communities of interest for trade and social ties such as Hawaii, the US mainland, Australia and New Zealand. Others could include Japan, Hong Kong, Singapore, France, and the United Kingdom.

2. Intraregional Communications: Reliable voice and eventually data links between the Pacific capitals and major towns in the region for commerce, trade, international agency activities, personal communications.

3. Intranational Communications: Reliable communications within each nation or island group to link its scattered towns and villages to the capital and to each other. These links would be used for many of the functions outlined above: for emergency communication, for links between rural development staff such as nurses, teachers, and extension workers, and for commercial as well as social communication.

4. Intraregional Conferencing: Voice teleconferencing links that can be configured to link communities of interest in the Pacific for education, consultation, administration. This requirement is based on the experience with the ATS-1 satellite for health and educational conferencing applications in Atlanta and in the Pacific. Examples of audio-conferencing applications would include:

- special seminars on topics such as law of the sea, tropical agriculture, and marine resources such as are now run over the PEACESAT ATS-1 system:
- educational seminars and tutorials such as for distance education such as are now provided by the University of South Pacific using ATS-1;
- consultation between remote social service providers including health staff, extension workers, and other development workers and centers of expertise around the Pacific such as schools of medicine, agriculture, etc.;
- consultations between government officials to supplement the meetings of regional organizations such as SPC and SPEC;
- administrative conference between staff of international agencies and corporations operating in several locations throughout the region.

This is a short list which needs considerable refinement and specificity. Other requirements could be added. A prime candidate would be national broadcasting services--first radio and possibly eventually television, and possibly some regional and subregional radio broadcasting coverage.

IV. THE STATUS OF SATELLITE COMMUNICATIONS IN THE PACIFIC

A. Operational System-INTELSAT

Despite the difficulties of serving the Pacific basin, the past couple of years has seen major changes in the provision of commercial satellite services. By late 1979 INTELSAT stations were located at the following sites:

American Samoa
Cook Islands
Fiji
Guam
Nauru
New Caledonia
New Hebrides
Solomon Islands
Tahiti
Tonga

If we map these facilities conceptually onto our set of requirements, we find that they meet the major requirement for reliable international/intercapital communication for the countries in which they are located, but still leave the smaller political units unserved: Kiribati (formerly the Gilbert Islands), Niue, Tuvalu, and the U.S. Trust Territories, soon to become independent entities. They fail to meet the other requirements of domestic communication between towns and villages within each island group and of teleconferencing among a variety of sites around the region.

B. Experimental System: ATS-1

At the time of writing (and it is hoped for the indefinite future, at least until a viable alternative is found) the NASA ATS-1 satellite provides a single voice channel for conference communications throughout the Pacific. Blocks of time are assigned to various instutitional users including the Pacific Trust Territories network, the University of the South Pacific, and the PEACESAT network which includes the above stations plus others scattered from Hawaii to New Zealand and Papua New Guinea. In addition, various subnetworks can be configured for pre-arranged topics such as special interest seminars, or for emergency consultations and disaster relief including epidemic outbreaks and earthquakes.

Considerable detail on the uses of ATS-1 has been published by the PEACESAT consortium headed by Dr. John Bystrom of the University of Hawaii. An analysis of satellite tutorial experience at the University of the South Pacific is being presented at this conference by Dr. Steven Rice.

V. ALTERNATIVES FOR MEETING PACIFIC TELECOMMUNICATIONS REQUIREMENTS

A. Expansion of use of the INTELSAT System

The only commercial satellite system now serving the Pacific uses INTELSAT to provide international service and for quasi-domestic service between Guam and American Samoa and the United States mainland. The chief advantage to using the INTELSAT system is that is is already in use for international communication and it provides coverage of the whole region. It could thus be extended to add regional and national services. However, several issues must be resolved if INTELSAT is in fact to be used to meet the remaining communication requirements in the Pacific:

1. Satellite Design: The INTELSAT satellite serving the Pacific is designed for major international traffic through Standard A or B stations. Considerably more power would be required to make it cost effective to use small earth stations (e.g., three to six meters in diameter) to serve the isolated towns and villages in the region.

2. Technical Standards: The INTELSAT system has allowed for considerable technical flexibility in domestic services but has held to rather rigid standards in international service--which is the legal definition of most traffic in the Pacific. However, precedents from domestic experience of other users in using small non-standard earth stations could be applied to regional Pacific service.

3. Tariff Structure: Current tariffs are based on rates devised for international radio and cable calls. They do not reflect the fact that regional calls are more similar to domestic than international traffic and that satellites in fact make the cost of providing service virtually independent of distance: as communication can go from any one station to any other station or group of stations in one hop through the satellite rather than through complex networks of microwave, cable, and/or radio links.

4. The audio teleconferencing service has not been offered and is not tariffed. However, with the installation of SCPC equipment, such a teleconferencing network could be provided using existing INTELSAT facilities.

B. Regional Satellites

1. Shared with other major users:

The small and scattered Pacific population makes it unattractive as a market for a regional satellite system, although its geographical characteristics are ideal for satellite service. Another option would be to configure a satellite system to cover the Pacific islands in addition to serving a major domestic market on the Pacific rim. The most obvious near term possibility is Australia. The PALAPA II system will cover the ASEAN nations but will not cover the Pacific Islands. Other possibilities include a satellite also covering Japan and China.

2. Shared with other services:

Institutional options include ownership by one of the nations which would lease capacity to the Pacific, or another institutional owner with all users leasing capacity as needed. Another approach would be to add capacity for thin route fixed telecommunications to a Pacific satellite launched to provide other services. The most obvious short term choice is the Navy LEASAT system designed to provide global ship communications. The planned INMARSAT system might be another possibility for shared capacity, but the institutional hurdles seem formidable.

3. A Replacement for ATS-1:

Many users of ATS-1 in the Pacific including members of the PEACESAT consortium have argued persuasively for a similar satellite to ATS-1 that would provide limited voice grade conferencing capability in the Pacific. The main arguments in favor of this approach are its low cost to the user: earth terminals cost from a few hundred to a few thousand dollars each. However, no means has been proposed to the author's knowledge of meeting the costs of building, launching and operating the space segment.

Although at the time of writing, VHF frequencies were not likely to be available for public satellite use following the 1979 World Administrative Radio Conference, but other frequencies may be available for the type of public services PEACESAT is advocating: the most promising appears to be in the 2.5 GHz band allocated for broadcasting but also available secondarily for fixed service. It was proposed to add fixed service to a UHF allocation for radio and television broadcast, but at the time of writing, it does not appear that this change will be approved at WARC.

VI. PLANNING PRINCIPLES

Two planning principles must be included here to assist in the evaluation of these options and the identification of other possible options.

Interconnectivity: The requirement that all nodes in the system be connected to each other. In other words, the capitals should be connected not only to each other, but also to the town and villages. And the towns should be able to communicate not only with the capital but with other towns inside the country and with other communities of interest in the region. Similarly, the public service institutions should be able to conference with each other, but also to communicate with capitals, towns and villages. The obvious model here is the worldwide telephone network which has the capability to allow subscribers in any national system to communicate with all other subscribers.

In practice, however, communities of interest tend to be predictably within the country or in major economic centers or areas with strong cultural ties. The predictability of traffic patterns might argue against a fully interconnected network in many parts of the world. For example, it might be sufficient for the villager in a developing country to talk to other villages in his region and to the regional headquarters and capital city. He may never need to call across international boundaries or even into another region of his own country, but in the Pacific, communities of interest are likely to cross national boundaries. A major percentage of HF radio traffic from Northern Tonga, for example, is routed through the INTELSAT earth station to New Zealand where many Tongans have relatives. In the Pacific Trust Territories it can be expected that after independence much communication will be across jurisdictional boundaries.

Aggregation of Demand: This concept is related to interconnectivity because it is through interconnectivity that several needs can be met. For example, what are the set of communication requirements facing a small nation? If they are as outlined above, it may be possible to plan a single system with the capacity to meet all these requirements with room for expansion. Thus townsfolk can communicate with the capital, with relatives overseas and in the villages, with regional headquarters of development projects, and with outposts of the university and agricultural extension and fisheries projects. Such an integrated system would also allow for cross subsidization of the less profitable rural services by the more profitable interurban services.

It is my opinion that a plan which aggregates demand and allows for interconnectivity of all users will be the most cost-effective means of meeting the Pacific Islands' telecommunications needs. The next step must be a detailed examination of the requirements with forecasts of demand and examination of service options so that reliable telecommunication services can be provided to enable Pacific Islanders to participate more fully in their own development.

PACIFIC ISLAND SATELLITE COMMUNICATIONS:

THE PRESENT SITUATION AND SOME FUTURE POSSIBILITIES

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Abstract

The diverse entities of the Pacific share the need and desire for up-to-date communications, which can best be provided by satellite. Many already use Intelsat, while others participate in the experimental PEACESAT and USPNet systems. A greater variety and quantity of services could be provided with a regional system using either leased Intelsat capacity, or a dedicated Pacific Basin satellite.

Introduction

A communications satellite can provide point-to-point service with cost and performance independent of distance between terminals. In addition the satellite's capacity can be shared among many users over a wide area, lowering unit costs for each user. In the Pacific, with the large distance between islands and the relatively small, widely scattered population, these considerations make satellites the preferred method of meeting the increasing need for communications services.

The Pacific Basin

The larger entities of the central Pacific are shown in Figure 1. There are U.S. territories and possessions and one state (Guam, American Samoa, Northern Marianas, Hawaii), French overseas territories (New Caledonia, Tahiti), British territories and independent members of the British Commonwealth (Solomons, Fiji, etc.). There are large countries such as Indonesia and Japan, and there are small ones like Tuvalu and Nauru. These are countries which have been independent for some time, such as Papua New Guinea, and several newly independent or scheduled for independence in the future (New Hebrides, Kiribati, Trust Territory of the Pacific Islands, etc.). In spite of the wide variations in political status, area and population, cultural background, and economic standing, all share the need and the desire for up-to-date communications.

Existing Satellite Services

The International Telecommunications Satellite Organization (Intelsat) has two active satellites over the Pacific. The majority of the circuits provided through the Intelsats connect the large countries on the rim of the Pacific: Japan, China, Korea, the U.S., and so forth. However, as shown in Figure 2, several of the island groups also have Intelsat stations. In some cases occasional TV is carried. All locations provide at least a few satellite telephone circuits to connect with the rest of the world.

Figure 3 shows an experimental conference network which uses the ATS-1 satellite launched in December 1966. All the stations shown, plus terminals in California, New Zealand, and Australia, participate in PEACESAT cultural exchanges. The ten southeast stations excluding American Samoa are also used by the University of the South Pacific to provide extension services beyond its Fiji campus. Because of the satellite's multiple-access nature, the other PEACESAT stations can listen to the USP exchanges as well.

These two networks illustrate extremes of technical possibilities. The Intelsat satellites each have a capacity of about 4,000 telephone circuits. The earth stations have steerable parabolic antennas from 10 to more than 30 meters in diameter and each costs as much as several million dollars. The PEACESAT terminals use simple crossed-dipole, helical, or Yagi antennas and cost only a few thousand dollars each. The reason is that the ATS-1 satellite, slightly more than half as large as an Intelsat, can concentrate its power into a single one-way voice channel. As a result it cost about the same as the Intelsats.

In addition to these two systems covering the entire Pacific Basin, there are domestic satellite systems covering Hawaii (part of U.S. coverage), Japan, and Indonesia. There are also military communications satellites, and the Marisat providing ship-to-shore communications.

Satellites Usable for Pacific Island Services

The most important characteristic for a Pacific satellite is coverage area. Both the Pacific Intelsats and ATS-1 (as well as ATS-3, which is nearly identical) cover the entire region. However the single-channel capacities of ATS-1 and ATS-3 are too small even for the limited requirements of the Pacific islands. Furthermore both are well past their design life, and it is possible that NASA will turn them off to save operating costs.

Other existing satellites might cover part of the islands. Indonesia's Palapa could possibly be used in Palau and Yap. Coverage of Japan's satellites (experimental point-to-point and broadcast - Kiku, Sakura, and Yuri) extends to Ogasawara so use by the Northern Marianas might be possible. The U.S. domestic satellites covering Hawaii would be usable in some cases as far west as Midway, but no further.

If consideration is extended from existing satellites to technically feasible ones the range of possibilities is much greater. Almost any combination of wide-area and spot-beam coverages could be provided, and tradeoffs could be made between circuit capacity and satellite power (and thus earth station size and cost). For example, Hughes Aircraft Company designed a satellite for public service applications, called Syncom 4. It would have provided one or two high-power repeaters covering the 48 contiguous states. If this satellite were stationed and aimed at Micronesia, it would cover all the former Trust Territories with a signal strong enough to allow TV reception by earth stations with 2 meter antennas costing little more than the PEACESAT terminals.

Another possibility would be the addition of a dedicated repeater to a planned satellite. This is the method chosen to implement the second-phase international maritime satellite system. Geosynchronous communications satellites planned for the Pacific in the near future include Intelsat V, TDRSS/Advanced Westar, and LEASAT. In the longer term, the Orbiting Antenna Farm being studied by NASA and Comsat, among others, could provide a permanent platform for such dedicated packages.

A Regional Satellite System - Example 1

One example of the service possible is the system established for Algeria by GTE, which has been in operation for more than three years. Algeria leases a single satellite repeater from Intelsat, and uses it with 15 earth stations to provide distribution of a TV program and a pool of up to 100 telephone circuits. The main station, co-located with the international earth station, transmits the TV program to the satellite and controls the telephone circuits. Each of the 14 remote stations can receive TV and can be equipped for up to 16 telephone circuits. The TV transmitter is removable and transportable, and can be used at any of the remote earth stations for special coverage. The telephone control system provides for expansion of the system to 31 terminals. All earth stations are Standard B equivalent, with 11 meter antennas.

Figure 4 shows a Pacific implementation of the Algerian system. The existing Paumalu earth station in Hawaii could serve as the TV transmitter and perhaps the telephone controller. Small earth stations could be put in each of the island groups (three are shown in the Marshalls because of their wide distribution compared with the other groups). Guam and American Samoa could be included in the network with minor additions to their existing earth stations. Extension of service to other islands within each group would be most economically provided by terrestrial means such as HF radio.

Within this broad outline several variations in detail are possible. The simplest telephone hardware arrangement would provide fixed channel assignments from each island group to, say, Hawaii. Honolulu would act as the toll center, using the international gateway capability of the new 4 ESS switch if necessary, and would connect one group to another, to the U.S. Mainland, or to international points, as required. Another alternative, slightly more complicated and expensive, would use demand assignment, which would allow direct connection between island groups. Hawaii could control the channel assignments, and would still act as a transit point for calls to CONUS or international points. Finally, and most expensive, SPADE and toll switching equipment could be provided at each island group, permitting direct connection to all points.

A ballpark estimate of the equivalent annual charges for this system, using Hawaii's toll switching, is:

Lease of pre-emptible Intelsat transponder	$1,000K
Additions to Paumalu earth station (TV transmit/receive and 96 voice channels)	77
Additions to American Samoa and Guam earth stations	32
9 earth stations @ $62.7K	564
Equivalent annual charges of satellite portion of total network	$1,673K

Note that this assumes installation and maintenance costs similar to those in Hawaii, and commercial interest rates.

At present, nearly all the island groups either have no TV, or have only limited-coverage cable or low-power transmitters using taped material. The costs above could be significantly reduced by deleting the full-time TV and leasing only a fraction (e.g., one-quarter) of a transponder. The earth stations could still provide spot coverage and special events, using existing Intelsat arrangements.

A Regional Satellite System - Example 2

The services offered in the first example could be expanded simply by leasing additional Intelsat repeaters. However, if the earth station size and cost are to be reduced significantly a new satellite design would be required. The second example shows what might be accomplished with a dedicated satellite using current technology.

The satellite would be a derivative of the Syncom 4 design discussed above. It would have two high power repeaters with a combination of spot and area beams covering Hawaii, American Samoa, Guam and the Trust Territories. One repeater would be used solely for TV, while the other could provide up to 500 telephone circuits. The same number of earth stations would be involved, but since the 2.5 GHz frequency bands would be used rather than 4/6 GHz, a new 8 meter antenna would be required in Hawaii. The small earth stations at 11 locations (including Guam and American Samoa) would have 1.5 to 2 meter antennas.

The small size and low cost of earth stations in this example could lead to, for example, use of the satellite for educational/health TV within Hawaii, spare telephone capacity for use elsewhere in Hawaii or the Pacific, and/or additional earth stations at locations such as high schools, libraries, hospitals, etc. A detailed cost analysis could indicate that rebroadcast of the TV program would be no cheaper than simply providing receive-only stations wherever required.

The estimated annual cost of this system is:

Half of TV transponder	$1,275K
1/5 of telephone transponder	510
Large (8m) earth station	77
11 small (2m) earth stations @ $21.5K	237
Equivalent annual charges of satellite portion of total network	$2,099K

Further Considerations

The use of Hawaii as a transit center for interisland, international, and U.S. Mainland telephone traffic would involve the possibility of double-hop satellite circuits. While this may be a somewhat undesirable feature, it should be an acceptable one in view of the quality of the service it would be replacing. Even in the case of so sophisticated a user of telephone circuits as Japan, double-hop circuits have been shown to be tolerable in certain circumstances.

In the examples, only U.S. territory and Micronesia coverage was considered. The British Commonwealth countries, French territories of the South Pacific and independent island nations could conceivably be included in the system, although provision of only one TV program would be a problem. A wider-based system would lower unit costs as long as system capacity were not exceeded.

The time scales involved would be one to two years for Example 1 and three to five years for Example 2, from a decision to proceed to full system operation. Capital expenditures could be spread over these periods.

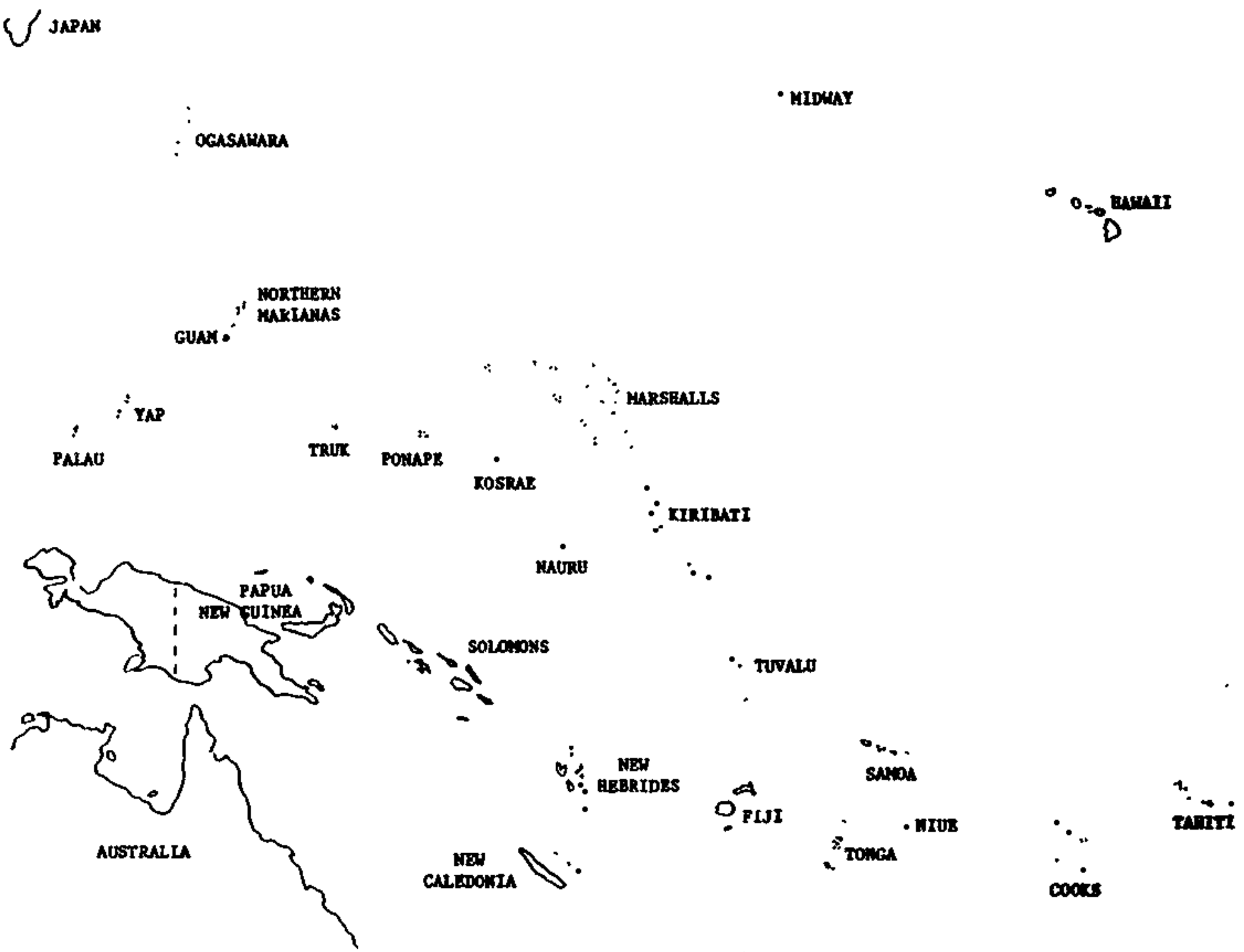
Conclusions

Satellites are already being used to provide reliable high-quality communications in the Pacific. There are several ways these services could be extended to nearly all the islands. The main barrier is the low level of economic development in most areas.

The economic viability of the two systems described here is difficult to assess, since demand for a service cannot be accurately determined when the service is not available. However, the development of industries such as tourism, fishing and deep-sea mining will both increase whatever demand presently exists, and provide the means to pay for the service.

Acknowledgement

I thank GTE International Systems Corporation, Hughes Aircraft Company, the ITU Regional Project in Fiji, the PEACESAT office in Honolulu, and Western Union Telegraph Company for information and assistance, and the Hawaiian Telephone Company for permission to publish this paper.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NAURU
PAPUA NEW GUINEA
SOLOMONS
TUVALU
NEW HEBRIDES
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1. THE PACIFIC ISLANDS

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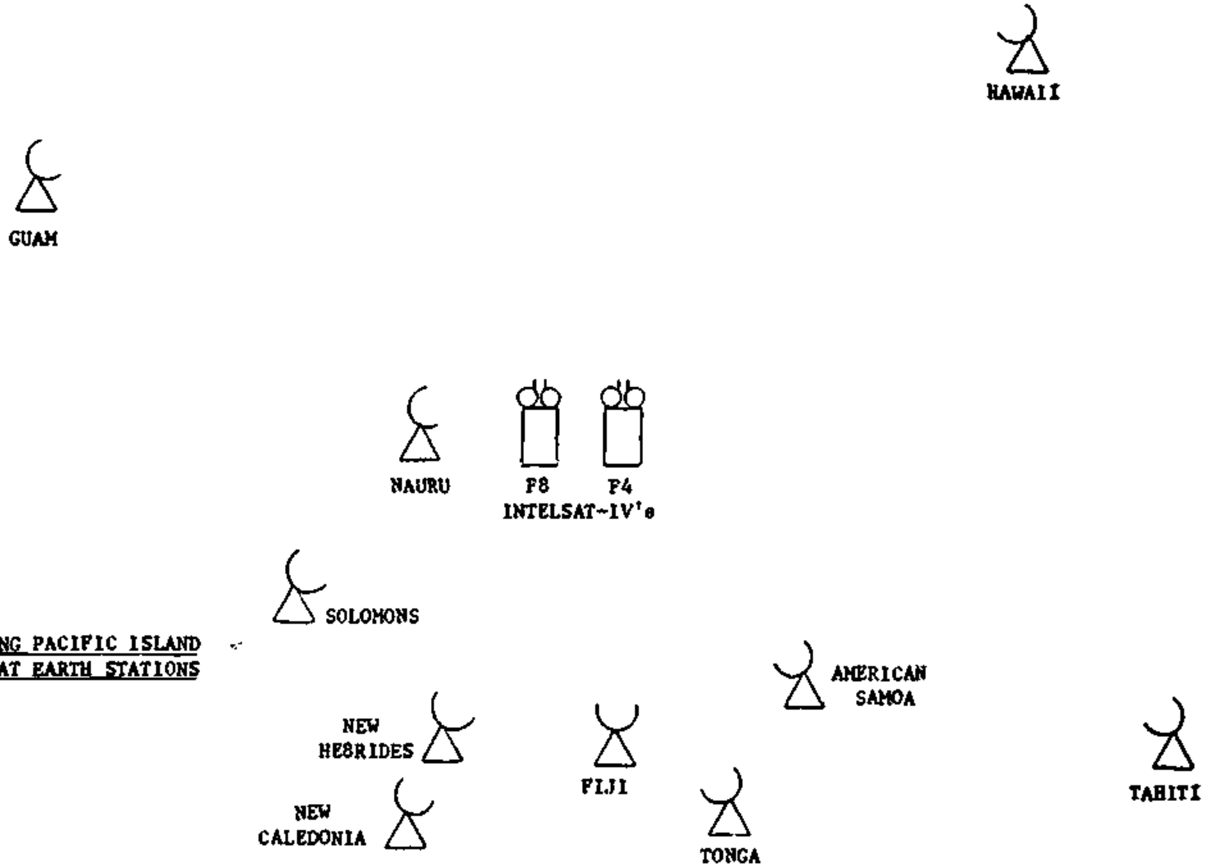
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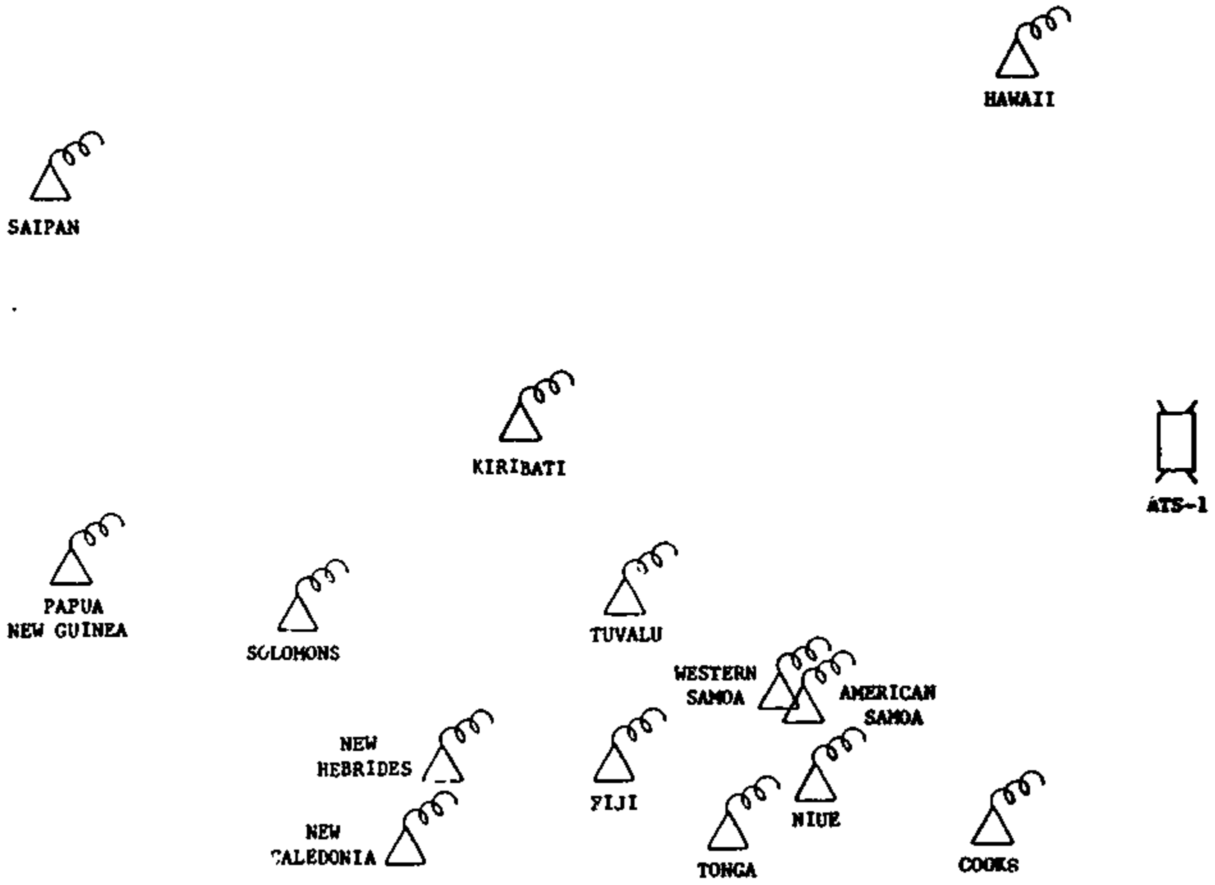
2. EXISTING PACIFIC ISLAND INTELSAT EARTH STATIONS

3. THE PEACESAT AND USPNET NETWORK.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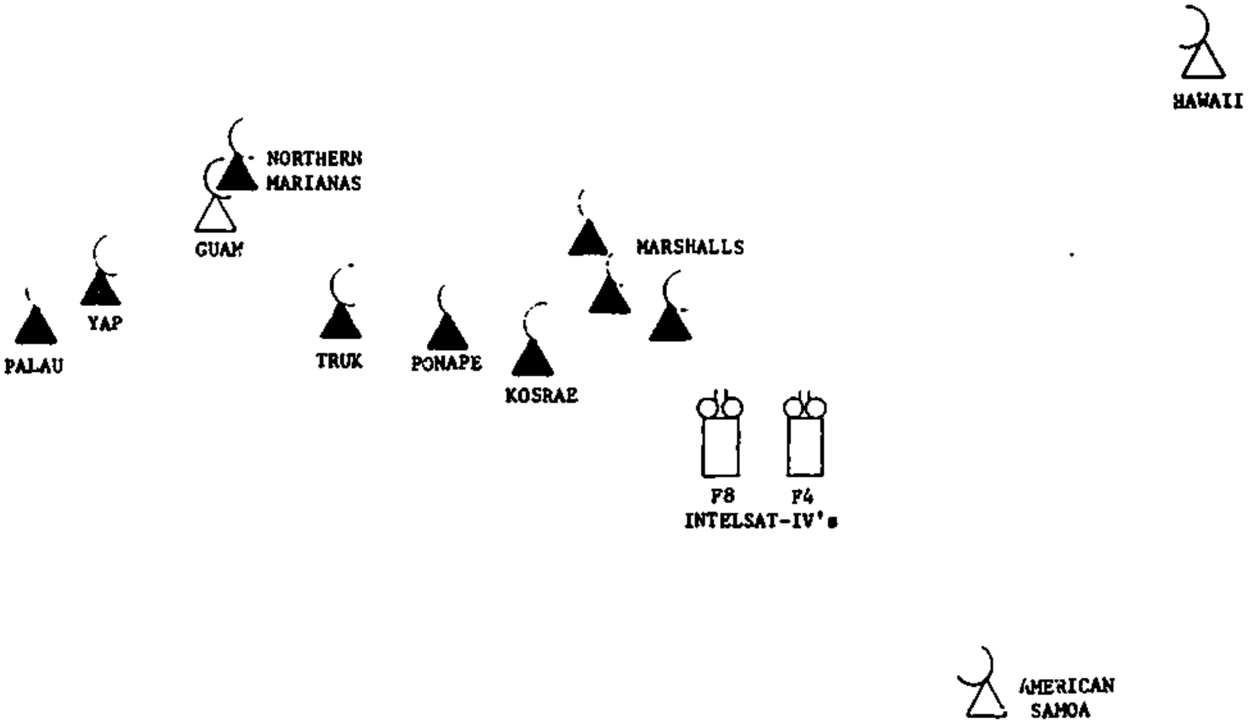
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F4
INTELSAT-IV's
AMERICAN SAMOA

4. EXAMPLE OF REGIONAL SATELLITE SYSTEM USING LEASED INTELSAT TRANSPONDER.

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APPROPRIATE TECHNOLOGY AND RURAL COMMUNICATIONS IN PAPUA NEW GUINEA

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ABSTRACT

In this paper the author suggests that the arguments of appropriate technology can and should be applied to communications technology in developing countries. A possible rural communications network for Papua New Guinea is cited as an example.

INTRODUCTION

The main argument in favour of appropriate technology is that the technology should be relevant to the situation, and be controllable by the people who are using it. For example, in an area where roads are very poor and engineering facilities limited, a bicycle rather than a truck might be a more appropriate solution to the transport problem. The bicycle can negotiate parts of the road where the truck would get stuck, and it can relatively easily be repaired, while the truck would require a skilled mechanic and workshop facilities.

Appropriate technology (A.T.) solutions have generally been made in terms of relatively simple techniques, and at first it might be thought that the relatively high technology of electronic communications might not fit easily into the 'appropriate' category. This paper, however, argues that the general principles of A.T. may be applied to available communications technologies to provide a coherent framework for communications within developing countries.

COMMUNICATIONS IN PAPUA NEW GUINEA

In Papua New Guinea, as in many developing countries, the vast majority of the people live in rural communities, often isolated not only from the towns but from other, similar communities.

Communications in rural Papua New Guinea is made difficult by factors of terrain and climate: most of Papua is occupied by the largest swamp in the world, and vast areas of mainland New Guinea are covered in wildly mountainous country, where peaks reach 4,000m and all but the highest country is covered in tropical rainforest. In the New Guinea islands region, similar problems exist on the larger islands such as New Britain in addition there are many isolated small islands which can be cut off by heavy seas, perhaps for 6-8 weeks continuously.

In one sense, Papua New Guinea already has an excellent communications system. Between and within the towns, a modern STD telephone system provides high-quality and reliable communications. Mountain-top microwave repeaters link towns not yet joined by roads, and the island centres are linked by troposcatter. The expatriate and business communities are well served. But the majority of the people, in the villages, are far from the telephone and have little hope of being connected into the network. The public utilities are concerned with providing a service and deriving revenue: in the towns, this works extremely well. Figure 1 illustrates this network.

In the rural areas, communications needs are served by the following:

1. 'Drops' from the microwave network. This could provide direct dialling facilities for a small town, but is unlikely to be widely used because of the high cost of terminal equipment, and the reduction of capacity on links between the towns.

2. VHF outstations. These provide good service in semi-rural areas, and can give direct dialling. Although expansion in this area is to be expected, large-scale coverage of the remoter rural areas is unlikely because of:

   a. hilly terrain;

   b. the 'line of sight' nature of VHF transmission;

   c. the relatively high cost of installations (4).

3. HF outstation service. Postal and Telecommunication services ('P & T ') maintain a network of high-frequency (HF) outstations. The network has recently been converted to single sideband (SSB) operation, and provides a nominal 24-hour service to remote Government outstations, plantations, missions, etc. Problems with this service may be summarised as follows:

   a. No direct dialling. Villagers are sometimes reluctant to negotiate with a 'foreign' operator.

   b. Variability in HF propagation.

c. Limited coverage. Although there are more than 1,000 HF outstations, these are widely dispersed. Many villages are a long way from the nearest outstation - perhaps a 'walk' of a day or two. For some isolated places, especially islands, there is effectively zero access to a radio.

d. Limited access. A further problem is that some outstation radio owners may be unwilling to allow their set to be used for general traffic (2), although legally obliged to do so.

e. Cost of installation. P & T will instal an HF radio free of charge in a Government outstation. A monthly licence fee of about K28 is then payable. For non-Government installations however, the cost has to be met by the user. Since the radio itself costs around K1,000, installation charges will inevitably restrict radios to the relatively wealthy.

4. Other HF networks. In addition to its own outstation service, P & T licences a number of private HF networks. These are used by commercial concerns, missions, etc. The National Emergency Services organisation operates its own HF network.

RURAL DEVELOPMENT

In his paper to the Pacific Telecommunications Conference 1979, Christopher Plant (1) argues caution in the expansion of telecommunications in the Pacific: "telecommunications developments are likely to tie the Pacific Islands more firmly to the exploitative machinery of the 'core' states rather than assist in any authentic 'development'". Here he defines the 'core' states as the developed nations of the Western World, and the 'periphery' as the still-unspoilt Pacific Islands region.

While not entirely endorsing all of Plant's observations, the author feels that his argument can be applied in microcosm to a developing country such as Papua New Guinea. Here the 'periphery' is represented by the vast rural area, with the majority of the population in a traditional village life, and where communications are poor. The 'core' consists of the towns, where most of the wealthy live, and where life is organised in a 'Western' style.

Since the Second World War, the main towns of Papua New Guinea have shown rapid (9) growth, and with growth have come the problems associated with cities in developing countries the world over. More people than can possibly hope to find employment have drifted to the towns to live with friends or relatives.

Housing authorities and social services grapple manfully but hopelessly with the urban unemployed. Shanty - town squatter settlements on the fringes of the towns are large and growing steadily. Inevitably, urban crime is increasing.

With this pattern of urban drift, one must question the whole idea of improving communications in the rural areas. Will television in the village demonstrate the 'city lights' to the villager and make him even more eager to join the rush to the towns? Will STD telephones allow the employed urban dweller to extol the virtues of his new cassette player to his friends at home?

Against these possibilities, however, must be set the very real advantages of opening up at least limited links between town and village. Many village schools would benefit considerably from the use of a two-way radio to link them to provincial education authorities. An overwhelming argument exists in favour of communications in the event of a medical emergency in the village: many villages are within reasonable distance of a small airstrip, and given the means to call for help, a light aircraft can be obtained to carry a sick villager to town, to hospital.

Notwithstanding the reservations already expressed on urban drift, the author's view is that some form of improved communication between towns and villages is an essential pre-requisite to real development of the rural areas.

Improvement in rural communications, thus justified, must be seen as part of an overall strategy aimed at improving people's lives in the rural areas, with health, education, and energy resources as other requirements. In October 1976, Prime Minister Michael Somare's Government produced a White Paper: 'The Post-Independence National Development Strategy' (8). This important document lays the foundation of Government policy by recognising that Papua New Guinea is a nation of villages, with more than 80% of its 3million population living in the rural areas. Figure 2 gives a guide to population distribution. The White Paper sets policy by indicating that the traditional way of life is to be preserved and indeed revitalized. The towns are to be seen merely as service centres for the villages. Urban facilities like hospitals are to be made more available to people living in the country by improved communications.

The Paper implies a decision on resource allocation - where possible the rural areas should benefit. This indicates an acceptance of social cost-benefit analysis. The implication for rural communications is that the short-term economics of village telephones are less important then the fact that communications is an essential catalyst to rural development on a wide front. A major expansion in rural communication facilities is therefore indicated.

THE POSSIBILITIES

The alternatives for rural communication might be the following:

(1) Extension of the microwave netowrk, with more 'drops' in remote areas;

(2) Extension of VHF links (with or without dialling);

(3) Introduction of satellite communications;

(4) Extension of existing HF networks.

Of these options, (1) and (2) may in general be rejected on grounds of cost.

The third option must be considered as a possibility.

A suitably-placed satellite could give access to the remotest corner of Papua New Guinea, and provide reliable, high quality speech circuits - and even television.

The last option is simply to extend and make more effective the existing HF networks.

APPROPRIATE TECHNOLOGIES?

The alternatives for rural communication in Papua New Guinea seem then to be either a satellite - based system, or one based on HF radio. To those familiar with the fading, interference, and general unreliability of the latter, the choice might be simple. This paper, however, suggests that for a developing country such as Papua New Guinea the choice is not so simple.

As satellite technology improves, low-cost groundstations will undoubtedly appear, although whether the cost of a station capable of two-way traffic with the satellite would ever be comparable with an equivalent HF radio is open to question. In any case, the technology of the ground-station would be far higher than anything previously available in PNG. This immediately raises the question of whether it is appropriate to introduce such technology into a country still in the early stages of its development. How would such equipment be maintained? Only by costly expatriate technicians, flown in at great expense. In the humid climate of PNG, experience has shown that the services of such technicians would be constantly required.

Perhaps the greatest argument against the use of satellites is that they are inherently a foreign technology: there is no way in which PNG or any similar country can put up its own satellite system. This means that it has to buy time (at considerable expense, even now) on someone else's satellite. Outside agencies, no matter what safeguards are written into the agreements, must then have ultimate control over the country's internal communications. On the other hand, HF radio, belittled by the satellite people (3) in Washington and admittedly an imperfect technology, does have an over-riding advantage - it employs the ionosphere, which to date is freely available to all. Its hardware, maintained and possibly built by nationals, resides entirely within the borders of the country and is completely controllable by the people therein.

HF radio, despite its well-known disadvantages, does have the tremendous advantage to a developing country of being a well-tried and tested technology. Papua New Guinea can provide its own national technicians to service such equipment: the University of Technology in Lae runs a Diploma in Communication Engineering course which produces graduates of an appropriate standard. There is even the exciting possibility of PNG producing its own low-cost HF radio for village use: the author's research project at the University of Technology is in the process of developing such a radio, which could be built in PNG by national technicians. (Figure 3).

The radio will be a rugged, sealed unit, with a minimum number of controls. Power in remote areas is to be supplied by solar (photovoltaic) panels, charging 'maintenance-free' batteries. The total capital cost of a complete installation is expected to be less than K600.

An important feature of such a project is the degree of participation by the villagers: while they cannot be expected to do more than operate the set itself, the aerial system offers more scope for involvement. Several lattice towers have already been successfully constructed from bush materials in the Huon Peninsula area, with aid of enthusiastic villagers (6) (Figure 4).

If adopted on a large scale, such a network would present obvious management problems: and yet it is desirable to provide communications to as many villages as possible. The author proposes that this difficulty may be overcome by surrounding each HF station with a number (up to about 10) of line-of-sight 'out-stations'. These short-range links could employ UHF or even 27MHz Citizen's Band (7) radios, and would considerably increase the effectiveness of the HF network.

CONCLUSION

On balance, it is desirable that rural communications in Papua New Guinea be improved; and Government policy is such as to encourage this. While satellite communications may be the most suitable technology for international links, consideration of the tenets of appropriate technology suggests that an improvement of existing HF networks may be preferred for rural communications.

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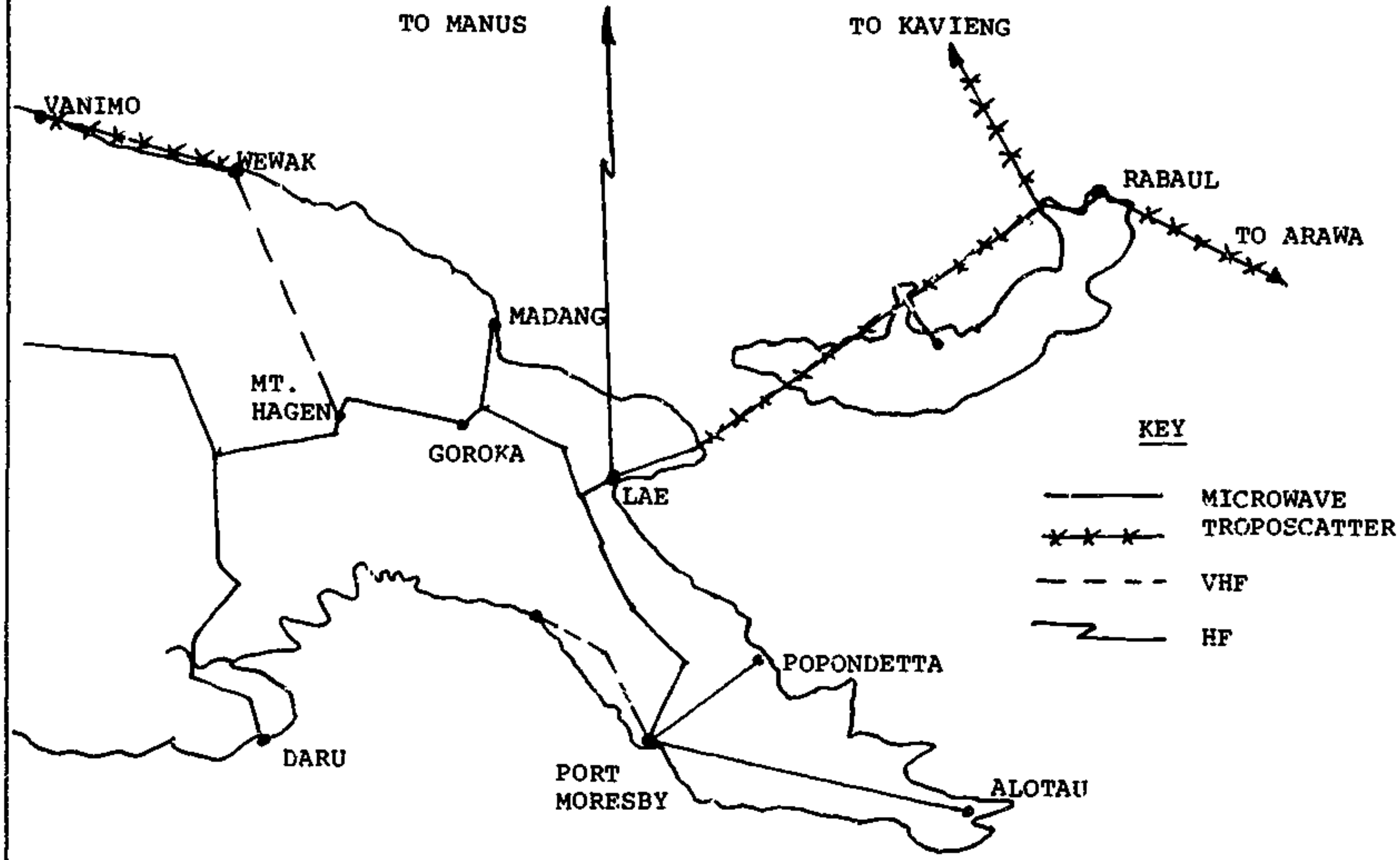
TO MANUS
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TO ARAWA
MADANG
MT. HAGEN
GOROKA
LAE
POPONDETTA
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PORT MORESBY
ALOTAU
KEY
MICROWAVE
TROPOSCATTER
VHF
HF

FIGURE 1 - PNG TELECOMMUNICATIONS NETWORK (MAIN ROUTES ONLY SHOWN)

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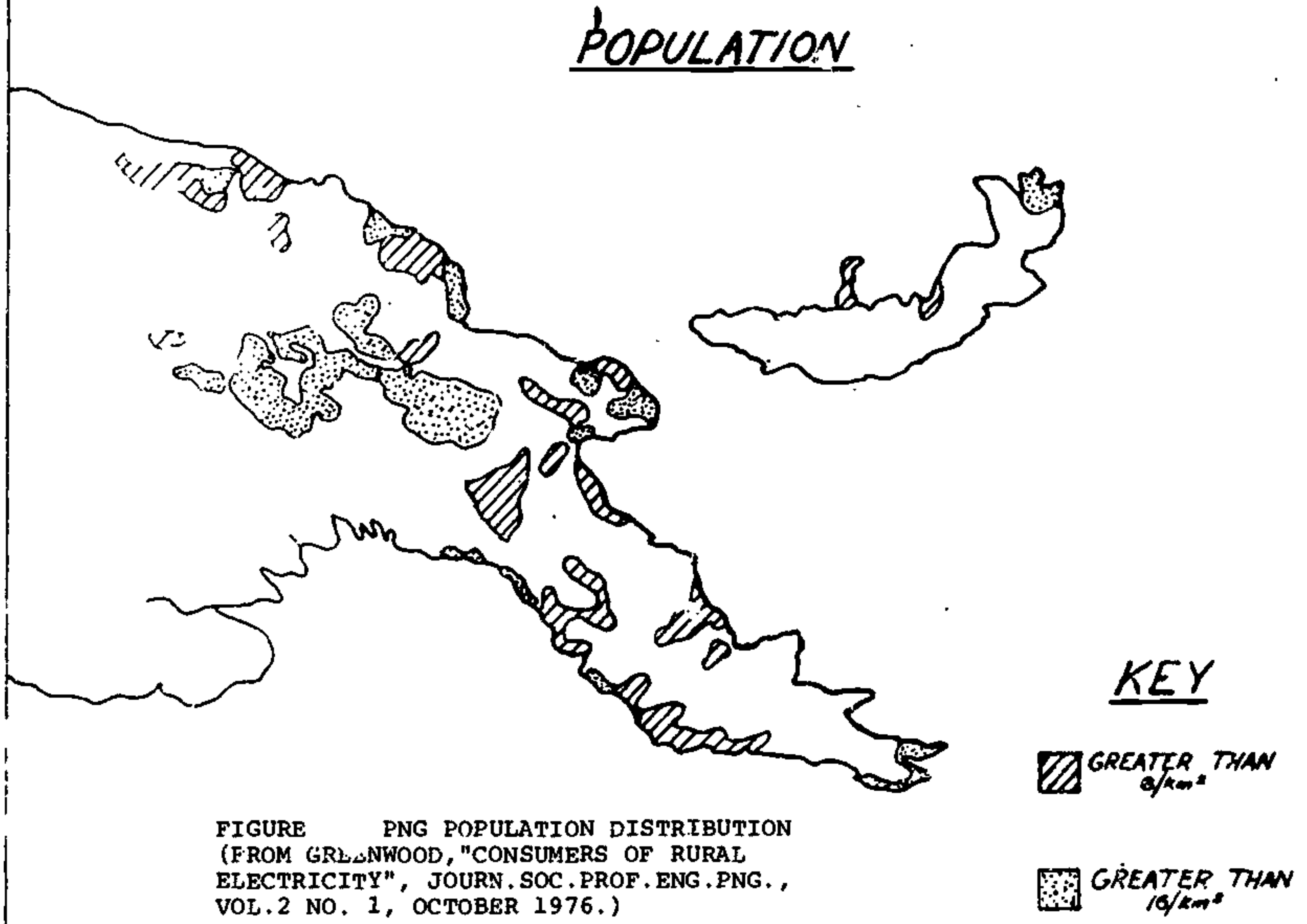
POPULATION
KEY
▨ GREATER THAN 8/km²
▒ GREATER THAN 16/km²

FIGURE PNG POPULATION DISTRIBUTION (FROM GREENWOOD, "CONSUMERS OF RURAL ELECTRICITY", JOURN.SOC.PROF.ENG.PNG., VOL.2 NO. 1, OCTOBER 1976.)

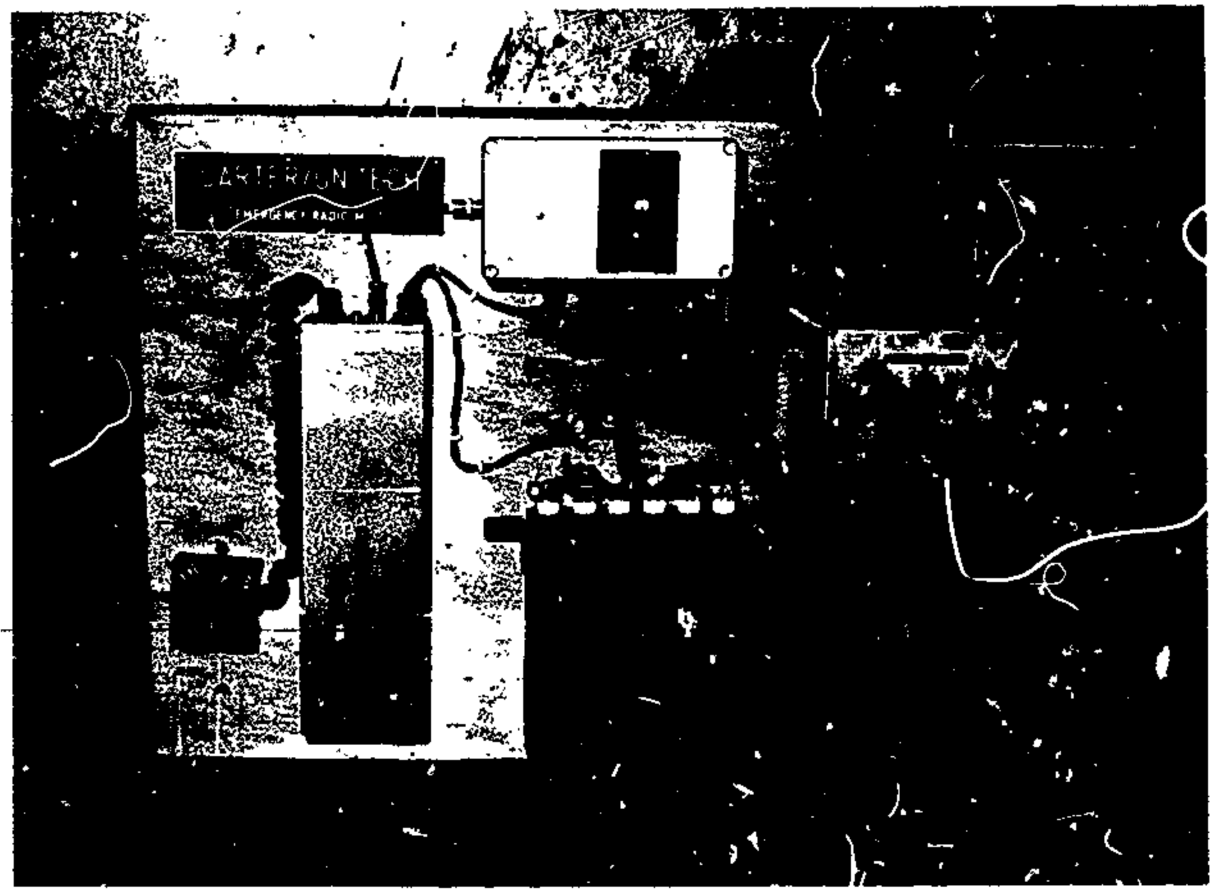
CARTER/UNITECH
EMERGENCY RADIO

FIGURE 3 - PROTOTYPE EMERGENCY RADIO

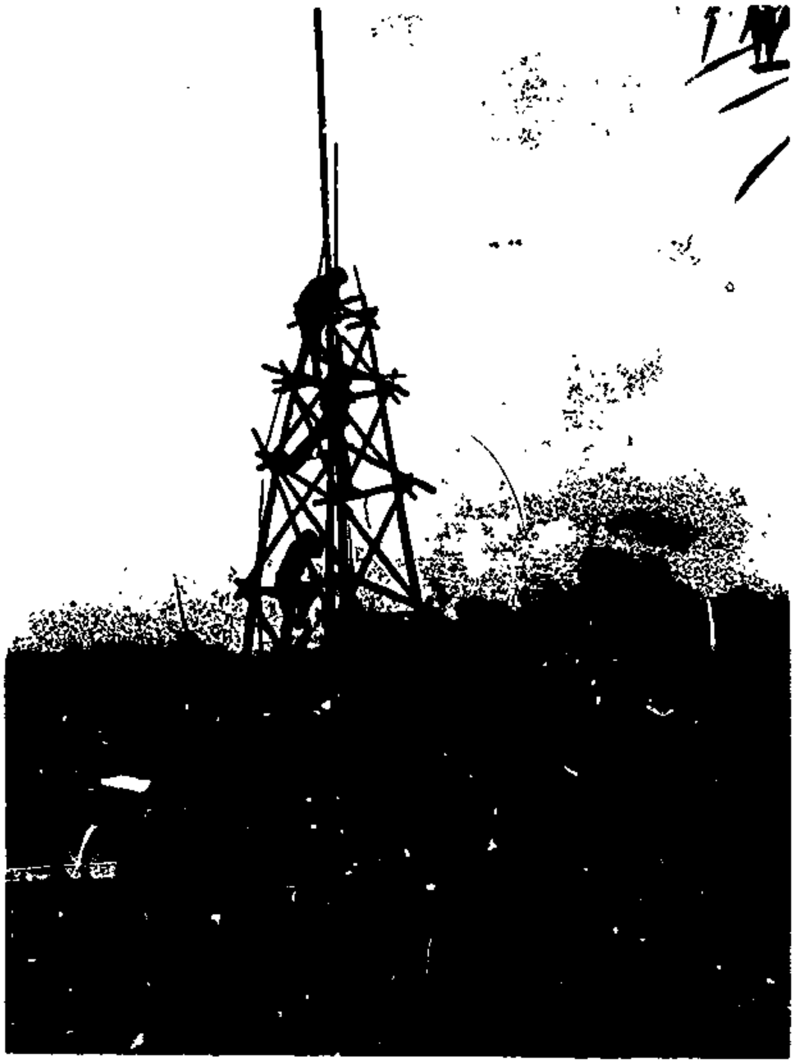

FIGURE 4 - VILLAGERS AND STUDENTS BUILD BAMBOO AERIAL TOWER.

PLANNING THE STATE OF ALASKA TELECOMMUNICATIONS SYSTEM

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Abstract

Alaska is developing a comprehensive telecommunications plan for the 1980's. This paper presents current efforts by the State of Alaska in the design and planning of an all digital, satellite linked, State of Alaska Telecommunications System (SATS). The planning, design and application of whole system concepts used in the SATS development are described.

Introduction

The State of Alaska has well documented characteristics that make reliable telecommunications essential: large geographic area, sparse multiethnic population, rugged terrain, extremes of climate, and virtually no interconnecting highway systems. Telecommunications facilities developed properly can provide cost effective and energy efficient "teletransportation" systems for the relay of information where roads are nonexistent and the cost of transportation of personnel and the information they provide is prohibitive. In our information society, publicly accessible telecommunications assume an importance comparable to publicly accessible transportation. (1) Increased reliance on telecommunications by Alaska government for program support and the extension of public services has created a need for comprehensive systems planning.

Throughout the 1970's, Alaska pioneered in the development of communications satellite technology. From the experimental days of NASA's ATS-6 televisions "direct broadcasts, to the construction of the first "thin route" domestic satellite system utilizing 100 small earth stations, the State has recognized the importance of telecommunications technology. (2)

In a State with only 9800 paved highway miles serving a land mass of over 586,000 square miles, the advent of reliable telecommunications has had a stimulating impact on Alaska's economic, social and educational development. Like the impact of canals, railroads and highways of the industrial age that spured growth in developing America, telecommunications here plays a similar role.

Alaska government has subsidized this development in order to decrease the gap between rural and urban communities. Besides health, education and entertainment links, telecommunications provides the means for government agencies to manage and administer their various development programs. This reliance on telecommunications makes government a major user of telephone and data services. Effective organization of Alaska governments telecommunications requirements has become an important planning activity. Development of an integrated system of communications networks during the 1980's will be a key factor in continued emphasis of Alaska governments utilization of the States telecommunications resources.

GOVERNOR'S TASK FORCE ON TELECOMMUNICATIONS

In February 1979, Governor Jay Hammond established a Telecommunications Task Force. Made up of prominent individuals from government and the communications industry, this task force has assessed current and future State telecommunication policy and planning issues.

Initially, the Task Force was divided into five working groups to review:

1. State needs
2. Converging technologies
3. The Television Demonstration project
4. The F.C.C. Joint Board proceedings
5. Level of service

Supporting these efforts are a policy steering committee to enable the task force to identify issues and a functional planning group made up of key user agencies to establish needs relative to telecommunications and the agencies mission. Emphasis on user driven policy and planning was given a high priority.

Functional Planning

In order to effectively assess State telecommunication needs, the functional planning group drafted a work plan to define, identify and integrate telecommunications facilities owned, leased, operated or planned by State agencies. The intent of the plan was to provide the Task Force with background data in a usable format. The work plan was divided into four general phases:

A. Survey of current facilities
B. Systems alternatives study
C. Systems, considerations
D. Systems improvements

Before these general phases were started a concise definition of telecommunications was determined and applied to agencies facilities. During phase A, a report was produced on each agency surveyed presenting a description and analysis of:

- Agency mission and services provided
- Current system description used to support the agencies mission
- Location of facilities

- Adequacy and current usage
- Current costs
- Projected communications service growth
- Communications service alternatives
- Summary and recommendations

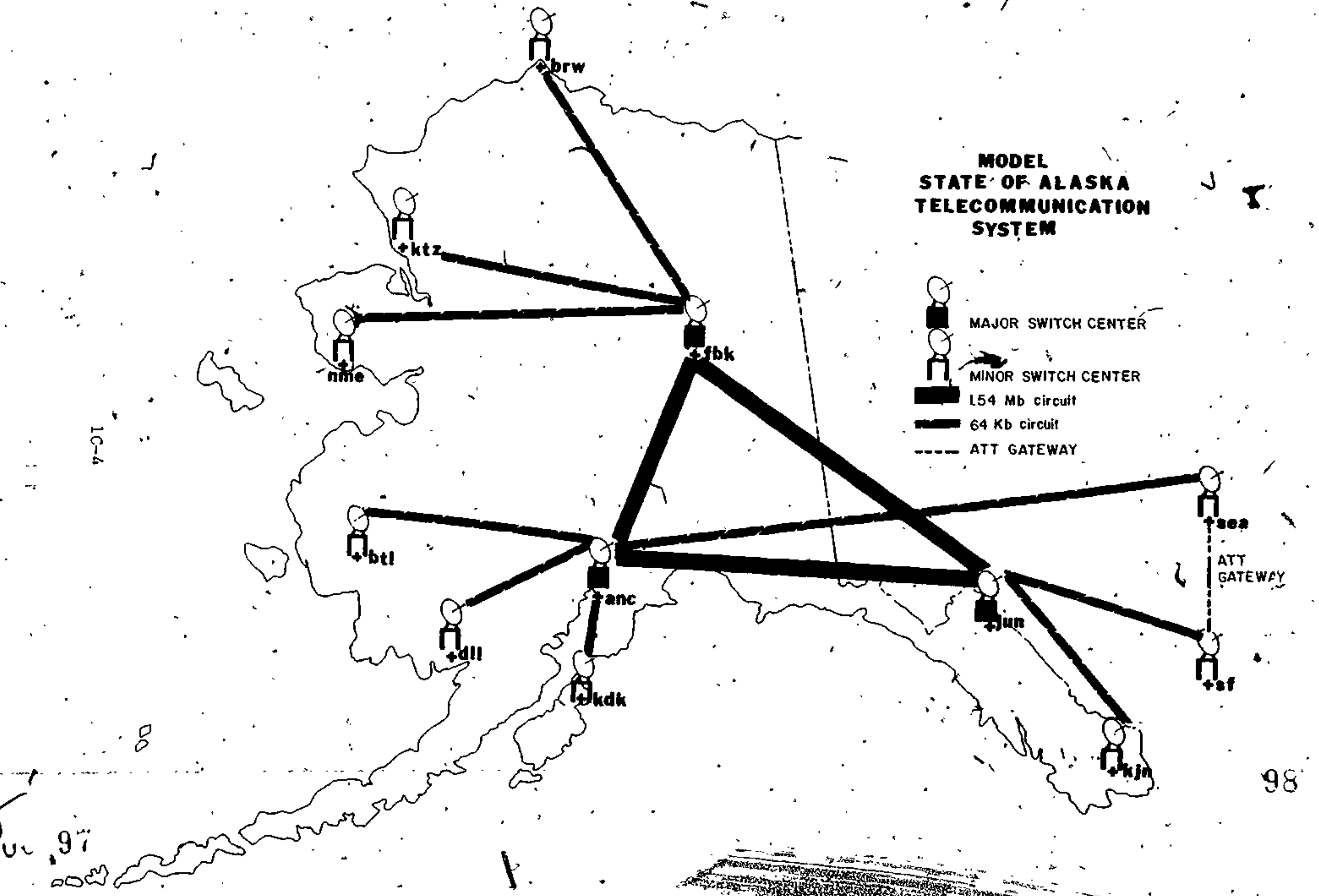
Once a composite cross-section of an agencies requirements, current facilities and plans were collected, a needs vs services analysis was conducted.

Upon completion of the facilities survey, alternatives to better services and cost control were developed. Considered during the systems alternative study were:

- Determination of the need for consolidation or improvement of present systems for FY 81 and over a longer term.
- Use of leased or owned telecommunications services.
- Development of program cost estimates (life cycle costing).
- Development of procurement and implementation schedules suitable for State Budgetary action.
- Development of a Five-Year implementation plan.

The results of the alternatives study were reviewed individually and on a whole system basis. The blurring to traditional distinctions between the various telecommunications methods is a crucial reason for basing telecommunications planning on a unified view - rather than on narrower portions of the overall picture. (3) Following close analysis, an overall picture began to develop indicating the need for a master development plan which would integrate and combine facilities into one major system.

After completion of the four phase work plan, the telecommunications planning group at the Department of Transportation and Public Facilities developed a plan for a State of Alaska Telecommunications System (SATS). SATS would provide Alaska government with a dedicated network for voice, facsimile, and data communication services. Importantly, SATS will also allow the State to effectively manage and control telecommunications costs while at the same time providing improved communications capability between State agencies and the public. The requirement to develop technical standards and equipment compatibility will also be met by providing a systematic development plan.



MODEL
STATE OF ALASKA
TELECOMMUNICATION
SYSTEM

MAJOR SWITCH CENTER
MINOR SWITCH CENTER
1.54 Mb circuit
64 Kb circuit
ATT GATEWAY
brw
ktz
nme
fbk
btl
anc
dll
kdk
jun
kjn
sea
sf
ATT GATEWAY
1C-4

STATE OF ALASKA TELECOMMUNICATIONS SYSTEM

The State of Alaska Telecommunications System would be developed around a telephone switching system with Anchorage, Fairbanks and Juneau as major centers. (Illust. 1) These switching centers would consist of digital systems capable of integrating both voice and electronic mail services within a single switch. Voice calls would be routed internally through SATS eliminating long distance toll calling. Likewise, all inter and intra agency memos, messages and letters could then be composed and transmitted through SATS to any agency office connected to or capable of dialing into the network. Capability for multi-station teleconferencing will be built-in to enable State offices to audio conference reducing the requirement to travel. Video conference capability would be developed over time if cost justified.

Another important feature to be included in SATS is to allow increased public access to State agencies and in particular to the process of government itself. Toll free central information services and a State agency telephone directory would be provided to citizens. The major switching centers will be equipped to allow the public to participate in program development through an electronic polling system. A prototype of this system is being developed and tested for use this fall.

Other aspects to be developed in SATS are: the extension of the network to ATT WATS interconnects and intrastate foreign exchange access, the use of satellite and meteor scatter systems for environmental monitoring of State facilities and lands along with a communications link to allow agency access for data base retrieval of ERTS and LANDSAT information from the Federal data bank.

A vital component of SATS is to specify a standardized emergency medical service development plan for health and public safety as well as the procurement of portable disaster communications equipment for command and control of emergency situations for government officials and field support. Equipment compatibility and coordinated radio frequency assignments for this service are essential.

Other aspects of SATS will specify how public facilities being developed in rural Alaska can utilize combined telecommunications facilities and assist agencies in coordinating usage. An integration of voice, data and television facilities at rural State offices would be more cost effective and provide those sites with greater multi-purpose capability.

The objective of SATS would be to provide government services in a more efficient manner to the public and to the government itself. If developed in the most cost and service effective manner, SATS would provide real alternatives to current modes of travel and communications.

In order to meet the specific requirements of government and the various public it serves. The SATS would be comprised of the following network components.

A. Administrative Telephone Network

- Centrex equipment located in Anchorage, Fairbanks, and Juneau
- Remote Centrex equipment located in Ketchikan.
- Dedicated 24 channel tie lines between major switching centers (T1).
- 64 Kbps data communications links to minor sites. Direct inward dial to major switching centers
- Fully redundant back-up
- Optimized traffic routing (long distance call control)
- Multi-station teleconferencing throughout entire network
- Toll free dial-in access for public input on crucial development issues. Central information for public access to government agencies through network.
- Call accounting and network management information reports

B. Administrative Message Network

- Utilizes the same switching equipment and tie lines as telephone network.
- All offices will have electronic mail access for filing inter and intra office messages, memos and letters. Word processing equipment would be standardized and equiped to communicate to any other station through the network. Similarly, access to data networks outside Alaska would be provided State users through value added network access.
- Facsimile centers combined with existing reproduction centers would be developed for large document transfer.

C. Administrative Data Processing Network

High Speed data links both point to point and dial-up for;

- Existing STAR/AJIS network
- State Library network
- University of Alaska computer network
- Marine transportation reservation system
- Legislative D.P. network
- Educational Telecommunications network
- Department of Labor

D. Public Service Telecommunications Network

- Combined State telecommunications facilities in rural communities
- Educational and instructional television facilities for DOE, U of A, and other State agency use in educational extension programs.
- Public involvement into government through tollfree access to electronic voting facilities and agency offices
- teleconferenciing facilities in regional communities to access the legislature, public forums, native associations etc.

E. Emergency Services Communications Network

- Uses existing State owned earth station equipment
- Link existing State owned terrestrial microwave facilities for AST, and emergency services to major switching centers on SATS system.
- Procure transportable earth station equipment for emergency/ disaster communications
- Provide tollfree service to major hospitals, police and other emergency services (911 services)
- Coordinated development with Emergency Medical Service, Civil Defense, local law enforcement and the Defense Communications agency.

F. Judicial Systems Network

- Court systems linked through State voice and data network
- Establish precedent for television linked hearings and court proceedings in rural communities
- Provide data access and records retrieval of legal documents from regional service areas.

G. Resource Information Network

- Establish remote sensing network via satellite and meteor scatter system to monitor State facilities and lands
- Provide this data in manageable form to agency planners.
- Utilize Landsat data for environmental and cartographic operations.
- Provide data links to Landsat data banks in South Dakota.

Summary

SATS development is now in it's preliminary stages. User agencies, and telecommunications planners are meeting to refine features and specific requirements. When completed, a systems specification will be composed and a request for proposal issued. Work on SATS is expected to begin first quarter of FY 81. Phased cut-over to the new systems is planned for early FY 82. Performance evaluation review techniques (PERT) will be used to keep the project on track. User training will be given a high priority to insure effective use of features incorporated into the SATS.

Never before have opportunities for integrated systems development been greater. The marriage of digital switching and transmission systems, satellites communications and the experience gained during a decade of telecommunications development have given Alaska the opportunity to plan and implement a unique State of Alaska of Telecommunications System.

Notes

1. Khan, Ata, "Transportation and Telecommunications": a study of substitution, stimulation and their implications - Report 121 Carleton University June 1974

2. Browne, Stuart P., Alaska Telecommunications System Development, Proceedings Intelcom 79, March 1979, p. 108

3. Interconnection for North Carolina and Beyond - The report on Public telecommunications. April 1979

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A MULTISERVICE LOCAL COMMUNICATION SYSTEM

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Abstract

A local switching and distribution system to provide a variety of communication services to users on an industrial, commercial, or educational site is described. This Multiservice Local System (MSLS) will deliver telephone, data, television, video conference, and remote control services by means of processor-controlled digital and broadband analog switches and optical fiber subscriber loops. A small-scale MSLS Demonstration Unit is now nearing completion at GTE Laboratories.

Introduction

Much of the business of General Telephone & Electronics is the operation of public telephone systems. Our operating telephone companies serve a wide range of customers, some of whom are large organizations having many telephone subscribers situated in a single location--often with a number of buildings on the customer's site. Typical of such customers are university campuses, military bases, and office parks. The capabilities of modern electronics are raising the expectations of these customers for communication services. They are developing needs ~~for a variety of~~ local communication services beyond modern voice telephone service. To enable GTE to respond to these customer needs, GTE Laboratories is engaged in a program, the name of which is Multiservice Local System, or MSLS for short. The objective of this program is investigation of an advanced, local, switched communication system that can provide, in addition to voice telephone service: switched video service for television program and video library distribution as well as for video conferencing; picture telephone service for the addition of video transmission to voice telephone calls; switched data service for data terminal and computer interconnection; electronic office service for word processing, electronic mail, and computation; and remote control and monitor for building operation and control.

GTE Laboratories has completed a design study of the MSLS to define the services that should be provided and to select between alternative design techniques. The result of this design study is a system concept that is depicted in Figure 1. As the figure shows, the system comprises a central switching facility that contains the voice, video, and data switching equipment, the video and audio library equipment, the central video conference control equipment, and the central remote control and monitor (RCM) equipment. The switching center is connected to TV and video conference subscribers by optical fiber cable. These optical fiber loops can also carry the narrowband services--telephone, data, RCM--by means of a loop time-division multiplexer. Alternatively, these narrowband services can be carried on conventional telephone pairs when they are available.

Video Switching and Distribution

The heart of the video distribution and video conference system is a broadband solid-state electronic switch. This switch permits any user to be connected at his desire to any one of a large number of video signal sources. The sources include TV broadcast signals, signals from video library equipment, and signals from television cameras for video conference operation. The broadband switch will handle analog NTSC television signals in the frequency band up to 20 MHz. The signals can be positioned in frequency so that crosspoint outputs can be frequency-division multiplexed in groups of three for transmission. The broadband switch is designed in modular form on printed circuit cards. Each card contains 64 crosspoints that can be configured using straps in a rectangular array having any dimensions between 1 x 64 and 8 x 8. A photograph of the switch card is shown in Figure 2. As can be seen, the card has connectors on 2 sides and 1 end. Program signals are supplied to the connectors on both sides. Subscriber connections are made at the end connector, which also carries power and control signals. Insertion of a card such as this into a nest is made possible by the use of a Zero Insertion Force Connector. This connector is designed so that its clamps can be retracted, permitting the card to be slid sideways into the connector. When the card is in place, the connector clamps are applied. A photograph of the switch nest is shown in Figure 3. The broadband switch card has cross-coupling attenuation greater than 65 dB and harmonic distortion in the signal paths below -65 dB. The broadband switch is controlled by a microprocessor system that receives control signals from the users. Formatted signal messages are received by line interface processors (LIPs) that serve eight users each. These LIPs communicate with each other and with the control processor over a high-speed bus moderated by an arbiter. The LIPs use 8085 microprocessors, and the controller, an 8086. Each has 32 K bytes of memory.

Video signals are transmitted between the switch and the user in analog form in order to save the cost of video digitizers. This mode of transmission is possible because repeaters are unnecessary for the distances involved, so that signal degradation does not accumulate. The signals are carried on optical fiber. LED transmitters and PIN diode receivers are used. Single-channel and two-channel transmissions on single fiber are used at present. For multi-channel transmission, optical transmitter linearity is important to keep cross-modulation between the signals acceptably low. For three-channel transmission, feed-forward or feed-back techniques are needed to linearize LED transmitters adequately. The optical transmitters and receivers in use at present can accommodate 19 dB optical transmission loss for single-channel operation and 15 dB for two- or three-channel operation. Thus, 2-km loop lengths are acceptable with practical fiber attenuation.

A variety of video library equipment will be available to the user through the broadband switch. He will have access to video tape players that can be loaded and controlled remotely by him. He will also have access to slide projectors for still information, to a microfiche reader that can be remotely loaded and controlled, and to a computer alphanumeric data file, the output of which will be presented as a television signal. The microprocessor system that controls the switch also controls the library equipment.

Video Conference System

On a site such as a large university campus or a hospital complex, a video conference system that permits video and audio interconnection of multiple offices and conference rooms can save considerable time of busy professionals by obviating their walking or driving to a single location for a conference. The video conference system uses the broadband switch to interconnect conference participants. In a conference involving up to five locations, each participant can be shown all the other participants by dividing the television screen into sections, one for each participant. This split-screen technique is suitable for division of the screen into as many as four sections. For larger conferences, video switching during the conference is more appropriate. For example, participants can be shown the person speaking at the moment, and the speaker can be shown either the previous speaker or the conference chairman. The chairman will control the conference by using the small pushbutton conference console shown in Figure 4. The console contains a conventional signaling pad for entering numerical control signals as well as buttons for controlling video switching and switches for remote camera control during the conference. The buttons permit the chairman to select the participant whose picture is to be shown to other participants. To aid him in this selection, participants' names can be displayed adjacent to the selection buttons by alphanumeric display units. Participants wishing the floor can indicate this to the chairman by causing their buttons to be illuminated. The conference console contains an 8085 microprocessor with 6 K bytes of memory. The microprocessor is the intermediary between the console switches and displays and the data line to the video switch control processor. It prompts the user in operation of the unit and formats and interprets data messages.

Data Service

At present, the ubiquitous computer terminal is connected to the computer either by permanent wiring or by use of the voice telephone system via an acoustically-coupled modem or a data set. Interconnection of terminals directly is generally not possible, except in message networks such as Telex. The MSLS data switch gives to data terminals and computers a service similar to that given to individuals by the telephone system. It connects terminals and computers upon demand and performs necessary interface functions to resolve disparities of speed and protocol. It also permits transmission of one-line messages in real time to one or more addressees, even though their terminals may be otherwise engaged. The data switch design is shown in Figure 5. It employs a high-speed bus interconnection network to transfer data between the interface processors. An arbiter monitors the bus to resolve contention problems between interface processors desiring bus access. The interface processors connected to the interconnection network perform necessary speed and protocol conversions. These interface processors and the switch controller are microprocessors configured as a distributed processing system.

Digital transmission within the MSLS uses bipolar signals on multi-pair telephone cable or digital signals multiplexed on the optical fiber. Bipolar signals have the properties of no DC content and small low-frequency content, reducing their potential for interference with voice telephone circuits. An analysis of their transmission on standard telephone cable shows that bipolar signals at rates up to 70 kb/s can readily be transmitted over distances of a mile or more. Figure 6 shows measured and calculated results for bipolar transmission at 70 kb/s over about a mile of 26-gauge telephone cable. Slight differences in sending-end filtering and cable length are responsible for some of the small differences.

Office Services

The MSLS will offer a variety of computer-based services to support clerical, administrative, and management office personnel. The services will include word processing, electronic message service, and computation service. They will be provided through the MSLS data switch and data transmission system and will employ both conventional data terminals and terminals having considerable data storage and processing capability. A large-capacity electronic file associated with the switching center will be used for mass storage of word-processing text, electronic messages, and word-processing and computation programs that can be downloaded into the high-capability MSLS data terminals when required.

Storage locations in the electronic file will be used as mailboxes in the electronic message service. Messages entered at data terminals will be deposited in addressees' mailboxes for recall and presentation on addressees' terminals at their pleasure. The electronic message service will provide a speedy, flexible interoffice memorandum service.

Computation services that will be available include interactive BASIC as well as standard and custom software packages. This service can be used by those customers who do not have a large in-house computer or to unload the big computer.

Remote Control and Monitor

Management of the physical plant of a large organization requires monitor and control of a large number and a large variety of devices. Such devices include heating, ventilation, air conditioning, and industrial process controls, as well as building security and safety monitors such as entry alarms, temperature and smoke alarms, roof load sensors, and liquid level alarms. The MSLS includes a comprehensive system to handle these requirements by incorporating the GTE Lenkurt System 51. This system is a computer-based monitor and control system developed by GTE Lenkurt originally for monitor and control of microwave communication systems. The System 51 is adapted to take advantage of other MSLS capabilities. For example, it includes a video entrance-door monitor connected with the video switching and distribution system so that video signals from the entrance-door monitor can be presented at any desired location within the complex.

MSLS Demonstration Unit

At present, the design and construction of a small-scale MSLS Demonstration Unit for installation at GTE Laboratories is nearing completion. The Unit will provide all MSLS services but will serve only a small number of subscribers. Its configuration is shown in Figure 7. As can be seen, the Demonstration Unit will be able to provide video conference service to as many as five locations simultaneously and will interconnect seven data terminals for data switching and office services. It will include a Lenkurt System 51 connected to a variety of sensing and control devices within the Laboratories' buildings. The Demonstration Unit's purposes include confirmation of design choices, evaluation of the utility of the new services provided by the MSLS, and customer demonstration. It is expected that the Demonstration Unit will be in operation early in 1980.

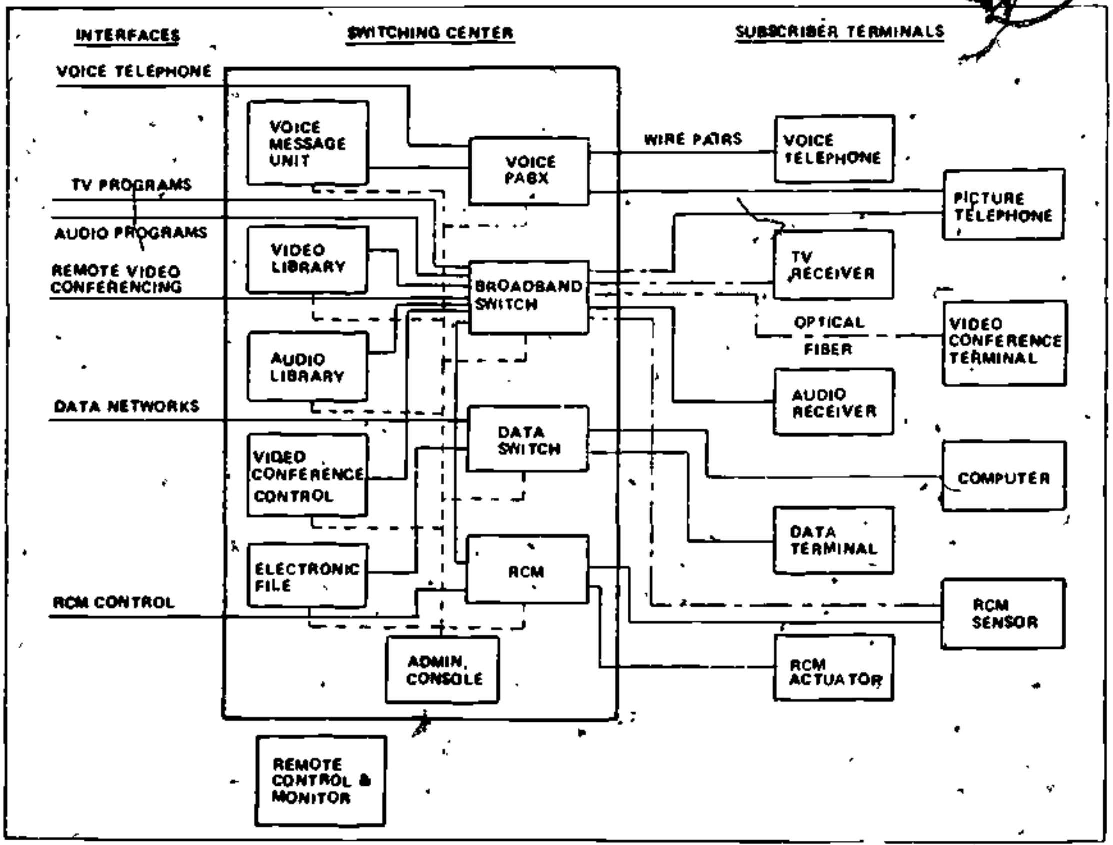
INTERFACES
SWITCHING CENTER
SUBSCRIBER TERMINALS
VOICE TELEPHONE
TV PROGRAMS
AUDIO PROGRAMS
REMOTE VIDEO CONFERENCING
DATA NETWORKS
RCM CONTROL
VOICE MESSAGE UNIT
VIDEO LIBRARY
AUDIO LIBRARY
VIDEO CONFERENCE CONTROL
ELECTRONIC FILE
VOICE PABX
BROADBAND SWITCH
DATA SWITCH
RCM
ADMIN. CONSOLE
REMOTE CONTROL & MONITOR
WIRE PAIRS
OPTICAL FIBER
VOICE TELEPHONE
PICTURE TELEPHONE
TV RECEIVER
VIDEO CONFERENCE TERMINAL
AUDIO RECEIVER
COMPUTER
DATA TERMINAL
RCM SENSOR
RCM ACTUATOR

FIGURE 1. SYSTEM CONCEPT

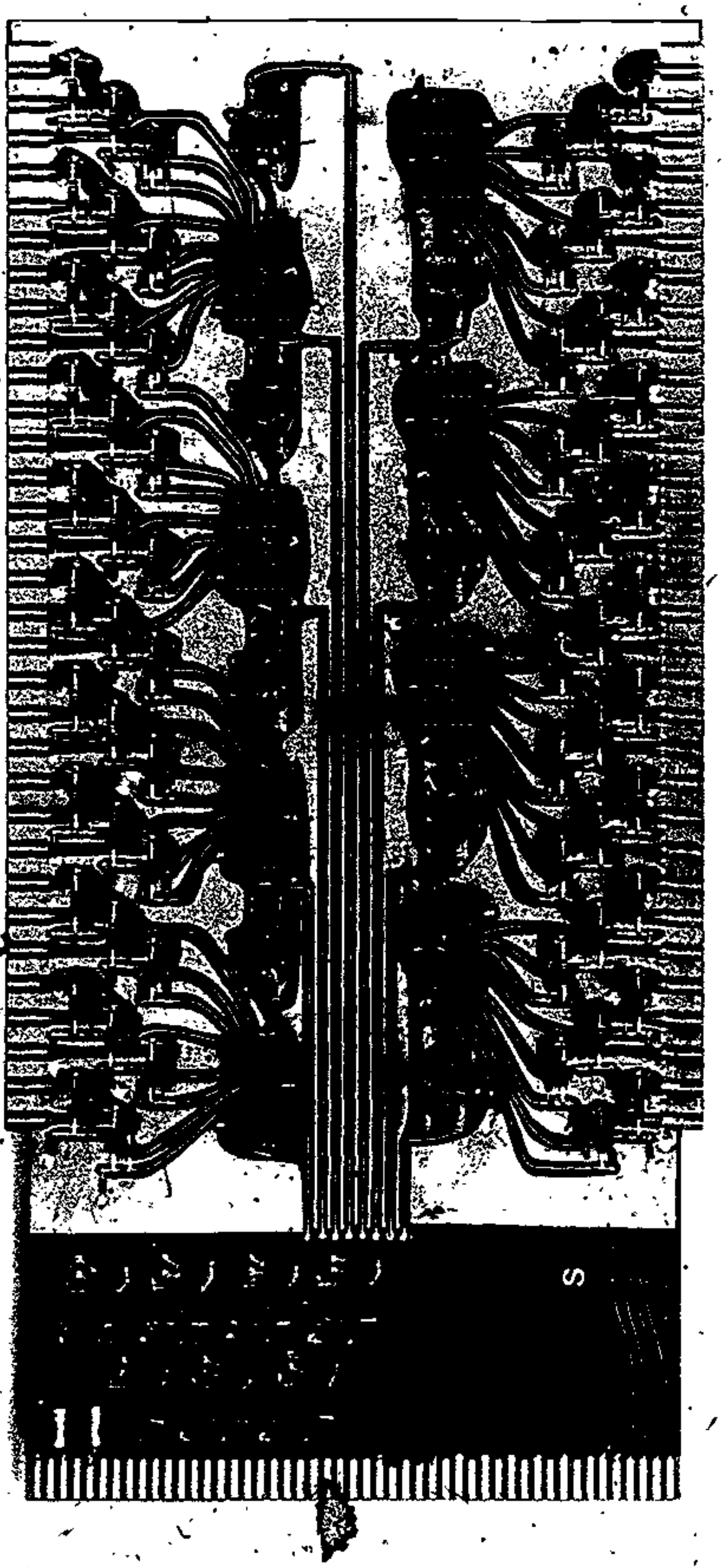

FIGURE 2. BROADBAND SWITH CARD

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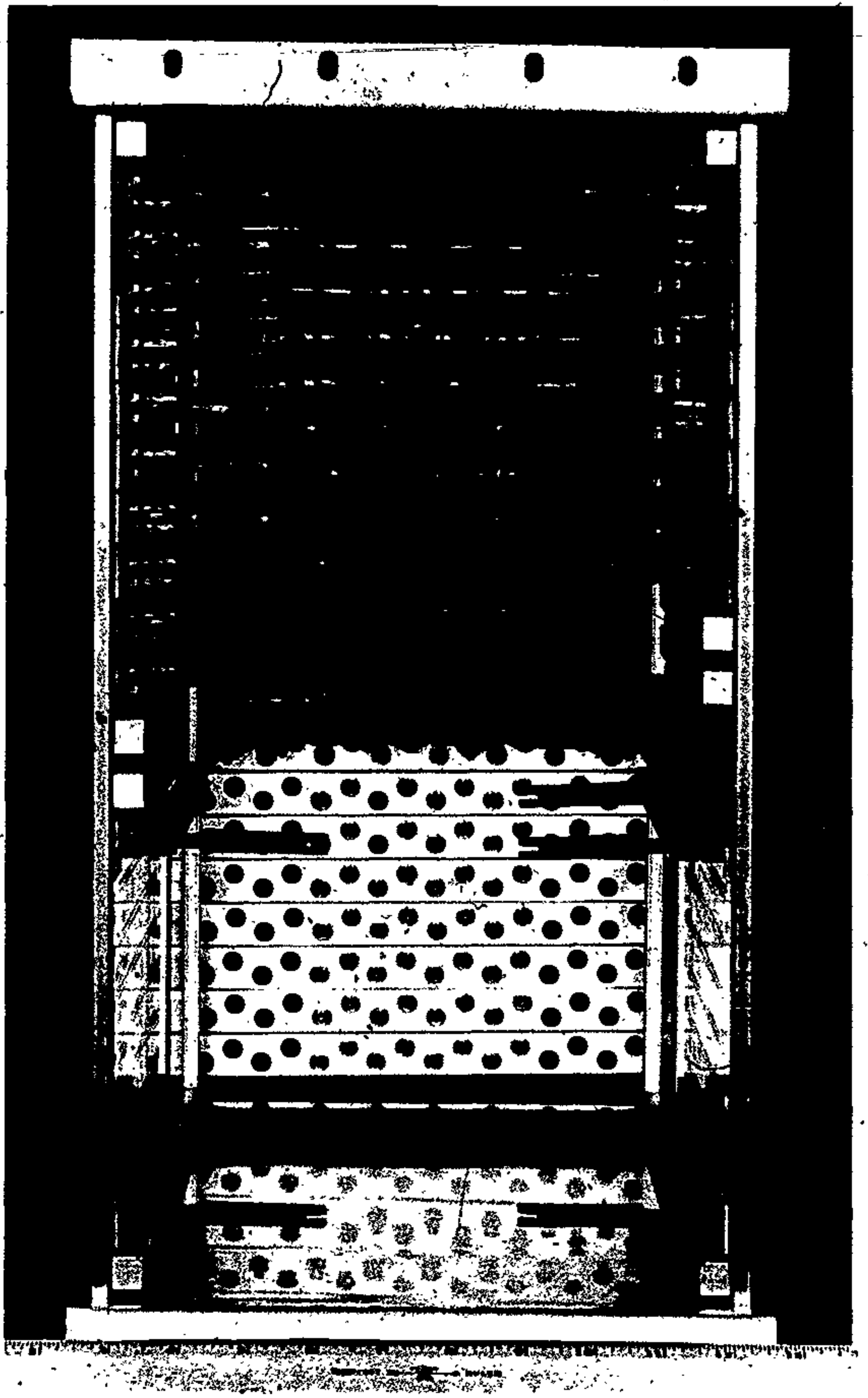


FIGURE 3. BROADBAND SWITCH NEST

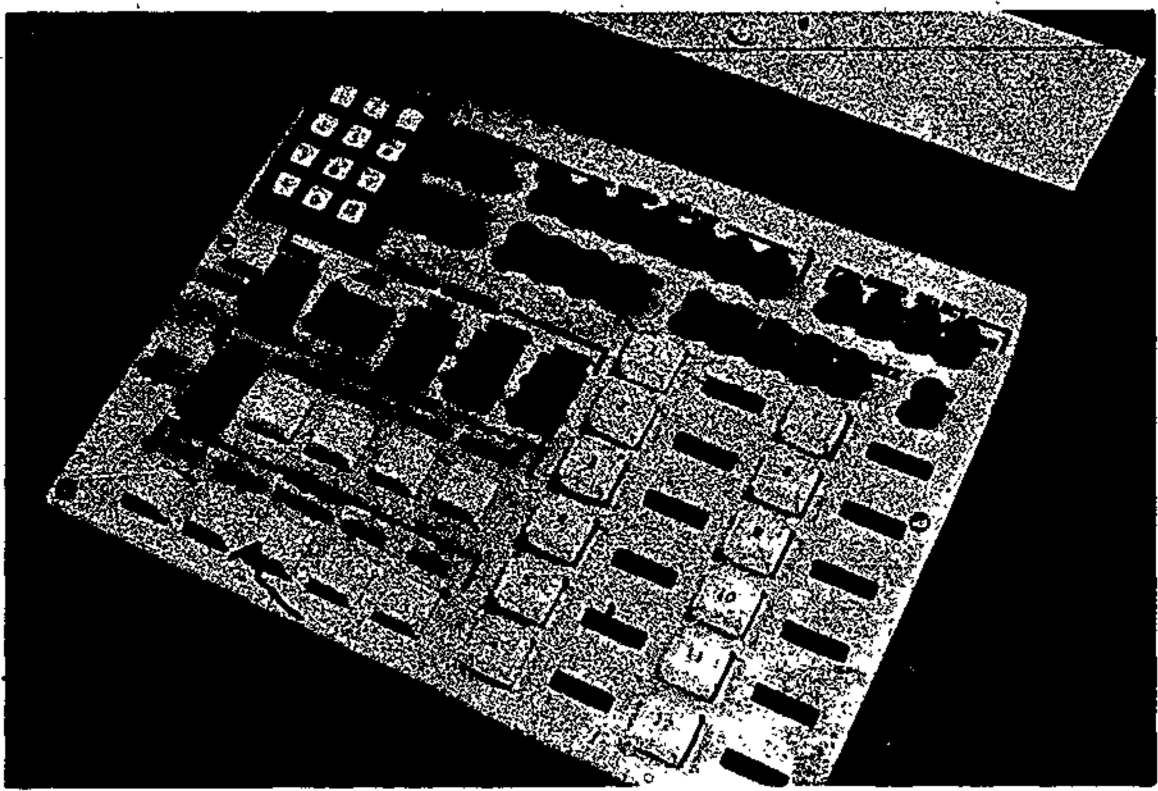


FIGURE 4. VIDEO CONFERENCE CONTROL UNIT

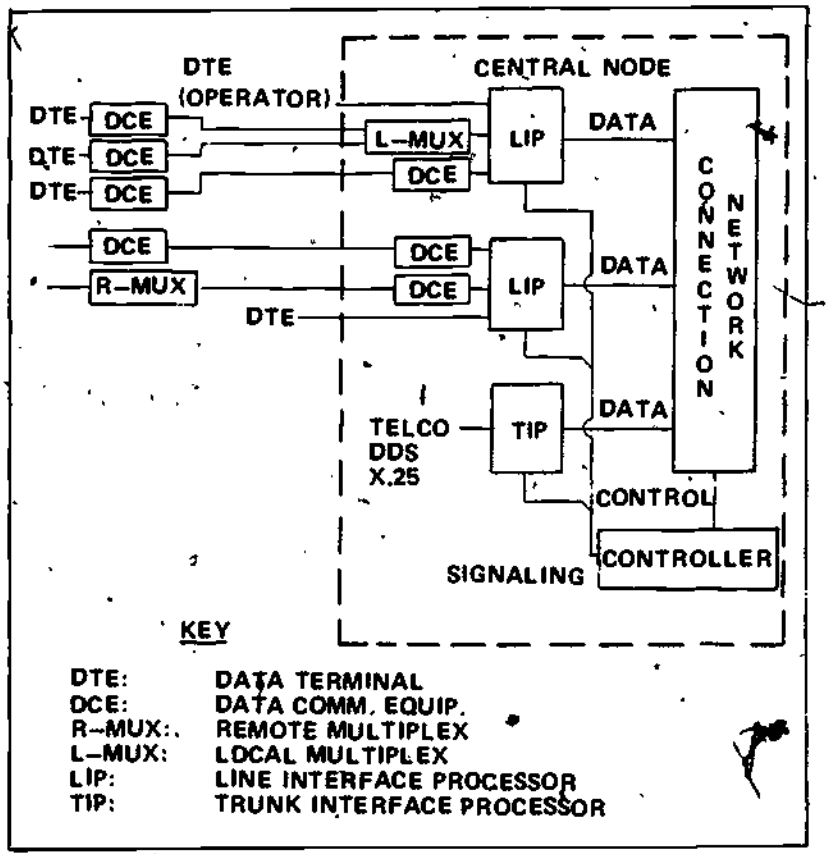
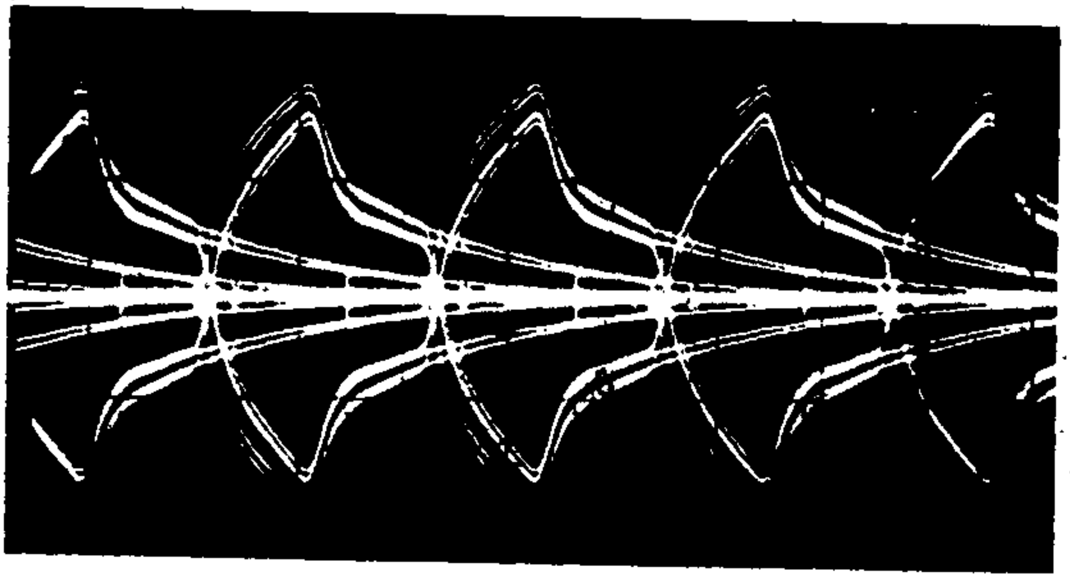
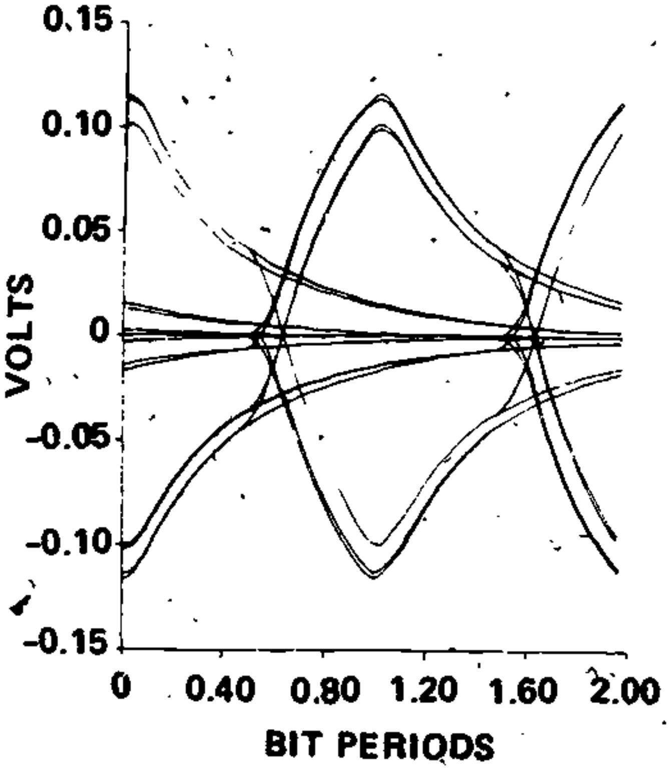

DTE (OPERATOR)
CENTRAL NODE
DTE
DCE
DTE
DCE
DTE
DCE
L–MUX
DCE
LIP
DATA
CONNECTION
NETWORK
DCE
R–MUX
DCE
DCE
LIP
DATA
DTE
TELCO
DDS
X.25
TIP
DATA
CONTROL
CONTROLLER
SIGNALING
KEY
DTE: DATA TERMINAL
DCE: DATA COMM. EQUIP.
R–MUX: REMOTE MULTIPLEX
L–MUX: LOCAL MULTIPLEX
LIP: LINE INTERFACE PROCESSOR
TIP: TRUNK INTERFACE PROCESSOR

FIGURE 5. DATA SWITCH DESIGN



MEASURED RECEIVED SIGNAL



CALCULATED RECEIVED SIGNAL

FIGURE 6. 70 kb/s BIPOLAR TRANSMISSION

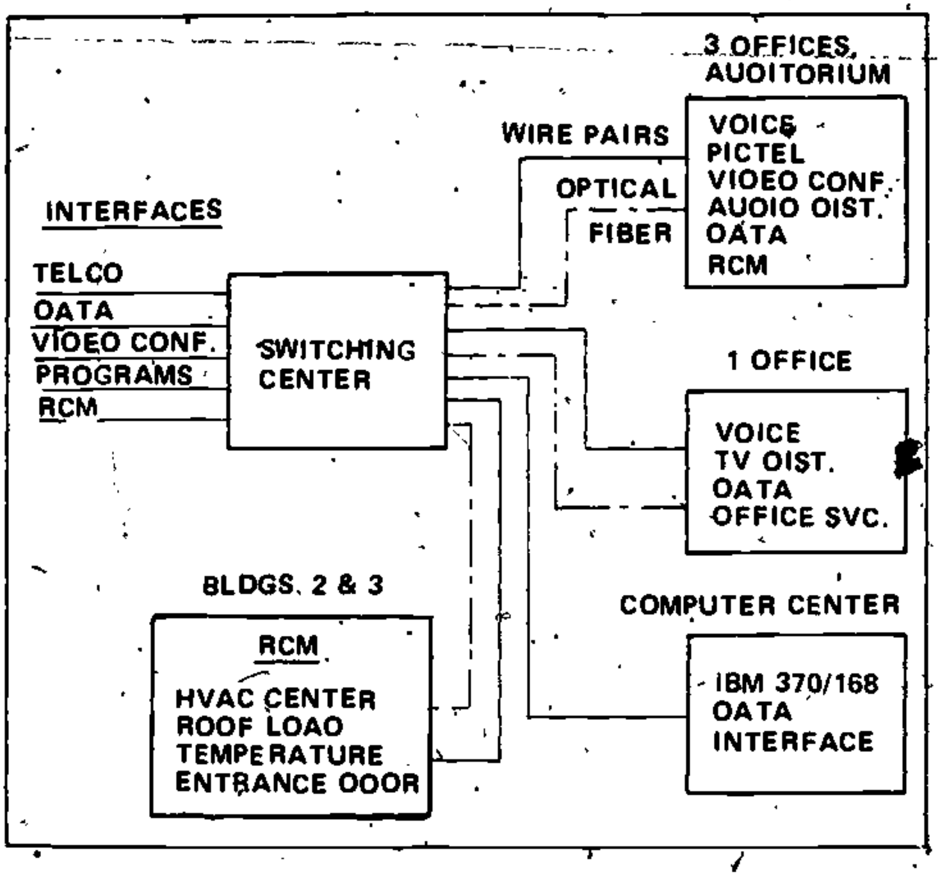

3 OFFICES, AUDITORIUM
VOICE
PICTEL
VIDEO CONF.
AUDIO DIST.
DATA
RCM
WIRE PAIRS
OPTICAL FIBER
INTERFACES
TELCO
DATA
VIDEO CONF.
PROGRAMS
RCM
SWITCHING CENTER
1 OFFICE
VOICE
TV DIST.
DATA
OFFICE SVC.
BLDGS. 2 & 3
RCM
HVAC CENTER
ROOF LOAD
TEMPERATURE
ENTRANCE DOOR
COMPUTER CENTER
IBM 370/168
DATA
INTERFACE

FIGURE 7. MSLS DEMONSTRATION UNIT

A MICROPROCESSOR-BASED MULTILINGUAL TELEX SYSTEM WITH PHONETICALLY CODED KEYBOARDING

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ABSTRACT

The present day telex system in India operates in English only, except that a few major post offices have separate telex systems in Hindi the national language. But a majority of the people are familiar with only their respective regional languages, and know neither Hindi nor English. There are as many as seventeen regional languages approved by the government. To enable the people to communicate in their own languages, a multilingual telex system would be imperative in the near future.

In this paper a microprocessor-based multilingual telex system, named as MMTS, is proposed. For line transmission purposes, two coding schemes (Symbolic and Abstract-phonetic) are suggested and evaluated.

Keywords: Microprocessor, Indian Languages, Telex System, Alphabet Coding, Multilingual Telex System.

1. INTRODUCTION

The present day telex system in India operates in English. A few major post offices have separate telex systems in Hindi, the national language. But there are seventeen regional languages approved by the Government of India. Most of the people know neither English nor Hindi; they can read-write only in their respective regional languages. Hence, these 'literatures' have to depend on persons who know English as far as telex communication is concerned. Similar conditions exist in many countries in the world. To enable people to communicate in their own languages, multilingual telex system need to be developed in the near future. It is in this context that the Indian scene offers an idealenvironment for development activity in this area.

A multilingual system for Indian languages needs to be computer-based due to the fact that the number of alphabets ranges from a few hundreds to few thousands; moreover they vary in size (in height and width). Therefore, in this paper a microprocessor-based multilingual telex system, named MMTS, is proposed and explained in detail. The language dependent features of the system are explained with illustrations, wherever necessary using the regional language Tamil. The criterion for selecting this language is its representative complexity of alphabet structure and form. The structure of Indian language alphabets, in particular Tamil, is briefly summarized in the next section.

2. CHARACTERISTICS OF INDIAN LANGUAGE ALPHABETS

In general the alphabets of all Indian languages could be grouped into

1) vowels,
2) consonants,
3) c-v letters, and
4) conjunct letters.

For example, Tamil has 12 vowels, 18 consonants and one special letter (ஃ AK) which is also treated as a vowel. All these alphabets appear in row 0 and column 13 of fig. 1[1].+ . The c-v letters are composite letters obtained by the combination of the vowel and the consonant in their respective columns and rows. They are listed in fig. 1 (rows 1 to 18 and columns 1 to 12). The special letter ஃ (AK) does not combine with any consonant. The conjunct letters are obtained by the combination of two or more consonants with a vowel. They are present in all Indian languages except Tamil. Therefore, the total number of alphabets in other languages are much more than Tamil (247) and varies from five hundreds to a few thousands [1] - [4]. Moreover the graphic form and size of the alphabets vary from language to language. The variations, for example, is as drastic as the alphabets ர (RA) and ணு (NU) in Tamil and ఒ (O) and స్త్రే (STRĒ)* in Telugu.

For typing purposes, typewriters are available for major Indian languages; they are like English typewriters having about 46 keys. The layout of this standardized Tamil typewriter keyboard is shown in fig. 2 [5]. An alphabet may consist of one or more of the symbols on the keyboard. For

---

+ These alphabets were generated using the linguistic approach.

* It is a conjunct letter with three consonants and one vowel.

example, the Tamil alphabet க (KA) is obtained by one key depression, கெ (KE) by two keys (ெ and க) and கொ (KO) by three keys (ெ, க and ா). This is true for the alphabets in other languages also.

3. CODING SCHEMES

There are two aspects to be considered here:

1) representation of the multilingual text, and

2) coding of the alphabets.

Multilingual Text Representation: It was stated earlier that the graphic forms of the alphabets vary from language to language. Therefore, the set of consecutive alphabets in a string belonging to a particular language must be identified. It could be done as shown below [6].

lang. code	lang. no.	text	lang. code	lang. no.	text	

The 'language code' is a one byte constant (unique identifier). It indicates that the next byte of the information stands for the 'language number'; it is not part of the text to be displayed. A separate key should be provided in the keyboard for the language code. The 'language number' is the number assigned to the language. For example, a typical assignment could be English as 0, Tamil as 1, Hindi as 2, and so on. By this scheme the text of any number of languages could be represented easily.

Alphabet coding: Many coding schemes are possible [7]. Here, we will consider two important schemes:

1) Symbolic coding, and

2) Abstract-phonetic coding.

In the Symbolic coding [7], the code generated for each key depression is transmitted directly on the line. Therefore, in this scheme only the keys are required to be coded. A 7-bit ASCII code could be used for coding; one key depression corresponds to one byte of information.

In the Abstract-phonetic coding [7], the alphabets are coded phonetically in terms of their constituent vowels and consonants. On an average two bytes are required to represent an alphabet by this scheme. Hence, this scheme could be used effectively where the average number of key depressions per alphabet is more than two. In the implementation, we have to perform additional code conversion from the key-code into the Abstract-phonetic code before transmission.

Selection Criteria: The selection of either of the schemes could be based on the average number of bytes of information to be transmitted per alphabet. For a language, let

B_s : the average number of bytes per alphabet in the Symbolic coding.

B_p : the average number of bytes per alphabet in the Abstract phonetic coding ($B_p = 2$).

n : total number of alphabets in the language under consideration.

p_j : probability of appearance of j^{th} alphabet where j varies from 1 to n.

d_j : number of key depressions required for alphabet j.

Then, $$B_s = \sum_{j=1}^{n} d_j * p_j$$

and $$B_p = 2.$$

If $B_s > B_p$, then Abstract-phonetic coding could be adopted for that language. As an exercise, for Tamil the probability distribution was derived using the frequencies of alphabets of modern Tamil prose from a 'random' sample of 14000 alphabets presented in [8] and the value of B_s computed was found to be 1.6046. The value of B_s computed with equiprobability is 2.0224. Similarly B_s could be computed for other languages.

To adopt either of the schemes uniformly for a set of languages, the average number of bytes per alphabet B_s^* is to be found out as follows:

Let l : number of language to be used.

B_{si} : the value of B_s for the i^{th} language where i varies from 1 to l.

p_i : probability of utilization of language i over other languages.

B_s^* : average number of depressions per alphabet over l langauge under Symbolic coding.

B^*_p : average number of depressions per alphabet over 1 language under Abstract-phonetic coding ($B^*_p = 2$).

Then, $B^*_s = \sum_{i=1}^{1} p_i * B_{si}$

and $B^*_p = 2$.

If $B^*_s > B^*_p$, then we can use Abstract-phonetic coding.

4. MMTS SYSTEM ARCHITECTURE

The MMTS system architecture is depicted in fig. 3. MMTS is based on Motorola's M6800 microprocessor family components [9, 10]. It consists of a multilingual terminal and its interface, a floppy disk and its interface, random access memories (RAMs) for program/data storage, read only memories (ROMs) for permanent program/data storage and an interface for communication line.

Since there are too many languages to be handled, it will not be economical to have separate terminal for each language. Hence, we should have one terminal to handle all the languages. The design of a common symbolic keyboard unit for all Indian languages and English seems to be technically feasible [11]. As mentioned earlier, since graphic form and size of the alphabets vary from language to language, it will not be possible to print the alphabets of all languages using 'block-type' (type-faced) printers. Instead, the dot matrix printers are ideally suited for our requirements. The dot matrix for the alphabets could be either stored in tabular form or generated through programs. But, the table look up procedure will not be suitable for our purposes since a large memory will be required due to too many alphabets with varying sizes.

The multilingual terminal consists of a keyboard with changeable key signs to display the appropriate symbols of the selected language, and a matrix printer. Since the complete MMTS is going to be in one cabinet, the multilingual terminal is interfaced to the microprocessor system busses through a peripheral interface adapter (PIA) rather than through a serial asynchronous communications interface (ACIA). PIA provides a parallel interface to control the matrix printer.

The MMTS interfaces with the communication line through an asynchronous communications interface adapter (ACIA) and a modem (either MC6800 (0-600 bps) or MC6862 (2400 bps) modem). The floppy disk system based on Calcomp 140 floppy disk derive controlled by the Rockwell's floppy disk controller is interfaced through a DMA unit to the microprocessor busses [12].

The ROMs are used for storage of the monitor program, the codes of communications protocol, encoding/decoding handling programs and the character generator program for the printer. The RAMS are used for data storage and in some configurations for storage of programs.

In areas where the number of languages to be handled is small (example, rural areas), the 'character generators' could be stored in ROMs: in such cases, the floppy disk subsystem need not be included in MMTS configuration. Otherwise, the 'character generators' could be stored on the floppy disk and brought into RAMs as and when required under the monitor control, thus eliminating the need for 'character generators' ROMs.

The floppy disk can be used to buffer messages for maximum utilization of communication channels, apart from being used for the storage of character generators. Moreover, the floppy disk based MMTS could be used for purposes like accounting, etc., during the 'idle' periods.

5. PHONETIC-BASED KEYBOARD DESIGN

The existing English keyboards, the Tamil keyboard shown fig. 2 and alike are symbol-based keyboards. That is, they are based on the symbolic decomposition of graphemes of the alphabets into primitive symbols. In the case of English, since the number of alphabets are small, it so turns out that each alphabet requires only one key-position in the keyboard. But from fig. 2, it can be seen that it is not so in the case of Indian language alphabets. There are number of drawbacks in symbol-based keyboard design, in particular for keying-in Indian language text. To cite one: the symbolically coded Indian language text on sorting does not result in collating sequence. Hence, symbol-based keyboard design needs re-evaluation.

Since the European languages, are non-phonetic and have very few alphabets of simple graphemes, the need for an alternate keyboard design (based on non-symbolic schemes) did not arise, whereas such is not the case with Indian languages. The analysis of the Indian language alphabets [7] revealed that they have a common phonetic characteristic and that it is possible to design a keyboard based on the same.

It is indicated in the previous section (fig. 1) that the vowels, consonants and special letters are the only basic letters. The number of these letters is about 55 in any Indian language. Composite letters are obtained by the combination of vowels and consonants; the combinations result in unique letters and graphemes. Alphabet decomposition is required mainly due to larger number of composite letters. Therefore, we can decompose these composite letters into their basic constituent vowels and consonants. In this case we need to have keys only for the basic letters (which are less in numbers). For example, Tamil have 12 vowels, 18 consonants and one special letter totalling 31 only. Therefore, to key-in Tamil using the phonetic decomposition method, it is sufficient if we have keys representing these 31 basic letters. To key-in composite letters, say க (KA), type the key for க் (K) and the key for அ (A). A character string like 'முருகன்' will be keyed-in as ம் உ ர் உ க் அ ன்.

Standard ASCII or EBCDIC code could be assigned to the keys as in the existing keyboards. The code generated by the key-depression could be directly stored for processing purposes. This internal code is almost similar to the Abstract-Phonetic code mentioned earlier. This coding scheme also has the advantage of providing the text in the collating sequence for sorting which cannot be obtained by symbolic coding. A processor is needed to interpret the key depressions for character generation on the printer or display associated with the keyboard.

To key-in multilingual text from the same keyboard, we need a multilingual keyboard and not uni-lingual keyboard. By incorporating the 'language code' into the keyboard as stated in [11], and the phonetic-based alphabet coding explained above, we can design a multilingual phonetic-based keyboard suitable for keying-in text of phonetic languages as well as the non-phonetic European languages.

6. LANGUAGE-INVARIANT ALPHABET CODE

The alphabets of Indian languages (may be phonetic languages) could be analysed to arrive at a common set of alphabets. In doing so, the phonetically identical alphabets are grouped together and assigned a unique one byte ASCII or EBCDIC code. This results in a language invariant alphabet code exdept for a very few special alphabets peculiar to each language. But by and large, the commonly used alphabets get assigned a single code. Hence, a text keyed in Tamil could be printed in any other language say Hindi by simply changing the language number. For example, the Tamil word 'மணி' (MANI) when keyed-in will get the phonetic code ம் அ ண் இ (M A N I). The same in Hindi is मणि (MANI) and the phonetic code for this word is म् अ ण् इ (M A N I). Since the alphabets 'M', 'A', 'N', 'I' are present in Tamil (ம் அ ண் இ) as well as in Hindi (म् अ ण् इ) and they are phonetically identical, they get assigned the same code. In other words the phonetic codes for 'மணி' and 'मणि' are the same. The distinguishing code is only the language number. Hence, by changing the language number, the text could be printed in different languages.

In order to arrive at a common alphabet set, it is necessary to analyse the alphabets of different Languages. Thealphabets of 12 Indian languages Tamil, Malayalam, Telugu, Kannada, Marathi, Hindi, Sanskrit, Oriya, Bengali, Assamese, Gujarathi, and Punjabi were analysed and a set of basic alphabets were obtained. Table 1 gives the set of alphabets (only the Roman translation according to Library or Congress Cateloging service is given to avoid lengthy presentation.

Advantages: The advantage of this code as far as telex is concerned, the language of origination could be different from the language of distinction. For example, a telex message originating of Tamil Nadu in Tamil could be received at New Delhi and printed in Hindi. In particular, the address part of the telex could be printed in Hindi for the postman to deliver it, but the body of the telex message could be left unchanged for the receiver. This is possible because the name and address are proper nouns, except a few differences like the word 'STREET' could differ from language to language. But this problem of translation could be tackled by a table look-up precedure since there are only a few languages.

7. CONCLUSION

The technical feasibility of the proposed multilingual telex system is apparent. The lower cost of microprocessor family components makes the system economically viable. The two coding schemes proposed should also be evaluated for other Indian languages for the final selection. It is envisaged that such a multilingual telex system will have a great social impact.

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TABLE 1 SET OF BASIC ALPHABETS OF INDIAN LANGUAGES

VOWELS AND SPECIAL LETTERS

A Ā I Ī U Ū Ṛ Ṝ Ḷ Ḹ

Ĕ E Ê Ē ĂI AI Ŏ O Ô Ō

ĂU AU AM AK AKH SHRI

CONSONANTS

K KH G GH Ṅ C Ĉ CH J Ĵ JH Ñ

Ṭ ṬH Ḍ Ṛ ḌH ṚH Ṇ T Ṯ TH Đ DH

N P PH B BH M Y Ẏ R L W V

Ḷ Ḷ Ṛ NJ Ś Ṣ S H KṢ

F Z R RXH Q

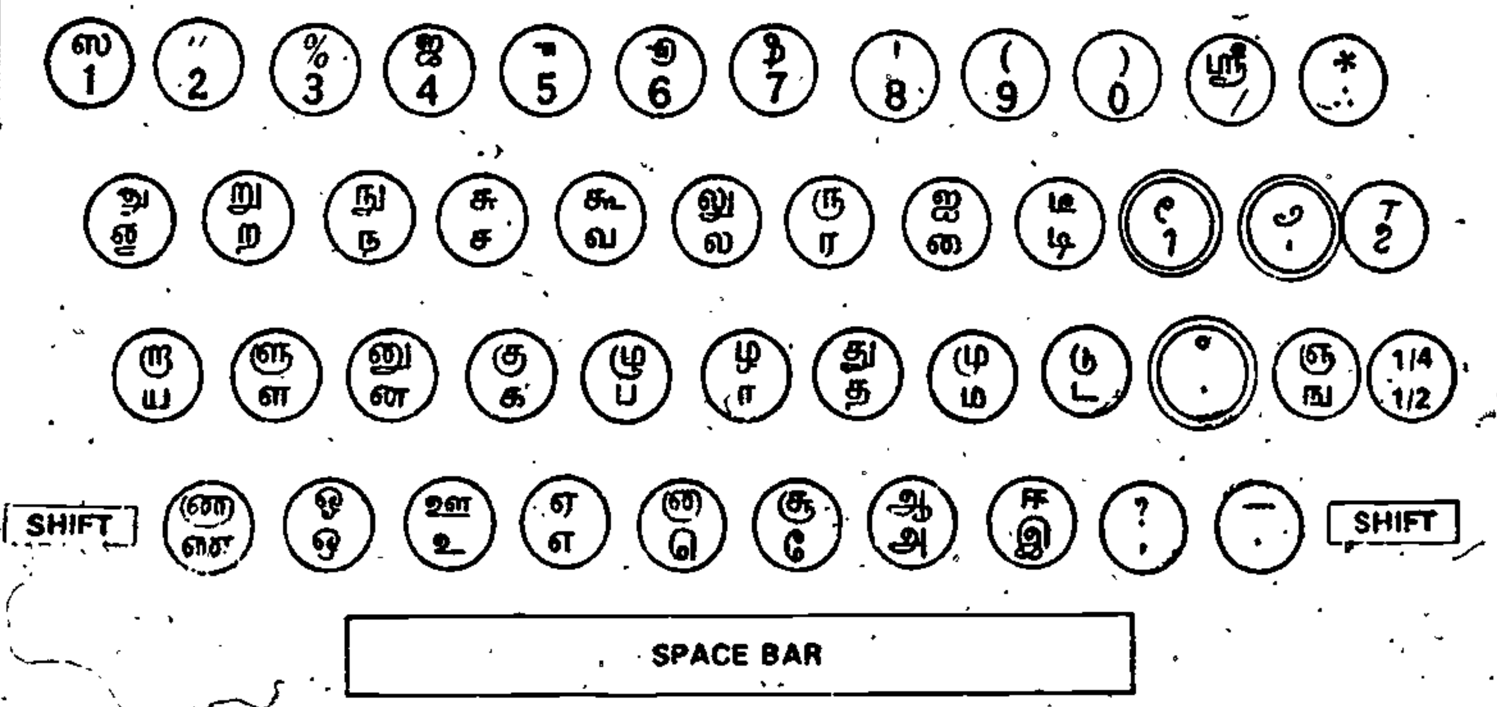
1C-29

	1	2	3	4	5	6	7	8	9	10	11	12		
	A	Ā	I	Ī	U	Ū	E	Ē	AI	O	Ō	AU		AKH
Vowels →	அ	ஆ	இ	ஈ	உ	ஊ	எ	ஏ	ஐ	ஒ	ஓ	ஔ	ஃ	
1	க	கா	கி	கீ	கு	கூ	கெ	கே	கை	கொ	கோ	கௌ	க்	K
2	ங	ஙா	ஙி	ஙீ	ஙு	ஙூ	ஙெ	ஙே	ஙை	ஙொ	ஙோ	ஙௌ	ங்	Ṅ
3	ச	சா	சி	சீ	சு	சூ	செ	சே	சை	சொ	சோ	சௌ	ச்	C
4	ஞ	ஞா	ஞி	ஞீ	ஞு	ஞூ	ஞெ	ஞே	ஞை	ஞொ	ஞோ	ஞௌ	ஞ்	Ñ
5	ட	டா	டி	டீ	டு	டூ	டெ	டே	டை	டொ	டோ	டௌ	ட்	T
6	ண	ணா	ணி	ணீ	ணு	ணூ	ணெ	ணே	ணை	ணொ	ணோ	ணௌ	ண்	Ṇ
7	த	தா	தி	தீ	து	தூ	தெ	தே	தை	தொ	தோ	தௌ	த்	TH
8	ந	நா	நி	நீ	நு	நூ	நெ	நே	நை	நொ	நோ	நௌ	ந்	N
9	ப	பா	பி	பீ	பு	பூ	பெ	பே	பை	பொ	போ	பௌ	ப்	P
10	ம	மா	மி	மீ	மு	மூ	மெ	மே	மை	மொ	மோ	மௌ	ம்	M
11	ய	யா	யி	யீ	யு	யூ	யெ	யே	யை	யொ	யோ	யௌ	ய்	Y
12	ர	ரா	ரி	ரீ	ரு	ரூ	ரெ	ரே	ரை	ரொ	ரோ	ரௌ	ர்	R
13	ல	லா	லி	லீ	லு	லூ	லெ	லே	லை	லொ	லோ	லௌ	ல்	L
14	வ	வா	வி	வீ	வு	வூ	வெ	வே	வை	வொ	வோ	வௌ	வ்	V
15	ழ	ழா	ழி	ழீ	ழு	ழூ	ழெ	ழே	ழை	ழொ	ழோ	ழௌ	ழ்	ZH
16	ள	ளா	ளி	ளீ	ளு	ளூ	ளெ	ளே	ளை	ளொ	ளோ	ளௌ	ள்	Ḷ
17	ற	றா	றி	றீ	று	றூ	றெ	றே	றை	றொ	றோ	றௌ	ற்	Ṟ
18	ன	னா	னி	னீ	னு	னூ	னெ	னே	னை	னொ	னோ	னௌ	ன்	Ṉ

Consonants

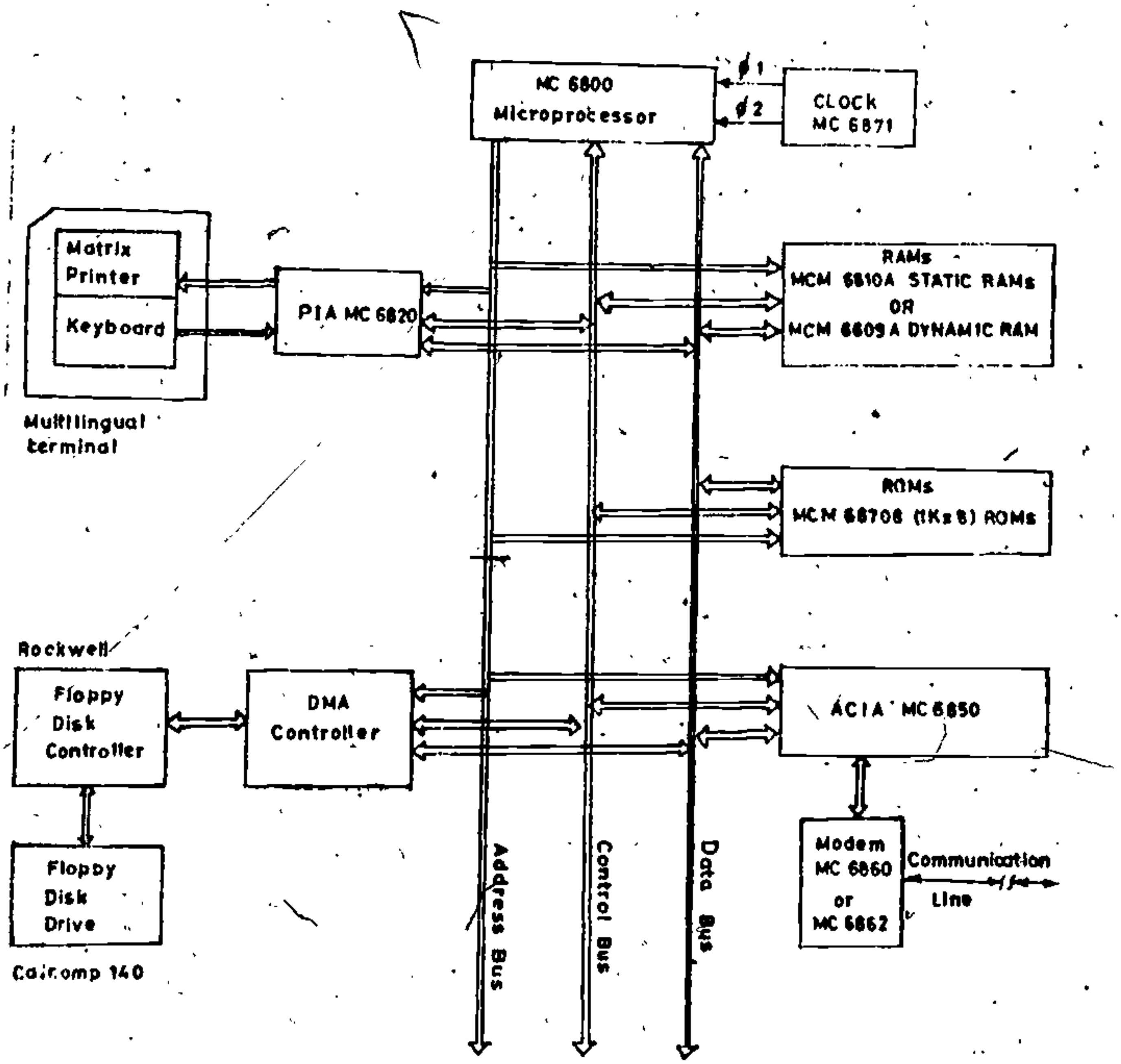
Fig. 1 SET OF TAMIL ALPHABETS

TAMIL KEY BOARD


1
2
%
3
4
5
6
7
8
(
9
)
0
/
*
SHIFT
1/4
1/2
?
SHIFT
SPACE BAR

DEAD KEYS (To be operated before main Character) : 3

FIG. 2 STANDARDIZED TAMIL TYPEWRITER KEYBOARD



MC 6800
Microprocessor
ϕ1
ϕ2
CLOCK
MC 6871
Matrix Printer
Keyboard
Multilingual terminal
PIA MC 6820
RAMs
MCM 6810A STATIC RAMs
OR
MCM 6609 A DYNAMIC RAM
ROMs
MCM 68708 (1K x 8) ROMs
Rockwell
Floppy Disk Controller
DMA Controller
ACIA MC 6850
Floppy Disk Drive
Calcomp 140
Address Bus
Control Bus
Data Bus
Modem
MC 6860
or
MC 6862
Communication Line

FIG. 3 MMTS SYSTEM ARCHITECTURE

PRIVATE VS. PUBLIC INTERNATIONAL NETWORKS: COEXISTENCE OR ANNIHILATION?

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Olympia, Washington 98502

Abstract

In the 1970's the data network field was dominated by private corporations which designed and implemented complex data networks. The emergence of numerous public data networks in the 1980's will have a major influence upon the development and evolution of data transmission. This paper examines some of the issues which exist in the potential confrontation between private and public networks. Issues associated with cost, telecommunications policy, and technology are considered and discussed.

I. Overview

The rapid proliferation of telecommunication networks on an international scale is having revolutionary effects not only upon our concepts of information transfer but upon our culture and way of life. Such networks have produced a society wherein funds may be transferred halfway around the globe in seconds; airline seats from Tokyo to Honolulu can be instantly confirmed from Paris; and, a manufacturer's inventory in Chicago can be immediately assessed from Hong Kong.

During the decade of the 70's, a multitude of private networks were designed and implemented. While these networks utilized transmission paths supplied by the telecommunications agencies of the world (i.e. common carriers), they relied upon hardware and software furnished by private corporate suppliers. Two principal reasons led network implementers to rely so heavily on the private sector:

(1) The common carriers could not provide the types of services demanded by contemporary information transfer needs. (e.g. volume dependent charges for a wide variety of data transfer rates).

(2) The tariffs for the available services were too high when compared to the costs of private networks.

During the latter part of the 70's, most of the major telecommunications administrations and common carriers of the world concluded that the unchecked proliferation of private networks represented a significant erosion of revenues. They reacted by instituting an aggressive program to implement public networks which would provide the services currently being provided by the private networks.

As we enter the 80's, several of these public networks have matured from "paper design" to operating entities. Thus, the stage has been set for a potentially major confrontation between common carriers and private network operators. Some of the principal issues involved are:

(1) Will currently implemented private networks be permitted to continue to operate? to expand?

(2) Will leased, dedicated line tariffs be increased to "discourage" private network operation?

(3) Will the emerging public networks satisfactorily address the multitude of technical challenges of generalized network design and operation?

(4) Will the telecommunication regulatory authorities of the world use the issues of privacy and transborder data flow to curtail or eliminate certain international data transfer?

(5) Will private networks be permitted to interconnect with the new public networks?

This paper examines some of the issues raised as telecommunication networks mature and enter the decade of the 80's - a period which will produce dramatic change as viewed by the user.

II. Some Historical Perspectives

The evolution of modern telecommunications services began with special purpose networks. These networks were designed to perform a single function in a controlled environment. An early example of such a network was the American Airlines reservations system (SABRE) which operated in the early 1960's. A significant step toward generalization began with the advent of the comuter time-sharing networks of the mid 1960's; some initial examples were MIT's project MAC, General Electric's timesharing network, Tymshare's TYMNET, and Computer Sciences Corporation's INFONET. These networks provided the end user with flexibility in terminal type and computer application.

The trend toward increased flexibility and greater sophistication continued in the late 1960's and early 1970's with the introduction of the Advanced Reserach Projects Agency Network (ARPANET). ARPANET (1) extended the generalization of networks to include heterogeneous host computers and (2)

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pioneered a network architecture which used the concepts of information packets (i.e. packet switching).

From these beginnings, the latter part of the 70's produced a plethora of private networks which exploited technology and provided users with a multitude of alternatives to reliable, cost-effective communication.

While this revolution in telecommunications capablity was being manifest, the world's telecommunications carriers appeared to be more pre-occupied with the expansion and improvement of classical services such as switched voice grade circuits, Telex, and leased, dedicated circuits. Innovation in data services was conspicuously absent in the 1960's and early 1970's.

However, in the mid 1970's, plans from the carriers began to emerge for new public services which would address the needs being demanded by users. Plans for networks such as Transpac, EPSS, Nordic, Datapac, and VENUS were discussed, for example, at the biennial International Conferences on Computer Communications in Stockholm (1974), Toronto (1976), and Kyoto (1978).[1,2,3].

Some of these networks have now progressed from design to operation. Perhaps the most notable are the Canadian Datapac and the French Transpac networks; Datapac began operation in 1976 and Transpac in 1979.

In the United States the 1970's saw the emergence of the so-called value added networks (VAN's). These networks used transmission facitilies provided by common carriers , such as AT&T, with technologically advanced hardware and software to provide a generalized class of data services. Examples of these networks are Telenet, which began operation as a recognized carrier in 1975 and Tymnet which began operation as a recognized carrier in 1977.

AT&T has responded to these developments by its announced plans for the Advanced Communications Service (ACS) network. If and when implemented, ACS would provide a very flexible, broad range of data transmission services. However, ACS faces severe regulatory difficulties in addition to the large technical problems posed by such an "all-encompassing" network.

Also worthy of mention are two other major U.S. Networks which have been proposed. First, SBS (Satellite Business Systems) - a high capacity data network being developed jointly by IBM, Comsat and Aetna and second, XTEN, a specialized network being developed by Xerox.

With this background and brief historical perspective, let us focus attention on the issues which will play a major role in the future development of private and public networks. The succeeding three sections will address cost, policy, and technical issues as they pertain to the evolution of data networks.

III. Cost Considerations

The vast majority of private networks which have been and are being implemented have, as their justification for existence, one or both of two factors - unavailiability of the desired service and/or high cost of common carrier services. For the purpose of illustrating the relative cost considerations, let us assume that the desired services are available from the common carriers as well as through development and implementation of a private network.

The issue, then, is one of cost. The user wishes to minimize his cost of data communication services and the carrier wishes to maximize revenues from these services. In the case of the carrier, the desire for a high rate of return on data services is compounded by the fact that these lucrative services are needed to subsidize less cost effective communication services such as providing voice telephones to sparcely populated areas.

A simple example will help illustrate the potentially large magnitude of the difference between user costs of public and private-network services in the U.S. and internationally.

Suppose XYZ company has a computer located in Dallas, Texas and has numerous key-board type terminals in two office buildings - one in New York, and the other in Hong Kong. These terminals need to have on-line access to the computer center. The following parameters are assumed:

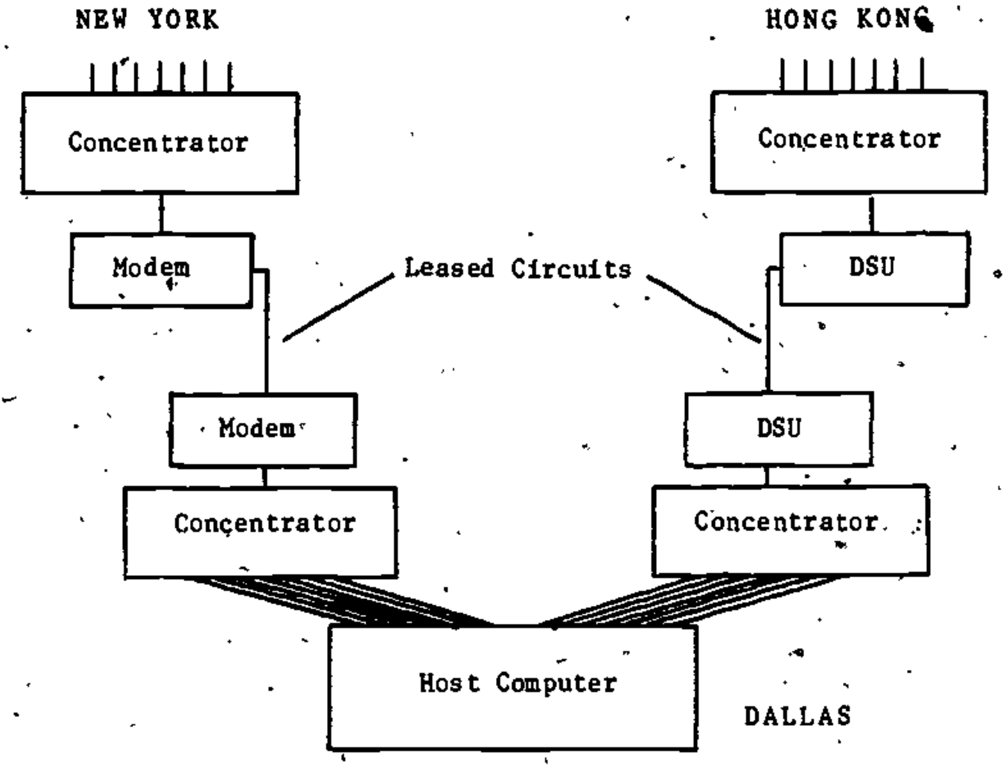
Number of terminals per location:	30
Average connect time:	1 hour/terminal/day
Terminal speed:	30 characters/second

One possible network solution is illustrated in Figure 1. The concentrators are assumed to be purchased at a price of $3,000 each; net monthly cost is $133 assuming 5 year life and 12% cost of money.

Since the terminals are co-located with the concentrator, they are "hard-wired" into the concentrator and hence, do not use the switched network. (If the terminals use the switched network to access the concentrator, the analysis is essentially the some with the addition of low speed modems and local toll charges, if any.)

Total base monthly cost from New York is then computed as follows:

1	DDS circuit (NY/Dallas)	$917 per month
2	DSUs	563 per month
2	Concentrators (Depreciation and Interest)	133 per month
	Total	$1,613 per month


NEW YORK
HONG KONG
Concentrator
Concentrator
Modem
Leased Circuits
DSU
Modem
DSU
Concentrator
Concentrator
Host Computer
DALLAS

Example - Network Configuration

Figure 1

If common carrier services were to be used, each terminal would dial the Dallas center from New York. (This is less expensive than individual leased lines.) Total monthly cost is computed as follows:

30 terminals x 1 hour/ day x 21 days/month x $24/hour = $15,120

In this highly simplified example, the cost to the user for a private network is about one-tenth the cost of available common carrier services from AT&T. (For the purpose of simplicity and illustration such factors as maintenance, spares, personnel, etc. have been omitted. In actual practice, they must obviously be considered.)

A third approach would be to use Telenet; the monthly cost using Telenet for this example would be about $2,800.

The above disparity in costs is equally apparent for international applications. When, in this example, New York is replaced with Hong Kong, the resulting costs to the user are:

Monthly cost for private network	$ 17,424
Monthly cost for direct dial access	129,654

Hence, the costs to the user for the private network is about one-eighth of the commom carrier cost.

To partially address this disparity, the international record carriers of the U.S. (RCA, ITT, WUI), in conjunction with several of the world's PTT addministrations, have instituted a new data service utilizing packet switching techniques. In the above example, the total monthly cost from Hong Kong using these services would be about $15,000 per month.

Costs to the user for this example are summarized in Table 1.

	New York/Dallas	Ratio to Private Network	Hong Kong/ Dallas	Ratio to Private Network
Private Network	$ 1,610	1	$ 17,400	1
Direct Dial	15,100	9:1	130,000	7.5:1
Packet Network	2,800	1.7:1	51,000	3:1

Monthly Costs for New York and Hong Kong Examples

Table 1

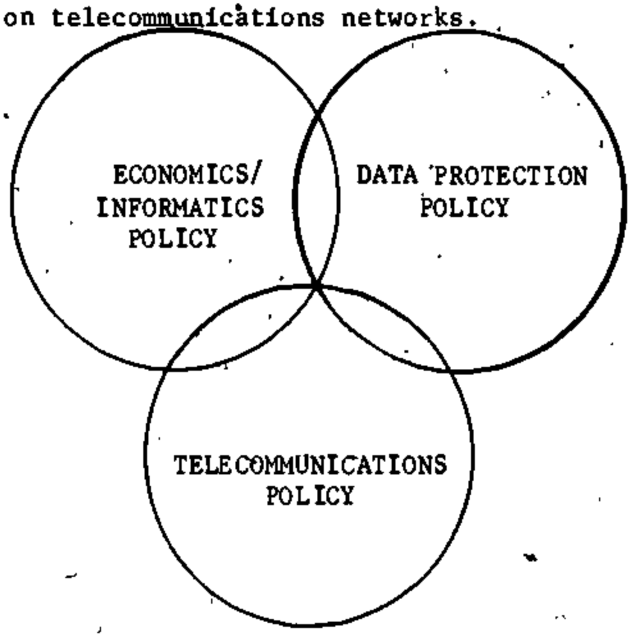
From these simplified examples, the economic motivation for private enterprises and innovation is clear. Recall, also, that for purposes of this discussion it was assumed that the services were identical; historically, this has not been the case.

A second observation from the above is that recently implemented services from the public networks are beginning to "close the gap" between the economics of private networks and those of publicly available facilities.

IV. Some Policy Issues

Policies set forth by governments have an effect on the direction of telecommunications evolution which is probably greater than the more technically oriented aspects of networks. This section of the paper presents a brief summary of some of the policy issues which are influencing the direction of telecommunications development.

As shown in Figure 2, there are three major policy areas which affect telecommunications on an international scale. These areas of economics/informatics, data protection, and telecommunications represent distinct issues which, when taken as a composite, are having profound influence on telecommunications networks.



Policy Issue Areas - Figure 2

Each of these areas is discussed below. A more complete discussion was presented in reference 4.

Economics/Informatics

Under current conditions, the countries of the world may loosely be divided into a dichotomy with respect to each other. Countries such as the United States represent informatics independent countries. As such, these countries tend to import (via telecommunications networks, for example) large amounts of raw data for processing and storage. The informatics dependents, on the contrary, tend to import a rather limited amount of technical information and media products.

The exact converse exists for the informatics dependent countries. They import relatively little raw data (again, via telecommunications networks) for processing but are heavily reliant upon the informatics independents for technical information and media products. This dichotomy leads to what has been termed the "imbalance problem".

From the perspective of the informatics dependents, this imbalance is perceived to have some, or all of the following adverse effects:

- Reduced growth rate of the data processing industry and profession
- Loss of control over data processing facilities
- Technical domination by other countries
- Technical dependency on other countries
- Introduction of inappropriate technology

When taken in composite, the concern by such countries is that of reduced national sovereignty.

It is, therefore, in response to these considerations that many governments are exercising great control over the flow of information and over the telecommunication networks which facilitate this flow.

Data Protection

The second major policy issue affecting the development of telecommunication networks is that of data protection. In the recent past, we have witnessed a greatly increased awareness on the part of both private and governement sectors of data protection (data security). Several European nations passed privacy protection laws in the 1970's; most of them within the last two years. The Council of Europe is nearing completion on the draft of a treaty which would be binding upon its members. The OECD is drafting data protection guidelines which member nations would be expected to follow.

Why all of this sudden activity? What are the ramifications in regard to telecommunication network development?

The central, dominant issue is the basic rights of the individual. While other motives sometimes become ascribed to data protection legislation, these generally fall into either ecomnomic/informatics policies or telecommunication policies as was depicted in Figure 2.

The advent of automated record-keeping systems, capable of providing instantaneous access to billions of characters of information, coupled with world-wide access via telecommunications, has quickly focused attention on the new potentials for the abuse of basic human rights. Some of the concerns of such systems are:

- Proliferation
- Vulnerability
- Misuse
- Accuracy
- Completeness
- Control
- Transmittal

The net result has been manifest in data protection laws having been passed in Austria, Canada, Denmark, France, Germany (F.R.), Luxembourg, Norway, Sweden, and the U.S. The scope of these laws varies, further providing some elements of confusion and uncertainty.

The general effect of the data protection issue on telecommunications will most likely be to retard the development and proliferation of networks - especially those which cross international boundaries.

For some additional information on the privacy and security issues, the interested reader if referred to references 5 and 6.

Telecommunications Policy

The third policy issue area which was depicted in Figure 2 was that of telecommunications policy. In the vast majority of the countries of the world, the provision of telecommunicaitons is the responsibility of a governmental agency - generally called Posts, Telephone, and Telegraph or PTT. The prime function of these administrations (the PTTs) is to provide the full range of communication services which are deemed necessary to support the national interests of their particular country. Secondarily, and closely behind this prime goal, is the requirement to generate income. In general, the postal sevices must be subsidized by the more lucrative telecommunication services.

Therefore, the world's PTTs will take a very dim view of any private network which, by virtue of its existence, could reduce total PTT income. In the early 1970's, the PTTs readily supplied telecommunication facilities to corporations implementing private networks. The revenue generated by these facilities was perceived by the PTT as beneficial. As these networks grew in capability, the concerns of the PTTs increased. In lieu of providing increased revenue, these networks, due to their highly efficient use of the available frequency spectrum of leased line facilities, were considered to be a threat to PTT revenue. This circumstance, coupled with the economic considerations discussed in section III, provides some clear insights into likely telecommunication policies.

The early 80's will see the introduction of numerous public data networks. Their use will be greatly encouraged by the respective telecommunications administrations. This "encouragement" will be manifest in the form of one or more of the following:

(1) Higher leased line tariffs
(2) Denial of appplications for new, private circuits
(3) Revocations of existing facilities.
(4) Nationalistic pressures

V. Technological Considerations

There exists a wide variety of available information describing the technological advances made in telecommunications over the last decade and predicting improvements and innovations over the forthcoming decade. While a comprehensive review of technology is beyond the scope of this paper, a few of the major technological factors which will exert influence on network development are outlined below:

(1) Satellites - While communication satellites may be considered a technology of the 60's, innovative applications have been rather limited. The future will see a much more diverse use of satellites in a broad range of applications. The use of higher transmission frequencies will facilitate smaller antennas which, in turn, makes the often discussed concept of the roof top antenna a closer reality.

(2) Hardware - Paced by large scale integration (LSI), the cost of telecommunications hardware devices is decreasing. While the technology may be approaching the point of diminishing returns, it is clear that the cost of hardware, relative to the remainder of the system, is continuing to decrease.

(3) Software - The early pioneers in network development were forced to develop their own network software at considerable expense. Now, some highly sophisticated network software is available from hardware vendors such a IBM (SNA), Digital (DECNET), and Comten (CNA). The availability of this software provides the network designer with a valuable base from which to begin. The use of such "standard" software can help reduce overall software costs.

(4) Fiber Optics - One of the major problems of telecommunication networks is the provision of the transmission path from major telephone company nodes to the extremities of the network - the so-called "local loop" problem. Recent experimental work has demonstrated that fiber optics could significantly reduce cost, increase bandwidth and provide a higher quality transmission path.

(5) Digital Transmission - The vast majority of the world's installed telephone plant uses analog transmission techniques. For most future installations, digital transmission facilities are being installed. The principal advantages for data networks are a higher grade of service (i.e. lower probability of bit error) and lower cost (i.e. modems are not required and transmission costs are lower).

(6) Communication Standards - Over the last decade, telecommunication devices and networks progressed more rapidly than standardization efforts. As a consequence, one finds a multitude of incompatible networks in operation today. Recently, much progress has been made in reaching agreements on standards on an international scale. Perhaps the most notable is the CCITT recommendation X.25 for host/network interfaces.

All of the above technological developments tend to encourage network development on a scale much broader than ever before. Networks are becoming easier to design and implement and their capabilities are becoming more diverse and more powerful.

VI. Conclusions

Attempting to reduce the multitude of complexities of international telecommunications to a few brief conclusions is difficult, at best; and, perhaps, overly presumptious. However, from the above brief discussion, some likely directions may be stated.

1. The decade of the 80's will be a period of major change, bordering on revolution and upheaval, as the world's telecommunication administrations introduce public data networks.
2. The use and expansion of private telecommunication networks will receive increased scrutiny from telecommunication administrations. In some countries, applications for new services will be denied.
3. While the public networks will play a more dominant role, they will not be able to accommodate, from a technical perspective, all of the types of interfaces currently being demanded. This problem will be a significant factor in greatly prolonging the role of the private network.
4. Demand for services is likely to increase at a rate higher than can be accommodated by new public networks. This, too, will tend to assure the private networks of a major role.
5. Standardization and interconnection of various national public networks remains an unresolved issue. This, too, will tend to prolong the role of the private network.
6. Tariffs for services such as flat-rate, leased circuits are likely to increase substantially in order to encourage the use of public data services.
7. A major question is that of interconnection of public and private networks. The most likely trend will be to permit some limited interconnection for cases in which the PTT's see this as a net positive increase in overall public network use.

Regardless of the precise outcome, the decade of the 80's will provide fascinating challenges for telecommunications planners and designers. It will be an era in which the role of technology becomes progressively more subservient to policy and economics.

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A MODEL OF MOBILE TO TELEVISION INTERFERENCE

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Abstract

One of the major problems created by the allocation of new frequencies to high capacity land mobile systems is that of their interference impact to UHF television receivers. This paper proposes a new interference model and provides an insight into the interference analysis. The results presented indicate that the extent of interference to television sets caused by mobile stations is negligible.

INTRODUCTION

The development of high capacity cellular systems for land mobile communications is currently proceeding in various countries. In both the U.S. and Japan technical and market trials were conducted in 1978 and it is expected that the demand for such a service will allow its rapid expansion to major metropolitan areas in the near future.

In the U.S. the upper portion of the UHF-TV band (806-890MHz) has been reallocated on a nation-wide primary basis to the high capacity land mobile service. In Canada the Department of Communications in a recent policy (1) announcement recommended that the same band be used to provide for the growth of mobile services. It is expected that high capacity cellular systems will be available in Toronto or Montreal by 1982.

One of the problems created by such frequency allocations is that of interference. In effect it has been argued that the density of mobile telephones will be such that they will interfere with consumer electronic equipment and in particular with UHF television sets. Several studies (2), (3) of M.T.*, that is interference to television sets from mobile transceivers have been conducted in the past. Whether mathematical or experimental, these studies attempt to predict a radius of potential interference around a hypothetical TV receiver. A recent study (4) suggests that this interference radius is of the order of 1056 ft and the conclusion has been drawn that it is not wise to assign TV channels 58 through 61 for use in an area also served by a high capacity mobile system.

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*We suggest the introduction of a standard notation for interference, where the first symbol is the interference source and the second symbol the interfered object. Hence the notations M.T. is interpreted as a mobile interfering with a television set.

In this paper a mathematical model based on the work of Chandrasekhar (5) is suggested to compute the probability of interference and the mean interference duration. The model is general enough to warrant its application to various interference problems. These include the interference from mobile transceivers to UHF TV receivers as well as the interference from CB transceivers to consumer electronic equipment.

INTERFERENCE MODEL

Our objective is to determine how various parameters affect the probability that a randomly selected TV receiver will suffer from interference caused by mobile transceivers in an area served by a high capacity cellular system.

The model is based on the assumption that several mobile transceivers are geographically scattered over a given interference area (Fig. 1). The radius of this circular area, denoted by R_i, corresponds to the distance beyond which a mobile transceiver will not cause interference to the TV receiver located in the center of the area. If the geographical density of mobile stations is denoted by D, the average number of mobiles in a circular area, A, of radius R_i will be given by:

$$\bar{n} = \pi R_i^2 D = AD \qquad \ldots\ldots (1)$$

We now assume that the number of mobile stations within this area is Poisson distributed with mean $\bar{n}$. Hence the probability of finding n mobiles in this area will be given by:

$$P(n) = \frac{\bar{n}^n e^{-\bar{n}}}{n!} \qquad \ldots\ldots (2)$$

If α denotes the probability that a mobile leaves the area A within a time τ, given that n mobiles were present in A at the beginning of this time interval, the probability $P_i^{(n)}$ that i mobiles will leave the area in time τ is given by:

$$P_i^{(n)} = \frac{n!}{i!\,(n-i)!}\,\alpha^i (1-\alpha)^{n-i} \qquad \ldots\ldots (3)$$

The probability P_i that i mobiles leave the area A, regardless of the value of n, is then given by:

$$P_i = \sum_{n=i}^{\infty} P(n)\, P_i^{(n)} \qquad \ldots\ldots (4)$$

Replacing in (4) the appropriate expressions of P(n) and $P_i^{(n)}$ we obtain the following Poisson distribution with mean $\bar{n}\alpha$:

$$P_i = \frac{(\bar{n}\alpha)^i e^{-\bar{n}\alpha}}{i!} \qquad \ldots\ldots (5)$$

Assuming stationarity, we conclude that P_i is also the probability for i mobiles entering the area A in time τ.

Having obtained an expression for P_i we now determine the various transition probabilities corresponding to a change of system state. If at time t there are n mobiles in an area A, at time $t+\tau$ the probabilities that for $k > 0$ there are n+k or n-k mobiles present, are given respectively by:

$$P[n:t;n+k:t+\tau] = \sum_{i=0}^{n} P_i^{(n)} P_{i+k} \qquad \ldots\ldots (6)$$

and

$$P[n:t;n-k:t+\tau] = \sum_{i=k}^{n} P_i^{(n)} P_{i-k} \qquad \ldots\ldots (7)$$

For mathematical convenience we now introduce the variables $x = n-i$ and $y = i \pm k$. Then we can rewrite equations (3) and (5) as follows:

$$W^{(n)}(x) = \frac{n!}{x!(n-x)!} (1-\alpha)^x (\alpha)^{n-x} \qquad \ldots\ldots (8)$$

and

$$P_y = \frac{(\bar{n}\alpha)^y e^{-\bar{n}\alpha}}{y!} \qquad \ldots\ldots (9)$$

A. *State Behaviour*

It is clear from (8) and (9) that the expected value of the random variables x and y is given by:

$$\bar{x} = n(1-\alpha) \qquad \ldots\ldots (10)$$

$$\bar{y} = \bar{n}\alpha \qquad \ldots\ldots (11)$$

Defining now the new random variable m as the sum of the independent random variables x and y, its expected value will be given by:

$$\bar{m} = \bar{x}+\bar{y} = n(1-\alpha) + \bar{n} \qquad \ldots\ldots (12)$$

In order to describe the time behaviour of the state of the system we let:

$$\bar{m}-n = (\bar{n}-n)\alpha = dn \qquad \ldots\ldots (13)$$

and

$$\alpha = \alpha_o dt \qquad \ldots\ldots (14)$$

Where α_o is the probability for entering or departing from the interference area per unit of time.

Thus we obtain:

$$\frac{dn}{dt} = (\bar{n}-n)\alpha_o \qquad \ldots\ldots (15)$$

with the solution:

$$n(t) = \bar{n} + (n_o-\bar{n})e^{-\alpha_o t} \qquad \ldots\ldots (16)$$

Equation (16) describes how a state n_o at time $t = 0$ will on the average "decay" to state $\bar{n}$ when t goes to infinity.

B. *Mean Life and Recurrence times*

The interference model introduced in section 2 will now be used to determine the mean life of a state and the average state recurrence time, where the state of the system is simply given by the number of mobile stations within area A at time t.

The state transition probabilities given by equations (6) and (7) can be expressed in terms of Laguerre Polynomials, L_n, and their derivatives. It can be shown that the following expression for the transition probability from state n at time t to state n at time t+τ is obtained:

$$P[n:t;n:t+\tau] = e^{-\bar{n}\alpha}(1-\alpha)^n L_n\left(-\frac{\bar{n}\alpha^2}{1-\alpha}\right) \qquad \ldots\ldots (17)$$

Using equation (14) and making $\tau = \Delta t$ we can replace equation (17) by the following approximation:

$$P[n:t;n:t+\Delta t] \approx 1-\bar{n}\alpha_o\Delta t-n\alpha_o\Delta t \qquad \ldots\ldots (18)$$

The probability that, having started in state n at time t the system remains in state n over the next k-1 occasions, Δt units of time apart and exits from state n at the k^{th} occasion will be given by:

$$\phi_n\left[(k-1)\Delta T\right] = P^{k-1}(n,n)\left[1-P(n,n)\right] \qquad \ldots\ldots (19)$$

where, for notational convenience we have denoted the probability given by equation (18), by P(n,n).

The probability density function $\phi_n(t)$ is obtained by rewriting equation (19) as follows:

$$\phi_n[(k-1)\Delta t] \approx \alpha_o(\bar{n}+n)\, e^{(k-1)\ln P(n,n)}\, \Delta t$$

or

$$\phi_n[(k-1)\Delta t] \approx \alpha_o(\bar{n}+n)\, e^{-(k-1)\alpha_o(\bar{n}+n)\Delta t}$$

Taking the limit $\Delta t \to 0$, $(k-1)\Delta t \to t$ we obtain:

$$\phi_n(t) = (n+\bar{n})\alpha_o\, e^{-(n+\bar{n})\alpha_o t} \qquad \ldots\ldots (20)$$

The expected value of t, that is the mean life T_n of state n is therefore:

$$T_n = \int_0^\infty t\phi_n(t)\, dt \qquad \ldots\ldots (21)$$

or

$$T_n = \frac{1}{(n+\bar{n})\alpha_o} \qquad \ldots\ldots (22)$$

Similarly we can find the mathematical expectation of the time required for the first return to state n. The mean recurrence time to state n, denoted by θ_n is given by:

$$\theta_n = T_n \frac{[1-P(n)]}{P(n)} \qquad \ldots\ldots (23)$$

Replacing P(n) by the appropriate expression given by equation (2) we find:

$$\theta_n = T_n \frac{\left[1 - \frac{\bar{n}^n}{n!} e^{-\bar{n}}\right]}{\frac{\bar{n}^n e^{-\bar{n}}}{n!}} \qquad \ldots\ldots (24)$$

The "availability" of state n, that is the fraction of time spent in state n will be given by*:

$$A_n = \frac{T_n}{\theta_n} = \frac{(\bar{n}^n e^{-\bar{n}}) / n!}{(1-\bar{n}^n e^{-\bar{n}} /n!} \qquad \ldots\ldots (25)$$

Since we are interested in the interference-free state, (n=0) we can conclude that an arbitrary TV receiver will be interference-free for a fraction of time A_0 given by:

$$A_0 = \frac{1}{e^{\bar{n}}-1} \qquad \ldots\ldots (26)$$

C. *Interference Probability*

A probably more meaningful measure of the availability of state n is given by:

$$\frac{T_n}{T_n + \theta_n} = \frac{\bar{n}^n e^{-\bar{n}}}{n!} \qquad \ldots\ldots (27)$$

which is simply the probability P(n) that n stations are present when their average number is $\bar{n}$.

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*It should be realized that A_n as given by equation (25) is not normalized, i.e. $\sum_{n=0} A_n \neq 1$.

Hence the probability of occurrence of an interference-free state (n=0) is:

$$P(o) = e^{-\bar{n}} \qquad \ldots\ldots (28)$$

Therefore it can be concluded that the probability of interference is given by:

$$P(n\geq 1) = 1-e^{-\bar{n}} \qquad \ldots\ldots (29)$$

Up to this point our model assumed that the mobile stations were continuously transmitting. However, it is known that the mobile traffic characteristics are bursty, in the sense that their peak to average load is extremely high. If we denote by ρ the average traffic load per mobile station, the probability of no interference when there are n stations in the interference area is given by:

$$P_{NI}(n) = P(n)\ (1-\rho)^n \qquad \ldots\ldots (30)$$

Summing over all possible values of n we obtain:

$$P_{NI} = \sum_{n=0}^{\infty} P(n)\ (1-\rho)^n$$

$$\therefore \quad P_{NI} = e^{-\bar{n}\rho} \qquad \ldots\ldots (31)$$

Equation (31) above, plotted in Fig. 2, gives then the probability of no interference when there are on the average $\bar{n}$ mobile stations in the interference area and when each station contributes to the traffic load by an amount ρ.

RESULTS

The interference model suggested in the previous sections allowed us to derive expressions for the mean life time, the recurrence time and the probability of interference. We will now discuss by way of an example the typical numerical results given by the model. Several authors indicate that a typical interference area is about 0.1 mi^2 and that an average mobile density of 10 mobiles per mi^2 is characteristic of a mature cellular system. We then conclude that $\bar{n}$, the average number of mobiles within an interference area, is of the order of 1. Lacking any experimental results we suggest that α_o the probability for entering or leaving the interference area, per unit of time is directly proportional to the average mobile speed, $\bar{v}$, and inversely proportional to the radius, R_i, of the interference area. Hence, if we assume that the constant of proportionality is one, we obtain:

$$1/\alpha_o = \frac{R_i}{\bar{v}} \qquad \ldots\ldots (32).$$

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Assuming an average vehicle speed of 10 mi/h and a radius R_i corresponding to an interference area of 0.1 mi^2 we conclude that $1/\alpha_o$ is equal to 64.23 s.

Substituting the values of $\bar{n}=1$ and $1/\alpha_o = 64.23$ s. in equations (22) and (23) we obtain:

$$T_n = \frac{64.23}{n+1} \quad s$$

and

$$\theta_n = \frac{64.23}{n+1} \quad (en!-1) \quad s$$

The probability of no interference computed from equation (31) is:

$$P_{NI} = e^{-\rho}$$

It is interesting to note that for typical values of ρ between 0.01 and 0.02 erlangs/mobile the probability of no interference varies between 99% and 98%.

CONCLUSION

One type of interference has been examined namely the interference caused by mobile stations in high capacity cellular systems to UHF television receivers. A model was presented that is useful in determining various interference related measures such as the mean life time and the mean recurrence time of the system state.

It has been shown that for the expected mobile densities and traffic loads the probability of interference is for all practical purposes negligible. It is therefore suggested that TV channels 58 through 61 could certainly be assigned for use in an area which is also served by a cellular mobile telephone system.

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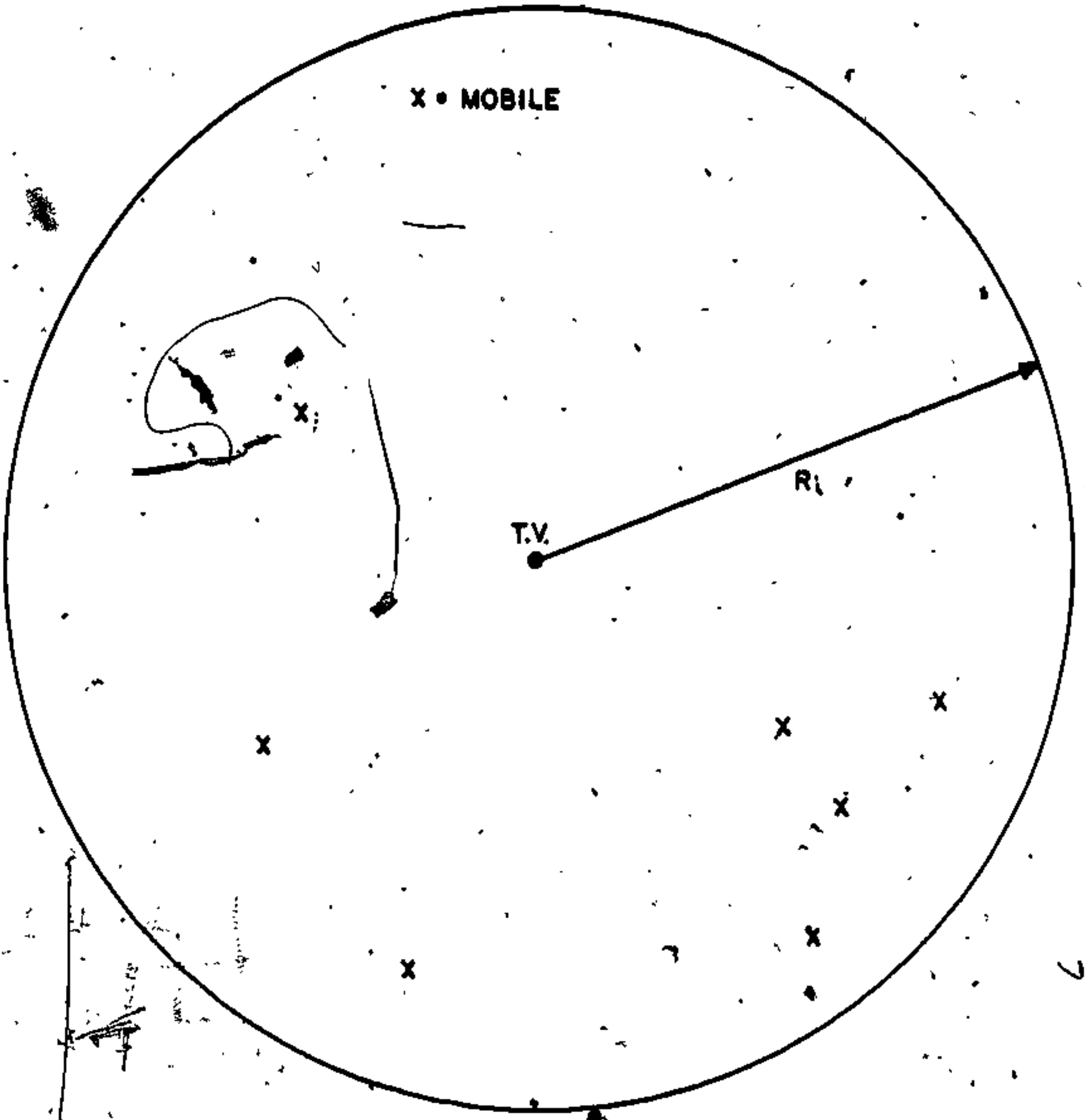
X = MOBILE
X$_i$
T.V.
R$_I$
X
X
X
X
X
X
X

FIGURE 1. MODEL OF THE INTERFERENCE AREA

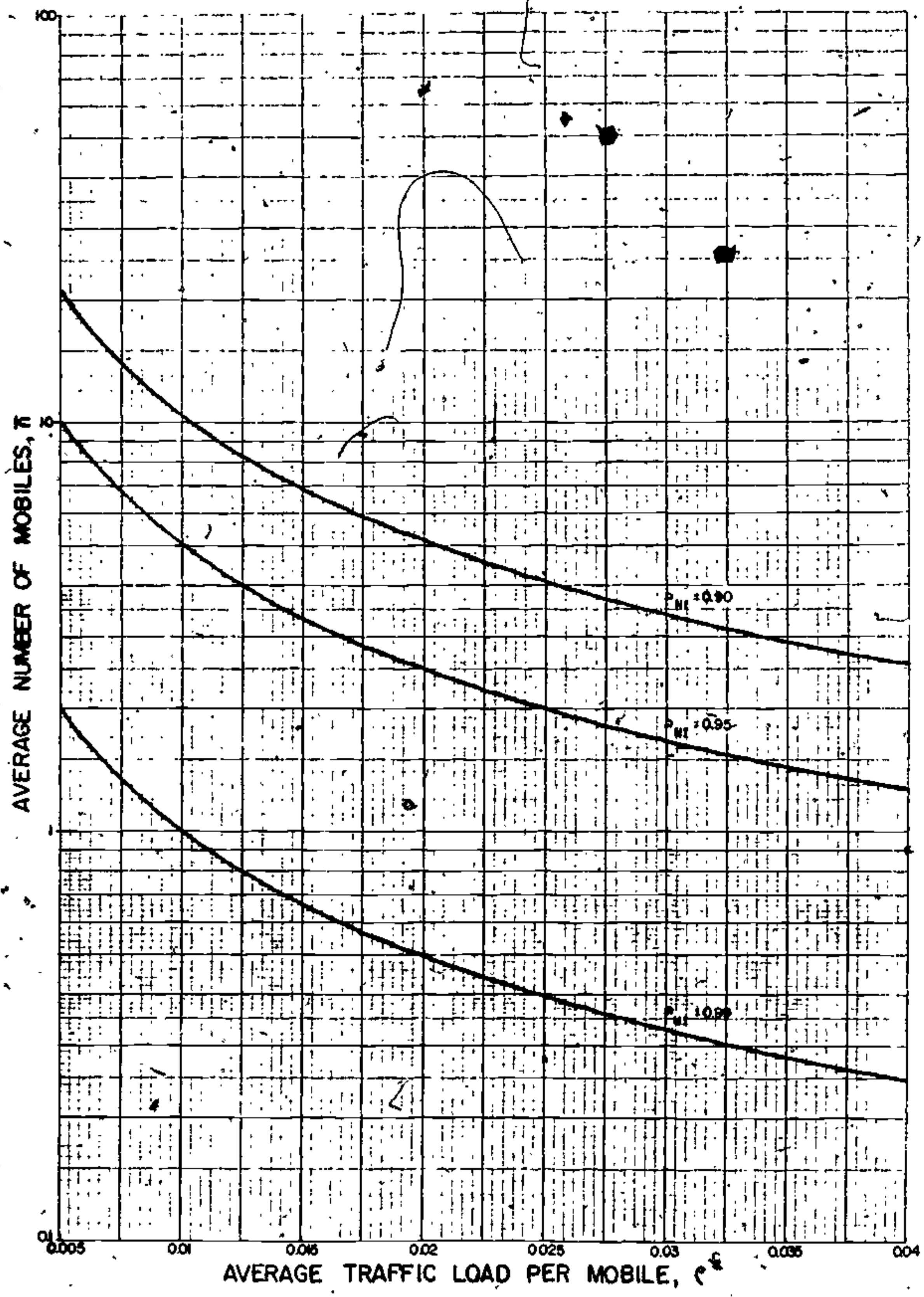

FIGURE 2. PROBABILITY OF NO INTERFERENCE

BIASED INVESTMENT DECISIONS

in

INTERNATIONAL TELECOMMUNICATIONS

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ABSTRACT

A major concern in regulatory and policy analysis of the U.S. international telecommunications industry is that of biased investment decisions by the carriers with respect to facilities. This paper investigates the potential for U.S. carriers to develop inefficient investment decisions with respect to submarine cable and satellite communications facilities. It includes consideration of the Averch-Johnson theorem within the context of the degree of regulation which prevails in the U.S.

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A. Introduction

A major concern in regulatory and policy analysis of the U.S. international telecommunications industry is the existence of biased facilities investment decisions by the communications carriers. This paper investigates the potential for U.S. carriers' inefficient investment decisions related to satellite and submarine cable facilities. It includes consideration of the carriers' economic incentives within the rate base regulation standard of the U.S. and the effects of such regulation on the decision-making process.

Subsequent to a brief summary of rate base regulatory methodology and the Averch-Johnson theorem regarding inefficient investment decisions, an analysis of cable versus satellite decision-making is presented. This is further related to the issue of cross-subsidies as a measure of rate base expansion and other incentives which may impact the decision-making process. Within this framework, it is concluded that available evidence does not support the contentions that biased investment decisions are prevalent.

B. Rate Base Regulation

The standard methodology for rate base regulation involves setting the firm's total revenue requirement equal to the sum of all operating costs and capital costs. In its simplest form, when the appropriate rate base is capital investment, this may be represented symbolically as follows:

$$RR = O + T + (V - d)r$$

where: RR = Revenue requirements;

O = Operating costs (wages, salaries, maintenance, depreciation, advertising, etc.);

T = Federal, state and local taxes;

V = Gross value of plant;

d = Accumulated depreciation;

r = Allowed rate of return.

This revenue requirement determines the overall revenue and rate level for the firm. After the rate level is determined, a particular rate structure must also be determined. Rate structure refers to the relationships between the tariffs for the various classes of service and, where appropriate, to the relationships between the tariffs for particular routes or geographic regions.

It is clear that several variations of the "rate base methodology" are available through variations in definitions of the particular parameters. It should also be clear that the basic "rate base methodology" may be applied at different levels of a firm's operations. For example, revenue requirements may be determined for an entire firm, for a particular class of service, for a particular region, for a particular route, or for some combination of these categories. Thus, the expression "rate base methodology" in itself encompasses a wide variety of approaches.

In the strictest sense, active rate base regulation generally does not take place in the United States overseas telecommunications industry and specifically has taken place only once since the 1958 "Bellwether" decision applicable to public message telegraph service.1/ This one instance is, however, limited to COMSAT services. Thus, any problems "inherent" with rate base regulation cannot exist in this industry except to the extent that the threat of active rate base regulation can alter behavioral patterns in a manner similar to actual rate base regulation. However, industry observers generally perceive five specific "problems" inherent in the rate base methodology of regulation as applied to United States international telecommunications:

(a) Biased (inefficient) investment decisions;

(b) Administrative effort and regulatory lag;

(c) Lack of adequate incentives to introduce cost-reducing technological changes;

(d) Inherent technical and definitional problems;

(e) Lack of adequate incentives for cost reduction.

This paper examines only the first of these problems from several points of view and concludes that the expectation of biased or inefficient investment decisions is generally not warranted.

Lucid and extensive treatments of rate base methodologies of regulation are available from a number of sources, most particularly Bonbright (1961) and Kahn (1970), and the reader is referred to these if interested in a complete examination. The comments here are confined specifically to international telecommunications.

C. Averch-Johnson Theorem

It was pointed out by Averch and Johnson (1962) and Wellisz (1963) that regulated monopoly firms which are allowed to earn a rate of return in excess of their (marginal) cost of capital may have incentives to make inefficient investment decisions. The specific result is a tendency for rate base expansion that produces a capital/labor ratio that is too great for the output selected. An implication is that the regulated monopolist may have an incentive to expand at a loss into what were previously competitive markets.

In the case where losses are incurred in competitive markets, such losses can be recouped in the firm's residual monopoly market where demand is relatively inelastic. The theoretical implications of this effect (known either as the A-J or the A-J-W effect) have been developed over the years by a number of authors[2] and in more recent times, some empirical work has been performed.[3] This empirical work provides, for the most part, limited although not unambiguous confirmation that such an effect exists.

D. Cable Versus Satellite

The commonly cited manifestation of this effect as applied to United States overseas telecommunications service is the carriers' expressed preference for transmission using cable facilities instead of transmission using satellite facilities. The simplest A-J hypothesis concerning relative use of cable and satellite circuits is that the carriers have an incentive to use a total cable circuit/satellite circuit mix that is "too great" for the output they select.

The U.S. International Record Carriers and the American Telephone and Telegraph Company (AT&T) directly own the cable facilities but only lease long-haul satellite circuits from The Communications Satellite Corporation (COMSAT).[4] Ownership of these cable facilities is split among the several carriers in proportion to relative use. Thus, the fear is that without "artificial" FCC imposed restrictions concerning the relative use of submarine cable circuits versus satellite circuits, the carriers would have little or no incentive to use satellite circuits. The use of satellite circuits does not affect the rate base on which they are "allowed" to earn profits; i.e., whereas investment in cable facilities is included in the rate base to calculate return, satellite lease charges are considered an expense.

It does seem clear from reference to carrier and COMSAT filed comments in several FCC proceedings and the related Commission decisions that the desired carrier cable circuit/satellite circuit mix is greater than that which currently exists.[5] Indeed, it is no doubt one of the purposes of Commission decisions requiring 50/50 market splits, "proportional fills", and "reasonable parity" to restrict the relative use of cable circuits (encourage the relative use of satellite circuits).

This stated carrier preference for cable usage, though, cannot be taken unambiguously as evidence supporting the existence of the A-J effect. The relative costs to the carriers of cable versus satellite transmission must also be examined. The appropriate costs for the carriers are those of building a submarine cable (or obtaining IRU's in such a cable) versus those for leasing satellite circuits from COMSAT. If it were true that these cable construction costs were less than satellite lease costs, the stated carrier preference for cable circuits would be independent of the existence of an A-J effect. Indeed, the carriers have claimed in the past that this is just the case. For example, prior to the time that the FCC rejected the SF TAT-6 cable that was favored by the carriers (30 FCC 2d 571), COMSAT offered to the U. S. carriers a bulk service of 800 circuits at $14,000 per circuit per year for a twenty-five (25) year period.[6] The SF cable would have had a capacity of around 800 circuits, and the COMSAT offer was conditioned upon a TAT-6 rejection. COMSAT claimed that the $14,000 per year lease payment would be less than the $16,000 per circuit per year revenue requirements associated with the SF cable. AT&T's response to this offer, however, pointed out that the $14,000 tariff rate offered by COMSAT was substantially in excess of the expected incremental cost of SF (TAT-6) circuits.[7] The $16,000 per circuit figure referenced by COMSAT was an average revenue requirement for all transatlantic cables assuming that the SF cable was constructed and installed.

The issue would be more complex were the satellite lease costs to the carriers less than the stated incremental costs for cable circuits. Assume for analytical purposes, that the two separate types of transmission are perfect substitutes for each other. The ordinary profit-maximizing monopolist has an incentive to utilize the least-cost (to the carrier) type of circuit. The existence of rate-of-return regulation alters this incentive when, as is currently the case, only one form of transmission circuit is included in the rate base. The carrier's decision-making process then involves a tradeoff under which the net benefits of lower cost (satellite) circuits would have to be weighed against the net benefits of rate base expansion.

Unfortunately, the issue is even more complex due to the uncertainty in the regulatory process as currently practiced. The existence of A-J type effects depends upon the existence of active regulatory constraints. They do not exist when regulation is inactive and is expected to remain inactive. A dynamic analysis is necessary which considers the firm's financial position over time and the effects of extended supra-normal profits upon regulatory activity.

In summary, although the A-J effect as applied to United States overseas telecommunications implies that the carriers will select a cable circuit/satellite circuit mix that is greater than optimal, uncertainties concerning future COMSAT prices and the dynamics of the regulatory process preclude drawing conclusions concerning the existence of such an effect from available evidence.

E. Cross-Subsidies

The task is no easier if one attempts to analyze the industry for international cross-subsidizations that are used as a method of rate base expansion. In this regard, FCC Docket 19947 was instituted by the Commission partially due to fears that such cross-subsidization did exist in the provision of leased channel service.[8]

The problems are both empirical and conceptual in nature. At the empirical level it is (or would be) difficult to establish the existence (or non-existence) of such cross-subsidies. In the first case, the carriers do not separately report profits by service category or by geographic area. Geographic breakdowns in addition to service category breakdowns would be necessary in order to test for the existence of cross-subsidization between services in that the degree of competition among the carriers differs by geographic area. In the second case the results from any disaggregated profit calculations that were performed, either by the Commission or by the carriers, would not be independent of a number of essentially arbitrary assumptions concerning costing principles and cost allocations. The results would therefore be of questionable value.

At the conceptual level, the fact that inter-service cross-subsidization requires a residual monopoly market in which demand is relatively inelastic must also be addressed. Such an issue appears moot with respect to the current overseas offerings of AT&T. AT&T's overseas offerings are essentially all monopoly services and therefore there is no competitive market to cross-subsidize. This would not be the case were AT&T to expand into the leased channel, alternate voice data (AVD) market (now restricted to the IRCs only) and might not be the case were AT&T to offer overseas switched voice grade data service. With the IRC's, the fear is that the leased channel offerings are being subsidized by residual message telegraph and telex services. The relative size of these latter two offerings, 70% of total IRC operating revenues in 1978, makes such an argument plausible.9/

The potential problem is with the structural conditions that are assumed for these residual markets. If it is assumed that the carriers operate essentially unconstrained by financial regulation, then it follows that they have no incentive to cross-subsidize separate services. They will behave as unconstrained profit maximizers. If it is assumed that some competition exists in the provision of service in these "residual" markets, then the ability to cross-subisidize is unlikely to be present. In practice, the conditions for such cross-subsidizations are most likely partially met. The carriers are probably constrained financially by at least the threat of active profit regulation, and they probably operate in the residual markets under what is best described as a cartel.

F. Quality of Service

As a final comment concerning input biases caused by rate base regulation, one should note what may be

> A tendency for public utility companies to adhere to excessively high standards of reliability and uninterruptibility of service, with correspondingly high and costly specifications for the equipment they employ.10/

Unfortunately, it would be difficult to substantiate empirically such a charge due to an inability to state with precision what the standards of "reliability" and "uninterruptibility" would be in the absence of rate base regulation. Nevertheless, it should be noted that a determination of the level of service quality to be achieved involves an economic analysis of the tradeoffs involved between service quality and costs. Higher quality levels are more costly and the "optimal" level of quality is not necessarily the maximum that can be obtained.

These seemingly "obvious" considerations are pointed out only because a reading of filed carrier comments at the FCC, a reading of certain FCC decisions, and discussions with government officials indicate that perhaps such considerations are not so "obvious". It appears that "diversity", "redundancy", and "balance" in transmission facilities, interpreted by some in terms of a ratio between cable and satellite circuits, are all called for by certain individuals and groups, independent of the appropriate cost considerations. The suspicion is that the selection of an excessive level of service quality may be dictated by A-J considerations.

G. Conclusion

One of the inherent problems of rate base regulation, biased or inefficient investment decisions, has been examined and found to be generally unlikely. Available evidence does not appear to support the contentions that such biased decisions are prevalent in the U. S. international telecommunications industry due to the lack of active rate base regulation and the concomitant economic incentives. However, certain factors considered independently of cost may provide the basis for some degree of inefficiency.

FOOTNOTES

1/FCC Docket 20778, the "International Audit" of all U. S. overseas carriers, is presently in process.

2/See Baumol and Klevorick (1970); Takayama (1969); Bailey and Coleman (1971); Bailey and Malone (1970); and Pressman and Carol (1971).

3/See Span (1974); and Coureville (1974).

4/The International Record Carriers, ITT World Communications, RCA Global Communications, Western Union International and TRT Communications, maintain ownership in terms of Indefeasible Rights of Use. COMSAT is the U.S. entity designated to participate in the INTELSAT satellite communications system.

5/See, for example: ITT Cables and Radio, Inc. - Puerto Rico, et al., 11 FCC 2d 781 (1968); AT&T, et al., 18 FCC 2d 392 (1969); Communications Satellite Corporation, et al., 29 FCC 2d 252 (1971), and 32 FCC 2d 103 (1971); ITT Communications, Inc. - Virgin Islands, et al., 31 FCC 2d 235 (1971); American Telephone and Telegraph Company, 32 FCC 2d 637 (1971); and American Telephone and Telegraph Company, et al., 13 FCC 2d (1968).

6/See COMSAT Memo Re: Bulk Rate 1973 in FCC Docket 18875.

7/See AT&T Letter Re: COMSAT Memos in FCC Docket 18875.

8/The "Leased Channel" Inquiry was initiated in 1974; see 45 FCC 2d 756.

9/Total operating revenue in 1978 for ITT, WUI, RCA and TRT amounted to $452.9M. Message telegraph service and telex service accounted for $52.5M and $266.3M respectively.

10/Kahn (1970), II, 53.

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SPECTRUM MANAGEMENT: YESTERDAY, TODAY, TOMORROW

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1. INTRODUCTION TO SPECTRUM MANAGEMENT -- All nations of the world are dependent upon the use of the radio spectrum to carry out national policies directed toward the achievement of national goals. Use of the spectrum is vital to the security and welfare of a nation and to the conduct of foreign affairs. Such use exerts in countless ways, a powerful influence upon our everyday activities, annually contributing significantly to the national growth, security and economy.

The radio spectrum is a limited natural resource which is accessible to all nations. It is imperative that the nations of the world develop and administer the use of this resource wisely thereby contributing to the maintenance of a free society and stimulation of the healthy social and economic growth of the worlds nations. This will in turn ensure continued spectrum availability to serve future requirements in the best interest of the nations of the world.

2. THE NATURE OF THE RADIO SPECTRUM

WHAT IS IT? The radio frequency spectrum in non-technical terms, is a valuable, highly contested natural resource, the medium upon which all communications-electronics (wireless) equipments are dependent for the transmission and receipt of their energy.

Like certain other resources -- air and water -- it is susceptible to oversubscription, as well as pollution, and is dependent upon enlightened use and management for effective use.

Its finite nature is stressed. The growth, through the application of technology, of the useable portion of the spectrum for transmission of information has been far exceeded by the increase in the uses of and demands placed upon it. If a simple analogy will be tolerated, this stream upon which the world users float their daily messages is growing by a trickle, while volume of messages increases at a gusher rate. Thus, management and regulation of this increasingly overused resource is mandatory if all of our messages are to get through.

HOW VITAL? How important and necessary are these many "messages"? In this increasingly technical global village, to borrow a phrase, we have become dependent upon the spectrum for world-wide communications -- the transmission of voice, data and the printed word. It is absolutely essential to the safety of air and sea travel, the operations and command and control of the defense structure, and space exploration programs, including manned and unmanned space travel, satellites, and even astronomy. Public safety, educational and entertainment broadcasting, business and industry, and the private citizen are users of this resource. Americans depend upon the frequency spectrum for everything from the Washington-Moscow "HOT LINE" to delivery of clean diapers and hot pizzas to their homes. Both the man in the White House and the man opening his automatic garage door are using the same spectrum. Were this resource to be rendered unusable tomorrow, the impact, to quality of life and upon organized society as we know it, would be felt by everyone, with effects varying from cataclysmic chaos to minor irritation.

HOW MANAGED? Because of the nature of the spectrum and the intense competition for its use, it is regulated both nationally and internationally. Our analogous "stream" knows no geographic or political boundaries. How then is this resource management effected?

--International regulation stems from the activities of the International Telecommunication Union (ITU) -- CCIR, World Administrative Radio Conferences, etc.; there being 149 member nations in the ITU.

WHAT'S REQUIRED? Inevitably, money is needed. To ensure that the responsibilities described here are suitably discharged. Technical expertise, in terms of sufficient and qualified personnel, is vital to the successful conduct of the spectrum management function. More qualified people must be encouraged to enter the field. Dedicated computer facilities to serve the analysis, planning, and frequency assignment function are required. A stronger effort by agencies involved in side effects research effort is needed.

THE NEED It is vital to every Government and public interest that the spectrum not be taken for granted as we all once did with air and water resources. Currently the industrial nations are moving rapidly ahead in communications-electronic technology and applications, which has resulted in increased national awareness of sovereign spectrum-associated rights. The challenge in spectrum management is enormous; its need unquestioned. We have been able to meet the challenge thus far, but the next decade will be critical. The assets, people, and the necessary tools needed must be forthcoming. It is hoped that an awareness of the situation will be the first step toward assuring that such assets are provided.

3. THE SPECTRUM IS BEING CHALLENGED TO DO MORE

By its nature the radio spectrum, albeit unseen, is a finite resource but is still ready to take on a greater load within its physical capabilities -- and herein lies the problem.

--enhanced defense readiness

As weaponry becomes more sophisticated and devastating, the need grows for more powerful warning and detection devices, for more sophisticated and effective countersystems, and for more sophisticated and reliable communication systems.

--more effective law enforcement

A most important tool for more effective law enforcement is the expanded use of new telecommunication technology in integrating all elements of police power and effecting a revolution in reaction time on the part of every individual police officer.

--broader coverage of educational tools and cultural experience

New techniques in the use of all telecommunication, not just the use of the radio spectrum, can deliver improved educational tools to schools and homes. They also can provide the means to offer a wide variety of choices to educational authorities.

--increased productivity of men and machines

The use of communication techniques, e.g., remote control of equipments, coordination of the flow of materials, and telemetering, can increase productivity while improving safety and easing burdens on manpower.

--improved mobile communications of all types

Person-to-person; on land, at sea, in the air, or in space.

--greater safety in travel on land

Each year people spend more time and travel farther on the highways. This mobility adds to the strength of a Nation, but also results in congested streets and highways and a constantly increasing accident rate. Communication techniques offer promise not only to control the flow of traffic but also to reduce its volume by making it possible for the public to accomplish more thorough communications from their homes and offices without the need to travel.

--greater safety in air travel

As more of our citizens fly the airways each year in larger aircraft, the radiocommunication requirements multiply. Maintenance of air safety has become increasingly a more difficult problem. Air collision avoidance and many other new safety systems will require more use of the spectrum as they are developed and placed into operational use.

--deeper probing of the mysteries of space

Communication techniques that contributed to the spectacularly successful moon exploration will be challenged to do more as the SKYLAB project and other outer space projects develop. Such projects require spectrum to be available on a worldwide basis.

--development of the ocean resources

Exploration of the oceans in search of new sources of food and other riches known to exist therein has been stimulated through new interests in oceanography. Such exploration and resource development must have the aid of communications-electronics and the spectrum.

4. THE SPECTRUM HAS CONSTRAINTS

There are some special constraints that make the task of meeting these demands uniquely challenging.

--the radio spectrum (the summation of frequencies used for communications-electronics purposes) is not limitless.

From a scientists's point of view, the electromagnetic spectrum extends over a wide range of frequencies -- from a few tenths of a cycle per second up through those associated with the mysterious cosmic rays far beyond the range of visible light and beyond one million million million (10^{18}) kilohertz. An appreciation of the great size of the electromagnetic spectrum may be had by comparing the associated wavelengths with familiar objects. On the low frequency end it extends from wavelengths equal to the diameter of the largest star -- about four times the distance from the Earth to the Sun -- to wavelengths shorter than the diameter of an electron. Such a range of size is almost beyond comprehension.

To the engineer, the radio spectrum is that part of the electromagnetic spectrum below three thousand million 3 x 10^9)KHZ. Of this range we have allocated and are using about one and one-third percent, with some experimentation as high as 10 percent, plus lasers in the vicinity of visible light. The upper 90 percent of the radio spectrum is severely hampered in its practical use by absorption of radio energy by water vapor in the atmosphere.

Some dream that lasers may open up much higher frequencies, into the visible spectrum, to provide vast communication capabilities. For practical purposes, however, present knowledge indicates that laser systems may be economical over a few high density traffic routes only. Even then, serious atmospheric limitations will confine their use to very short distances, or to specifically built pipes, or to space.

--the spectrum is not elastic

The frequencies used to represent channels of communication are not just numbers which may be divided into smaller numbers without limit. We must remember that, just as two motor vehicles cannot occupy the same space at the same time without disastrous interference -- commonly called an accident -- two radio signals of the same frequency and amplitude cannot occupy the same geographical space at the same time. Each radio operation requires a finite part of the spectrum -- a channel or traffic lane -- in time or space; otherwise there is interference.

--the spectrum is not flexible

Certain tasks can be performed only by using certain frequencies. All parts of the spectrum cannot be substituted for all other parts for every use because of propagation, atmospheric and bandwidth characteristics.

5. THE ECONOMIC IMPACT OF THE RADIO SPECTRUM

Use of the radio spectrum benefits the Nation's economic life as well as its social life, directly and indirectly, tangibly and intangibly. It benefits the national economy through increased productivity of man and machine which is reflected in higher wages, lower prices, more business, greater opportunity for capital investment with increased job opportunities, and larger contributions to the Gross National Product. It supports many activities which otherwise might be too costly to carry on. A measure of this contribution is available in:

--Increased Productivity:

It has been estimated that three vehicles equipped with two-way radios can do the work of four without radios; and that with a radio system of 100 units, a savings of over $200,000 can be realized over the life of the vehicles.

Also, police officials have estimated that without radio it might be necessary to double the number of patrol cars -- elimination of a single one-man patrol car will save about $50,000 a year.

An additional measure of the spectrum's contribution to the economy can be found through economic analysis -- by measuring the Nation's investment in communication-electronic equipments and annual sales or revenues for equipment, operations and services directly dependent upon the availability of the spectrum.

--Capital Investment in Use of the Spectrum:

The United States is a large user of communications-electronics in all aspects of its national life, both Government and non-Government. Statistics demonstrating this are illustrated in the following slides. The significant point is that these huge inventories of communication-electronic devices are dependent upon access to the spectrum for their operation.

--The Incentive to Research and Development:

The great growth in the use of the spectrum and the benefits afforded have led to demands for more and more uses to meet the changing needs of our society. These demands have generated pressures to increase spectrum productivity and to bring into cultivation the higher parts of the spectrum. Relief for these pressures lies in research and development directed toward:

--increasing the efficiency of use of the spectrum to give greater productivity per megahertz of spectrum and less interference to other uses from harmonic or other spurious radiations by improving communication-electronic equipments up to at least the state-of-the-art;

--increasing our knowledge of the propagation characteristics of the spectrum, particularly above 10GHz and on conditions obtaining for very short periods of time;

--developing and applying new modes of radiocommunication such as communication satellites and lasers;

--developing and employing economical modes of communication which do not require use of the spectrum, such as wide-band cables and waveguides, capable of transmitting thousands of voice channels with a quality and cost of service adequate to encourage their use instead of microwave and satellite services, thereby saving the spectrum for those needs which cannot be met by wire or cable; and

--equipping our frequency managers with the tools needed to get the greatest return from the use of the spectrum in the national interest.

6. THE FREQUENCY MANAGEMENT PROBLEM

Finally, there is the major task of frequency management itself -- the task of so managing the use of the radio spectrum as to ensure achievement of national objectives; the task of managing the use of a resource of great importance, size and complexity, with the demand exceeding the supply in some important instances.

There are six essential or key elements for efficient management:

1. Adequate facts and data base;
2. Value analyses of radio services;
3. Continuing information as to telecommunication research in progress;
4. Engineering capability to keep interference to a minimum and get the greatest return from the use of the spectrum;
5. Development of standards and policies; and
6. Adequate measurements of use.

The extent to which these key elements are deficient is a problem.

Adequate Facts and Data Base.-- Adequate facts and the capability to store, retrieve, manipulate and analyze those facts quickly to produce management statistics in time to be of value to decision-making are essential to efficient and effective frequency management.

Urgently needed are:

More information on the nature, essentiality and magnitude of requirements. For example,

--why is telecommunication needed, is it needed to carry out a mission assigned by the President, the Congress or others;

--is the requirement valid, has a decision been taken at a sufficiently high policy level that other means of communication are not satisfactory and radio-communication must be used, taking into account the value of the spectrum for other purposes which may be excluded;

--is the amount of spectrum requested the minimum needed for the task, considering modern equipment design, modern methods, systems analyses, minimum power and bandwidth, directive antennas, etc.;

--what is the relative priority of the need;

--is there redundancy or duplication included within the requirement or with other authorizations;

--what is the interface with the spectrum, will there be an impact from spurious emissions?

Today, each potential user decides, in the light of missions, policies, rules, regulations, frequency allocations, availability of frequencies, desires and funds, whether, what, and how much radiocommunication is needed to perform a task. Too rarely are adequate cost-effectiveness analyses and adequate justification given, either in specific applications or in allocation proceedings.

The problem is easy to state; it is very difficult to solve. But it must be solved if we are to have effective frequency management and get the most benefit from use of the spectrum. The collection and analyses of information basic to an estimate of need is time-consuming and expensive; considerable skill may be required. Experience has taught us that it is very difficult to look into the future, beyond about 5 years, with sufficient accuracy to be of much value. Given answers to the questions posed, the task of analyzing the facts and taking decisions on nearly one million applications a year is enormous.

Additional technical parameters such as characteristics of antennas, antenna orientation, terrain features, equipment characteristics, and actual hours of use for existing and planned operations.

The problem here is one of money and manpower. The United States has outstanding authorizations for between seven and ten million transmitters. It would be an enormous task to collect, assemble, introduce into the data base, and keep up to date the quantity of technical data needed. To carry out the task will impose a heavy burden on both industry and Government. Nevertheless, it has to be done if we are to get maximum benefit from the use of the spectrum. A start has been made in this direction.

More propagation measurements, including the effect of off-path scatter and weather, in the frequency band 4 to 40 GHz, to yield the facts necessary to the establishment of criteria for the sharing of frequencies by space and terrestrial systems, including domestic satellite communication both above and below 10 GHz.

Engineering capability to keep interference to a minimum and get the greatest return from the use of the spectrum -- In the early days of radio the supply of the spectrum channels was sufficient, or increasing demands could be met by splitting channels or moving up into unused spectrum. Today, however, increased demands and continued use of yesteryear's methods threaten saturation in certain parts of the spectrum in the larger urban areas. There is, now, no easy solution; channels have been split about as far as economically feasible; and, with today's technology, higher parts of the spectrum cannot be used successfully for needs such as land mobile radio. Nevertheless, there are solutions; intraservice allocation of frequencies to categories of services (block allocations) can be reduced in favor of greater flexibility of use based on local/regional coordination and engineering; or, better yet, the earlier mentioned common user approach, with equal opportunity of access for all qualified users, can be used.

Pending acceptance of the common user concept and more sophisticated equipment, there is need to explore further the advantage of local/regional coordination and engineering of channels, supported by a central ADP facility in place of the outmoded intraservice allocation method. This step could make immediately available to approved two-way users in the larger urban areas, enough channels to take care of essential needs for several years. Such an ADP center should be equipped with adequate data and engineering models and be able to handle quickly and accurately the many requests and recommendations by the Area Frequency Coordinators.

The problem is to: a) win acceptance for the concept and put into operation; b) establish the local/regional frequency coordinators with adequate data and communication access to the central ADP; and c) get the funds to make it possible.

7. DEVELOPMENT OF STANDARDS AND POLICIES

There is need for more rigorous control of spurious effects of both transmitters and receivers which serve only to pollute the spectrum. For example, certain radars have strong harmonics which fall within the microwave-satellite frequency bands and devices such as radio door control receivers have interfered with aviation.

There is need for standards to govern the response of receivers to unwanted adjacent channel signals from properly operating systems. For example, insufficient selectivity in TV receivers prevents the use of other frequencies adjacent to the TV channels in areas where such TV channels are used.

8. ADEQUATE MEASUREMENT USE

No business can long survive without some measure of its output, quality control of its product and ability to perform cost-effectiveness analysis. Nevertheless, spectrum managers are often placed in the position of fulfilling their responsibilities under such handicaps. Such handicaps can be removed by providing a spectrum measuring/monitoring capability. Such a capability is ideally based on a system that is computer controlled and capable of measuring frequencies between 50kHz and 18GHz. The U.S. Government has developed such a system that, upon command from the computer, will tune to a desired frequency, make the pertinent measurement, analyze the data, display it, and record it on magnetic tape.

9. FUTURE USE TRENDS

Projections of future uses of the spectrum can be little more than reflections of the past, on the assumption that conditions will continue to change as seen in the following slides:

AN OVERVIEW OF TRANSBORDER DATA FLOW ISSUES

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Abstract

Included in the scope of the term "transborder data flows" is the transmission over computer-communications systems of automated data to be processed and stored in foreign data processing systems. A number of issues, including privacy protection and data security, that arise in various transborder data flow (TDF) situations are discussed in this paper, including the potential effects on TDF of national privacy protection laws and pending international agreements. Sets of associated technical requirements are examined.

INTRODUCTION

In the last decade there has been a dramatic increase in the growth of internationally operated computer-communications systems. In essentially a continuous operation, at electronic speeds, data are transmitted from terminals to computer systems in a network, requested processing is performed, and results are returned. In other cases, data are maintained on-line in remotely accessible files in the network. Such networks are operated by vendors of remote computing services and/or information services, industry associations, and private corporations (especially by the so-called multinational corporations). Examples are Telenet and Tymnet in the United States, Datapac in Canada, Transpac in France, RTED in Spain, and the NTT packet network in Japan.

International remote computing services are provided by General Electric Information Service's Mark III system, Tymshare, and Lockheed's DIALOG information services, to name a few. Community-operated systems include SITA and AIRINC (airlines reservations networks in Europe and in the U.S., respectively), SWIFT (international interbank funds transfer system), European Informatics Network (EIN), EURONET, and ARPANET. Private networks are operated by IBM, Hewlett-Packard, and numerous other large business firms, manufacturing companies, and banks in the United States and in other highly industrialized countries. The data communicated in these systems is largely related to business activities of the parties involved or of the subscribers, but also includes personal information on individuals.

The increasing worldwide use of computer-communications and remote computing services has created an increasing demand for them, and an associated international "trade". Competition has arisen between domestic vendors in a country and international vendors. Other issues traditionally associated with trade have also surfaced — tariff structures, charges, government regulation, preferential treatment of domestic vendors over foreign vendors, taxes and duties on data processed abroad, and regulation of private networks. Additional regulation is being proposed on the basis of data content, such as personal data on individuals, and other types of data that may be considered sensitive.

To date, transborder data flows in international computer-communication systems have proceeded relatively freely among the industrial countries of the world, subject only to economic and technical considerations, but the flows have not been balanced. Most of the international data processing services are offered from very few, highly industrialized countries (such as the United States). Multinational corporations, likewise, tend to be headquartered in only a few countries. As a consequence, data are flowing to these countries for processing and storage, or for decision making purposes, from countries that subscribe to remote data processing services or contain subsidiaries of multinational corporations. Thus, organizations in the public and the private sectors in many "computer poor" countries depend heavily on computer systems located in or operated from abroad. It is not surprising, therefore, that a number of concerns over this situation have emerged in countries from where transborder data flows originate (1-4):

- The possible erosion of the sovereignty of a country when large amounts of data about its economy, resources, citizens or government operations are transmitted abroad. Increased vulnerability to disruption of access to these data and the lack of control over them can put a country in a position of significant dependency on other countries.

- The possible erosion of privacy protection available to individuals in their home countries when personal data about them are transmitted to countries where privacy protection laws are weaker or entirely absent. The possibility of foreign "data havens" arises.

- The increased complexity and technical difficulties in assuring data security and maintaining accountability in networks that span several countries, employ different types of transmission technologies, are operated by different organizations, and are subject simultaneously to several sets of different laws and regulations.

- Potentially adverse effects on the development or continued existence of domestic data processing expertise and industry in those countries that utilize foreign data processing services on a large scale.

These concerns and the possibility that restrictive measures may be taken by data exporting countries to alleviate them, are also alarming vendors of remote computing and information services, multinational corporations, and those engaged in international trade. They fear that free data flows will be constrained by national laws (i.e., the so-called "non-tariff barriers" are used to limit communications); international business, commerce and information exchanges will be discouraged; and protectionist policies will be instituted regarding international computer-communication systems and services.

Two of the concerns listed above -- privacy protection and data security, are currently in the international focus. This paper examines the issues involved, and the associated technical considerations. Further discussion of the other issues can be found in recent literature (5-8).

PRIVACY PROTECTION ISSUES

Since the early 1970s, privacy protection laws and regulations have been enacted in several industrialized countries to control the collection, use, dissemination, and transmission abroad of personal data about individuals (in the most recently enacted laws -- in Norway, Denmark, Austria and Luxembourg, also included in the scope of coverage are "legal persons": corporations and associations). Focus is on personal data that are maintained in automated data processing (ADP) systems for reasons that include the following:

- o Automation of personal information record-keeping systems is on the increase, as is their use in making decisions about individuals.
- o ADP systems and data bases are subject to misuse, and they are vulnerable to various threats on a scale that is significantly greater than in manually maintained record-keeping systems.
- o Experience has shown that much of the personal data collected into record-keeping systems are of questionable relevance and of low quality for the uses to be made of them. Automation of such systems increases the potential for unfair decisions.

A recent public opinion poll in the United States (9) shows that these concerns are increasing . For example, over 64% of the respondents felt that automated record-keeping systems pose a threat to personal privacy, and over 50% were concerned about the uses of personal information by the government and the private business.

Responding to such concerns, the United States, Canada, and several European countries (Sweden, Federal Republic of Germany, France, Norway, Denmark, Austria, and Luxenbourg) have enacted laws to provide privacy protection (10,11). That is, to grant individuals a set of rights regarding the collection, storage, processing, use, and dissemination of personal data about them by record-keeping organizations, and to place certain associated requirements on these organizations.

Due to differeing perceptions of the problem, and differing political and legal systems and traditions, the national privacy protection laws tend to exhibit considerable variations in: (a) the scope of applicability and coverage (e.g., government, the private sector, or both), (b) data subjects that are covered (e.g., individuals, legal persons, or both), (c) systems that are covered (automated, manual, both), (d) privacy rights granted to data subjects, (e) requirements placed on record-keepers, (f) types of enforcement ties and mechanisms, (g) systems of penalties for non-compliance, and (h) transborder data flow restrictions. Figure 1 summarizes the laws and their features.

Figure 1 Features of National Privacy Laws

Country	Scope	Data subjects	Enforcement
United States	Federal government Some state govrn. Parts of private sector (credit, education, banks)	Citizens Aliens admitted for permanent residence	Self-enforcment
Federal Republic of Germany	Both government and private sector	All residents	Data Protection Commissioner
Sweden	Both sectors	All residents	Data Inspection Board
France	Both sectors	All residents	National Commission on Informatics and Liberties
Norway	Both sectors	All residents and associations	Data Surveillance Service
Denmark	Both sectors	All residents, legal persons	Data Surveillance Authority
Austria	Both sectors	All residents, legal persons	Data Protection Commission
Luxenbourg	Both sectors	All residents, legal persons	Existing government authorities
Canada	Federal government Some provinces Some parts of private sector	Citizens Aliens admitted permanently	Privacy Commissioner

The privacy rights granted to data subjects (individuals) by the existing privacy protection laws tend to be quite similar, since they are based on a set of principles that evolved internationally from a Code of Fair Information Practices conceived in the United States (12), Council of Europe resolutions (13,14), findings of the U.S. Privacy Protection Commission (15), and studies in other countries. Briefly, individuals are afforded the following rights: (a) to know what personal data record-keeping systems exist in the country, (b) to learn what data about themselves these contain, (c) to inspect these data and request corrections or amendments, (d) to have some control over uses of personal data about them beyond the uses originally stated, and (e) to have available ways to exercise these rights and seek redress for damages. The general requirements on record-keepers are that they adopt a policy of openness over their record-keeping practices and uses of personal information; that they establish facilities and procedures to permit data subjects to exercise their rights; and that they implement data management policies and practices to assure that data confidentiality is provided, data quality is maintained, and precautions are taken to provide data security and prevent their misuse.

Privacy protection becomes a matter of concern in transborder data flows because of the differences in privacy protection laws (as outlined in Figure 1) which may make the privacy laws of some countries appear weaker than those of other countries. The latter may then restrict transmission of personal data to the former countries on grounds that privacy of its citizens is being threatened. For example, the European approach to privacy protection has been to create "omnibus" laws which apply broadly to all record-keeping organizations in the government and the private sector. In contrast, the United States has adopted a "sectoral" approach, targeting privacy and fair information practices at specific parts of the governmental structure and the private sector (e.g., the federal government, state governments, health care, consumer credit, education, etc.). Because the latter process is relatively slow, and since gaps in privacy protection still exist, privacy protection in the United States is not yet complete and may appear weaker than in European countries that have enacted privacy laws. This observation may then be used as rationale for applying restrictions on personal data transmissions to the United States.

This prospect has led to strong protestations by U.S. data processing enterprises and corporations. They maintain that TDF restrictions are not necessary for protecting privacy, but are meant to serve an ulterior objective to reduce the U.S. competition in the European data processing markets (16).

The potential legal obstacles and conflicts in privacy protection requirements in the TDF context have prompted international bodies to study the problem and develop solutions. Thus, the Council of Europe has developed a draft international convention to establish a minimum set of privacy protection principles (17), and the Organization of Economic Co-Operation and Development (OECD) has drafted a set of guidelines for privacy protection (18). The United States has participated in the latter activity. Both draft documents acknowledge the need for continued free flow of information between countries and avoidance of non-tariff barriers, but they also permit countries to adopt measures that increase the level of privacy protection.

Implementation of privacy protection requirements in transborder data flow situations involves a number of procedural and technical measures and raises additional problems. For example, the language differences, location of inspection sites, identification requirements, maintenance of data quality, and accountability for compliance. It seems clear that when personal data about individuals are transmitted abroad, the individuals should not suffer inconveniences in exercising their privacy rights which are exceeding those normal in their home countries. An organization in the home country that sends personal data abroad should be responsible and accountable for complying with home country privacy protection requirements, and serving as an interface between the individuals involved and the data processing organizations abroad. The latter should be responsible for maintaining data confidentiality and security, and preventing any misuses of the data in their custody. This responsibility could be established by privacy protection laws in the host county or by contracts.

Since the United States at present is not providing legally enforceable privacy protection with the same scope as European countries, organizations in U.S. are susceptible to possible restrictions on incoming data flows. They may need to demonstrate to privacy protection authorities abroad that they have a committment to privacy protection. Voluntary compliance with principles of the OECD guidelines may offer one approach. This has been urged by several U.S. industry and business groups as well, such as the U.S. Chamber of Commerce and the Business Roundtable (these have urged enterprises to voluntarily adopt privacy protection principles for employee records, in particular). Voluntary compliance is an alternative that could be implemented quickly by each enterprise individually, and in ways that adapt to the specific privacy protection needs and requirements that may arise in TDF situations.

DATA SECURITY

Implementation of privacy protection requirements specified by law or adopted voluntarily involves establishing procedures for permitting data subjects to exercise their privacy rights, and procedural or technical means for maintaining data quality, confidentiality and security. Indeed, these are important for good management control in any system. In each there are available considerable technical capabilities, but there also exist certain state of the art shortcomings. Furthermore, any problems that may arise with data quality, confidentiality, or security in implementing national-level privacy protection laws are likely to be more severe in transborder data flow situations.

The need for data security safeguards depends, in addition to requirements stated in applicable privacy protection laws, also on the specifics of the computer and communications systems involved, such as the sensitivity, volume and frequency of use of the stored data; the size and diversity of the user population; and the structure and operating environment of the system. For example, security threats are likely to be more serious in systems that permit simultaneous access to many users at remote terminals on resource-sharing basis, that process unrelated tasks concurrently with sensitive data, and that permit users from other organizations to share the system resources concurrently with the record-keeping organizations processing.

After a decade of concern and research, there are now available a number of techniques for implementing physical security, access controls in computer software, and communications security (19-21). For example:

- Except for international standards, physical security is well in hand for protecting computer installations against natural disasters, preventing unauthorized access to the premises, providing safe data storage off-line, and setting up back-up facilities.

- Software security techniques have made considerable advances and, while software security cannot be guaranteed completely, secure software systems with limited capabilities are evolving (e.g., use of the "security kernel" approach).

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- Techniques for providing unforgeable identification and authentication have also made considerable progress; the development of digital signatures is especially relevant in the context of data security in transborder data flows.
- New development in cryptography, such as the Data Encryption Standard (DES) and public-key cryptosystems (22,23) are making communications security easier and less costly to achieve.

The use of encryption is an important element in providing data security in international computer-communications systems. However, there exist a number of non-technical factors that may complicate the achievement of effective security in these systems using encryption or other techniques:

- While international standards for technical aspects of data communication are being developed (e.g., by the International Telecommunications Union in Geneva), no standards have been developed for communications security.
- Existing international agreements, such as the International Telecommunications Convention of Malaga-Torremolinos, recognize the rights of all countries to regulate their telecommunications, and to monitor all communications crossing their borders. Thus, the use of encryption depends on whether the governments involved insist on access to the keys, or prohibit the use of encryption entirely.
- Internationally, there is no uniformity in legal prohibitions of interception or diversion by private parties of data transmitted in telecommunication systems.
- There is a wide variation in the technical characteristics and quality of the telecommunication systems in various countries and, correspondingly, there are wide variations in their security vulnerabilities.

A recent survey of security features in European computer-communication systems (24) concluded that, based on a sample of 23 systems, there is a growing concern over the adequacy of data security in these systems. The typical security features implemented include private circuit access, automatic terminal identification, use of passwords (including multiple passwords), manual access control (operators acting as intermediaries), and very limited use of encryption.

In general, from the point of view of implementing security-related requirements of privacy protection laws, there are a number of security state of the art shortcomings that must be kept in mind when formulating requirements for privacy protection or for effecting management control (25):

- Absolute security is not achievable in contemporary, automated, multiuser, resource-sharing computer systems or networks, since it is not technically feasible to prove the correctness of the operating system design or implementation, nor can hardware be guaranteed to be free of design flaws.

- Physical security cannot be guaranteed against sophisticated penetration or overpowering attacks.
- Personnel trustworthiness cannot be predicted reliably, nor assured or maintained.
- Currently proposed encryption techniques appear to provide high levels of protection, but it is not clear that they can resist massive computer-aided trial-and-error or analytical attacks.
- The "confinement problem", leakage of sensitive data from a protected system using some externally observable system variable (e.g., the execution time of a program) as a carrier to be modulated by the data to be leaked, has not been solved adequately (26).

To date, no privacy protection law or TDF requirement has specified that absolute security must be provided, but when requirements are stated vaguely they may be interpreted to imply a need for more security than can be provided in practice. As a result, organizations may expend resources in unnecessary and unproductive pursuit of high levels of security, while the data subjects are led to believe that data about them are provided with more protection than is the actual case. Even reasonable security may be difficult to achieve in large systems because:

- Risk analysis methodology and techniques have not yet evolved to levels where they can be used as totally adequate guidelines (27). Lacking are authoritative quantitative metrics for effectiveness assessment.
- Complexity of large software systems defies analysis for design weaknesses or implementation errors; exhaustive identification of vulnerabilities is very difficult if not totally infeasible.
- Threat detection and monitoring techniques are inadequate for discovering and preventing in real time covert penetration attacks.
- In statistical data bases from where personal data are released only in aggregate form, it is still possible to compromise the data (i.e., associate released data with identifiable individuals) by using sophisticated query strategies (28).

Finally, a system of security safeguards is effective only when it is designed correctly and continues to operate correctly. In international computer-communication systems this implies standards, ability to audit and monitor the overall system's operation, access to equipment that may be located in several countries, and cooperation from all parties involved. While the necessary procedures can be established within some contractual agreement, certain aspects of enforcing compliance may require effective international agreements and support.

Other technical questions in providing privacy protection nationally and in transborder data flow situations arise in the areas of accounting requirements regarding uses and disclosures of personal data, maintenance of data quality, and auditing of compliance. These have been discussed elsewhere in literature (25,29) along with examination of associated costs (30,31).

CONCLUDING REMARKS

Increases in transborder data flows have raised a variety of issues that include concerns over possible erosion of national security and sovereignty, loss of data processing and communications markets, and threats to individual privacy when personal data are transmitted abroad. The privacy protection and security issues, in particular, are in the current focus of national legislative efforts and international harmonization activities. Concerns are also increasing in less developed countries over possible "data colonialism." Under certain circumstances, various countries may find reasons to place restrictions on data outflows and, thereby, interfere with international data communications activities, as well as with international trade and operations of multinational corporations. It is advisable for organizations that are likely to feel the impacts of such restrictions to become familiar with the TDF issues and, if appropriate, to take steps to voluntarily subscribe to privacy protection principles as these relate to their international data communication activities.

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VIDEOTEX
IMPACT ON LOCAL NETWORK

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At GTE, we believe that Videotex and Videotex related services will be successfully introduced in the United States. The components are all available: inexpensive computer systems with massive amounts of storage; packet networks with distance insensitive tariffs; special "Viewdata" semiconductors for use in personal computers and video games. Information providers are building test pages and test applications. Large corporations are conducting market tests. We believe the birth of Viewdata is imminent.

The emergence of Videotex is causing the telephone industry to examine the impact this new service will have on the telephone network, in particular, the local network. In 1985 there will be 100 million households and it has been projected that every other household will have a terminal. That is 50 million new terminals on our telephone network. These terminals will not replace voice communications but will add new loads to the local network; letters will be replaced by electronic mail; checks replaced with electronic funds transfer; shopping trips replaced with purchasing-at-home; magazines, books and newspapers replaced with video displays. Additional new services will address educational and leisure needs. All of these Videotex services will add load on the local network and will impact the telephone industry's ability to service its customers.

To gain an insight of the potential impact, consider a scenario:

> The National Chess Federation establishes a chess tournament for all its members to be played via interactive Videotex. The total membership is paired and play is accomplished by displaying a player's chess board, chess pieces and moves in his opponent's Videotex mailbox. Members of the federation are allowed to follow others' games after they have been eliminated; non-members of the federation are allowed to observe any match in progress on their Videotex terminal for a fee.

This scenario is designed to show two characteristics of Videotex that will impact our local network. First, the local network is designed for 20 minutes of usage per household per day. A chess tournament such as in the scenario will cause significantly longer holding times. Second, the local network is designed with a given concentrator factor, which assumes that within a given group of households only a small percentage of users will be using their phone simultaneously. In today's more modern digital switches, generally the concentration factor is 4 to 1 or 192 simultaneous users per group of 768 phones. With this concentration factor, if half of the future terminal owners, 25 million, wanted to watch the last game of the chess tournament, the local network of 100 million households could be jammed for the duration of the game.

The intent of this paper is not to show potential disruptive aspects ~~of~~ Videotex, but to point to new opportunities for the telephone companies. The first opportunity will come from the longer holding time of applications such as the chess tournament. This will yield greater revenues to the telephone industry if Videotex is billed on a usage sensitive basis. The second opportunity occurs because massive numbers of simultaneous Videotex users can jam the voice communications network. This indicates that our current network needs improvement. This need to improve the telephone network, justified by additional revenue from supporting Videotex service, could allow the telephone companies to evolve from their current residential voice offering to a new voice/data offering. With sufficient planning this evolution can be easy and profitable. A potential evolution series could be:

TODAY

The voice switch of today is used to route Videotex data to a packet switch which is connected to the national packet data network. The packet switch may or may not be owned by the telephone company.

TOMORROW

With the introduction of digital switches and their remote switching units, we will be able to go digital directly to the subscriber and eliminate the requirement for modems and thus supply a more economical data service. As the data load picks up we will nail up connections through the voice switch to the packet network and eventually when sufficient load exists, route the data around the voice switch directly to the packet switch.

DAY AFTER TOMORROW

Once the data network for Videotex is established, new services can easily be added, such as simple terminal for operator services. Perhaps the telephone companies can even supply the residential system that does everything: environmental controls such as gas, electric and air conditioning; Videotex; voice; alarms and a residential communications module that interfaces the residence to the outside world. This module would interface to: CATV for massive data transfers, such as would be required for video conferencing with your boss from your office in the home; FM broadcasts, so the power company can cycle your air conditioner during brown outs; the telephone network for voice and Videotex applications.

These are fun and wonderful services to anticipate but there is also a practical world that must be considered. How does the telephone company maintain 50 million voice/data communication lines? In the past transmission errors on the local loop were not significant because an extremely complex associative computer called the human brain was receiving the information. But the inexpensive computers that will be utilized in Videotex services must have a good communication line. The telephone company must develop the ability to test each line not only for outages but also to detect that the line is degrading.

This ability to test the local loop implies that each residence will contain an intelligent telephone terminator to allow line turn around and to isolate the line from the myriad of customer supplied equipment attached to fit it in the residence.

An additional service feature of the intelligent telephone terminator may be to assure that only one piece of residential equipment at a time is using the telephone line. The residential user will not be capable of determining that the reason his Videotex terminal keeps failing is because simultaneously with his Videotex activity his environmental control unit is being interrogated, over the same telephone line, by the electric company. The telephone company will probably have to assume the responsibility for resolving these types of problems because to the residential user it will appear as a telephone company line problem.

The ability to service these 50 million new terminals will probably be the most interesting opportunity that Videotex will create for the telephone companies. New equipment and capabilities will be required to support these users and with proper planning the evoling network can encourage additional new services to be offered. The opportunities will become endless and fantastic.

THE PALAPA SYSTEM IN REGIONAL TELECOMMUNICATION DEVELOPMENT

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1. INTRODUCTION

In developing countries, such as Indonesia, telecommunications system requirements are often, at least in some local areas, greater than in developed countries where a basic system has long existed and fulfilled certain minimum needs. Further, meeting requirements is often impeded by generally inadequate facilities, such as obsolete plant and equipment sourced to a multiplicity of manufacturers spread throughout the world. The result is the lag of telecommunication expansion behind other sectors of development at the very time when its capabilities are essential to carrying the myriads of messages associated with completing the enormous number of urgently needed national programs. A complicated factor may also be a telecommunications budget, which because of other urgent needs, is either too limited or is significantly eroded by providing innumerable quick fixes to existing facilities. Long term goals are thus compromised, fiscal resources may be inefficiently used and perhaps most debilitating, the general inadequacy of telecommunications may cause frustration and discouragement, thus inhibiting the impetus toward development.

Indonesia has experienced its share of these conditions. It has also boldly placed a high priority on investment in telecommunication development. As a part of this work, a national satellite communication network (the PALAPA* System) has been implemented. This paper briefly recounts the reasons for this descision, describes the system which is already being extrapolated from a national to a regional arena and discusses some technical, implementation, and international coordination aspects of bringing the PALAPA system into full utilization as both an instrument of regional advancement and as a model of regional cooperation, in particular, discussions are focused on the ASEAN** region.

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*The name PALAPA symbolizes Indonesian national unity. It derives from the "Gajah Mada oath," the declaration of the 13th century Prime Minister of the Javanese Majapahit empire who said that he would not eat again of the (fruit of the) palapa until the country were united from Sabang (the northwest) to Merauke (the southeast).

**ASEAN: Association of South East Asia Nations, consisting of Indonesia, Malaysia, The Philippines, Singapore and Thailand.

2. NATIONAL DEVELOPMENT AND PALAPA

National Experience

There are many who believe that the world could exist only with an extensive communications system and that without communications we would never understand each other. This idea has a deep meaning and concern in Indonesia, where its people are composed of varied ethnic groups, speaking distinct regional tongues and having diverse religions. Among the other factors of the infrastructure, telecommunications has a prominent role in unifying the nation politically, socio-culturally, economically and in the areas of defence and security.

Efforts to generally improve the infrastructure in Indonesia started immediately after independence on August 17, 1945. Limited number of skilled personnel and lack of financing were the major constraints encountered during the early development.

National Development

In a series of national five year development plans, the first being embarked upon in April 1969, the government set a high priority for telecommunications development.

During the period of 1969-1976, significant achievements were made. Terrestrial facilities were constructed to link population centres in the western and eastern parts of Indonesia.

Construction of automatic exchanges was made in parallel, providing many communities with telephone and telegraph services. Video and audio programs are also disseminated through the microwave system.

Despite the fact that terrestrial facilities had been constructed in a large part of the country, high quality telecommunication services were still lacking in the remaining part. Dense forest, mountains, rough terrain, swamps and wide spans of water posed obstacles to the extension of terrestrial transmissions networks. It was realized, it would require a long time to provide terrestrial links to all parts of Indonesia, while the potential demand for telecommunication services was steadily increasing. The inadequacy of service in some areas was so great that potential telecommunication service customers developed their own private networks. These were not only expensive and inefficient in the national perspective but caused the disintegration of national telecommunication investment.

The need for an integrated national telecommunications network was obvious. After reviewing the technical and economic feasibility, it was decided to exploit the advantages of satellite communication in the Indonesian telecommunication network.

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The Present System (PALAPA-A)

The Indonesian Domestic Satellite Communication system, PALAPA, was brought into operation in August 1976. The original system has a space segment composed of two HS-333D geosynchronously stationed satellites at 83°E (PALAPA A-1) and at 77°E (PALAPA A-2) and a ground segment composed of one master control station (MCS) and 39 ground stations, connected to their respective telephone exchanges. Since July 1978 the entire system has been operated and maintained without expatriate staff.

At present the system carries three types of services:

- Telephony
- Telex and telegraphy, and
- Television

Telephone, telex and telegraph signals are transmitted via FDM/FM carriers for heavy traffic routes and via SCPC for thin routes: The latter mode is provided at all sites with demand assignment capability. Television signals are transmitted utilizing a whole transponder.

Since the time of initial network implementation, the ground segment has been expanded. Ten STs* are in progress of being installed. A domestic lease of thirteen STs has been added and more than ten television receive (TVRO) terminals are already in operation. The locations of 40 ground stations and additional 10 STs are plotted in Figure 1. Spacecraft EIRP and G/T contour are shown in Figure 2-a and Figure 2-b respectively.

The Second Generation System (PALAPA-B)

Since increase loading of PALAPA in the coming years is foreseen, continuity and reliability of service demand special attention. In this regard, preparations for the second generation PALAPA satellites (PALAPA-B) are in progress. The Invitation to Tender was issued in May 1979 and Tender Proposals were received in August 1979. Evaluation and negotiation are presently at the final stage. The first spacecraft launch is presently scheduled for mid 1982.

Improved performance characteristics have been specified for PALAPA-B. The first significant improvement is in spacecraft EIRP:

- Minimum EIRP over ASEAN area : 32 dBW
- Minimum EIRP over Indonesian area : 34 dBW

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*ST: Small Terminal ground station with an antenna diameter of 5 meters or less. Its G/T ranges between 18 to 22 db/K.

Relative to present PALAPA-A characteristics, a 3 to 4 dB improvement in "the worst case location" of ASEAN coverage would be achieved. This accommodates the wider use of STs in the region, providing greater narrow band capacity and delivering a better quality video signal.

The second significant improvement is increasing the sensitivity of the spacecraft receiver about 10 dB compared to PALAPA-A. This characteristic will enable STs to handle about 50 SCPC channels with a 100-Watt HPA as well as considerably easing the ability to uplink a TV carrier if so desired.

The combination of higher EIRP and sensitivity in the spacecraft constitutes a very cost effective solution for the near future, enabling STs to provide good quality video service and greater telephony capacity. Further, as the number of STs increases in the region, as well as in other domestic satellite systems such as Canada and the United States, a continuing decrease in their cost can be expected.

The capacity of each PALAPA-B spacecraft is 24 transponder, double the present spacecraft capacity, through application of frequency reuse techniques in 6/4 GHz band. Present traffic projections and assessments of the spacecraft design show that ASEAN requirements until 1990 can be met with a 24 transponders spacecraft (see Table 1). The launching of two PALAPA-B spacecraft will then provide 24 transponders as back-up, thus increasing the reliability of the system.

Table 1

Estimated transponder requirement up to 1990

User	1978 requirement (transponder)	1990 requirement (transponder)
INDONESIA		
Perumtel	6	9
TVRI	1	2
Hankam	1	1
Sub total	8	12
ASEAN		
Philippines	1-1/2	3-1/2
Thailand	-	3
Malaysia	-	1-1/2
Occasional ASEAN TV	-	1
Sub total	1-1/2	9
Grand total	9-1/2	21

Satellite Orbital Positions and Intersystem Coordination

The present PALAPA satellites, occupying positions to the west of the country, are faced with potential interference problems to and from a large number of satellite systems. Based on the past experience and analysis of interference levels, it was found that there is almost no allowance for accommodating the higher sensitivity and EIRP of PALAPA-B. This has forced the system planners to explore other possible positions along the geosynchronous orbit. After studying the trade-off among relevant spacecraft parameters, the decision was made to file for three positions overhead: 108, 113 and 118 degrees East longitude.

Advance Publication of PALAPA-B spacecraft parameters was issued in the Special Sections of I.F.R.B. Circulars No. 13[illegible], on June 1979. Comments were received from the administrators of India, Japan and the United States (acting for INTELSAT). The coordination process with the INTELSAT system has been concluded favourably. Agreements have already been reached with India for INSAT. Coordination with Japan for CSE is also completed. Filing the frequencies of the PALAPA-B into the International Frequency Master Register is in process.

3. PALAPA IN A REGIONAL DEVELOPMENT CONCEPT

ASEAN Experience--the need for telecommunications

Indonesia is an "island type" country, with some big islands such as Sumatera and Kalimantan which represent "land type" geography; its people has many similarities with the people of her neighbouring ASEAN countries, portrays on a national level what exists to a larger extent on the regional level.

In addition to other affiniti[illegible]e ASEAN countries have experienced similarities of recent history and sub[illegible]nt development aspects and their related problems. Pre-World War II conditions were characterized by a gross lack of infrastructure. Much of what did exist was ruined during the war, worsening the situation. Efforts to generally improve the infrastructure started after the war and for many subsequent years development was mainly approached from an economic viewpoint, emphasizing increased gross national product and per capita income as goals.

In this respect, the important role of telecommunications is obvious as it has long been recognised that a very close relationship exists between economic development and telecommunications and that an economy cannot be developed efficiently and effectively without the availability of adequate telecommunication services.

ASEAN Development--the reliance on telecommunications

In the evolution of the national development pattern, a basic concept prevails, namely to establish unity in political, socio-cultural, economic, defence and security aspects. In this context, development in the telecommunication sector is directed toward supporting other sectors to bring this concept into reality, thus the extensiveness of telecommunication services is emphasized. In addition, these services must be rendered with due regard for the smooth operation of government administration, the convenience of socio-cultural life and the efficient transactions of economic activities, here the intensiveness of telecommunications is emphasized.

Telecommunications supports and stimulates all forms of regional cooperation, carrying information of development activities, creating better understanding among peoples and enabling all nations in the region to progress together and to live harmoniously.

ASEAN Rural Development--the expansion of telecommunications

As development gradually fulfills the basic needs of the people, both personally and in regards to their social institutions, the desire to have a more broad and more diverse development appears. The social factors of growth become more critical and cannot be relegated to either the background or to the distant future, because improved social benefits accelerate desires and expectations. This in turn emphasizes the need to establish a mechanism which will produce self-sustaining and cumulative indigenous economic improvements.

In this awareness, the effort to attain equity in the development of all sectors is accentuated more than before. Such development is intended to ensure that all members of society, particularly the people at the grass roots level, have a chance to enjoy the fruit of development, thus, the importance of a rural development program is obvious, especially when it is realized that about 80% of the population in the ASEAN region dwell in vast rural areas.

Rural development has considerably lagged behind urban development. This imbalance has caused migration from rural to urban areas. Big cities, such as Bangkok, Jakarta and Manila have become more and heavily populated, raising many social problems as these cities exceed their capacity limits in providing accommodation and public utilities, while industrialization in urban areas is not yet capable of absorbing the people drawn from rural areas. These phenomena can be further extrapolated to a global situation. It is therefore not surprising that the role of telecommunications as a pioneering force for rural development has been the subject of studies in several international forums within the United Nations.

PALAPA--its role in ASEAN telecommunications development

The advent of the PALAPA system in the region opens a large range of possibilities for applications for domestic as well as for intra-regional communications. Expansion of telecommunications to both rural and remote areas is hampered by the unavailability of a cost effective system while the intensiveness of rural and remote telecommunications development is largely constrained with the absence of a general technical solution. A satellite communication system has potential capability to face these challenges and this capability will be dynamically increasing as the cost of both space-segment and ground-segment decreases with time.

The characteristic of cost insensitivity to distance in a satellite communication system enables it to provide intra-regional communication services for essentially the same cost as for domestic applications. A lower rate tariff pattern is thus encouraged and the growth of intra-regional traffic will be stimulated.

As a general concept for applications, the PALAPA system may be employed to provide services on links where utilization of terrestrial system is relatively expensive. The PALAPA system and the terrestrial system complement each other to constitute a high quality and reliable regional telecommunication network, capable of meeting the present and future requirements.

Rural and Remote Areas Telecommunications

In addition to recognition of telecommunication requirements for rural areas, the ASEAN region, characterized by its mountains and archipelagos has many remote areas. These are often strategically located along international waterways. Others are the vast plantations, industrial operations, such as oil fields, mines and lumbering, local government offices and security posts. These activities are by their nature isolated, but their demand for good telecommunications is also recognized.

The existing rural and remote areas telecommunication networks in the ASEAN region consist mainly of open-wire lines, HF and some VHF radio systems, the choice depending on distance, terrain, geographical conditions and security. These facilities provide telephone, telex or telegraph services to connect these areas to their respective parent town.

When there is a need for video program distribution, wide band transmission facilities are required. These are extremely expensive when provided by terrestrial transmission means. This requirement is easily met by STs, which can be equipped with TV receive capability at very low cost. It is interesting to note experience in Indonesia where there is a tendency for people who live in rural and remote areas to demand television more than telephony service. This is reflected in the number of TVRO stations installed or being planned. It is noted that fulfilling this need has several infrastructural and development benefits, however, some possible negative effects might arise and need to be avoided.

A general solution to rural and remote area requirements may be the utilization of low cost STs. Cost estimates* for an ST capable of transmitting and receiving several voice channels are about $20,000 per station.

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*Albert L. Horley, "The Prospects for Rural Telecommunications Via Satellite," presented at a workshop on space Telecommunication Systems, Indonesia National Institute of Aeronautics and Astronautics, Jakarta, March, 1979.

in quantities of 100. It also appears that ground stations costing $10,000 or less can be expected in the late 1980's. Such costs would be very competitive, even with narrow-band terrestrial facilities. An ST offers several attractive features:

1. General solution for rural and remote areas telecommunication development
2. Low cost
3. Easy installation
4. Good quality telephony, telex and telegraphy transmission
5. TV reception capability, and
6. Flexible accommodation to traffic growth.

Based on the above, it is expected that the future rural and remote telecommunication network will witness a significant expansion in the use of STs.

Border Communications

A large proportion of ASEAN national boundaries occurs within the seas and along international waterways. There exists in many locations centuries-old affinities between people who now find themselves separated, not only by water, but also by the "modern" national state concept. Community interest, from a traffic view point, is also created by commercial activities and security purposes as well as the personal relationships which exist between people living in neighboring areas. Interconnecting such border sites would, depending on the respective national routing configuration and switching hierarchy, include a satellite hop to the transit center in country A, utilization of terrestrial subcable or an INTELSAT hop to country B, and finally, terrestrial service or another domestic satellite hop to the destination. Such needless systems loading, inefficiency and potential circuit degradation are obvious. Direct "international" paths are needed. Utilization of STs to access PALAPA at border sites provides a technical solution which may consume less resources than the process of reaching the agreement required to implement such stations.

Intra-Regional Communications

A regional satellite communication system can be viewed as consisting of several domestic satellite sub-systems. Each of these networks contains a number of ground stations which link large cities and which are also spread into the rural and remote areas. Communication for border areas, discussed above, represents a static solution in an area where dynamics are needed. Interconnectivity between any stations, accessing the PALAPA system should be an available option in meeting regional telecommunications traffic requirements. The difficulties which may arise due to utilization of more than one satellite can be solved by coordinated regional planning including optimum use of terrestrial facilities, where available, and the judicious placement of second small antennas at certain sites to handle this thin route traffic. Where regional stations access the same satellite, intra-regional communication capability is only a matter of channel expansion of the ground segment, thus the cost will be minimized.

In the establishment of intra-regional communications, coordination with INTELSAT is required to avoid technical and significant economic harm to the INTELSAT global system. This coordination process has been concluded favourably.

Submarine-Cable Back-Up

The growth of submarine cable systems in the region will provide large capacity trunks to interconnect international centres, i.e. Bangkok, Jakarta, Kuala Lumpur, Manila and Singapore. As the traffic grows, consideration of a back-up system is necessary. Interruption of submarine cable service may take some time for restoration depending on the availability and the distance of the maintenance-ship from that fault location. As the traffic increases, interruptions may not be tolerable and the need for a back-up system may develop.

A cost-effective back-up system could be provided by PALAPA, considering that each international centre has (or will have) an existing ground station operating with PALAPA already. The additional cost for such capability lies mainly in the expansion of equipment at ground stations and tail links.

Utilization of a satellite to restore service during submarine cable outage began several months after the launch of the first commercial communication satellite, Early Bird, in 1965. Restoration of cable service via satellite increased in the years following Early Bird.

In this configuration, the PALAPA system would temporarily carry traffic of the submarine cable system. It is therefore assumed that INTELSAT would not consider that such circumstance caused her economic harm. However, formal coordination with INTELSAT must be conducted in the future if this configuration is planned to be implemented.

4. ASEAN UTILIZATION OF PALAPA

Since the establishment of ASEAN, regional cooperation has increased rapidly. Increasing interests and activities are reflected by several committees which have been formed such as, ASEAN Committee on Trade and Tourism, on industry, minerals and energy, on transportation and communication, The ASEAN Bank Council, and the committee on Food, Agriculture and Fishery. All committees are subdivided into a number of Sub-committees and supported by the existing working groups which perform technical studies.

Aside from the above, there are various organizations of specific character, such as The ASEAN Automotive Federation, The Rubber Industries Association of South East ASEAN Nations, etc. Cooperation in the field of telecommunications is discussed in the Sub-Committee on Posts and Telecommunications.

Considerations on ASEAN utilization of PALAPA

When the decision was made to adopt domestic satellite service for Indonesia, it was soon realized that the spacecraft beam would cover not only the area of Indonesia but also the area of neighbouring countries. In particular, attention has been given to meet the requirements of other member countries of ASEAN, in an effort to support cooperation for regional development.

A pre-feasibility study of an ASEAN Regional Satellite Communication System was first initiated in Manila, in November 1974. The study arrived at the preliminary finding that there is a need to provide satellite communication for domestic, intra-regional, maritime and aeronautical applications among the ASEAN countries. At a subsequent meeting, held in Singapore in December 1975, the working group concluded that an alternative to meet the requirements for an ASEAN Regional Satellite System is to expand the PALAPA system.

A study group convened in Bandung (Indonesia) in June 1977 to explore the possible utilization of PALAPA for regional applications. The meeting discussed among other things, that any future development of PALAPA should bear the objective of achieving an ASEAN Regional Satellite Communication System.

To further study whether the second generation PALAPA can satisfy the border and domestic telecommunication requirements of the ASEAN region, a working group of senior technical and economic experts in telecommunications met in Jakarta, in July 1978.

The working group anticipated the action needed to be taken after the exhaustion date of the second generation PALAPA, considered the development of other wide band facilities; reviewed the terms and conditions for the use of PALAPA; studied other forms of participation in the use of the regional satellite communication system; and reviewed the applicable provisions of INTELSAT Agreement on the use of domestic satellite for intra-regional communication.

Coordination with INTELSAT

Pursuant to Article XIV(d) of the INTELSAT Agreement, coordination between members of ASEAN and INTELSAT has been conducted, concerning the compatibility of PALAPA-B and the INTELSAT system. The main purposes of coordination as contained in the Article XIV(d) of INTELSAT Agreement, are:

- To ensure technical compatibility between the two systems ,
- To avoid significant economic harms to the global system of INTELSAT.

Article XIV(d) was applicable as PALAPA-B is intended to carry a part of the international traffic within the region. If PALAPA-B were intended for domestic applications only, Article XIV(c) would be applied instead of Article XIV(d). In this case, economic aspects are not considered, only technical compatibility assessments are applicable.

The Fourth Extraordinary Meeting of the INTELSAT Assembly of Parties was held in Manila, Philippines in April 1979. The meeting decided to accept the conclusion of The Board of Governors of INTELSAT that PALAPA-B is technically compatible and ~~will~~ not cause significant economic harm to the global system of INTELSAT.

One of INTELSAT considerations in assessing economic aspects is the fact that PALAPA-B is proposed to carry international traffic between ASEAN countries, originating or terminating only in remote areas where it would not be economic to use wideband facilities to access INTELSAT earth stations. Therefore, traffic between such international centres as Jakarta, Bangkok, Singapore, Kuala Lumpur and Manila would not be affected.

Progress Toward ASEAN Utilization of PALAPA

Several milestones have been reached toward realization of the concept of utilizing the PALAPA system fo domestic services. These are:

- The Philippines:

  Domsatphil of The Philippines has leased 1-1/2 transponders, effective January 1979. Eleven earth stations are already operational in the system.

- Malaysia:

  A Leased Agreement for PALAPA space segment capacity was signed on [illegible] August 1979. Malaysia will utilize 1 transponder, effective on July 1980.

- Thailand:

  A Memorandum of Understanding between the governments of Indonesia and Thailand has been signed on 3 March 1979.

As regards border communications between Indonesia and the Philippines, at the Meeting of the Working Group on Philippines--Indonesia Border Communications, held at Quezon City, Philippines, in July 1977, it was found that the PALAPA system is the practical way to provide reliable circuits for border communications between Davao City in the Philippines and Menado, Indonesia. Provision for facilities at both the Davao and Menado earth stations had been discussed at the subsequent meetings. The Philippines is further considering the use of the Zamboanga earth station to provide similar circuits to Menado.

Border communications between Indonesia - Malaysia are planned for several links:

Kuching (Malaysia) - Pontianak (Indonesia)
Tawaou (Malaysia) - Nunukan/Tarakan (Indonesia)
Melaka (Malaysia) - Pakanbaru (Indonesia)

Border communications from several locations in Indonesia to Singapore are being considered.

5. CONCLUSION

The details cited above point toward several conclusions. One is the similarity of needs among developing countries, in particular, improved telecommunications. All the ASEAN members have such needs. One of the member states, Indonesia, has taken a step in establishing a domestic satellite system which is also applicable in satisfying many of the regional telecommunication needs.

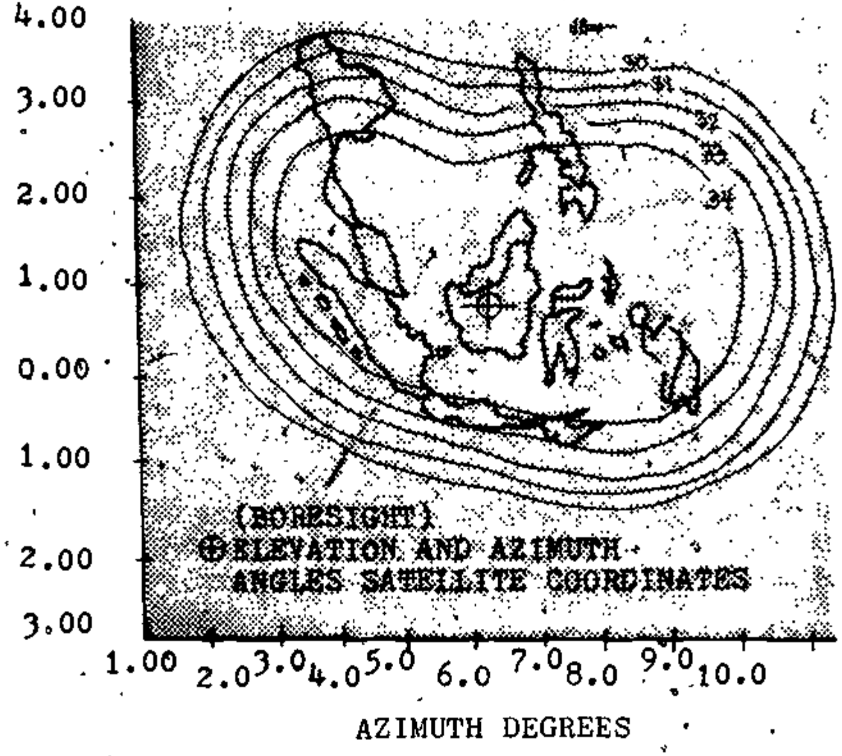
In the ASEAN context, the region has many other similarities which point toward a common solution. The world beneath us, as defined by the geology and geography of the region, has provided a common earthly platform beneath our feet. Considering surface features, the similar topography has socialized our peoples along parallel paths and our broad seas have been used for centuries as an avenue of commerce, thus further intermingling our cultures. The atmosphere around us brings similar blessings.

Finally we share a common open sky wherein PALAPA brightly shines. Harnessing this energy on a regional basis is therefore only natural.

If these thoughts seem to be more philosophical than technical, I would like to note that we in Asia also derive some satisfaction in seeing a conclusion which considers our total environment, which is harmonious in all aspects, not based solely on fiscal considerations. Profits are desirable but are not always paramount.

At this point, I would hasten complete my conclusion. PALAPA has on a national scale, done what would otherwise have taken even greater resources of time, money and human activity to accomplish terrestrially. The space segment exists, and an improved satellite is in process of provision. The PALAPA system already provides service to isolated places. Lease service, both domestic and regional, exists and is being expanded. PALAPA has the capability to serve as back-up for regional submarine cable system. It is complementary to other communication means and capable of providing a high quality and reliable regional network.

A fringe benefit provided by PALAPA is the cooperation it has stimulated in the area of regional development, bringing together peoples and promoting peace and prosperity through its ASEAN coverage. As regional latent and suppressed demands are met, new needs for telecommunication services can be expected. The overall effect will contribute toward improving the standard of living throughout the area, evolving a uniform standard of development and will enable all nations in the region to progress together.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3.00
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(BORESIGHT)
⊕ ELEVATION AND AZIMUTH ANGLES SATELLITE COORDINATES
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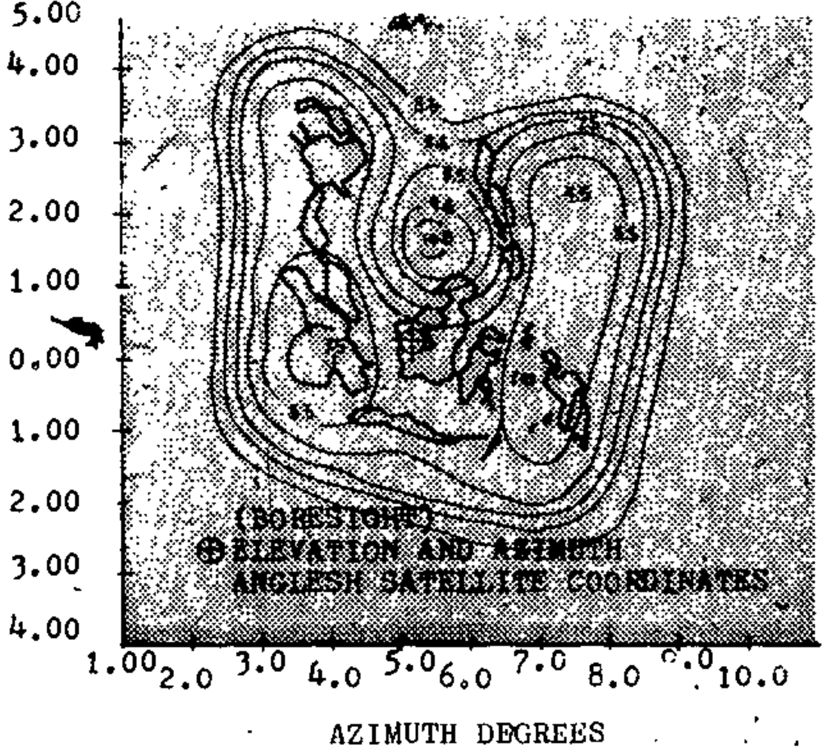
AZIMUTH DEGREES

FIGURE 2a: PALAPA EIRP CONTOURS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⊕ ELEVATION AND AZIMUTH ANGLESH SATELLITE COORDINATES
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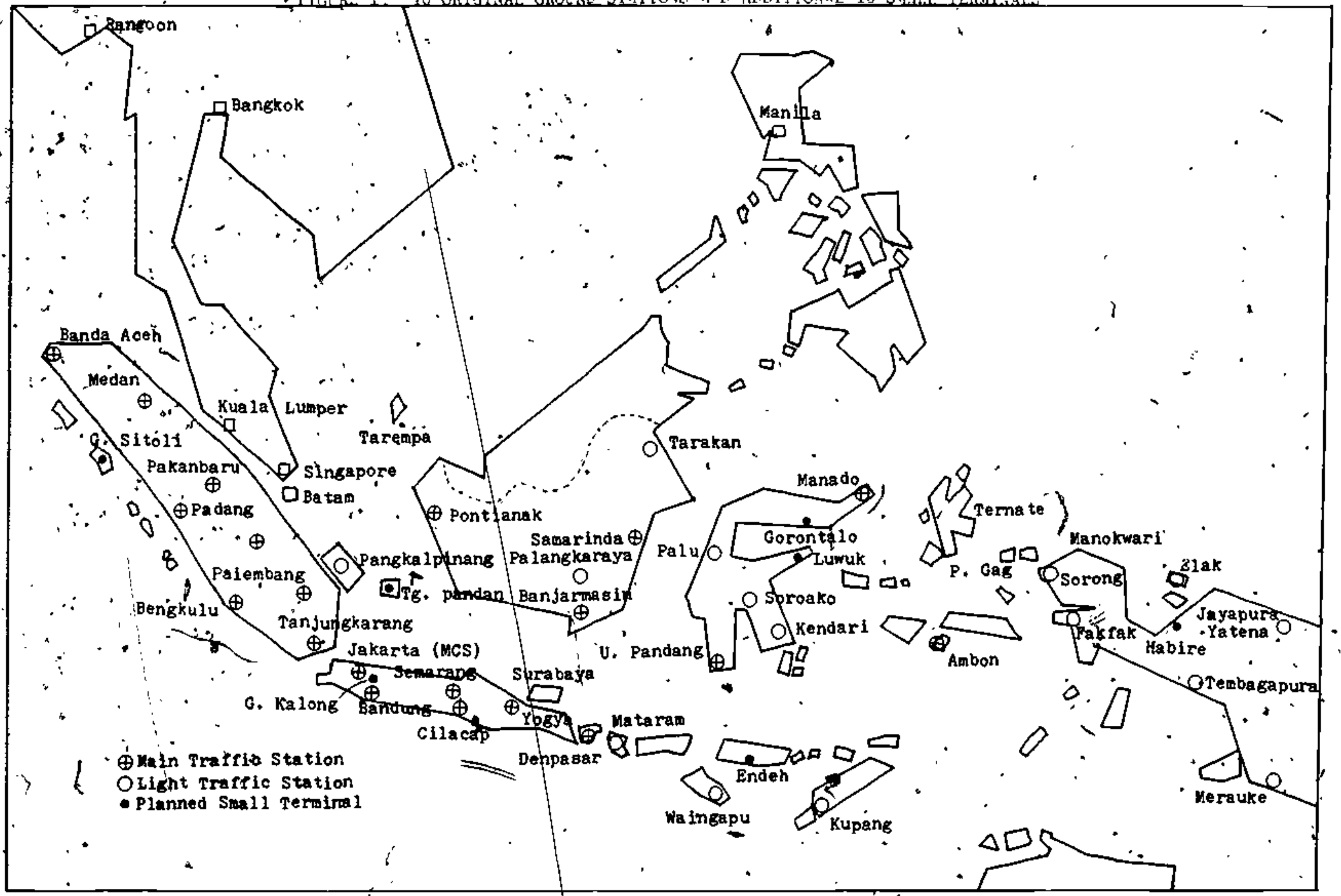
AZIMUTH DEGREES

FIGURE 2b: PALAPA G/T CONTOURS

FIGURE 1. 10 ORIGINAL GROUND STATIONS AND ADDITIONAL 10 SMALL TERMINALS


Rangoon
Bangkok
Manila
Banda Aceh
Medan
Kuala Lumper
Tarempa
G. Sitoli
Pakanbaru
Singapore
Batam
Padang
Pontianak
Tarakan
Manado
Ternate
Samarinda
Palangkaraya
Palu
Gorontalo
Luwuk
Manokwari
Pangkalpinang
Palembang
Tg. pandan
Banjarmasin
Soroako
P. Gag
Sorong
Biak
Bengkulu
Tanjungkarang
Kendari
Jayapura
Yatena
Fakfak
Nabire
Jakarta (MCS)
U. Pandang
Ambon
Semarang
Surabaya
Tembagapura
G. Kalong
Bandung
Yogya
Cilacap
Mataram
Denpasar
Endeh
Waingapu
Kupang
Merauke
⊕ Main Traffic Station
○ Light Traffic Station
● Planned Small Terminal

ACHIEVING APPROPRIATE SATELLITE SERVICE IN THE PACIFIC ISLANDS

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Abstract

The time may be right for the development of an appropriate satellite communication service for the Pacific Island nations. If such a service is to become a reality, it should be affordable and based on the genuine requirements of the people concerned. Involvement of one or more major nations will also be necessary in order to make the total system viable.

Genuine progress in any field requires the right resources, the right people, and -- at least equally important -- the right moment in time. We may be approaching that necessary combination in the long and sometimes discouraging effort to achieve appropriate satellite communication service in the Pacific Islands.

To define terms: the focus of this discussion is communication satellite service for the small Pacific Island nations, although it is recognized that the hardware which provides that service might also render similar or different service to other entities with other requirements. Furthermore, the specific institutional arrangements must be worked out by the parties who are directly affected, and no forecasts, proposals, or other second guessing arrangements will be found here.

Some principles toward such a development might be in order. First, while the system as a whole may need economic assurances from one or more of the major nations, the Pacific Island service should be designed for affordability by small island countries. A nation's telecommunication service is too important to exist at the whim of another nation's grant programs. Second, the service should be based on the total requirements of the people for whom the service is intended. It is useful but insufficient to have good telephone service between capital cities. A good circuit to Washington or Sydney or Paris can be a fine thing, but it can hardly compare in value to reliable communication with remote villages or other islands in one's own or neighboring countries, particularly in times of sickness or natural disaster. As operating principles, then, it seems reasonable to seek (a) an affordable service that (b) is designed to respond to the requirements of the users.

How might these requirements be determined? The statement of requirements must be acceptable to the user nations, and thus the mechanism for preparing the statement must be a matter for them to decide. It seems safe to guess, however, that it will not be necessary to conduct yet another round of detailed surveys and studies. Quite a lot is known about present Pacific Island communication systems and problems. Traffic will certainly increase when appropriate facilities exist, but projecting the curves for increased traffic loads will be a matter of cooperatively applying the experience and common sense of the carriers and affected governments. There has been enough experience and experimentation with satellite communication systems -- both operational and experimental -- that it would seem sensible for a small, reasonably objective working party established by the island nations to review the present traffic requirements, the lessons of the satellite experiments, and the projections of need by government and industry. Then the working party could prepare a recommended statement of present and future requirements and submit it to the respective governments. The result should be a general consensus which would be an adequate base for system responses by potential suppliers of the service. Then the serious negotiating concerning specific costs and tradeoffs could begin.

This negotiating inevitably would involve one or more major industrialized nation, as well as the island nations who would use the prospective service. The reason for this major nation involvement is straightforward: given the sparse populations and the limited present industrial base of the island nations, it is unlikely that a full satellite system can be devoted solely to their requirements and remain affordable. Furthermore, the Pacific Islands service will need some time to mature, and thus some initial subsidies or guarantees may be necessary in order to bring the system into being, regardless of its long-run affordability by the island nations themselves.

This of course raises the question of why the major nations now may be interested in helping to see that such a service is launched. Different countries may have different sets of reasons, but one might imagine the following agenda for the United States. First, the U.S. has formal obligations in the Trust Territories, Guam, and American Samoa. These obligations involve a responsibility to assist the process of development, and they also involve communication directly in the day-to-day administration of U.S. responsibilities. A new satellite service could be both desirable and cost-effective in carrying out the U.S. responsibilities of the next several years. Second, we live in an era in which the interests of developing nations may not be ignored by the major powers except at their own peril. Related to this general point is the lesson of the 1979 World Administrative Radio Conference, in which it was demonstrated firmly that world communication is not simply a technical matter to be negotiated by engineers. Any country which even acknowledges its world neighbors must regard the means of communication as a major resource, to be developed and managed with the care afforded other major resources such as water supplies, croplands, and mineral wealth. In the major world forums today the stakes are high, every nation has one vote, and we all need all the friends we can get. Third, it is sometimes not recalled that the United States has a historic commitment to assisting the development of communications in smaller nations. In 1961, in setting forth the space policy which led to the Communications Satellite Act of the following year, President Kennedy anticipated a world communications system, advancing with the technology to serve all parts of the globe efficiently, specifically including service where individual portions of the coverages might not be profitable. Technical assistance to newly developing nations was also a specific part of the President's satellite communications policy. This policy was echoed as recently as late 1978 when Ambassador Reinhardt announced at the UNESCO Twentieth General Conference "a major effort to apply the benefits of advanced communications technology -- specifically communications satellites -- to economic and social needs in the rural areas of developing nations." So there are three major reasons for a U.S. agenda of support for Pacific Islands satellite service: first, formal responsibilities in the area; second, the recognized interdependence of nations and the recognition of telecommunications as an important mutual resource; and third, a historical commitment to help others realize the benefits of the technology. Other nations may have other agendas that lead to the same conclusion for support, and it would seem reasonable to welcome interest from many quarters.

For the U.S. the Pacific Islands satellite development would be a continuation of work begun. No organization in the world has done more to advance the technology of satellite communication than the American space agency, and with its user experimentation programs on ATS-1 and -3, ATS-6, and CTS, NASA and other agencies of the U.S. government have specifically provided for programs of experimentation by developing nations as well as by domestic U.S. user groups. One result of this experimentation, combined with the operational experience of Intelsat and the Indonesian system, is that a realistic definition of a Pacific Island service is probably within reach.

In considering that mix of experimentation and operational experience, it would be easy -- but unwise -- to assign too little weight to the experimentation, particularly that conducted on ATS-1 and ATS-3. Thanks to the work of Martha Wilson and her colleagues, the importance of ATS-1 and ATS-6 in Alaska is well documented and well known. Not yet so well known, but perhaps no less important in the long run, is the role of ATS-1 in providing essential linkages within one of the world's truly international universities, the University of the South Pacific, which has headquarters in Suva and a constituency in a dozen nations of that region of the Pacific. And when many people in the Islands think of satellite communication, they think of PEACESAT, the long-running ATS-1 experiment that has provided informal and formal narrowband networks over the Pacific for many years. Why have several experimental networks -- primarily voice networks of uneven quality -- been so popular with their users over the years? Some observers have jumped to the conclusion that even a simple satellite like ATS-1 will be popular if it's free. To think that is to miss the point.

The real answer, however, is nearly as simple. ATS-1 is popular because it works. In the old Quaker phrase, it speaks to the condition of those who use it. In fact it is not free: while NASA provides the circuit time at no charge, the terminal equipment must be provided by the users. A signal of success is that even in many areas where money is very hard to find there is enough for the simple, rugged, reliable ATS-1 earth station, with its off-the-shelf parts and minimal power requirements. It doesn't provide video, but most of us don't need video for most things anyway. What it does provide is simple, reliable voice communication, rain or shine, as long as the generator works and the electronics don't get too wet.

It's no wonder, then, that the fans of ATS-1 (and its relative ATS-3) are finally forcing a closer look at requirements, and it's heartening to see signs of a more flexible approach by Intelsat, or the statement by Edgar Griffiths of RCA about regional networks that really are tailored to the requirements of their users.

Suppose a working group were to draw upon the experience, wisdom, and dreams of the Pacific Islands, preparing a solid consensus list of requirements; and suppose a working system were to result. What sort of system might it be? That which follows is no more than a first guess, presented in order to encourage thought about the actual requirements and the proper system.

In this hypothetical system, the list of requirements will be broad but not very flashy. It will include voice communication between villages and islands as well as between countries; it will include voice maritime and aeronautical communications; it will include provision for facsimile and slow-scan video where they are required. And it will have full-motion video for those areas that have the requirement and can bear the costs for origination, transmission, and reception.

It is easy to see that the resulting hypothetical system would be based on earth stations that are as simple, rugged, and inexpensive as they can be made. Services would be offered on a modular plan, starting with the simplest voice communication. Perhaps a very small island country could start with one audio channel, a party line connecting its islands and villages. For international traffic, simple connections should be possible via existing international systems, perhaps an Intelsat port serving that country or a region.

The very simplest earth station would be for receive-only audio, and as part of the hypothetical system it seems reasonable to include a system-wide audio channel operating 24 hours a day to provide regional weather forecasts, natural disaster warnings, etc. in the major languages of the Pacific. Some system administrative traffic and technical test signals may be put on this channel, too. One value of this channel, in addition to the information transmitted, would be that the village earth station operator can always know whether his receiver is healthy.

Countries which have greater requirements, either immediately or during the life of the system, could of course add modules of more sophisticated and expensive service.

Is such a service practical? In candor, nobody knows for sure. Small, inexpensive earth stations generally imply large, expensive satellites. Frequencies as desirable as those used for ATS-1 apparently will not be available. Total system costs depend on the total load of the system, and that in turn depends on carriers and customers beyond the Pacific Islands.

On the other hand, it is clear that the nations of the Pacific Islands, like emerging nations everywhere, recognize the importance of telecommunication. They know that they must have appropriate communication systems, and they know that it is the industrial nations that have the technology, the systems expertise, and -- until now, at least -- international command of the frequency spectrum.

Perhaps most important, there is a recognition by the Island Nations and by the major powers that none of us can take back the 200 years since Captain Cook sailed these waters. For better or for worse, we live together in this century on this planet. That does not mean that we all must be alike; it does mean that appropriate telecommunication is a common fundamental need.

How will this need be satisfied among the Pacific Island nations? Some possibilities have been suggested here. Perhaps the next step should be the development of that consensus statement of requirements. A useful signal from the U.S. and/or other major powers would be a modest grant that would permit interested Island nations to confer, establish their mechanism for stating requirements, and eventually conduct informed negotiations for service. It is gratifying that there have been informal expressions of serious interest by a number of parties. It may indeed be true that the right resources, the right people, and the right moment in time are at hand. Now the task is to be certain that the opportunity doesn't get away. That task is the responsibility of every person who shares the vision of a truly useful, appropriate, affordable telecommunication service for the Pacific Islands.

Large Scale Data Communication System Using Packet Switching Network

Teruyoshi Kawai and Yutaka Makita
Nippon Telegraph & Telephone Public Corporation (NTT)

Abstract

This paper describes an outline of a large scale data communication system using packet switching network, concepts for selecting and utilizing the packet switching network, and several points concerned with system design.

1. Introduction

This system is intended to furnish an on-line real time service of employment insurance and employment information, etc. Data terminals are installed in 750 places throughout Japan and center system is installed in Tokyo.

A packet switching network is used for connecting between data terminals and the center system. This commercial public packet switching services, developed under NTT auspices, is scheduled to cut over in 1979. This system replaces the current system which the Ministry of Labor has initiated in 1964.

Now, the design and development of this system is implemented by NTT under the guidance of Ministry of Labor. The installation of the Large Scale Front End Processor (FEP) and data terminals is carried out by NTT.

2. System Outline

2.1 System Configuration

This system, as shown in Figure 1, consists of data terminal equipments, FEP and several Host computers (HOST).

2.2 Center Equipments

(1) FEP & Host Roles

The center equipments consist of FEP and several Hosts.

FEP roles are as follows:

1) Message switching between data terminals and several Hosts.

2) Message collection and distribution for data terminals or Host.

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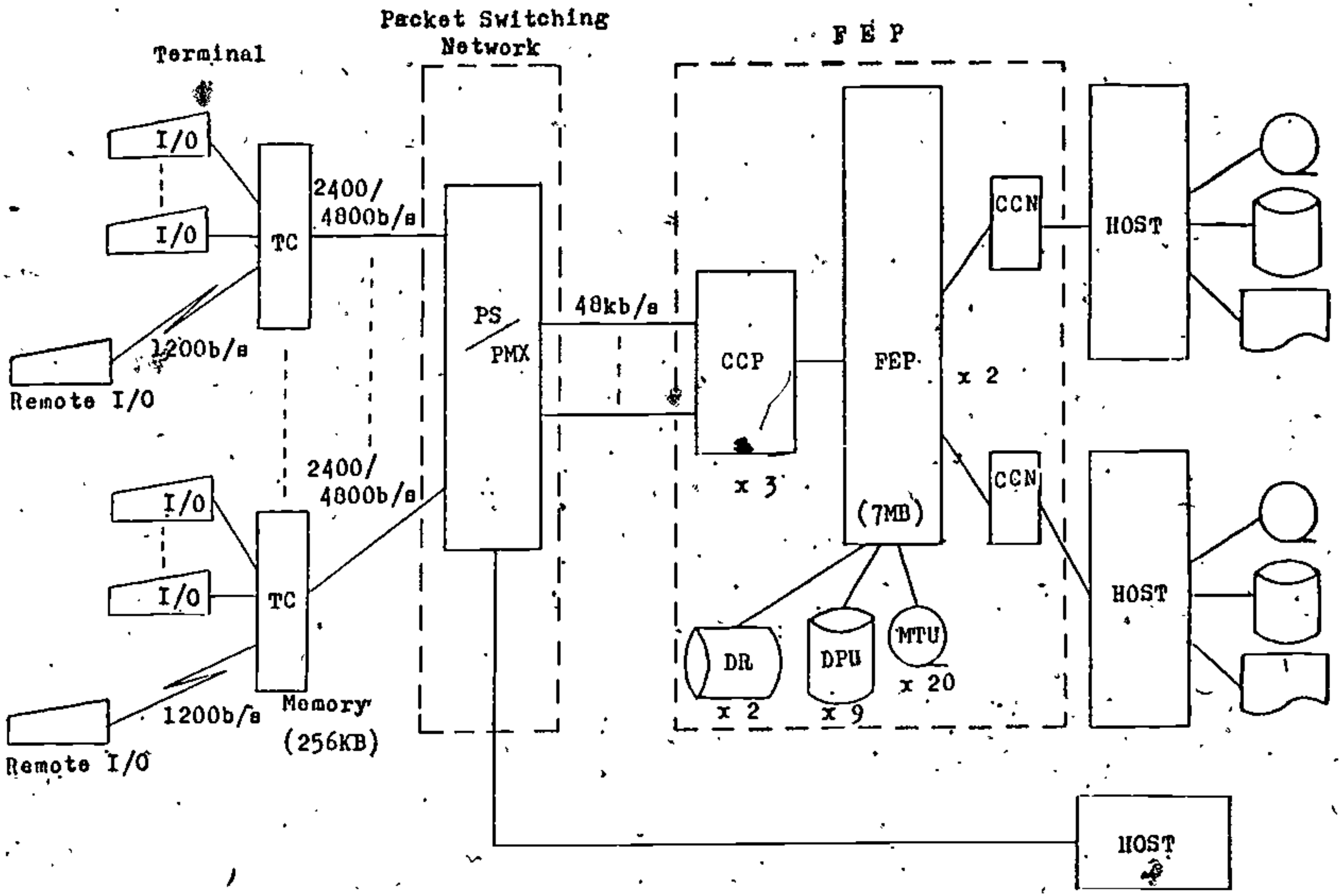
Terminal
Packet Switching Network
F E P
I/O
I/O
TC
2400/ 4800b/s
1200b/s
Remote I/O
I/O
I/O
TC
2400/ 4800b/s
1200b/s
Remote I/O
Memory (256KB)
PS / PMX
48kb/s
CCP
x 3
FEP
(7MB)
x 2
CCN
CCN
DR
x 2
DPU
x 9
MTU
x 20
HOST
HOST
HOST

Fig. 1 System Configuration

3) Message accumulation in case of data terminals or Host troubles.

4) Communication with packet switching network and data terminals.

HOST roles are as follows:

1) Job processing, such as employment insurance or employment information, etc.

2) Updating data base.

3) Communication with FEP.

(2) FEP Hardware Configuration

FEP forms a duplex system. One is for on-line service and the other is for the standby set and batch processing. FEP facility equipments are DIPS (Dendenkosha Information Processing System). FEP consists of Communication Control Processors (CCP), Gathered Magnetic Disc Pack Units (DPU), Magnetic Tape Units (MTU), Magnetic Drums (DR), Line Printers (LP), Card Reader (CR), Computer Connecters (CCN). Major hardware units are duplexed to obtain sufficient system reliability.

2.3 Data Terminal Equipment

In this system, data terminal equipments are Optical Character Reader (OCR), Printer (PR), Window Machine (WM), Line Printer (LP), Display (DISP), and Terminal Controller (TC). "Remote I/O terminal (R I/O)" system at little traffic places is utilized for efficient use of communication lines and saving cost of TC.

2.4 Network Configuration

In this system, packet switching network is used as communication lines. Communication speed of terminals is 2,400 b/s of 4,800 b/s in proportion to traffic. Data terminals are connected with the Packet Multiplexers (PMX) which are installed at seven large cities (Sapporo, Sendai, Tokyo, Yokohama, Nagoya, Osaka, Fukuoka).

Communication speed of FEP is 48 k b/s. FEP is connected with Packet Switch (PS). In addition to packet switching lines, leased circuits of 1,200 b/s communication speed are used between TC and R I/O.

Network configutation is shown in Figure 2.

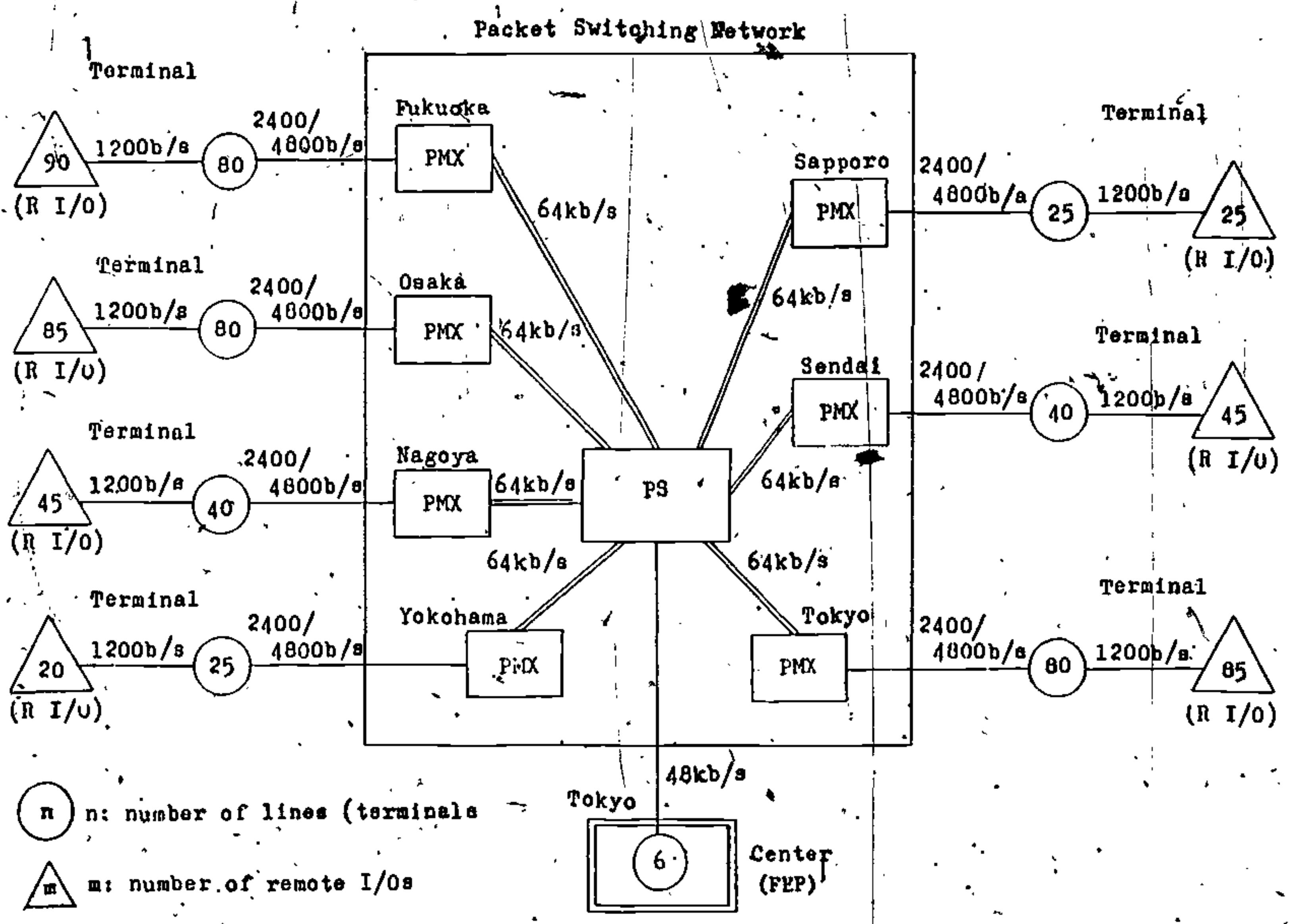
Packet Switching Network
Terminal
90
(R I/O)
1200b/s
80
2400/
4800b/s
Fukuoka
PMX
64kb/s
Terminal
85
(R I/O)
1200b/s
80
2400/
4800b/s
Osaka
PMX
64kb/s
Terminal
45
(R I/O)
1200b/s
40
2400/
4800b/s
Nagoya
PMX
64kb/s
PS
64kb/s
Terminal
20
(R I/O)
1200b/s
25
2400/
4800b/s
Yokohama
PMX
Sapporo
PMX
64kb/s
2400/
4800b/s
25
1200b/s
Terminal
25
(R I/O)
Sendai
PMX
64kb/s
2400/
4800b/s
40
1200b/s
Terminal
45
(R I/O)
64kb/s
Tokyo
PMX
2400/
4800b/s
80
1200b/s
Terminal
85
(R I/O)
48kb/s
Tokyo
6
Center
(FEP)
n
n: number of lines (terminals
m
m: number of remote I/Os

Fig. 2 Network Configuration

3. Concept for Selecting Packet Switching Network

In this system, the reasons of selecting packet switching network are as follows:

(1) The volume of traffic per terminal is comparatively little.

(2) 750 Terminals are located throughout Japan.

(3) Distance between terminals and the center is far, because the center is located at Tokyo.

(4) Message length is relatively short.

(5) The number of communication lines connected with the center is few because of using high communication speed (48 k b/s).

(6) Many of line concentrators or multiplexing equipments are not necessary which reduce network cost.

(7) Delay time in packet switching network is little.

For reference, the comparison of several network systems - - - packet switching network, circuit switching network and the leased circuits - - - is shown in Table 1.

4. Utilizing of Packet Switching Network

The utilization of packet switching network in this system is shown in Table 2.

4.1 Terminal Mode

Terminals in packet switching network are classified into Packet Mode Terminal (PT) and Non Packet Mode Terminal (NPT). PT has the function of assembling or disassembling packets. NPT does not have that function.

It was discussed to determine that the terminal mode in this system is PT or NPT, which uses High Level Data Link Control (HDLC) protocol. The reasons of selecting PT are shown as in Table 3.

4.2 Selection of VC or PVC

Virtual Call (VC) and Permanent Virtual Circuit (PVC) are basic service in packet switching network. It is possible to connect with any terminal in VC mode, though it is necessary for call establishment packets such as Call Request, Call Accepted, Clear Request, etc.

Table 1. Comparison - Network Configuration

Item (System Character)	Packet Switching Network	Circuit Switching Network	Leased circuit (Conventional network)
Relatively little traffic	Fit	Relatively fit	Unfit
Short Message	Fit	Relatively fit	Unfit
Long distance from terminals to center	Fit	Relatively fit	Unfit
Number of line connected with center	Few	Relatively many	Many
Communication lines cost	Inexpensive	Relatively Expensive	Expensive
(Ratio of cost) ***	(0.6)	(0.8)	(1)
Interface specification (Network protocol)	Complex	Simple	Simple
Error control in network	Provided between nodes	None	None
Transmission delay time	Present (little)	None	None

*** This comparison is based upon the following assumptions.

(1) Message length --- about 128 Byte

(2) Traffic --- about 10^8 transaction/year

(3) Number of terminals --- 370

(4) Concentrators and multiplexing equipments are used in case of the leased circuits.

(5) Tariff (unfixed) --- ¥0.7 ∿ 1.0/packet

Table 2. Utilization in this system

Item		Data Terminal	FEP (Center)
Communication speed		2,400/4,800 b/s	48 k b/s
Number of lines		370	6
Electrical and physical protocol	Physical condition	IS 2110	IS 2993
	Electrical condition	V.28	V.35
	Connected circuit	V.24 (X.21 bis)	V.35 (X.21 bis)
Link control protocol		HDLC-BA (X.25 LAP-B)	HDLC-BA (X.25 LAP-B)
Network control protocol	data transmission	X.25	X.25
Number of logical channels		2500	2500
Terminal mode		PT	PT
Connection mode		PVC	PVC

Table 3. Comparison - NPT and PT

Item	NPT	PT	Comments
Utilization of logical channel	Impossible	Possible *	* Simultanous communication with several terminals
FEP software	Relatively many	Little	FEP most communicates with several I/O at same terminal simultaneously
Terminal controller software	Equal	Equal	
Interface specification	Flexible (HDEC only)	Restrictive	User can design protocol free
Flexibility of protocol in future (Standardization)	Flexible	Restrictive	
Communication cost	Relatively expensive	Relatively inexpensive	According to tariff

The other hands, in PVC mode the connected terminal is always specified when a calling terminal calls request. Therefore, it is not necessary for call establishment packets.

In this system, PVC mode is selected as shown in Table 4.

Table 4. Comparison - PVC and VC

Item	PVC	VC	Comment
Correspondence of LCN to terminal I/O	Simple	Complex *	* Correspondence of LCN to terminal I/O changes whenever call is established. Therefore, FEP software is complex. In PVC that correspondence is not necessary
Diagnosis of communication lines or terminals from center side (FEP)	Easy *	Difficult	
System design concept on using communication lines	* Same	New design	* Design concept is the same as concept using leased circuits
Message exchange from a terminal to another terminal	* Impossible	Possible	* In this system, message exchange is dealed with FEP.

4.3 Logical Channel

Logical Channel (LCN) can be used in PT. In this system, many LCNs correspond to terminal I/O devices because FEP software and TC software can be simplified.

4.4 Optional Service Facilities

There are many service facilities of packet switching network such as Direct Call, Abbreviated Address Calling, Closed User Group, Line Identification, Lump-sum Center Payment, etc.

Those services except Lump-sum Center Payment are not necessary in this system because "PT" and "PVC" is selected.

5. Software Design

5.1 Protocol Hierarchy

(1) Link control protocol

Link control protocol is High Level Control Procedure (HDLC-BA : X.25) between network and terminals.

(2) Network control protocol

This protocol is packet transmission procedure (X.25) ..... DT, PR, PN, RQ, RF packet, etc.

(3) Application level protocol

This protocol is formed in this system, and consists of following items:

1) Message length

2) Send sequence number of message (each I/O)

3) Terminal number

4) Input or output identifier

5) Message kinds ----- inquiry, message exchange, message collection, message distribution, command, etc.

6) TC-FEP control command

a) System control command --- call request (TC & I/O), TC start and termination, center on-line start and termination, etc.

b) Recovery control commands --- FEP restart, Host failure and restart, etc.

7) Detail kinds of Message

(4) Text control information and text ..... slip number, format control, etc.

5.2 Several Points on System Design

(1) Message Loss Recovery

Message loss recovery is important item on system design. Error recovery technology such as transmission error control (...HDLC), packet loss recovery and packet flow control (End-to-End control), is carried packet switching network. However, packet loss in packet switching network is occured extremely little. Moreover, in case of terminal (TC or I/O) and center (FEP or HOST) failures, messages are possibly lossed.

In order to recover loss message, sequence number is given to messages in the application protocol of this system. (Ref. 5.1 Protocol Hierarchy)

(2) Diagnosis of Communication Lines or Terminal Troubles

Communication Lines between FEP and TC are not connected directly in packet switching network. Therefore system designer must give care to the diagnosis and the judgement of communication line and terminal troubles.

The function of "Remote Loop 2" which is provided by packet switching network is very useful tool. This fuction is that by looping physically at DCE, the message (EQ packet) which the center (PT) sends to the terminal via packet switching network, returns to the center (PT) again.

(3) Sending Failure Message

Many terminals are installed in this system. Therefore, it is necessary to send failure or recovery messages from the center to all terminals in failure of FEP.

6. Conclusion

This system service is scheduled to cut over in 1981. At present, design and development is continued. The following various system tests are scheduled.

Data terminal ~ Packet switching network,
FEP ~ Packet switching network,
Data terminal ~ FEP or HOST, etc.

7. Acknowledgement

The authors express their thanks to the many people who participated in this project.

STANDARDIZATION OF PROTOCOLS FOR PACKET SWITCHED DATA NETWORKS

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Abstract

The International Telegraph and Telephone Consultative Committee (CCITT) issued its first Recommendation (Rec X25) relating to Public packet switched data networks in 1976. In 1980 the CCITT is due to ratify several more important Recommendations which will enable a world wide standardized packet switched data service to be implemented.

The various Recommendations issued are referred to, but particular reference is made to the efforts of the various common carriers who are implementing or planning to implement packet switched data services, to ~~achieve~~ achieve a common sub-set of protocols which will apply on all networks wherever they are implemented and which should thus ease the problems of interworking and the connection of customers to these new public networks.

Evolution of Packet Switching

Packet switching involves the handling of discrete blocks of information and switching them as entities in a series of steps across a network from sender to receiver. The earliest proposals for a packet switched system were the result of a study into a combined voice and data network which could continue to function even if some switching nodes were made inoperable due to enemy action (1). Whilst the application of the concept of packet switching to combined voice and non-voice services generally in a military environment is now once again being actively pursued, the greatest progress has been in its application for data communications in a business environment.

The best known of the early packet switched data networks were those of the Advanced Research Projects Agency (ARPA) (2) in the USA, and of the National Physical Laboratory (NPL) (3) in the United Kingdom whose networks were brought into service in 1969 and 1973 respectively. Because of the interest raised by these and other research based networks the British Post Office (BPO) decided in 1971 to implement in conjunction with its customers a public Experimental Packet Switched Data Service (EPSS) (4). Due to the lack at that time of any recognized standards for a public network considerable effort was made by the BPO to include in the network design as many possible varients as were feasible and to include interworking facilities to the switched telephone and telex networks to enable simple non-intelligent terminals to obtain low cost access to host computers. Full maintenance, network management and billing facilities were also incorporated. For various reasons delays were inevitable and the service based in effect on seven nodes was not eventually brought into commercial use until early 1977. By this time

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several other common carriers had also decided to introduce public packet switched data services and by early 1980 networks in the USA, Canada, France, Spain and the United Kingdom will be in full operation together with a network - EURONET (5) - covering the nine member countries of the European Economic Community (EEC).

In December 1978 the first international packet switched data service outside N. America was opened linking the networks in the USA (Telenet and Tymnet) with the United Kingdom's (IPSS) which itself will be connected to the national service PSS which is to supersede EPSS in March 1980. Other international links are also expected to be established during 1980 including the linking of EURONET to N America and by 1984 a world wide packet switched data service seems now to be a realizable objective.

The Need for Standards

The key to the interconnection of any telecommunications service on an international basis is the establishment at an early stage of internationally agreed standards or Recommendations as they are generally known. These Recommendations need to define not only the services and facilities to be provided but also the methods to be used to set-up and clear-down calls, the routing of traffic, the charging principles to be adopted, the numbering plan and network interworking rules for both terrestrial and satellite links. The actual Recommendations as determined by the CCITT need to be implemented by each and every common carrier if a world wide, as distinct from a national service is to be implemented. Unlike the telephone and telex services a wide range of terminals can be connected to any data service and this thus necessitates Recommendations being established for the interfaces between these terminals and individual networks. These interface Recommendations are generally the most difficult to finalize since they involve not only the common carriers but also the data processing industry and the International Standards Organization (ISO).. To help resolve responsibilities in the interface area the CCITT has issued (6) Recommendation A20 which defines the responsibilities of the CCITT and other international organizations for the standardization of data transmission.

Whilst standards for public packet switched data services are essential if international interworking is to be achieved it is equally true that standards are also necessary to enable information to be exchangesd between data terminals once a "call" has been established. Unless these latter standards can be defined then the amount of traffic flowing and the pattern of traffic could be effected leading to possible reductions in revenue to the common carriers. Progress in this area needs to be such as to ensure that future computer systems conform to standards to a sufficient extent to permit a variety of types of intercommunication between such systems irrespective of a particular system supplier. This concept is known as "Open System Interconnection" whereby any computer program, terminal, or user may meaningfully intercommunicate with any other. Studies are proceeding in both ISO and the CCITT the approach being firstly to define a general model which would be application and implementation independant and then secondly to agree Recommendations for specific applications and system components which would be implementation dependent, in conformity with the general structure of the model. The ISO has identified a 7-level structure (7) for the full definition of user-to-user communications through a switched communications network and this is shown in Fig. 1.

HIGHER LEVEL PROTOCOLS

LEVEL NUMBER	FUNCTION	EXAMPLES	RESPONSIBILITY	
7	APPLICATION	DATABASE TIME SHARING ELECTRONIC FUNDS TRANSFER ORDER ENTRY	ISO	NOTE 2
6	PRESENTATION CONTROL	DATA STRUCTURE FORMATS VIRTUAL TERMINAL PROTOCOL FILE TRANSFER PROTOCOL	ISO	
5	SESSION CONTROL	SESSION MANAGEMENT	ISO	
4	TRANSPORT END-TO-END	NETWORK INDEPENDENT INTERFACE	ISO	
3	NETWORK CONTROL	X25 LEVEL 3	CCITT	NOTE 1
2	LINK CONTROL	X25 LEVEL 2	CCITT	
1	PHYSICAL CONTROL	X25 LEVEL 1	CCITT	

STANDARD TRANSPORT SERVICE

NOTES: 1. ISO for private networks
2. CCITT for Network Services (ISO collaboration)

FIG 1 - ISO 7-LEVEL MODEL

The Evolution of Standards

Within the CCITT Recommendations are ratified or amended at the end of each Plenary Period of four years. The first Recommendations relating to Packet Switched Data Services were agreed in 1976 (8) and published in 1977. Important Recommendations issued at that time were those relating to:-

User Classes of Service - X1
User Facilities - X2
Interface for Packet Mode Terminals - X25
Hypothetical Reference Connections - X92
Network Parameters - X95
Call Progress Signals - X96

The actual issue of these standards depended to a great extent on the efforts of those common carriers namely Bell Canada, French P.T.T., BPO, Telenet and NTT (Japan) who were at that time implementing or had implemented public packet switched data networks an[illegible]o the work of the CCITT Special Rapporteur - Halvar Bothner-By of Nor[illegible] In the normal spirit of co-operation found within the CCITT many compromises had to be made to reach agreement which in the case of the BPO meant the EPSS protocols being abandoned as non-standard and in the case of other carriers necessitating major modifications to implemented or planned systems which in some cases delayed their opening.

Within Europe an added impetus was given to the standardization of packet switched data services with the decision by the Commission of the EEC to place a contract collectively with the nine Community based Telecommunications Administrations for a packet switched data network, EURONET, to enable users within the Community countries to gain low cost access to scientific, technical and socio-economic data. One of the stipulations in the contract was that the network would be implemented in accordance with international standards, in so far as they were available, and would be enhanced in stages to keep pace with future standards. The Commission subsequently placed contracts with commercial companies to develop user-to-user procedures for search and retrieval so that all users might use the same procedures irrespective of the data base being accessed.

When EURONET was being planned it was realized that low cost access would only be achieved if access could be given to the network via individual national switched telephone networks and the data communications group (CD) of the Conference of European Postal and Telecommunications Administrations (CEPT) was requested to specify the necessary standards to apply for such interworking. These standards were defined as the EURONET Switching Protocol (ESP) 20. Because the CEPT recognized that a European standard in isolation would not in itself guarantee a world wide standard the proposals, which in effect were implemented on EURONET, were discussed within the CCITT and in 1977 were accepted as Provisional Recommendations albeit with some modification. The Recommendations agreed in 1977 and issued in 1978 (9) were namely:-

Packet Assembly/Disassembly Facilities	-	X3
Interface for character mode terminals accessing a PAD facility	-	X28
Information exchange between a PAD and a Packet-Mode Terminal	-	X29

At the time Recommendation X25 was published the Level 2 Link Access Protocol (LAP) was based on one of the High Level Data Link Control (HDLC) procedures which was in the course of being standardized by the ISO, namely the two-way simultaneous Asynchronous Response Mode (ARM). Subsequent studies within CCITT and ISO indicated that the preferred Link Access Protocol should be based on the Asynchronous Balanced Mode (ABM) now known as LAP"B". A revised version of X25 was thus issued by the CCITT in 1978 (9) including not only the LAP"B" version but also further clarification of other parts of X25.

It is currently anticipated that EURONET will be brought into line with X3, X28 and X29 and incorporate LAP"B" as well as LAP of X25 by mid-1980 Other networks in the world expect to do likewise but for some networks not yet in operation only LAP"B" will be offered it being recognized as the single standard for future networks.

Because of the need to effect international interworking, standards for a world wide numbering plan and for internetworking needed to be established and the CCITT issued in 1979 (10) Provisional Recommendations for:-

International Numbering Plan - X121
Interworking between Packet Switched Data Networks - X75

Once again these are being implemented on EURONET and on other networks as necessary and their availability should expedite the provision of a world wide service. An indication of the status of standards and Recommendations for packet switched data services has been published in recent articles (11) (12).

There has been criticism that the standards have been prepared too early, that they are incomplete, and are implemented differently on the various networks (13). Some have even opposed standards on the grounds that they inhibit development. However, an extensible approach which does not inhibit development is desirable and there is now an urgent need for existing published Recommendations to be finalized as far as is possible so that the CCITT can ratify them at their Plenary in 1980. There is also a need to bring existing networks into line with the then agreed Recommendations and for new networks to be implemented in accordance with these Recommendations. Of particular interest are the further defining of Recommendations X3, X25, X28, X29 and X75 by March of 1980 so that the considerable number of packet switched data networks now being planned can provide a common sub-set of facilities and common standards and thus ease the problems of interworking and simplify user connection. The current situation in regard to the plans of European Administrations for packet switched data services is shown in Fig. 2.

Country	Date of Service
Austria	1982*
Belgium	1981
Denmark	1982*
Finland	1983*
France	1978
F.R. Germany	1980
Ireland	1982
Italy	1982
Netherlands	1980
Norway	1980
Portugal	1981*
Spain	1973 (Non X25) 1980 (X25)
Sweden	1979
Switzerland	1982
United Kingdom	1977 (Non X25) 1980 (X25)
EEC (EURONET)	1979

*under study

FIG. 2. PLANS OF EUROPEAN ADMINISTRATIONS FOR X25 BASED PUBLIC PACKET SWITCHED DATA NETWORKS

Future Trends in Standardization

Recently several of the common carriers who have or will shortly open packet switched data services have recognized the need to bring their particular implementation of X25 into line with each other. Some of the networks were introduced when few standards existed and others will become operational just as the CCITT agrees revised Recommendations as can be seen from Fig. 3.

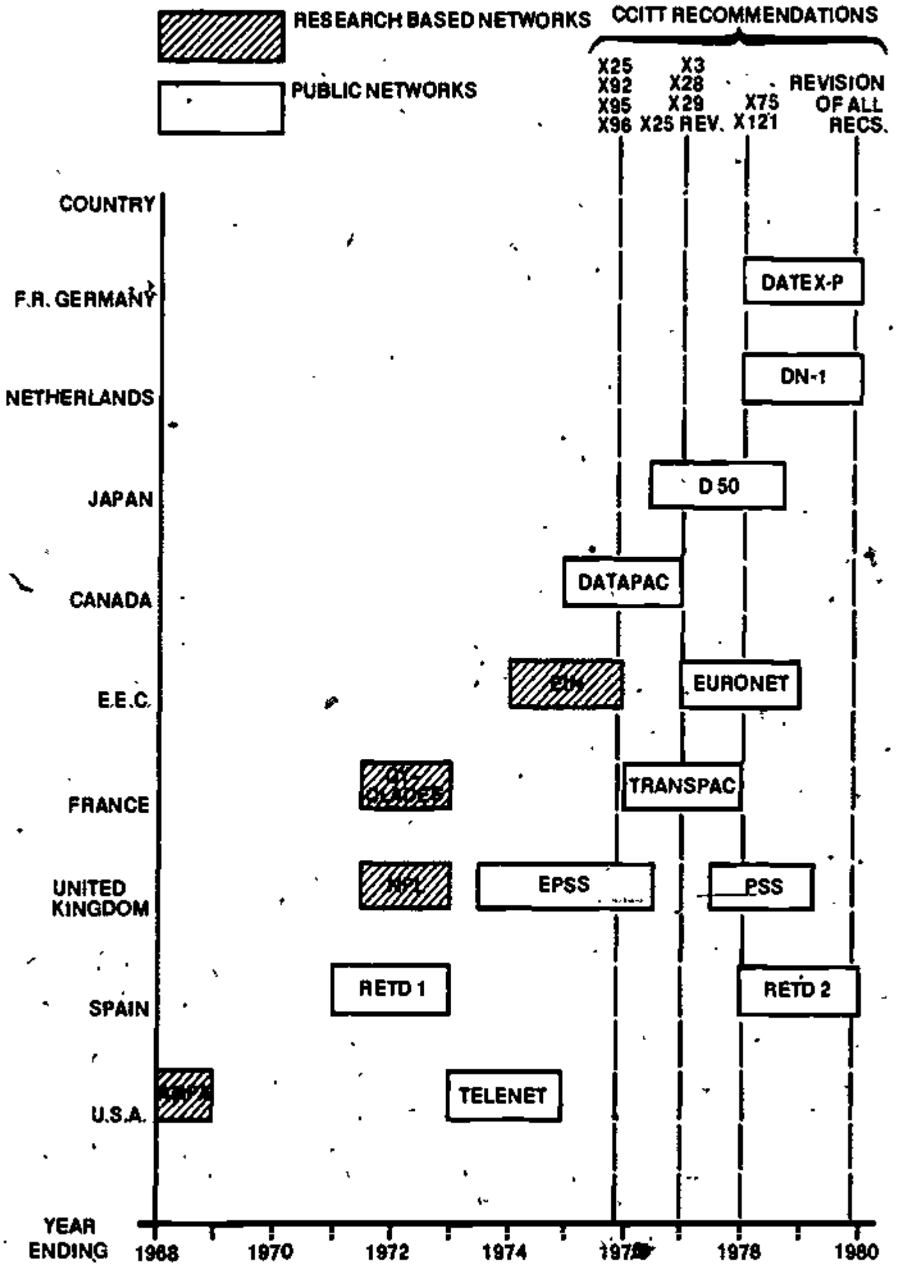

FIG. 3. RELATIONSHIP BETWEEN DESIGN PERIODS OF NETWORKS AND ISSUE OF CCITT RECOMMENDATIONS

It now seems likely that as far as X25 is concerned all networks could from early 1981

(a) Implement all facilities designated 'E' for essential in Recommendation X2 as specified in 1980. This could include a redefined flow control parameter selection facility, and a throughput class selection and negotiation facility

(b) Allocate logical channel 0 for all single channel DTE's

(c) Standardize all data fields to an integral number of bytes in length

(d) Offer LAP'B' although some may not offer LAP

(e) Include facility and Address Fields in Call Connected packets sent by the DCE

(f) Rationalize the P(R) significance aspects to permit both local and end to end significance

(g) Implement a 180 second network timeout for incoming calls.

Further additions are also envisaged for X3, X28, X29, X75 and X121 with a view to their inclusion in the next issue of CCITT Recommendations which is expected to be published in early 1981. Unfortunately however it may not be feasible in X25 or X75 to define a multi-line operation and a Recommendation for this facility may have to await discussion in the next Plenary Session of the CCITT 1981-1984, although if agreement can be reached a Recommendation could be issued in 1981 or early 1982 under the accelerated procedure of the CCITT.

Conclusions

Over the past eight years the CCITT has made considerable progress in the standardization of Recommendations for packet switched data networks. Unfortunately progress within the ISO on user to user protocols has not been as fast but there is now a keen interest being shown in standards by users themselves which could lead to user specified standards which the data processing-industry may find itself having to adopt.

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"User Applications of Canada's Datapac Network"

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Canada is a country with 23 million people unevenly distributed throughout some ten million square kilometres of territory. About 80 percent of this population is, however, concentrated within a very narrow corridor 4500 kilometres long -- but only 200 kilometres wide -- just north of the Canada-U.S. border. Besides this geographical dispersion, there are severe natural barriers to communications within the six time zones. Yet virtually every home and business in the country is connected to Canada's vast telecommunications network. The TransCanada Telephone System, a consortium of the major telephone companies, has approximately 86 million miles of copper wire installed and over 52,000 route miles of high-capacity microwave system, plus advanced satellite communications. Through The Computer Communications Group of TCTS, Canada was the first country in the world to put a nationwide digital data transmission system, The Dataroute, into commercial operation. And similarly, CCG introduced Datapac, Canada's first packet switched data communications network. This paper describes CCG's development of user-oriented packet switched services and some specific Datapac applications.

The end-users of data communications have been intimately involved in virtually every stage of the design, development, engineering, installation and application of Canada's Datapac packet-switching network, one of the first systems in worldwide commercial operation.

The basic network and individual services have been designed to meet the computer-communications requirements of our customers -- whether they are large government departments, financial institutions, oil companies, academic or public organizations, or businesses in a wide range of industries, from time-sharing to retail shoe-selling.

Datapac has been exceptionally successful both in terms of the number of customers on the system, a number which is continually increasing, and in revenues for the telephone organization in Canada, the TransCanada Telephone System. This acceptance in the marketplace is a direct result of the dialogue and interaction with users, including manufacturers, every step along the way.

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We were anticipating practical user needs right from the beginning, when, in January 1974 TCTS first announced plans to build an intelligent network for data communications, using packet switching technology. In October 1974, further plans for the network, to be called Datapac, were announced. And, a month later, the first draft of the Standard Network Access Protocol, the essential machine language standard for packet-switched data communications, was published. This document was circulated very widely to manufacturers, users (both customers and non-customers), universities, international standards organizations, carriers, regulatory agencies and other concerned organizations. A great deal of feedback was received which was integrated into the final actual standard.

To connect low volume inquiry/response terminals to data bases, an initial service called Datapac 1000, was actually in service from 1974 using interim technology.

During this period of development, our marketing forces were very active in explaining packet switching theory and the practical advantages to the potential market place, transmitting information and absorbing data requirements in a constant market research process. Benefits such as low cost, with charges based on the amount of data transmitted; high accuracy; reliability; and the efficiencies of a shared, universal packet-switched network were highlighted for users.

These inherent advantages of packet switching technology form part of the decision criteria which users take into account when evaluating data communications services. Because Datapac is a shared, public network, this allows efficient sharing of facilities over a much broader universe than either private systems or shared private networks. In addition, communications on an international basis will be possible as public packet networks throughout the world interconnect. And because Datapac is built around a standard protocol, communications between formerly-incompatible systems and different manufacturers equipment is becoming possible.

Datapac offers a high degree of accuracy, with virtually error-free data transmission as a result of three levels of error control built into the network:

1) The first level occurs on the access line where the Frame Level Logical Interface of SNAP ensures that user data from a SNAP access line is transferred to the network as error-free as possible. Error detection is handled by a Cyclic Redundancy Check (CRC) field in the user data link control procedure and error correction is handled by re-transmission.
2)The second level occurs within the network itself -- data transmitted on the internodal trunks is also protected by a CRC, as well as by an end-to-end software checksum, which are re-calculated at every node. Because the checksum and the CRC apply to both the header and the data of the packet, they prevent both the delivery of incorrect data as well as delivery to an incorrect location.
3) The third level occurs in the end-to-end sequential numbering of packets within Datapac, which enables detection of out-of-order or missing packets between source and destination nodes.

Rates were filed in November 1976 with the Canadian Radio-Television & Telecommunications Commission (CRTC) and other appropriate regional (provincial) regulatory agencies. Datapac Serving Exchanges (DSEs) were established in 53 Canadian communities across the country to provide a nationwide intelligent network.

In our assessment of the Canadian computer communications environment, the order of our priorities determined the development of specific packet-switched network services. First of all, we wished to provide basic access to the network for intelligent terminals and computers with X.25 capabilities. At the same time, we wanted to offer Datapac access for the large body of asynchronous terminals. We identified a later requirement to reach the retail and point-of-sale market, which includes electronic cash registers and many other terminal devices. Because of the massive population of 3270-type terminal users, this was a key candidate for a packet-switched network service, as was the overall remote batch market.

These are the markets we initially identified as important in Canada -- they are probably significant in other countries, too. Now, I'll describe how we have aimed Datapac services to meet the needs of users in those areas.

The first two packet-switched services were called Datapac 3000 and 3101. Datapac 3000 allowed intelligent devices, such as computers, to be connected with the network by means of the SNAP protocol, compatible with X.25, the internationally approved protocol for accessing packet switching networks.

The other initial service, Datapac 3101, connected non-intelligent asynchronous teleprinter-type terminals to the network by means of a Network Interface Machine (NIM) which supplies the intelligence to packetize data for transmission over Datapac to the appropriate computer, and depacketize return data traffic for presentation to the terminal.

Both services, even before commercial implementation, were being used by actual data users in internal field trials by Bell-Northern Research and Bell Canada's Corporate Systems Organization (CSO), one of the largest computer facilities in the country.

The network was officially available on a commercial basis when Datapac rates were finally approved on June 14, 1977. Of course, CCG had been working with various organizations for some time, with trial installations operating for a number of data customers.

For these first customers and, in fact, for all potential users, the reduction in data communications costs by up to 70 percent, depending on usage and system configuration, is one of the very attractive benefits of Datapac. This, along with the assured accuracy and reliability, has allowed organizations not previously data users to get into computer communications economically for the first time. And it has enabled other sophisticated customers to develop innovative new applications of computer communications for their company or for their clients.

Network reliability is always another prime customer consideration. For Datapac, TCTS has an availability objective -- which we are meeting -- of 99.80 percent. This is a result of (a) standby equipment; (b) the provision of alternate routes through the network; (c) sophisticated network monitoring and control systems (made economically feasible through sharing); (d) the intelligence of the network which can monitor its own performance and correct instances of deterioration -- often before the user is affected.

To maintain this high level of performance, a National Data Control Centre in Ottawa provides network surveillance for TransCanada Telephone System member companies and is manned 24 hours a day, 7 days a week. Datapac network surveillance responsibilities of the NDCC include alarm surveillance, network control and software changes, which are accomplished through the use of the National Control Centre Node, a unique node within the network. All alarms and billing information are collected in this node and transmitted to the host computer.

Early on in our planning, we recognized that industry-oriented and application-specific systems were becoming increasingly important to the user.

High on our market priorities list was the retail environment, an industry with extremely high data communications potential because of the pervasiveness of individual terminal outlets right down to the consumer level. By allowing Electronic Cash Registers (ECRs), ECR concentrators and other point-of-sale devices like credit check pads to access the packet switching network and tie into a host computer, a data communications service would have real business value to the organizaions involved.

Accordingly, we developed Datapac 3201, an access service supporting buffered, pollable, asynchronous terminals operating under the ISO poll/select asynchronous transmission line protocol. It uses NIMs to link these terminals to the network, with no special hardware or software required. The link between the Datapac network and the host computer is provided by Datapac 3000 service. Typical on-line, real-time applications of Datapac 3201 include data collection at the point-of-sale for retail accounting control, inquiry/response systems for credit verification and inventory control. Terminals supported include: NCR 28/125 ECRs NCR 751 digital concentrator; NCR 724 ASCII Communications Interface; TRW 4234, 4235 & 4236 ASCII Communications Interface; NCR 2150 series of POS terminals and NCR 726/255 POS system.

For some smaller firms -- such as a florist chain linking several locations via the network -- which were involved in field trials of Datapac 3201 service, this was an entirely new venture in data communications. For others, it was an enlargement of existing capabilities and a chance to gather and use management data, such as inventory information, in more of a real-time fashion.

Similarly, at this time we introduced another application-specific service which was intended almost exclusively for the consumer loan industry. Called Datapac 3203 in our numbering scheme, this is an access service supporting buffered, pollable, asynchronous terminals operating under an enhanced IBM 2740 mod II transmission line protocol, linking the terminals to the network through NIMs.

One of the realities of computer communications in Canada is a direct result of our geographical position and economic-social-political interrelationship with the United States. The existence of multinational corporations and companies doing business in both countries dictates the necessity for a great deal of transmission of data across the border. And data users in our marketplace, to fulfill their organizational goals, require efficient international computer communications services which take advantage of the latest technology -- packet switching.

So we developed appropriate hardware, software and standards which would allow interconnection between Datapac and packet switched networks operating in the U.S. In January 1978, TCTS filed rates for connection with Telenet and TYMNET, interconnection which allowed subscribers in more than 100 cities in the U.S. to access host computers and terminals in 55 Canadian Datapac Serving Exchanges. The key to the linking of these packet networks was the acceptance and implementation of agreed-on international standards based on the already-approved X.25 protocol.

Datapac/Telenet and Datapac/TYMNET were the first commercial linkings of X.25 packet networks -- although we had achieved this before on an experimental basis. We are now working with other overseas carriers, through Teleglobe Canada, the Crown corporation chartered to provide overseas telecommunications services, to introduce links between Datapac and European packet switched networks.

Datapac International Service to Hawaii is now available through your DASNET packet switched network, provided by the Hawaiian Telephone Company through a direct connection to Telenet in the continental U.S.

It was estimated that there were approximately 13,000 IBM 3270-type terminals operating in Canada, used widely in private line applications such as insurance networks for policy and claims processing, the financial industry for credit verification and manufacturer dealer networks. So from a strategic view point we felt there was a real market demand for a Datapac service for these terminals. Certainly, the large population of 3270-type terminal users also wanted to achieve the cost, performance and flexibility benefits of packet-switched facilities without costly private system implementation.

Our Datapac 3303 access service, introduced in February 1979, allows 3270-type data terminals (using the Binary Synchronous Communications Protocol) to access host computers over the national network. This would include support of terminals like IBM 3270, CCG's own Vucom 2, Courier 270/275 and Sycor 290.

Typical applications achieved an average response time of three seconds, which made Datapac 3303 very attractive to users with response time-critical requirements.

In addition, the average 3270 user would experience savings of around 30%, with some users saving up to 45% over existing private-line systems.

For example, on one inquiry/response and data entry type of application for a typical TCTS customer, a manufacturer in 16 locations, the cost for a Datapac 3303 system was $16,072 -- versus $21,946 using a traditional digital service -- a saving of 27%. Similarily, a time-sharing provider's network configuration using Datapac 3303 was $13,436 -- a 32% saving over the estimated $19,712 cost via private-line data facilities.

Both Datapac 3303 and our most recently-announced service, Datapac 3304, are very important access services designed for specific applications in the high-volume synchronous remote batch and data collection market. Datapac 3304 provides support for multi-leaving HASP remote job entry terminals and computers. In addition to addressing the immediate needs of specific existing terminals (and users), the related interfaces provide access to packet networks for many other synchronous intelligent devices such as minicomputers performing data collection or file transfer functions.

Because of this, considerable dialogue was carried out with potential customers, manufacturers, other network providers, front-end suppliers and software houses. Items addressed included the interface protocol specifications and how end-to-end status and control information should best be handled by the network and the user.

As described, we have designed and introduced a variety of packet-switched data communications services over Canada's Datapac network, keeping in mind not only the technical possibilities but also how any technological improvements in computer communications would be put to practical use by data users. To bring this into down-to-earth terms, let me give some specific examples of Datapac applications by firms in greatly divergent industries and with completely different needs.

Kinney Shoes is the number 1 shoe retailer in Canada, and part of the U.S. Kinney Shoes/F.W. Woolworth/Woolco organization. Even before the announcement and filing of Datapac 3201, the service designed to link electronic cash registers and POS terminals to host computers over Datapac, we were involved in detailed discussions with EDP and general management people in this organization. At the same time, we were working with a manufacturer on the development of appropriate Network Interface Machines (NIMs) which could integrate the SNAP/X.25 protocol so as to interconnect ECR terminals and host computers over the packet-switched network.

This was a time-consuming and intensive process. We had some delays and implementation difficulties, but Kinney Shoes is now operating over Datapac, with 106 stores across Canada on the system. This is an example of an application of data communications which would not have happened, or at least not for a considerable time, if it were not for packet-switched data communications. Datapac represented to Kinney Shoes a virtual cost/saving of 60% over a dedicated, private line system. At the cost for traditional data communications services, however, the organization was not about to implement such a system. But with the reduced costs of Datapac, it was practical and cost-justifiable to obtain sales and inventory information using computer communications.

In the time-intensive world of retailing, the immediacy of information can be crucial to profitability. Utilizing data communications, Kinney Shoes have streamlined procedures: stock goes immediately where it's needed, inventory turnaround time is ten days faster and they can spot sales trends quickly and react actively to them. They now have a sales reporting and inventory control system that utilizes an electronic cash register at the point-of-sale which not only rings up the sale, but also the style number, size and employee number. Through Datapac, this data is transmitted immediately to Kinney's inventory control centre so that stock is replenished and mark-downs recorded. It replaces a previous manual and batch system of marked cards. Inaccurate and dated information is virtually eliminated with data communications.

Another case study where immediate and reliable data can have extensive financial implications is a nationwide data communications system which CCG developed, using Datapac, for the Toronto Stock Exchange. Their system provides trading data on stocks, bonds, options, commodities, Nasdaq and U.S. mutual funds on more than 20 North American markets. As well as price quotes, statistics, previous trades and group comparisons, the TSE system provides commission calculations, full inquiry and response capabilities for all customers and complete wire service information. Over 100 terminals on Datapac provide brokers in 22 Canadian cities and the United States with complete market data instantly and economically.

A third customer is one who has a very high profile considering energy concerns nowadays. And it is an industry in which the transmission of accurate data is particularly crucial for the timely distribution of stocks which could avert crisis situations. Imperial Oil, a Canadian subsidiary of EXXON, came to CCG and together with their data specialists we designed a network which economically linked 14 medium-size automated oil terminals across the country to host computers. We evaluated with the customer the alternatives of a system via private line or packet switching and were able to do it at 55% of the cost using a four-tiered distributed data processing approach and Datapac.

There are over 2,000 connections to the network and some 200 customers now operating on Datapac with a wide variety of applications. The key to the effective implementation and utilization of CCG's various packet switching services is the close cooperation between our planning, sales, engineering and installation people and the EDP specialists and general management staff of the potential user. This liaison provides the working framework for development of an appropriate data communications system based on the customer's real needs and the available technology.

We are proud to say also that the technology behind our packet network is Canadian - both software and hardware. The research and development on the switch, called an SL-10, was done to our specifications by Bell-Northern Research in Ottawa, Ontario and the switch is manufactured by Northern Telecom Canada. We have been greatly encouraged, not only because Datapac services are now receiving good acceptance by the marketplace in Canada but also because the SL-10 packet switch we developed is being purchased for similar networks in other parts of the world. The Deutsche Bundespost has recently made the decision to use the Canadian SL-10 for its large public packet network in Germany. Switzerland is also definitely using the same switch and other carriers and private networks are actively examining its application.

In Canada, The Computer Communications Group of the TransCanada Telephone System have taken packet switching from a technological idea through engineering and service development to actual implementation and application by data users. At each stage of the process, we have worked with all concerned parties -- business, industry, manufacturers, government, academic, regulatory, international standards bodies and consultants -- to ensure that Datapac would meet the real-world needs of users now and in the future. The number of customers on the system, the number of orders now placed and three full years of experience in operating the network convince us that packet switching is a sound, practical, economic technology and permits a range of service offerings that has wide appeal and acceptance by users.

The Doctrinal Context of Telecommunications Policy in Developed Countries

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Policy-making in the field of telecommunications is the heir to several quite separate constitutional traditions. On the one hand there is, a view presumed to descend from Milton via Mill and the Fathers of the American Constitution which inhibits all interference by government in the circulation of information and ideas. The proponents of this total separation of culture from government insist on the antiquity of their position, although it is actually a late 19th century intellectualization or extrapolation of laissez-faire economics. On the other hand, there is a line of policy-making dating back (in Britain, at least) to the construction of the canal system and the later railway network by which it was and is deemed appropriate for Parliament and Government to make policy in the field of transport and, indeed, to make provision for public ownership of basic communications facilities. The telegraph is historically a mere extension of the railway system and both systems were thought from the very start to be most appropriately inaugurated by private enterprise but taken over by government when fully developed. The private railway entrepreneurs of the early 19th century were provided with recallable franchises, not with an inalienable right to own forever basic communications facilities (1).

It is the contention of the writer of this paper that a certain amount of historical sand is being thrown in our eyes in much of the contemporary discussion concerning telecommunications regulation; by examining the historical roots of the present discussion concerning the role of the state in telecommunications planning it might be possible to make certain useful adjustments to the notion of what the "true faith" should really be in the democratic western world. What we have to keep in mind throughout is that telecommunications issues are continuations of older media issues and that inherited doctrine is much more diverse and imprecise than the proponents of the strict "western" view, for instance, at UNESCO would have us believe.

Communications facilities in all European societies have always been subject to two pressures: towards vigorous nationalization and equally vigorous international rationalization. Thus the Thorn and Taxis messenger system of the Holy Roman Empire upon which the whole trans-European information system depended for many centuries (right from the late middle ages into the Enlightenment) was an attempt to overcome the combined deficienceis of local and regional coaching and news-dissemination systems (2). There were private news systems such as those of the Fugger Bank and there was a growing desire on the part of princes to equal the speed and efficiency of these private interests; all business competition in mercantilist economies was based upon the swiftness of carriage of information and for a good international system to develop local governments had to create road inspection organizations and oblige local authorities to ensure that routes were kept clear. The creation of a national communications system became an international obligation, neglect of which would bring immediate local economic repercussions. The government of England did not greatly object to the fact that the international traffic was ultimately guaranteed by the authority of the Holy Roman Empire.

Governments, of course, maintained their own message systems, as they still do, for really important matters of state and as the era of mechanical devices dawned, they found it more and more difficult to ensure that theirs were superior to the methods available to the ordinary public. Throughout the 19th century there was a constant search for faster ways of reporting wars, conferences, revolutions, with newspapers, commercial intelligence merchants and governments all in mutual competition. The need for better communication within the growing overseas territorial empires of the European states led directly to the development of the three great international news agencies which dominated the world until the inter-war years: Reuters, Havas and Wolff; all three occupied an important position within their respective nations, even though Reuters always prided itself (apart from certain lapses during wartime) on keeping its financial affairs separate from those of government. Nonetheless, all the great agencies of the 19th century and these which have established themselves in the world league in the present century (AP, UPI, AFP and DPA) have both competed with government and cooperated with it to obtain and disseminate important international news (3). It has been impossible even for those national agencies which are owned entirely by newspaper publishers and other holders of private capital to remain entirely independent in judgment. They, like the governments of nations, are national institutions and must form their priorities according to national perspectives. The pioneering agencies of the 19th century were themselves major investors in telecommunications facilities, which function they performed only at the behest of national governments of other societies as well as their own: thus Reuters for a time obtained major concessions in the telegraph cable business across large areas of Europe and Asia, and these activities were closely supervised by government, sometimes sanctioned, occasionally forbidden.

It was not merely the major news-collecting enterprises which were subject to certain orders of governmental policy. Newspapers themselves considered their freedoms, where they enjoyed them, in a rather different light from that of later theory. All newspapers came to depend upon railway and postal concessions for their distribution and upon telegraphs, telegrams and cables for their news collection, and decade after decade have been obliged to negotiate the terms by which these very basic necessities have been supplied. But their links, in most societies accepting press freedom, with government have been even more deeply enmeshed. The basic content of a European newspaper in the age of the telegraph consisted in information supplied either by government or by politicians in their capacity as party spokesmen; the newspaper and the platform were symbiotic institutions and press freedom was conceived in most societies as a branch of political freedom because it was a branch of political activity. The newspaper was the link between the party and its supporters and most newspapers were owned by or subsidized by political parties or wealthy supporters of political parties. With the coming of display advertising (in the 1880's) and of the mass press no longer dependent upon external finance the position changed only marginally, since press owners were almost invariably deeply involved in politics. The owners of the Times, among the first newspapers to pride itself on its financial independence and its freedom of the necessity to take political bribes (as it had been obliged to do in its early years), were very keen Parliamentarians, and as newspapers reached further and further towards the mass audience their publishers sought political power with increasing fervour; it has been the custom only in the present generation (and then only in a few of the Anglo-Saxon countries) for newspaper publishers to eschew the political life. Northcliffe prided himself on usurping the privileges of elected politicians: "The larger the circulation of the press, the less powerful the politicians," he once remarked. Beaverbrook, Rothermere and the French press barons of the 1920's and the 1930's were all busy in politics; William Randolph Hearst was by no means alone among the early American newspaper dynasts to fancy himself a statesman. The Berlin newspaper magnates who flourished before the collapse of Wiemar were failed activists. Publishers saw the task of statecraft almost as a logical corollary of their businesses, as a way of guaranteeing their market, as a natural adjacent duty to publishing. Their power arose automatically from their command of the mind of the masses.

In the fashionable abnegation of political linkages today, American newspaper personnel are unconsciously exporting American constitutional ideas, which are much newer and untraditional than is sometimes realized. Watergate has been the occasion of a vast international celebration of "Fourth Estatism" and of the reassertion in journalism schools the world over of the inquisitorial rights and obligations of the reporter. In practice investigative journalism has been built more upon government leaks than anti-government revelations; in the highly pluralistic poly-centered context of the American state every reporter's scoop is some official's handout. In the context of the more monolithic nations of the rest of the democratic world an excessive reliance on "first Amendment" thinking can even be damaging to the working of a free press if it tempts publishers to work along illusorily liberalistic lines. The best security of journalism often lies precisely within its political allegiance; one may point to the way in which, belatedly, an objective American press helped to bring the Vietnam War to an end, but one may also point to the way in which reporters in France whose political indentity was overt played a similar role in bringing to an end the military adventure in Algeria.

France is in fact a very good example of a country which regards the state not as the enemy of freedom but as the triumphant creation of an act of social liberation, the Revolution of 1789. Politicians in France despite (or because of) the press freedoms finally bestowed in the law of 1881, are all heavily involved in the management of the press. The French government controls all telecommunications activity on French soil but also manipulates the content of all radio and television and the ownership of all newspapers of note; it controls the major advertising agency and chooses the directors of all broadcasting companies; it even exercises de facto controlling power in a series of radio stations sited on the territory of neighbouring states, but beamed at the population of France. Although the broadcasting system of France has long been the subject of parliamentary discontent and frequent reform, the grievances have usually been that the broadcasting system has fallen into managerial and financial chaos rather than that governmental influence has been excessive; the left has complained of the lack of editorial freedom in French radio and television but no one believes that it is possible in France for a public institution to function without political supervision-- even a public institution like a newspaper, where the shares are all formally held by private individuals. In any dispute or during any period of uncertainty, France looks to the state (i.e., the government) to take the initiative. She has a different view of the state rather than an excessively etatist ideology.

In practice the content of the French written press is not much more influenced by government than that of the Anglo-Saxon countries. In the latter, where radio and television, both public and private systems, are held to be independent of all governmental influence, a powerful feeling of responsibility holds producers and managers back from the kind of fisticuffs which are considered permissible in the printed press. In the United States, television has very rarely attempted to mobilize opinion on any topic upon which public and political opinion is not already fairly settled and in the case of American public television there is far less politically sensitive material than in the average state-dominated European broadcasting system, even including France. The fact of the matter is that every democratic society creates a field of forces in which the media operate and whether they are, in a formal sense, committed highly or marginally to "fourth estate" policies, comparable sets of pressures come to settle over every controller of every information medium. Some societies, such as the USA and Sweden, are far more committed to precise freedoms than others (such as Britain and France) and provide much easier access to governmental information or more protection to journalists in the field of libel and contempt of court, but nonetheless, throughout the democratic societies of the West, the practical involvement of government in the whole range of information media is considerable and is, in the context of the new telecommunications, necessarily increasing.

The problem at the present time is that western governments are refusing to recognize the realities of their own media and of their own arrangements, partly because they are engaged in a fierce debate with Third World countries and the socialist camp over media control. They are attempting to preserve western press freedom against forces which would almost certainly undermine them if they could, but they are doing so often upon misstatements of how western media really function. "Newspaper-readers in one-paper or chain-dominated cities can turn to radio and television for alternate reports. The people of the United States, moreover, have become critical consumers. They question advertising claims, politicians and press reports, as well as established institutions," writes Leonard R. Sussman more hopefully than convincingly in an essay on developmental journalism (4). In fact, the media of small American towns often offer very little to the citizen; quasi-monopolies dominate the world of information. The phenomenon has been unavoidable: the trouble is that by pretending the situation is other than it is, less pressure exists for the new media offered by advanced technology to be used to make the ideal closer to reality.

In the present decades, all nation states are in the throes of a new bout both of policy-making and of basic doctrine-making. The congeries of positions, nostrums and institutions which make up the western press is endeavouring to offer to the Third World a far more comprehensive and consistent view of doctrine than it in reality possesses. Indeed, there is a late century crisis in Western journalism which is partly concealed by the furious nature of the debate over news flow and the so-called New World Information Order. The crisis tows in its wake a much broader set of issues affecting control of the new computerized information systems. Western editors and publishers are trying to defend, on moral and sociopolitical grounds, forms of journalism which are exploitative of readers, increasingly devoid of political content and profit-seeking in their motivation, under cover of defending a purist press freedom. It is the lack of practice of those very freedoms of information which undermines the western position, more than any breach of logic. The failure of the western press, (to give one random example,) to signal the overthrow of the Shah, or to evaluate the potential of the Ayatollah in his own context, rather than harp on the financial implications for the West (5) demonstrated the real structural flaw in western journalism and the failure of the current system of international news to operate effectively in a many-centered world. Necessarily the concomitant doctrines of the west--free flow, freedom from governmental restraint, separation of common carrier systems from editorial control--are in disarray, and this disarray renders more difficult all further and more material matters relating to telecommunications planning, since these matters have been throughout history inseparable phenomena.

Let us examine in some detail one representative set of policy issues--those surrounding the development of the new teletext and videotex services--to see how the failure of doctrine in matters relating to the press is the counterpart of confusion and lack of progress in the development of physical systems. Britain has appeared to rush into teletext because it possesses two separate but geographically "total," competive broadcasting systems both of which are public bodies anxious to increase their general social remit. To the BBC Ceefax was at first merely a device for aiding the deaf television viewer, but the radio industry made clear that Ceefax was a mass medium if it was anything and proceeded on that basis (although it has subsequently been distressed by the failure of the medium to take off with a mass public). The IBA brought out an almost identical and compatible system and encouraged the commercial broadcasters whom it regulates to proceed with a second public service, despite their fears about a medium which might distract viewers from watching advertisements. There was no interposing body to make the point that this new medium, even though it is carried on a television signal, might be better thought of as an additional reportorial or editorial medium, a new possession of society which government ought to allocate to new holders. The broadcasters simply grabbed the new device and ran with it, past the Annan Committee which was considering the whole of the future broadcasting in Britain, past the MacGregor Committee, which was considering the whole of the future of the press in Britain, past the Home Office, which was supposed to be holding the ring. Simultaneously the Post Office moved ahead with its own far more important medium, videotex, known in Britain as viewdata, the transmission of text symbols via telephone wires to the ordinary television receiver. The Post Office in Britain is not technically a common carrier and it therefore found itself in a quandary from which it has not yet been able to extricate itself; it was presiding over a new public medium of infinite capacity and yet was nervous about providing the service as a common carrier for fear that it would be held editorially responsible for the entire content. There existed no national policy-making to turn to and no coherent inherited national doctrine. Review bodies over many decades had left behind nothing on which the Post Office could build, apart from the BBC which had itself emerged in the 1920's as a result of a similar conundrum; in the event the Post Office has decided to move ahead as if it were a common carrier, not to create a special new 'viewdata-BBC' but to offer common carrier services, and merely cover itself for libel and other damages by insisting that all information providers sign an indemnity. Even so, the Post Office will exclude items of material from its storage computer, and therefore from the public, if any question of legality is raised, until such time as the legal matters are resolved. We have therefore, already in Britian in the new media, opened up the whole question of prior censorship without intending to do so. We have also foreclosed in the case of the teletext services, on the whole issue of information pluralism without any informed national discussion taking place. The new media in which Britain is a conspicuous pioneer, is doctrinally speaking, a shambles, and hostages have been thus offered dangerously to destiny. Other nations such as Germany and France, moving into the field of new electronic home information systems, are doing so slightly better prepared, in terms of national policy and doctrine; the United States is slowly revealing the unpreparedness of its own institutional provisions: viewdata, which is designed as a public, socially universal, data-base, is being brought in by private companies and utilized as a private exclusive system. The very principles of the First Amendment, intended presumably to enhance all areas of freedom of expression, are being used again, as they have been in the case of broadcasting, as props to private capital on a quest for gigantism. There exists neither institution nor doctrine by which the new media can be used to roll back the tide of corporatism and media concentration.

A similar tale can be told of other spheres of modern telecommunications in western countries. The coaxial cable was heralded in the 1960's as a tool of abundance, as the technology of a new community-oriented politics, as an interactive democratizing medium; it seems to have ended up as a supplier of suburban pornography and first-run movies and very little is heard of the high ideals enshrined in the report of the Sloan Commission. In quite a different aspect of the new devices, word processors and telemail systems, one can now see the development of a movement to reduce office staff and save paper-based labour of various kinds, where, with a different set of purposes, the equipment could be designed to de-bureaucratize rather than merely to automate, to change organizations for the better rather than just weed out a few excess typists. Between concept and reality there falls a shadow of purposelessness or rather misplaced purpose which deprives society of much of the life-enhancing potential of the new instruments.

One reason why the provision of telecommunication services finds itself in something of a doctrinal crisis in the late 20th century is that many societies find it hard to draw a line between purely industrial sub-industries and the national telecommunications base. The new text services, telemail, facsimile, teleconferencing and home computer devices involve extensions of public investment and new areas for private exploitation. The current fashion for de-regulation (i.e. removing 'government' from information) is partly in conflict with the vision of a rapidly expanding telecommunications sector, since the latter entails a great increase in public involvement, certainly in the societies of Western Europe. Without government direction and investment there can be no real or rapid advance; industry requires government to create the medium and to remain as the major partner in the enterprise. The question is where to draw the line between governmental and non-governmental roles in these new services, where the parallels and precedents run out between physical services and electronic substitutes, where the function of network creation separates from a myriad of 'attachments.' There is no abstract or general argument to apply. There is often no national plan mapping out differentiated roles and interests. In the last five years or so videotex has been reinvented several times over, not in the pursuit of some technologically pure version of the medium, but almost entirely as a result of regulatory imprecision. There are systems where information storage seems to be the exclusive function of the central headquarters and systems where storage is highly distributed. The vision is the system is not that of the technologist but that of the telecommunications bureaucrat, in a quandary.

The societies of Europe and other continents live today in great danger that the unplanned superfluity of American telecommunications capacity will be employed to drive national information systems out of business in favour of privately owned (possibly foreign-owned) cost-cutting message services. We have a choice, for example, in Europe, of introducing satellites as cheaper and faster methods of mail delivery, or of permitting private corporations to introduce intra-corporate mail systems which will undermine the efficiency and viability of national systems. A rapid and superficial advantage will wipe out a long term national and international asset. The "will" is perhaps used with excessive pessimism--at some point, battle will be joined on this and comparable questions, but in societies which have so far failed to argue out the principles which are the essence of planning in this area of policy. This is not an argument for old-style indicative planning, but rather of a deliberate drawing together of ideals and precedents, a working out of benefit-and-loss between national and private interest, between what is the proper sphere for government and what the proper sphere for private cultural development. There is very little truly new to add to the 1863 debate over the nationalizing of the Victorian telegraph system; it's just that the implications have still failed to be grasped.

Notes

1. See, J.L. Kieve, *Electric Telegraph--A Social and Economic History*, Newton Abbot, David & Charles, 1973, pp. 119-153.

2. Anthony Smith, *The Newspaper--An International History*, London and New York: Thames & Hudson, 1979, Chapter 2, passim.

3. Phil Harris, New Dependence: The Case for a New World Information Order--Final Report to UNESCO of a Study of the International News Media, Centre for Mass Communication Research, Leicester, 1977, pp. 20-62.

4. Leonard R. Sussman, Developmental Journalism: The Ideological Factor. In Philip C. Horton (ed.), *The Third World and Press Freedom*, New York: Praeger, pp. 74-92.

5. William A. Dorman and Ehsan Omeed, Reporting Iran the Shah's Way--Iranian Realities, Long Ignored, Still Elude American Correspondents, *Columbia Journalism Review*, Jan/Feb 1979, p. 27.

SOCIAL ASPECTS OF TELECOMMUNICATIONS POLICY IN CANADA

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Abstract

Telecommunications policy in Canada is in the process of evolving from a number of policies related to specific areas such as broadcasting. Under existing government policies, new developments such as satellite-broadcasting networks will be expected to be of social, cultural and economic benefit to Canada. Decisions are required now on measures to direct such developments towards established social objectives.

LEGISLATIVE BACKGROUND

In writing about telecommunications policy in Canada, it is important to note first of all that we are not referring to one, unified policy but rather to a number of different policies and practices under the general heading of telecommunications. Telecommunications in Canada today encompasses broadcasting as well as the services and systems of common carriers such as telephone companies and the national satellite corporation. Historically, in Canada as in other countries, broadcasting has been treated separately, both for policy and regulatory purposes. However, as new distribution technologies have been developed in recent years, broadcasting is increasingly regarded as a part of the total telecommunications environment.

This trend of increased interaction can be illustrated by the fact that the federal Minister of Communications has sought three times in the past few years to change the legislation related to various aspects of telecommunications by introducing a Telecommunications Bill into Parliament. None of the three Bills introduced in the House of Commons was passed before the end of the sessions concerned. Since the change of government in May 1979 from the Liberal party to the Progressive Conservative party, the new Minister of Communications has indicated that he plans to introduce a revised version of the Telecommunications Bill in the current session.

There are two major reasons why the Bill is repeatedly introduced. One reason, which has already been mentioned, has to do with the increasingly evident convergence of the communications technologies such that broadcasting issues are becoming entangled in questions about technical systems owned and operated by the common carriers. The second reason stems from the jurisdictional disputes between the federal government and the provincial governments over which level could and should have control over different aspects of the telecommunications field.

For those unfamiliar with the Canadian scene, it is important to realize that communications is one of a number of fields over which there has been lack of agreement between the federal and provincial authorities about where their relative jurisdictions begin and end. Federal-provincial disputes of this type are fairly frequent in Canada and have been a feature of Canadian political life ever since 1867 when the British North America Act was passed by the British Parliament. With regard to authority over telecommunications, the BNA Act is, naturally, silent on whether this is a federal or provincial area of jurisdiction. Only the telegraph is acknowledged in the Act and is assigned to the exclusively federal sphere. The invention of the telephone and all subsequent developments to use the radio spectrum for telecommunications purposes could not be specifically referred to in a statute of 1867 so the judicial interpretation of the statute has come to play an important part in the determination of government authority in Canada.

The most important judicial interpretation was that of the Radio Reference case in 1932, decided by the Judicial Committee of the British Privy Council. In that judgement, it was determined that radio communication was an exclusively federal matter so that all licensing of radio broadcasting stations as well as radio transmitters of all types became the responsibility of the federal government alone. Subsequent court cases in the Supreme Court of Canada (when it became the final court of appeal) have followed the reference case and confirmed the exclusive authority of the federal government over all broadcasting, including cable TV. While provincial governments have had to abide by the courts' rulings, several of them have never fully accepted the federal government's exclusive right to regulate and control broadcasting.

This dissatisfaction has become increasingly evident, especially since the early 1970s when cable TV began to develop rapidly in Canada. Since that time, most of the provinces have started to insist that cable TV is properly a local service and, as such, should be under the jurisdiction of the provincial level of government. Those provinces which own their own telephone company - Alberta, Saskatchewan and Manitoba - have been particularly insistent on their need to control cable TV because of that industry's potential effects on the provincial telephone system, especially when new information services are developed which could be carried on either distribution system. Quebec, too, has put forward strong arguments over the past ten years for its need to have cable TV jurisdiction although for many years this province has had a much broader goal of jurisdiction over all communications systems for reasons of cultural sovereignty within Quebec.

Governmental jurisdiction over telephone and telephone-related activities has developed into a curious situation in which three telephone companies are subject to federal authority while the others are subject to the province in which they operate. Generally speaking, those companies which provide telephone services across provincial boundaries come within the federal jurisdiction while those which operate only within one province are provincially regulated. Bell Canada (which provides service in much of Quebec and Ontario as well as part of the North West Territories) and British Columbia Telephone (which provides service in B.C.) are federally regulated as is Canadian National Telecommunications -- CNT -- which provides service in both northern Territories and in parts of B.C., Alberta and Newfoundland. Because Bell Canada and B.C. Tel are the two biggest telephone companies, providing about two-thirds of all telephone service in the country, the federal government's authority in this area is significant.

The basis for governmental control over a telephone company in Canada is much as it is in the United States: regulation as a public utility with a view to ensuring that "just and reasonable" rates are charged to its customers. At the federal level, the Canadian Radio-television and Telecommunications Commission (CRTC) is responsible for regulating all of broadcasting and for the rates of the federally regulated carriers including Telesat Canada, the satellite corporation. The CRTC was responsible for broadcsting only, until April 1976. At that time, it was given additional responsibilities for telecommunications by the transfer of authority over telephone and other common carrier rates from the Canadian Transport Commission. However, having broadcasting and common carrier regulation within one body does not mean there is an over-all telecommunications policy at the federal level. Further legislative changes are needed in the form of a Telecommunications Act, to provide a unified policy framework.

Aside from whatever legislative changes may occur at the federal level, and however the authority for regulation may become divided between the federal and provincial levels, major questions have to be answered soon in Canada about the direction in which new and emerging communications technologies are developed. The increasing urgency for these divisions had led to proposals for a Royal Commission of Inquiry and to other ideas of examining alternatives in a public forum. Because an inquiry conducted by a Royal Commission or similar body could take up to two years to complete, the Minister of Communications in the last government preferred to choose a different method of seeking recommendations for action.

In November 1978, the Honourable Jeanne Sauvé appointed a Consultative Committee on the Implications of Telecommunications for Canadian Sovereignty, since known as the Clyne Committee. The Committee was asked:

> to produce specific recommendations on a strategy to restructure the Canadian telecommunications system to contribute more effectively to the safeguarding of Canada's sovereignty; and
>
> to make recommendations on the future of the Canadian telecommunications system in relation to new technologies and the need for Canadian software and hardware resources to meet foreign competition, with particular reference to the role of broadcasting in contributing to the preservation of the sovereignty of Canada, including:

a) the use of communications satellites to the best advantage of Canada;
b) the status of the cable companies in relation to broadcasting and to the common carriers in the provision of new services;
c) the importation of foreign programming;
d) the framework and timing for the introduction of pay-television nationally.(1)

The Committee took as its definition of sovereignty: "the ability of Canadians (both in government and in the private sector) to exercise control over the...direction of economic, social, cultural, and political change".(2) Like many other groups which have studied one or other aspect of telecommunications or broadcasting in Canada, the Committee saw the parallels for Canada between the 19th Century development of railway networks and the 20th Century development of communications networks in ensuring the ultimate prosperity and sovereignty of Canada. In these ideas, there is for Canadians a strong awareness of the economic strength of the American marketplace and its influence on the much smaller Canadian market. For this reason, the Clyne Committee follows along a familiar path when it says:

> In approaching telecommunications we should realize that its importance demands we view it in a special way. Telecommunications, as the foundation of the future society, cannot always be left to the vagaries of the market; principles that we might care to assert in other fields, such as totally free competition, may not be applicable in this crucial sphere. We must look at it freshly, without preconceived ideas.(3)

Thus, it is generally assumed as a cornerstone of telecommunications policy that some government direction is required. Where the arguments arise within Canada is on the extent to which government should interfere with commercial or corporate decision-making about the exploitation of technical innovations to meet future consumer demands. The Clyne Committee's recommendations on the action needed by the federal government were favourably or unfavourably received by the various communications industries according to how they might be affected by the proposed actions. The Committee's report was published in March 1979, only two months before the change of government so no actions have resulted directly from its work. The present government's Minister of Communications, the Honourable David MacDonald, cannot feel bound to follow up on the recommendations of a Committee established by the previous government.

Meanwhile, though, events in the development of communications technology in North America and in industrialized countries elsewhere make the need for clear government direction ever more pressing. There are a number of developments going on at this time, including satellite-broadcasting networks, videotex and information collection networks, and common carrier systems using fibre optics technology. In this short paper we will look at the first of these, in the context of social objectives for telecommunications policy in Canada.

THE SOCIAL OBJECTIVES

There are essentially two generally accepted social objectives towards which telecommunications policy is to be directed. The first is to ensure equal access of all Canadians to service as far as is possible; a significant aspect of this is to ensure that people in rural and remote areas are as well served as possible even though the economic costs are higher. The second main objective for policy direction is tied to the need for cultural growth and development in Canada. There are really two aspects to this. One is to provide opportunities for Canadian creative expression; the other is to encourage the development of communications services which use Canadian-produced goods and resources, thus providing employment for Canadians. Both these objectives apply to broadcasting policy and to the various proposals for telecommunications policy which the federal Ministers of Communications have put forward in recent years.

Ostensibly, satellites are just technical systems of distribution which might earlier have been treated as having to do only with rate structures and non-discriminatory access by all potential customers. Now, however, as the content carried on conventional broadcasting networks will be carried by non-conventional means, the issues and policy surrounding Canadian broadcasting become more prominent in discussions. For the federal government, the broadcasting policy is enunciated in section 3 of the Broadcasting Act, approved by Parliament in 1967; the policy is heavily concerned with the sovereignty of Canada through domestic ownership and control of broadcasting stations and networks.(4)

The broadcasting system and especially the Canadian Broadcasting Corporation, has been directed particularly towards cultural sovereignty for Canada. This is more than ever so now because the federal Minister of Communications, the Honourable David MacDonald, also holds the portfolio of the Secretary of State in the new federal Cabinet. The responsibilities of the former position include the technical development of satellite communications and of Telidon, international communications, the technical licensing of radio spectrum usage in Canada, and the CRTC. The responsibilities of the latter position include those for the national institutions of arts and culture, the CBC, and funding for the arts and for citizens' organizations engaged in a variety of social and cultural activities.

THE EQUAL ACCESS OBJECTIVE

In seeking to ensure that there are equal access opportunities to communications services for all Canadians, it is important to realize that there are approximately six million people who live in rural areas and in remote settlements. That is about one quarter of Canada's population. For reasons of social equity, both federal and provincial levels of government have long favoured the improvement of communications services (broadcasting and telephone, principally) for people outside the urban centres. There is clear recognition that the differential costs of service provision between urban and rural areas can only be overcome if special technical and financial resources are used in a concerted effort to extend service beyond its normal economic limits. Because of its capability to provide linkages over long distances and to overcome poor atmospheric conditions, the communications satellite has been perceived as the answer to the communications problems of northern Canada. Before the first Anik satellite was launched in 1972, it was claimed that, not only would signals be sent between southern Canada and the north, but also there could be better communications between northern settlements.

The use of satellite linkages to provide broadcasting services to rural and remote areas has been pioneered in Canada, through the work of the federal Department of Communications, Telesat Canada and the Canadian Broadcasting Corporation (CBC). Since 1972, a number of small communities in northern Canada, many of them inhabited by the native people, have been provided with television reception through the Anik satellite and the installation of ground stations linked to low power rebroadcasters in the communities concerned. Clearly, the use of the satellite to provide high quality television signals for local distribution is a vastly superior method than that available previously of taped TV program packages. The distribution facility works well although it is costly for the numbers served, compared to the cost of the conventional TV transmitter used to reach large populations in a southern city. The economic cost of this service, however, was expected by the federal government to be balanced against the social benefits of reducing the isolation of people in the north from the mainstream of Canadian life.

Due to the prohibitive costs involved, the capability for TV transmission from the north to the south or between places in the north has been almost nil. The result of this extension of broadcasting service has, thus, been limited to better quality and more immediate reception of TV programs from outside the north; it has not allowed the people in the north to respond effectively to what they receive. Nor has the satellite linkage so far allowed people in the south -- almost all of Canada's population -- to become more familiar with what the north and its people are like. Because of limitations in its production budget, the CBC has been able to do very little programming for its Northern Television Service especially for or about the north; the result is almost all the programming is either from southern Canada or from foreign sources, mostly American.

According to many spokesmen for the native people themselves, the effect of this TV content on the native people, especially children, has been extremely detrimental. The two aspects most frequently cited are the effect on children's behaviour and the effect on community life and involvement caused by excessive hours of TV watching. Studies of the social effects of television on people in the north have been undertaken by social scientists but, in almost all cases, these have been done only after the introduction of television service.(5) We must conclude that the social benefits predicted for the service to the north did not depend on concrete evidence of social need; nor was the content of the service specially designed to meet the social needs of northern people. As this experience shows, it is not enough to promote the right to reception of broadcasting service without reference to the relevance and selection of the content received.

CURRENT DEVELOPMENTS

Although communications satellites are not new in Canada, their widespread use for the provision of broadcasting-type services is a new idea. Until the fall of 1979, the Anik satellites of Telesat Canada had been used in only a limited way for the distribution of television and radio signals. Except for the provision of CBC signals to a number of isolated northern communities, via a local rebroadcaster, the satellite linkages have been used primarily by the CBC for network purposes of sending programs to the different time zones across the country. On an occasional basis, several of the private broadcasting TV networks have used satellite distribution but they generally rely on mirowave transmission for network transmission. The ground reception of signals from the satellite has been by Telesat-owned and more recently broadcaster-owned earth station equipment.

Now, however, with the lower priced earth stations becoming available in North America for purchase, several communities in the northern half of Canada have acquired earth stations and are illegally receiving signals off American domestic satellites which carry numerous TV signals, including pay television services. The illegality has mainly to do with the reception of signals from a foreign satellite, in violation of the Intelsat Agreement as well as an agreement between Canada and the United States. The ownership of the earth stations is theoretically restricted in Canada to broadcasters and common carriers. Because there is usually no TV network on the Canadian satellites other than CBC's, it is apparently irresistible for the northerners to turn to other available satellites and receive a wider choice of TV programs. While the problem of illegal reception of American satellite-carried signals is confined to a few northern communities, it could remain a minor headache for the federal government. However, earth stations may soon be acquired by southerners and there remains a lack of Canadian material via satellite from which to choose for reception.

In fall of 1979, the federal Department of Communications began to experiment with the provision of small earth stations to a few households and small cable TV systems in northern Ontario to provide reception of CBC television and of the Ontario educational TV network, TV Ontario. Other experiments of this type are being considered in other provinces. However, the choice of TV signals on the Canadian satellites remains limited and, in order to make this type of reception attractive, there are now plans to provide a "package" of TV signals through the Anik satellites to be made available to all Canadians within reach of an earth station hook-up (probably via the local cable TV system). In order to make this package attractive to viewers - and to the cable TV operators - there is consideration being given to proposals for carriage of Canadian pay television services which would consist of original programming previously unseen by viewers.

THE CULTURAL DEVELOPMENT OBJECTIVE

As ideas are proposed of carrying new broadcasting services by satellite -- such as pay television -- it becomes unavoidable to discuss the cultural and economic implications of such a development. The major questions revolve around problems such as how much of the content should be Canadian-produced and who (broadcasters, cable TV operators, film and video producers, or others) should be permitted to operate a pay TV service. The answers given to these questions will result in pay TV services which will have profound effects on the existing broadcasting industry and on the commercial viability of Canadian program producers, both in Canada and internationally.

Pay television in Canada has been proposed for at least five years, mainly by cable TV operators. More recently, the idea of using existing satellite channel capacity to distribute pay television has been suggested as a means of both strengthening Canadian programming and using more fully the satellites operated by Telesat Canada. So far, no applications for the introduction of pay TV in Canada have been approved by the CRTC; although the subject of pay TV has been examined twice at Public Hearings held by the Commission, it has remained unconvinced that the services proposed would not harm the existing broadcasting system.

The cultural development objective relates to policy directions for telecommunications, especially broadcasting, in the opening up of opportunities for Canadian creative expression. There is a strong social and cultural need, endorsed by many public inquiries over the years since the development of radio broadcasting in the 1920s, for opportunities to exchange messages and ideas between Canadians spread out across a land which is four thousand miles wide and extended about two thousand miles from the American border to the High Arctic settlements. People scattered over such a large country and with so many different cultural heritages and regional lifestyles have few opportunities to meet face to face so that the communications systems have been called upon to provide a substitute meeting-place. If there is to be an opportunity for Canadians to see themselves on television, then there must be a strong program production industry within Canada. Yet, Canadian creative artists have limited opportunity to produce and sell Canadian programming to TV networks within this country because of the popularity and comparative cheapness of American programs - programs already sold to American networks and, thus, sold for Canadian showing at less than their original production costs.

Television broadcasting in Canada is heavily dependent for content on foreign programming. Through Canadian content regulations, the CRTC requires 60% of all TV programs broadcast to be Canadian-produced. However, the vast majority of English Canadians' viewing time is spent in watching foreign programs, almost all of that American.(6) As long as most viewers in Canada remain dissatisfied with the quality of much of the Canadian programming available to them, the preponderance of viewing hours will continue to go to foreign programming. Government policies to strengthen the independent program production industry and to require more quality programming from the broadcasters, especially CBC, will continue to spread. But, within the context of a commercial broadcasting industry dependent on mass audiences for its advertising revenue, the objective of producing high quality programming has remained elusive in Canada.

Part of the attraction of the idea of pay TV is that it would be a different method of financing program production and would, presumably, get away from the tyranny of mass television ratings. The evidence to support this contention is lacking to date because there is no comparable situation either in Canada or in other countries. The development of pay TV in the United States has occurred for different reasons and probably has different results than would be achieved in the Canadian context.

A secondary consideration in the objective of cultural development through a pay TV-satellite network would be Canadian production of the equipment required to distribute a pay TV signal through scrambler-descrambler mechanisms, to conduct a reliable fee-collection system, and to provide the earth station facilities. It would be a part of this objective to ensure that Canadian industry would be able to produce the required hardware for all of these, if possible. Again, the size of the domestic market for such equipment is much smaller than in the United States so the tendency is to buy from American companies already making similar equipment. By doing so, Canadians in effect would have determined for them the type of pay TV service they could develop and, thus, the type of programming which can be sold on the service. The alternative of making Canadian equipment at a competitive price requires either a high tariff barrier to foreign equipment or else the realistic probability of foreign sales. The same problem applies to the production of Canadian programming.

If tariff barriers are unrealistic for political and economic reasons, then the only alternative is for Canadian producers to sell to other countries. If competition in industrialized countries is too strong, then the possibilities for sales in less developed countries will become of greater interest. The potential economic benefits in a stimulus to electronics-related manufacturing industries and to program producers through export sales are extremely attractive ideas to those who see Canada engaged in a technology race with other countries or who see participation in the international market as a way of lessening our own reliance on foreign equipment and content.

The potential social, cultural and economic benefits for Canadian society are extolled by the proponents of satellite-broadcasting networks to justify why such services should be introduced. Where the difficulty arises is in the disagreement between interested parties in industry and government about which means can lead towards the social objectives outlined above. For this reason, besides a lack of realistic assessment of the potential benefits, the federal government still hesitates to make decisions on how to direct the introduction of satellite-broadcasting networks. If we wait long enough, the development of direct broadcast satellites will increase considerably the complexity of the decisions which must be made to protect Canadian sovereignty.

FOOTNOTES

1. Consultative Committee on the Implications of Telecommunications for Canadian Sovereignty, Telecommunications and Canada (Ottawa: Minister of Supply and Services Canada, 1979), Preface.

2. *Op. cit.*, page 1.

3. *Op. cit.*, page 2.

4. The whole of section 3 is too long to quote here but section 3(b) is the essential part for our purposes:

> the Canadian broadcasting system should be effectively owned and controlled by Canadians so as to safeguard, enrich and strengthen the cultural, political, social and economic fabric of Canada.

5. See, for example, the article by Gary O. Coldevin, "Anik I and Isolation: Television in the Lives of Canadian Eskimoes", Journal of Communication, Autumn 1977 (Vol. 27, No. 4), pages 145-153.

6. Canadian Radio-television and Telecommunications Commission, Special Report on Broadcasting in Canada, 1968-1978 (Ottawa: Minister of Supply and Services Canada, 1979) Volume 1, page 51.

TELECOMMUNICATIONS IN THE FEDERAL REPUBLIC OF GERMANY

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Abstract

Recent technological developments of new forms of telecommunications have highlighted the problems, existing under the present organisation of broadcasting by the Laender (states) and the management of telecommunications in general by the federation, between public infrastructure and private use.

Introduction

The Federal Republic of Germany is a highly, technologically developed society producing much of the telecommunication equipment currently in use. General communications policies date back as far as the sixteenth century (relating to the press) so that any areas pertaining to either the mass communications or general telecommunications are rigorously advised at all levels: technological, legal, political and social. There is much forward planning concerning new developments, with high priority currently being given to the further development of new forms of communication that can be implemented with the extension of telecommunication networks, emphasising their economic and social significance. Thus the telecommunications system of West Germany, as an infrastructure for the transmission and distribution of communications, increasingly gains significance for economic, social and political development, with the Deutsche Bundespost as telecommunications enterprise thereby being in a position to further control and carry out new development of the telecommunication system.

The economy of the Federal Republic of Germany has been one of the strongest and most stable of the western, developed countries and her population highly technically skilled: total population around 64 million.

National Policy Co-ordination

In accord with the 1928 Telecommunication Installations Act, the federal government is the only entity that has the exclusive right to set up and operate telecommunication installations in the Federal Republic of Germany. The Federal Minister of Posts and Telecommunications has sole responsibility over non-military communications, thus giving the Deutsche Bundespost sovereign authority in the field of telecommunications. They are thus also responsible for the provision of networks. In addition to this right of telecommunication sovereignty, is the right to use telecommunication facilities. Article 14 of the Postal Administration Law stipulates that the Federal Minister of Posts and Telecommunications issue the statutory instruments concerning the conditions of use and rates to be charged for using the postal and telecommunication installations. The Deutsche Bundespost, in principle, is obliged to admit everyone as a user of its installations or to connect everyone as a customer to the relevant local network (c.f. articles 7 and 8 of the Telecommunications Installation Act). The Telecommunication Regulations thus govern the details of the relations to the customer and define his or her rights and duties.[1]

Broadcasting, on the other hand, comes under the responsibility of the member Laender (states), who are responsible for legislation relating to the organisation of broadcasting and also for the organisation of programming. The structure of broadcasting in the Federal Republic of Germany is organised under public ownership and control, giving it the features of federal departmentalisation, public holding, and the principle of social control exercised via a complex structure of broadcasting councils, superintendents, executive councils and programming co-councils for each of the respective broadcasting institutes. The two exceptions to this form of organisation are the radio channels, German Wave (Deutsche Welle) and German Radio (Deutschlandfunk).

New telecommunications developments such as the currently mooted installation of return-channel, cable television systems in West Germany have posed problems for the legal aspects of this organisation of the broadcasting system. These are, that new technology will greatly increase the capacity of the transmission network and along with this, the number of programmes. Hence the Laender would need to work out whether, and under what conditions other organisers of broadcasting programmes should or could be permitted to operate in addition to the public broadcasting institutes as they are constituted under the present law.

Basic organisational problems within the existing telecommunication networks will also need to be solved. One is that the question as to whether or not cable-limited broadcasting distribution in local and regional networks would be amenable to different forms of organisation must still be answered, even though the Deutsche Bundespost does have sole responsibility in the field of switched telecommunications networks: i.e. the key problem between public infrastructure and private use.

Presently existing forms of telecommunication networks in the Federal Republic of Germany:

i) a switched network of telephony (dial-up)

ii) a switched network of teletyping in the form of a telex service (dial-up)

iii) data communication - by transmission of characters belonging to a defined character set. The idea being that the data is not so much intended for reproduction in a printer as for processing in a data processing system

iv) mobile radio services (also a switched network) which permit communications between motor vehicles, rail vehicles and ships, as well as between land stations

v) a distribution network of audio and video broadcasting which permits a unidirectional distribution of acoustic and visual information to the public. In various cities, master antenna television systems have been installed so that the broadcast transmission is led from a central receiving station via a tree-like cable distribution network to the home radio receivers.

There are other forms of telecommunications whose volume of use is, as yet, rather low, and so will not be discussed here.

i) Telephony

The Federal Republic of Germany lags well behind other highly industrialised countries so far as the density of telephones and telephone main stations is concerned, but it has made up considerable ground in this area over the last fifteen years.

Table 1 Number of main stations and telephones in West Germany for the years 1950, 1960, 1970 and 1975 expressed in millions

	1950	1960	1970	1975
Telephones	2.5	6.0	13.8	20.0
Main Stations	1.5	3.3	8.8	13.2

About 54% of households in the Federal Republic have a telephone, but a breakdown of this statistic reveals that the penetration rate differs sharply according to income, size of community and age of subscriber. Thus only 21% of low income families had a telephone as compared with 43% for the middle income groups and 88% for the highest income groups. For communities with less than 5,000 inhabitants, 47% of households tended to have a telephone as compared with 69% in cities of over 500,000 inhabitants. The surprising feature is that on the outskirts of big cities only 53% of households had a telephone. Finally, the age distribution of subscribers clearly indicated that people over 60 years of age are insufficiently covered by telephone services.

ii) Teletyping

The Federal Republic has the largest, single, coherent telex network in the world (1975 statistics being the latest published) with around 104,500 subscribers (total world subscribers = 750,000). The increase in the information traffic on this system has been about 6% annually for domestic traffic and 12% annually for international traffic. The world-wide structure of the telex network gives it an important role in the international exchange of information. About 30% of all traffic goes to foreign countries and the total telex network is geared almost exclusively to business communication.

In order to be able to adapt the telex service to the needs of modern information transmission, the entire network of the Deutsche Bundespost will be converted to a new electronic switching system. And~~, in~~ addition, new telex PBX's with electronic switching devices and memory banks will enable them to be adapted to the needs of office organisation also. The turnover from the telex service amounted to 665 million DM for the Deutsche Bundespost for 1974.

The telegraph service by comparison, also being related to the telex service, showed a downward trend. This service differs from the telex service in that it is not a subscriber service, being available for everyone's use.

iii) Data Communication

Looking at developments in this significant area we see that data processing was at first carried out by the use of independent computers with local data input and output. The data, at this stage had to be transported to and from the computer on physical data carriers (e.g. punched-cards, magnetic tapes, magnetic discs). At the beginning of the 1960's, however, this process began to be centralised by the innovation of data teleprocessing. The old, independent computers were replaced by a computer centre with remote data input and output and, as a result, it became possible to include all those offices where the use of an independent computer would have been economically impossible. That is the real benefit of data teleprocessing systems and the main reason for their installation to date.

By 1973 24% of the computer systems existing in the Federal Republic were equipped for data teleprocessing via the public network. And, by 1974, a total of 24,500 terminals were connected to the telecommunication network of the Deutsche Bundespost. It is assumed by the Telecommunications Commission that about the same number of terminals is connected to private networks. Apart from these public telecommunication networks that have been established by the Deutsche Bundespost, it also approves private telecommunication installations so long as they comply with certain conditions. The private installations may only be used for the internal communication purposes of the licensee and must not be connected to the public communication networks. The Deutsche Bundespost leases circuits for these private telecommunication installations.

The relative situation regarding the use of these various means of data communication may be seen from the statistics available in the 1976 report: at the end of 1974 2.8% of data communication was carried out via the datex network; 34.6% via the dial-up telephone network; 38.8% via various types of leased circuits; and 18% via main stations equipped for direct dialling.

iv) Mobile radio services

Land-based services: The expansion and technical perfection of this service make it more or less unique in the world, though it is very expensive by comparison with the other services. By the end of 1975 about 8,000 private radio-telephones had been connected to the public land mobile radio service.

There is also a special service known as The International Radiotelephone Service for the Rhine which, at the end of 1974, had a total of 18,244 national and international ship stations.

Maritime radio service: This form of telecommunication is subject to the international agreement for the regulation of communication and distress signals to as well as between ships at sea. The number of licensed ship stations in the West German network is about 4,000.

There is also an International Aeronautical Service which is operated in co-operation with the Federal Administration of Air Navigation Services (Bundesanstalt fuer Flugsicherung) for the safety of air traffic. This radio service makes communication possible between aeronautical stations and aircraft as well as between aircraft. At the end of 1974 a total of 7,879 aircraft stations and 1,024 aeronautical stations were in operation.[3]

v) Distributed telecommunication

The home market for television and radio receivers is nearing saturation point as the figures, available for 1976, tend to indicate: 96% of West German households possess a television set; 37% of households have a colour set; and 16% of households own more than two sets. The position with regard to radio, also for 1976, is that 97% of households possess a radio receiver (95% had ones with short-wave reception on them also)[4]; 48% of households had two or more receivers; 44% also owned a car radio.

New or extended telecommunication networks

Technological progress is at the base of further developments within the sphere of telecommunications. The biggest factor in this regard has been the recent, rapid development in the field of micro-electronics which may best be characterised by the concentration of many logical functions and a great number of storage elements into the smallest possible space. The prime importance of this development of micro-electronics, as part of its miniaturisation of components function, lies in the fact that electronic equipment is now far more economical to use due to the greatly reduced costs of its manufacture.

The influence of micro-electronics on the development of communication transmission technology, as well as on the development of information processing technology is also of equal significance. On the one hand, with the breakthrough to software-programmed microprocessors this technology makes possible the greater decentralisation of data-processing and, consequently, a shift of 'intelligence' to the work-place. On the other hand, the use of micro-electronics for communication techniques also renders possible the economic developments of extended or new forms of telecommunications.

A major impetus for new forms of telecommunications has been provided by cable and broadcast reception technology.

Initially, master antenna television systems (MATV's) were installed because they ensured a better qualify reception in 'shadow' areas. However, it was soon realised that these MATV's offered greater possibilities, such as their utilisation to feed in additional programs. In this capacity the MATV's would then become "cable television systems" or CATV's. The possible creation of CATV systems in this form has generated lively discussion and heated debate largely to do with privileges of private interests and the question of political control vs. the possibility of greater political participation by the public that may eventuate from the introduction of this new form telecommunication in the Federal Republic.

At present it is estimated that such a system would be introduced and utilised throughout the Federal Republic between 1985-2000 although several experimental networks are already under way.[5]

The technical possibility of equipping broad-band distribution systems with a so-called return-channel that would permit the transmission of information from the subscriber to a central point has also given impetus for further development. Such a system would make possible the recording of information as well as the retrieval of programs by the subscriber, and, to a limited extent, would also permit dialogue between the subscriber and the central point. Needless to say, the possibility of such a return-channel has greatly captured the political imagination of both the public and the authorities. For its use could provide a means for realising greater participation of citizens in the political process than hitherto. Hence there is some very rigorous and cautious working through of ideas, possible regulations and so forth going on in both the federation and the Laender on this front.

These technologically stimulated openings for new telecommunication media could lead to an evolution of both switched narrow-band telecommunications and of the broad-band distributed mass communications. Such developments have also greatly influenced the technology that is presently largely used for the production and distribution of traditional print media e.g. the eletronic production and transmission of texts. Ultimately it also renders possible the facsimile transmission of printed matter. And, as a result, the traditional differences between printing technique and broadcasting are blurred over. This raises urgent questions, in each case, with regard to the adequate form of organisation of these media in the future. Also, serious socio-political and economic problems are raised concerning loss of jobs and frustrated training programs within the printing industry itself: to wit, the printers strike in Munich, early 1978, over the introduction of fully computerised cold-type-setting by the Sueddeutsche Zeitung.[6]

Socio-political aspects are an important part of the considerations taken into account for the development of new forms of telecommunication since the question of social control must always be at the forefront of the minds of governments and bureaucratic administrations of control. Consideration of access and marketability, for example, need to be considered, for certain structural factors affect the use of telecommunications e.g. level of income, regional location, age structure etc. Thus one of the questions that need to be asked is whether the new communication systems will facilitate a levelling out of the present privileges of access to information or whether they will accentuate the present trend or, perhaps, even create new disadvantages.

The use of dialogue in educational and health services, for example, could have a great positive influence on the socio-political development of the society, while, on the negative side we need to list the very real and serious problems associated with the 'safekeeping' of data and the ways of protecting the privacy of the citizen from the electronic assault of the all too readily available telecommunications techniques in this sphere, particularly the centralised computer data banks, to the corporate interests and the authorities, but not to the private citizen. The debate over these issues reached significant enough proportion to move the federal government to set out protective legislation in this sphere in 1977: the 'Bundesdatenschutzgesetz'.[7]

One form of the use of the broad-band distribution network that I've not yet mentioned, which has recently been discussed and put into practice to a slight extent is the limited distribution of programs, a form of usage that has become known as pay television. This is strictly a subscriber-use form with two types of service available: a) programs transmitted over a specific channel (subscription television) b) specific individual programs (coin television). Thus not even a return channel is required for pay television.

The Commission estimated that the stablishment of a broad-band distribution network without a return channel would require an investment of around 9 billion DM (1976 estimate) if all communities with a population over 33,000 are included (with a 53% degree of penetration) and approximately 22 billion DM if all populated areas are to be covered, with an additional 3 billion DM to be added to this sum for long-distance and regional networks.

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The operating costs of such a distribution network (without a return channel) would be in the order of 200 DM annually, per subscriber.

On the other hand, the Commission estimated that with the present level of technology available, it would be possible to cover the whole area of the Federal Republic of Germany with four additional television programs by using television broadcasting satellites. Such a satellite system would require an initial investment of around 800 million DM, with an additional 15 billion DM to 25 billion DM required for the receiving equipment (based on 1974 prices). These satellites, then, would not be a substitute for, but rather complementary to the broad-band system.[8]

A 1975 report on the press in relation to the electronic media from the perspective of the Laender made the point that neither the public institutes nor private undertakings were in a position to raise the investment requirements for the thorough-going establishment of a cable television system in any form in the immediately forseeable future. To this, the report added that neither are there sufficient households at present (i.e. a sufficiently wide market) that could purchase the receiving equipment and pay the program subscriptions, the warrant high priority for the establishment of such a system in the near future. They also report that the effects of the current economic recession must be taken into consideration in this sort of planning.[9]

Other developments, such as video cassettes, video-recorders, electronic mail, video-text or the facsimile newspaper, which is both technically available and legally admissible in the Federal Republic, will have to be omitted from discussion. The subject of data communication, however, warrants further discussion. This has been the fastest expanding area of telecommunications in West Germany and, as mentioned previously, an area that has generated a good deal of concern in recent years. This concern is basically to do with the protection of the privacy rights of citizens in the face of the spiking of personal data about citizens at the various data banks which, in the words of the Commission itself 'greatly aids the administration of justice'.[10]

Data transmission at present is available via dialled and point-to-point connections, and, at the end of 1974 there were 24,500 data stations (terminals) in the Federal Republic of Germany connected to the telecommunications network of the Deutsche Bundespost (with about the same number of terminals in private, internal networks). By 1985 the Eurodata study predicted that there would be 6.8 times as many computers installed in West Germany as existed in 1972, and about 15 times as many terminals.

In relation to the number of computers in service, 24% of the systems with facilities for data teleprocessing were designed to operate via the public network in 1973. By 1980 it will be 36%. For the smaller type of computers, the increase is to be from 20% in 1972 to 62% in 1985. The corresponding percentage for medium and large computers is expected to fall from 51.5% to 22.2% and 28.7% to 15.7% respectively. In absolute terms, however, a heavy increase is expected in all three categories. The shift in the relative distribution of large, medium and small computers is seen as a step towards the decentralisation of data processing, whereby the smaller computers are often operated in conjunction with larger systems.

The aforementioned Eurodata study has also predicted that by 1985 the Federal Republic of Germany will have 200,000 terminals using telecommunication circuits of the Deutsche Bundespost, giving her the largest supply of data stations in the whole of western Europe.

Ironically or, perhaps, ominously, in the face of the discussion about concern for citizen rights the Commission reported that:

> Data communication plays virtually no part in the lives of private households; it is contentrated in institutuations in the economic, social, cultural and political sectors.[11]

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AN ELECTRONICS INDUSTRY FOR THE PACIFIC ISLANDS

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ABSTRACT

The Pacific Basin and particularly the Pacific Islands are graced by mild climate, a handsome, vigorous people and by some of the world's most spectacular scenery. The Gods were less generous in providing these areas with a means to develop a 20th century economy.

If we narrow our focus to the central Pacific Islands, we find some real constraints to economic development. The central Pacific Islands by and large lack significant deposits of minerals. They are virtually devoid of fossil fuels. Reserves of oil, natural gas and coal range from nil to insignificant. With few exceptions, extractive industries are not possible. Similarly, the islands are out of the normal trade routes, lack developed infrastructures, do not have domestic markets of any dimension and are a long ways from export markets. Therefore, conventional industry requiring either capital intensive plants or high density, low cost labor find little attraction to the islands.

Before exploring electronics as a means of aiding economic viability, let's pause a moment and consider whether in fact a 20th century economy is required or even desired by the Pacific Islands people. We'll pause only a moment because this is a debate that has raged since Capt. Cook and the Resolution first sailed into the warm waters of the Pacific. It is an argument that will continue many years in the future, well after the last Pacific Island home is equipped with an interactive video set cum computer peripheral!

The point is, we are here to discuss technology not sociology, and in any event the arguments are mooted. The "Zoo" theory advanced by the U.S. Department of the Interior 15 or 20 years ago (that of keeping the Pacific Islands in their idyllic and pristine condition) was bypassed by history and by the political and social ambitions of the Islanders. So the question is not whether we will have change, the question is, how do we live with change and how can we direct it towards what Hawaii's Gov. Ariyoshi terms a pattern of "*preferred growth*".

An electronics industry in this context is especially worth exploring for it may provide a means of satisfying some of the economic and social goals of the Islands while at the same time not infringing too harshly upon the existing life style.

Electronics fulfills a lot of the characteristics needed for successful application to the Pacific Islands. It is a clean industry. Electronics does not bring smokestacks to town. In fact, on your next visit to the San Francisco Bay area, drive down to "Silicon Valley" and look at the industrial and research parks around Mountain View, Cupertino and Santa Clara. These are pleasant, attractive, well-landscaped buildings. They certainly contribute a higher standard of architecture to their community than do most of the hotels in the concrete jungle surrounding us here on Oahu. Electronics has high value to weight ratio. This is especially true for telecommunications, data equipment and semiconductors. This is critically important as it minimizes the cost of transport. In fact, if you consider the high technology product of an R & D industry the value to weight ratio is almost infinite since the product is expressed on paper in computer programs or in software.

Let's consider the spectrum of things we've been talking about in the electonics industry and see how they may be applied to different areas. The range of items under discussion include:

A. Research and Development Laboratories and/or Applied "Design and Development" Laboratories

B. Semiconductor Assembly

C. Manufacture of consumer goods

D. Manufacture of Telcoms, data equipment and systems

E. Service Industry

F. Ancillary businesses in the infrastructure

RESEARCH AND DEVELOPMENT

Projecting only a very few years ahead, the R & D Laboratories will no longer be tied to locations proximate to major universities. International subscriber dialing networks allow teleconferencing, facsimile and data circuits and interactive publicly accessed systems. All of these allow the researcher to follow the sun and to locate where he will.

Satellite terminals and low cost, high density submarine telephone cables are rapidly making this possible. A researcher in Fiji could use his View-data set to access a data base in London or Palo Alto. In the United States this is already occurring. I know of one case of a scientist who happens to be a paraplegic. He performs most of his research work for General Electric Co. from his home. The company has astutely provided a computer terminal that allows access to material necessary for an economically productive endeavor.

SEMICONDUCTOR INDUSTRY

We generally think of the semiconductor industry as being extremely high technology, of being out of the cutting edge of the state-of-the-art. But fabrication of semiconductor devices, that is, assembly of the units, lead bonding and the like are manufacturing processes requiring only an adept labor force and a minimal amount of supporting infrastructure. The enormous semiconductor industries in Penang and Kuala Lumpur, Malaysia, in Indonesia, Singapore and the other ASEAN nations use a manufacturing technique developed by the American semiconductor companies. This specialization of labor allows a villager from a Malay *Kampong** who has never even used a television set to fabricate microprocessor LSI circuits.

**village*

CONSUMER ELECTRONICS

Consumer electronics are produced on an extremely competitive basis. It is a business requiring large amounts of labor at quite low wage scales. It also requires the movement of large quantities of material in and out, so the consumer goods plant must have economical, long distance transportation facilities. A note about "low wages" is in order. Low wages is a relative term. Many developing countries find consumer electronics attractive because despite the modest wage scales they do create many jobs very quickly.

HIGH TECHNOLOGY PRODUCTION: Telecoms, Data Sets, Instrumentation et al.

These products exhibit a very high value to weight ratio. They typically yield high profits because the value added in manufacture is large. The nature of these products requires a fairly well developed technological infrastructure. Production facilities are closely related to research and development capacity. A high percentage of plant employees must be trained engineers and professional level personnel. Generally this industry flourishes near major universities or in the presence of research institutes. Production runs tend to be shorter, therefore printed circuit board artwork generation and board etching facilities are needed in close proximity to the production facility.

A consumer assembly plant may manufacture 100,000 pocket calculators of a single type. All of the materials for this large production run can be kitted or staged and sent in a continuous supply stream with precise scheduling.

The high technology plant will have production runs of 50 to 500 boards each and may be manufacturing a dozen or more different items at the same time. Complex scheduling, cash flow and production control requires closer communications with the vendors and subcontractors.

SERVICE INDUSTRY

Developing countries face many dilemmas brought on by the march of technology. Equipment tends more and more to be designed for the large North American, Japanese and Western European markets. A remote, developing country or even a developed country remote from those major population centers is forced to use equipment designed for different geographical and social parameters and especially a different set of economic constraints.

Consider telephone central office switch gear. Most developing countries would be well off with simple direct control electro-mechanical switching. Perhaps common control cross-bar of even Strowger Step-By-Step. But the manufacture of these types of switching are being terminated by the major suppliers. The dual prods of labor cost and sophisticated customer requirements have moved the manufacturers to develop processor controlled digital switches.

From an economics standpoint, the developed countries quite readily substitude capital for labor. A developing Pacific Basin country usually has an opposite set of criteria. It is short on capital, has an abundance of inexpensive labor and has customers requiring only basis *P.O.T.S** service. The Island telephone system also lacks a workforce with the technological skills necessary to maintain sophisticated products.

The equipment manufacturers resolves this problem through the use of easily replaced plug-in printed circuit board modules. In theory, this relieves the distant telephone company or P & T from a requirement of having highly skilled technicians. On the other hand, it means they must invest a much larger amount of scarce capital in spares and standby equipment because the turnaround pipeline for the modules is quite long.

If you have a factory in California's Silicon Valley and install a central office on the U. S. East Coast it is valid to make this statement, "Just send us the defective card by air parcel post or UPS Blue and we will turn it around within 24 hours.". It is quite a different matter when the unit is installed in the Pacific Basin and the module must:

A. Clear local customs

B. Be documented properly, perhaps with a bond

C. Be transported

D. Clear U.S. Customs, again with another bond posted

E. Repair or replace

F. Transport back

G. Customs clearance and handling fees again to get back into the owner's country.

Even a relatively sophisticated society as Honolulu faces this problem. At any given moment there are thousands of modules in transit between the mainland U.S. and the Hawaiian Islands. These are for telephone, data, computers, automobiles and all of the other types of products permeated by electronics.

As this permeation continues and intensifies with cheaper and cheaper integrated circuits and especially microprocessors, this problem will grow. Problems though, create opportunities. A depot level servicing opportunity exists in many Pacific and Asian locations. The cooperation of the original equipment manufacturer is critical in this. Test fixtures, spares, technical manuals, calibration standards must be provided by the O.E.M.'s.

**Plain Old Telephone Service*

ANCILLARY BUSINESS

As the electronics industry in an area develops it exerts a sometimes subtle, sometimes profound influence on the local business infrastructure. Building of factories, renting of office space, housing for expatriate managers, improved living standards for local professional and middle-management staff, all create positive business opportunities in the community.

Electronics also brings opportunities for those who wish to contribute to the supporting infrastructure. Often these business opportunities require limited amounts of capital and only a passing familiarity with electronics technology. They, therefore are well within the province of local entrepeneurs. A partial list includes:

A. Component Distribution. Local electronics stores selling resistors, transistors and integrated circuits, solder, hand tools. Initially, the distribution source will provide for sudden expansion and overruns, but an adept businessman will soon cater to the needs of the manufacturers and his engineers and will expand to become a primary perhaps franchised distributor.

B. Printed Circuit Board Fabrication. A full fledged, double sided, plated thru-hole or multi-layer PC board plant is a capital intensive enterprise requiring some special skills. On the other hand, the electronics industry often requires simpler, small scale production of single or double sided boards for prototypes, test equipment and short-run production. If the local electronics industry has a high R & D complement, opportunities exist for graphic layout and PCB artwork taping, photo reproduction of artwork, precision silkscreen manufacture, silkscreen printing or printed circuit boards, chassis and front panels.

C. Precision Sheetmetal and Chassis Fabrication. A relatively modest investment in punch presses, box finger brakes, and other high grade sheet metal tools will result in a viable business near any electronics center. Plating shops capable of anodizing and eriditing and plastic shops who can handle, cut, drill, fabricate front panels, and faceplates are needed.

D. Technical Writing. Especially by writers with multi-lingual capability and a knowledge of basic graphics production processes are always in demand.

E. Custom Board Loading. PC Board "stuffing" facilities require only rudimentary work benches, skilled workers, temperature controlled soldering irons and common sense production control. Subcontracting for larger assemblers creates dozens of opportunities.

HAWAII

The State of Hawaii is actively engaged in developing an electronics industry. Mike Colvin from the Department of Planning & Economic Development of the State will later present a paper on his state's effort. Briefly, Hawaii has opted for a high technology industry. A Research and Development orientation with production facilities for high value, low weight products. Hawaii is a relatively high labor cost area and has a successful economy based on tourism and tropical agriculture. The State sees alternate economic solutions to development needs in an electronics industry.

Hawaii creates many electronics engineers per year most of whom travel to the mainland to find employment. This creates both economic and social problems which a successful industry can resolve. The Hawaiian Islands also need lower level jobs for the many thousands of immigrants from both the mainland U.S. and Asia, who must be accomodated each year.

AUSTRALIA/NEW ZEALAND

Australia is a developed country with broad based industry and extensive mineral deposits. It has an existing electronics industry oriented toward local demands. As a political matter, Australia has traditionally had a high tariff barrier designed to protect its domestic market from outside predators. This has been a major reason for creating a high manufacturing cost environment which makes the European, Japanese and American electronics companies quite happy. Otherwise the Australians would pose a major threat to the Southeast Asian market.

It is a political comment perhaps not germane to a discussion at the PTC, but the Australians may yet wind up on a par with the major suppliers of the North. As ASEAN develops, it is quite probable that they will go the route of the European common market in creating tariff barriers. Most of the multinational companies already realize that they must (as they well should) provide technology transfer and a share of the economic benefits through joint ventures or licensing.

New Zealand is also a developed country but its home market is relatively small, not allowing for a domestically oriented electronics industry on a broad basis. Still, anyone who is involved in radio communications in East Asia is aware of at least one Kiwi company that has successfully penetrated the mobile radio markets, long thought to be the exclusive domain of American manufacturers.

FIJI

This Island group has many attributes for an electronics industry. There is a good population base of approximately 600,000 people. The location is a bit off the normal stream of electronics component manufacture, but does have very good air transportation schedules. Both the Fijians and the Indians are a vigorous people with a good work ethic and demonstrated ability.

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On the short term, Fiji could decide to use its relatively low labor rates to attract the "busy hands" labor. Perhaps a semi-conductor industry could be attracted due to the labor capabilities, clean water, stable government, adequate power. This would require establishment of a free trade zone and tax concessions or other incentives following the ASEAN country examples.

Tax concessions and free trade zones often evoke negative images in developing countries. An important consideration, though, is to remember that most of the traditional abuses of these economic stimulants came from the old trading companies. During the colonial era they too often took advantage of a fundamental need for import substitution. The electronics industry that is postulated here is export oriented and an entirely different set of parameters obtain. The multi-national electronics companies, particularly the semi-conductor industry demonstrate an enlightened self-interest that allows the host country to exert more control while allowing their foreign partners to retain and repatriate the profits.

Fiji has a very desirable climate and living style. As its industry develops, it could look towards longer term possibilities. It should be easy to attract design and engineering talent. Both local engineers who have gone abroad to study and work and other commonwealth, Western European and American technologists would welcome life in a South Seas environment. That is, as long as they have telecommunications facilities to provide remote access to their data bases.[4] One consultant of international stature, D. George Peck & Associates is already based in Suva.

Fiji has the advantage of ample land and even more important, an English language facility. English is definitely the language of electronics.

GUAM

A good location in the Western Pacific, close to Asian component sources and directly in line with the North American markets favors Guam. Existing laws allow a quite substantial rebate of federal income taxes. This should make Guam especially attractive to U.S. manufacturers. Guam benefits from the equal protection of laws under the U.S. Constitution. Japanese companies, under pressure to improve the balance of payments with the United States could well take advantage of the fact that a product manufactured in Guam enters the United States duty free and is considered an American product providing over 50% of the value is added in Guam. For such Japanese companies, Guam offers a shield under existing law, from U.S. income tax.

This gives Guam a decided advantage over the present Japanese trend of establishing and manufacturing on the U.S. mainland.

Guam could also provide a toe-hold for American companies entering the Asian market.

The English language capability on the Island is good and Guam (although under U.S. law) is outside the U.S. customs barrier. A company could import printed circuit boards from Taiwan, components from Japan and Hong Kong and assemble them on the Island.

Still another facet of Guam is the presence of large military forces. From Hawaii's experience, this can provide considerable technology transfer by employing "moonlighting" technicians and military wives.

External telecommunications facilities are quite good, as Guam is the hub of many cable and satellite links.

Guam is not without problems though. The Agana government has been politically unstable. Now with a businessman as Governor, the near-term potentials should be improved. As an organized U.S. territory, Guam is subject to the U.S. minimum wage laws, which means that wage rates are quite a bit higher than in other Asian countries.

Air Transport in Guam is barely adequate and schedules in and out of Guam by the American carriers are unfortunately, on the decline.

On-Island transport and the local telephone and power system bear improvement. The Guamanians are not unaware of this and are providing considerable emphasis in making needed infrastructure improvements but there is yet a long road to travel.

Fair or not, many U.S. engineers have a negative image of Guam as a place to live. Hawaii offers more inducements as far as a lifestyle and of course, is many thousands of miles closer to the American Mainland. Nevertheless, a high technology industry on Guam could probably attract many competent Asian engineers. This would require compliance with regulation of the U.S. immigration and labor authorities, but favorable precedents do exist.

Samoa on the surface appears to have even greater opportunities for an electronics industry. In Samoa labor is decidedly less costly than in Guam, however, scratching the surface shows a number of problems that make it quite difficult to attract an industry to other American or Western Samoa. These include:

A. Small population and labor base*

B. Limited land area

C. Inadequate Utilities and Telecommunications

D. Off the beaten path. Samoa is out of the flow of electronics components and products. Both sea and air transport is quite restricted.

E. Infrastructure: Electronic manufacture is non-existent, the economics of infrastructure is still developing.

*Less of an absolute problem in Western Samoa than in American Samoa.

F. Political and Social Concerns. As lovely as the Samoans are and as attractive as the Polynesian lifestyle is and as stable as their governments have been in recent decades, the perception of the average American or Japanese businessman is quite different. They place Samoa quite low on the priority list for plant site selection.

What was said for the Samoans holds true in greater or lesser measure for Tonga, the Cook Islands, French Polynesia and Kiribats.

TRUST TERRITORY OF THE PACIFIC

What formerly was the U.S. Trust Territory of the Pacific and what is now finding political maturity as the Commonwealth of the Northern Marianas also has some interesting potential for development.

Recently at the 1979 Hawaii Congress of Planners, a young Micronesian approached to discuss the possibility of an electronics industry for his Island, Ponape. He is an electrical engineering graduate from the University of Hawaii but had no opportunity to practice his chosen profession at home so he was pursuing additional education in the United States.

Applying some of the criteria used in examining the other mid-pacific Islands: land, people, costs, political stability, he was given a firm "maybe!".

Certainly the electronics industry is worthy of evaluation. The Japanese are very sympathetic and favorably disposed to the Islands they formerly occupied. There is a good potential for tax advantages and potential duty free entry into the United States.

On the other hand, infrastructure problems are great and probably insurmountable for the immediate future. Power, water, land transport, external air transport have not kept pace with what one would expect from a U.S. administered territory.

An exception could be the Northern Marianas. Saipan has adequate transport and good international communications via ties to the Hawaiian Telephone Company. The people of the Northern Marianas have an English language competance and are comfortable with the Japanese.

CONCLUSION

Electronics is booming on a world-wide basis. As the cost of virtually all products rise, electronics costs are diminishing. The complexity and usefulness of its products is enhanced daily as increased application in all sorts of industries are found. If for no other reason than the above, the electronics industry may be worth exploring for it may be the means of satisfying the economic and social goals of the Islands while not infringing too harshly on the existing life style.

ELECTRONICS AND HAWAII

"A WINNING COMBINATION"

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Abstract

This paper describes why Hawaii is interested in promoting the electronics industry, why Hawaii is suitable for the electronics industry and what the State is doing to support electronics industry expansion. Included are comments on the Hawaii State Plan, community support, labor force, education and compatible industries.

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ERIC

Electronics and Hawaii are a winning combination. We want you to know precisely why.

First, the State seeks industry which is compatible with the special quality of our Hawaiian environment. You know us as a place of fantastic beauty.

Our water is naturally pure, abundant, and needs no chemical treatment. We have, perhaps, the best natural water system anywhere in the world.

The air in Honolulu is the cleanest air of any major urban center in the country. Yet, Honolulu now is America's 13th largest city.

Our Islands are special and we want to keep them that way.

The second basic reason we are committed to electronics is that we seek industry in which our rich and ethnically diverse population can realize its full potential.

We especially want our talented young people to be rewarded for the high value which the people of Hawaii place on education. In this regard, we are deeply concerned, which brings me to my third point:

The current structure of our economy. Tourism is, as you know, Hawaii's largest industry. Tourism is larger than defense spending, sugar and pineapple combined.

Tourism is expected to nearly double by the year 2000, while the others are not expected to grow significantly.

Our future prospect, then, is to become increasingly dependent on a single industry which provides relatively lower-skill and lower-paying jobs.

So when we speak of our desire for economic diversification, it is not merely rhetoric. It is a fundamental reason why we are seeking to expand our electronics industry and why new firms can expect to be treated well in the Islands.

We are working systematically to bring electronics firms to Hawaii.

Governor George R. Ariyoshi is personally committed to, and involved in, that effort. As he has noted, "Expansion of the electronics industry has the support of the State and County government agencies, the State Legislature and private industry."

With the support of Governor Ariyoshi, the Hawaii Legislature has enacted into law a State Plan.

A reading of this plan clearly shows that Hawaii is not anti-growth, as sometimes described. Rather --

We pursue a policy of Preferred Growth, and in every respect the electronics industry fits the priorities set forth in the Hawaii State Plan.

Electronics is a smokeless industry.

Electronics provides challenging, high-skill employment and good pay.

Electronics can increase exports and reduce imports, which is a basic concern of ours.

Because electronics is expected to triple sales world-wide by 1990, we see a potential for significant economic diversification.

The 1979 Legislature appropriated $125,000 to expanding electronics for the Hawaii Institute for Electronics Research, a cooperative effort of the University of Hawaii -- the State Department of Planning and Economic Development -- and private industry.

The State Economic Development Division has a well-established program of promoting preferred-growth industries, and we are prepared to engage in product promotion, provide low-interest loans, and assist in finding locations, recruiting talent, and marketing.

We believe this expansion effort can succeed for three basic reasons:

Number one -- Talent. Hawaii has a reserve of professional, managerial and technical talent which can be put to work in electronics and more such talent in the educational pipeline -- as well as a reserve pool of highly motivated and skilled workers.

A second reason is science. Hawaii has a strong, diverse scientific community. Hawaii will provide a good climate for electronics research, development and manufacturing.

Number three -- Pacific location. We occupy a unique Pacific role which spans East and West in population makeup, language, culture, transportation, communication and business contacts.

In describing point one, Hawaii's electronics talent, Hawaii's tradition of seeking educational excellence should first be stressed.

It is deeply rooted in both our missionary history and our plantation-immigrant history.

Today, 32% of the adult population of Hawaii has completed 13 or more years of schooling, compared to a U. S. average of 28%.

The University of Hawaii has an excellent school of engineering and department of electrical engineering.

It provides extensive, up-to-date hands-on training in solid-state electronics and computers, in addition to traditional basics.

Each year, 70 students graduate from the University of Hawaii, and 90% of them reluctantly leave the Islands for employment elsewhere.

As a matter of fact, many of the top electronics and related companies in the country are engaged in wholesale recruitment of Hawaii talent to the Mainland.

Hundreds more graduate from Mainland Universities, and are frustrated in their desire to return to Hawaii to work. These students represent a ready reserve of talent for Hawaii manufacturers.

The University placement service lists 30 Hawaii-born electronics engineers now living on the Mainland who would like to return home; undoubtedly, there are many more.

Fifty engineers and technicians are listed by the State Labor Department. These individuals unable to find suitable employment in electronics who would be immediately available to fill job openings.

As further evidence of this reserve talent pool, consider the experience of Hawaiian Telephone Company. They have no trouble hiring electrical engineers and, in fact, they have 75 engineers on their waiting list, now living on the Mainland, seeking to move to Hawaii..

The University of Hawaii has a statewide community college system which graduates 40 to 50 electronic technicians a year.

This training program is generally responsive to industries which create quality employment, and it could be expanded as demand warrants.

Both the size and nature of Hawaii's labor pool is also an asset for electronics. As of July, 1979, 23,000 active job seekers were listed with the Honolulu job bank, including 3,000 technical, managerial or professional workers. This represents the minimum available labor force, since there are many additional job-seekers listed only with private agencies.

Hawaii has a steady influx of immigrants from Pacific and Far East nations -- more than 9,000 in 1977.

Many are trained in electronics or capable of being trained, and together they provide an ever-expanding work force for the industry.

A specific demonstration of the availability of electronics workers occurred recently when a Mainland manufacturer advertised in Honolulu's newspapers. He was astounded by the response. After the first half day, he stopped taking applications and disconnected his telephone.

Our employees are a bargain. Average pay for electronics and taparable skill areas is less in Honolulu than in major Mainland areas.

More importantly, Hawaii workers are motivated, dedicated and enthusiastic.

- In a 1978 survey of employers, all Hawaii employers described the more than 300 electronic workers here as above average in quality.

This impression of a motivated work force is supported by State Labor Department statistics which shows that 99% continue in their jobs from one year to the next.

Let us turn to point two -- we provide an excellent climate for science. A climate that is supportive, stimulating and very possibly generating opportunities for new applications of electronics.

Hawaii is the leading center for scientific research and development in the Pacific and the University of Hawaii is one of the leading university research centers in the country. It is consistently in the top 3 percent among U. S. universities in receipt of Federal research and training grants, at an average of $30 million plus dollars annually.

We are in the forefront of research into alternate energy potentials, such as geothermal energy, biomass energy (derived from sugarcane and other fast-growing plants), and ocean thermal energy conversion. We believe, realistically, we have an excellent chance of becoming the first State to achieve self-sufficiency in renewable energy resources.

Hawaii is a major marine research center in such areas as marine food producti[illegible]nd manganese nodule mining.

Our astronomical observation site on the Big Island's Mauna Kea is the highest and southern-most site in the world.

It has the cleanest, driest air of any observatory in the world, or what astronomers call the best "see".

As a result, we are rapidly becoming the international capital for astronomical observation and research.

The fundamental point is that we have the concentration of talent and program necessary for science to flourish. This is an asset we have nurtured carefully since the early days of Statehood.

The third basic point -- in the same way science benefits, electronics can benefit from our unique Pacific location.

The East-West Center, for exchange in communications, envirohmental policy, business development and resource systems, is the only one of its kind in America.

The roots of half our people are in Asia. We understand the Pacific, and we are uniquely positioned to open Pacific markets.

Communications are excellent; Hawaii is the only place in the U. S. in which you can call both the East Coast and Asia in the same working day.

Transportation is readily available and affordable. Air parcel post rates from Hawaii to New York are the same as from California to New York.

Air freight costs are negligible for the high-value, low-weight type of production we seek: $30 to ship a 20-pound item to the West Coast. Air service to the U. S. Mainland and the Far East is frequent, with well over one thousand flights a week arriving and departing Honolulu International Airport.

Our Pacific location offers Far East marketing potential, and our communications/transportation links are excellent.

Cost is competitive with comparable living costs, and cost of government, and industrial and office space is reasonably priced and widely available. Government and industry are cooperating in this effort, and we stand ready to assist firms interested in Hawaii. They will be welcomed and will enjoy ongoing support and cooperation.

It is as our Governor said, "We are convinced that electronics and Hawaii can be a winning combination".

HUMAN CONSIDERATIONS IN ON-LINE SYSTEMS DESIGN

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Probably the most important aspect of an on-line system, as far as an on-line user is concerned, is that it can be used directly by the person with an information need without delegating the search process to an information specialist, i.e., a data processing technician. This being so, it is all-important that on-line systems by "acceptable" to both existing and potential users.

This phenomenon was initially defined by Calvin Mooers. According to Mooers' Law: "An information retrieval system will tend not to be used whenever it is more painful and troublesome for a user to have information than for him not to have it." In this paper, we will consider some of the important factors concerning human acceptance of on-line systems, as well as factors influencing ease of use of these systems. These factors will ultimately determine whether the on-line system is used repeatedly and whether it is preferred to other sources of information.

In preparing this paper, it became quickly apparent that studies on the behavior of users in an on-line systems environment are extremely rare. However, the findings of those studies which were available have been summarized and are presented in the hope that they will enable the data processor to build more effective on-line systems. To ignore the user, and his reaction, will simply cause users to become frustrated, lose interest in the on-line system, and turn to alternate sources of information.

Getting back to Mooers' Law, and if is is accepted as being valid, then two questions must be raised:

1) What factors influence ease of use from the users viewpoint?
2) What ultimately determines whether a user will make use of a system repeatedly?

There are probably as many different answers to these questions as there are users. However, in evaluating the studies referenced in this paper, the following answers occurred most often:

- A) User Acceptance
- B) Time Factors
- C) Hardware Factors
- D) Language of Communication
- E) System Sensitivity
- F) Errors and Error Messages
- G) Symbiosis

The remainder of this paper is directed toward expanding and defining each of these areas.

A. USER ACCEPTANCE

In a study performed by Dr. R. V. Katter, several factors were presented that appear to influence user acceptance of an on-line system. He defines four "effects" that the neophyte user may well experience at an on-line terminal. The first is a pressure effect. The immediacy of feedback provided by the on-line system, which is one of its most important and obvious attractions, may in itself be disconcerting and intimidating to some inexperienced users. Because the terminal responds rapidly, the user falsely feels that he must respond equally rapidly. Certain users may be conscious of this pressure and begin to compensate. Consequently, they do not allow themselves adequate time to fully interpret the on-line feedback, they make hurried decisions, and their search interaction becomes suboptimum as a result.

The second effect reported by Katter is the peephole effect, which tends to be a characteristic reaction to the user of typewriter terminals. For the inexperienced user, the typewriter terminal may create the effect of a peephole through which the contents of a data base can only be viewed in very small pieces. Although a system response may commence in a relatively short time, the full message is spelled out laboriously at approximately reading rates, and the user is given no feeling of the "conceptual distances" that the system may have to travel in order to produce a response. The typewriter is not a good browsing device. It gives the impression of "plodding" and the user has difficulty in visualizing his complete search strategy, perhaps more so than if he were using a conventional manual method. All of these factors contribute to the feeling by users that the system is somehow very mysterious. The user of a CRT display unit is less likely to feel the peephole effect, although it may still be present in a milder form.

A third effect noted by Katter is termed the fishbowl effect. In a manual system, such as a printed index or card catalog, the search is conducted in relative privacy. Some neophyte users feel that this privacy is denied them when they operate a terminal, especially when it is located in a crowded public area, and that their deficiencies in searching and keying are being that one's on-line actions are being "monitored" by not necessarily sympathetic persons in the computer installation.

Dr. Katter described his fourth observed effect as a lack of sympathy effect.

This is due primarily to the realization that the on-line terminal is viewed by the user as an expression of the concerns and self-interests of others who do not share one's local or personal views, values or goals. The remoteness of the computer and data base to which the terminal is hooked are acutely obvious to the new user. At the same time, the remote computer can seem to be an active, somewhat self-governing entity, that is busy satisfying the needs and concerns of many other persons, with whom the user may share little mutually. The new user with such a perception may not expect the system to be very sympathetic. This, in turn, causes the user to have a lack of sympathy with the system, other users, and data processors.

Taken together, these four effects account for the subjective feeling of a subject-object role reversal that has been described by many fledgling users of on-line terminals. Instead of perceiving the system and the terminal as an object that he, the subject, molds to his wishes, the user feels himself to be the object that is being molded and manipulated by the system.

There are several other reactions and factors which will directly affect user acceptance of an on-line system. Some users have an innate phobia relating to the suspected "fragility" of the on-line system. They are afraid that if they make a mistake (e.g., hit a wrong key), this will cause drastic and irreparable damage to the hardware or data base. It simply means that designers and managers of informaton systems should do all they can to reduce wild fears of this type. However, it is equally important that users must be told to abide by system rules and that they not be allowed to "play around" with the system. Certain other users are hostile because they dislike typing, are very poor typists, or basically feel that typing is demeaning or beneath their dignity ("I have had a secretary to do my typing for almost 20 years"). Despite these various adverse reactions, on-line retrieval systems have generally been accepted with great enthusiasm, although not all users wish to conduct their own searches; some still prefer to delegate to an information specialist. In some information centers, the introduction of an on-line terminal was found to attract new users, users who did not take advantage of previous batch-processing capabilities, and even people who had previously made no use of the centers facilities in any form. In some cases, at least, the on-line system attracts requests that would be completely unsuitable for processing in a batch mode.

It is important to realize that the "subject-object role reversal" concept mentioned by Dr. Katter is usually a temporary experience for a new user. The time period associated with this phenomena depends on how data processors view the situation.

If data processors attentively react to user requests, this feeling tends to disappear with increased practice in using the system. It is also quite possible that the user's awareness of this phenomenon will not be as vivid as depicted here. Nevertheless, some users will be aware of it, and their acceptance of the on-line system will be affected accordingly. Most new users will tend to adopt a non-commital, provisional attitude toward the system. Although they are not quick to find fault, they will tend to reaffirm the positive values of manual tasks with which they are more familiar.

Two other important factors relating to user acceptance should be noted. The first is the novelty factor. Some use of terminals is undoubtedly due primarily to the fact that they are new and attractive because of their novelty. Even if a user adopts an on-line system when it is first made available, there is no guarantee that he will continue to use it on a long-term basis. To outlive the novelty period, it must help the user solve informational problems. The second and related factor concerns education.

Generally speaking, it is true that when an on-line system is initially installed at a user location, the majority of potential users will not have had previous exposure to any form of on-line terminal. While this novelty may attract certain users, it may very well repulse others who are inclined to avoid the unknown. This entire situation is likely to change dramatically within the next decade or two as on-line systems are used increasingly for educational purposes in universities, colleges, high schools, and even elementary schools. Problems of this type relating to user acceptance, while important now, may be virtually non-existent in the near future.

B. TIME FACTORS

The on-line user expects "rapid" response from the system. When he comes to expect a system response of a few seconds or less, he tends to be disturbed if he has to wait much longer. In a study conducted by J. I. Schwartz, it was determined that when response time exceeded 15 seconds, due to system problems, hardware malfunctions, or unusual conditions, users who were not used to such a delay became both disoriented and impatient. They will generally stand by, however, as long as they are reasonable confident that the system will eventually respond. For this reason, it is important that some form of "PLEASE STAND BY" message be transmitted by the system as soon as possible after it is known that processing delays will occur.

Operators using an on-line terminal throughout the working day tend to become bored if they are forced to wait lengthy periods for system responses. Such boredom soon lends to feelings of fatigue. This factor alone will decrease operator performance levels. In a study conducted by H. Sackman, it was reported that users with tasks requiring relatively small, simplistic computations (e.g., typical business problems) become increasingly uncomfortable as computer response time to their requests extended beyond 10 seconds, and as irregularity and uncertainty of computer response time increases. Users with problems requiring more complex computations (e.g., engineering or scientific problems) tolerated longer intervals, up to as much as 10 minutes for response time in longer-running tasks.

Probably one of the most important, yet overlooked, technical considerations is pacing in on-line systems. Pacing involves procedures whereby the terminal user is clearly told what he should uniformly expect in terms of response time. Obviously, pacing is accomplished in different ways in different systems.

In another study relating to pacing, Dr. Katter and D. A. Blankenship determined that if system response were always instantaneous, the user's attention would never need to leave the terminal except to attend to his part of the mutual problem-solving process. In this case, both terminal and user times would be employed at maximum efficiency, since the system would wait on the user only when necessary, and the user would never have to wait on the system. The fact is, however, that response times are usually not instantaneous (or even desirable) so that the user has the possibility of using the delay either for rest or for other work, whether it is related or unrelated to the on-line problem-solving process.

If response times are always short, the user may use the delay for a brief rest or diversionary activity such as shutting his eyes, moving or stretching his body, looking around, moving a paper, or to passively track the system's activity. As response time becomes longer, however, the user is tempted to use the waiting period for other work. Here a psychological problem can arise due to tension created by the unfinished task when a system response indicates that the terminal is waiting on the user before he has completed the peripheral task which he anticipated he would be able to finish during the delay.

For at least the above stated reasons, it is psychologically rewarding for the user to be able to accurately predict the period of response delay. This would indicate that for some intermediate part of the range of distribution of possible response-delay periods, there is a clearly establishable value-tradeoff for the user between invariability and shortness of the response-delay period. No matter what the length of the required response-delay period might be, as long as it was reasonable, users prefer to be able to predict it accurately.

Unfortunately, many data processors approach on-line systems and response time naively. The initial system will provide the fastest level of response. However, as additional systems and users become involved, response time will degrade. It is therefore important to anticipate an end level of response time (with all systems and users on-line) and create some type of timing mechanism which will stabilize response time. The timing factor in this mechanism would, of course, be reduced as new systems or terminals are added until the desired response level is achieved. A simple software loop can be employed to solve this problem.

In their study, Katter and Blankenship describe four commonly used devices which can be implemented to pace man-machine interaction:

1. Confirmatory Signals. These are practically instantaneous acknowledgements that a message entered into the system is being processed. They do not necessarily imply that the message will be accepted as legal or interpretable after further processing.

2. Attention Signals. These consist of especially noticeable light or auditory signals, signals usually reserved for indicating that the system is now awaiting a response from the user. They may be programmed for single, intermittent, or continuous notices. In some system, the attention signal is usually preceded by the lack of a confirmatory signal that should have followed the completion of his action, plus a standard delay to allow the user to notice the absence of the confirmatory signal.

3. Cueing Signals. These are usually terse, short symbol indicators that show what control actions the user "may" take, "must" take, or "may not" take to forward the interaction process. They can be introduced by any of the display devices, but more preferable are computer-switched back-lighting lamps behind the appropriate function keys.

4. Status Display. This consists of a dynamic display that provides the terminal operator with some indication of the fact of, or the state of, computer processing on tasks he has assigned to it. Ordinarily, it is not designed to capture or demand attention in the same manner as attention signals. In fact, many systems make this an on-request function of the system.

Another aspect of pacing was defined in a study performed by H. Sackman and M. M. Gold. They introduced the element of interarrival or thinking time. This is the time interval between the completion of computer response and the insertion of the user's next input message. After several independent investigations, the observed median responses were remarkably close, in the range of 9-13 seconds. This suggests that there may be some merit to forced temporal spacing between computer messages and human responses to achieve improved human problem-solving. Hopefully, this will facilitate creative thinking instead of remedial action. As mentioned earlier, when the system responds too quickly, there is subconscious pressure on the user to respond rapidly also, possible to the detriment of his overall search strategy. A paced response delay alleviates this unnecessary pressure.

Finally, users particularly dislike unpredictable response times. It is only logical that they should prefer a constant delay to a possible shorter, but variable, response. Unpredictable conditions disturb the user and interfere with his efficient use of the system. This assertion implies that if delays are long, but predictable, a user can conceivably carry on some other activity instead of wasting time waiting for a response that may come now or later. There is, of course, an upper limit to the time frame.

Psychological aspects of response time in man-machine interaction have been addressed in a study conducted by R. B. Miller which identifies various classes of human action and purpose at the on-line terminal. These different human purposes and actions tend to point to the same conclusion, i.e., response time of around 10 seconds will permit the kind of thinking continuity essential to sustained human problem-solving.

C. HARDWARE FACTORS

The only hardware that the on-line user is directly concerned with is the terminal itself. In order to satisfy his information requirements, the user needs some type of keyboard to allow communication with the on-line system. He needs a display unit in order to view his own messages, as well as system responses. And, finally, he may have need for printout capabilities. Typewriter terminals can meet all these requirements, whereas, if a CRT display is used, a supplementary on-line printing device must normally be added.

Nevertheless, CRT terminals offer certain definite advantages over typewriter terminals from the human factors point of view. They generally permit more rapid communication, are less noisy, and allow user errors to be corrected more easily or, at least, they give the user the impression of allowing easier error correction, although various studies have proven that they may cause more errors initially. A CRT display is almost essential for some types of applications (e.g., display of lengthy documents), since the time delay associated with a typewriter printout may prove intolerable.

Video consoles also permit a much greater variety in the display of alphameric data. This point was well made in a study performed by S. R. Mayer. Basically, what he concluded was:

> The growing economic feasibility for man-machine communication offers many new possibilities for improved information display over that offered by teletypewriters. Not only do video consoles improve the display of geometric information, but they offer new opportunities for organizing alphameric information into more effective formats than that of conventional linear displays.
>
> Earlier computer display designers concentrated on what was displayed, trying mainly to identify and include necessary information. Display design is now moving toward consideration of how required information should be formatted. New formats, movement or blinking of information for emphasis, timed appearance or disappearance of information, and color coding are but a few of the many possibilities that are emerging for computer displays.

The keyboard itself is also important. A keyboard in which keys are dedicated to major system commands or functions saves user time, reduces the likelihood of errors, and is overwhelmingly preferred by a majority of users. However, experience has shown that users [illegible] have difficulty locating the appropriate key, and others are [illegible] by the presence of so many unfamiliar keys on the keyboard. Keys, [illegible] buttons, and other devices must be adequately labeled and arranged for [illegible] use. This should be a primary requisite in selecting terminals.

Visual factors are particularly important to the user of a CRT display. Lengthy use of such a display has been known to cause operator fatigue. The variables that determine image quality include luminance, contrast, regeneration rate (if a CRT is not regenerated fast enough, it gives the impression of a flicker), chromaticity, resolution, and size and style of characters. These, too, should be included in terminal selection criteria.

In a study conducted by J. H. Carlisle, an application system was implemented under both typewriter and CRT terminals. The purpose of the study was to determine which device, if either, increased operator throughput, i.e., a greater amount of data being entered or retrieved. The behavior of the two terminal groups was compared on the basis of:

A. The number of data elements retrieved and examined by the operator.
B. The precision of the search measured in terms of a "relevance" score derived by having an experienced information specialist evaluate

each retrieval on a 10-point scale.

C. Elapsed search time.
D. The number of errors made in a search.
E. The number of different individual search strategies used by an operator.
F. The operator's own satisfaction with his use of the terminal.

Basically, what Carlisle concluded was that the CRT terminal operators overwhelmingly preferred their terminals, while the typewriter terminal operators were somewhat less enthusiastic. The video console users took, on the average, 60% more time, made 300% more errors, and achieved relevance scores 40% higher, while retrieving about 42% more data than the typewriter terminal users. There was a strong positive correlation between the number of errors occurring and the amount of time spent searching, a high negative correlation between relevance scores and number of errors, a weak negative correlation between searching time and relevance scores, and a high positive correlation between relevance scores and the amount of data retrieved.

Overall, his study concluded that users preferred CRT terminals, the user was able to enter and retrieve more data, and initially, at least, more errors were generated. However, other studies have shown that the greatly increased error rate at the video terminals was due to the fact that the video keyboard was less familiar to the operator than the teletype keyboard. It is important to note that with increased usage (experience) not only did the error rate for CRT's decrease drastically, but the retrieval rate increased accordingly.

D. LANGUAGE OF COMMUNICATION

Users should be able to communicate with the system in the simplest possible way. Therefore, commands should be brief and unambiguous. Moreover, dedicated keys are desirable. For the user who is not an information specialist, a system that is constructed around natural language (English-like) is more preferable than one based on codes. Inexperienced users have a great level of difficulty with Boolean expressions. This simply means that users favor systems which will accept an English sentence or phrase as a search argument. In fact, it is desirable to have a comprehensive system entry vocabulary.

Everything possible should be done to reduce keying needed at the terminal. Users should be able to select terms from displays by a term indentifier, the use of a light pen, or by touch panel. Abbreviations for command names should be acceptable, or even possible work truncation. One of the more common practices is to use default values to reduce the amount of keying needed. More often than not, the user prefers to have the system automatically initiate the most likely action. This would mean that user response would be required only on the exceptions.

There are a limitless number of areas which could be investigated to simplify and expedite interaction with the on-line system. This most often overlooked facet of this entire exercise is the need to continually review and enhance the language of communication. Data processors, for any number of reasons, tend to install a system, monitor it for a short period, and move on to other pressing matters. This means that the user is saddled with a system which may or may not be in need of refinement. If it does, and nothing is done to rectify the situation, use of the on-line system will tend to dwindle. Obviously, after the expenditure and commitment of corporate (organizational) resources, no one really wants the on-line system to be dropped or used ineffectively.

E. SYSTEM SENSITIVITY

From the human considerations standpoint, perhaps the major defect of existing on-line systems is their universal sensitivity to simple human errors. Theoretically, and in practice, an on-line system should be able to accomodate the relatively infrequent user who may never acquire complete fluency in operating the terminal. Unfortunately, most on-line systems require absolute perfection in spelling, punctuation, and spacing. From the user point of view, it is both irritating and frustrating to have a term rejected for what he considers to be a trivial reason. Additionally, the user should be allowed to use common abbreviations, and have these abbreviations recognized by the system. Typically, where abbreviations have been used, they tend to be data processing inventions, and not ones with which the user is familiar.

On-line systems should incorporate at least minimum levels of character-string recognition and other fail-safe procedures to save the time of the user and, hopefully, reduce his frustration. In addition, it may be necessary to provide generic or phonetic search strategies in some types of application systems.

Generally speaking, all of these efforts require extensive planning and design activities on the part of data processing. Too few organizations have adopted the posture of conforming to the terminal user's needs. In those few organizations where an effort has been made, it is all too common for an illegal search strategy or simple human error to bring the on-line system completely down. Obviously, great emphasis and attention must be place on ensuring on-line system integrity. Otherwise, users become suspicious of the quality of the information provided by the on-line system.

F. ERRORS AND ERROR MESSAGES

When a user does make an error, he should be informed immediately by the system. Error messages must be explicit and should tell the user how to make the appropriate correction. Error correction should be easy and should disturb as little of the search as possible. Where feasible, error correction should not force the search to be aborted, and cause the entire entry to be rekeyed. Unfortunately, too many on-line systems contain poor error messages. It is not enough to tell a user that an error has occurred. He must be told the precise nature of the error and what he must do to correct it. Otherwise, the user will find himself in a frustrating loop. Not only is this a consideration of an application system, but it should be employed in operating systems and TP monitor communications to the user.

In his study, Sackman identified two types of errors: typing errors and comprehension errors, i.e., relating to system procedures and protocols. The former type of error is more easily detected and corrected. Typing error rates decrease with increased experience in using the system. One might expect that more improvement might take place in comprehension errors, and that typing errors would be maintained at a more consistent level at some point in the future. Unfortunately, that is not the case with comprehension errors. Comprehension errors were found to be highly and inversely correlated with user productivity levels. In fact, not only do comprehension errors remain relatively constant within existing systems, but they actually tend to increase as new application systems are added.

In the Katter/Blankenship study, analysis stated that error-control programs should be designed to:

1. Reduce the probability that the user will produce what he perceives to be an error that the system does not detect.
2. Reduce the probability that the user will generate a message that the system cannot accept or interpret.
3. Immediately notify the user if the message is unacceptable by the system.
4. Immediately diagnose errors and suggest corrective action.

These facts merely reconfirm what other researchers found, however, their study went farther in that they suggest the important desirable features or an on-line error-control program. They are:

A. Entry Preparation Display - For controlling the kinds of errors detectable by the computer and humans, and those detectable by humans only, a valuable display for the neophyte on-line user is one that unfailingly shows him clearly and explicity and full message he is about to release to the system for processing.

B. Entry Preparation Display Editing - For the message entry display, a valuable provision is the ability to identify the word or phrase in error. Additionally, a rapid means for deletion or correction of the word or phrase in error should be employed.

C. Variable Spelling Approximator - Some means should be implemented to handle the most common operator spelling errors, e.g., automatic substitution. This same vehicle could be employed to facilitate abbreviations.

D. Flexible Error Description Feedback - A user, regardless of his experience level, will sometimes need assistance for specific types of entries. Therefore, it is advantageous to include "HELP" screens, i.e., instructions. For the neophyte user, a detailed help screen may be in order while a short help screen may suffice for the experienced user. These help screens can either by dynamic or, more commonly, on-request.

E. System Error Monitoring - In order to eliminate system-detectable errors, it is advisable to implement a program that identifies and stores the various types of errors. This is especially valuable during the developmental stages of the system, since this information can be used for system refinement. Additionally, if errors made by the user can be saved, then the appropriate level and type of subsequent user education can be initiated.

Overall, errors, their identification and correction, is one of the most important facets of any on-line system. Unfortunately, it is also one of the most neglected areas. This area alone accounts for the greatest level of user dissatisfaction.

G. SYMBIOSIS

As the reader might well suspect, man-machine interaction capabilities have by no means been fully exploited. In many applications, a large amount of effort away from the terminal precedes actual interaction with the system. Unfortunately, this approach detracts from the interactive (conversational) benefits to be gained. We understand that on-line systems should have both extensive searching and browsing capabilities to further the precept of interaction. But what can be employed to accomplish this goal?

W. J. Hansen stressed the importance of user engineering principles for the design of interactive on-line systems. His fundamental principle was "know the user." To meet this fundamental tenet, he grouped specific user-engineering principles into these broad categories. They are:

1. Minimize memorization
   Selection not entry
   Names not numbers
   Predictable behavior
   Provide access to user information
2. Optimize operations
   Rapid execution of common operations
   Reorganize command parameters
   Display inertia
3. Engineer for errors
   Good error messages
   Trap out common errors
   Reversible actions
   Data structure integrity

Hanson strongly stated that users should, whenever possible, select from lists (menus) displayed rather than typing character-strings. By selecting from a list, the user is spared the need to remember various commands, and the probability of error is thus reduced. Moreover, a video console can display many characters in the same time that it would take a user to type very few. Files, commands, and other entries should be identified by names rather than numbers. The system must always respond in a predictable way (i.e., must not appear to be idiosyncratic), and it must inform the user when he needs to be informed (e.g., the status of a particular operation).

The system should be as unobtrusive as possible. Operations frequently conducted should be optimized in terms of command requirements and interaction time. And a display should change as little as necessary to carry out each new request. Otherwise, user disorientation will inevitably occur.

Finally, the system must be engineered to prevent catastrophic errors and to permit easy recovery from as many errors as possible. Error messages should be specific and explicit. The system must be designed to avoid very common errors, because an error that occurs constantly must be attributed to poor system design rather than user weakness. And users should be provided with an easy method of reversing an action he recognizes as being incorrect, while maintaining data integrity.

This paper has attempted to review a few of the human considerations that are of importance in the design and operation of on-line systems. Human engineering must be employed if man-machine interaction is to be improved. Systems that are poorly desinged from the human considerations standpoint reduce the tolerance of the user. If allowed to continue uncorrected, it will increase search time which will, in turn, increase the overall search cost. But, most important, it will cause the user to become frustrated. And the frustrated user tends not to return for more.

PROPOSAL OF AN INTELLIGENT LINK APPLIED TO COMPUTER NETWORKS

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Abstract

Usual computer networks consist of "computers" and "communication lines". But in this study, we have tried to reconstitute the communication lines in order to increase their functions by uniting the transmission of information and the processing in a body. A new transmitting and processing system denominated as an Intelligent Link has been proposed, which is regarded as a pipeline computer with processing functions given by software.

I. INTRODUCTION

In the recent years, many kinds of computer networks have been constituted [1], [2] in order to share load [3], software, hardware and data file [4] and for the sake of increment of the reliability [5]. Each computer is interconnected by using subnet consisted of communication lines and minicomputers for switching. The communication lines are not only wire systems but also radio systems [6]. Thus, usual computer networks consist of "computers" and "communication lines". Protocols are required upon the networks for resource sharing between different computers [7], [8].

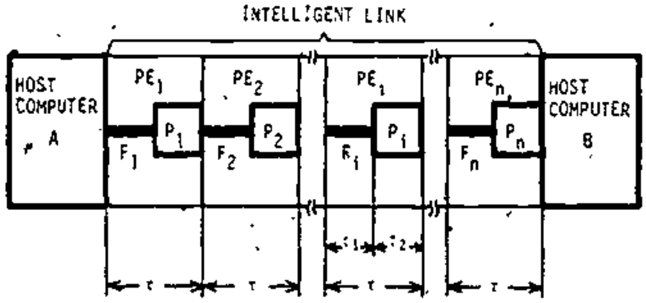
In contrast to the existing communication lines connecting the HOST computers, the inter-computer link is proposed to be composed of suitable number of transmitting and processing units. We denominate the linkage system as an Intelligent Link. This can be regarded as a pipeline computer whose functions are given by software. The processors in the intelligent link are to be connected by optical fibers.

Under the above proposal, we describe how to provide the intelligent link with processing functions and how to process the given data.

Moreover, we discuss allocation of functions into each system element (transmitting and processing unit) of the intelligent link, and relation between the processing time in each system element and the throughput of the intelligent link. Finally, we may consider the possibility of a computer network employing the intelligent links.

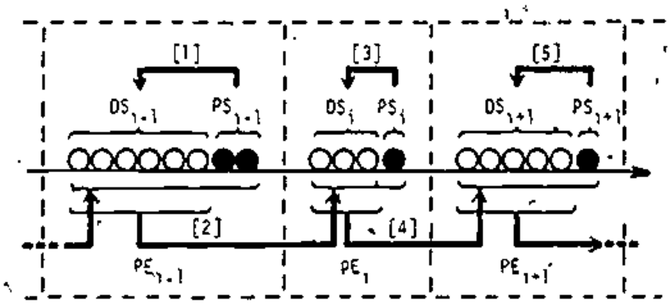
II. AN INTELLIGENT LINK

An Intelligent link proposed in this paper is a pipeline computer with functions given by software, so that different data may be processed in pipelining. Let us consider an interconnection between a HOST computer A and B shown in Fig. 1. In usual conception, the link between HOST computers is



PE_i : i-th system element
n : the number of system elements
F_i : optical fiber in PE_i (which means the transmission line.)
P_i : processor in PE_i
τ : processing time in PE_i
τ_1 : delay time in F_i
τ_2 : processing time by P_i

FIG. 1 AN INTELLIGENT LINK



PS_i : segmented program in PE_i (program segment-set)
DS_i : segmented data in PE_i (data segment-set)
[ ] : sequence in the processing structure

FIG. 2 SCHEMATIC REPRESENTATION OF THE PROCESSING STRUCTURE.

realized with a communication line. However, we consider to interconnect two HOST computers with an intelligent link. Let us suppose that the intelligent link is constituted by arranging n system elements. Generally the communication line in the system element is considered as a single optical fiber, but the bundle of an optical fiber is possible too. In the former case, the transmission of program-data is serial bit sequence. On the other hand, in the latter case, the program-data is transmitted at the same time in accordance with the number of fibers in the bundle.

From the configuration of information processing on the intelligent link, The processing time in each system element PE_i in Fig. 1 should have identical value τ $(=\tau_1+\tau_2)$.

Fig. 2 displays the structure of the intelligent link processing data while giving the processing functions into each processor P_i arranged specially and performed at the same time.

The pipeline processing in the intelligent link is different from that of usual pipeline systems which range from a logic circuit level to a architecture element level. In usual pipeline systems, functions of system elements are given initially by means of the hardware [9]. However, the functions of this pipeline computer are given by the program segmented for transmission, where the program, of course, is for processing of the following data. Namely, the processing functions of each system element of this intelligent link are given by means of software. Therefore, these processing-functions are arbitrarily given by segmented program PS_i's.

In the intelligent link, contents of segmented programs are variant in accordance with the contents of their segmented data and progress situation of their data processing. Under the above conditions, automatic generation of programs are considered in Fig. 2. Generally after DS_{i-1} is processed by PS_{i-1} in PE_{i-1}, a new program-data set $PS_i \cup DS_i$ is generated. Similarly PS_i and DS_i behave in PE_i. By that technique, arbitrary data are transmitted with arbitrary processing. Therefore, in each system element PE_i of the intelligent link, each program can be loaded independent of the value n in terms of the data processing.

FORMULATION OF PROCESSING STRUCTURE

In the intelligent link, how to give the processing functions into each system element and how to process the data are, from Fig. 2, expresses as follows:

$$PS_i[DS_i] \rightarrow (PS_{i+1}, DS_{i+1}) \qquad (1)$$

where,

$\alpha[\ ]$: operation, α is a operator.

$(\ ,\ )$: row

Let us concretize the expression of the processing structure. The processing configuration of the intelligent link is divided into following three cases:

[Case 1]

1) PS_i is executed in P_i.
2) DS_i is translated into DS_{i+1} after the execution.
3) PS_i and DS_i generate PS_{i+1} after the execution.

The above is formulated as follows:

$$e\text{-}PS_i = Exc((PS_i)) \qquad (2)$$

$$e\text{-}PS_i[[DS_i]] \rightarrow DS_{i+1} \qquad (3)$$

$$e\text{-}PS_i[[PS_i \cup DS_i | CI_i]] \rightarrow PS_{i+1} \qquad (4)$$

where,

Exc(( )): execution of a content in (( ))
β[[ ]] : operation for processing, β is a operator for processing.
$\cup$: sum
| : conditional
CI_i : control in PE_i, which belongs to PS_i.

[Case 2]

PS_{i+1} is generated only by PS_i. In this case, only (4) is changed into the following:

$$e\text{-}PS_i[[PS_i | CI_i]] \rightarrow PS_{i+1}. \qquad (5)$$

[Case 3]

PS_{i+1} is the first subprogram of unexecuted parts in PS_i. (4) in Case 1 is changed into the following:

$$e\text{-}PS_i[[PS_i | CI_i]] \rightarrow SP[PS_i]=PS_{i+1} \qquad (6)$$

where,

SP[ ]: the first unexecuted subprogram of the program in [ ].

III. SOFTWARE OF THE INTELLIGENT LINK

Let us consider the case of processing according to Fig. 1. The PE_i in the intelligent link is given the function processing DS_i by PS_i. Similarly, PS_{i+1} should be generated for processing of DS_{i+1}. From the mechanism of the intelligent link, the HOST computer A must generate PS_1's, which are sent to PE_i $(i=1,\cdots,n)$.

III-I. SOFTWARE FOR PIPELINE PROCESSING

It can be considered that each datum in the data stream is suited to that of program repeated by DO statement which is a control statement for repetition. In other words, the data stream processed by pipeline processing is generated as a row of data for program included in DO statement. In this case, PS_i in PE_i is generated by program included in this DO statement. An example of processing data stream is shown in Fig. 3.

The stream of the program PS_i and data DS_i is, of course, generated by not only the above method but also the other methods.

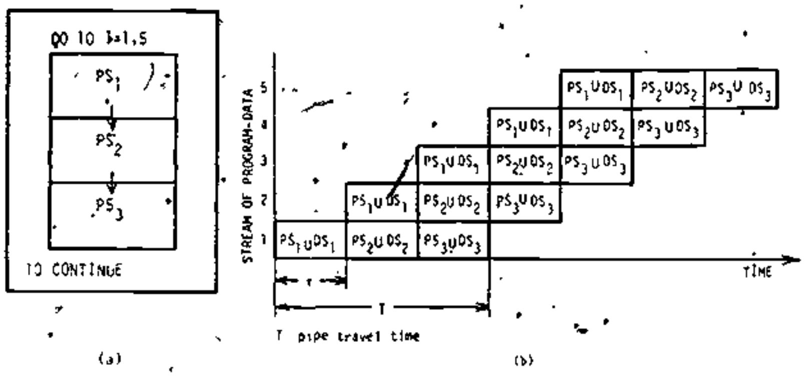


FIG. 3 AN EXAMPLE OF THE PIPELINE PROCESSING. (a) PROGRAM EXECUTING THE PIPELINE PROCESSING TO DATA STREAM. (b) THE PIPELINE PROCESSING.

III-II. KINDS OF SEGMENTED PROGRAM PS_i

Control statements are roughly divided as follows:

1) Control for repetition (DO statement)
2) Decision (IF statement)
3) Jump (GO TO statement)

In pipeline processing by the intelligent link, it is impossible for control of processor P_i to jump to programs before PS_i when PS_i processes DS_i. Therefore, although there is a case where Jump is required, Jump (GO TO statement) must not be used. However, since a program structure using Jump may be replaced by that without Jump [10], the above restriction for pipeline processing is avoided.

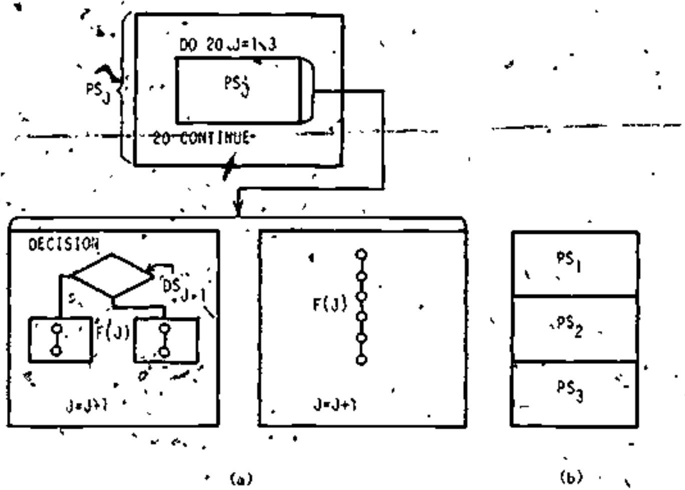


FIG. 4 KINDS OF PROGRAM PS_i. (a) THE CASE WHERE PS_i STEMS FROM PS_{i-1}. (b) PS_i IS INDEPENDENT EACH OTHER.

There are three kinds of PS_i, which correspond to Case 1, Case 2, and Case 3 in the classification of processing configuration of previous formulation. For example, we explain the kinds of PS_i according to Fig. 4.

[PS_i in Case 1]

The PS_i consists of DO statement, program body PS'_i and CONTINUE statement. The change of program PS_i is due to the control variable and decision of routing of programs by processed data as shown in Fig. 4(a).

[PS_i in Case 2]

The PS_i consists of the same factors as that in Case 1. The change of program PS_i is only due to the control variable of DO statement without decision of programs as shown in Fig. 4(a).

In the above cases, the number of PE_i used for PS_i is due to the final parameter of DO statement. On the basis of DO statement, PS_i $(i=1,\cdots,n)$ generated the following PS_{i+1} in order. On the other hand, there is a different case as the following.

[PS_i in Case 3]

Each PS_i is independent respectively as shown in Fig. 4(b). The first program PS_1 is made in HOST computer A. Especially, PS_1 in Case 3 implies all the following PS_i $(i=2, 3,\cdots,n)$.

IV. THROUGHPUT OF THE INTELLIGENT LINK

Described previously, τ is sum of time delay τ_1 of $PS_i \cup DS_i$ in fiber and the processing time τ_2 of DS_i by PS_i. From the property of pipeline processing, τ should be identical in every PE_i. However, each τ is not identical because of processing of arbitrary segmented data by the segmented program. Therefore, the blocking on $PS_i \cup DS_i$ generally occurs among PE_i's. Then, we define the rate of transfer of $PS_i \cup DS_i$ per unit time as the throughput of the intelligent link. To serve the convenience of the analyses on the throughput, we notice the reciprocal of the throughput.

IV-I. DISTRIBUTION OF PROCESSING TIME IN PE_I

Let the processing time in each system element PE_i be t. We suppose that t has the exponential distribution with the mean value $1/\mu$ $(=\tau)$, where μ means the average rate of processing in PE_i, and τ is defined anew. The probability density is

$$f(t)=\mu e^{-\mu t}. \tag{7}$$

It is not reasonable for pipeline processing that blocking happens for a long time among PE_i's when each PE_i executes the processing.

Let us consider a distribution of t caused in $t \leq a$ according to (7). The probability density is given by

$$f_a(t) = \frac{\mu e^{-\mu t}}{\int_0^a f(t)dt} = \frac{\mu e^{-\mu t}}{1-e^{-\mu a}}. \tag{8}$$

The value of "a" may be selected when PS_1 is generated in HOST computer A.

Though the distribution is truncated at $t=a$, it will occur the blocking among PE_i's. However, the throughput will increase in comparison with the distribution of (7). In this case, the increment depends on the value of "a". Therefore, we notice the ratio

$$\frac{a}{\frac{1}{\mu}} = a\mu \lesseqgtr 1 \tag{9}$$

as a comparison "a" with $1/\mu$.

IV-II. AN INTELLIGENT LINK CONSTITUTED OF TWO SYSTEM ELEMENTS

Let us consider the intelligent link constituted of two PE_i's interconnecting the HOST computer A and B. In the buffer of HOST computer A, $PS_1 \cup DS_1$ queues. Let us suppose that each mean value of processing rate of PE_1 and PE_2 is the same value μ_a in terms of the property of pipelining. When processing times of each $PS_i \cup DS_i$ in PE_1 and PE_2 are t_1 and t_2 respectively, the mean time τ^*_a when $PS_1 \cup DS_1$ in PE_1 transfers to PE_2 as $PS_2 \cup DS_2$ is given by

$$\begin{aligned}
\tau^*_a &= E\{\max(t_1, t_2)\}\ [11] \\
&= \int_0^a x\,dp(\max(t_1, t_2)<x) \\
&= \int_0^a x\,d\left(\frac{1-e^{-\mu x}}{1-e^{-\mu a}}\right)^2 \\
&= \frac{1}{(1-e^{-\mu a})^2}\left[\frac{2}{\mu}(1-e^{-\mu a})-2ae^{-\mu a}+ae^{-2\mu a}-\frac{1}{2\mu}(1-e^{-2\mu a})\right] \\
&= 1/\mu^*_a
\end{aligned} \tag{10}$$

where, μ^*_a is the throughput of the intelligent link in this case.

We arrange the queueing models in Fig. 5 for evaluation of the throughput of the intelligent link. The relation between $\tau(=1/\mu)$ and $\tau^*(=1/\mu^*)$ is given by $\tau=2\tau^*/3$ [11].

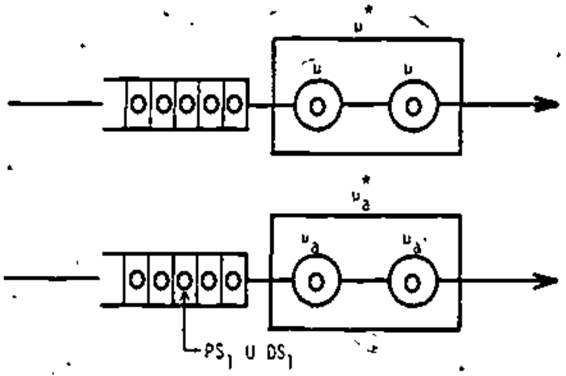


FIG. 5 QUEUEING MODELS FOR EVALUATION OF THROUGHPUT OF THE INTELLIGENT LINK.

COMPARISON BETWEEN $\tau^*_a(\mu^*_a)$ AND $\tau(\mu)$

The difference between τ^*_a and τ is as follows:

$$\begin{aligned}
&\tau^*_a-\tau \\
&= \frac{1}{\mu^*_a} - \frac{1}{\mu} \\
&= \frac{4(1-e^{-x})-4xe^{-x}+2xe^{-2x}-(1-e^{-2x})-2(1-e^{-x})^2}{2\mu(1-e^{-x})^2}
\end{aligned} \tag{11}$$

where, $x=a\mu$. Thus,

$$(\tau^*_a-\tau)_{x\to 0} = -\frac{1}{\mu} \tag{12}$$

$$(\tau^*_a-\tau)_{x\to\infty} = \frac{1}{2\mu} \tag{13}$$

The graph of (11) is shown in Fig. 6 under $\mu=1$. From the graph it may be shown that τ^*_a is less than τ when the value of the truncated time $t=a$ is less than the twice of mean processing time $1/\mu$.

COMPARISON BETWEEN $\tau^*_a(\mu^*_a)$ AND $\tau_a(\mu_a)$

The difference between τ^*_a and τ_a is as follows:

$$\begin{aligned}
&\tau^*_a-\tau^* \\
&= \frac{1}{\mu^*_a} - \frac{1}{\mu^*}
\end{aligned}$$

$$= \frac{4(1-e^{-x})-4xe^{-x}+2xe^{-2x}-(1-e^{-2x})-3(1-e^{-x})^2}{2\mu(1-e^{-x})^2} \tag{14}$$

where, $x=a\mu$. Consequently

$$(\tau_a^*-\tau^*)_{x\to 0} = -\frac{3}{2\mu} \tag{15}$$

$$(\tau_a^*-\tau^*)_{x\to\infty} = 0 \tag{16}$$

Under $\mu=1$, the graph of (14) is shown in Fig. 6. The identity (16) is evident from (8) and Fig. 5.

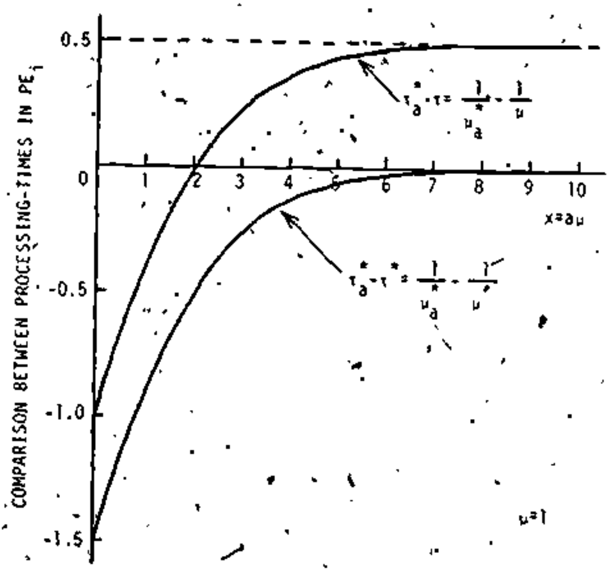


FIG. 6 THROUGHPUT OF THE INTELLIGENT LINK.

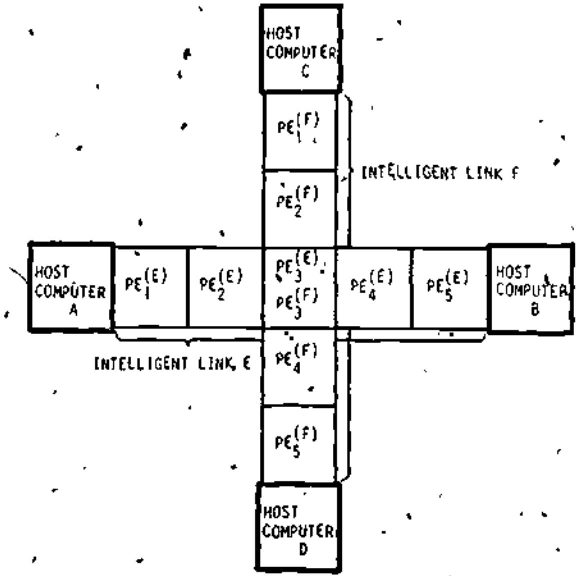

HOST COMPUTER C
$PE_1^{(F)}$
$PE_2^{(F)}$
INTELLIGENT LINK F
HOST COMPUTER A
$PE_1^{(E)}$
$PE_2^{(E)}$
$PE_3^{(E)}$
$PE_3^{(F)}$
$PE_4^{(E)}$
$PE_5^{(E)}$
HOST COMPUTER B
INTELLIGENT LINK E
$PE_4^{(F)}$
$PE_5^{(F)}$
HOST COMPUTER D

FIG. 7 A COMPUTER NETWORK EMPLOYING INTELLIGENT LINKS.

V. A COMPUTER NETWORK EMPLOYING INTELLIGENT LINKS

It may be said that a new computer network is realized by intelligent links instead of usual communication lines.

Let us consider the simple computer network shown in Fig. 7. The subnet in usual conception consists of the intelligent links E and F. In this case, the system element $PE_3^{(E)}$ in the intelligent link E is the system element $PE_3^{(F)}$ in the intelligent link F too. It is natural that $PE_3^{(E)}$ ($PE_3^{(F)}$) is for switching. If the switching is regarded as one of functions of pipeline processing, the function of $PE_3^{(E)}$ should not be considered as a special element. Because functions of the intelligent link are given at will in accordance with the contents of processing, the degree of freedom for constitution of the computer network may be large.

On the other hand, protocols used in this computer network may be simple because of many common properties due to high degree of coupling between HOST computers.

VI. CONCLUSION

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For increasing the function of communication lines, we have proposed the concept of the intelligent links which are pipeline computers being able to process the arbitrary data stream by software. Also, the processing structure has been described. Consequently, we have obtained the possibility of realization of a new computer network uniting the functions of the pipeline computers and that of communication lines in a body.

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TELECOMMUNICATIONS:
ITS ROLE IN CUSTOMER SERVICES AT HONOLULU FEDERAL SAVINGS & LOAN

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ABSTRACT

Electronic Funds Transfer Services (EFTS) such as direct deposit, bill payment, automatic teller machines, etc. have become important services being offered by financial institutions. Honolulu Federal Savings and Loan (HFSL) is committed to offering its customers the best possible level of services of which EFTS is the cornerstone. This paper presents existing EFTS activity at HFSL and the resulting role of telecommunications.

1.0 INTRODUCTION

Honolulu Federal Savings & Loan (FSL) was founded in 1929 and is Hawaii's largest with assets over $1.3 billion. The growth of HFSL over the past five years (see Figure 1.0) is largely due to well-planned programs offering Electronic Funds Transfer Services (EFTS) to Hawaii's savers.

Towards the late 1960's, HFSL set the framework for a greatly expanded role in customer services by becoming one of the first financial institutions in Hawaii to utilize teleprocessing with the installation of an online teller system to handle the daily savings and mortgage transactions.

In 1974, HFSL began replacing passbooks with plastic cards known as "Passcards". The Passcard brought about statement savings and provided the needed mechanism to offer a wide variety of Electronic Funds Transfer Services (EFTS) that are heavily dependent upon telecommunications.

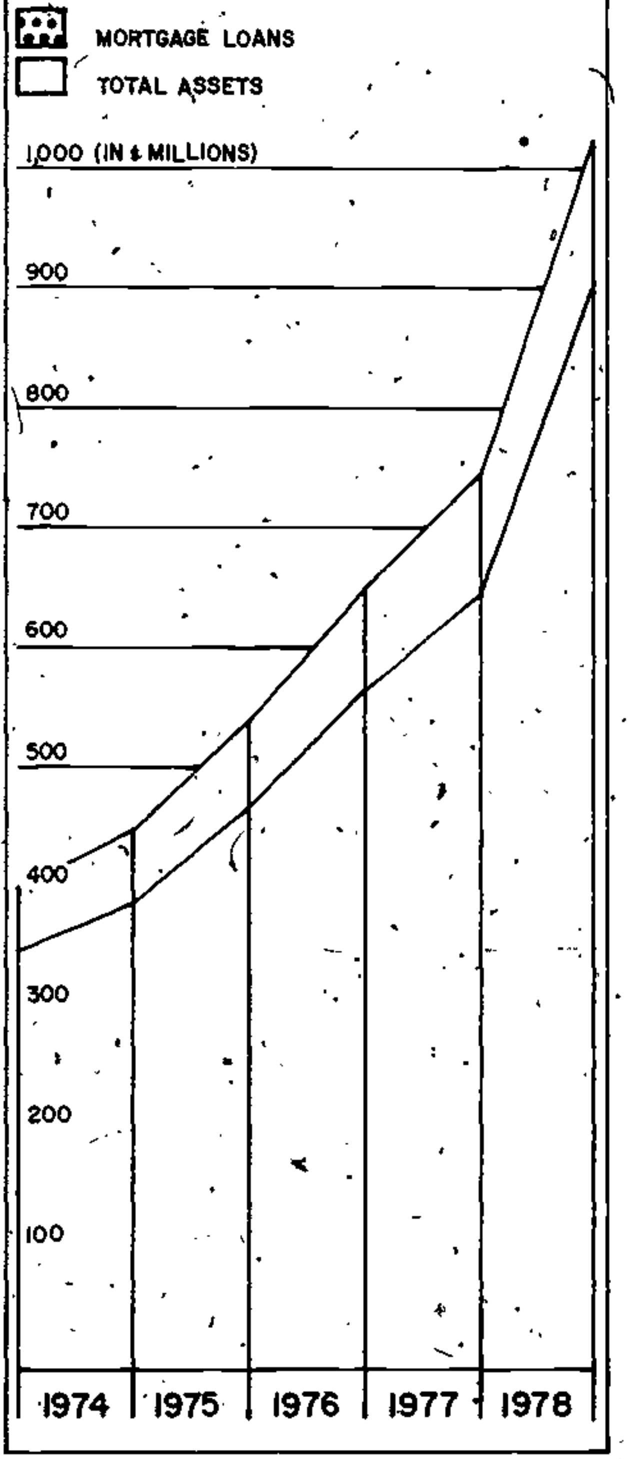
In 1975, HFSL introduced five online Automated Teller Machines (ATM), known as "Honolulu Lulu", and now offers 14 "Lulus" in branch offices on all the major islands. The success of Honolulu Lulu spurred seven savings and loans to form SLH, Inc. In 1975, SLH began offering Instant Transfer (IT) services consisting of shared ATM's and Point-Of-Sale (POS) terminals at shopping centers and supermarkets for customer withdrawals, deposits, check cashing and inquiries.

During 1976, telecommunications at HFSL took on an expanded role with a revolutionary computer-assisted bill payment program known as the "Passcard Payment Service (PPS)". The service allows customers to call a PPS operator and pay any bill day or night. The operator utilizes online display terminals to make entries for automatic payment the next working day. In 1979, new technology allowed HFSL to introduce LULU BELL. Any PPS customer who has a push-button telephone has direct access to their bill payment account utilizing an Audio Response Unit (ARU). This opened the potential of having a HFSL banking terminal in every home.

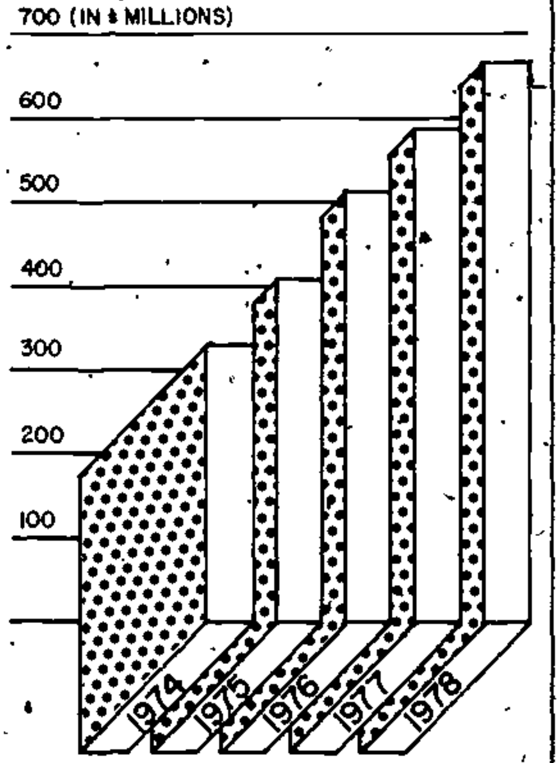
The value of telecommunication in providing customer services has stimulated its application within HFSL. The Accounting Department utilizes an online general ledger system; the Personnel Department has an online payroll/personnel system; and near future plans call for online accounts payable, inventory control, electronic mail, connection of word processing to the central computer, and an online Management Information System (MIS). As can be noted, data processing plays a major role at HFSL; it has become its heartbeat and telecommunications the arteries of the organization.

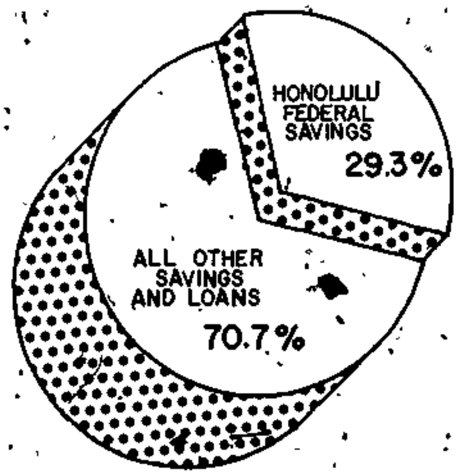
The importance of telecommunications will continue to grow with a corresponding requirement for improved levels of telecommunication capabilities. Honolulu Federal is currently troubled by telecommunications reliability, incompatible protocols, limited communication speeds, inadequate

FIVE YEARS GROWTH IN REVIEW



SAVINGS GROWTH





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(AS OF JUNE 30, 1978)

security, and difficult network management. To successfully expand the use of telecommunications over the next five years, the communications vendor must offer:

- A standard communications interface (i.e., X.25).
- Data security (encryption).
- Greater reliability/flexibility (virtual networks).
- High speeds (50 KBS).
- Usage sensitive rates.
- 100% availability

Without the above, the growth of EFTS as a successful public service is extremely limited.

The following subsections provide a more detailed description of the application of telecommunications in providing customer services.

2.0 HFSL TELLER SYSTEM

HFSL installed its first computer system in 1964. Batch processing on an IBM 1440 disk system supported various applications within the company. Recognizing the need for a more responsive service to its customers and efficient branch operations, HFSL elected to install a "full service" online teller system in December of 1969.

The online teller system supports a number of applications to include savings, mortgage loan, collections, savings loans, property improvement, and a Customer Information File (CIF). It is available from 7:30 a.m. to 6:00 p.m., Monday through Friday, and until 12:00 p.m. on Saturday performing a variety of transactions to include deposits, withdrawals, check cashing, balance inquiries, add/update customer records, mortgage payments, account inquiry by name, etc.

The online system is in support of Honolulu Federal's 21 branches as well as the 34 branches of four other financial institutions. On an average day, the online system processes some 6,000 deposits, 17,000 withdrawals, 20,000 inquiries, and 12,000 miscellaneous transactions for a total of 55,000+ transactions. The transactions originate from 55 branches covering all the major islands of Oahu, Maui, Kauai and Hawaii.

The teller network consists of 250 terminals on 14 leased multidropped lines operating at 1200 baud using an asynchronous protocol.

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3.0 PASSCARD PAYMENT SERVICE (PPS)

The Passcard Payment Service (PPS) is a telephone bill payment system that HFSL began offering in July 1976 and is one of the first in the nation.

The system has two methods of handling payments. One utilizes an audio response system (LULU BELL) to automatically answer phone calls and accept customer payments via touch-tone telephone. The second utilizes display terminals where customers call PPS operators who directly update the customer's payment record. The terminals are also used for online maintenance of customer files, such as adding/deleting payees for customer payments.

PPS allows customers to pay any individual or company in the United States for 10¢ per transaction or unlimited use for $1.00 per month. The customer can elect to have recurring fixed payments (e.g., mortgage, car, etc.) made automatically. These preauthorized and all other payments go out the next working day and the customer is provided with a descriptive monthly statement of all bills paid from their interest-bearing (5-1/2%) bill payment account.

The PPS operators are available from 7:00 a.m. to 11:00 p.m. Monday through Friday and Saturday from 8:00 a.m. to 4:00 p.m. After hours and holiday calls are taken by an automatic answering service. LULU BELL (audio response) is available for bill payment from 6:00 a.m. to midnight every day of the year.

Telecommunications has allowed HFSL to reach out into the customers home to provide convenience banking. Over 80,000 payments are made each month for some 22,000 active customers. The following shows a breakdown of how the payments are made:

. Preauthorized	- 39.5%
. Lulu Bell (Audio Response)	- 12.5%
. PPS Operator-Assisted	- 48.0%

As can be seen, 52% of the payments are made without human intervention. Since LULU BELL was just introduced in January of 1979, the 12.5% is expected to increase to 15% by 1980. Without advancing technology and telecommunications, such services would be impossible to provide.

The telecommunications network in support of PPS consists of a communications controller (manufactured by Periphonics) to handle the audio response transactions, and twelve remote IBM-compatible 3270 display terminals (manufactured by ITT/Courier) using bisynchronous protocol at 9600 baud.

4.0 HONOLULU LULU

Honolulu Lulu has been one of the most successful savings and loan automatic teller services in the nation. Since its inception in 1975 with five Honolulu Lulus in five branches, the service has grown to 14 branch locations stretching from Oahu to the island of Maui, Kauai and Hawaii.

Honolulu Lulu is available during the hours of 6:00 a.m. to 2:00 a.m. the following morning every day of the year. Customers can perform balance inquiries, withdrawals, deposits and check cashing transactions at their convenience. Customer acceptance has been tremendous with an average ATM monthly transaction volume of 7,000; well above the national S&L average of 4,000 transactions. Some of the Honolulu Lulus experience between 12,000 and 16,000 transactions every month.

The Honolulu Lulu network consists of IBM 3614 ATM's operating at 1200 baud using the IBM SDLC protocol. The outer island ATMs are multiplexed over a common line with the outer island teller system at 4800 baud.

5.0 INSTANT TRANSFER (IT)

Instant Transfer (IT) is an EFT service offered by the following savings and loans in Hawaii:

- Honolulu Federal Savings & Loan
- State Savings & Loan
- American Savings & Loan
- Hawaiian Federal Savings & Loan
- First Federal Savings & Loan
- International Savings & Loan
- Territorial Savings & Loan

IT is managed by SLH, Inc., a service corporation made up of the seven savings and loans. Since the inception of SLH in 1976, IT has grown to provide customers access to twelve (12) Point-Of-Sale (POS) terminals installed in Times Supermarkets and five (5) Automated Teller Machines (ATM). There is one ATM in the wall of Sears Ala Moana Shopping Center, two free-standing ATM's at Pearlridge Shopping Center, one ATM at Kaneohe Shopping Center, and one ATM at the Pearl Harbor Navy Exchange.

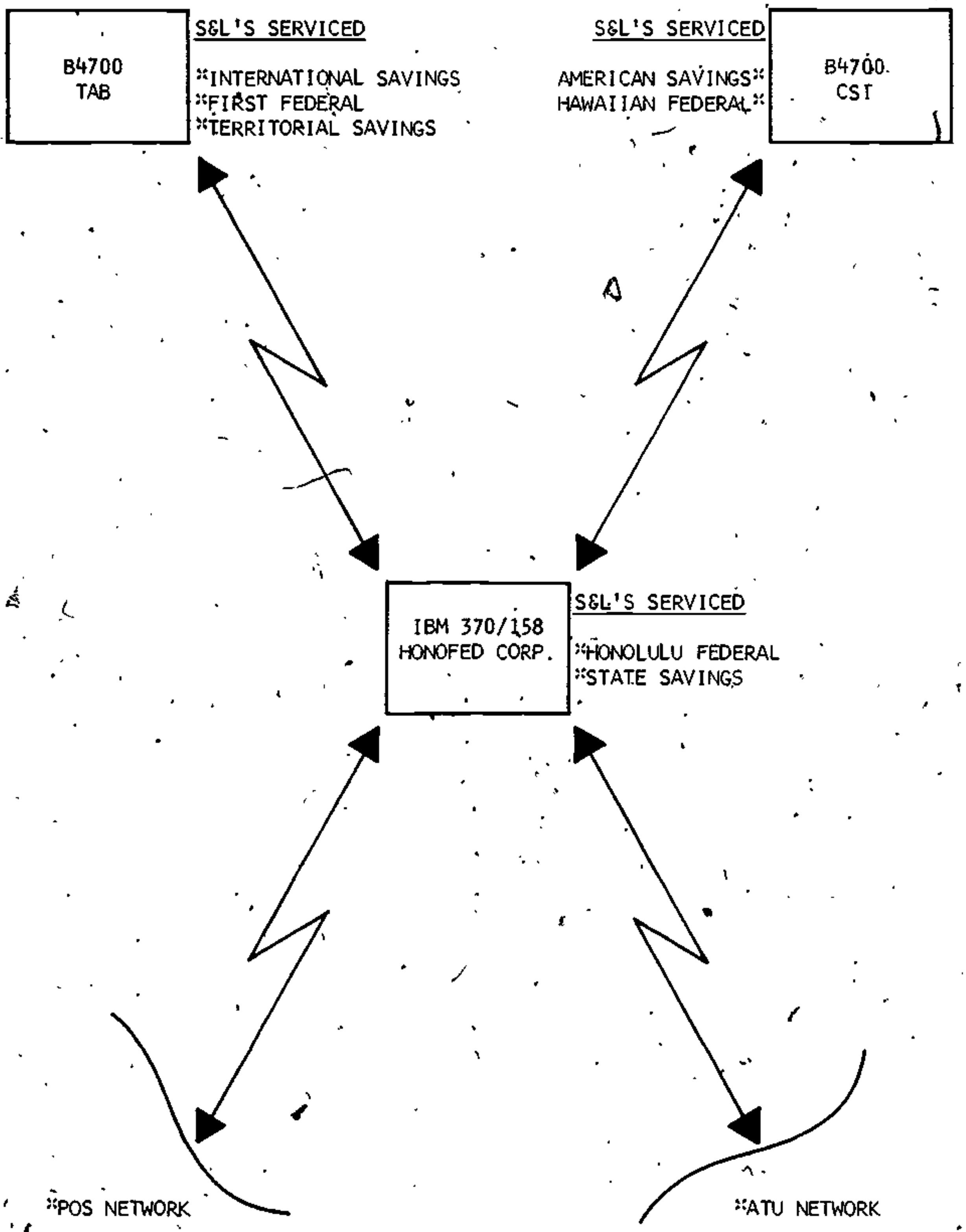
These POS and ATM's, known as Remote Service Units (RSU), allow a customer seven-days-a-week access to perform cash withdrawals, deposits, check cashing and balance inquiry transactions. The RSU's are technically available from 4:00 a.m. until 2:00 a.m. the following morning, but in practice are limited by the stores' or shopping centers' hours of operation.

The Hawaii Instant Transfer (IT) service is one of only a few projects in the nation utilizing an online central switch to route transactions to different computer centers for processing RSU transactions. HONOFED Corp., a subsidiary of Honolulu Federal Savings & Loan, uses an IBM 370/158 Model 3 as the central switch. The switching system is managed by HONOFED-written software known as "COPs" for its traffic cop role in managing the transactions. Two of the participating savings and loans use HONOFED Corp. for their online processing, while the other five are serviced by two other data processing centers using Burroughs computers (see Figure 5.0). Transactions destined for one of the five outside associations are switched to that association's computer center for processing and authorization.

Each POS terminal averages some 20 transactions a day, while the ATM's average 250 transactions per day. The result of the merchant-operated POS terminals versus customer-operated ATM's are as follows:

	POS	ATM'S
Daily Transactions per Terminal	20	250
Unit Transaction Cost	$0.97	$1.00
Transaction Distribution		
- Deposits	13%	10%
- Withdrawals	80%	88%
- Checks Cashed	7%	2%

The IT network consists of Concord 750 POS terminals operating at 1200 baud using an asynchronous protocol, and IBM 3614 ATM's operating at 1200 baud using IBM's SDLC protocol. The IBM 370/158 communicates with the two Burroughs computers asynchronously over point-to-point lines at 1200 baud.


B4700
TAB
S&L'S SERVICED
*INTERNATIONAL SAVINGS
*FIRST FEDERAL
*TERRITORIAL SAVINGS
S&L'S SERVICED
AMERICAN SAVINGS*
HAWAIIAN FEDERAL*
B4700
CSI
IBM 370/158
HONOFED CORP.
S&L'S SERVICED
*HONOLULU FEDERAL
*STATE SAVINGS
*POS NETWORK
*ATU NETWORK

6.0 OVERALL TELEPROCESING CONFIGURATION

The overall teleprocessing configuration (see Figure 6.0) consists of a central IBM 370/158 running IBM's DOS/VS and CICS/VS as the teleprocessing monitor. The communications network is a combination of leased multidropped lines and dial-up ports. The need for a number of communciations protocols is due to the variety of telecommunications devices and the lack of an available industry standard.

Within CICS/VS are HFSL-written application programs to handle the teller system, Honolulu Lulu, Instant Transfer, PPS, Lulu Bell, and the back office services. The system shown in Figure 6.0 is summarized as follows:

Online Teller System

Software:	DATALINE (responsible for processing all branch teller activity).
Line Type:	Fourteen (14) leased multidropped lines serving 55 branches on all the major islands.
Protocol:	Asynchronous (IBM 2260)
Speed:	1200 BPS
Modems:	Universal Data Systems (UDS)
Terminal:	TRW/FDSi Teller Units
Typical Branch Configuration:	1 Terminal Controller 3 Teller Terminals 1 Display Terminal

Honolulu Lulu (ATM'S)

Software:	COPS (responsible for managing the Honolulu Lulus and routing transactions to account processing routines).
Line Type:	Five (5) leased multidropped lines serving 12 locations on Oahu and one each on Maui, Kauai and Hawaii.
Protocol:	IBM's Synchronous Data Link Control (SDLC)
Speed:	1200 BPS
Modem:	Gandalf Modems Micom multiplexer for sharing outer island lines with teller system
Terminal:	IBM 3614 ATM
Configuration:	Single IBM 3614 in branch wall as a single drop

Instant Tranfer (ATMs and POS)

Software:	COPS (responsible for managing IT, ATMs and POS terminals and routing transactions to appropriate computer center for account processing).
Line Type:	Five (5) IBM 3614's share a single line with Honolulu Lulu's on Oahu Thirteen (13) POS terminals share two leased lines on Oahu
Protocol:	IBM's Synchronous Data Link Control (SDLC) for the IBM 3614's Asynchronous (IBM 2260) protocol for the POS terminals
Speed:	1200 BPS for ATMs and POS
Modems:	Gandalf for IBM 3614 UDS for Concord POS
Terminal:	IBM 3614 ATM Concord Computing 750 POS Terminal
Typical Configuration:	IBM 3614's located in shopping centers Concord POS location in supermarkets

Remote Computer Center Connections (IT Network)

Line Type:	One (1) point-to-point leased line for each of the two Burroughs data centers connected to IBM 370/158
Protocol:	Asynchronous
Speed:	1200 BPS
Modems:	Universal Data Systems (UDS)
Computers:	Burroughs

Passcard Payment Service (PPS)

Software: PPS (responsible for processing all bill payment transactions originating from either a display terminal or audio response unit).

Line Type: One (1) point-to-point line

Protocol: IBM 3270 bisynchronous

Speed: 9600 BPS

Modems: Gandalf Modems

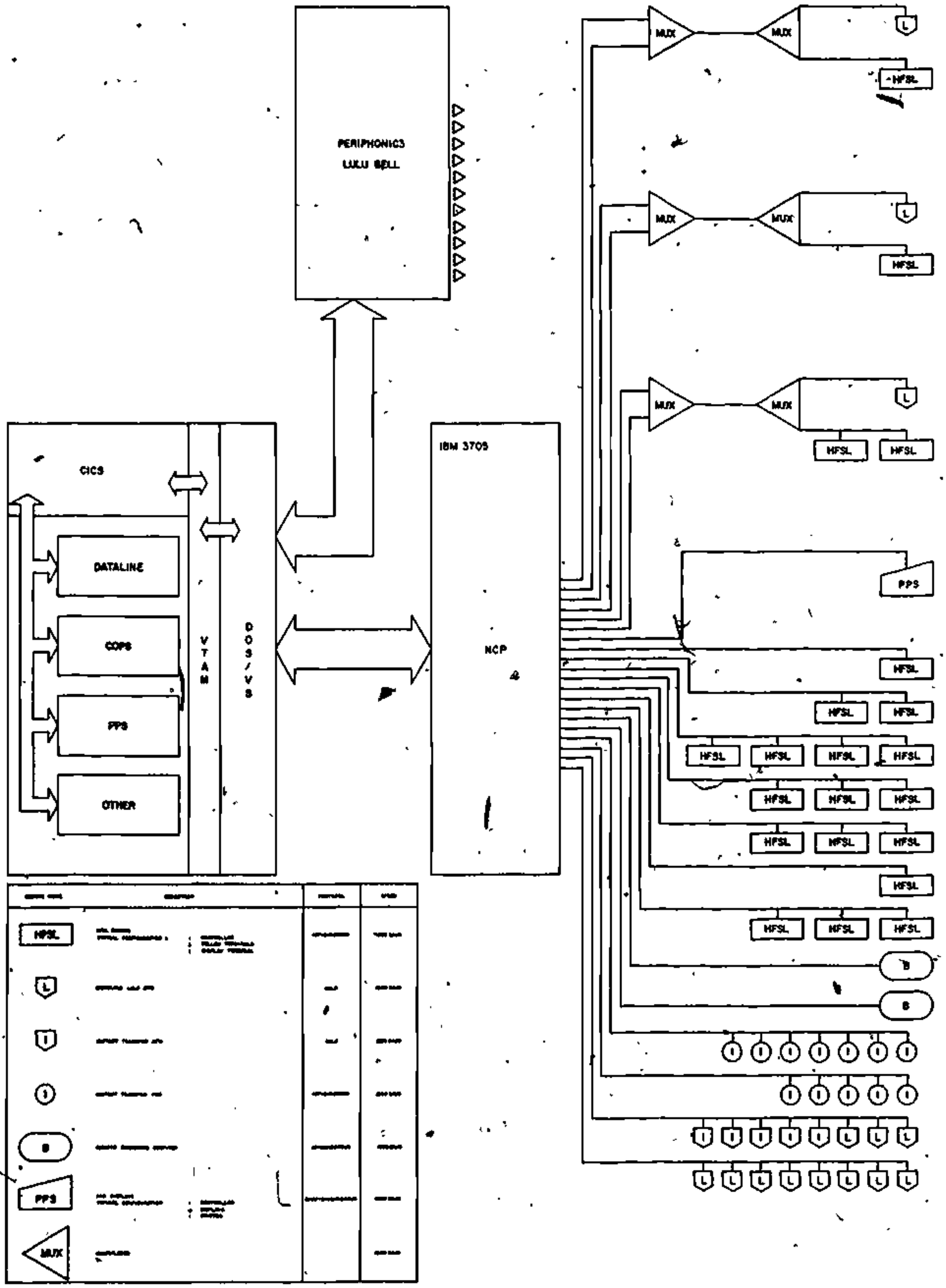
Terminal: ITT Courier CRTs (IBM 3270 compatible)

Configuration: Single Courier Controller with 12 display Terminals and two printers

Lulu Bell (PPS Audio Response)

Line Type: Fifteen (15) rotary dial-up ports

Configuration: Periphonics Audio Response Unit consisting of a PDP/11 emulating a local IBM 3270 controller to the IBM 370/158


PERIPHONICS
LULU BELL
IBM 3705
NCP
CICS
DATALINE
COPS
PPS
OTHER
VTAM
DOS/VS
MUX
HFSL
PPS
L
I
B

Hierarchical Design of a Family of Local Computer Networks

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ABSTRACT

In this paper, the design of a hierarchical family of local computer networks is presented. A family of local networks, each member of which is tailored for a certain class of applications, can be more effective than a single, general purpose data network. The networks in this family share the same protocol software and have the same hardware architecture. They range from a 100 to 500 Kb/s coaxial cable network for industrial test stations to a 100 to 150 Mb/s fiber optic ring network. One member of this family has been operational since 1977. Two other members of this family --one is a CATV-based, 1 Mb/s CSMA network, the other a fiber optic 150 Mb/s ring network-- will be operational by the early part of 1980. In addition to examining the design objectives and the technical approaches that have been adopted for our network family, the two networks currently under development are described in this paper.

1. Introduction

The recent advances in microprocessor technology and the increased number of applications for these inexpensive tools in office and industrial automation have greatly increased the need for local computer networks -- geographically clustered sets of intercommunicating, resource sharing computers, terminals and intelligent devices.

Viewed from the perspective of the network architecture designer, local networking introduces some new problems in constructing data networks. The "locality of reference" and the wide bandwidth of local networks tend to increase the variety of the computer equipment to be joined into a network. Besides complicating the problem of adding new nodes to a local network, the connection of widely diverse devices within a computer network can cause serious network performance degradation.

Since local networks, like geographically dispersed networks, are typically composed of heterogeneous hosts, they present a new-equipment connection problem. In general, the growth rate of a local network in terms of newly connected equipment is much higher than in other networks. Software compatibility is a major consideration in the local network design since the cost of developing protocol software tends to dominate the cost of entire system development.

The economic and functional advantages of local networks will soon motivate the replacement of many current monolithic computer systems with local networks of intelligent terminals, "personal" computers and special purpose maxi-computers. The effective integration and exploitation of these local networks remains the major problem to be solved.

Using a "family" of local networks allows us to meet many of the problems of local networking. The network family consists of a hierarchical set of local networks, each of which supports a certain class of applications. The applications range from connecting high performance maxi-computers together to connecting simple sensor devices to small computers.

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Each set of local networks in the network family will share the same type of network adaptor. A layered protocol design will be used in implementing the network adaptors. The adaptors for the lower level networks will contain only the lower layers of protocol and will therefore be both cheaper and easier to implement.

Complex networks can be constructed containing wide varieties of diverse hardware by connecting different levels of local networks together with standard gateways. Each type of hardware can be connected into a network using a transmission medium suitable for its capabilities and using a network adaptor that provides the necessary features at a reasonable cost.

In this paper, we will first describe the motivation which leads to the design of a hierarchical family of networks. A detailed design of two high performance prototype networks will then be presented. The paper concludes that the design of a hierarchical family of networks is a natural solution to the problem of interconnecting different sets of computer equipment to achieve the sharing of resources.

2. Network Requirements and Design Objectives

The computing devices to be connected into a local network range from high performance maxicomputers to simple electronic sensing devices. Their applications vary considerably and so do their connection and communication requirements. Some of these requirements and applications are identified in the following classes:

a. The connection of mini and maxi computers requiring a high performance network with intelligent communication facilities. This allows the communication functions to be handled entirely by the network interface nodes, thereby removing the burden from the host systems.

b. The connection of intelligent devices such as microcomputers or intelligent terminals requiring a message switching network for sharing communication facilities and interchanging information.

c. The connection of smart electronic devices such as microprocessor-controlled sensors and data-acquisition devices requiring a simple and reliable communication network to transmit and to disseminate information.

Besides these requirements, each network must connect different equipment supplied by different vendors. This practically rules out the possiblity of using or modifying any vendor supplied or commercially available networks. A research and development project was formed to design and implement a family of networks to fulfill the above range of requirements.

The networks constructed must be capable of supporting diverse network elements (ranging from maxi computers to smart electronic sensors) and meeting all the above-mentioned requirements. They must also satisfy the following design objectives:

- Inexpensive Network Interconnection -- The cost of network interface should not exceed 40% of the cost of equipment to be connected into the network.
- Software (Protocol) compatibility -- The Protocol used by all networks must be compatible and the software developed for each network adapter must be interchangeable.
- Simple and Reliable Communication Subnet -- Reliability is a major concern to network users and simplicity is the key to a reliable system.
- Flexible and Extensible Network -- The network must be flexible in anticipation of new types of equipment to be added into the network and any future operational environment changes.

3. Technical Approaches

Given these diversified network requirements and design constraints, the following technical approaches were chosen.

A. Family of Networks -- Having a hierarchical family of computer networks will allow us to meet our described requirements most readily. Each network in the family is tailor-made for a certain class of equipment and can best serve a specific range of applications. The entire network family is linked together through standard gateways as shown in Figure 1. There are at least three classes of networks. The "HOST" network connects mini and/or maxi computers, each network adapter serving as a "front-end" machine for the host computer attached to it. The "INTELLIGENT" network connects microcomputers and intelligent terminals, each network adapter serving as a packet-switching node for the attached equipment. The "TERMINAL" network connects the conventional low speed terminals and serves as a data bus for all terminals. Each class of networks will use the same type of network adaptor and will share the same set of protocols and the same architecture (i.e. topologies, addresses, and routing).

B. Unified Architecture -- The advantages of using "ring" and "bus" architectures have been demonstrated by many network designers [FARB72, BABI77, METC76]. For example, using them eliminates the complex problem of routing. In addition, the ability to broadcast messages greatly simplifies the task of constructing a distributed control protocol.

C. Standard Network Adapters -- The implications of the rapidly decreasing hardware cost are twofold. First, it pays to place intelligence in the adapters since the cost of that intelligence is decreasing much more rapidly than the cost of the communicating resources. On the other hand, the growth in popularity of low-cost intelligent processors and easy access to local networks creates the need for interconnecting these low-cost processors with the main frame maxi-computers. Some care must be made to match the connecting cost to the cost of the processors to be connected. A natural solution to this problem is a hierarchical design of the network adapters. An ideal configuration of this family of adapters is shown in Figure 2. Four major modules are specified, each module supporting one layer of protocol.

- Media Access Module -- This is the only media dependent module defined in the adapter. This module implements some access protocol to coordinate the use of the media in a way to prevent degradations and interferences. A Media Access Module will provide the necessary interface functions in sharing a bus with widely varying types of equipment. An example of this is the TERMINAL network shown in Figure 1.
- Transceiver Module -- This is a full-duplex transceiver which supports a link level protocol similar to the HDLC [HDLC76] protocol described in the next section. An adapter containing (1) this transceiver module and (2) a media access module will provide for a reliable transfer of data over a given media. The transceiver module has been designed to interface with different "media access" modules. Currently, two media access modules have been defined (one for coaxial cable and the other for fiber optics cable).
- Microprocessor and Buffer Memory -- This module is used to offload communication functions from the attached hosts. The number of communication functions to be off-loaded from the host depend on the capability of this module and the relative cost of implementing such functions in this module or in the other adaptor modules. The minimum functionality that must be provided by this module is a reliable datagram service.
- Host Interface Module -- This is the host dependent module which makes the adapter appear as an ordinary device to the host. In general, it is a Direct-Memory Access (DMA) type of device.

Two prototype designs (one for coaxial cable and one for fiber optics cable) will be presented in the later sections.

D. Layer of Protocols -- The layer approach of protocol design has been advocated by many ~~protocol~~ designers [ISO78]. This approach fits nicely into our family of network environment in that each layer can be designed to be functionally independent of the others, thereby allowing the assignment of each layer to its appropriate group of hardware modules. A prototype of three layer protocols and their interfaces is shown in Figure 3. A detailed description of these protocol layers is also presented in Section 5.

4. Protocols supported by the Adapters

Each network adapter may incorporate three levels of protocols as shown in Figure 3 -- the lowest level protocol implemented by hardware, the other two levels implemented mainly by software. Because of the scope of this paper, we will only briefly discuss the protocol supported by the adapter. A detailed description can be found in [BIBA79].

4.1 Level-1: the physical level protocol

There are two versions of the level-1 protocol, one for coaxial cable link and the other for fiber optics link. The level-1 protocol for coaxial is a CSMA/CD protocol which can be summarized as a "listen-before-talk" and "listen-while-talk" protocol with a deterministic backoff and retry scheme. Much research has been devoted in the study of the performance characteristics of the CSMA protocols. A recent paper by [TOBA79] concludes that CSMA/CD outperforms all other CSMA protocols.

The level-1 protocol for fiber optics is a "token" controlled protocol very similar to the protocol developed by Farber [FARB72] at U.C. Irvine. A "token" is circulated around the ring and only the node that holds the "token" may transmit. A detailed description of our protocol can be found in [FRAL79].

4.2 Level-2: an HDLC-like link level protocol

Our link-level protocol is an HDLC-like, bit synchronous protocol using the HDLC framing technique, the HDLC bit stuffing procedure, and the CRC algorithm, but with substantially simplified control procedures. A simple positive acknowledgement with time-out and retransmission is used for error control.

4.3 Level-3: the network level protocol for reliable datagrams

The DARPA Internet Datagram Protocol [POST79] was selected as the base for our network level protocol for the following reasons:

- The datagram protocol appears to be a common denominator in several network level protocols. It can be implemented as a sublevel of other network level protocols such as its counterpart-- the virtual circuit protocol [POUZ79].
- The datagram protocol is particularly suited for transaction oriented communications since it eliminates the control overhead at the price of a modestly larger protocol header.

However, a general datagram service provides no guarantee that the transmitting datagrams will be delivered. This leaves to the upper-level protocol the burden of ascertaining the delivery of every transmitted datagram. Therefore it was decided that a simple modification to the datagram protocol would be made to provide a "reliable" datagram service in which the delivery of the datagram is always guaranteed with no errors or duplications. In addition, we also guarantee that no deadlocks or traffic congestion will occur in the constructed networks.

5. Coaxial Cable Network Adapter (CCNA)

The UMC-Z80 microprocessor system [ACC78] and the Coaxial Transceiver are the two fundamental hardware modules for implementing a CCNA. The UMC-Z80 system consists of one processor board and one memory board, both of which can be directly inserted into the UNIBUS backplane of a PDP11. The transceiver card can easily be integrated into the UMC-Z80 system through its TTL or RS232C interfaces. A schematic diagram of the hardware architecture for the CCNA is presented in Figure 4. A brief description of these hardware features is presented in this section.

A. "Coaxial Cable (Medium):" The coaxial cable is a rigid, 1/2 inch diameter CATV cable. Two types of connectors that are commonly used with coaxial cable are splices and taps. Standard CATV components are used because of their low cost and high availability. The baseband transmission mode was chosen because of its low cable attenuation losses and low component cost.

B. "Coaxial Transceiver (Medium Access Module):" The coaxial transceiver is designed to operate in CSMA/CD mode with the deterministic backoff and retransmission scheme described in the previous section. The transceiver acts as a half-duplex modem for the data transmission device to the coaxial cable, supplying data, control, and timing to "Transceiver Module". The Coaxial transceiver essentially implements the level-1 protocol.

C. "Serial Input/Output Channel (Transceiver):" The Z80-SIO [ZILOG79] is a dual channel multi-protocol circuit designed to perform a wide variety of link level protocols such as IBM Bisync, HDLC and SDLC. The CCNA uses the SIO device to perform HDLC framing, HDLC bit stuffing, local and broadcast address recognition, CRC generation and checking, and modem control. We use two SIO channels, one for cable reception and one for transmission. Clocked by the coaxial transceiver, the SIO is the performance "bottleneck" of the current CCNA. The currently used SIO has a maximum clock rate of .88 Mb/s. Alternative SIO's, if used, would permit rates of 2 to 3 Mb/s.

D. "Data Transfer:" The Z80 DMA [ZILOG79] channel is used to move data from Transceiver to Buffer and from Buffer to Host Interface. The Z80 DMA is a programmable data channel which provides bulk data transfer capability between two Z80 data ports (e.g., memory, peripheral devices). Three internal Z80 DMA channels are used: one for Host-Interface/CCNA data transfers, one for Transceiver input, and one for Transceiver output.

E. "Processor/Buffer" A 4 MHz Z80 processor [ACC78], 32 Kbytes of RAM and several programmable counters/clocks constitute the Processor/Buffer module of the CCNA. RAM is used for both programs and data buffers with a small ROM providing bootstrap capability from the host. All I/O is interrupt driven.

F. "Host Interface:" The CCNA provides a two-mode host interface: a small (32 byte) shared memory is used for CCNA control registers; a DMA interface to the host memory (e.g. the PDP11 UNIBUS) is used for bulk data transfer. This Host Interface appears as three "pseudo-devices": one for datagram transmission, one for datagram reception, and the third for adapter control.

6. Fiber Optics Network Adapter (FONA)

The FONA is currently still in the hardware procurement stage and some of the detailed specifications have not been defined precisely. The information presented here is for reference purposes.

The initial configuration of the FONA is shown in Figure 5. Some of the essential components are defined as follows:

A. Fiber Optics Cable (Medium) -- A simplex, laser injected fiber optics link of length up to 1 Km and with data rate at 150 Mb/s.

B. Fiber Optics Transceiver (Medium Access Module) -- This fiber optics transceiver will transmit data over a fiber optics cable at a rate of up to 150 Mb/s with a clock driven by the attached "T/R" logic. The "T/R" logic is a hardware implementation of the "token"-control protocol described in the previous subsection.

C. DMA Controller (DMAC) and Buffer Memory -- This module provides a fast memory access rate (up to 4.7 M word/sec of 32-bits word) to a buffer memory which is a multiple of 4K byte pages. The buffer memory contains at least four buffers of one page each, two pages for transmission and two for reception.

D. UMC-Z80 -- This is the same hardware used for CCNA to provide the link level transceiver function, the processing power, and the datagram service as defined in the previous subsection. The software developed for CCNA works as is for the FONA.

7. Conclusion

Using of a hierarchical family of local networks is a practical and desirable way to implement a mixed data network. It allows a wide variety of processing hardware to be interconnected without causing any undue performance degradation within the local networks. It also provides for a cheap and efficient network interface for all types of equipment.

One member of this family of networks [SHER78] has been in operation since 1977. This network interconnects a large number of engine test stands via adapters consisting of media access modules only. Two other members of this family of networks (one is a CATV based CSMA/CD network and the other is a Fiber Optics Ring network) will be in operation in the early part of 1980. Several other intelligent networks have been planned and are expected to be operational in the later part of 1980.

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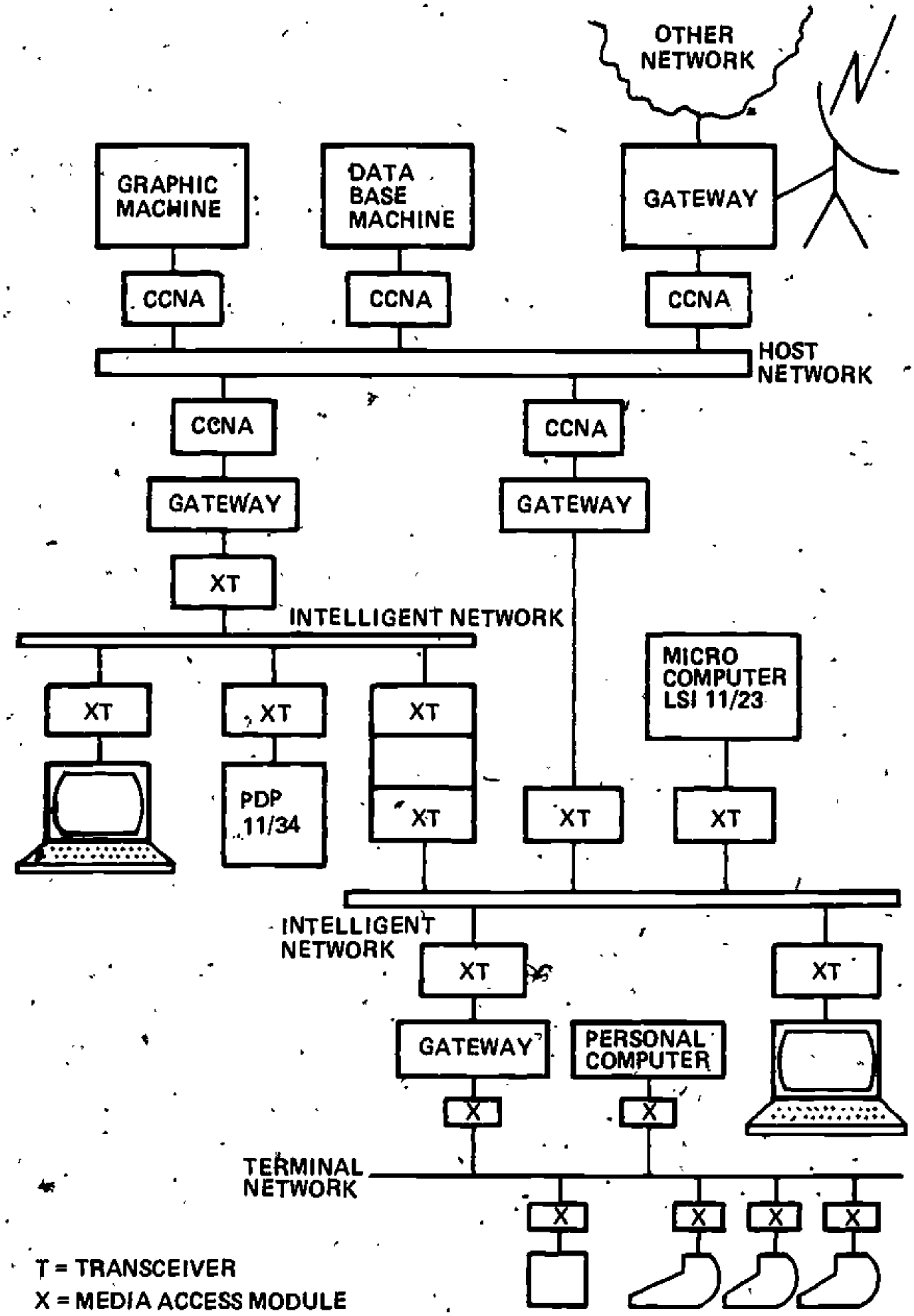

OTHER NETWORK
GRAPHIC MACHINE
DATA BASE MACHINE
GATEWAY
CCNA
CCNA
CCNA
HOST NETWORK
CCNA
CCNA
GATEWAY
GATEWAY
XT
INTELLIGENT NETWORK
MICRO COMPUTER LSI 11/23
XT
XT
XT
PDP 11/34
XT
XT
XT
INTELLIGENT NETWORK
XT
XT
GATEWAY
PERSONAL COMPUTER
X
X
TERMINAL NETWORK
X
X
X
X
T = TRANSCEIVER
X = MEDIA ACCESS MODULE

Figure 1. A Family of Local Networks

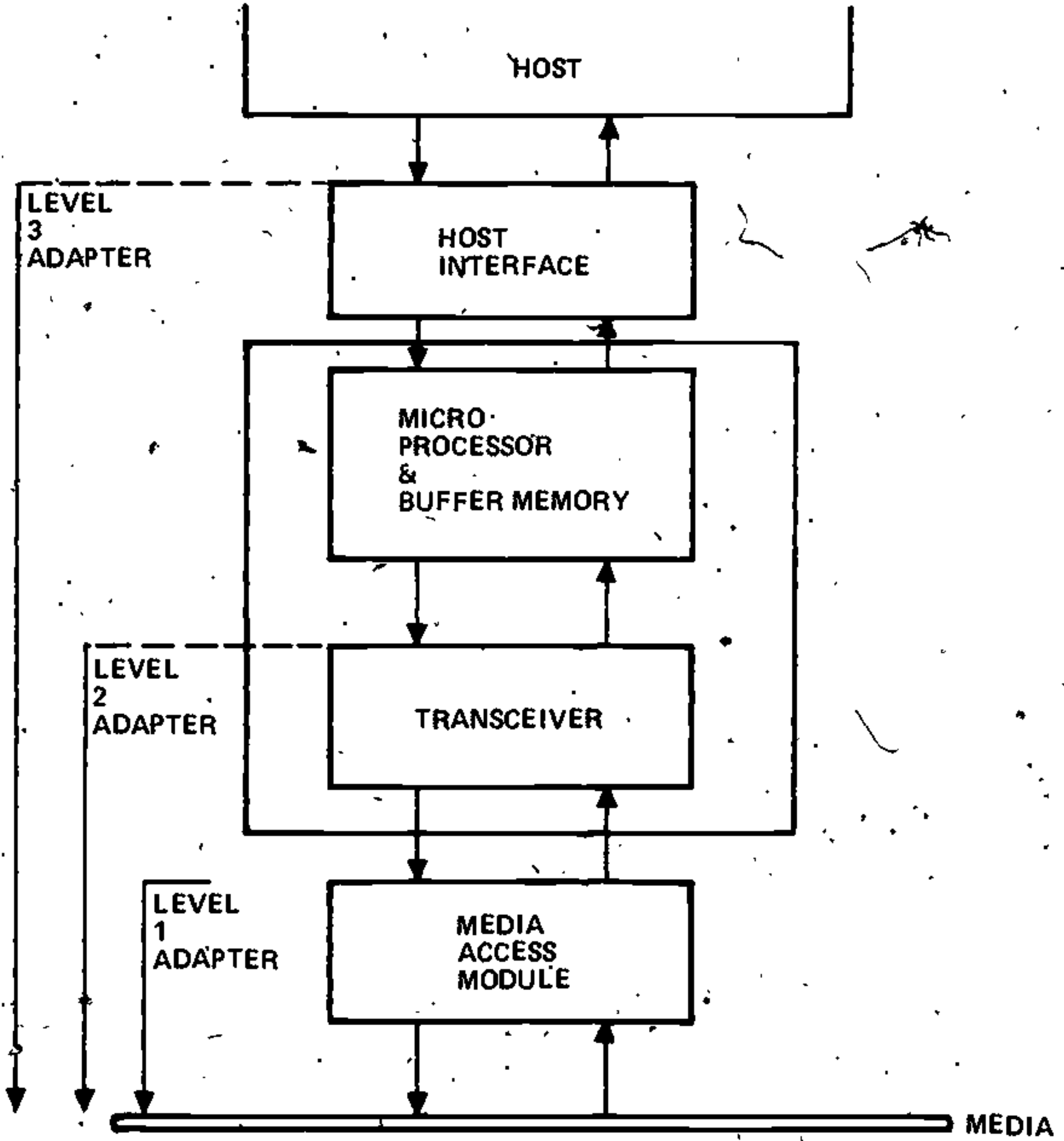

HOST
HOST INTERFACE
MICROPROCESSOR & BUFFER MEMORY
TRANSCEIVER
MEDIA ACCESS MODULE
LEVEL 3 ADAPTER
LEVEL 2 ADAPTER
LEVEL 1 ADAPTER
MEDIA

Figure 2. Hierarchical Design of Adaptor

316

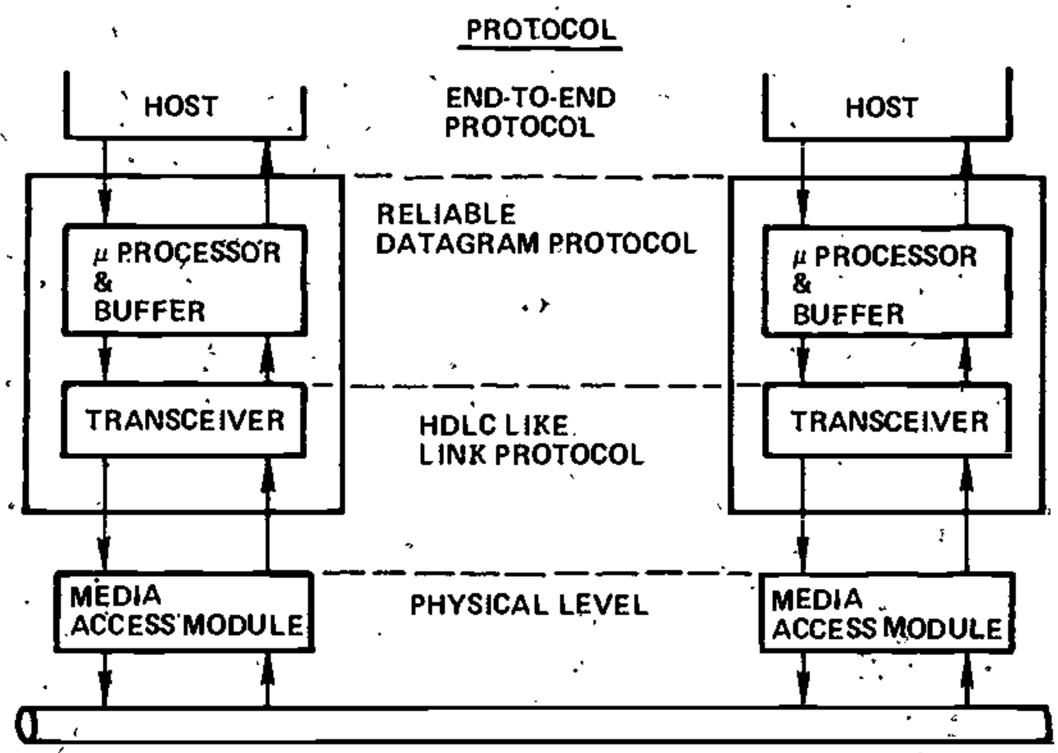
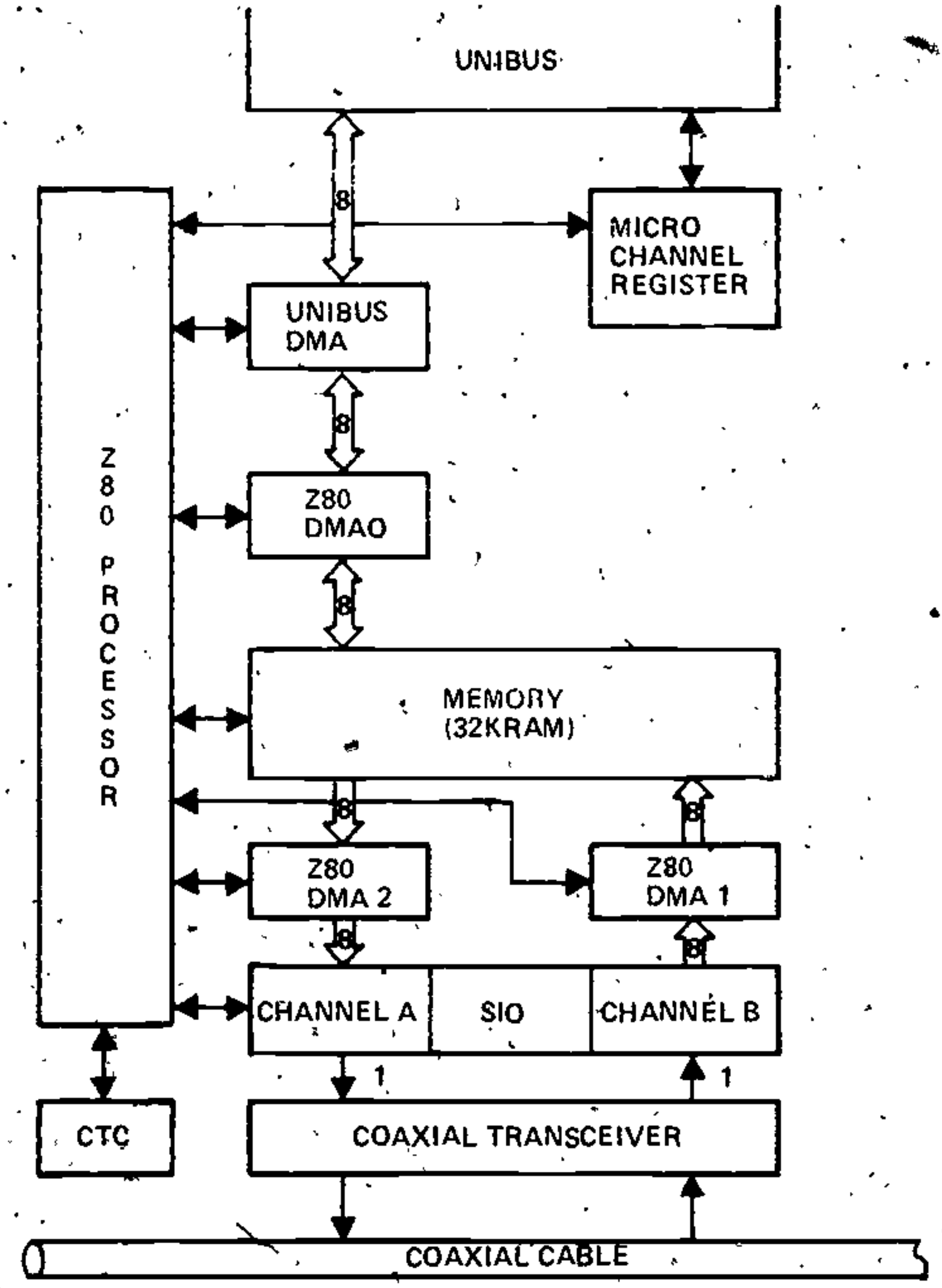

PROTOCOL
HOST
END-TO-END PROTOCOL
HOST
RELIABLE DATAGRAM PROTOCOL
μ PROCESSOR & BUFFER
μ PROCESSOR & BUFFER
TRANSCEIVER
HDLC LIKE LINK PROTOCOL
TRANSCEIVER
MEDIA ACCESS MODULE
PHYSICAL LEVEL
MEDIA ACCESS MODULE

Figure 3. Layers of Protocol


UNIBUS
8
MICRO CHANNEL REGISTER
UNIBUS DMA
8
Z80 PROCESSOR
Z80 DMAO
8
MEMORY (32KRAM)
8
8
Z80 DMA 2
Z80 DMA 1
8
8
CHANNEL A
SIO
CHANNEL B
1
1
CTC
COAXIAL TRANSCEIVER
COAXIAL CABLE

Hardware Architecture of the Coaxial Cable Network Adaptor

Figure 4.

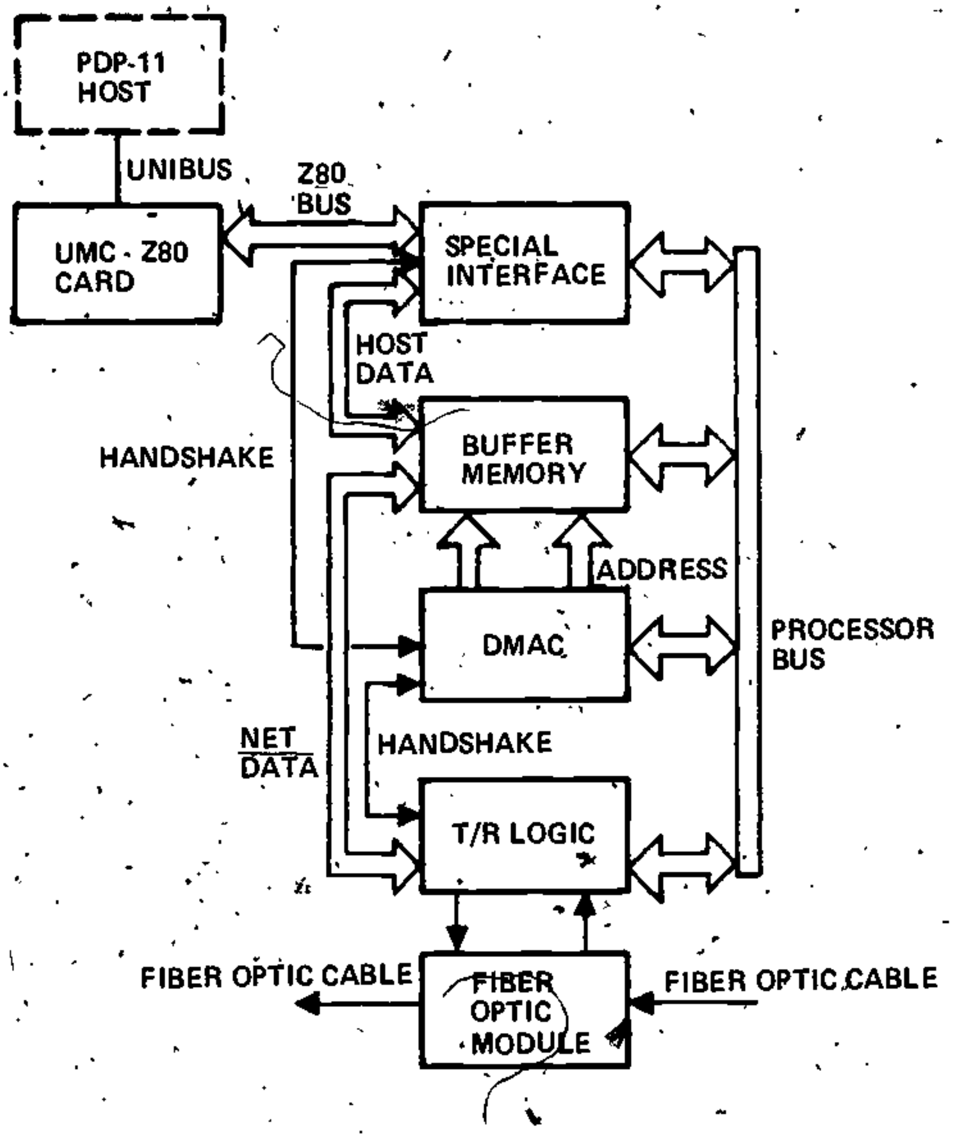

PDP-11
HOST
UNIBUS
Z80
BUS
UMC - Z80
CARD
SPECIAL
INTERFACE
HOST
DATA
BUFFER
MEMORY
HANDSHAKE
ADDRESS
DMAC
PROCESSOR
BUS
NET
DATA
HANDSHAKE
T/R LOGIC
FIBER OPTIC CABLE
FIBER
OPTIC
MODULE
FIBER OPTIC CABLE

Figure 5. Initial Configuration of the Fiber Optic Network Adaptor

Burst Distribution and Switching: Algorithms in a SS/TDMA System

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Abstract

Analytical models and suitable algorithms for obtaining efficient burst distribution and switching sequence in a SS/TDMA communications satellite system are presented. Basic system parameters are identified and pertinent measures of efficiency are defined. A high degree of uniformity in the beam-to-beam traffic matrix is shown to be advantageous for achieving higher efficiency.

1. INTRODUCTION

In a multiple beam communications satellite system with fixed interconnections between pairs of beams, the efficiency of utilization of the space segment operating in the TDMA mode may become limited by the connectivity constraints. The system efficiency can be enhanced by permitting flexible connectivity, that is by allowing the same transponder to be time-shared not only among different pairs of earth stations within prespecified beam regions but also between different pairs of beam regions. The required flexibility entails on-board switching of beam interconnections to enhance the efficiency of transponder utilization. Such a 'satellite switched' TDMA (SS/TDMA) configuration, sometimes referred to as Space Division Multiple Access (SDMA) system, is thus a natural extension of the simple TDMA system (1). A model for the TDMA burst assignment and scheduling has been developed (2) to analyse the efficiency of the system utilization. It is of interest to design an optimal algorithm for beam switching and burst assignment for a SS/TDMA satellite system subject to the system constraints and flexibilities. Ito et al (3) proposed the "greedy algorithm" for this purpose, while Wu (4) proposed an algorithm based on the magic squares. The purpose of this paper is to formulate a simple heuristic algorithm to minimize the number of switchings and/or the frame length, and thus to optimize the system efficiency. General features impacting the system efficiency and the relationship to alternative algorithms are indicated.

2. BASIC DEFINITIONS

2.1 Beam-to-Beam Traffic Matrix (BBTM)

Let there be μ beam regions $B_1, B_2, \ldots, B_\mu$ covering a set of λ earth stations $S_1, S_2, \ldots, S_\lambda$. The coverage is specified by the $(\lambda x \mu)$

'beam coverage matrix' B with elements $B_{\ell m} = 1$ if $S_\ell \in B_m$ and $B_{\ell m} = 0$ if $S_\ell \notin B_m$ ($1 \leq \ell \leq \lambda$; $1 \leq m \leq \mu$).* We first recognize that only the beam-to-beam traffic is of prime consideration here; station-to-station traffic is not involved explicitly except in connection with appropriate grouping of traffic elements to form TDMA bursts. Thus, it is useful to introduce the beam-to-beam traffic matrix (BBTM) $\hat{\Gamma}$ with elements

$$\hat{\Gamma}_{mn} = \text{traffic from beam region } B_m \text{ to } B_n \tag{1}$$

Note that the diagonal elements $\hat{\Gamma}_{mn}$ are not necessarily zero.

The relationship between the beam-to-beam traffic matrix $\hat{\Gamma}$ and the station-to-station traffic matrix Γ is given by

$$\hat{\Gamma} = B^T \Gamma B, \tag{2a}$$

that is, $$\hat{\Gamma}_{mn} = \sum_{i=1}^{\lambda} \sum_{j=1}^{\lambda} B_{im} \Gamma_{ij} B_{jn} \tag{2b}$$

where B^T is the transpose of B.

2.2 The Efficiency of System Utilization

Obviously, the basic parameters of system utilization are as follows:

1) The BBTM $\hat{\Gamma}$ and related quantities, viz.,

$$\left.\begin{aligned} \hat{\Gamma}_m &= \sum_{n=1}^{\mu} \hat{\Gamma}_{mn} && = \text{net outgoing traffic from } B_m;\ m=1, 2, \ldots, \mu \\ \hat{\Gamma}'_n &= \sum_{m=1}^{\mu} \hat{\Gamma}_{mn} && = \text{net incoming traffic to } B_n;\ n=1, 2, \ldots, \mu \\ \hat{\Gamma} &= \sum_{n=1}^{\mu} \sum_{m=1}^{\mu} \hat{\Gamma}_{mn} && = \text{total network traffic} \end{aligned}\right\} \quad (3a,b,c)$$

---

*Here the notation $S_\ell \in B_m$ implies that the earth station S_ℓ is within the coverage region of the beam B_m. Similarly $S_\ell \notin B_m$ implies that S_ℓ is outside the coverage region of B_m.

2) The total number ν of transponders $T_1, T_2, \ldots, T_\nu$

3) The common frame length γ of the transponders

4) The capacity C_o of a single transponder per unit frame length

5) The total number η of connectivity switches made over the frame length in all the transponders, either synchronously or asynchronously

6) The fill-factors of the transponders, $\{\phi_k;\ k=1, 2, \ldots, \nu\}$, and the overall mean fill-factor

$$\bar{\phi} = \left(\sum_{k=1}^{\nu} \phi_k\right) \Big/ \nu$$

for the satellite as a whole

7) The overall satellite effective capacity C

8) The throughput

$$P = \frac{\hat{\Gamma}}{\Gamma_T},$$ where Γ_T is the net transmission and the difference

$$\Delta_\Gamma = \Gamma_T - \hat{\Gamma}$$ is the overhead capacity.

Clearly, if $\hat{\Gamma}^{(k)}$ is the amount of traffic and $\Gamma_T^{(k)}$ the total content (traffic plus overhead) in the k^{th} transponder T_k, then, remembering $\sum_k \hat{\Gamma}^{(k)} = \hat{\Gamma}$ and $\sum_k \Gamma_T^{(k)} = \Gamma_T$, we have the relationships:

$$\phi_k = \frac{\hat{\Gamma}^{(k)}}{C_o \gamma}, \quad \bar{\phi} = \frac{\hat{\Gamma}}{\nu C_o \gamma} \tag{4a,b}$$

$$P = \frac{\sum_k \hat{\Gamma}^{(k)}}{\sum_k \Gamma_T^{(k)}} = \frac{\hat{\Gamma}}{\hat{\Gamma} + \Delta_\Gamma} \tag{4c}$$

$$C = \frac{\hat{\Gamma}}{\gamma} = \nu C_o \bar{\phi}. \tag{4d}$$

Also, one can write the net overhead as the sum due to switching, preamble, and guardspace requirements

$$\Delta_{\Gamma} = (\eta\delta_s + N_{\beta}\delta_p + \nu\delta_g)C_o \qquad (4e)$$

where δ_s is the time taken for a single switching, δ_p is the time duration of a single preamble preceding each burst, δ_g is the time duration of a guardspace at the start of each transponder frame, and N_{β} is the total number of (TDMA) bursts.

The optimality of an algorithm for switching and traffic assignment in a SS/TDMA system is determined on the basis of the following objectives for a given BBTM Γ and unit capacity C_o (also, given values of δ_s, δ_p, δ_g):

a) Maximize the satellite fill-factor $\overline{\phi}$ (i.e., minimize ν or γ or both)

b) Maximize the throughput P (i.e., minimize the overhead Δ_{Γ}; and, hence, minimize η or N_{β} or both)

c) Maximize the satellite capacity C (i.e., maximize ν or $\overline{\phi}$ or both)

Clearly, not all of the above criteria are independent; e.g., for a given γ (and hence C), the $\overline{\phi}$ and ν vary in inverse proportion to each other, as expected. Definite trade-off exists in the choice of the number of transponders, ν, which has conflicting impact on the satellite effective capacity and fill-factor. In general, the problem may be subject to prespecified constraints on the value of the frame length γ, TDMA earth station equipment, and pattern of switching (e.g., switching only in the uplink or only in the downlink connectivity, or in both; synchronous or asynchronous switching; etc.). For simplicity, consideration will be limited in the present paper only to downlink switching case. Thus, the number of transponders will be taken to be equal to that of the beams ($\nu=\mu$). The earth station equipment constraints, if any, obviously affect the earth segment cost and performance and also have an impact on the allowable burst overlap characteristics. The total number of switchings evidently affect the overall satellite weight through the communications subsystems weight as well as efficiency through overhead, and thereby directly influence space segment cost, reliability, and performance. Obviously, a basic concern in the SS/TDMA burst assignment problem is devising separation of elements of the BBTM in time so as to have an a-priori elimination of burst overlaps for the transmitting and receiving stations as far as possible.

3. ALGORITHMIC CONSIDERATIONS

3.1 Partial Beam-to-Beam Traffic Matrix (PBBTM)

The burst nonoverlap characteristic can be satisfied by composing transmit and receive sequences of elements of the BBTM in a cyclic order, such as illustrated in Figure 1, leading to the schematic representation of these sequences as illustrated in Figure 2. The SS/TDMA burst configuration obtained from this pattern of groupings of the elements of the BBTM is schematically illustrated in Figure 3, with the arrows indicating the instants of time when the switchings commence. The elements occupying the various transponders at any particular instant (between two consecutive switchings) can be said to constitute a 'partial' beam-to-beam traffic matrix (PBBTM). The m^{th} PBBTM will be denoted by $\hat{\Gamma}^{(m)}$ (see Figure 1); and this decomposition of the BBTM $\hat{\Gamma}$ into the PBBTM's $\hat{\Gamma}^{(1)}, \ldots, \hat{\Gamma}^{(\mu)}$ is illustrated in Figure 4.

Since the elements of any of the PBBTM thus obtained will not necessarily be equal, automatic avoidance of overlap is guaranteed only if switching commences for each partial matrix after the largest element therein is processed. Obviously, this implies inefficient utilization of the satellite capacity, since in the SS/TDMA frame of each transponder, time slots remain vacant or unutilized corresponding to the differences between the sizes of the largest element and other elements within the individual PBBTM's. Clearly, the degree of inefficiency decreases as the variations in the relative sizes of the elements of the individual PBBTM's become smaller. Larger degree of uniformity in the sizes of the BBTM (or PBBTM) elements, therefore, ensures higher achievable efficiency for SS/TDMA system. Thus, the design of the beam coverage regions and the SS/TDMA burst assignment algorithm should preferably permit the highest possible degree of uniformity in the relative sizes of the elements of the BBTM and the PBBTM's, respectively. Simple algorithms are formulated below to minimize the number of switchings or to optimize the transponder fill-factor.

3.2 An Algorithm to Minimize Number of Switchings (η)

The lower limit $\eta=\mu^2$ corresponding to μ transponders each with μ switchings can be achieved by the cyclic arrangement method outlined above. The efficiency can be improved by minimizing the unused space C_u and frame length γ by adopting a noncyclic search method, followed by a frame reduction method, briefly described below.

According to the search method, first of all, the largest μ elements subject to the nonoverlap constraint (i.e., only one element from each row and each column) are selected to form the first PBBTM $\hat{\Gamma}^{(1)}$; the next μ largest nonoverlapping elements to form $\hat{\Gamma}^{(2)}$, and so on. The specific steps of this simple search algorithm are as follows:

Step 1 - Pick up the largest element of the BBTM, omit the row and column it belongs to, pick up the largest element in the remaining matrix, omit the corresponding row and column, and so on, continuing the process until μ elements are selected.

Step 2 - Form the PBBTM $\hat{\Gamma}^{(1)}$ with the μ elements selected in Step 1 and repeat Step 1 with the remainder of the BBTM to select μ elements again to form $\hat{\Gamma}^{(2)}$, and so on, until all the elements are exhausted and the original BBTM $\hat{\Gamma}$ is split into μ PBBTM $\hat{\Gamma}^{(1)}, \hat{\Gamma}^{(2)}, \ldots, \hat{\Gamma}^{(\mu)}$.

Step 3 - Compose SS/TDMA bursts using the elements of the PBBTM's separated by synchronous switchings following transmission of the largest element of each PBBTM.

The frame reduction method consists of trying to accommodate the elements of a particular PBBTM $\hat{\Gamma}^{(m)}$, say, within the empty spaces encompassed by one or more of the other remaining PBBTM $\hat{\Gamma}^{(m')}$, $m' \neq m$, without violating the nonoverlap constraint. The procedure involved is illustrated in Figure 5, schematically representing the SS/TDMA burst configurations for an arbitrary 4 x 4 BBTM.

3.3 Algorithm to Minimize the Frame Length (γ)

We now consider the algorithm (3) that minimizes the frame length γ ab-initio. Obviously, it suffices to look for an algorithm which yields a frame length γ_m corresponding to the maximum row (or column) sum. The minimality of γ can only be achieved by allowing extra number of switchings (and perhaps additional amount of unutilized space or capacity), if necessary. Again, the overall efficiency depends on the degree of uniformity that the BBTM possesses.

Obviously, the formation of PBBTM and composition of respective SS/TDMA bursts must be done in this case with reference to the row (or column) having the largest row sum (column sum). We refer to this row (column) as the 'reference' row (column) and form the PBBTM starting with the largest element, called the 'reference element', within the reference row (column). An algorithm similar to the algorithm described above can be followed, with the additional constraint that the maximality of the reference row (column) and the reference element must be maintained at each step. The specific steps of this algorithm are given below

Step 1 - Select the 'reference' row (or column) and the 'reference' element.

Step 2 - Disregarding the row and column which contain the selected element, select the maximum element in the residual elements. Repeat this procedure μ times, each time eliminating the row and column containing the element selected previously.

Step 3 - Extract μ elements found in the Step 2, thereby dividing the given matrix into two parts. Sum up the traffic demands of each row and column of two matrices, respectively.

Step 4 - In the first matrix, when there exists an entry greater than the reference element, put back the excess amount of traffic to the second matrix (remainder matrix).

Step 5 - In the remainder matrix, if the total traffic demands of some rows (or columns) exceed that of the reference row (or column), put back the traffic from the first matrix to some extent to the second matrix so as to maintain the sum of reference row (or column) in the second matrix maximum within the constraint of Step 4. [Note: If every element in the first matrix becomes zero at the conclusion of this adjustment process, select the second largest element in the original matrix as the reference element and repeat the above procedure (Steps 2 through 5)].

Step 6 – Repeat the entire procedure with the second matrix (Steps 1 through 4). This procedure thus decomposes the original BBTM into several component PBBTM's.

Step 7 – Compose SS/TDMA frame by arranging the nonzero elements of the first PBBTM in appropriate transponders, starting from the beginning of the transponder frames.

Repeat the above procedure with other PBBTM's successively, each time starting with the time slot next to the time slot occupied by largest element of the previous PBBTM.

The frame length in this case can be written as

$$\gamma = \frac{\hat{\Gamma}_{max}}{C_o} + N_m \delta_p + n_m \delta_s + \delta_g \qquad (5a)$$

where $\hat{\Gamma}_{max}$ is the largest row (or column) sum, N_m is the number of bursts into which the $\hat{\Gamma}_{max}$ is split up and n_m is the number of synchronous switchings required to exhaust $\hat{\Gamma}_{max}$ following the algorithm described above. Clearly, the values of n_m and N_m depend on the specific data pattern. The total number of switchings in all the transponders now becomes

$$\eta = n_m \mu \qquad (5b)$$

The overhead capacity is given by

$$\nabla_\Gamma = \mu(n_m \delta_s + \overline{N}_\beta \delta_p + \delta_g) C_o \qquad (5c)$$

where $\overline{N}_\beta$ is the mean number of bursts per transponder. The amount of unused capacity is consequently given as

$$C_u = \mu C_o[\gamma - (n_m \delta_s + \overline{N}_\beta \delta_p + \delta_g)] - \hat{\Gamma} \qquad (5d)$$

The parameters of systems efficiency are determinable using the above results.

The process of forming PBBTM and the resulting burst distributions in the transponder frames is illustrated by using the BBTM of an elementary example. The PBBTM's in the present example as well as the resulting

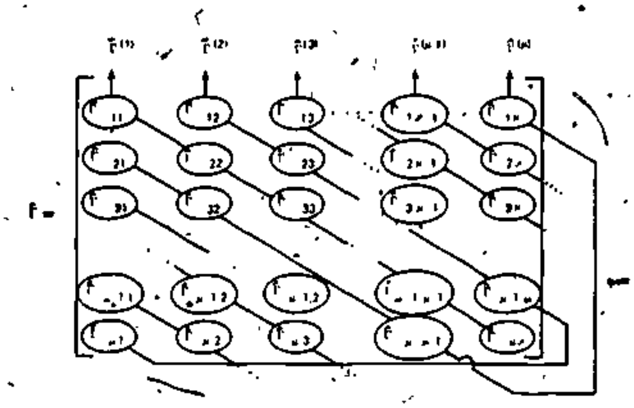
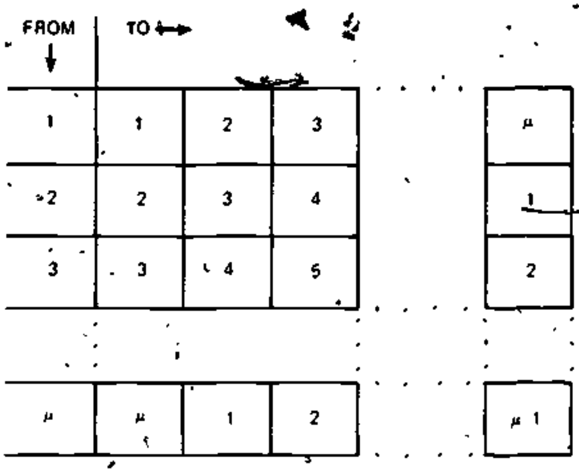

$\hat{f}^{(1)}$
$\hat{f}^{(2)}$
$\hat{f}^{(3)}$
$\hat{f}^{(\mu-1)}$
$\hat{f}^{(\mu)}$
$\hat{F} =$
$\hat{f}_{11}$
$\hat{f}_{12}$
$\hat{f}_{13}$
$\hat{f}_{1\mu-1}$
$\hat{f}_{1\mu}$
$\hat{f}_{21}$
$\hat{f}_{22}$
$\hat{f}_{23}$
$\hat{f}_{2\mu-1}$
$\hat{f}_{2\mu}$
$\hat{f}_{31}$
$\hat{f}_{32}$
$\hat{f}_{33}$
$\hat{f}_{3\mu-1}$
$\hat{f}_{3\mu}$
$\hat{f}_{\mu-1,1}$
$\hat{f}_{\mu-1,2}$
$\hat{f}_{\mu-1,3}$
$\hat{f}_{\mu-1,\mu-1}$
$\hat{f}_{\mu-1,\mu}$
$\hat{f}_{\mu 1}$
$\hat{f}_{\mu 2}$
$\hat{f}_{\mu 3}$
$\hat{f}_{\mu,\mu-1}$
$\hat{f}_{\mu\mu}$

FIGURE 1 A CYCLIC GROUPING OF THE ELEMENTS OF THE BEAM-TO-BEAM TRAFFIC MATRIX (BBTM) TO FORM SS/TDMA BURST CONFIGURATION



FROM ↓	TO →				
1	1	2	3	. . .	μ
2	2	3	4	. . .	1
3	3	4	5	. . .	2
⋮	⋮	⋮	⋮		⋮
μ	μ	1	2	. . .	μ 1

FIGURE 2 SCHEMATIC REPRESENTATION OF THE CYCLIC GROUPING OF ELEMENTS (TABLE 1)

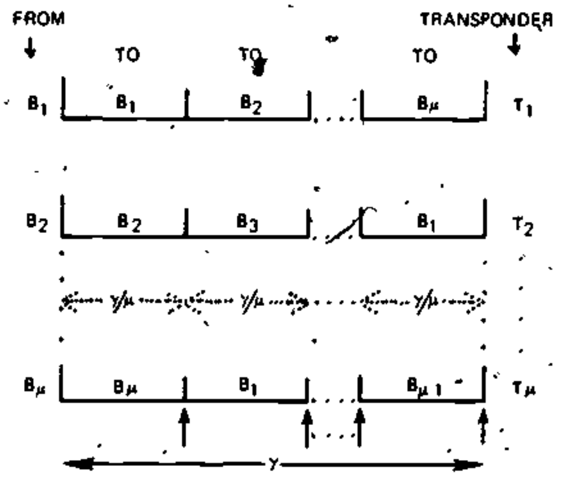

FROM
TRANSPONDER
TO
TO
TO
B_1
B_1
B_2
B_μ
T_1
B_2
B_2
B_3
B_1
T_2
γ/μ
γ/μ
γ/μ
B_μ
B_μ
B_1
$B_{\mu-1}$
T_μ
γ

FIGURE 3 SS/TDMA BURST CONFIGURATION UNDER CYCLIC GROUPING OF ELEMENTS

$$\hat{F} = \underbrace{\begin{bmatrix} \hat{f}_{11} & 0 & 0 & \cdots & 0 \\ 0 & \hat{f}_{22} & 0 & \cdots & 0 \\ 0 & 0 & \hat{f}_{33} & \cdots & 0 \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & \hat{f}_{\mu\mu} \end{bmatrix}}_{\hat{F}^{(1)}\text{-1st COLUMN OF TABLE (1)}} + \underbrace{\begin{bmatrix} 0 & \hat{f}_{12} & 0 & 0 & \cdots & 0 \\ 0 & 0 & \hat{f}_{23} & 0 & \cdots & 0 \\ 0 & 0 & 0 & \hat{f}_{34} & & \\ \vdots & \vdots & \vdots & & & \vdots \\ \hat{f}_{\mu 1} & 0 & 0 & & \cdots & 0 \end{bmatrix}}_{\hat{F}^{(2)}\text{ 2nd COLUMN OF TABLE (1)}} + \cdots + \underbrace{\begin{bmatrix} 0 & 0 & 0 & \cdots & \hat{f}_{1\mu} \\ \hat{f}_{21} & 0 & 0 & \cdots & 0 \\ 0 & \hat{f}_{32} & 0 & \cdots & 0 \\ 0 & 0 & \hat{f}_{43} & & \\ \vdots & \vdots & \vdots & & \vdots \\ 0 & 0 & 0 & \cdots & 0 \end{bmatrix}}_{\hat{F}^{(\mu)}\text{-}\mu\text{th COLUMN OF TABLE (1)}}$$

FIGURE 4 DECOMPOSITION OF THE BBTM INTO A SET OF PBBTMs

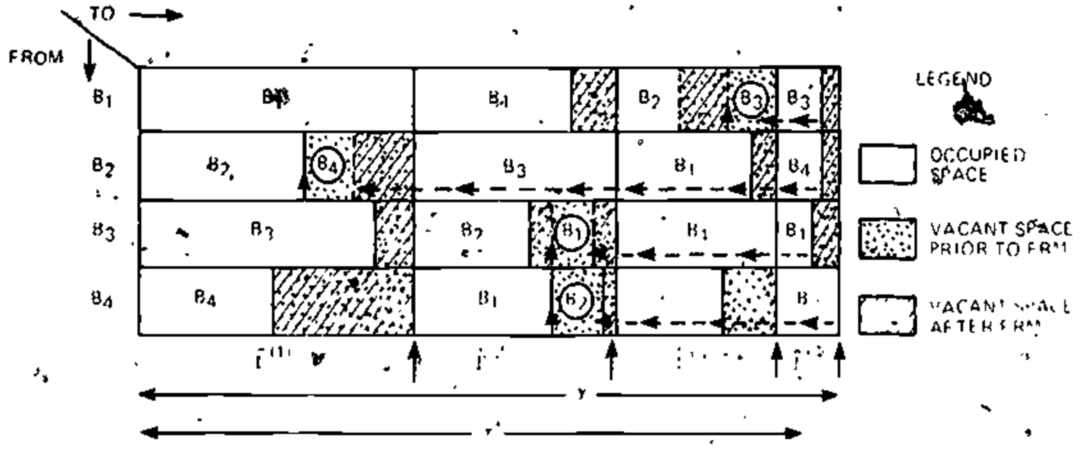

TO
FROM
B1
B2
B3
B4
LEGEND
OCCUPIED SPACE
VACANT SPACE PRIOR TO FRM
VACANT SPACE AFTER FRM
γ
γ'

FIGURE 5 AN ILLUSTRATION OF THE FRAME REDUCTION METHOD (FRM)

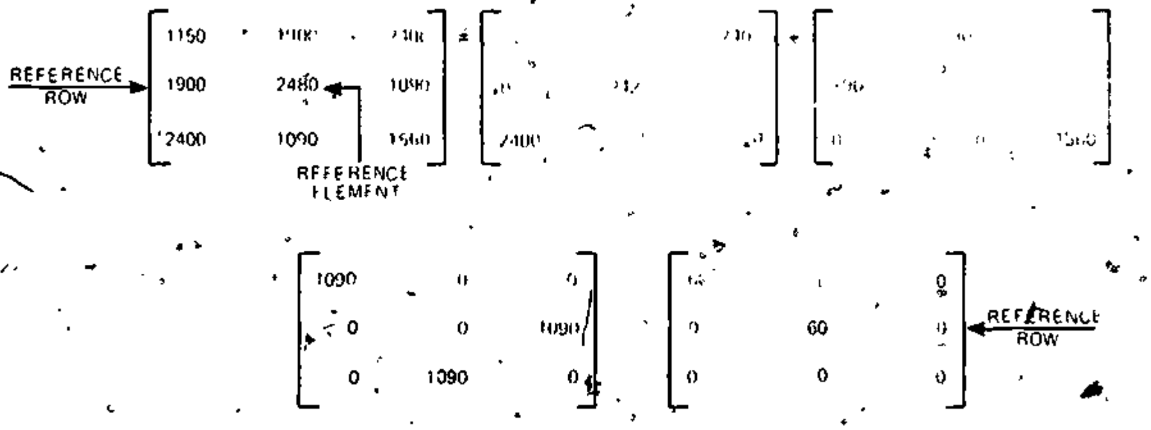

REFERENCE ROW
1150
1900
2400
2480
1090
1560
REFERENCE ELEMENT
2400
1090
0
1090
0
0
60
0
REFERENCE ROW

FIGURE 6(a) ILLUSTRATIVE EXAMPLE OF FORMATION OF PBBTM FROM BBTM FOR ALGORITHM TO MINIMIZE THE FRAME LENGTH

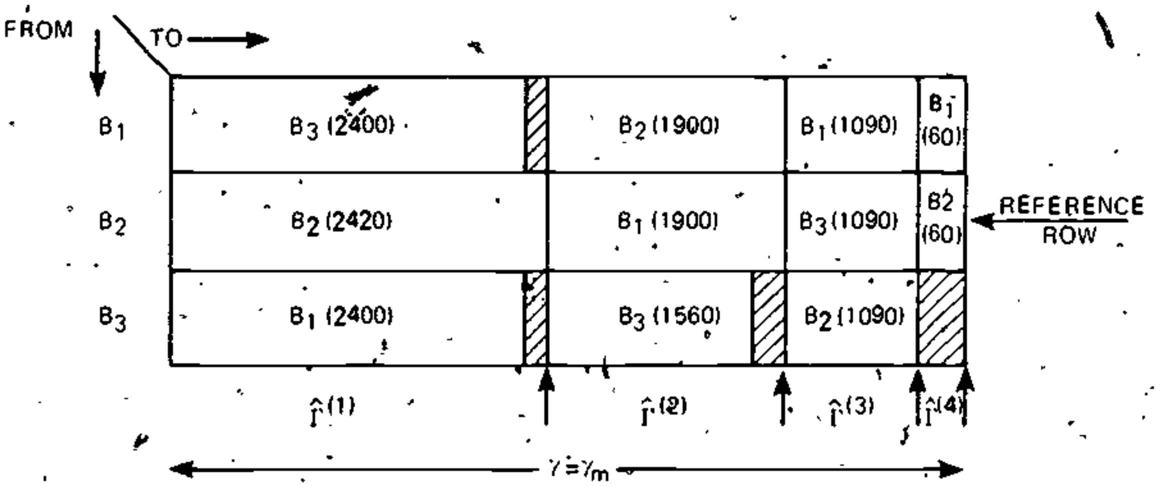

FROM
TO
B1
B2
B3
B3 (2400)
B2 (1900)
B1 (1090)
B1 (60)
B2 (2420)
B1 (1900)
B3 (1090)
B2 (60)
REFERENCE ROW
B1 (2400)
B3 (1560)
B2 (1090)
$\hat{\Gamma}^{(1)}$
$\hat{\Gamma}^{(2)}$
$\hat{\Gamma}^{(3)}$
$\hat{\Gamma}^{(4)}$
$\gamma = \gamma_m$

FIGURE 6(b) THE SS/TDMA FRAME FROM THE EXAMPLE OF FIGURE 6(a) burst distribution in transponder frames in Figure 6. The 'reference row' and 'reference element' are indicated by the labelled arrows, as are the switching times. The unused space is represented by shaded portions of the transponder frames.

In reference to the example at hand, we observe that while use of the algorithm reduces the frame length as well as the amount of unutilized space, it increases the number of switchings, as expected. The trade-off between the overall efficiency and the operational convenience is well illustrated by this simple example. As stated before, the choice of a specific algorithm in a particular application will largely depend on the structure of traffic data base (including beam coverage pattern), and the type of optimization objective (e.g., frame length vs. number of switchings) involved.

4. SUMMARY AND CONCLUSIONS

We have considered the impact of satellite switched TDMA (SS/TDMA) mode of transmission on the system efficiency. The basic parameters involved have been identified and specific measures of system performance or efficiency have been formulated. The methods of optimization of pertinent parameters or efficiency of system utilization have been investigated, and algorithms for specific type of optimization suggested.

The implications of choice of different beam coverage patterns in context of SS/TDMA system optimization are discussad. It is concluded that beam coverage design with maximum possible uniformity of intra-beam and inter-beam traffic is most suitable for achieving the optimal SS/TDMA system.

Referances

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A VIEW OF TELECOMMUNICATIONS POLICIES IN THE UNITED STATES

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Abstract

There is a need to understand the telecommunications philosophies and policies of the Pacific Basin Countries in order to establish a base to develop a possible consensus on telecommunications issues.

This paper covers what the authors believe are the basic philosophies, major historical events and the current issues and policies of the United States in telecommunications, as viewed by the private sector.

A VIEW OF TELECOMMUNICATIONS POLICIES IN THE U.S.

INTRODUCTION

Telecommunications services in the United States, as in the rest of the world, are fast converging into a blended service of voice, video, data and text through digital transmission. Unlike most of the other countries, however, the United States has no single government owned or private telecommunications carrier either domestically or internationally nor is there a single government entity such as a Ministry of Telecommunications responsible for policy development.

Regulation of each type of telecommunications technology --e.g. telephone, telegraph, microwave, satellites, and digital transmissions--is treated quite differently by the substantive law, as though each were a completely separate and independent service. Furthermore, policy development occurs in different forms and in different forums, so that it is difficult for those outside the U.S. to achieve an integrated view of public policy within the United States. Policy initiatives come from the Executive branch, and the Congress of the federal government, and administrative agencies such as the Federal Trade Commission (FTC) and Federal Communications Commission (FCC) and state or local governments. Also public policy in the United States is often initiated by private companies moderated by judicial restraints and by nonprofit foundations whose major activity is policy analysis. In order to understand this diversity in policy making, it is necessary to review a few basic principles and historical circumstances which gave rise to this unique and often mysterious system which may appear to defy logic but not the fundamental philosophy.

BASIC PHILOSOPHY

1) The cornerstone of U.S. policy is the Declaration of Independence which establishes that all men are created equal. Thus there runs a strong bias toward equitable access to telecommunications services and nationwide coverage for all facilities.

2) The constitutional system established a government of checks and balances with three equally powerful institutions--the Executive, the Legislative, and the Judicial--which also explains the penchant for decentralization of power in the communications system, so that no centralized control over the communications system would ever be possible.

3) A three tiered system of federal, state, and local government means that regulation is shared by all three levels of government, e.g. cities control access to street rights of way for telephone and telegraph poles and lines and local zoning laws control the placement of microwave towers. State public utility commissions and Telecommunications Agencies regulate intrastate rates while the Federal Communications Commission regulates interstate and international service.

4) The First Amendment to the Constitution established the right of free speech for every citizen. Thus telecommunications providers are obligated to be common carriers and have no jurisdiction over the content of information transmitted.

5) There is a strong commitment to an unregulated commercial marketplace in which it is assumed that both products and services at the lowest cost will be generated by the pull of consumer demand.

All of these basic philosophical principles are imbedded in the substantive law--the Communications Act of 1934 which declares the purpose of the Act as:

> "...to make available, as far as possible, to all the people of the United States a rapid, efficient, Nationwide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of national defense, for the purpose of promoting safety of life and property..."(1)

HISTORICAL DEVELOPMENT

It is not an accident of fate but conscious decision that led to postal, telegraph, and telephone services being provided by independent institutions rather than a unified government department. Although authority to establish post roads and a postal service was given to the federal government in the

Constitution, the electronic services were permitted to develop initially in an unfettered marketplace. Telecommunications and transportation were closely related and telegraph poles were initially established on the railway right of ways which were often built on lands deeded by the federal government. There were early competitive railways and competitive telegraph and telephone companies and only through market competition did the monopoly service of Western Union become established in telegraphy and the dominance of telephone by AT&T become established--which led first to state regulation and then federal regulation of interstate telecommunications.

Part of the reason for diversified ownership of different forms of communications was lack of foresight on the part of existing service companies when new companies were developed, e.g. Western Union turned down the opportunity to buy Bell's patents which became the basis for the AT&T company.

In 1912, when the British government assumed ownership of the British telephone system, the United States remained alone among the major countries with private companies providing all telephone service. Thus in 1913 the U.S. postmaster general started a debate over the nationalization of telegraph and telephone services under his department, urging that the use of wires for transmission was a natural extension of the constitutional authority to establish post offices and post roads. The telephone companies argued that a government monopoly of telephony and telegraphy would be unworkable because there would be no regulators to regulate the government monopoly. Nevertheless President Wilson, under the pressure of wartime exigencies nationalized the railways as well as telephone and telegraph services. The experiment in government ownership was shortlived, as the government was unable to operate without sharply increasing rates when lower rates had been promised. The public outcry was so great that less than a year later Congress proposed the immediate return of telegraph and telephone services to their private owners--and so ended public ownership of the monopoly common carriers. (2)

Another important reason why services are provided by so many competitors is that antitrust policy has played a significant role in breaking up business organizations which appear to become too large or too integrated either vertically or horizontally. Originally Bell agreed to stay out of telegraphy and Western Union agreed to stay out of telephony in 1879 in a private settlement over their respective patents. This agreement was circumvented, however, by incorporating the American Telephone and Telegraph Company (AT&T) to set up long lines to interconnect local telephone companies. By 1909, AT&T was able to buy control of Western Union which would result in one company supplying most of telecommunications. This situation came to an abrupt end in 1913 under threat of federal anti-trust action. In the so-called Kingsbury commitment, AT&T agreed to abandon it's interests in telegraphy. AT&T turned to radio telephony and acquired patent rights which led it into the broadcasting business with cross licensing agreements with General Electric and the Radio Corporation of America (RCA). However, Westinghouse was the first to put a broadcasting station on the air--KDKA in Pittsburg in 1921, and it too became part of the cross licensing agreements. This would have vertically integrated the broadcasting business with telephony had it not been the zeal of the Federal Trade Commission in compliance with its mandate to administer the antitrust laws. Although the concept of AT&T as a common carrier for "toll broadcasting service" did not meet with major success in the marketplace (a harbinger of teleconferencing in the 1970's) (3) AT&T controlled the voice quality major inter-city telephone lines which were not made available to lease to other broadcasters. The broadcasters had to use Western Union and postal telegraph lines which in many instances were not voice quality. AT&T through its subsidiary, Western Electric, also began to manufacture and market radio sets in competition with its cross licensee, RCA. At the same time the Federal Trade Commission launched an inquiry into the broadcasting industry. The result was that the various companies sorted out an orderly division of responsibilities with AT&T bowing out of broadcasting in exchange for the leasing of long lines for interconnection to the RCA controlled broadcast network--the National Broadcasting Company.

Under another antitrust litigation, AT&T entered a consent decree with the U.S. government in 1956. The consent decree prohibited AT&T from engaging in unregulated communications services limiting it to tariffed services as regulated by the FCC.

Thus the antitrust laws have had a substantial impact upon the telecommunications industry. In the sixties and the seventies the FCC launched into a lengthy series of regulatory inquiries attempting to define the line between communications services and products which were tariffed (and in which AT&T could participate) and data processing services and products which were to be provided by an unregulated and competitive marketplace.

One of the more interesting recent developments has been a general trend toward deregulation and competition in industry through a series of administrative decisions by the FCC. First the FCC opened up competition in the equipment which could be attached to the basic telephone system in the Carterfone decision (4) decided in 1968 followed by a decision in the same year to permit MCI, Inc., (5) to establish a centralized common carrier service for interstate private line service via terrestrial microwave which would also be competitive with the Bell established interstate telephone service, and the FCC also decided to open up domestic satellites to competition in what was called the "open skies" policy for domestic satellites. Rather than give the telephone companies the sole responsibility for domestic satellite telephone service, the FCC authorized Western Union and RCA to put up satellites which have now become operational. Although the FCC authorized AT&T and GTE to put up a satellite system, the satellite was not permitted to be leased for other than telephone service initially in order to permit the competitors an opportunity to build their competitive services. More recently, Satellite Business Systems (SBS), a partnership of COMSAT, Aetna, and IBM was authorized by the FCC to offer a business satellite service and the Xerox Corporation has also filed for authority to establish a direct private line service XTEN using both microwave for intracity and satellite for intercity service.

The public switched network is still maintained as a monopoly for the Bell System, GTE and the smaller telephone companies. What is called the "local loop" service within the particular city also remains under monopoly control, but the trend toward competition may open up the local service also to competitive services. Certainly cable television could provide an alternative local interactive voice as well as video service.

The current trend is toward:

1. direct allocation of costs to particular services rendered

2. less internal cross subsidy of services

3. permitting carriers to compete with newcomers but only through arms length subsidiaries.

How to encourage competition between regulated and unregulated industries is a major problem to be solved by policy makers as voice, video, data and hard copy services meld into a single service. The time honored policy of allocating telephone service to AT&T, telegraph to Western Union, and letters to the United States Postal Service appears no longer to make sense technologically.

CURENT OPEN ISSUES

As indicated in the preceding sections the U.S. is a dynamic telecommunications environment both technically and in terms of policy and regulation. The technology has created the need for new regulations. The old regulations do not appear to apply and because of this the Federal Government, states, industry, and users alike are participating in formulating the U.S. policies in telecommunications. The prime concerns are the need for an overhaul of the 1934 communications act to meet the current needs based on new technology and services, the separation of a regulated communications industry from an unregulated information processing industry (FCC computer inquiry #2) and the concern for international information flow.

A. The Communications Act

The activities leading to amendment of the communications act are concerned with all aspects of telecommunications policies and issues in the United States as well an an organizational structure for regulatory bodies. In order to accomplish this amendment every aspect of telecommunications is being reviewed or has been reviewed by the U.S. house of representatives and senate sub-committees concerned with the amendments. Hearings have been held which covered a wide span of the telecommunications industry, data processing industry and users. One bill in the house and two in the senate are now pending and are expected to be consolidated.

B. The FCC Computer Inquiries

Computer inquiry number one of the FCC initiated on November 10, 1966 culminated in responses from interested parties in 1968. The primary concern of that inquiry was the definition of communication services versus data processing services and which of these services should come under regulation. The primary conclusion of that inquiry was that all data processing services should be unregulated, communications services regulated and hybrid services to be reviewed on a case-by-case basis to decide whether they were communication services with incidental data processing or data processing services with incidental telecommunications. Carriers were also allowed to provide unregulated data processing services through a separate subsidiary.

Computer inquiry number two which followed on August 9, 1976 (6), was based on the previous inquiry and was designed to obtain information, views and recommendations from interested members of the public to assist the commission in resolving regulatory and policy questions presented by the technological advances being made in the communications and information processing fields. It focused on the definition of data processing. This has been interpreted as looking at the telecommunications industry from the point of view of what should be regulated and what should be unregulated. The commission has released its "tentative Decision" and "Further Notice of Inquiry" on July 2, 1979. In the regulatory process under this Tentative Decision and Further Notice the Commission has allowed for responses to it and has opened the door for interested parties to react to their definitions and regulatory schemes. As you can see this inquiry is not over and will continue for some time in the future.

C. International Information Flow

The international information flow issue is gaining increasing attention and at the International Conference on Information Technology and Society in Paris the week of September 24, Mr. Brzezinski made a video tape presentation on the international information issue which can be summarized as follows:(7)

-The U.S. is committed to a free flow of information

-Information resources should be made available to all countries

-Trade in information goods and services should be free between countries

-Telecommunication facilities and services should be transparent in data processing terms

-Differences between nations must be resolved in an atmosphere of mutual respect and without disrupting settled international practices

From our view it appears that this position is supported by U.S. industry, users and other interested parties. On this particular issue U.S. industry and government have participated in international forums and studies. Three major areas of participation are the International Chamber of Commerce, the OECD, and the Intergovernmental Bureau of Informatics.

D. U.S. Government's Position On Telecommunications

In a recent address to the Congress on September 21, the president has stated his position regarding telecommunications policy and issues in the United States geared towards amending the 1934 communications act and Computer Inquiry #2. This can be summarized in a number of major points as follows:

1. Technology has invalidated the old assumption that all aspects of telecommunications service are natural monopolies.
2. Innovation is hobbled by uncertainty and by the need to respond to artificial regulatory conditions instead of real consumer demand.
3. Competition is a fact of life in this industry, it should not be rolled back and we should not allow it to continue developing haphazardly.

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4. Competition should be encouraged and fully competitive markets should be de-regulated. Some communication services such as local exchange may remain regulated monopolies indefinitely.

5. Restrictions resulting from out-of-date definitions base on the distinction between telecommunications and data processing should be removed.

6. Rules that divide some communication services between domestic and international companies are outmoded and need change.

7. We need a new system which would be administered openly by public officials because these are important public policy decisions that should not be left solely to the industry.

8. Universal availability of basic telephone service at affordable rates must be maintained.

9. Extend to rural Americans the benefits of all the new communications technologies.

10. Rules that restrict rural telephone companies from offering cable TV services should be removed.

11. Appropriate jurisdictional boundaries should be set between federal and state regulatory bodies.

12. The FCC should be given the authority to develop efficient means of assigning broadcast frequencies.

13. The technical quality of the telecommunications network should be protected.

14. Public participation in regulatory decision making should be encouraged.

This Presidential message can be regarded as the official position of the Executive Branch concerning telecommunications policies. This statement is consistent with the long established policy of encouraging competitive markets whenever and wherever possible. It represents the most progressive step toward integrating policy with respect to communications and computerized services.

CURRENT POLICIES NATIONAL AND INTERNATIONAL (8)

This is a brief review of what we believe are the current established major U.S. policies in the area of spectrum allocation, satellites, specialized telecommunications carriers, interconnection, attachment, and international telecommunications. It is re-emphasized here that we are looking at current major U.S. policies in the broader sense, not just that of a government, but also the practices and policies of American industry, universities and foundations.

A. Spectrum Allocation

The U.S. policy concerning spectrum allocation on a national basis is primarily one of conservation, and efficient use and is geared toward stimulating a mass market for the electronics industry.

The policy concerning spectrum allocation for overseas is in support of the allocation of satellite parking places for specific band widths on an as needed basis. During the recent World Administrative Radio Conference (WARC), the U.S. position supported by industry was geared towards Region 2 covering North and South America. The U.S. proposed a new concept in the division of a higher frequency range between broadcast and fixed satellite systems (Frequency Separation Plan). This solution will allow for more satellite parking spaces by intermixing the two types of satellites at the same orbital slot, in fact will enable one satellite to service both requirements. In terms of Region 3 which covers the Pacific area the U.S. has not taken any major steps. Its interesting to note that Region 2 covers the 48 states plus Alaska but not Hawaii.

B. Satellites

As stated previously the domestic satellite policy is for open competition through approval by the FCC to insure that the proposed domestic satellite system is a viable entity technically and financially. Any organization which has the capability can propose to enter this market in competition with those already approved.

In regard to international satellite policy the U.S. supports Intelsat through COMSAT but also supports the concept of explaining the need for regional satellite systems. The U.S. in a broader sense of government, industry, universities and foundations has assisted countries in Latin America and Southeast Asia in studying and developing Domestic and Regional satellite systems.

A prime example of this is the University of Hawaii working with the United Nations as well as with support of the U.S. government through ARPA to assist in the development of satellite technology and the use of domestic and reginal satellite systems. Major work has been performed with both Korea and Indonesia. The U.S. government with its experimental satellite system and the Agency for International Development (AID) has assisted both India and the South Pacific in understanding and developing basic communications systems and educational systems.

C. Specialized Telecommunications Carriers

The policy towards telecommunications carriers providing specialized services is one of competition as in satellite systems. Any viable entity can propose to enter the market in competition with existing carriers in such areas as data network services, telecommunications services for intracompany use, facsimile systems, message switching, and office of the future systems. Examples of such companies are Graphnet, MCI, GTE/Telenet, Tymnet, Southern Pacific, XTEN, AMERISAT and the specialized offerings of ITT.

On an international basis certain specialized carriers have become international providers of specialized services via facilities of the existing International Record Carriers (IRC's). Both Telenet and Tymnet have implemented such systems in cooperation with the IRC's and the national telephone companies or administrations of other countries.

D. Interconnection

Interconnection in the United States is defined as the interconnection of different common carriers services as well as the interconnection of leased lines to switched networks. The overall U.S. policy concerning this is freedom of interconnect in all aspects; the interconnection of, for example, specialized carriers like MCI with the Bell System for voice and broadband communication.

E. Foreign Attachment

What is known as foreign attachment in the United States is the attachment of other than common carrier products to the common carrier services. In the U.S. the policy is for freedom of attachment. This ranges from telephone handsets through PBXs to modems and data terminals. This is translated into allowing manufacturers and agents whether domestic or foreign to sell products to end users for direct attachment to switched or leased facilities. The requirement is that the interface specifications to those networks must be met. In regard to the telephone switched network a FCC certification procedure is required. It should be emphasized here that the common carriers are in competition with the private manufacturers and also must go through a certification procedure for attaching their equipment to their own facilities or other facilities of other carriers.

F. International Communications (8)

A policy that is of concern to this conference is the U.S. attitude towards international telecommunications. During 1977 and 78 the federal government took a number of steps to provide an improved framework for coordinated international policy making which included the following:

- the National Telecommunications and Information Administration (NTIA) was established within the Department of Commerce
- the International Communications Agency was established
- Implementation of International Communications Policy assigned to the Deputy Secretary of State
- a delegation plus chairman to the 1979 WARC was formed

Although many Executive Branch agencies have specific interests in international communications it is the NTIA, the Department of State and the ICA that have primary policy responsibility. These organizations are now in the process of formulating an overall policy.

The current policy towards international carriers is to have competitive carriers for all types of services with the exception of the public telephone switched service.

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The telephone companies have that responsibility. Up to the present the only international data carriers are the international record carriers (IRC's). To interconnect to the telephone switched network of the United States for data transmission (with the exception of Canada and Mexico) one must simulate that system by interconnecting the switched networks of the overseas carriers through the U.S. international record carriers to either Western Union broadband or similar services and not interconnecting directly to the public telephone network. In brief the public telephone switched network of the U.S. is not available for international data communications beyond North America. However this situation should be rectified in the near future.

A VIEW OF SPECIFIC POLICIES TOWARDS THE PACIFIC BASIN

The United States, its industry and institutions support the agreement concerning the technical barriers to trade adopted at the Tokyo round of the GATT multilateral trade negotiations. This agreement is based on the underlying principle to reduce and eliminate technical barriers to trade. The American National Standards Institute (ANSI) for example, which is a voluntary body of the industry sector assisted in writing the section of the agreement for the U.S. The U.S. was a major mover towards obtaining the agreement and believes in the elimination of technical barriers to trade.

The U.S. is a basically free telecommunications environment where national and international manufacturers can market telecommunications equipment to end users and to the carriers for direct attachment to carrier facilities. Therefore the U.S. would then support the creation of a similar environment in the Pacific Basin in order to enhance trade, industry and the development of technology.

In regard to the transfer of technology in telecommunications the U.S. has primarily left this to private industry, non-profit organizations and universities. However, the U.S. government is giving increased attention to the development of communications in the lesser developed, developing and newly industralized countries (8). U.S. assistance to Third World Communications has come through either bilateral channels through AID, ICA, ExImBank or via multilateral channels through the World Bank, regional international banks and U.N. agencies.

An example of technology transfer is through the International Telecommunications Union where American companies have contributed resources to education and study programs in Latin America and Southeast Asia. Another example is the East West Center located in Hawaii which has a Communications Institute and contributes to the education of members of the Pacific Basin governments, universities and other entities in telecommunications technology and policy.

The private sector and Universities in the U.S. offer scholorships in research in telecommunications at their laboratory locations. The private sector also offers research, development and knowhow in telecommunications through the establishment of development laboratories, education centers, scientific centers and manufacturing facilities. Many suppliers of data processing and telecommunications equipment have laboratories and plants located through the Pacific Basin counties. An example of practical uee of new telecommunications technology geared to the needs of countries is Earth Resource Management through remote sensing by NASA's LANDSAT Satellite. IBM Scientific Centers in Mexico, Brazil and the Philippines, for example, work with the national government in research and development of computer programs in conjunction with satellite remote sensing for management of resources important to those countries.

The U.S. government through AID has a reimbursable technical assistance program for assisting countries which can afford to purchase communications systems, but which require technical assistance. AID finances and makes available U.S. technical teams to define development requirements or specifications and to advise on the kinds and sources of applicable U.S. technology.

The United States government objectives in providing communications assistance are: (8)

- to assist developing nations expand their capacity to utilize communications technology to meet the basic requirements of the public

- to help developing nations strengthen indigenous communication and information systems

- to strengthen the ties between communications leaders and institutions in the U.S. and their counterparts abroad

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The U.S. through government, industry and users participates in major telecommunication standards programs on an international basis and believes that the Pacific Basin should become an increasing major force in this area in order to have their interests addressed. Through industry, universities and foundations the U.S. has contributed to telecommunications standards in the area of public voice networks, data networks, videotex, teletex and modem interfaces. As an example, the U.S. is a major contributor to the open systems interconnect program of the International Standards Organization and the data network standards activity of the CCITT.

In order to have a voice for the Pacific, the U.S. through ANSI together with its Pacific Basin partners were instrumental in establishing the Pacific Area Standards Congress which meets annually and has as its members the official standards bodies of seventeen countries in the Pacific Basin. In addition, the U.S. supports the Pacific Telecommunications Conference and the plans for the formation of a permanent Pacific Telecommunications Council as a voluntary independent organization which has as its major objective the interchange of information and views concerning telecommunications in the Pacific area and to bring forth those views to the established national, regional and international bodies.

CONCLUSION

This paper has given the reader a brief summary of a complex telecommunications environment quite different than those of the other Pacific Basin countries. Hopefully it has helped towards establishing a basis for the mututal understanding of the differences and likeness of telecommunications policies within the Pacific with the objective of contributing to a continous dialogue.

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THE RELATIONSHIP BETWEEN BROADCASTING REGULATION AND STRUCTURE: THE AUSTRALIAN CASE

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Abstract

The evolution of the structure of the Australian broadcasting structure, and the history of programme regulation is briefly described. By a series of ad hoc developments there has recently been a policy shift in favour of creating diverse structure, and a lessening of general regulation. This has been accompanied by tighter regulation in specific areas, because of greater public backing. The consequences in terms of need for policy to create structure and ensure public accountability are discussed.

Broadcasting planning in Australia has historically proceeded by ad hoc decisions, and lack of comprehensive planning policy. What are now firmly entrenched elements of the system, such as the national broadcasting system, arose in response to various pressures, but not in response to any broad, articulated policy. Planning in the sense of engineering planning has been well developed in a technical sense, but has had to respond to ad hoc decisions made in the social or politcal area.

Broadcasting regulation has likewise proceeded in response to prevailing pressures. It has gone through several phases. There has historically been almost no consideration of the relationship between structure of the system and regulation. With the increase in activity in broadcasting development in Australia since about 1970, however, a wider appreciation of policy has begun to emerge. Academic interest, and treatment by the quality press, has sharply increased. While this has not lead to a change in decision making methods, and probably never will, it has led to a more comprehensive debate on broadcasting policy. Regulation and relationship between structure and regulation are areas which are undergoing change as a result. This paper traces the development of policy in those areas to the present, discusses likely developments. Finally, it discusses the relationship between structure and regulation and political environment.

Development of Structure

Until the early seventies, Australia had what was referred to as a dual system of broadcasting, commercial stations - both radio and television - relying on advertising revenue and national stations run by the Australian Broadcasting Commission. This body is a statutory corporation funded from the Federal Budget.

Radio broadcasting began in 1923. An attempt was made to develop a subscription system, but it failed. Eventually, those early stations were divided into what became the commercial system, and another group which, after a number of organisational changes, was incorporated into the ABC, when that body was created in 1932.

The funding of the ABC was due to a desire to serve less populated areas which the commercial sector found unprofitable, and because of some feeling against the already strong advertising influence on commercial broadcasting. There was also a desire to provide a place for quality, and cultural commitment in broadcasting, based on the strong example of the BBC, which had been founded some six years earlier.

The circumstances and timing of the origin of the ABC are important. Unlike the BBC, it was never in a monopoly position, and never had the opportunity to impose an ethos on broadcasting which that organisation had. Secondly, it accepted from the beginning a duty to do the service and minority broadcasting which the commercial sector in Australia was both unwilling and uncompelled to do.

Simultaneously with the establishment of the ABC, the commercial radio sector grew rapidly. By the early thirties it was well entrenched, and most of the stations which exist today in the capital cities had been set up. By the end of the decade, further expansion in country areas had brought the numbers very close to the present day level. ABC station growth was more steady.

Thus, the dual system of ABC and commercial sectors was established to be carried over later into television (1956). It remained basically unchanged until the emergence of the third sector, public broadcasting, in the seventies.

During those early years (until 1948) programme standards existed as regulations made under the Wireless Telegraphy Act, and under the direct control of the Minister of the day, as distinct from statutory officials with defined responsibilities and independence. There was also a code of rules drawn up and enforced by the Federation of Australian Commercial Broadcasters.

Neither official regulations nor codes of rules covered the ABC which jealously guarded its own standards. The act under which it was set up required it to do adequate and comprehensive programming. The ABC's role, while thus officially comprehensive, was not that in practice. The commercials' role developed into overtly majority broadcasting. The market place dictated this, not any design or regulation. It did do a certain amount of local or community broadcasting, especially in rural areas.

There was no attempt to coordinate the outputs of the two systems, and not much real attempt to ensure that either system actually catered for a wide range of tastes. Regulation was benign, and more directed towards censorship of material considered offensive by community standards, as interpreted, than to anything positive.

The overall result was a substantially laissez-faire system dictated by perceived market requirements. There was little real attempt by Government to influence events, either operationally or structurally. Policy relating to programme content was almost entirely reactive. When more deliberate attempts were made in the sixties and seventies to obtain higher standards through regulation, this tradition proved very hard to combat.

By the late 1940's, there was a good deal of dissatisfaction with departmental responsibility in broadcasting. The Labor Government of the period also wished to see tigher regulation of commercial broadcasting. In 1948 it therefore set up the Australian Broadcasting Control Board, with regulatory, planning and some semi-judicial powers. In 1949 the Labor Government was succeeded by a conservative government, which retained the Act unchanged.

The Regulation Phase

With the creation of the Board, increased attention was given to programme regulation. In 1956, with the ~~coming of te~~levision, programme standards were required to be formulated under the amendments to the Act of that year. The Minister, in explaining the 1956 Bill, dealt at length with the social power of television, and stated that self-regulation would not be sufficient to secure programmes which would be of a suitable standard to satisfy the public. In supporting written standards, he said that "the Government believes that the basic objective of achieving proper standards of quality in television programmes can be realised in this way". The Minister was attempting to allay the considerable public concern about the possible effects of television.

But the strongly established ethos of commercial broadcasting was too strong for the Board to have much effect. It suffered from having virtually no sanctions which it could impose, and legal questioning of the validity of its power to make and enforce standards.

During the late sixties and early seventies the Board made several attempts to force commercial television channels to raise Australian content levels, and improve childrens' programming. These attempts were largely frustrated by the industry.

Thus, while officially Australia had the policy and apparatus for close regulation, the actual outcome was substantially laissez-faire. The broadcasting industry was politically strong enough to protect itself from what is saw as undesirable interference in its commercial affairs.

The Beginnings of Structural Change

Both the ABC and the commercial system were enjoined by legislation to be "adequate and comprehensive" in programming.

But neither were, and the result was the growth of dissatisfaction by significant minority groups. In the early seventies, various interest groups began to form to press for various forms of radio broadcasting, such as educational, classical music, and later, foreign language or ethnic broadcasting.

This pressure coincided with and was related to the opening of FM radio in Australia and a change in technical policy in allocating the AM or medium frequency band. At the same time, from 1972-1975 a Labor government was in power which wished to reform the media. In retrospect, it had no clear idea of how this would be done, but it did provide a climate in which pressure for reform could succeed.

The result was the ad hoc development of a non-commercial, non-ABC group of stations, known as public broadcasting, and some innovative extensions to the ABC, especially in access broadcasting. Ethnic radio was also begun.

Towards a new Structural Policy

Essentially, the new developments were an attempt to gain by structural change what regulation had failed to do. However, it was not until late 1975 that this was articulated, in a report to the Government by a working party set up to recommend future policy for public broadcasting. This report, after questioning whether the formal close regulation policy to obtain adequacy and comprehensiveness had been a success said "...... it is recommended that this close regulation policy be overthrown in favour of a policy of deliberately licencing a varied range of types of broadcasters to follow their own natural interests. By so doing, adequacy and comprehensiveness will be provided from the whole service". It went on to say, "As a consequence of the increase in diversity of types of station, it follows that detailed regulation by government could be greatly relaxed." The report advocated more direct public control over broadcasting, through public licence renewal hearings. It also recommended criteria by which future public broadcasters would be selected to give greater diversity.

Further Development

With the return of the conservative government in late 1975, there was some doubt that the new innovations would continue. However, broadcasting continued to be a live issue, and after some uncertainty, the new developments were largely confirmed.

In addition, the commercial industry took the opportunity of the return of the new government to press for complete self-regulation. The outcome after an inquiry by the Broadcasting Tribunal, the new licencing and regulatory body set up to replace the old Board, was a recommendation for much more self-regulation except in certain defined areas. These were childrens' programming on television, advertising content, and Australian content.

The development of the public broadcasting sector has continued.

The Present Position

So far, no firm Government action has been taken on the self-regulation report, probably because of fear of the outcry from some vocal pressure groups set up to maintain what are described as community standards. But in practice self-regulation exists. However, action has been taken over childrens' programming, with an advisory committee being set up to advise the Tribunal, which has so far shown some strength in dealing with the stations.

The Government has also announced that ethnic television will be set up, and has established a review panel to advise on structure.

Conclusion

All of these developments were in the customary tradition of ad hoc development. Essentially, however, there has been a significant policy shift, summarised as follows:

- the formal close regulation policy, followed from 1948 to about 1975, has been tacitly recognised as having failed, although some, especially on the extreme left of politics, still advocate that it could be made to work if applied more stringently.
- it has been replaced by a policy of restricting regulation to those areas in which there is firmer political and public backing for the regulations, and by a policy of deliberately diversifying broadcasting communications.
- it remains to be seen whether the new, restricted but tougher regulation policy, is a success. So far it appears to be, because of the backing it has been given. The outcome will depend upon the strategy its opposition, mainly the television industry, can employ to mobilise political and public opinion against it.
- the diverse structure so far only exists in radio, and its audience is small, and its funding base insecure. But the legislative framework and general agreement exists to expand the sector. However, the 'mass' audience is still the preserve of the commercial broadcasters.

In a sense the policy being adopted is a result of defeat of the earlier attempts to provide a diverse service, catering for all tastes, through a restricted structure with only two types of station, commercial and national. In another sense it is a more liberal policy, recognising that the freest policy is one which gives the maximum freedom to the broadcaster to proceed according to his own volition. That volition is governed by the objective of the broadcaster and the source of funding. In the commercial sector the objective is to make a profit, and it is therefore inevitable that those broadcasters will turn to the mass sectors of the market.

However, there is no doubt that there is an interchangeability, in the policy sense, between structure and regulation, if the objective of policy makers is to cater for all preferences. And it may well be that in societies where the mass media is powerful, and there is a mixed economy, laissez-faire tradition, as in Australia, the deliberately diverse structure option is more practicable.

What concentration on structure does is shift the responsibility for government agencies from day-to-day regulation, to responsibility to arrange for a deliberately diverse system. This goes to the problem of choosing licensees, and assessing adequacy of performance for renewal. It is to these problems of public accountability and selection, to which attention is now turning, as the inevitable consequence of the recent policy shift.

Information Inequality*

An Emerging Policy Issue for the United States

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INTRODUCTION

One hears, with increasing frequency, concern about the growing gap between the information "haves" and the information "have nots". While this is expressed most often with reference to the developing nations of the world, much the same can be said about this in the United States. There are significant shifts in the demand for skills taking place in the United States, shifts that appear to move inexorably towards the need for higher level skills in what has been called information based or knowledge based occupations. At the same time, there are growing minorities in the States whose languages and skills are not Anglo-Saxon nor even western derived. A knowledge or information gap made apparent by changing socio-economic-cultural patterns certainly appears plausible. Add to this the energy-economic forces that may, conceivably make more difficult the maintenance of small business abetted by the growing computerization of information, i.e. the substitution of large data bases for magazines--and one should certainly take the probability of information inequality in the United States seriously.

It is important that the trends moving our society to one of information inequality be made more explicit. If this can be done it is conceivable that means could be found through judicious actions of the policy makers to stem what many consider to be a serious problem for a democratic society. This paper seeks to identify the forces operating and through the use of several scenarios of possible futures make explicit the emerging issue of information inequality.

NETWORK INFORMATION SERVICES AND THE NETWORK MARKETPLACE

An important new industry is rapidly emerging from the marriage of computers and telecommunications. This industry permits users to interact directly with one or more computers, associated data files and problem solving algorithms from remote terminals. It may include access to distributed information systems within and between organizations, remote transaction recording, data base inquiry and computer conferencing. Collectively these services, products, and information supplied by this industry have been called Network Information Services.

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Some of these services now being offered and growing at rates between 40% and 100% per year include remote shopping and bill paying, news on demand, electronic message delivery (electronic mail), remote medical consultation and diagnosis, electronic funds transfer, office automation, remote instruction and interactive training and education.

Network information services connect the needs and resources of users to the capabilities and services of producers and facilitate transactions between them. All the usual services of a marketplace can be offered within a large information network. Products and services can be advertised and sellers can be located; ordering, billing, and deliveries can be facilitated; and all manner of transactions can be consumated including wholesale, retail, brokering, and mass distribution. Indeed, the entire range of such products and services for business, industry, the consumer, and government can be perceived as a marketplace--a marketplace on a communications network or the network marketplace.

EMERGING TRENDS

Trends in Technology

Technology factors point to a certain inevitability leading to the emergence of the network marketplace. The continuing and even accelerating developments in large-scale and very large-scale integration point to the development of increasingly intelligent terminals with considerable memory capacity. The cost of designing information processing functions into terminal equipment or appliances continue to fall as engineers substitute information processing for transmission under the assumption that it is essentially free. The trend towards digital communications will accelerate, and terminals and terminal stations capable of dealing with intermixed signals--voice, video, image and data are being developed.

Trends in the Communications Infrastructure

There is likely to be a continued proliferation of specialized carrier services for network application over the next decade or more. The distinction between Value Added Carriers and Common Carriers is likely to disappear as the major carriers either purchase the existing value added carriers for their arms-length subsidiaries or offer the same services via subsidiaries of their own as resale carriers. AT&T's role in providing packet-switched value added networks hinges on the outcome of the debate concerning industry structure and on differentiating communications and computing. It is likely that in ten years or even less the issue will be moot, replaced by concern with regulating communication carriers providing network information services in a market that does not have natural monopoly characteristics as does transmission itself.

While the cost of long-line services for the delivery of intra-corporate electronic messages, office automation and EFT will continue to decline for the major users and thereby become more accessible to them, the cost of local distribution is not likely to alter very much, thereby denying access to smaller users. CATV may increase its saturation to about 50% by the late 1980's, assuming no major shifts in public policy, but is likely to continue to limit most of its services to broadcast retransmissions and subscription sports and entertainment. The proliferation of satellite earth stations, the use of some special broadcast modes and CATV and the availability of shared-use facilities are likely to permit some general access to network services. However, the nature of the infrastructure for some time to come seems to point to access limited to major users of teleconferencing, electronic message services, funds transfer and other forms of what is now known as Office Automation.

Trends in Terminals and Computers

Innovations in terminals, intelligent appliances and telephones are likely to continue unabated. Terminals will be responsive to service needs and will drive the direction of the emerging marketplace. There is likely to continue to be extensive competition and, because of the nature of the technology and fragmented market demands, many small suppliers linking themselves to special markets and clients. A "liberated" Western Electric joining the highly competitive industry can only enhance the prospects for lower-cost and wider access to the marketplace. Projections of revenue trends point to the terminal, computer, and software accounting for the major percentage of the total revenue developed by the delivery of network information services. Should AT&T respond to the investors to enter the more profitable network information services market, there will be pressure to lift the 1956 consent decree.

Trends in Networks

Data network traffic will probably continue to grow at a very rapid rate over the next two decades, perhaps as much as 40% per year as has been estimated by several sources. But even by the end of the century voice traffic will still constitute the bulk of the network traffic. While data traffic may make up approximately 1% of the total network traffic, it could account for at least 18% of the revenue. Large investments will be required to enter these businesses, but the very high returns, competing favorably with those available in other sectors of the economy, could attract the necessary capital. Indeed, the revenues from the lease purchase or rental of terminal/computer equipment can be as much as four times that obtained from the delivery or transmission portion of the marketplace.

Recently the Federal Communications Commission issued proposed rules to govern regulated communications carrier activities in the area of network information services. Their Tentative Decision seeks to dictate the type of data processing activities permissible by carriers and the structure of the "resale" carrier market. (Resale carriers lease communications circuits from underlying carriers to be resold as components of an enhanced data or network service and are often referred to as value added carriers). The Commission's Tentative Decision draws upon the findings of the Computer Inquiry II.

Briefly summarizing the Tentative Decision:
The communications carrier industry will be divided into three basic categories:

- Voice service
- Basic non-voice (data transmission)
- Enhanced non-voice (data processing plus transmission)

The provision of enhanced non-voice network services i.e. data processing and communications may be supplied by the same carrier but cannot be provided by an entity that supplies voice or basic non-voice service to the public. Thus, should AT&T or GT&E wish to offer network services they must do so through a separate company as a resale carrier. Data processing services provided by resale carriers will not be regulated although the communications portion for resale acquired from the underlying carrier would have to be tariffed. Finally, and of special interest to this discussion, is the ruling concerning terminal equipment. Terminal equipment is divided into two categories: basic media conversion devices/transducers and enhanced equipment (smart terminals). Basic equipment may be provided by underlying carriers but the enhanced equipment may not. Resale carriers may provide enhanced terminal equipment on an untariffed basis.

These proposals point to a world where it will be quite profitable for industries seeking to enter the network marketplace to do so as resale carriers. Because of the continued higher cost of local distribution communications, the cost of these value added services will be relatively high. Except for the increased but tariffed communication revenue that might accrue to the underlying carriers, there is little incentive for them to offer such services on the public network. Instead, they will offer network services to major users via "separated" resale carrier networks. Indeed, the Tentative Decision encourages this bypassing of the public network!

Trends in Policy

There is not now nor in the wings a network policy for the United States. The proposed Communications Act of 1979 dealt with communications as was the Act of 1934. The proposed Act was, indeed, a rewrite of the past rather than an attempt to look into the future and structure a network policy for the nation.

Network services via the marketplace require the interaction of three technologies crossing both regulated and non-regulated industries. The

Common Carriers are regulated, but the terminal/computer industries and the information providers are not. Carrier services have natural monopoly characteristics, but it appears that network services may not share them.

Policy trends now in motion will favor the development of business, government and specialized large network service users. Competition under regulation is likely to continue to encourage the emergence of additional carriers for network services. While the distinction between value-added carriers and the common carriers are disappearing, it is likely that the Federal Communications Commission will permit these services to be offered via a separate resale approach. In any case, there will be many more private or single-purpose (or limited-purpose) networks in existence by the end of the century.

Trends in Social Values and Economics

Over the next two decades, we can expect social and cultural values to emerge that will create mixed attitudes toward the network marketplace. In its favor is the fact that the marketplace is non-polluting, energy efficient and is supportive of trends towards the adoption of "appropriate technology" that provide the potential for access across a wide range of economic and social levels. The marketplace requires new skills, in keeping with a trend toward continuing education and career flexibility and mobility. The provision of network services may be labor-intensive but requires intellectual upgrading. The network can expand group interaction and create social networks not bound by geography but by areas of interest. An accessible network marketplace could create a climate in which diversity and pluralism can flourish.

However, there are values that may hinder the evolution of the marketplace. Computers, terminals, recorded voices and computer-simulated speech can be depersonalizing and certainly create fear and resentment among many. The adoption of many services such as remote purchasing and banking may be delayed because of a perception of the depersonalizing effect of the technology among significant portions of the populace. Perhaps more important will be a continuing concern for the maintenance of personal and organizational privacy. Any significant breakdown in privacy safeguards result in an increased fear of the technology and of one's inability to control one's own environment. And there is the fear that increasing activities on the network will lead to decreasing personal interaction and increased isolation from society. Finally, while new skills will be required, the population will be an older one, possibly not willing nor able to shift careers and lifestyles easily.

As in the case of values, the nation's demographics will also create a somewhat confused environment for the network marketplace. On balance, however, it appears to be a favorable one. Single-person households, smaller families and a greater economic independence for women would appear to create a need for a more efficient use of time, hence the use of the network for such time-consuming or unpleasant duties as banking, shopping and general information seeking. Female participation in the labor force will require the sharing of household duties and may result in their being done at odd hours via the network marketplace. Despite the continuing high rate of inflation, higher personal incomes may provide more disposable income. These factors, coupled with higher education levels, might suggest a shift toward more appropriate and efficient methods of carrying out routine tasks. They could also lead to the seeking of intellectual and recreational activities via the network, even at a greater cost than alternative modes of stimulation. Despite some evidence of a "return to the city" movement, the long-term trends continue to point to increased suburban populations at a time when energy costs are increasing. Remote transactions via the network will appear increasingly attractive as energy costs increase.

However, one cannot and should not overlook the growing numbers of elderly without increased disposable income. And, too, there is the relative growth of the Spanish-speaking populations that may not be in the network marketplace, unless there are specific policy directives that will make access universal.

The United States has entered the Post-Industrial Society; service industry expansion is giving way to information industry growth. There are continually increasing demands for information as bureaucracies, both private and governmental, shore up their economic positions. Increasing labor costs stimulate the search for greater productivity, and computers appear to offer this promise. Network operations, in turn, can increase the productivity of the computer services provided. The loss of mass markets to foreign competition has stimulated the search for more highly specialized products, and these are increasingly information products. The production and distribution of knowledge worldwide requires new forms of organizations with increased complexity, resulting from the increased fractionization and specialization of the market. Firms cannot now easily define their markets; the United States and traditional world market demands are shifting in line with shifts in values and demography. To seek out these markets will require access to more and better information.

Inflation is likely to be at the rate of between 8-10% per year over the next two decades. There will be a severe tightening of the money supply, thereby reducing the capital necessary to launch new industries, especially if there are more attractive opportunities in other investments, such as energy. However, there are segments of the network marketplace industry which offer significantly attractive returns (i.e. the provision of digital information products and services via specialized value-added networks).

THREE SCENARIOS FOR THE 90's

How these trends interact can best be observed through several scenarios. We have developed three: A technology driven future, a market driven future and, a policy driven future which essentially emerges out of the previous two. We begin with the scenario for a technology driven future.

The Technology Driven Future

By the last decade of the 20th Century, the nation will be served by a diversified, fragmented multi-network marketplace. The number of special-purpose networks providing digital, voice, image and facsimile services in mixed as well as single modes will double and approach the neighborhood of 5000. These networks will be largely service and industry-specific and include terminals with sufficient intelligence to interface with computers, networks and other terminals in similar industries and related applications. The networks themselves will actually be capable of serving several related industries or applications but, in general, the network marketplace will be fragmented and serve only the needs of the major multi-plant businesses and industries.

Most of the Fortune 500 industries and about one-third of the medium size industries in the nation will account for almost 80% of network usage.[1] A significant portion of this service will be delivered via shared networks through a resale provision authorized by the Federal Communications Commission in order to better utilize the satellite networks that will be in place before the last decade of the century. Following in the footsteps of SBS and X-TEN, other broadcast satellite carriers such as Western Union and RCA as well as AT&T will offer digital services utilizing the smaller ground terminals that will enable more industries to access a satellite. While the "final mile" cost will be reduced somewhat, service charges and interconnect costs are both likely to remain relatively high[2], making it difficult for small or occasional users of network services to enter the marketplace except for special forays through a shared-use private network. The major users will continue to be the larger multi-plant corporations which will have become accustomed to intra-corporate electronic message and other transaction delivery systems with the attendant features of the automated office.

Most of the smaller businesses and almost all consumers will still find the network marketplace too expensive. For example, those interested in message transmission may be willing to accept charges of between 13¢ and 18¢ per message, but the high initial cost of equipment and service/interconnect charges will require a very significant level of message use in order to be cost effective. Similarly, those concerned with office automation may be willing to accept a transaction or message charge of between 50¢ and $1.00, but only if they can perceive some significant reduction in labor, and it is unlikely that the small business or the consumer will be able to achieve such economies. Consumers, especially, are likely to be unwilling to make the initial investments in terminals and monthly service charges unless they can access a variety of services with little or no additional expense.

Despite the growing transparency of the networks and the increasing intelligence of terminals (abetted by the availability of microprocessor firmware), consumers will still find a limited range of services available to them--possibly too limited to warrant their investment in "front end" charges. Without a considerable acceleration in the rate at which AT&T plans to convert its national switched network to an all-digital system[3], and without the

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regulatory authority for a more rapid introduction of its Advanced Communications System and other regulatory pressures, the establishment of standardized address codes is unlikely to occur. This deficiency is likely to limit easy access by consumers and small businesses to multiple network services. Present technology trends do not indicate a substantial reduction in the cost of local distribution charges, monthly service or interconnect charges nor do they offer much hope for the availability of highly intelligent-low-priced terminals adaptable to varieties of consumer services and networks. The likely conditions under which universal network services at affordable rates could become a reality will only emerge from the multiple impacts of technology, the market and public policies acting in concert.

By the mid-nineties a situation reminiscent of the early years of the telephone will emerge. There will be many incompatible networks served by special-purpose terminals and switching systems designed to deliver services to those that can afford the entry cost. There will, however, be a significant difference that could lead to important political actions. In the early years of the telephone the issue was simply communications, with the value of the network dependent upon the number of people attached to it. In the nineties the issue will be one of inequality of access to information, with the specialized networks doing quite well financially because of the valauble and efficient services they will be providing. For some time, thoughtful observers have expressed the fear that the emerging Information Society will produce a new class of information elite[4], and, indeed, there does exist two classes of people and businesses: the information users and the information used.

Evidence of this societal and economic split will become apparent through the growing incidence of failures of small businesses that no longer can purchase the information they need to remain competitive as the information becomes increasingly available only in electronic form. Even now, mergers of common and value-added carriers are occurring, and a major computer/terminal network service provider has merged with a specialized carrier.* Instead of decentralization and the availability of increased business opportunities, the trend continues toward concentration of the components of the network marketplace. This greater concentration of intellectual power in the emerging Information Society can only lead to concentrations of industrial and financial power which are not in concert with the American economic dream.

The personal computer, while not capturing a very substantial portion of the market (not every home will house an identifiable personal computer, though in every home there are likely to be many functions performed by microprocessors), will serve to demonstrate to the consumer the power of information access. Consumer movements concerned with broadcasting and common carrier services indicate growing public interest in the widening split between the information inequality is likely to become one of some significant public concern, hence of political action.

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* Telenet is now an arms length subsidiary of GT&E and General Electric has purchased Cox Cable Communications.

The Market Driven Future

The profit potential to be derived from doing business in the network marketplace will become increasingly evident as the cost of labor increases and the same is true in the purchase of goods and services. A single purchase triggers a string of additional transactions such as those involving inventory control, delivery schedules, repair team dispatching, routing, credit checking, etc. If the travel agent or sales clerk can be replaced by an intelligent terminal in the home or office and with appropriate interactive software and if the purchase transaction can, at the same time, trigger the stream of events necessitated by that transaction, the benefits to the sellers would become substantial. By the mid-nineties these benefits will have become attractive to the sellers. The buyers, too, will want to conserve time and travel and seek access to the network marketplace.

However, for a marketplace to be valuable, many buyers and sellers must be able to access the marketplace. The more buyers and sellers in the marketplace the greater its value to all. It is, therefore, important for the sellers to provide access to a large number of potential users.

By the mid-nineties it will have become quite evident that the cost of a network transaction is less than the cost of that same transaction--considered in all of its dimensions--performed by any other means. Projections of future costs increase this difference in favor of the network transaction. Furthermore, new buyers as well as new sellers are becoming more interested in entering the network marketplace. However, there are high entry costs especially for the consumer. Not only must the consumer have available a terminal capable of reaching into several networks, there is also the problem of the relatively high cost of communications. In an interactive transaction, message unit costs as well as terminal connect time charges can be high[5].

In the last decade of this century, the Market can drive the development of the network marketplace along several paths:

1. It is expected that broadband cable television systems will have reached about 50% of all the TV households in the United States. This represents a potential network marketplace membership of somewhat over 50 million households. The advantages of product and service selling via the three-dimensional images of television will eventually be seen to outweigh even the lower costs of catalogues and possibly even throw-away newspapers. This will be especially true if the viewer can make a purchasing decision and take action without leaving the home or even the chair. Major merchandisers will seek to purchase time on cable systems in the more heavily saturated markets, especially those with attractive buying power[6], for the presentation of video catalogs buy on the condition that the cable system provide some means for feedback. While telephone feedback directly to the seller is likely to be used, this will not be as cost-effective to the seller as feedback via the

cable to a mini-computer either at the cable head-end or the seller's warehouse. Feedback via the broadband cable, utilizing digital techniques and either time or frequency-division multiplexing will be a great deal less expensive than the telephone.

2. If, however, the sellers cannot or will not deal with the cable industry (and even if they do, at least half the households will still not be served[7]), it will be necessary for the sellers to utilize the telephone. By demonstrating the increased potential for the utilization of the telephone for buying and selling, sellers could create a significant demand on the telephone companies for increased local digital services at lower costs. Furthermore, if at the same time they are encouraging the cable television companies to, in effect, enter the local distribution services business, AT&T will be encouraged to accelerate the conversion of its local loop to a digital system and provide more intelligent telephones via its Common Channel Interoffice Signalling system (CCIS). Assuming policy authorization, it is possible that AT&T's CCIS will be accelerated. Provisions for accelerated depreciation are likely to be encouraged so that AT&T can more quickly extend digital local loop services to those required by the network marketplace.

3. We can expect several major merchandisers, banks, and other financial institutions, and possibly the airline industry to offer their own network services. They might do this by paying the consumer's communications costs outright through the use of nationwide WATS services such as those currently being provided through the use of an 800 number. The costs of these services are likely to fall as smaller satellite ground stations become more ubiquitous and there is further bypassing of the local loops, or at least significant reductions in the "final mile" cost. A seller could, in effect, create a network by providing multiple services to those wishing to utilize the communications for which the seller pays. Conceivably, the seller could also provide some sort of service, including an appliance (terminal), which would require the continued marketing of useful information or instructions for the operation of the appliance. Banking, home protection and safety services might fit that category, as will education, computer games and hobbies. Electronic message services to the home will emerge as a significantly attractive market to encourage challenges to the Postal Service, which, in any case, will make some progress towards electronic mail within its own organization despite painful labor difficulties. Entertainment services via a network, perhaps incorporating the video-disc or more likely cable, are network services that could be provided through the growing distribution of digital networks that may be less than public but somewhat more than a private seller's network. Finally, the several Teletext demonstrations throughout the world will certainly have an impact on the information services market, and it is very likely that a variety of information services, tied possibly to some purchasing services, will emerge during the nineties via a seller's network.

The key issue will be: Who bears the cost of the terminal if the seller assumes the cost of the communications? If the variety of services are sufficiently large and varied, one might expect the consumer to invest in a terminal station. Whether or not this happens will ultimately depend on the offerings in the network marketplace.

4. The ever-widening availability of small earth stations with their ability to reduce "final mile" charges leads naturally to the consideration of the future of Direct Broadcasting Satellites. Already in operation in Japan, there will be increasing pressure for their introduction into the United States[8]. Were this to occur, broadband access to every home would be a reality. This, of course, is competitive to both the expansion of cable television and to the conversion of AT&T's national switched network to digital services via the use of optical fibers.

The Direct Broadcast Satellite is also a threat to the institution of broadcasting as it is now perceived, and as it will very likely be perceived for the remainder of this century. There is and will continue to be an overriding principle of localism in this nation's broadcast policies. One can, indeed, argue whether, in actual practice, this localism is meaningful[9]. Nevertheless, for a variety of reasons, not the least of which is the personal financial interest of many lawmakers in broadcast properties, it is highly unlikely that the Direct Broadcast Satellite will emerge as the universal broadband network.

5. Facilitating access to the network marketplace is the business of information facilitators (or middlemen)--organizations that sell computer services rather than computers, terminals or communications. Today these firms offer raw computer power, packaged or specialty software and on-line services which include access to data bases that they may or may not own. These "middlemen" can conceivably play a very significant role in shaping the emergence of the marketplace.

We may expect these firms to offer information-providers the opportunity to market their wares in the marketplace by providing them with terminals, computers, appropriate software and procedures for accessing a network which the facilitator may assemble from existing carriers--in short, by providing value-added network facilities to the information providers. At the same time, the facilitator might seek to assemble a network of users and purchasers for these services. This might be done by providing appropriate software to terminals that are in place, or even leasing terminals to enable users to access the marketplace. Initially, they might also provide the communications through a national WATS line on behalf of their providers or become resale carriers offering communications services at lower cost to users in order to provide access to the more highly-valued information.

The extent to which the facilitators can reduce information equality will, in the final analysis, depend on the degree to which the facilitators can provide low-cost access, and/or the extent to which they can recover these costs in the price of the information or services market.

The Policy Driven Future

One of the major deterrents to information equality is the lack of network equality. In contrast to the situation in Europe, Canada and Japan where public data networks are being developed, we have seen that our future is one of the increasing privatization of networks and the services they can provide. The previous scenarios illustrate the factors that make this so. First and foremost, one must point to the continuing high cost of local communications. While the costs of long-line services have been reduced considerably over the years and promise to decline further with the increased utilization of distance-insensitive satellites, the cost of local distribution services have not gone down. In addition, there is a continuing need for special terminals with appropriate software to access the special service networks.

From the preceeding discussions, three powerful forces emerge that will exert considerable pressure on the policy makers, and the Congress:

1. In the last decade of this century, the issue of information inequality will be raised not only by activist consumer groups but by members of business and industry who will see this inequality affecting their profits. In addition, scholars and philosophers as well as public men of principle will see this continuing inequality of access to information as a direct threat to the democratic process.

2. The profit potential of the emerging network marketplace will exert a powerful impetus to network expansion as business exerts pressure on the policy makers to make all 100 million households accessible to them for the sale of information products and services.

3. European, Canadian, and Japanese progress towards public data networks will open them to the full force of United States information products and services. It is likely that United States firms will find it more attractive to market their information services and products to these more easily-accessible systems, adopting existing standards and essentially by-passing all but the more affluent United States firms while serving a more diverse set of clients overseas. This could have, and indeed will have, a pronounced effect on United States and foreign productivity ratios--possibly to this nation's disbenefit. Furthermore, foreign branches of United States multinationals will seek to influence domestic policy in order to make it easier to do business in international information.

These factors taken together create a Policy Driven Future. Several alternatives for this future have already been discussed. There are four possibilities for the future of the local distribution loop that may result in increased performance at lower cost--the necessary conditions for the emergence of the network marketplace.

1. We discount the Direct Broadcast Satellite as a serious competitor in the provision of network services. Broadcasters will argue, and to some

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extent with justification, that if current trends in that industry continue the DBS will do great damage to the concept of localism in broadcasting. While it is theoretically feasible to extend the current trend toward smaller and smaller ground terminals for point-to-point network services to rooftop antennas for small businesses and even the home, the broadcasters will argue that it will be impossible to restrict their use solely for network services and that in a short time they will be used for broadcasting that by-passes the local broadcast station.

2. By the last decade of the century, and assuming no policy of government subsidy, cable television will reach a national saturation of about 50%. Indeed, we expect that by the mid '80's saturation will have reached somewhat over 30% and will result in considerable interest on the part of advertisers. They will see in cable the opportunity to reach specific markets, similar to that provided by direct-mail marketing. This may increase the rate of cable saturation, but unless there is a very significant introduction of major new services, possibly those described in the Market Driven Forecast above, there is little likelihood that the 50% penetration estimate will be exceeded. This by itself will not produce a competitor for the local loop distribution system. Cable will have to provide two-way interactive capability that is highly reliable. This will require design standards of somewhat higher quality that those required for retransmission of broadcast television or Pay-TV. Some firms, such as Warner Communications, are now offering two-way services[10]. By the mid-nineties we would expect several additional cable television firms, perhaps having merged with computer or terminal firms, to offer network service capability at the local loop. But without some form of government support, it is unlikely that cable will emerge as a meaningful competitor that might create an environment that could lead to reduced costs.

3. In the mid-nineties there will be increasing pressure for universal network service access. Congress will be asked to declare a Universal Network Acess principal at "affordable rates" much as they did when promulgating the Communications Act of 1934 with respect to telephone service. Pressures will emerge not only from consumers but also from business and industry seeking access to a ubiquitous network marketplace open to all. One way of moving towards this goal is to permit AT&T to pursue its ACS objectives. We foresee this possibility occurring in conjunction with the separation of Western Electric from AT&T. This is likely to occur by the mid-nineties and will be preceeded, certainly before 1985, by the approval for AT&T to pursue its ACS objectives but via a separate arms length subsidiary, thereby setting a pattern for continuing competition under regulation in the network services business. By the mid-nineties AT&T, SBS, Xerox, several major CATV companies, GT&E and possibly one or more specialized carriers will emerge as the major network providers as resale carriers. While it is quite unlikely that the Communications Act of 1979 will be enacted into law even by the mid-nineties, several elements of the proposed Act are likely to be in place. Most significantly, the Universal Service Compensation Fund, which, as it is currently written, applies only to telephone service, will be expanded to

include network services. By the mid-nineties, all of the carriers, including the cable television companies which will be classed as common carriers, will be recipients of the Fund in order to provide universal network services at affordable rates. Competition under regulation, which is the current practice in the long-line and value added markets, will thereby be extended into the local loop.

There is little likelihood that this nation will be served by a single unified network. The pressures noted in the Technology and Market Driven forecasts will encourage universal network access but will also seek some assurance from its provision by a monopoly carrier. For many years to come, the network services industry will require constant innovation, and there is considerable doubt that such innovation can be provided by a monopoly carrier. One can and should raise the question of whether there will be sufficient capital for research and development in the network services industry if there is no single large carrier from which the high cost of research can be derived[11]. However, the major network infrastructure is essentially in place; indeed a major portion of that structure, the satellite, was developed almost entirely by federal defense and NASA monies. The research necessary to support the emerging network marketplace is likely to be less capital-intensive, concentrating primarily in terminals, computers, microprocessors, applications and languages.

4. A fourth option, however unlikely, should nevertheless be considered. It is conceivable that there will be no candidates to compete for the local distribution market. It is conceivable that the returns in other areas of the network services market--in terminals, in services, in specialized networks, etc.--are much more attractive than the returns from serving the local loop. Indeed, it is likely that should AT&T enter the network markets in a competitive manner through a separations policy, it too will seek relief from having to provide less profitable local distribution services. After all, data services offer very significant returns, and from a return on investment viewpoint, firms may wish to concentrate on this market--firms including AT&T. Furthermore, if the returns on local distribution services do not warrant the entry of competitive companies, the local loop may be relegated to a nationalized form of operation.

The notion of a United States PT&T is often frightening and extremely unlikely in this century. Any form of PT&T would be compared to our own Postal Services and to European systems which are, clearly, not as efficient nor inexpensive as our system. But they emerged out of entirely different traditions. There is no reason to assume that a U.S. PT&T, built on the careful structure established by AT&T as the most efficient telephone system in the world, must necessarily crumble if managed by the government. The incentive for maintaining a high-quality POTS system is the efficient and profitable access to and use of a network marketplace, and everyone benefits from this marketplace. For without the local distribution system, profitable and universal network services could not be delivered. Information equality via network equality is in the national interest.

CONCLUSIONS

There is likely to be a continued proliferation of special-purpose networks serving the special needs of the major firms and heavier users of data transmission. Rather than a trend towards a unified network, there is likely to be a sort of federated approach, a collection of cooperating networks that will communicate with one another because of a common interest or service need. These federations might be assembled on an industry-wide basis, such as the airlines, oil companies, food merchandisers, general merchandisers, insurance, the automobile industry and the like. Smaller groupings comprising scientific users, schools, hospitals, etc., might very well follow.

At the present time, what is not evident is a strong trend towards a universal network available to all economic levels and to the public. The European pattern is not being followed in this country, and, barring any major change in policy, is not likely to be emulated. Instead, there will be continued dependence on market demand, and this demand will initially be felt in the business and government sectors. Small business and consumer access are not likely to be generally available before the end of the century.

There may be increasing consideration of some form of government intervention in the sector which houses the providers of information, services and goods for sale on the network. This will be precipitated by the increasing awareness that this nation has not established provisions for information inequality. Some networks might be established by creative merchandising organizations, but these are likely to serve rather narrow groups of customers. It should be remembered that, for a market to function efficiently, there must be many buyers and sellers available to each other.

There is not likely to be a vigorous demand for universal network services. Indeed, even if this demand peaks in the mid-90's, it may be matched by the more or less normal reconstruction of the existing common carrier telephone network into a network for digital voice as well as data services. It is likely that accelerated depreciation rates for the carriers will be allowed so that this trend can be speeded up should the need occur. Alternatives such as the establishment of a U.S. PT&T, while interesting in the abstract--especially if the carriers do create separate firms to compete in the network services and terminal areas--are unlikely developments in our society. However, should the concept of universal and equal access to information become an important social, economic and political cry, such government actions are not to be entirely discounted.

FOOTNOTES

1. Electronic Message Systems: The Technological, Market and Regulatory Prospecta, Kalba Bowen Associatea, et. al. Submitted to the Federal Communications Commisaion in fulfillment of FCC Contract No. 0236 April, 1978

2. Ibid.

3. Bell System Technical Journal, Vol 57, No. 2, Feb. 1978.

4. Nora, Simon and Minc, Alain: L'Information de la Societe, support a M. le President de la Republique, La Documentation Francaise, Paris, Janvier, 1978.

5. A rationale for the British Post Office development of Prestel was to increase the utilization of the telephone in the U.K.

6. Cable Television remains a service purchased by middle and upper middle income families. Furthermore, since CATV systems are franchised for specific areas in a city, its demographics are known quite accurately.

7. Interest by major merchandisers in cable could stimulate the growth of cable if operators choose to provide the somewhat more sophisticated electronics required and intelligently market the new prospects.

8. Comsat has announced that it will seek FCC approval to offer a Direct Broadcast Satellite for the delivery of subscription television services. They forecast offering to the public a small 1 meter dish for about $300 in 1983.

9. Dordick, Herbert S.; Bradley, Helen G. and Wyde, Richard S.: Maximizing Diversity in Public Broadcasting Through Satellite Technology, A Report prepared for KCET, Los Angeles, with funding by the Corporation for Public Broadcasting, 1977.

10. In Columbus, Ohio, a system known as Qube offers viewers limited options for "talking back" to their television sets. Viewers can select movies, respond to polls, second-guess football and basketball referees and play games. There is still some uncertainty about how to use two-way interactive television.

11. In 1977 the budget of the Bell Telephone Laboratories was slightly over $900 million.

TELECOMMUNICATIONS POLICY IN NEW ZEALAND

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Abstract

The necessity for a clearly articulated and widely debated telecommunications policy is only at this moment becoming appreciated in New Zealand. Homes and industries alike have been critically affected by telecommunications. Yet the process of telecommunications policy formulation, and its social impact, has received insufficient attention from social scientists. It has been left to engineers to comment on "the place of telecommunication in ... society" (1), and politicians to be guided by short-term, ad hoc expediency. The recent establishment of a Communications Advisory Council indicates recognition of deficiencies in policy formulation and planning.

Introduction

New Zealand's present status as one of the more developed countries in the Pacific is reflected in the state of her telecommunication development. Comparison of the current penetration of telecommunication services available in N.Z. with other developed countries, reveals that N.Z. has so far been able to keep abreast of telecommunication developments. By March 1976 about three per cent. (30,000 people) of the total workforce were employed in the manufacture or servicing of telecommunication equipment, or were involved in the provision of telecommunication services. At the same time, capital assets (including land, buildings and equipment) of organisations providing telecommunication equipment and services were in excess of NZ $700M. The majority of telecommunication equipment currently in use has been imported (probably less than 30 percent. is locally manufactured). Recognition of the economic and social significance of telecommunications at governmental level is reflected in the establishment of the Communications Commission by the Government in June 1976, "to survey the evolution, present use and existing forward planning of telecommunications as affecting New Zealand." (2). Following the Report of this Commission in 1977, the Government decided to establish a Communications Advisory Council as the advisory body to whom it could look to formulate, coordinate, review and recommend longer term national telecommunications policy. Membership of this Council is to be drawn from Government and private sectors, from the tertiary education sector, and the New Zealand Planning Council.

Most of the equipment, and particularly major items, used in New Zealand are the result of developments overseas - frequently supplied direct by overseas manufacturers. Within the critical economic constraints of a country with just over 3 million people, a balance has had to be struck between economic and social demands for improved telecommunications, and the ability to pay for them and profit from them.

National Policy Coordination

The principal Government agencies which have been responsible for the provision, operation and maintenance of public telecommunication services in New Zealand have been the Post Office and Broadcasting, responsible to the Postmaster-General and Minister of Broadcasting, respectively.

The uniformity of the national telecommunications system is accounted for by this longstanding monopoly system. For example, Western Electric's representative was not permitted to start a telephone company in 1878, but instead dealt with and through the Director of Telegraphs. The collaboration between Government and overseas companies at this point indicates the pattern of future policy-collaboration for the mutual benefit of both New Zealand and the overseas company. More recently came the establishment of the Austral Standard Cable factory, a subsidiary of I.T.& T., and the supply arrangement entered into whereby the New Zealand Post Office oversees production costs, in return for a guarantee that 90 percent. of its underground cable orders will be placed with the firm. Typically, New Zealand relies on competitive world tendering for a centrally unified system.

A. The Post Office

The Post Office Act, 1959, gives the Post Office sole responsibility for regulation (except broadcasting) and provision of public telecommunication services, such as the establishment and operation of inland and international telephone and telegraph services, and, through a licensing system, the right to decline to allow private apparatus to be connected to the Post Office operated telephone network. Such licences have been strictly regulated. It also has the particularly sensitive responsibility for control of the radio-frequency spectrum. Requests to open up new radio stations are made to the Post Office, which, in its role as a guardian of the scarce spectrum-space resource, and its scale of priorities regarding national and international coordination, has frequently declined requests, and thus earned a reputation for inflexibility.

B. Broadcasting

Broadcasting has, since 1936, been a Government department, and, although its internal structure has been changed with whirlwind rapidity over the last six years as television became a giant political football, the Broadcasting Corporation remains responsible for public broadcasting services. It has the right to establish its own transmission links, separate from the Post Office, and it has established its own microwave links for television networking purposes. The present organisational structure is designed to restore direct Ministerial responsibility, to improve administrative efficiency and financial viability. The Corporation, of nine members, has the broad responsibility "to develop, extend, and improve" public broadcasting services, having "regard for the general broadcasting policy of the Government" (3). A three member Tribunal has the power to consider applications and grant warrents for additional radio stations, public or privately-owned. Aside from a short-wave or relay station, a person (including the Corporation) must obtain a warrant or authorisation from the Tribunal before he may be granted a licence by the Post Office.

A post-war trend which has become increasingly apparent, is the development of private systems in the radio sphere. Mobile radio services have developed in Government organisations such as Police, Forestry, Defence and Electricity Supply, which has caused the Post Office to complain of increasing fragmentation in the area of coordination. Indeed, the major conclusion of the 1977 Communications Commission Report - which took into account the revolutionary potential of the emerging information sector - was that there was "a need in New Zealand for more effective coordination in the overall development of telecommunications." The following comments will be concerned with public telephony, telegraph, telex, and Facsimile, data transmission, and international telecommunications.

1. Public Telephony

Since the mid-1960's New Zealand has been among the top five nations in terms of density of telephone connections. Installations have grown from 1.3M (1972) to 1.67M (1977), with a steadily rising number of applicants awaiting installations, from 13,382 (1972) to 29,571 (1977). Developments in technology have tended to reflect those of the developed world, such as the increase in automatic exchanges - over 93 percent. of telephone subscribers are now on automatic exchanges. High capacity microwave and coaxial cable broadband bearer systems were introduced in the late 1950's. As many as 120 telephone circuits may now be carried on two cable pairs, and Post Office engineers are currently investigating the use of optical fibre to replace wire. STD was introduced in 1976, and by the end of 1977 over 350,000 subscribers in northern cities had been provided with this facility.

This latter facility was made possible by an international Post Office Corporation collaborative agreement whereby a five-year supply agreement was entered into with Nippon Electric Co. Ltd. of Japan for the supply of crossbar automatic telephone switching equipment. The rating system follows the U.S. pattern of local free calling, rather than the U.K. metering of local calls. A rental charge covers unlimited calling within the local exchange system.

As a policy issue, public telephony as a whole receives little or no public comment. Decisions are taken, with regard to technological changes, based on advice and information from an indigenous group of experts. Bearing in mind the continuing availability of maintenance spares, this advice is tempered with such independence and innovation as is possible in the international market place. Decisions regarding improvements follow, as may be expected, the demographic and political power contours of the country. STD, for example, was introduced first in the northern cities and more tardily in the south. The majority of two or more party lines (9 percent. of total subscribers in 1976) are in rural areas, as are the majority of the 107 (1976) manual exchanges. However, improvements in the service for rural subscribers have been a recognised long-term policy.

Occasionally policy issues, such as the introduction of local call metering, are raised, and a small flurry of debate occurs, but otherwise there is little public discussion. A consistently high demand for residential connections has been attributed to the relatively low cost of the service, wider area free calling, the isolation of a fair proportion of the community, immigration levels, and dwelling increases.

2. Telegraph, Telex, and Facsimile

For its first half century of existence telegraph provided the country's basic internal communication service. More recently the decline in usage has been rapid, with 4.9 million telegrams lodged in the year ending 31st March 1974, compared with 3.6 million in the year to 31st March 1977. The number of teleprinter offices, which form the public telegraph network, have also declined from 120 in 1976 to 118 in 1978. These offices interwork through gentex (automatic circuit switching), augmented by point-to-point circuits between some major cities.

Fully automated inland and international telex was introduced in 1964, with a substantial immediate and continuing demand for service. From a total of 647 subscribers at the year ending 31st March 1967, there were 2,713 subscribers (an increase of 269 over the previous year), at 31st March 1977. The charging system comprises a basic rental system for each installation, with a single fee per unit time usage irrespective of internal destination. The rents have increased steeply, from NZ $650 per annum (standard machine) and NZ $900 per annum (teleprinter plus tape reperforator and transmitter) in 1975-6, to NZ $1350 p.a. and NZ $1800 p.a. respectively in 1977-8. Public access to telex facilities is possible at public telex booths in six of the major towns and cities. Operator-assisted public telex facilities are available at 18 other centres.

Development of facsimile has been slow until comparatively recently, when improved phototelegraphic equipment has been imported. The Post Office introduced public international and limited inland phototelegraph services over 30 years ago. More recently, private facsimile apparatus has been type approved by the Post Office over the public telephone network.

3. Data Transmission

It was in the area of data transmission that the 1976 Communications Commission felt itself most hindered by lack of information, since there has been "no comprehensive survey of computer usage and applications in New Zealand" (4). In general, however, the Government sector estimates that it accounts for about 75 percent. of the existing usage. Almost all major hardware is currently imported, and figures for the import costs of data processing machines and accessories clearly indicate recent trends; in 1971 almost NZ $2.95 million, in 1976 NZ $30.26 million.

The introduction of remote teletype terminals in 1968 provided the first requirement for data transmission over the country's communications network, and the following year the Government computing services were reorganised into a Centralised Government Computer Bureau including all Departments.

The use and requirements of data transmission telecommunications facilities has also grown rapidly, with the increase in number and use of remote terminals. Because of the wide geographical distribution of Government Departments, and the centralised computing resources of the Government, the State Services Commission (Computer Services Division) forecasts that: "the provision of computer networks will be one of the main areas of development over the next five years." This development reflects the world-wide move to distributed computer processing facilities.

The telecommunications services developed for transmission of data have been provided by the Post Office, which leases circuits for data transmission. It leases data modems (200 and 600/1200 bauds) for use on leased lines, and provides a datel service for the exchange of data using switched telephone networks, both local and toll. The datel service is restricted to speeds of 200, 600 or 1200 bauds.

The charges for data modems are rapidly increasing, costing (depending on speed and type) between NZ $100 and NZ $175 at 31st March 1977, and between NZ $186 and NZ $360 per annum at 31st March 1978. For datel service, a telephone must be leased especially for the purpose, and the use of a Post Office modem is mandatory. Rental for this is as for a business telephone connection, and similarly has greatly increased in cost, from (depending on class of telephone exchange) NZ $85.75 to NZ $134.75 per annum at 31st March 1976, to NZ $208.20 to NZ $326.40 per annum at 31st March 1978. On top of this is the rental for the modem (5).

It has been commented that in the early days firms found themselves persuaded into buying systems to solve problems they did not have, and there were a number of 'burnt fingers'. However it is apparent from submissions to the Communications Commission that both Government and industry fully appreciate the impact and special importance of data processing and transmission. The Post Office notes that "a probable need will develop in the future for a digital package switching, common user systems and end to end digital links..." (6).

4. International Telecommunications

New Zealand has international telecommunication links via cable, satellite and radio to almost all countries of the world. She has been linked by telegraphic cable to Australia for over 100 years, but with increasing demands, further major developments have included COMPAC telephone cable (1962/3), SEACOM (1967), the Post Office Warkworth Satellite earth station (1971), and the Australia-New Zealand TASMAN submarine cable (1975). TASMAN has a total capacity of 640 circuits; COMPAC, with about three remaining years of its recognised 20 years of economic life, has a capacity of 80 telephone channels. The Warkworth Satellite earth station operates via the Pacific INTELSAT IVA satellite, which has become increasingly important for simultaneous television transmission of overseas events. New Zealand is represented on the Board of Governors of INTELSAT through membership of the Asia Pacific Group (APG). Originally formed in 1967, with eight members, since 1973 this group has consisted of five Commonwealth countries (N.Z., India, Singapore, Sri Lanka and Malaysia).

All incoming and outgoing international telephone calls are transmitted via an International Gateway telephone exchange in Auckland. At this exchange international operators dial direct to subscribers in other countries, and overseas operators (in some cases subsribers) dial direct to subscribers on automatic telephone exchanges in New Zealand.

New Zealand has an important role to play in the Pacific, with regard to international radio services. High powered transmitting and receiving stations provide telegraph and telephone services to places in the Pacific not served by cable or satellite. Such direct radio services operate to Apia, Rarotonga (and other islands in the Cook group, by Rarotonga Radio through feeder stations), Niue, Nukualofa, Ross Dependency and the Chatham Islands. International telecommunication aid to developing countries in the region, through advisory and training services, and general upgrading of telecommunications services, is an important aspect of policy, and New Zealand participates in the work of the South Pacific Bureau for Economic Cooperation (SPEC), and the Economic and Social Commission for Asia and the Pacific (ESCAP).

International considerations are of critical importance in policy planning and implementation, and the overall development of telecommunications in New Zealand. The Post Office acts as administrative member, cooperating with other interested organisations, with the I.T.U., INTELSAT, INMARSAT (Intergovernmental Maritime Consultative Organisation), the Commonwealth Telecommunication Organisation, COMPAC, SEACOM, and TASMAN. The degree of independence in planning decisions is circumscribed by the need to conform to internationally agreed arrangements. In addition, as the Communications Commission noted, "standards are set for transmission performance and compatible signalling systems to enable traffic to be satisfactorily interconnected via the international network" (7).

5. Broadcasting (sound and television)

Broadcasting services in New Zealand are provided by the Broadcasting Corporation of New Zealand (BCNZ), created by the 1976 Broadcasting Act, and by private (radio) station operators. Five previous forms of control date back to the introduction of the first "wireless" stations. BCNZ is responsible for three operating Services, Radio New Zealand (RNZ), Television Service One (TV1) and Television Service Two (TV2). There are nine private (sound) broadcasting stations, providing a community-type service.

RNZ operates 21 stations on a daily 24-hour service throughout the country, feeding 54 MF transmitters, and two HF transmitters of the External Services Division. The three major networks, National, Concert and Community, are distributed by a chain of programme circuits leased from the Post Office. MF radio transmission is over 61 of the 108 channels available in the MF band between 525 and 1605 kHz., with 28 stations of 5kW or more, and 33 stations of less than 5kW. The Communications Commission Report points out that "New Zealand is one of the few countries in the world where so much MF coverage is achieved and hence its use will continue to be of great importance to New Zealand broadcasting in the future" (8). The HF service operates to Australia and the Pacific Islands, transmitting the national programme in the international HF bands of 6, 9, 11, 15 and 17 MHz., using two 7.5 kW transmitters operating into a selection of 11 aerial arrays as required. This service, besides carrying news, current affairs, talks and comment, carries home service news and magazine programmes in Maori, Tongan, Samoan, Niuean and Cook Island Maori. "Te Reo O Aotearoa" opened in October 1978 as the Maori and Pacific Island Broadcasting Unit of RNZ, to provide a more focussed service for the important Polynesian minority groups. The longstanding local broadcasting system is considered a very important part of the national system, and decentralised administration is designed to facilitate responsiveness to local communities.

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Television utilises the 625-line system, with colour transmission using the PAL system. By March 1977 the number of television licences was 815,798 (302,212 colour), and over 85 percent. of homes were equipped with television sets.

It is in the frequent reorganisation of the television services that most public debate has occurred. Following the BBC model, the system is based on public service broadcasting, yet in the Labour Government's 1975 broadcasting plan it was designed to be "competitive yet complementary". Labour deliberately broke up the NZ Broadcasting Corporation, a single corporation whose twelve years alongside a National government had, they felt, emasculated it, and replaced it with the Broadcasting Council of New Zealand, consisting of three separate and independent regionally-based public corporations. With the change of government in 1975, another Broadcasting Act set up the present BCNZ structure, as a public corporation responsible to Parliament through the Minister of Broadcasting. TV1 operates principally from Wellington and Dunedin, and TV2 from Auckland and Christchurch.

More recently, however, further changes have occurred, and radical changes, including the suggestion that TV2 should be abolished, have been mooted (9). Under the latest system, competition for ratings and revenue - a fight which has absorbed TV1 and TV2 since their inception - disappears. TV1 and TV2 will no longer be mirror images of each other in structure and intent, and instead a single television enterprise will serve the two TV channels. This will be known as Television New Zealand, having as its stated basis "the highest degree of complementarity". Production, consisting of the sports section, light entertainment, news and current affairs, will form one arm of this enterprise; administration, including scheduling, overseas programme purchase, and advertising, will form the other. The Chairman of BCNZ considers that this retreat from competition - instituted, paradoxically, by a Labour government and eliminated by the more conservative National government - indicates the resurgence of the BBC ideal of public service broadcasting.

Underlying this restructuring and much of the concurrent debate is the question of finance. Many consider that the political decision that New Zealand should have two television channels was too ambitious in the light of the country's resources, and the quality of programmes available (10). Traditionally, advertising is accepted as a legitimate source of revenue for broadcasting, and in the early NZBC days advertising and licence fees provided about equal parts of broadcasting's operating costs. However by 1977-78 advertising revenue provided over two-thirds of broadcasting's revenue. In April 1979 an appeal for a rise in the cost of licence fees of $10 p.a. was judged politically unacceptable and turned down by the Government, and instead new cuts were encouraged, with the Prime Minister emphasising the need for cost-consciousness and close scrutiny of expenditure (11). Cost-saving is considered to be a major component in the latest organisational change - the fourth in as many years.

It has been maintained that the present system consolidates executive powers in the politically-appointed chairman of BCNZ, with the chief executive becoming both policy-maker and administrator. It is feared that the degree of public accountability in public broadcasting is such that it exposes broadcasters to "the whims and fancies of their political masters" (12). The tension between independence and public accountability remains an important problem.

Comment

Clearly, over the years organisations involved in telecommunications in New Zealand have been deeply involved in policy formulation and planning. However it is only with the revolutionary potential of new forms of communication, and new techniques such as data communication, teleprocessing, and facsimile, that public recognition of the need for continuing examination has become apparent. This recognition has been institutionalised through the setting up of the Communications Commission, and subsequently the Communications Advisory Council.

In many vital regards New Zealand's telecommunication policy is circumscribed by developments overseas. For example, once decisions have been made for equipment supply, even though the policy is one of competitive tendering on the world market, the demands of system and equipment compatibility, and international agreements, limit the choices available. Because of costs, and the limited resources available from a country with a population of only 3.1 million (1976), a stringent order of priorities is needed, and many features familiar to consumers in other developed countries (such as ISD; FM broadcasting; CATV, CTV, and ETV), are either lacking or are introduced some years after initial development overseas. The problem of a lengthy lead time inherent in telecommunication planning is well recognised by the Post Office: "At any stage, the ability to provide service is often influenced by the restraints or decisions in previous years as well as in the current year, and it is not always possible to change direction, reverse a trend, or recover from an unsatisfactory situation, except over a period of time...." (13).

While the Communications Commission noted that "all evidence points to New Zealand having developed into a high telecommunication usage country with relatively high standards of service in comparison with other countries" (14), it is also quite clear that there are insufficient resources to match the growth in demands - both for existing services, and for new developments in telecommunications. Implementation of policies, and the prior planning of such policies, is thus a profoundly political question. While existing telecommunication systems may have developed through the political pressure of heavy public demand, the rapidity of progress in communications over the last decade has meant that policy decisions regarding technical matters have had to be well in advance of the public at large. The development and evolution of new concepts of communication have had to be established ahead, rather than evolving through public demand based on historical values.

Such considerations have tended to involve a relatively small group of decision-makers, principally drawn from the Post Office and Broadcasting institutions; however a wider forum for discussion of policies critically relevant to national economic policies has been provided by the Communications Advisory Council, which is still at an early stage of its development. The more highly visible aspect of communications policy is that relating to the internal structure of the broadcasting system. Here, the classic conflict between creativity and control has been fought out, as broadcasters found themselves increasingly attacked on their day-to-day expenditure, salaries, and duplication of services.

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Increased revenue through further advertising has been mooted, though with commercials at present averaging 9 minutes per viewing hour, the two days (Sunday and Monday) at present free of commercials will probably be used for advertising. Much of the debate has been set against a background in which it is acknowledged that New Zealand over-extended itself in providing a second TV channel. Both political parties were keen to see it established, and having invested capital in TV2 it is unlikely to be discontinued. However it has indicated most clearly the problems for small nations in telecommunication planning, and the difficulty of weighing political considerations of public demand against financial and economic restrictions. At many levels New Zealand's experience in telecommunications policy and planning, and the adaptation of systems to smaller and less rich nations, can be of considerable benefit to less developed countries in the Pacific basin.

FOOTNOTES & REFERENCES

(1) *Telecommunications in New Zealand.* Report of the Communications Commission: Government Printer, Wellington, N.Z., April, 1977. p.4.

(2) Ibid., p.3.

(3) *New Zealand Official Yearbook.* Department of Statistics. 83rd Annual Edition: Government Printer, Wellington, N.Z., 1978. p.346.

(4) *Telecommunications in New Zealand*, p.19.

(5) *New Zealand Official Yearbook*, 1976, 1977, 1978.

(6) *Telecommunications in New Zealand*, p.82.

(7) Ibid., p.108.

(8) Ibid., p.93.

(9) *Otago Daily Times*, 14 March 1979.

(10) *Christchurch Press*, 19 March 1979.

(11) *N.Z. Truth*, 10 April 1979.

(12) *National Business Review*, 11 April 1979.

(13) NZPO submission to *Telecommunications in New Zealand*, p.159.

(14) *Telecommunications in New Zealand*, p.116.

PSINET: A Private Packet-Switched Corporate Data Network - From Concept to Operation

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ABSTRACT

The realization of an integrated private corporate data network is done in several important steps, each of which requires careful planning and coordination:

1. Data communications requirements definition,
2. Preliminary network design,
3. Financial analysis,
4. Detailed network design,
5. Implementation planning,
6. Application qualification,
7. Application conversion, and
8. Fully-loaded operation.

This paper presents the experience of the author as program manager for implementation and planning of PSINET, the General Telephone of the Northwest packet-switched data network.

1. Introduction

Early in 1977 the Network Planning department of GTNW began to observe the fast growth in internal data communications networks. This growth was exhibited in the heavy utilization of dedicated point-to-point "private line" circuits for several large applications. Foreseeing applications slated for implementation within a three year time period following that point in time, it became evident that the ability to manage the growth with quality service was questionable. In addition, growth in demand for the same services by customers of GTNW was of a like magnitude. Thus, internal data communications requirements directly competed with customer requirements, further stressing the network's ability to keep pace.

By late 1978 it became clear that an integrated network to handle all internal data communications for GTNW was required. Such a network would be required to handle a broad set of applications, some with large terminal populations. Both synchronous and asynchronous data terminal equipment (DTE) would have to be served, over a broad range of speeds. Multiple hosts were being accessed, with various terminal types, speeds, codes, protocols, and switching requirements. At the same time, GTE corporate data processing was conceiving a regional network of data processing centers, thus implying bulk host-to-host data transfer. Probably of greatest significance among the foreseen future applications is a general family of network support systems, the most prominent being the electronic collection of toll and local measured service data, a data volume as large as all the rest combined.

All of these requirements, as well as foreseen future requirements, led a task force representing the Western Region of GTE telephone operations to the conclusion that a packet-switched data network would best fulfill the requirements.

This paper outlines the specific evolution of the GTNW Packet-Switched Intelligent Network (PSINet) from general requirements definition through the present state, equipment installation. The plans for full operational conversion are also outlined to show one company's approach to private data networks.

2. Pre-Implementation Configuration

As the first step in evolving to an integrated network, the existing and soon-to-be-implemented networks had to be identified. Since each application was implemented with a distinct network, the task of developing an inventory for these networks reduced itself to describing each application and its configuration. Figures 2-1 thru 2-9 show these networks. Additionally, data concerning traffic on these networks, types of terminals, line speeds, and protocols was compiled. Table 2-1 was the result of the survey to collect these data.

As can be seen from the figures, GTNW serves customers over a five state area, crossing through the operating territories of other carriers. Much of this area is sparsely populated, with weather that can seriously hamper access to remote sites. All of these considerations had to be added to the requirements for an integrated network.

3. PSINET Configuration

After analysis of the requirements identified from existing and foreseen applications, it became clear that a GTNW-owned packet switching network would best provide the level of service and features necessary to meet the future data communications environment. In response to corporate requirements of compatibility and maximum applicability, the Telenet TP-4000 packet switch/concentration was selected as the nodal processor in the network. Figure 3-1 shows the placement of nodes determined to best serve the distribution of traffic and terminals. The location of hosts is concentrated in Everett, Washington and Beaverton, Oregon with little host-to-host traffic occurring. Thus, the "backbone" links on the nodes tend toward a tree/star topology. This, however, does not preclude more generalized connectivity, since the TP4000 provides switching between any two ports of the network. A key ingredient in selection of the equipment was the ability to supply a Network Control function. Telenet does this, and the Network Control Center (NCC) is collocated in Everett, Washington with the corporate data test center.

4. Major Implementation Events

Once the strategic issues had been identified and an acceptable supplier of a solution chosen, it remained to place these facts in the framework of a fundamental plan. Such a plan was presented to the executive committee of GTNW which steers all data processing activity in the company. To complement the requirements definition and description of the proposed network node locations, an exhaustive financial analysis of the capital and annual cost figures was performed. The "before" figures were developed by deriving the cost per private line circuit to install and maintain from the aggregate cost of all equipment involved. Additionally, further levels of concentration in the access to a node would allow reduction in modems used. All of these related figures were projected over a 10-year life and the present worth of annual charges and capital expended was brought back. The final results indicated capital cost savings in the $5 million range and annual cost savings in the $10 million range over a 10 year period, calculated at present worth. The capital costs savings for 1989 alone could be as much as $2 million with annual charge savings as much as $6 million. Given the viability of the technical solution and the favorable financial picture, approval to implement PSINET was given in 1st quarter 1979.

Following several months of training and refinement of requirements and switch configurations, responsibility for implementation of the network was given to a team composed of representatives of the key organizations in GTNW concerned with the data network, with the author as program manager. The first order of business was to establish a direct liaison with the major vendor, by this time known as GTE Telenet, in the form of a program manager. This allowed the team to form a concrete configuration of TP4000 orders which could then be planned on for conversion of applications.

The next major decision to be made was the selection of the initial sites and applications to be placed on the network. Since the most critical and technically demanding applications are implemented with synchronous terminals and protocols, a set of asynchronous applications were chosen as the "first wave" to be converted. The "second wave" will qualify the critical synchronous applications performance. In order to identify the major steps to be taken in achieving these strategic goals, a strategic plan for the implementation was outlined. This is shown in Attachment 4-I.

Having identified the applications which will enter the network first, a qualification test plan for each application was formulated. These plans contain the location of the terminal, the exact transactions to be performed, and the expected results. As each application passes these tests, conversion of that application to fully-loaded operation can commence. This cycle is performed in parallel, thus allowing several applications to be qualified at close intervals. The conversion planning has probably the most demanding requirements for detail and coordination, since so many elements of the company are involved, and thus will proceed over an extended period. A conversion to fully-loaded operation is also constrained by limited resources to move modems, to re-wire private-line facilities and to train users.

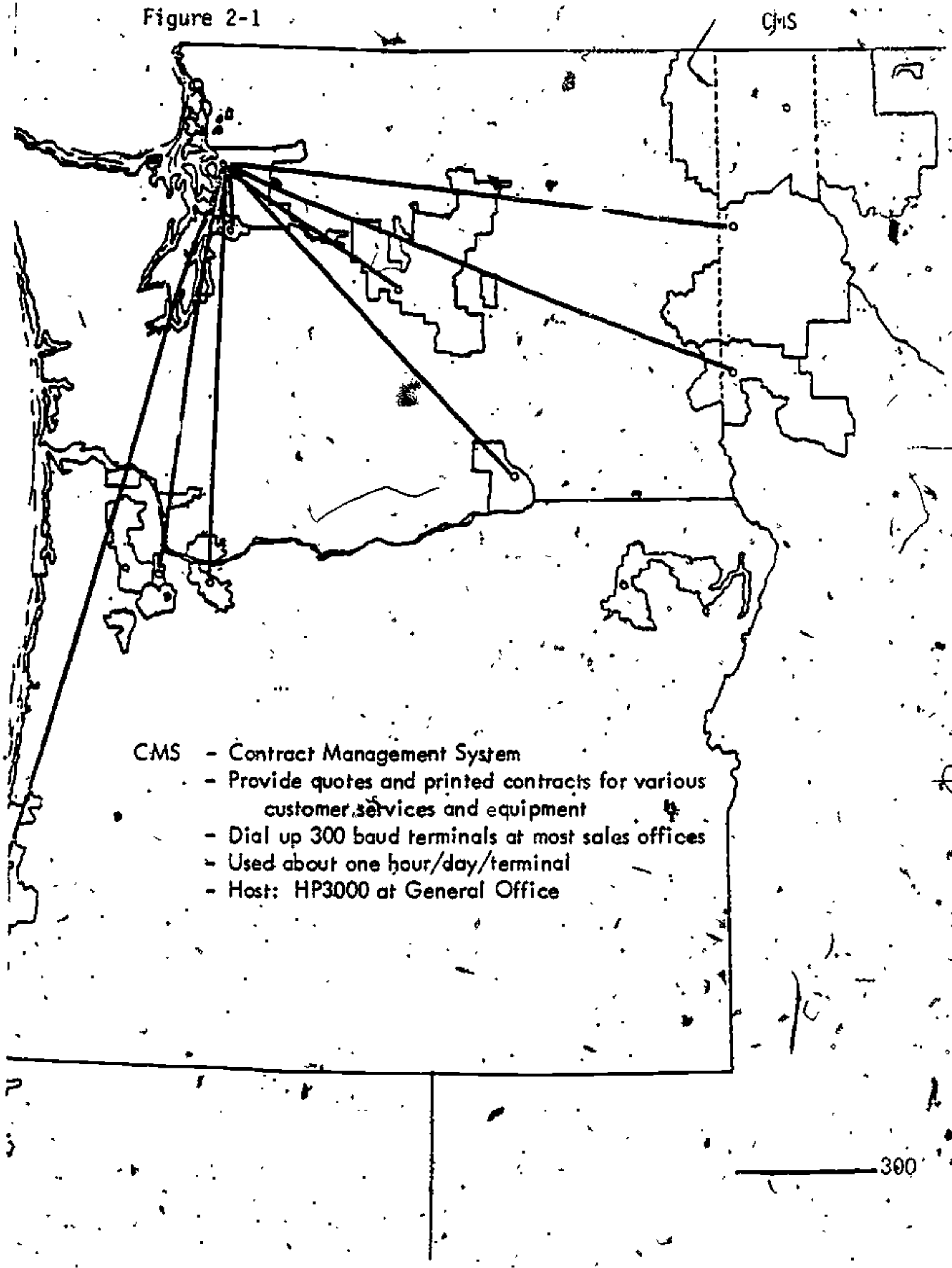
5. Summary

The key elements in a successful implementation of a private data network are:

a. Careful and thorough definition of data communications requirements,
b. Early identification of a program manager, with responsibilities derived from commitment from top management,
c. Early and continual involvement of affected users, thus ensuring cooperation and understanding by those whom the network is to serve,
d. Clear and objective test plans, thus eliminating indistinct objections to use of the network.

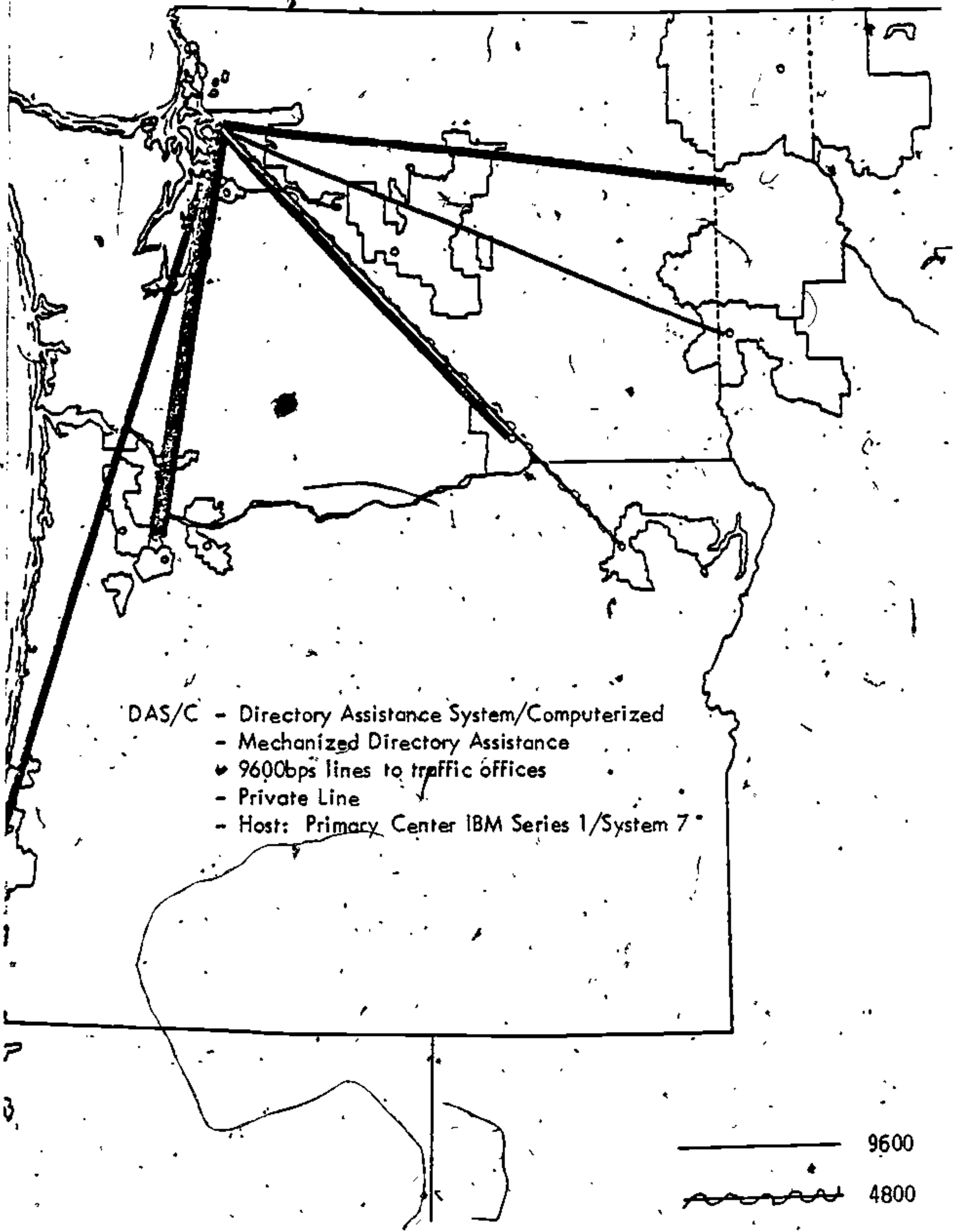
Given these elements, and given the resources and vendor support to implement the plans, a private data network should make sense for many large corporations today.

Figure 2-1



CMS - Contract Management System
- Provide quotes and printed contracts for various customer services and equipment
- Dial up 300 baud terminals at most sales offices
- Used about one hour/day/terminal
- Host: HP3000 at General Office

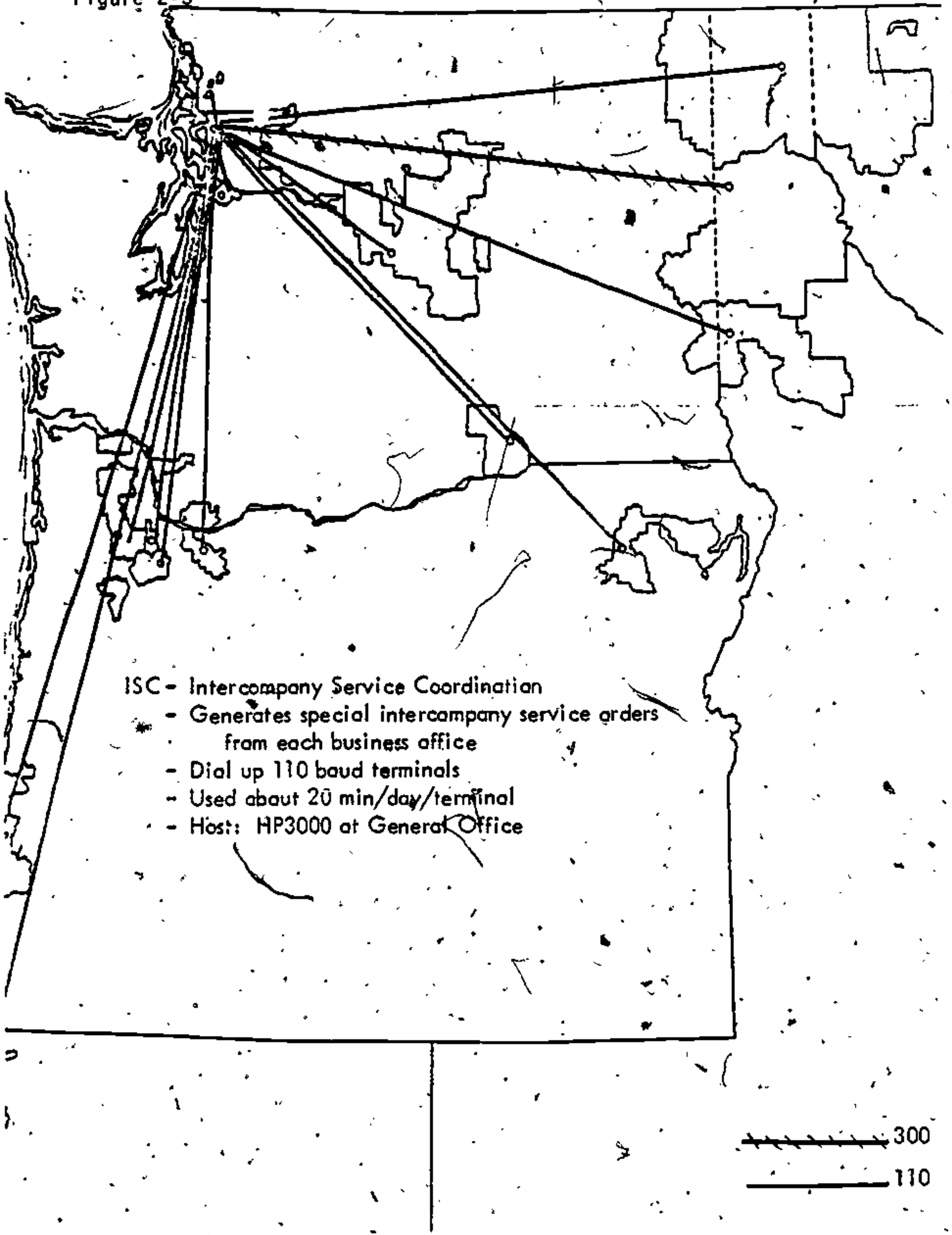
Figure 2-2 DAS/C



DAS/C - Directory Assistance System/Computerized
- Mechanized Directory Assistance
- 9600bps lines to traffic offices
- Private Line
- Host: Primary Center IBM Series 1/System 7

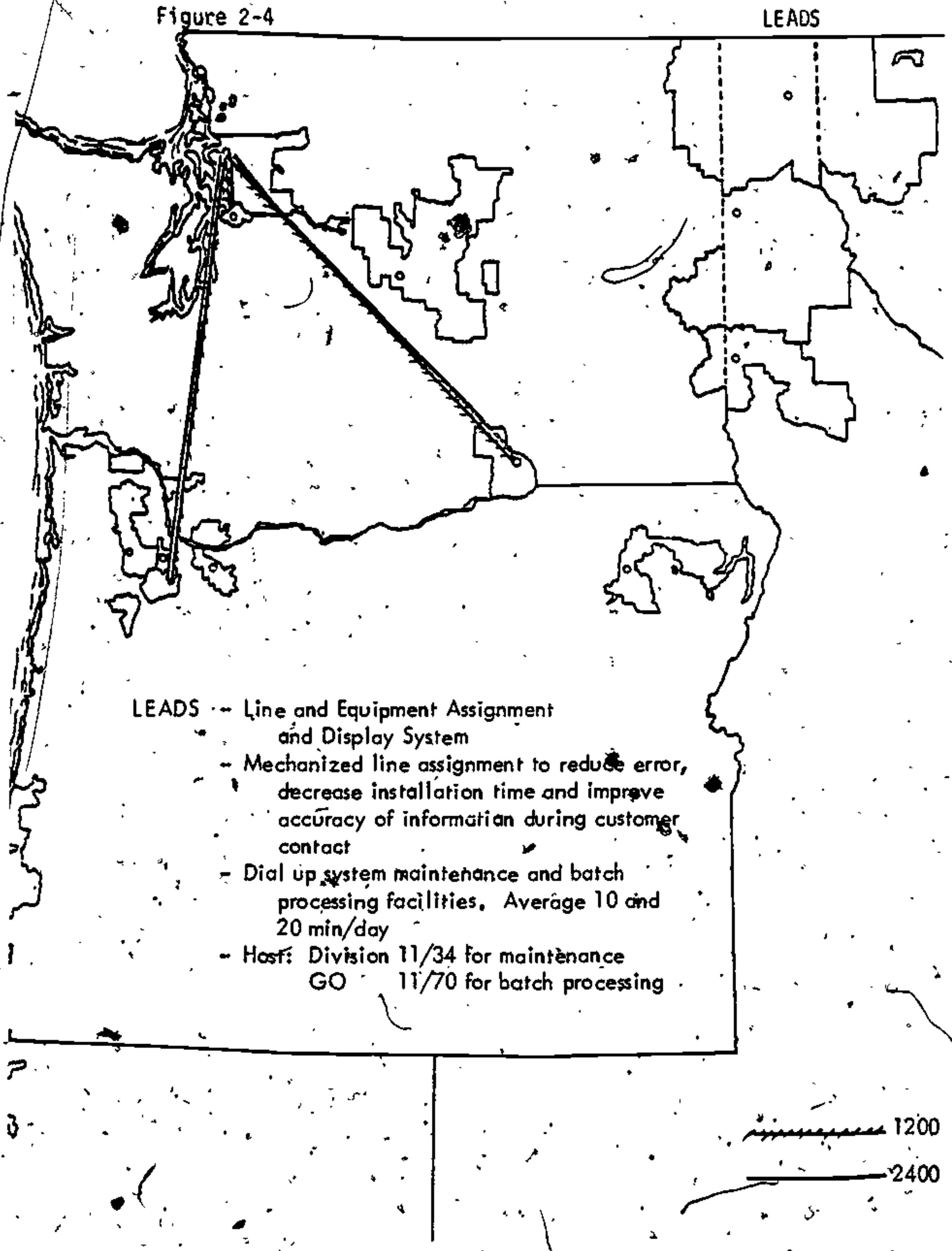
Figure 2-3

ISC



ISC - Intercompany Service Coordination
- Generates special intercompany service orders from each business office
- Dial up 110 baud terminals
- Used about 20 min/day/terminal
- Host: HP3000 at General Office

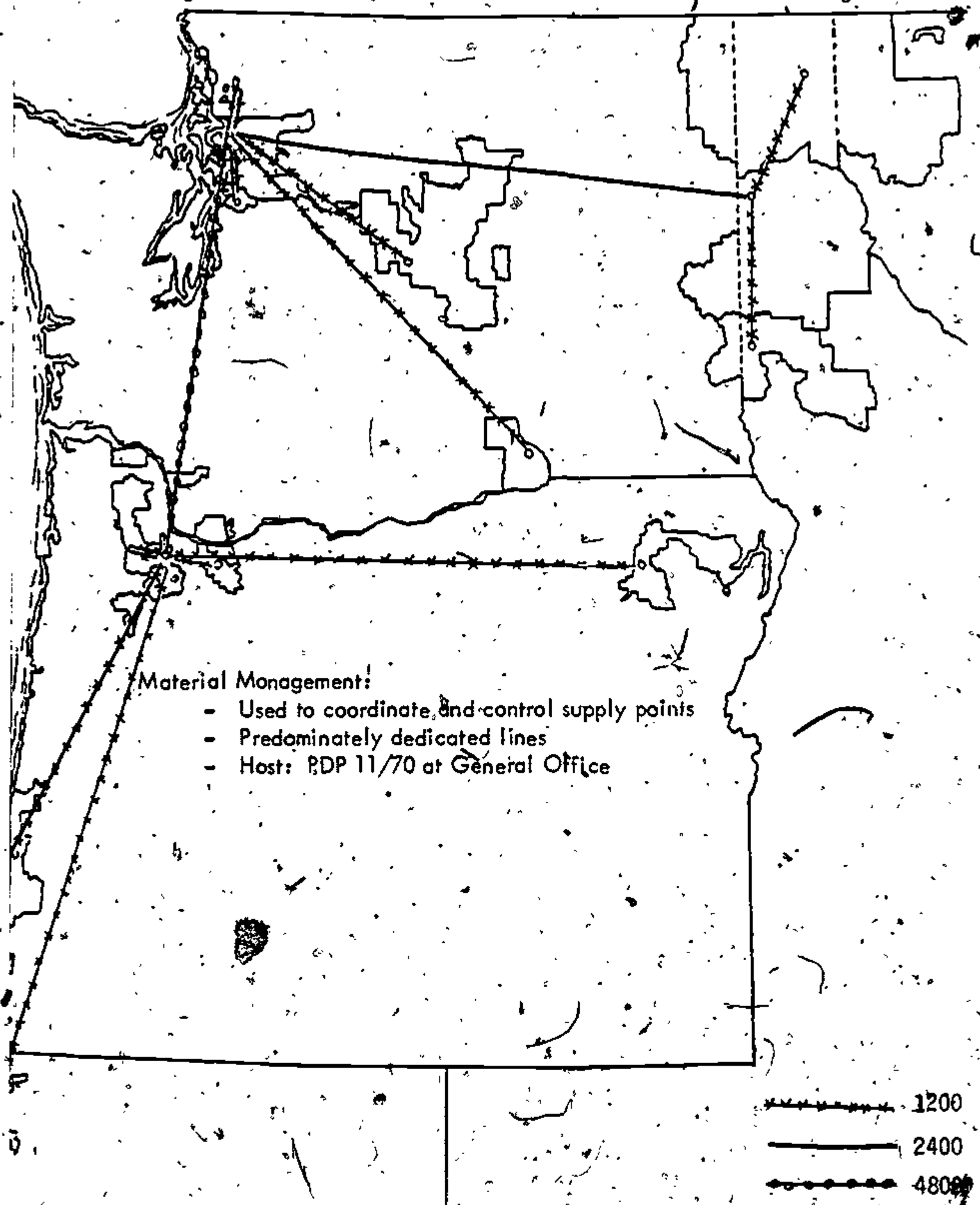
Figure 2-4



LEADS -- Line and Equipment Assignment and Display System

- Mechanized line assignment to reduce error, decrease installation time and improve accuracy of information during customer contact
- Dial up system maintenance and batch processing facilities. Average 10 and 20 min/day
- Host: Division 11/34 for maintenance
  GO 11/70 for batch processing

Figure 2-5 Material Management

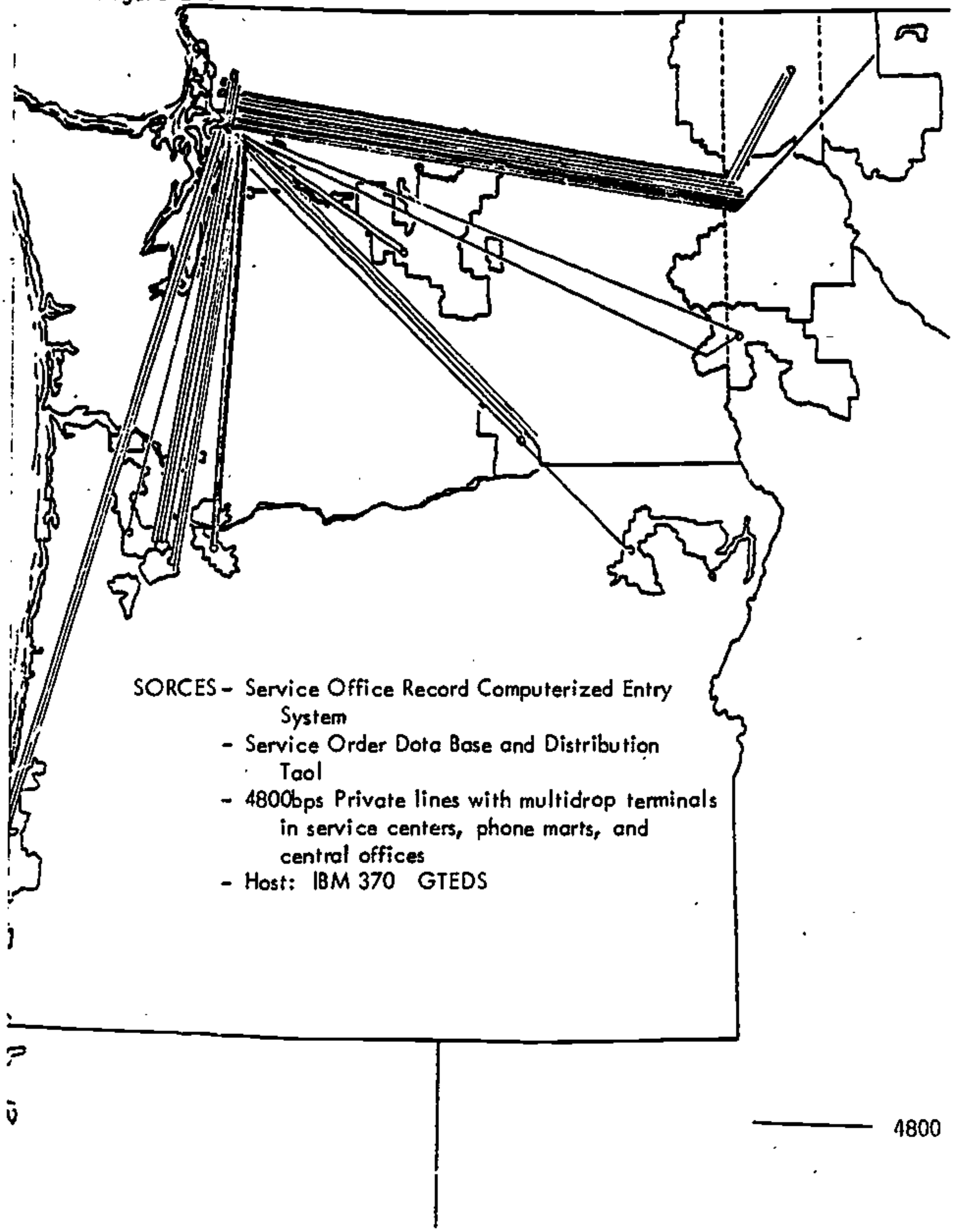


Material Management:

- Used to coordinate and control supply points
- Predominately dedicated lines
- Host: PDP 11/70 at General Office

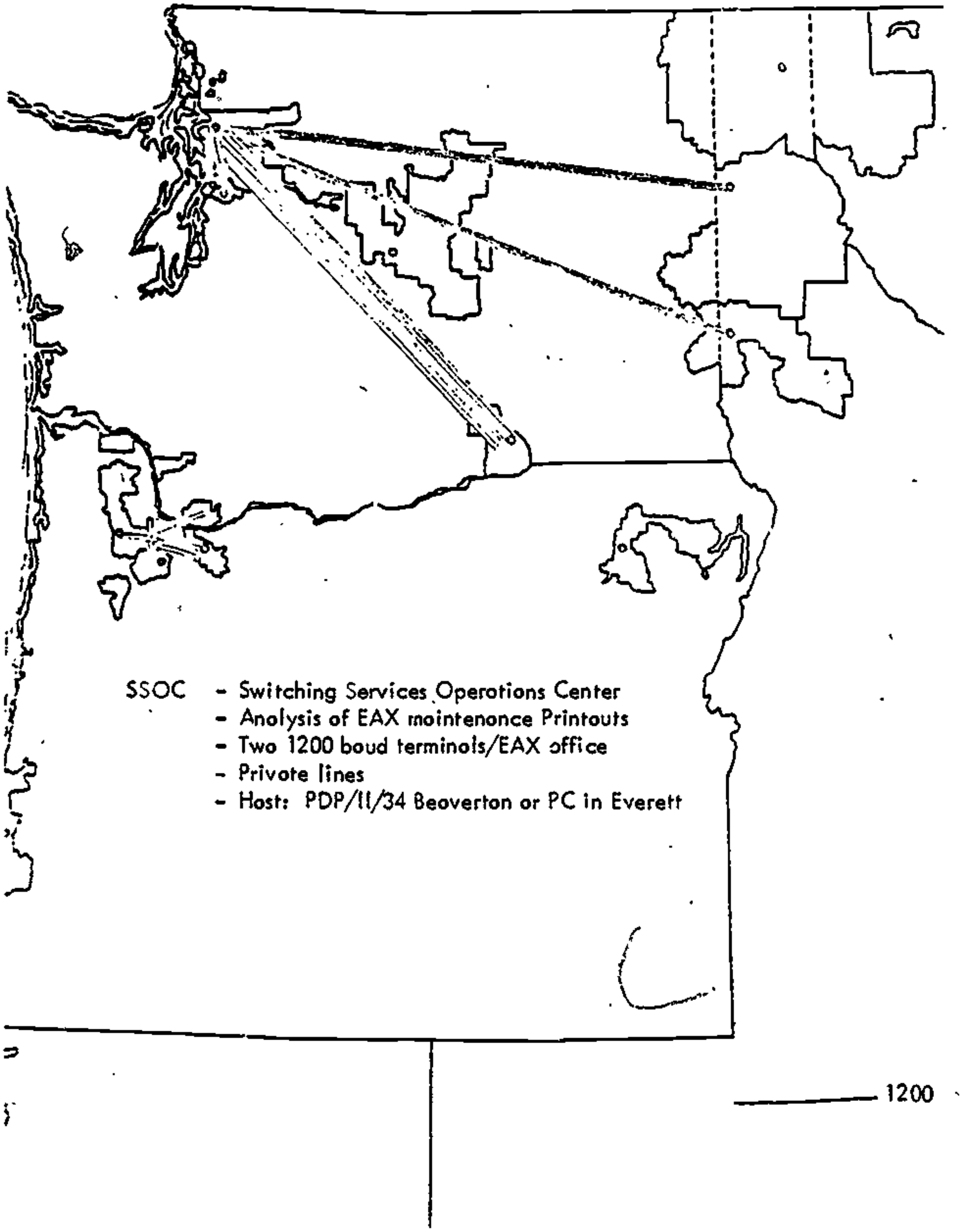
Figure 2-6

SORCES



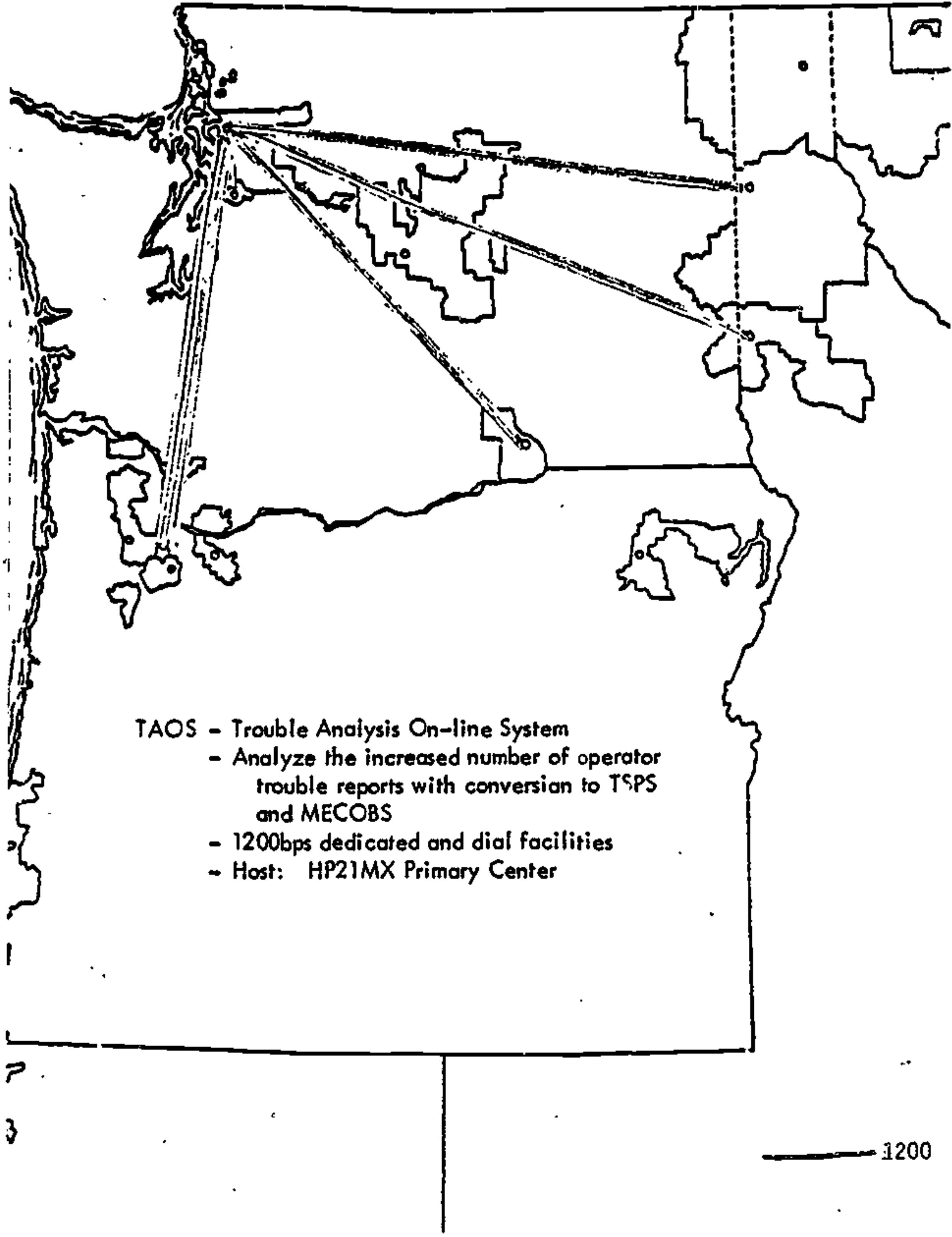
SORCES - Service Office Record Computerized Entry System
- Service Order Data Base and Distribution Tool
- 4800bps Private lines with multidrop terminals in service centers, phone marts, and central offices
- Host: IBM 370 GTEDS

Figure 2-7 SSOC



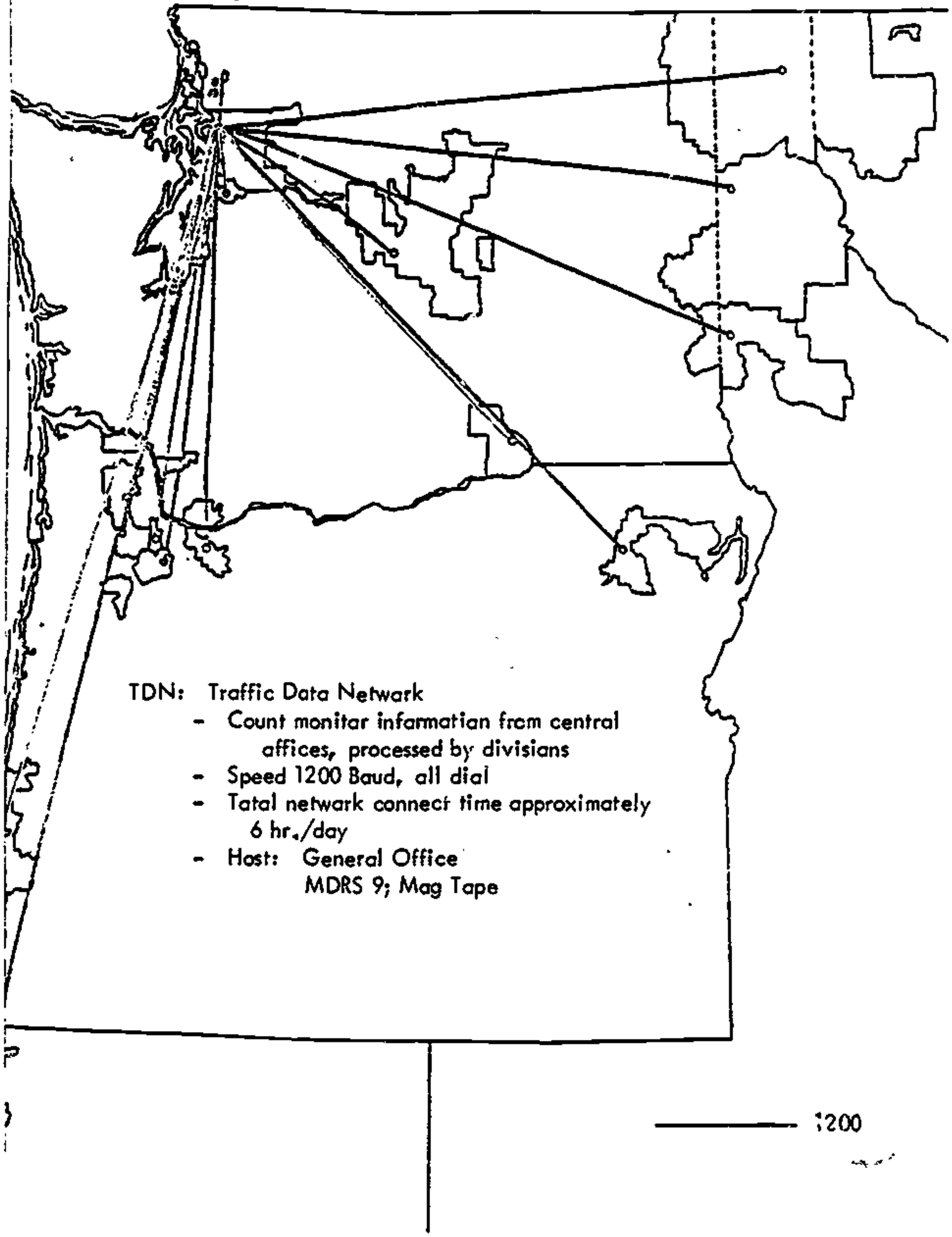
SSOC
- Switching Services Operations Center
- Analysis of EAX maintenance Printouts
- Two 1200 baud terminals/EAX office
- Private lines
- Host: PDP/11/34 Beaverton or PC in Everett

Figure 2-8 TAOS



TAOS - Trouble Analysis On-line System
- Analyze the increased number of operator trouble reports with conversion to TSPS and MECOBS
- 1200bps dedicated and dial facilities
- Host: HP21MX Primary Center

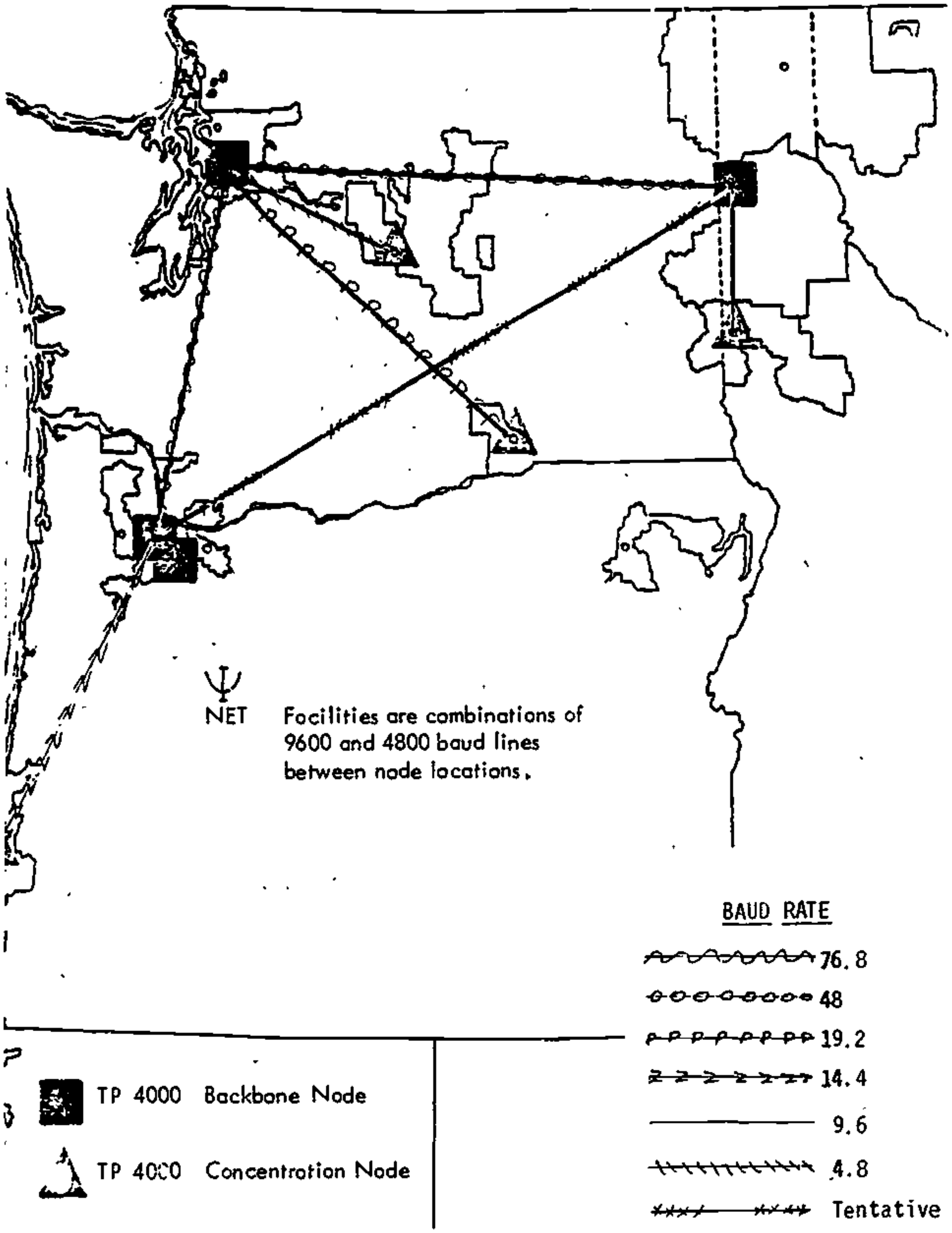
Figure 2-9 TDN



TDN: Traffic Data Network

- Count monitor information from central offices, processed by divisions
- Speed 1200 Baud, all dial
- Total network connect time approximately 6 hr./day
- Host: General Office
  MDRS 9; Mag Tape

Figure 3-1 PSINET


NET
Facilities are combinations of 9600 and 4800 baud lines between node locations.
BAUD RATE
76.8
48
19.2
14.4
9.6
4.8
Tentative
TP 4000 Backbone Node
TP 4000 Concentration Node

PSINET Implementation Strategy

PHASE I - Central Office Equipment - Completion Target, 11-16-79

Major Milestones:

- 4 TP 4000's (Everett, Beaverton I, Moscow, Coos Bay) installed and on-line to NCP
- Internodal Facilities (Backbone) installed and operating
- CNCC established
- "First Wave" training complete
- Qualification Test Plan document complete

PHASE II - Qualification Testing - Completion Target, 1-18-80

Major Milestones:

- Test locations attached to PSINET
- Hosts attached to PSINET
- Applications qualified/rejected
- CNCC fully operational
- 4 TP 4000's (Beaverton II, Coeur d'Alene, Kennewick, Wenatchee) installed and on-line to NCP
- Internodal Facilities installed and operating

PHASE III - Operational Conversion - Completion Target, End - 2Q80

Major Milestones:

- Access Network installed
- "Business-as-usual" Administration in effect

Attachment 4-1

6

Table 2-1

Application - Narrative	Host Location	Host	Line	DTE	DTE Topology/Distribution	Messages Per/Day	Host Input Message	Avg. DTE Output/Day	Host Output Message	Avg. DTE Input/Day	Peak Hour Traffic	Projected Growth Year
		Characteristics&Volume					CHARACTERS		CHARACTERS			
1978												
CMR	EDC	370/158	Dial 2400	IBM3741 (16)	One Per Division	4K	0	0	75	4.4K	N.A.	MSG[2]
CMS	G.O.	HP3000	Dial 300(10)	ASCII ASYNCH.	One Per Business Office Mktg. Consultant	* (Total 5.8 connect hrs./day)					N.A.	*
ISC Order Mgmt.	G.O.	HP3000	Dial 110(10)	3	E-5 N-4 S-7 G.O.-5 See Attachment 9	200	1K	12K	1.2K	14K	20% 10:00-3:00 24 hrs./day 7 days/week	30%
Materials Management	G.O.	370/158	1	1	1	4K	40	10K	40	200	N.A.	*
RCS	Tampa	L66	3	ASCII ASYNCH.	26 User I.D.s	* (Total 5 connect hrs./day)					N.A.	*
RJE	EDC	370/158	9.6kb Ded(3)	11/70 HASP	G.O.	255K	80	2.4M	100	22.5M	10 hrs./day	40%
RMCS	PC, and Beaverton	11/34	Ded P.L. 300 bps	#1, #2, #3 EAX(13)	4	55K	75	270K	75	270K	24 hrs./day 7 days/week	MSG[2]
SORCES	EDC	370/158	4W, C2 4800(40)	3270 BSC (550/80)	See Attachment 3	280K	44	76K	615	363K	N.A.	100%
TAS	EDC	370/158	1	1	1	4K	60	15K	0	0	N.A.	MSG[2]
IDH	EDC	370/158	Attach. 4		One Per CO Over 2K lines	60K	4	4.5K	0	0	100%	MSG[2]
UCS	K.C., Mo.	CDC 7600	3	ASCII ASYNCH.	35 User I.D.s	* (Total 6 connect hrs./day)					N.A.	*
1979												
CEDAR (1Q79)	G.O.	HP3000	Ded. P.L.	CRT	Each C.O. over 2K lines	*	*	*	*	*	*	*
CMR (2Q79)	G.O.	11/70	5	5	See Attachment 5	16K	132	13K	132	51K	N.A.	2%
COMPS(2Q79)	G.O.	11/70	5	5	5	-	-	-	-	-	--	-
COTAP(2Q79)	G.O.	11/70	5	5	5	-	-	-	-	-	--	-
DAS/C (1Q79)	P.C.	Series 1	6	4978(28) BSC	E-23 N-25 S-30	40K	10	5K	960	486K	9% 10 a.m.	6%
LEADS (2Q79)	G.O.	11/34	7	CRT ASYNCH.	7	*	*	*	*	*	N.A.	MSG[2]
Materials Management (2Q79)	G.O.	11/70	5	5	5	10K	132	6.6K	132	20K	N.A.	20%
TAOS	P.C.	HP21	Attach. 6			*	*	*	*	*	*	*
TAS (2Q79)	EDC	11/70	5	5	5	-	-	-	-	-	--	-
Future (1980s)												
CHAS	G.O.	HP3000	*	*	*	*	*	*	*	*	*	*
CPR	G.O.	11/70	*	*	*	*	*	*	*	*	*	*

See following pages for notes and acronym expansion

* Unavailable or Unknown

DATA COMMUNICATIONS STANDARDS
AND
IBM'S SYSTEMS NETWORK ARCHITECTURE

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Abstract

Communications standards are playing an increasing role in the world of data communications - a world which is experiencing a proliferation of new public data networks. Using the International Organization for Standardization (ISO)* provisional architectural model as a touchstone, this paper explains the various communications standards activities currently being proposed or implemented and their interrelationships. While it is IBM's practice, generally, to support communications standards, its decisions regarding the implementation of individual standards are based upon technical and business considerations. This paper will provide insight into the various communications standards being supported by the IBM Corporation. Included also is a correlation of these various standards with IBM's Systems Network Architecture.

OPEN SYSTEMS INTERCONNECTION

With the aim of giving users a wide range of choice of various elements of a communications served data processing system, the International Organization for Standardization (ISO) has begun development of network system standards entitled "Open Systems Interconnection". Figure 1 is a graphical representation of the ISO provisional model. ISO's goal is to develop a standardized architecture for distributed systems, up to and including the application level. It is important to note, however, that the current ISO thrust is not to develop architectural interfaces between the various control levels of a single system (1-2, 2-3, etc.) but instead the architecture, when developed, will direct itself to what are called "peer-to-peer" protocols. For example, level 3 network control protocol to level 3 network control protocol of a remotely located system.

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*The International Organization for Standardization is composed of standards groups from over 20 countries which together develop standards to facilitate international exchange of goods and services.

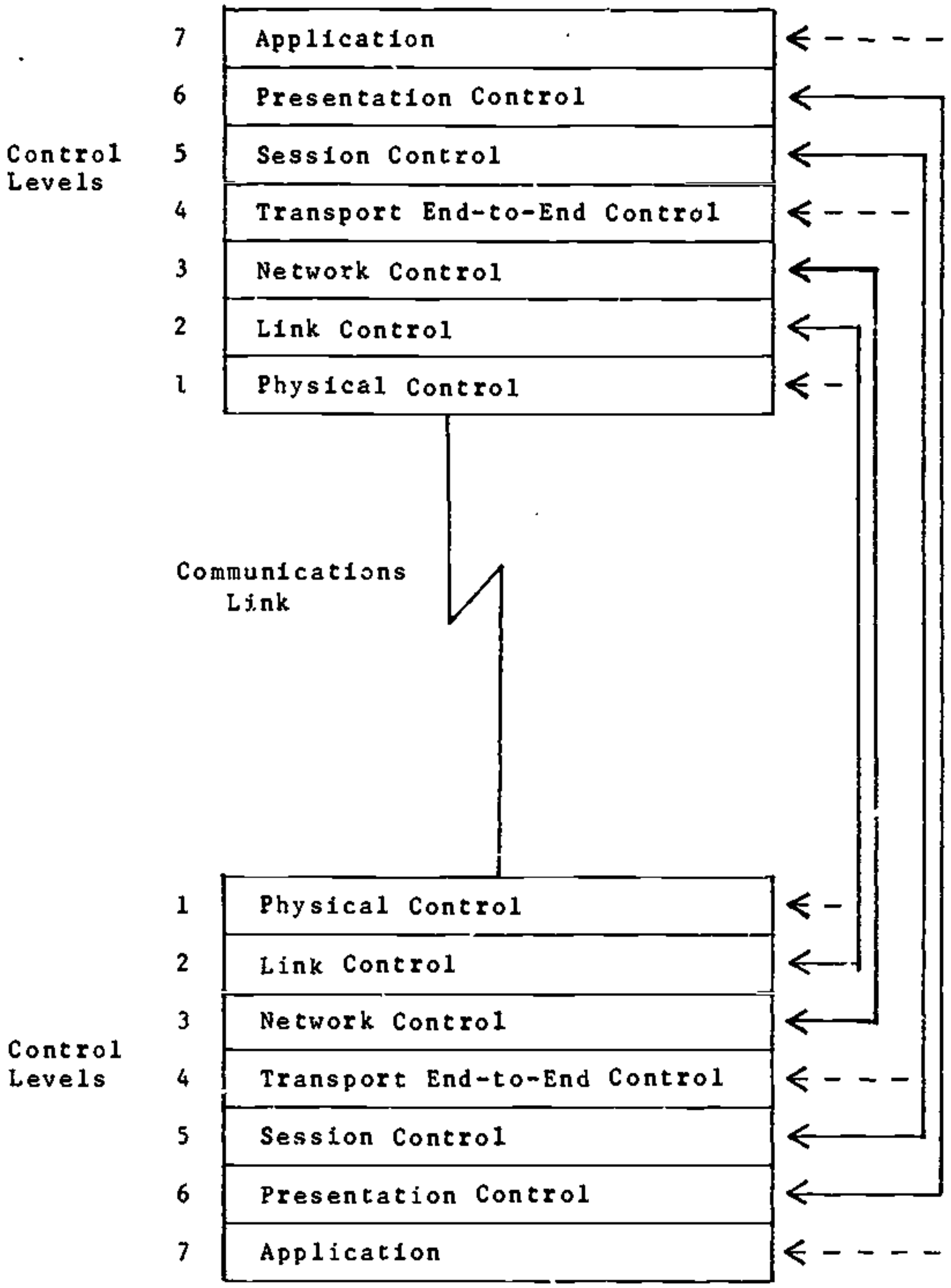
7
Application
6
Presentation Control
Control Levels
5
Session Control
4
Transport End-to-End Control
3
Network Control
2
Link Control
1
Physical Control
Communications Link
1
Physical Control
2
Link Control
3
Network Control
Control Levels
4
Transport End-to-End Control
5
Session Control
6
Presentation Control
7
Application

FIGURE 1 - ISO PROVISIONAL ARCHITECTURAL MODEL

IBM's architecture is called Systems Network Architecture (SNA) (1). Originally announced in 1974, SNA is IBM's blueprint for current and future communications products and systems.

As shown by Figure 2, the provisional model differs only slightly from SNA. For example, under SNA, control levels 3 and 4 are called Path Control and include both the network control and the end-to-end control which are identified as separate levels of the ISO model. Additionally, under SNA, control level 7 "end-user" is in fact the customer and is defined to allow the user complete freedom in whichever application he may choose. At this particular point in time, ISO activities project inclusion of the application level and presume complete system standardization.

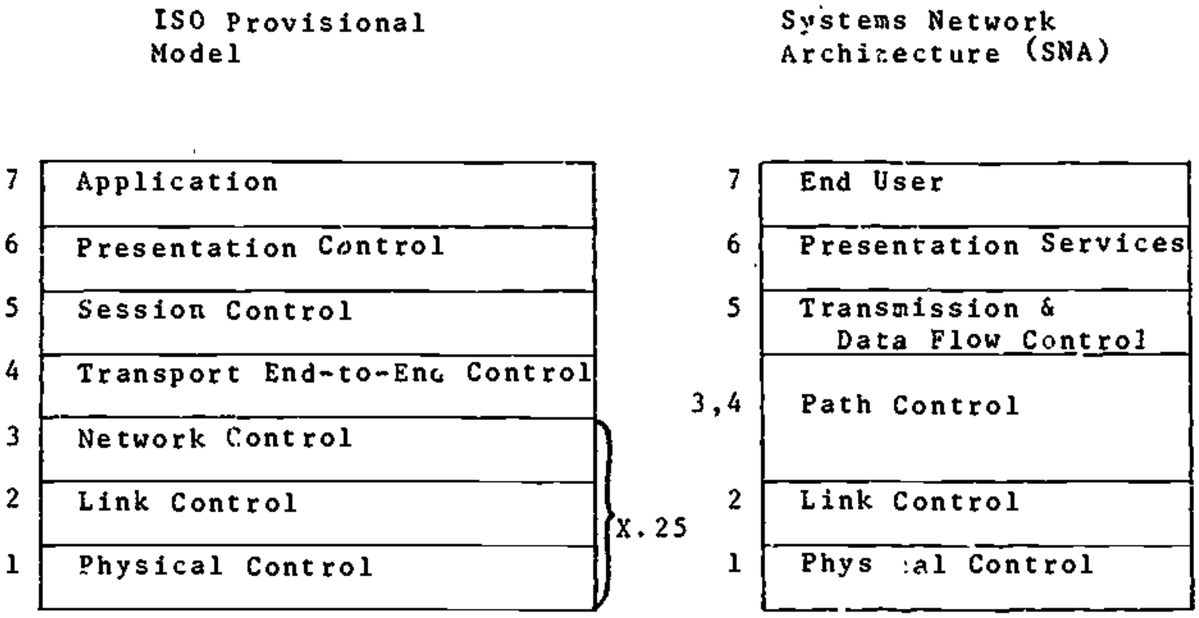
ISO Provisional Model
Systems Network Architecture (SNA)
7 Application
6 Presentation Control
5 Session Control
4 Transport End-to-End Control
3 Network Control
2 Link Control
1 Physical Control
X.25
7 End User
6 Presentation Services
5 Transmission & Data Flow Control
3,4 Path Control
2 Link Control
1 Physical Control

FIGURE 2

CONTROL LEVELS OF THE ISO PROVISIONAL MODEL AND THEIR SNA COUNTERPARTS

PHYSICAL CONTROL

Level 1 is the physical control level and it is identical in SNA and in the ISO model. This level includes the commonplace EIA RS232 type, the conventional CCITT* V24, and the newly introduced CCITT X.21 interface (2) for circuit switched and leased circuit services. IBM supports both the traditional, as well as the new X.21 interface. In addition, it supports a variety of nonstandard communications interfaces such as: channel service unit (CSU) for use on DATAPHONE** Digital Service (DDS), data access arrangements for interconnection with the U.S. switched telephone network, and a variety of special interfaces in both the serial and parallel transmission modes of operation.

Because it uses commands and coded character sets to represent individual functions, whereas the traditional interfaces use individual electrical leads for each interface function, X.21 has been referred to as a "simple" interface. In addition to a reduction in interface leads, X.21 offers enhanced functions and control by means of its use of coded characters. In line with this streamlining, there is encouraging standardization activity on a "mini-interface". This would have physical and control characteristics similar to X.21, and would be used on switched telephone networks. At this stage, this activity appears very promising. One possible exception in the standardization of level 1 interfaces appears to be the recently introduced EIA RS449. While it will offer improved characteristics, it employs the conventional "individual leads per function" approach of older interfaces with the result more complexity (either 37 or 46 pin interfaces) is added to the design of components to support this interface. Because of this added complexity, many manufacturers and carriers seem reluctant to implement EIA RS449 and are taking a "wait and see" attitude.

LINK CONTROL

Level 2, link control, of the provisional model refers to the data link control used to frame users date and transport information either between elements of a users system as in SNA, or between the users Data Terminal Equipment (DTE) and the network node as in the case of store and forward communications systems. In many standards, user choice and flexibility is allowed. For example, the ISO data link control standard, High Level Data Link Control (HDLC) (3) defines 3 basic modes of operation (only one need be chosen) with a number of additional optional commands and responses. This is equally true with ANSI* data link control standard - Advanced Data Link Communications Control Procedures (ADCCP). The level 2 data link control embodied in IBM's SNA, SDLC, is in fact a subset of HDLC and ADCCP and conforms to those standard's Normal Response Mode (NRM) of operation. This mode is one of the 3 basic modes introduced above and most widely used in multipoint terminal environments whereby secondary stations (terminals) are polled by a "primary" or host location.

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* The International Consultative Committee for Telegraph and Telephone headquarters in Geneva, Switzerland, is part of the International Telecommunications Union.

** Registered servicemark and trademark of the American Telephone and Telegraph Co.

NETWORK CONTROL

Level 3, network control, of the provisional model defines address and transmission headers to facilitate routing of information within the network. CCITT international standard, X.25 (5) which defines packet headers, is an example of standardization of level 3 functions. In IBM's SNA, levels 3 and 4 are combined so that path and flow control are included as well in the transmission headers. While there are differences in functions (SNA contains many more), it is important to note that in X.25, level 3 protocols are defined for operation between the DTE and the network. In SNA, path control is a DTE to DTE function.

Referring again to Figure 2, note that CCITT recommendation X.25 is not only control level 3 but includes the first 3 control levels of the ISO model-physical, link, and network control. While not yet developed, levels 4-6 will be end-to-end control and device dependent functions and they are beyond the scope of X.25. Based on the above and again as shown by Figure 2, CCITT X.25 standards cover the movement of information between devices and the network and do not specify or cover characteristics of attached devices. One should conclude therefore, that contrary to some public opinion, adherence to the X.25 standard will not give users the "any-to-any" which they seek. Only by matching at these higher level control protocols, can one approach the ideal of any device communicating with any (other) device. Although articulated in great detail in SNA, because these higher level standards have not been drafted by ISO, no further discussion of them will be included in this paper.

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* The American National Standards Institute. A federation of approximately 180 organizations which serves as the national coordinating institution for development of national standards and represents the U.S.A. in certain international standardization organizations.

OTHER PACKET NETWORK CONSIDERATIONS

While X.25 defines the levels required to move information from a DTE to a packet network (in the packet mode) many feel that this interface definition is "too rich" and hence too costly for simple synchronous terminals which might wish to attach and to operate. The ability to operate in full duplex ABM mode, handle 4096 virtual channels and accommodate "unnatural" buffer sizes are examples of the problems simple DTE's project. Additionally, at this particular time there is not complete uniformity of network implementations of X.25 (6). To allow for simpler synchronous terminals, at lower or minimal cost, IBM has proposed a single channel interface which essentially would require the packetization and polling functions to be located in the network node, thereby eliminating most of the additional requirements from the simple Single Channel DTE (SCDTE). Adoption of this proposal would allow the terminal to operate in essentially the same fashion as on physical private line circuits. By incorporating the call-establishment procedures of X.21 in the SCDTE, this proposal would enable switched virtual circuits to be handled in a fashion similar to that of switched physical circuits.

In addition to the simple single channel data terminal equipment interface proposal defined above and under study by CCITT, there are a number of additional interfaces and enhancements worthy of note. CCITT standard X.75 defines the access protocols between 2 different public packet networks. It is IBM's view that inasmuch as SNA and other architectures define "private packet networks of a type" that there may be advantages to the use of X.75 for attaching private packet networks to public packet network facilities. Todays approach is to treat attachment of a private network as if it were a single packet mode DTE. Additionally, for certain start-stop terminals which do not have the basic means nor capability for conforming to X.25, CCITT standard X.28 has been defined. It covers interfacing start-stop devices to special packet network nodes which provide the packet assembly-disassembly (PAD) function. Moreover, a number of network suppliers provide direct support to binary synchronous communications (BSC) terminals via network node capabilities called network interface machines. Figure 3 shows the variety of packet network interfaces under consideration at this time.

OTHER CONSIDERATIONS

There are a number of enhancements to X.21 currently under discussion; the mini-interface for use on switched telephone like networks, the ability to multi-point terminals on X.21 based digital private line service, and the ability to "streamline" the interface by providing a multiplexed X.21 link interface. This latter capability solves physical attachment problems and is based upon the advantages inherent in the basic X.25 multiplexed interface.

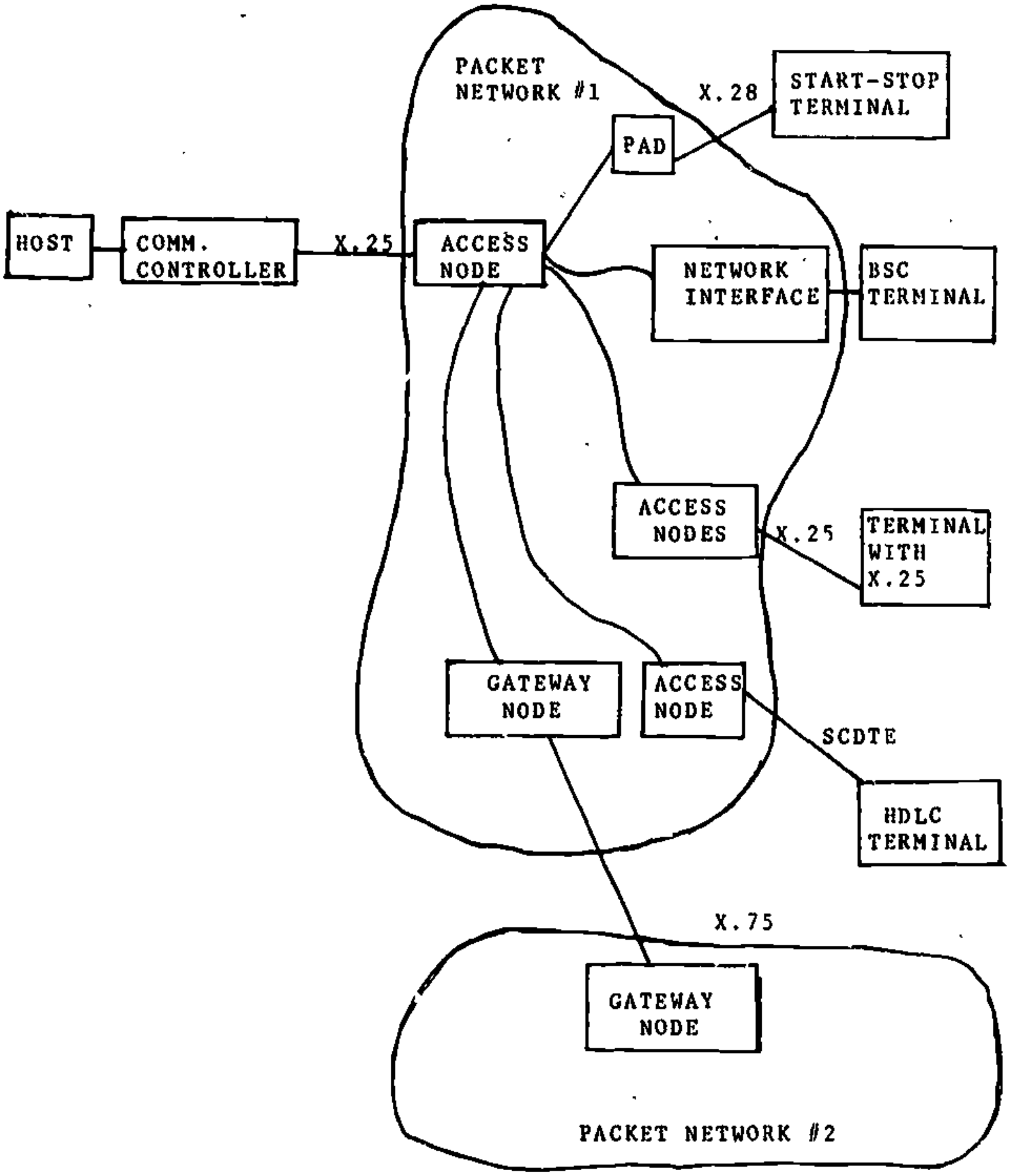
PACKET NETWORK #1
X.28
START-STOP TERMINAL
PAD
HOST
COMM. CONTROLLER
X.25
ACCESS NODE
NETWORK INTERFACE
BSC TERMINAL
ACCESS NODES
X.25
TERMINAL WITH X.25
GATEWAY NODE
ACCESS NODE
SCDTE
HDLC TERMINAL
X.75
GATEWAY NODE
PACKET NETWORK #2

FIGURE 3 - SOME OTHER PACKET NETWORK INTERFACES

SUMMARY

As the world of communications-served data processing systems grows in sophistication, communications standards are becoming increasingly more important and crucial to all parties involved. Because of this, great care and diligence must be taken to ensure the development of standards in the interest of users. While recognizing communications standards are increasingly becoming more wide in scope, IBM's position, to the extent it makes good technical and business sense, is to support and "converge" on these standards.

IBM today is actively supporting X.25 standardization. X.21 and HDLC essentially are integral parts of the X.25 standard and IBM has already announced certain subsets of those on a world-wide basis. In certain countries where those interfaces are available for attachment to public packet networks, the level 3 packet interfaces of X.25 are being provided by IBM today on a special "RPQ" basis.

It is IBM's intention to continue to work closely with appropriate standards bodies to develop technically excellent communications standards which will be in the interest of its users.

References

1. Systems Network Architecture General Information, GA 27-3102; available through the local IBM Branch Office

2. Orange Book, Volume VIII.2 Public Data Networks, CCITT Sixth Plenary Assembly, Geneva (September 27 - October 8, 976)

3. Data Communications - High level data link control procedures - Frame Structure, ISO Standard ISO/3309-1976

4. IBM Synchronous Data Link Control General Information, GA 27-3093-2; available through the local IBM Branch Office

5. Provisional Recommendations X.3, X.25, X.28 and X.29 on Packet-Switched Data Transmission Services, CCITT, Geneva (1978)

6. A Comparison of Four X.25 Public Network Interfaces, M. Brethes, M. Hess and A. Saito, ICC Proceedings, Boston, June 1979

REPORT OF THE GTE
TEST OF IBM 3270 BI-SYNCHRONOUS
POLLED TERMINALS ON THE TELENET
PACKET SWITCHING NETWORK

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GTE SERVICE CORPORATION
TAMPA, FLORIDA

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1. PROBLEM DEFINED

The challenge of this test was to verify that IBM 3270 (and/or its equivalent) polled bi-synchronous terminals could be connected to the Telenet network and to determine the relative performance of this technology for GTE application systems.

In a polled conventional network, an IBM host constantly sends "poll" messages to check whether any of the terminals connected to it via communications lines have any data to transmit. These Terminals cannot send data except in response to a poll. Poll messages are line overhead and serve no function in the network.

The hardware/software technology is emerging that will satisfy the need to put 3270 polled bi-synchronous terminals on packet-switched networks. After examining all known vendors in this specialized field, Cambridge Telecommunications, Inc. (CTX) was chosen for this test because their hardware and software is the only known product that is available to perform this function that works.

This technology is CTX' implementation of X.25 Level 4 protocol currently being defined by ISO and CCITT in their Open System Architecture development.

2. SCOPE

2.1 Scope of need

GTE is committed to further automating business operations in the 1980's. Terminals at various operations centers will provide a wide range of information for maintenance and administrative personnel by enabling access to several existing and planned computer systems simultaneously.

GTE internal automation plans require support of a wide range of terminal and computer equipment which use asynchronous and bi-synchronous protocols for data transmission. Instead of having separate networks for each system and for the different types of transmission protocols, it is advantageous to have one network being able to handle many types of transmission protocols.

Traditional circuit switching performs somewhat inefficiently for most data traffic because of the dedication of channel capacity. The network technology of Telenet, X.25 packet switching, has proven to be an excellent means of efficiently handling asynchronous data. However, there is an equal need to support IBM's 3270 polled bi-synchronous protocol on private Telenet networks.

Advantages of packet switching - such as efficient line utilization, distance insensitivity, and network reliability - are provided

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by intelligence in the network. In order to use private networks effectively, batch synchronous and polled bi-synchronous data is needed in addition to asynchronous traffic. Also, adding bi-synchronous traffic meets a fundamental need of automating telephone operations - the need for one terminal to access several applications systems on dissimilar hosts (some using asynchronous protocols, others using bi-synchronous protocols) simultaneously.

2.2 Hardware/Software Products Used in the Test

Data Modified Emulator (DMEP)

DMEP is an interface program produced and marketed by Cambridge Telecommunications, Inc. (CTX) that is used to provide access to X.25 packet switching networks for IBM 370 or equivalent Host Processors and, in addition, is capable of providing support for conventional networks.

DMEP runs in a standard IBM 370X communications controller under BTAM or TCAM. The IBM Emulation Program (EP) operates concurrently in the 370X as a subsystem of DMEP. No changes to current EP Configurations or existing 370 Host software are required. A wide variety of terminal types including ASCII, TTY, 2741, 3767, and 3270 clustered terminals may be connected to DMEP thru the packet switching network.

Support for a conventional network (in the sense of configuration of IBM and other terminals supported by a standard IBM supplied EP) is provided by the Emulation Program. All EP supported terminals are also supported by DMEP regardless of whether they are connected to the 370 communications controller via point-to-point or multipoint communications lines, through the switched network or over private lines, using ASCII or EBCDIC.

CTX 9101 - Intelligent Network Interface Processor

The 9101 is a microprocessor-based communications computer produced and marketed by CTX that supports one 2400 bps to 50 kbps X.25 access line and up to three 2400 to 9600 bps BSC/3270 half or full duplex input lines which can be multi-dropped. The CTX Intelligent Network Interface Processor (9101) connects a variety of synchronous and asynchronous terminals to X.25 Packet Networks. It allows terminals such as IBM 3270 BSC clusters and asynchronous TTY's to communicate through X.25 networks with IBM host computer mainframes. The 9101 manages all X.25 functions with no changes required to the host software or the terminals software/hardware. The X.25 access line can be configured with either bit-framed HDLC or BSC-framed HDLC. Asynchronous lines operate at 110 to 9600 bps with automatic speed detection standard.

The IBM host access method (TCAM or BTAM) is unchanged, so it issues polls to DMEP which appears as a virtual cluster of 3270 terminals.

DMEP replies appropriately but does not send the poll through the network. The CTX 9101 sends polls to the real cluster of 3270 terminals. It transmits only data blocks in X.25 format over Telenet to DMEP. The host and 3270's do not know that a real leased line does not exist. The host polls as it believes it should. The 3270 is, in fact, connected by a real line to a 9101. The difference could be apparent to the 3270 field operator, since he would either request a call for each active terminal or have this ability incorporated in regular session start-up procedures.

Terminals in Tampa for this test

A 4800 bps circuit was installed between the Atlanta Telenet node and Tampa. This circuit was connected to a CTX 9101 device which was located at the Flagship Bank Building in Tampa. Although the 9101 can accommodate up to three BSC lines, only two were used for this test. On the first line, a Teletype 40/4 was connected and on the second line an IBM 3271-2 with a 3277 CRT was attached.

VM/370 host in Boston used by CTX for testing

To initially set up the test to verify the 9101 was working properly, both terminals in Tampa accessed a 370/138 CPU with Virtual Memory (VM) located in Boston. This host contained the Conversational Monitor System (CMS) operating with the Telecommunications Access Method (TCAM).

It was connected to a 3705 Communication Control Unit which contained CTX's DMEP software.

The Host in Marina Del Rey, a GTE Data Center

Another 4800 bps circuit was installed between the Los Angeles Telenet node and an IBM 3705.

The 3705 was connected to a 370/165 II CPU host using the IBM TCAM access method.

Application in Marina Del Rey

Customer Information Control System (CICS) in the Marina Del Rey CPU host provided support for the local online application system. The application that we were accessing was a service order processing system used by General Telephone of California.

Configuration

A configuration of the hardware and software used in this test and their relationship to the Telenet public network is diagramed at the end of this report.

3. ORGANIZATION AND CONDUCT OF THIS TEST

3.1 Organization

The Advanced Telecommunications Planning Group of the GTE Service Corporation was responsible for the conduct and success of this test.

3.2 Conduct of the Bi-Synchronous Test

On Monday, June 18, the physical connection between the 3270 and 40/4 terminals in Tampa and the host in Los Angeles was established. We were able to access the VM host in Boston to verify the 9101 was working properly by this date. Response times between the 3270 via Telenet to the VM host in Boston were very fast - consistently less than 3½ seconds.

The actual test began Tuesday, June 19 and lasted until Monday, June 25. Each day, the terminals established a connection with the GTE application which lasted nearly two hours. During that time, transactions were entered into both the 3270 and the 40/4 terminals based on the screen format generated by the application. Response times were recorded for most of the transactions entered during the test.

Since TSO (Time Sharing Option) was available in the Marina Del Rey IBM host that was running the application, we decided to attempt to access it with our terminals in Tampa. This was done very easily, and response times to TSO were recorded.

4. RESULTS

4.1 Data Integrity

In the planning stages of the test, we received from General Telephone of California the input format for the application we would use for our test. We varied the entries as must as possible. The length of the lines varied between 5 and 65 characters, with the number of lines varying from 3 to 15 lines. Some of the lines were all numeric, some all alphabetic but most were alphanumeric.

The formats were sent via Telenet to the application residing in the GTE Marina Del Rey Data Center 360/165. The application system, in turn, produced a tape file daily of all transactions generated by the terminals.

This file of transactions would normally go to subsequent batch runs in the production application processing cycle which is run daily. This tape, instead of being fed into the daily production batch cycle, was printed and was forwarded to us in Tampa. We then compared the input generated on the terminals in Tampa to the output we received. It matched completely, indicating there was no altered data and no data lost as a result of sending it via Telenet as compared to sending it via a private, dedicated network.

4.2 Response Times

Response times were taken during the test but were not conclusive because of the light load generated during the test by just two terminals.

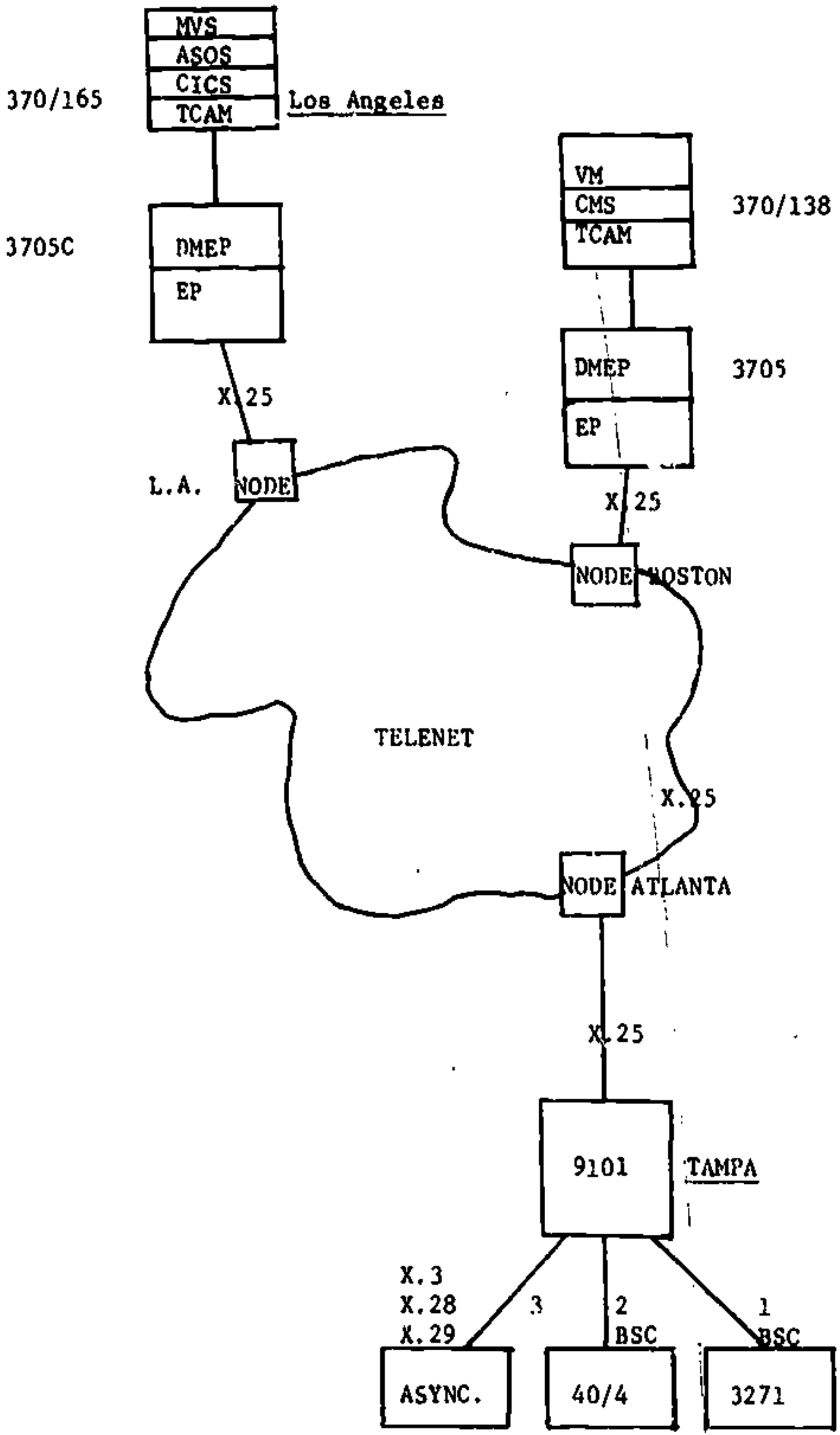
We did record response times during our test and found them to be comparable to what General Telephone of California is experiencing with the application in a production environment today.

Overall, we were pleased with the response times experienced during this test. However, more work is needed in this area so we can determine response times in heavily loaded production environments.

5. Conclusions

The test has indeed proven that it is possible to accommodate 3270 polled bi-synchronous data transmission on the Telenet X.25 packet-switching network. Using the CTX 9101, only two steps (initializing the 9101 and accessing the Telenet host) were needed before the first transaction could be entered. Thus, the technology is emerging to add bi-synchronous data traffic to public and private X.25-based packet switching networks.

CONFIGURATION OF THE HARDWARE AND SOFTWARE IN GTE's TEST OF 3270 POLLED BI-SYNCHRONOUS TERMINALS OVER TELENET


MVS
ASOS
CICS
TCAM
370/165
Los Angeles
3705C
DMEP
EP
VM
CMS
TCAM
370/138
DMEP
EP
3705
X.25
L.A.
NODE
X.25
NODE
BOSTON
TELENET
X.25
NODE
ATLANTA
X.25
9101
TAMPA
X.3
X.28
X.29
3
2
BSC
1
BSC
ASYNC.
40/4
3271

Pacific Telecommunications Conference
Honolulu, Hawaii January 7-9, 1980

"Marketing Packet Switched Networks"

By P.J. Murphy
The Computer Communications Group
TransCanada Telephone System
Ottawa, Canada.

Session: Packet Switched Networks (II)

In Canada, The Computer Communications Group of the TransCanada Telephone System have taken packet switching from a technological idea through engineering and service development to actual implementation and application by major data communication users.

Introduced by TCTS in 1977, Datapac was Canada's first packet switched network and one of the first in the world in commercial operation. Today, the number of customers on the system, the number of orders now placed and three full years of experience in operating the network convince us that packet switching is a sound, practical, economic technology and permits a range of service offerings that has wide appeal and acceptance by users.

The addition of Datapac to our existing portfolio of network services has been both challenging and rewarding. Today, I welcome the opportunity to share with you the implications of this and specifically our experience in marketing packet switched networks.

I do not intend to give a highly technical presentation, but rather to address this subject from a marketing perspective.

In order to provide a background for my discussion, I would like to take a few moments to discuss the Canadian geography and our population distribution since these factors have had a significant influence on our communications development. In addition, I would like to describe the TransCanada Telephone System structure and the corporate organization of Bell Canada.

Canada has a population of approximately 23 million inhabitants scattered over 10 million square kilometers of territory. About 80% of that population is spread along a very narrow corridor 4500 kilometers long, just north of the american border. The other 20% is scattered over the remaining vast territory of our country, but this 20% requires great innovation and resources to serve effectively, even with basic communications.

Addressing these communication needs is the TransCanada Telephone System comprised of nine telephone companies and the Canadian satellite corporation Telsat. These individual companies work together under a committee structure and each owns and operates the telecommunication facilities in its own territory. These facilities include approximately 138 million kilometers of copper wire, over 83 thousand kilometers of high capacity coast-to-coast microwave and almost 100 satellite earth stations.

Bell Canada, the largest of the 10 TCTS member companies, is also the parent company for Northern Telecom Canada and Bell-Northern Research. This corporate organization of research, manufacturing and operations has, we believe, resulted in one of the world's leading telecommunication systems.

The TCTS Datapac network is a prime illustration of how effectively these organizations work together. The research and development of the switch, called an SL-10, was done to our specifications by Bell-Northern Research in Ottawa and the switch manufactured by Northern Telecom Canada. This union has resulted not only in success for Datapac domestically, but also in demand for the SL-10 switch internationally. The Deutsche Bundespost has recently made the decision to use the Canadian SL-10 for its large public packet network in Germany. Switzerland has also selected this same switch and other carriers and private networks in other parts of the world are actively examining its application.

There is no question that the resources of the various organizations supporting The Computer Communications Group have played an important role in Datapac's success, but, equally as important is the fact that we do not market packet switched networks -- at least, not in isolation. No one network technology or network approach is totally suitable to every data communications requirement, so we in CCG believe it is necessary to provide a complete portfolio of network services. This portfolio approach enables us to select the optimum service or combination of services to satisfy each customers unique communication needs. CCG's fundamental approach to marketing networks is therefore centred on a portfolio of services based on private line, circuit switching and packet switching technologies.

Having briefly mentioned packet switching and Datapac in my opening remarks, I will now focus on CCG's other network options -- private line and circuit switching.

With the introduction of The Dataroute by CCG in 1973, Canada was the first country in the world to put a nationwide digital data transmission system into commercial operation. Prior to that time, private line data transmission was available through the use of specially conditioned voice band circuits. Dataroute service was developed in response to growing customer demands for less costly data communications, for better transmission quality, and for new service offerings which take advantage of today's technology. This data only network provides total end-to-end digital data services in a broad range of asynchronous and synchronous speeds for both full and half duplex systems. The Dataroute network, in addition to providing private line services for our customers, is also our basic transport medium upon which our switched network options such as Datapac are built.

As of this point in time, CCG's circuit switching options are based on the use of the analogue telephone network. Dataphone service, at speeds up to an including 2400 bits per second, is used extensively for local data transmission and to a lesser degree for long haul traffic. Multicom family of services, through the use of specialized or dedicated analogue switching equipment, provides for switched voice and data transmission between major Canadian cities at speeds up to and including 50 kilobits per second.

In approximately one year, CCG will introduce a circuit switched digital data service which will be based on the use of our new digital switches being installed for voice services. These digital switches which are called DMS (Digital Multiplex Switch), have been designed by Bell-Northern Research and are manufactured by Northern Telecom Canada. These switches, together with our digital transmission facilities, will have a significant impact on the basic cost of providing total communication services, both voice and data. With digital switching at up to 64 kilobits per second, this service will augment and to some degree replace our existing circuit switched analogue services.

With the addition of packet switching and Datapac, this then completes our portfolio of network services. This portfolio will also permit the development of a family of value-added services to further satisfy customer needs. Such services include message switching, electronic mail and "office of the future" type business services. In other words, the network capability is the foundation upon which all other services can be based.

To this point, I have identified two fundamental areas we believe to be essential to the marketing of packet networks. The first was an organization with skills encompassing research, manufacturing and operations which enables the translation of leading-edge technology into network services for the marketplace. Secondly, a market approach based on a complete portfolio of network services to provide the flexibility and choice necessary to address the total requirements of customers today and in the future.

I will now focus more specifically on packet switching and highlight our experience over the past decade in marketing Datapac. Throughout this time period, the end users of data communications have been intimately involved in virtually every stage of the design, development, engineering, installation and application of the Datapac network.

As a result of fundamental data research and detailed data market studies conducted early in the 1970's, we were able to determine both the markets to be addressed and the sequence in which specific Datapac services should be developed. First of all, we wished to provide basic access to the network for intelligent terminals and computers with X.25 capabilities. At the same time, we wanted to offer Datapac access to the large universe of asynchronous terminals. We also identified a later requirement to reach the retail and point-of-sale markets, which include electronic cash registers and many other terminal devices. Because of the massive population of 3270-type terminal users, this was a key candidate for a packet switched network service, as was the overall remote batch market.

In order to accommodate the variety of terminals within these various market segments prior to the widespread availability of X.25 interfaces, the need was identified for the development of Network Interface Machines (NIM's). These NIM's would supply the intelligence to packetize data for transmission over Datapac to the appropriate computer, and depacketize return data traffic for presentation to the terminal. From a users perspective, the NIM enables terminals to be linked to the Datapac network with no special hardware or software required.

With the commercial availability of Datapac in 1977, the first two packet-switched services supported ...

- Intelligent terminals and computers conforming to the Standard Network Access Protocol (SNAP), Datapac's version of the X.25 international standard.
- Non-intelligent asynchronous teleprinter-type terminals dominent in timesharing and data base access applications.

Over the next two years, additional Datapac services were developed and introduced for ...

- Buffered, pollable, asynchronous terminals operating under the ISO poll/select line protocol found in retail point-of-sale applications.
- Buffered, pollable, asynchronous terminals operating under an enhanced IBM 2740 Mod II line protocol intended almost exclusively for the consumer loan industry.
- IBM 3270-type terminals in widespread use in on-line systems both in industry and government.
- IBM multi-leaving type terminals in common use in Remote Job Entry (RJE) applications.

Having addressed the existing terminal population with a comprehensive family of Datapac services, our attention then focused on how we could assist customers to connect their host computers. Our close liaison with manufacturers and independent software organizations in the development of X.25 interfaces was starting to result in the availability of products in the marketplace but further options were required to compliment this evolution.

First, was the development and provision of Datapac Access Software (DAS) for users with host computers and 370X-type front end systems. This software package, once loaded into his system, would provide the necessary interfaces between his conventional teleprocessing access methods and the Datapac network. In addition, end-to-end support was included to enable communications with his remote terminals connected to Datapac via one of our NIM based services.

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For customers with other types of systems, we modified and enhanced our existing NIM concept for terminals in order that this could also be used for the connection of host computers. This NIM to NIM capability resulted in the availability of a "transparent" form of datapac service whereby all customers wishing to use the Datapac network could do so without making changes to their systems. This approach has the added appeal of providing a graceful migration path between conventional forms of communications and X.25 packet-mode links.

One of the realities of computer communications in Canada is a direct result of our geographical position and economic-social-political interrelationship with the United States. The existence of multinational corporations and companies doing business in both countries dictates the necessity for a great deal of transmission of data across the border. So we developed appropriate hardware, software and standards which would allow interconnection between Datapac and packet-switched networks operating in the U.S.

In January 1978, TCTS filed tariffs for connection with Telenet and TYMNET, interconnection which allowed subscribers in more than 100 cities in the U.S. access to host computers and terminals in 55 Canadian Datapac Serving Exchanges. The key to the linking of these packet networks was the acceptance and implementation of agreed-on international standards based on the already approved X.25 protocol. Datapac/Telenet and Datapac/TYMNET were the first commercial linkings of X.25 packet networks.

Datapac service to Hawaii is now available through your DASNET packet-switched network, provided by the Hawaiian Telephone Company through a direct connection to Telenet in the continental U.S.

We are also working with overseas carriers through Teleglobe Canada, the Crown corporation chartered to provide overseas telecommunication services, to introduce links between Datapac and European packet networks.

There are over 2000 connections to the network and some 200 customers now operating on Datapac with a wide variety of applications. The close cooperation between our planning, sales, engineering and installation people and the EDP specialists and general management staff of potential users has been a key factor in the effective implementation and utilization of CCG's various packet switching services. To ensure this, sales and technical support groups have been established to provide "state of the art" consulation.

Datapac services, even before commercial implementation, are being used by actual data users in internal field trials by Bell-Northern Research and Bell Canada's Corporate Systems Organization (CSO), one of the largest computer facilities in the country. Subsequently, major customers are encouraged to participate in these trials in order that they can assess firsthand the benefits of packet switching and at the same time benchmark the performance of Datapac.

Today, with critical business functions being put online to computers, network management is a prime customer consideration. Datapac has an availability objective -- which we are meeting -- of 99.80 percent. This is a result of (a) standby equipment; (b) the provision of alternate routes through the network; (c) sophisticated network monitoring and control systems (made economically feasible through sharing); (d) the intelligence of the network which can monitor its own performance and correct instances of deterioration -- often before the user is affected.

To maintain this high level of performance, a National Data Control Centre in Ottawa provides network surveillance for TransCanada Telephone System member companies and is manned 24 hours a day, 7 days a week. Datapac network surveillance responsibilities of the NDCC include alarm surveillance, network control and software changes, which are accomplished through the use of the Network Control Centre node, a unique node within the network. All alarms and billing information are collected in this node and transmitted to the host computer.

In summary, essential to the marketing of packet switched networks as is true for all networks, is a focus on the eventual user -- the customer -- from the initial research and planning to the actual installation and management.

Today I have just briefly touched on some of the considerations involved in marketing packet switched networks. Within this is a challenge, involving all aspects of marketing, to resolve the optimum combination of networking technologies and to translate these into a complete portfolio of services to both satisfy and stimulate the computer communications marketplace.

PANEL ON

THE 1979 WORLD ADMINISTRATIVE RADIO CONFERENCE

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Director General
Department of Communications
Ottawa

Mr. R. Butler
Deputy Secretary General
International Telecommunications Union
Geneva

Mr. R. Kirby
Director
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Presidente
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SUMMARY

This panel will describe the role of the International Telecommunications Union (ITU) and the special meaning of World Administrative Radio Conferences (WARCs) that are held periodically by the ITU. The impact that the 1979 WARC will have on the role and work of the CCIR over the next decade will be explored. The significant results of the 1979 WARC deliberations as they impact on Pacific Basin countries with special emphasis on mobile radio and satellite allocations will also be summarized. Finally, more than 150 radio amateurs played key roles in all aspects of the WARC deliberations. In this regard new opportunities for amateurs as well as the amateur experimental satellite program and associated WARC results will also be reviewed.

PLANNING THE EVOLUTION OF THE VIDEOTEX NETWORK

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Abstract

The purpose of this paper is to discuss the evolution of the videotex system concept with special emphasis on network requirements. The logical format of the long term videotex network is presented and examples of possible configurations using a switched data network are given.

I. INTRODUCTION

Videotex is the generic name given to a new class of interactive visual information services for bidirectional transmission of data, usually based on the telephone line. A TV set is often used as the display, with an adapter module interconnecting the telephone line and the TV set to a hand-held keypad (or sometimes a keyboard) with which the customer interacts with the system. Data is retrieved interactively from videotex exchanges through the telephone line, and characters and graphics are displayed on the screen of the TV set. Although broadcast videotex-like services are also possible, based on TV-line/frame grabbing technology, they are not considered in this paper, since generally they are not fully interactive.

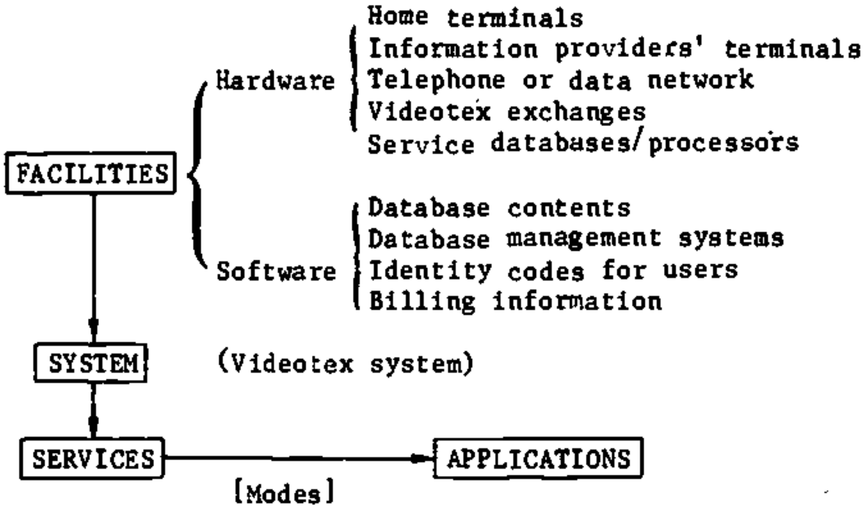
Videotex services are being tested in a number of countries including Canada (e.g. Bell Canada's Vista [1]), the U.S.A. (e.g. Dept. of Agriculture's Green Thumb), England (e.g. BPO's Prestel), France (e.g. CCETT's TELETEL), West Germany, Holland, Finland, Denmark, Sweden, Spain, Switzerland, Hong Kong, and Japan (e.g. CAPTAINS). Information retrieval seems to be generally accepted as the introductory service but other interactive services are possible. Once the system becomes popular it will open the door to other opportunities. Indeed, to obtain a cost-effective system the facilities must be shared as much as possible among different services. The videotex service possibilities are briefly reviewed in Section II.

Since videotex is basically a visual service, the requirements and alternatives for coding visual information are discussed in Section III.

The expected increasing demand for videotex services will require an expanding network of videotex centres. This is the subject of Section IV. The logical format of a long term videotex network is presented and examples of possible configurations are given.

II. VIDEOTEX SERVICES

A review of the literature on new services (e.g. References [2],[3]) shows that there appears to be much confusion about what constitutes a service. Indeed, most published lists of services turned out to contain applications rather than services. In fact, a combination of facilities (comprised of hardware, software and network) constitute a system which gives rise to services. The services are then put to several applications by the users; this can be shown diagramatically as follows for videotex:


FACILITIES
Hardware
Home terminals
Information providers' terminals
Telephone or data network
Videotex exchanges
Service databases/processors
Software
Database contents
Database management systems
Identity codes for users
Billing information
SYSTEM
(Videotex system)
SERVICES
APPLICATIONS
[Modes]

1. Information retrieval
   - [General]
     - News, weather, sports, etc.
     - Timetables
     - Advertising
     - Price lists
     - Etc.
   - [Customized]
     - Shopping basket
     - Stock price levels
     - Profiled information
     - Etc.
2. Interest matching
   - Houses
   - Cars
   - Jobs
   - Car pools
   - Babysitters
   - Etc.
3. Messaging
   - [Store-&-retrieve, Store-&-alert, Store-&-forward]
     - Greetings
     - Personal messages
     - Electronic mail
     - Etc.

4. Commercial transactions		Reservations (restaurants, hotels, car rentals, transportation, etc.) Ticket purchases Catalogue purchases Electronic funds transfer Etc.
5. Questionnaires		Puzzles Tests Polls Surveys Etc.
6. Personal database		Personal diary Recipes Bibliographic references Mailing lists Etc.
7. Calculations		Tax calculations Loans Finances Operational costs Calculated information retrieval Etc.
8. Computer Games	Customer-computer Customer-customer Downline loaded	Mazes Word guessing Chess Strategy and tactics Etc.
9. Education		School & university instruction Specialized training Education of the handicapped Language-training Etc.
10. Software distribution for execution in terminal		Calculations Games Computer aided instruction Etc.

This list is used to illustrate some of the potential applications of videotex. In general, the applications of videotex are very large in number and also overlap each other; for example, reservations and purchasing applications could both be considered to be part of the message services category.

It is important to mention these applications of videotex, however briefly, since they constitute the bedrock for all subsequent planning, design and implementation. Many important decisions regarding picture coding, terminal design and network topology rest on judgements concerning what will be the most popular videotex applications.

III. VISUAL INFORMATION CODING

An important part of the videotex system design is the coding of visual information displayed on the screen of the TV set. Audio may be eventually integrated with visual information to enhance the user-appeal of the service; however, this topic will not be discussed in this paper. The visual information which has to be encoded can be divided into the following classes:

1) ALPHANUMERIC TEXT

There are two kinds of alphanumeric text, general and positional, depending on whether or not the text can be re-formatted without distortion of meaning.

i) General Text: This is the usual form of presenting textual information divided into sentences and paragraphs. This form of text can easily be re-arranged without distortion of meaning, regardless of the number of characters per row and the number of rows in the display terminal.

ii) Positional Text: This text is encountered in information which is organized in columns and rows, namely tables. It may also be used to compose simple pictures (e.g. histograms) which are aptly described as 'typewriter graphics'. Positional text would also be found in conjunction with graphics for annotation purposes.

2) GRAPHICS

There are two types of graphic figures: lines (e.g. polygons, arcs, circles, rectangles, etc.) and solid shapes or areas defined by closed lines and filled with a uniform colour and brightness, crosshatch, or texture.

3) STILL VIDEO IMAGES

As opposed to graphics, still video images do not have regions of different colour and/or brightness delimited by lines, but rather the variations may be gradual from pel to pel (pel = picture element). Due to the large number of bits necessary to describe an image and the relatively low data rate of the telephone line, it is desirable that the image coding, transmission and build-up at the terminal is done by superimposing layers of increasing resolution rather than by completing each pel before the next is transmitted.

4) FULL MOTION VIDEO

Full motion video, such as television, is outside of the present scope of videotex. In the future this may become possible by merging videotex and TV technologies.

5) SPECIAL EFFECTS

Flashing displays and very simple moving graphics are possible and may be considered as special effects; for example, updating the hands of a clock in real time.

Having discussed the classes of visual information, we can now examine three methods of coding this information which have been proposed in the international arena:

1) ALPHA-MOSAIC

Examples of systems using this type of coding are Prestel and Teletel. With NTSC television standards, the alphanumeric information is fixed on a grid of (say) 20 rows by 40 columns. Graphic information is composed by subdividing each 'window' into 6 'panes'. This creates a fixed graphics grid of (say) 60 rows by 80 columns. Graphic information is sent in the form of 'graphic characters' or graphic elements juxtaposed to build the image. If the picture has been stored in an alpha-mosaic manner in the database, any improvement in the resolution of the user terminal does not improve picture quality or graphics. The information transmitted to the user terminal is almost independent of the complexity of the picture (about 800 bytes per frame in this case).

2) ALPHA-GEOMETRIC

Telidon [4], a videotex system developed by the Canadian Department of Communications, and Scribblephone [5], a terminal-to-terminal visual communications system developed by Bell-Northern Research (the research subsidiary of Bell Canada and Northern Telecom), are examples of systems using alpha-geometric coding. Alphanumeric information (comprising, say, 20 rows by 40 columns) is transmitted by means of ASCII codes; but it can be specified on the screen within one pel accuracy. This permits subscripts, superscripts and annotations. Graphic information is stored as vectors (lines and arcs) on a conceptual grid of, say, 4096 lines by 4096 columns. Picture quality depends on the display resolution of the user terminal. The amount of information transmitted to the user terminal depends on the complexity of the picture (25 bytes to 4000 bytes, 1200 bytes being 'typical').

3) ALPHA-PHOTOGRAPHIC

This method, which is being studied by Bell-Northern Research, is allowed for in the alpha-geometric scheme by permitting a pictorial description mode. One scheme involves transmitting the picture in pel-by-pel format or, better still, as successive layers of increasing resolution.

The alpha-mosaic coding scheme was adopted for the initial Bell Canada Vista demonstration, because decoder chips were readily available and because the scheme was simple and relatively inexpensive at the time. The Vista pilot demonstration has since been upgraded to include alpha-geometric capabilities, to help determine whether the higher-quality graphics justify the higher costs.

Ideally, the coding method should be as independent as possible of the kind of display terminal, resolution of the display, and the speed of transmission. Hence, in the long term, the alpha-geometric description, with suitable provision for alpha-photographic coding for certain parts of the image, is to be preferred. This allows alpha-geometric and alpha-photographic images to be displayed juxtaposed and/or overlaid.

However, the current higher cost of alpha-geometric decoders, (mainly due to the requirements of a sophisticated processor, associated firmware, and a bit-mapped memory of the display) might hinder the immediate and exclusive adoption of this coding scheme.. Many market researchers feel that the initial product offering must be inexpensive because the users (and even the providers) of videotex are not fully aware of the cost/benefit tradeoffs. A Layered Capability Structure (LCS) approach to terminal design has therefore been suggested to reconcile the opposing requirements of low initial cost and upgradability [6]. Probably firm standards will not be agreed upon until the various strategies are tested in the marketplace and the user reactions are evaluated. This delay may also allow time for the more sophisticated encoding schemes to become more economical as the costs of memory and microprocessors go down further.

IV. VIDEOTEX NETWORK

The communications network for videotex is the sum total of the telecommunications facilities interconnecting the videotex terminals, databases and processors. As far as the customer is concerned, there are two types of communications: direct terminal-to-terminal (e.g. Scribblephone [5], Visual Ear [7], videogames, and home computers [8]) and terminal to videotex exchanges.

This section discusses a modular approach to the design of the videotex network. Growth in system capacity is achieved by adding new modules to the system rather than by increasing the size and complexity of a single centralized facility. This proposal is based on current Bell-Northern Research studies of the optimum growth strategy for the intelligent network.

There are two levels of service in videotex: the meta-service and specific services. The videotex meta-service includes the local access to the videotex network and the user interface (e.g. echoing characters to the terminal and handling communication errors), the billing mechanisms, and the routing of requests to specific service centres. Specific services may be provided by databases and processors connected to the network.

At present the division of functions among the service centres and the videotex exchange (interface machine) is not standardized. No mature systems exist. Most probably all the functions, including services, will initially be provided by the videotex exchange (e.g. for a market trial configuration). However, as soon as a particular service attains a significant penetration and becomes better defined and quantified, a separate (dedicated) database or

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processor could provide that service in an optimum way. It is essential to combine the service offerings in such a way that the system utilization is maximized in order to yield a cost-efficient system (e.g. offer both interactive and batch services). It is also important to aim for fully automated systems requiring little or no maintenance. In the limit the videotex exchange could probably be reduced to a concentrator/intelligent-switch/billing machine, with the services being provided exclusively by dedicated auxiliary databases and processors.

Keeping the videotex exchanges as the interface to the service centres has distinct advantages, for example:

- easier routing, accounting, charging, and billing;
- easier user protocols (e.g. common log-on procedures) and easier switching from one service to another;
- fewer ports/modems necessary in the system because they are shared.

With the proposed configuration, a given user is registered with a single videotex exchange, and all his requests for service are interfaced through that exchange. If for some reason (e.g. when travelling) a user accesses a videotex exchange other than his own, that centre would be responsible for obtaining credit clearance and sending accounting information to the exchange with which the user is registered. Alternatively the user would be able to access a distant videotex exchange through the telecommunication network if he so desires, at an additional cost for communications, of course. Some of the service centres will be the responsibility of independent service suppliers (e.g. information suppliers, real-estate agents and educational establishments). Suppliers in the U.S.A. could be connected to the Canadian videotex network via the existing Telenet and Tymnet interconnections to Datapac. Communications can also be used for load sharing: the computational load of responding to a large number of users can be distributed among several sites rather than being centralized at a single site. Updating duplicated and complementary distributed databases will also make extensive use of communications facilities.

Thus a distributed computer network is formed, and for the purpose of this analysis it is convenient to divide the network into logical subnetworks as shown in Figure 1. It can be seen in that figure that there is a backbone network of videotex exchanges and a number of service networks. The way in which each service network is connected to the videotex network will depend on the location and distribution of the various computers. They may be connected directly at each videotex exchange or through gateway ports, for example.

The salient feature of this configuration is the presence of an intelligent network which provides the access and vehicle for a number of independent and/or interrelated services. Economical and reliable service will be achieved in the long term by the network of distributed databases and distributed processors with their interconnection logically structured into layers. The main capability of this network will be to provide efficient interactive communications either between two or more customers or between a customer and the service centres.

For technical and economic reasons the responsibilities of each database/processor in the network will be determined by the demand. For example, in the case of information retrieval, rather than divide the databases into local, regional, provincial, and national on the basis of the kind of information they contain, the hierarchy should follow a structure similar to that of classes of telephone switching centres whose location and size are primarily governed by traffic. Indeed, the content of each database is determined mainly by the demand and updating patterns. Each database will keep statistics of the information requested from it and the information it requests from databases further up in the system (tributary databases) and periodically will send those statistics to the tributary databases and also perhaps to network control centres. These in turn will decide which information should be stored and updated in each database. This is analogous to stockroom and warehouse management problems; if an item is not in a database, the request is conveyed one step higher in the hierarchy. In practice there will be a dynamic balance between storage needs and communication traffic to satisfy both user requests and database update requirements for an optimum price within the appropriate response time limits.

It must be emphasized that the diagram in Figure 1 represents a general purpose logical structure. The choice of actual communication links appropriate in each case will be made on the basis of the needs and availability. It is very probable that packet switching data networks will prove particularly suitable due to the fact that videotex data consists of bursts rather than a steady stream. An example of an implementation using a data network is shown in Figure 2.

The role of the videotex exchange in this approach is that of a front end processor with a minimum of three functions:

1) user interface procedures (e.g. handling communication erro. messages and echoing characters to the user terminal); the module implementing these functions will be referred to as the Videotex Interface Module (VIM);

2) routing of calls (e.g. establish and control temporary connections between the user terminals and service computers);

3) checking customer identity and keeping track of billing.

No matter what types of communication facilities are used, the above functions will have to be provided; the only question is where. In the diagrams of Figures 1 and 2 these functions are centralized in each videotex exchange and the service centres are connected through the 'back door' of the videotex exchanges.

There are two potential problems when using a front end processor as a common access for all videotex services. First of all, there is a potential congestion problem (front end bottleneck). Secondly, the reliability of that front end must be very high, since its failure would prevent all the users connected through that front end from accessing any service. Thus, from this point of view, a large number of front ends are desirable, so that if one of them is down; alternative ones can be made available.

An alternative is to have the front end handle user interface procedures only and let the billing and routing be distributed among a number of videotex exchanges connected via a packet switched network as shown in Figure 3. Such a system can reduce the bottleneck problems but would be more difficult to manage. With this configuration each videotex exchange must monitor continuously all communications under its supervision. If a videotex exchange or service centre breaks down the users may easily be served by another machine in the network.

V. CONCLUSIONS

The videotex service possibilities were briefly reviewed and the conceptual differences between services and applications clarified. The requirements for coding visual information were then described in some detail and coding alternatives compared. Although the alpha-geometric/ photographic picture description is preferred for the long term, it may be too early to adopt it as a standard, because it is not yet known if the general public will be willing to pay a higher price to get better resolution graphics. The Bell Canada Vista pilot demonstration thus offers both alpha-mosaic and alpha-geometric capabilities to permit comparison of the two schemes.

A logical network evolution strategy for videotex has been proposed which can accommodate increasing numbers of users and services. The service possibilities have been briefly reviewed. Introductory systems will be centralized at distinct nodes (videotex exchanges). However, in the long term the network will evolve towards a decentralized (distributed) structure. This will be more efficient and reliable. The result will be an intelligent network providing the access and vehicle to a number of different services.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the invaluable comments of Tony Marsh and Don Sawyer of Bell-Northern Research Ltd.

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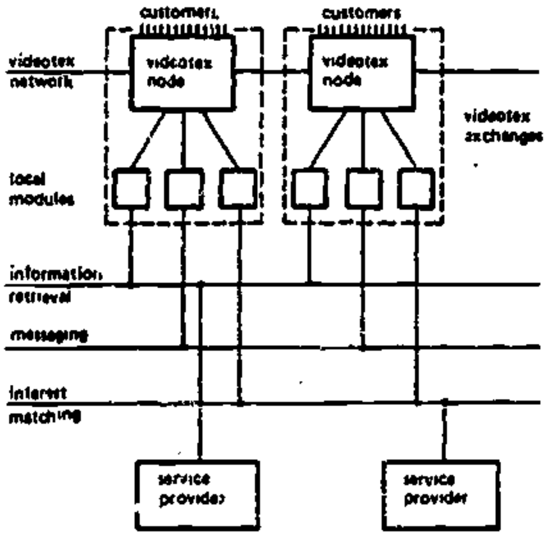
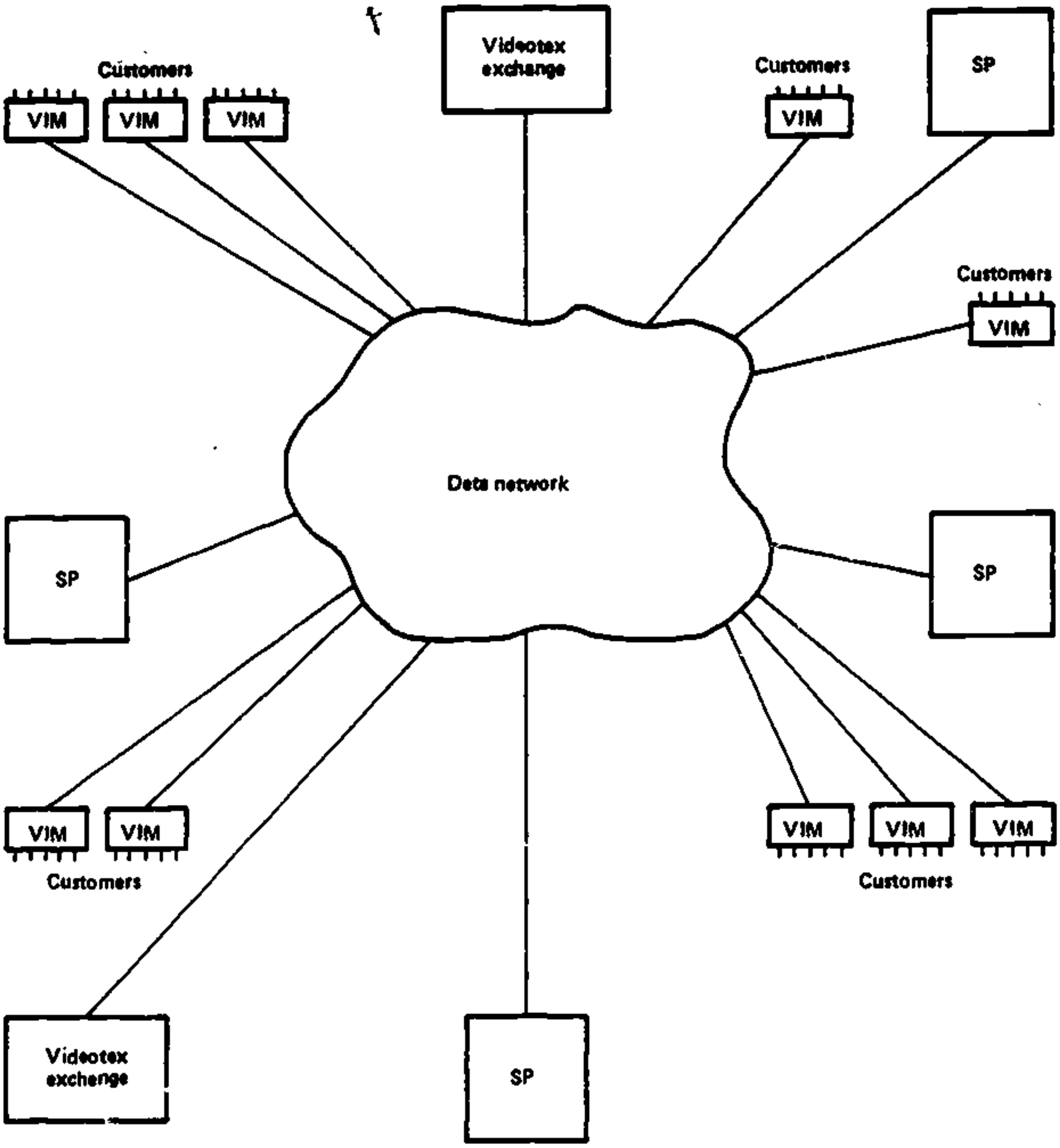
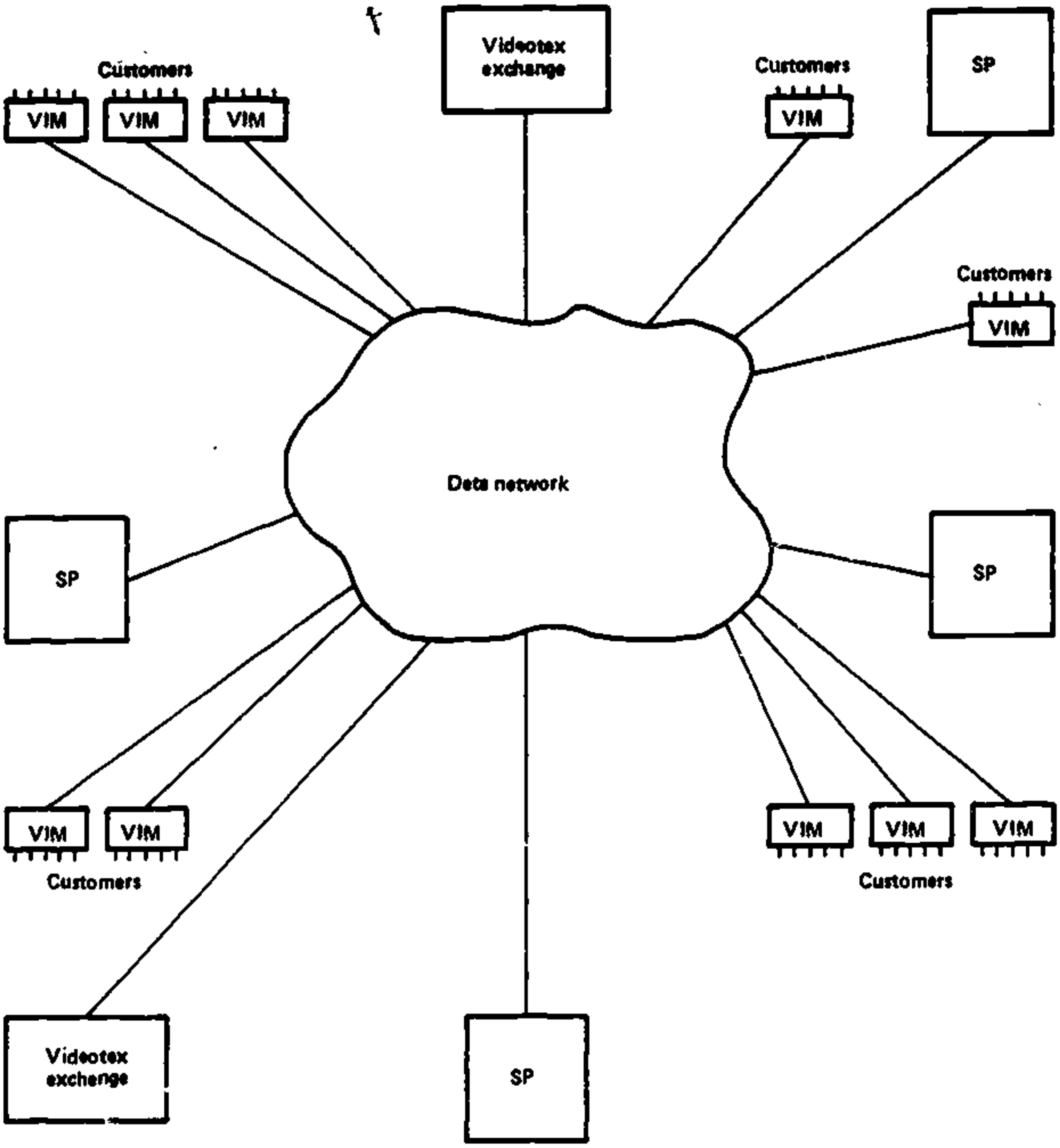

customers
customers
videotex network
videotex node
videotex node
videotex exchanges
local modules
information retrieval
messaging
interest matching
service provider
service provider

Figure 1. Long Term Logical Videotex Network.


Customers
VIM
VIM
VIM
Videotex exchange
Customers
VIM
SP
Customers
VIM
Data network
SP
SP
VIM
VIM
Customers
VIM
VIM
VIM
Customers
Videotex exchange
SP

SP = Service provider
VIM = Videotex interface module (user interface)
Videotex exchange (controls routing and billing)

Figure 3. Videotex Implemented on a Data Network: Customers Connected to Interface Modules (VIM).


Customers
VIM
VIM
VIM
Videotex exchange
Customers
VIM
SP
Customers
VIM
Data network
SP
SP
VIM
VIM
Customers
VIM
VIM
VIM
Customers
Videotex exchange
SP

SP = Service provider
VIM = Videotex interface module (user interface)
Videotex exchange (controls routing and billing)

Figure 3. Videotex Implemented on a Data Network: Customers Connected to Interface Modules (VIM).

DIGITAL DATA SWITCHING FOR VOICE, DATA, FACSIMILE AND DISPLAY INTEGRATED TERMINALS

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Abstract

An integrated terminal which transmits voice, texts, or pictures is proposed for office automation. Control techniques and digital data switching for the terminals and the varieties of service they offer are discussed.

1. INTRODUCTION

In traditional offices, text data and picture information are processed, stored, and transmitted manually using paper. Such modern electronic devices as word processors and office computers are being implemented to automate offices to meet increases in personnel expenses and business.

To increase office efficiency, it is necessary to access dispersed storage so that memorized information can be used mutually as data bases. The information is handled in digital format and high speed, high quality digital data transmission is required. Digital switched data networks to meet these requirements are being developed and implemented in various countries. In Japan, both circuit switched data network and packet switched data network will be in service in fiscal 1979.

Office machines such as word processors, office computers for information processing, file memories for storage, telephone sets, data terminals, and facsimile terminals for information transmission are combined with digital data networks to enhance office productivity resulting in the promotion of office automation.

This paper proposes a voice, data, facsimile and display integrated terminal for when office automation has progressed. The control techniques for the integrated terminal is described based on an experimental system. Digital data switching for the terminals and the varieties of service they offer are discussed.

2. COMMUNICATION SYSTEM FOR OFFICE AUTOMATION

2.1 INFORMATION EXCHANGE

Modern electronic word-processable typewriters or keyboard displays, copiers, and office computers are being used as instruments for office automation. Data terminals and facsimile terminals are being implemented as new telecommunication terminals in addition to the telephone sets which have been the main means of communication.

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Full Text Provided by ERIC

Modern electronic machines for information processing have been used separately by themselves. But they are getting to have communicating abilities by themselves or to be connected to computers with communications function. As a consequence, broad information exchange can be realized by connecting these machines directly to digital data networks, or indirectly through a data PABX, as shown in figure 1.

2.2 VOICE, TEXT AND PICTURE INTEGRATION

When office automation makes good progress and various kinds of advanced equipment such as word processors and office computers are in wide use, people will want information exchange to be as natural as possible. For example, it will be desirable to communicate with computers using voice instead of keyed codes from a keyboard printer and to communicate using voice, texts and pictures simultaneously through digital data networks.

To realize such communication, it is necessary to transmit voice through digital data networks. Also, a terminal that can transmit voice, text and pictures is required.

3. INTEGRATED TERMINAL

3.1 VOICE TRANSMISSION

In conventional telephone networks, voice is transmitted in analog form with 4 kHz band width or in digital PCM form with 56 or 64 kbit/s transmission rate. For voice transmission through digital data networks, digital coding at the terminal is necessary. Several coding methods are available(1), such as waveform reconstruction type PCM or ADM and or analysis-synthesis type coding. These are to be adopted as follows:

(1) High rate PCM (56 to 64 kbit/s) is suitable for public data networks because of its easy connection with conventional telephone networks and high speech quality.

(2) Low rate PCM (40 to 48 kbit/s) and ADM (16 to 32 kbit/s) are suitable for closed or private data networks for economic coding.

(3) Analysis-synthesis type coding (2.4 to 9.6 kbit/s) are suitable for long distance transmission in closed data networks because of the low transmission rate.

3.2 TEXT TRANSMISSION

Because of the many chinese ideographs (Kanji) in written Japanese, facsimile terminals have been very important for text transmission in Japan. Nowadays, word processors that deal with Kanji are being developed. They have word processing functions corresponding to those of English word processors or teletex terminals with communications functions. Kanji word processors have following features:

(1) Input : keyboard

About 8,000 characters are available.

(2) Output : CRT display or dot printer

CRT display expresses 1,000 to 2,000 character/screen.
Dot printer outputs at a speed of 20 to 40 character/s.

(3) Information amount or transmission rate

CRT display : 2 to 4 kbyte/screen
Dot printer : 40 to 80 byte/s

Characters can be transmitted one after another as key-in proceeds or can be transmitted at high speed after a text is stored and edited.

3.3 PICTURE TRANSMISSION

In Japan, about 100,000 facsimile terminals are in service for text or picture transmission through a conventional analog telephone network. Thanks to the progress in facsimile apparatus technology, digital facsimiles which digitize information and use one or two dimensional coding schemes have been developed and are spreading rapidly. CCITT studies group 4 (G4) facsimile following group 3 (G3) as digital facsimile(2). The features of G4 facsimile are considered as follows:

(1) High level data link control (HDLC) error control procedure is applied to image information transmission.

(2) Two dimensional coding scheme is used.

(3) The control function of the facilities in digital switched data networks is provided.

This G4 facsimile will be recommended for application to digital data networks and will play an important role in office automation. The amount of information transmitted is estimated at about 50 kbyte/sheet.

Nowadays, advanced picture transmission terminals that use CRT displays and light pens and transmit colored pictures drawn on the screen with the light pen have been developed. The amount of information is estimated at about 20 kbyte/screen. This kind of terminal is expected for picture transmission.

Table 1 shows the information transmission features of voice, text and picture.

3.4 VOICE/DATA MIXED TRANSMISSION

For voice/text/picture mixed transmission, there are two kinds of methods: alternate transmission and simultaneous transmission. The former is easily realized by switching from one to the other by manual key operation. The latter is discussed here. Voice transmission through digital data networks must be transmitted at speeds less than 48 kbit/s(3). Alternatives are as follows:

(1) Sharing the transmission band in a channel

The bit stealing method is used as shown in figure 2(a). The example transmission rate is
40 kbit/s (for voice) + 8 kbit/s (for data).

If PCM is applied, 5 bits can be used for voice coding. Voice quality under this condition may satisfy the required level because of end-to-end digital one-link transmission.

(2) Framing voice

Voice is coded by ADM technique into 16 to 32 kbit/s or by analysis-synthesis technique into 2.4 to 9.6 kbit/s, and the digitized voice is converted into an HDLC frame as in figure 2(b). In voice communication, about 50 to 60 % of the total speech period is silence. Therefore, data frames can be inserted in the silences, and each channel can be utilized efficiently. Data can be transmitted almost in real time, though it must wait for silence.

This type of terminal can be applied to both circuit switched networks and packet switched networks. In the latter, to keep voice transparency, the information receiver of the terminal must absorb the delay variation, which is caused by store-and-forward delay in the network in addition to 0 insertion for HDLC flag discrimination.

For facsimile, the amount of information transmitted is about 50 kbyte/sheet. This is too much to be transmitted mixed with voice. Therefore, it is necessary to divide the information into blocks and then to mix them with voice. The block length should be short for voice quality but long for facsimile information transmission efficiency. The block length should be determined by the relation between the required voice quality and transmission efficiency.

4. STRUCTURE OF EXPERIMENTAL INTEGRATED TERMINAL

To test voice, text and picture mixed transmission of an integrated terminal, an experimental system was prepared that integrated a voice transmitter receiver, keyboard printer for text transmission, digital facsimile terminal for picture transmission, and CRT display for word processing. The structure is shown in figure 3. The features of the terminal are as follows:

(a) Voice transmission in data format through digital data networks

(b) Transmission of voice, texts and pictures in real time

The functions are as follows:

(1) Voice signal from the transmitter is coded into 16 kbit/s ADM digital format for low transmission rate and economic coding, and transferred periodically to Memory (M) by Direct Memory Access Circuit (DMA).

(2) The text and picture data and call control information are transferred to Memory (M) through Serial I/O Interface (SIO) and Parallel I/O Interface (PIO).

(3) Voice information is fetched periodically from Memory (M). Address (A), Control (C) and Header (H) are attached to the voice information, and the information is transmitted to line after Flag (F) and Frame Check Sequence (FCS) are added via the HDLC circuit. Because of the addition of A,C,H and FCS, the information is sent out at an overspeed of 24 kbit/s. In the silences, data are sent out.

(4) It is connected to digital data networks by CCITT X.21 interface and the information is transferred in the form of a 6 + 2 envelope at a speed of 32 kbit/s in the networks.

(5) To absorb the delay variation, the terminal stores the received information in Memory (M) and fetches it.

(6) Data and voice information fetched from Memory (M) are distinguished from each other by Header (H). Data is sent to the object device and voice is sent to the receiver after it is decoded.

(7) Retransmission requests due to voice transmission errors are ignored to keep voice transparency.

5. SWITCHING FOR INTEGRATED TERMINALS

The above integrated terminal handles both voice, which is suited to circuit switched networks, and data such as texts and pictures, which are suited to packet switched networks. Therefore, it is desirable for the terminal to be accessible to both circuit switched data networks (CSDNs) and packet switched data networks (PSDNs). Thus, a hybrid switching system that accommodates the integrated terminals and can access both networks on a call by call basis is required. Figure 4 shows an example of such a hybrid switching system. The features of the switching system are as follows:

(1) All channels are multiplexed on Super Highway (SHW) and circuit switching is performed with Single Stage Time Division Switch (TSW).

(2) Inter-office signalling and TSW control for circuit switching are performed by a cluster of Microprocessors (MPs).

(3) Packets are sent and received with Signal Sender/Receiver (SS/SR) which accesses all channels on SHW.

(4) Processing for packet switching, such as packet assembly and disassembly, is executed by Central Controller (CC).

To perform hybrid switching, it is necessary to distinguish circuit switched calls from packet switched calls on a call by call basis. Integrated terminals and hybrid switching systems will be included in Integrated Services Digital network (ISDN).

6. VARIETIES OF SERVICE WITH INTEGRATED TERMINALS

The following services, for examples, are available using the integrated terminals described in Section 4:

(1) Conversation between man and computer by voice through digital data networks.

(2) Teledictating by voice with simultaneous text transmission.

(3) Conversation between man and computer by voice, texts and pictures transmitted in real time.

These applications are depicted in figure 5.

7. SUMMARY

An integrated terminal which can transmit voice, texts and pictures has been proposed. The control techniques for the integrated terminal were described based on an experimental system. Furthermore, digital data switching for the terminals and their varieties of service were discussed. Such terminals should be made available for versatile application as office automation proceeds. The terminal proposed here meets this need.

ACKNOWLEDGEMENT

The authors express their appreciation to Dr. M. Kato and Mr. R. Nakamura in Musashino Electrical Communication Laboratory for supporting their work, and to their collegues for their technical advice.

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(2) Report of the meeting held in geneva, 11-15 December 1978: COM XIV-No.70 -E, CCITT Study Group XIV, 1979.

(3) Public Data Networks: Series X Recommendations and Questions (Study Group VII), CCITT Orange Book Vol. VIII. 2, ITU, Geneva, 1977.

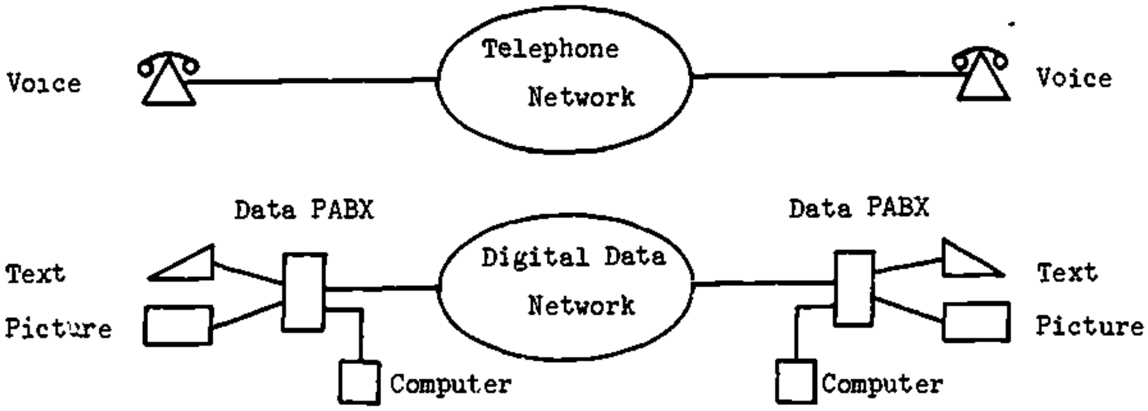
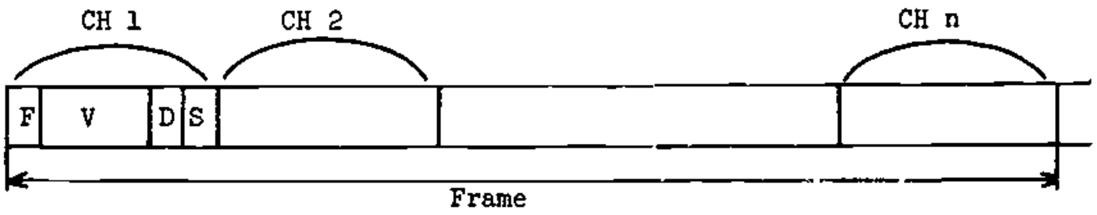

Voice
Telephone Network
Voice
Data PABX
Data PABX
Text
Picture
Digital Data Network
Text
Picture
Computer
Computer

FIGURE 1 INFORMATION EXCHANGE

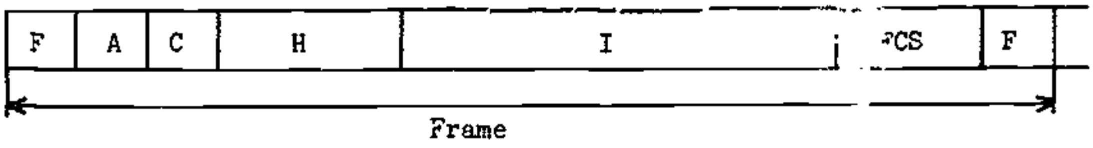
TABLE 1 FEATURES OF VOICE, TEXT AND PICTURE

	Voice	Text (Kanji Display)	Picture (Digital Facsimile)
Information amount	2.4-64 Kbit/s	2-4 Kbyte/screen	50 Kbyte/sheet
Transmission	Periodical	Block	
Disirable Error Rate	less than 10^{-4}	less than 10^{-6}	


CH 1
CH 2
CH n
F
V
D
S
Frame

F: Flag, V: Voice, D: Data, S: Signal

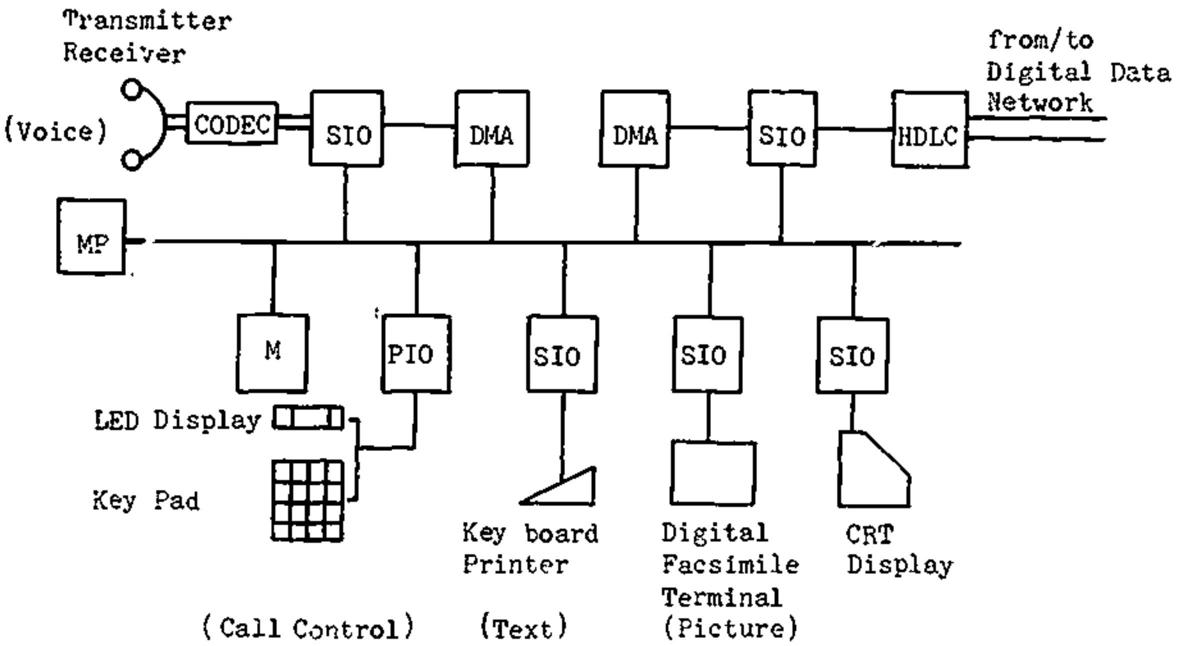
(a) BAND SHARING


F
A
C
H
I
FCS
F
Frame

F: Flag, A: Address, C: Control, FCS: Frame Check Sequence, H: Header, I: Information

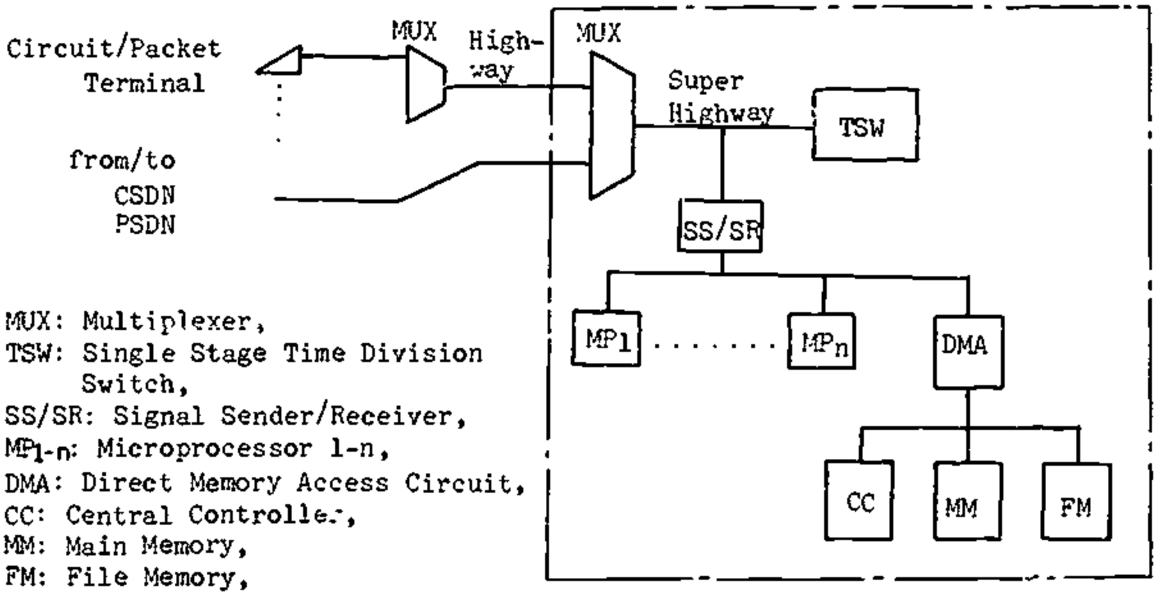
(b) FRAMING

FIGURE 2 VOICE/DATA MIXED TRANSMISSION


Transmitter
Receiver
(Voice)
CODEC
SIO
DMA
DMA
SIO
HDLC
from/to
Digital Data
Network
MP
M
PIO
SIO
SIO
SIO
LED Display
Key Pad
Key board
Printer
Digital
Facsimile
Terminal
CRT
Display
(Call Control)
(Text)
(Picture)

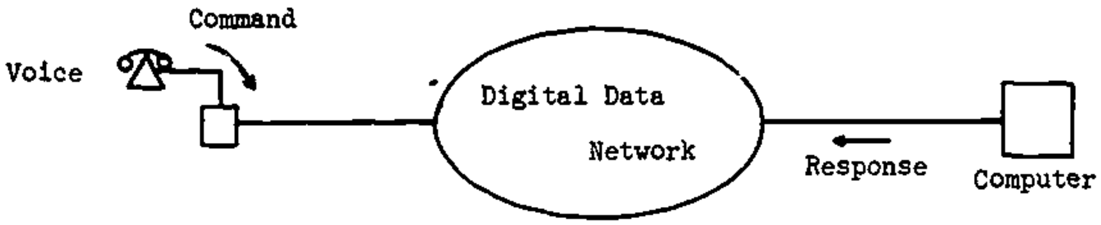
MP: Microprocessor, M: Memory, CODEC: Coder-Decoder,
SIO: Serial I/O Interface, PIO: Parallel I/O Interface,
DMA: Direct Memory Access Circuit, HDLC: HDLC Circuit

FIGURE 3 EXPERIMENTAL INTEGRATED TERMINAL

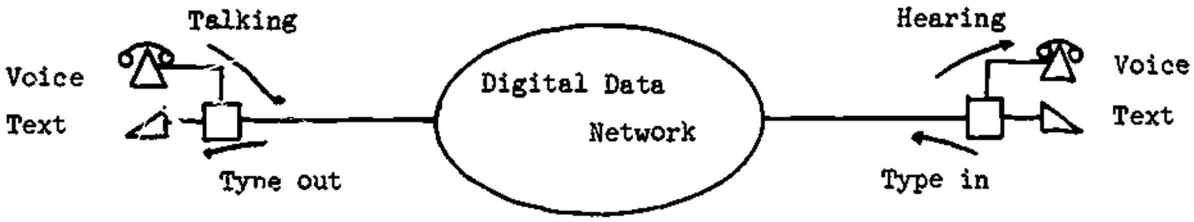

Circuit/Packet
Terminal
MUX
High-
way
MUX
Super
Highway
TSW
from/to
CSDN
PSDN
SS/SR
MP_1
MP_n
DMA
CC
MM
FM

MUX: Multiplexer,
TSW: Single Stage Time Division Switch,
SS/SR: Signal Sender/Receiver,
MP_{1-n}: Microprocessor 1-n,
DMA: Direct Memory Access Circuit,
CC: Central Controller,
MM: Main Memory,
FM: File Memory,
CSDN: Circuit Switched Data Network,
PSDN: Packet Switched Data Network

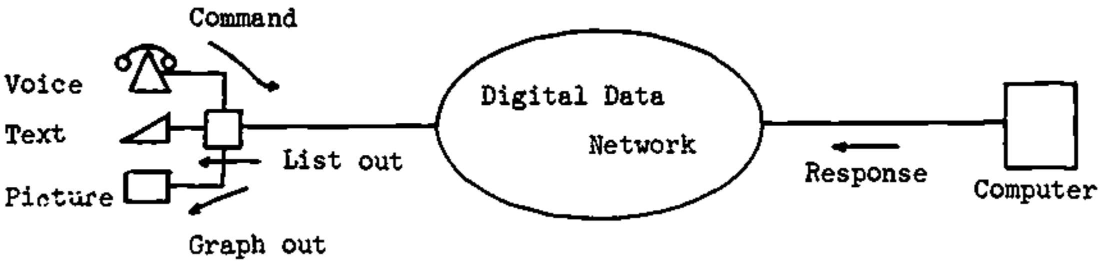
FIGURE 4 HYBRID SWITCHING SYSTEM


Command
Voice
Digital Data
Network
Response
Computer

(a) MAN-COMPUTER CONVERSATION WITH VOICE


Talking
Voice
Text
Type out
Digital Data
Network
Hearing
Voice
Text
Type in

(b) TELEDICTATING


Command
Voice
Text
Picture
List out
Graph out
Digital Data
Network
Response
Computer

(c) MAN-COMPUTER CONVERSATION WITH VOICE, TEXT AND PICTURE

FIGURE 5 SERVICE VARIETIES WITH INTEGRATED TERMINALS

PROBLEMS OF INTERWORKING BETWEEN VIDEOTEX, FACSIMILE AND TELETEX SERVICES

by Y. CHAUVEL, P. BONICEL and A. POIGNET
C C E T T

ABSTRACT

The development of new communication services (essentially VIDEOTEX, FACSIMILE and TELETEX) has recently created a difficult interworking situation ; the problem appears both as solvable and extremely conplex because each of the referenced services has not yet been utterly settled. An alternate approach is proposed in this paper by mean of an integrated graphic communication service, the "facsitex".

Previous to entering the central debate about interworking, it is of first importance to recall, with as much accuracy as possible, the scope and main features of each service, on the basis of available documents from standardization bodies, industry or administration laboratories.

1.1 FACSIMILE SERVICE

The facsimile service offers distant and faithful reproduction of an original document by use of telecommunication network or links ; telephone lines are mainly used, which gives a point to point service ; diffusion networks are well adapted to multipoint delivery.

Structure of transmitted information :

The coding is independant of the nature of the document analysed, whether it is hand written matter, type written text or synoptics. The system works on a dot by dot basis which enables it to handle any kind of pictorial information limited only by the spatial bandwith (size of elementary dot).

Terminal groups :

Three groups of facsimile terminals have been standardized by CCITT (COM XIV) to be used on telephone networks :

Group 1 - terminals allow transmission of a DIN A4 document in six minutes. There is a poor compatibility between existing terminals of this group due to late standardization. The major part of today operational devices belong to this group.

For group 2 - terminals, transmission time has been reduced to 3 minutes ; terminals have been available for several years ; many European administrations are starting a public service named Telefax defined by CEPT (European Commission for Post and Telecommunications) and based on this group.

Group 1 et 2 - make use of analogical concept ; on the contrary new group 3 defines digital devices transmitting a DIN A4 document in an average time of one minute ; the transmission time depends on the real amount of information in the document, by use of a coding scheme to reduce redundancy.

The French Telecommunication Administration is now supporting the developement of a low cost ($400) terminal on the basis of group 3 specification and intended to large scale use CCITT COM XIV has starded working on the definition of a group 4 terminal adapted to data network.

Beside the common point to point transmission we can imagine system configurations oriented to broadcast applications. Some experiments have been run at the CCETT taking advantage of the existing DIDON network (Data broadcasting network). We have demonstated the feasability of a system simultaneously delivering to numerous terminals a copy of a document analysed at one emitting point, using either on the air or cable broadcast network.

1.2 TELETEX SERVICE

The Teletex service offering automatic transmission of texts is under development in numerous countries. The service includes facilities for the editing of the documents, transmission, and intends to provide the receiving subscriber with a document that is nearly identical with that produced by the sending subscriber terminal as for as its contents, layout and format are concerned (1).

Terminal characteristics

Teletex is memory to memory text transmission service which allows trans port of documents structured in pages of standard format (ISO A4, A4L or North American). The subscriver equipment (fig. 1) has four operational modes : local editing, sending, receiving, printing.

Local editing

usual text editing facilities are offered : insertion, deletion, moving of characters, justification, tabulation, paragraphe-mixing, etc...

Sending

the transmission uses a 2400b/s data rate.

Receiving

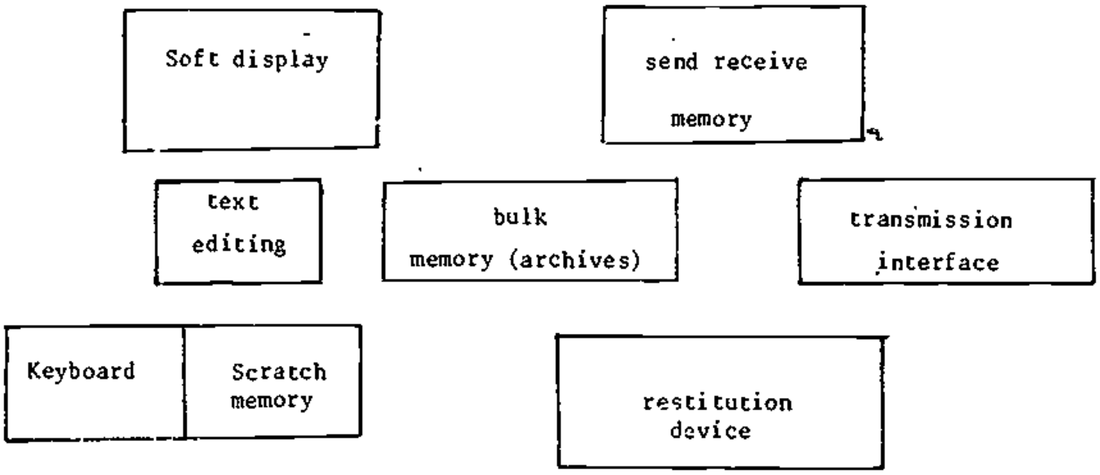
automatic receving is possible without disturbing local operations provided a sufficent memory is available. The procedure for sending and receiving is studied in COM VIII.

---

(1) terms of the draft recommendation Fx.

Printing of the document is under local control athough real time printing(without temporary storage in the memory) is not excluded.

Figure 1


Soft display
send receive memory
text editing
bulk memory (archives)
transmission interface
Keyboard
Scratch memory
restitution device

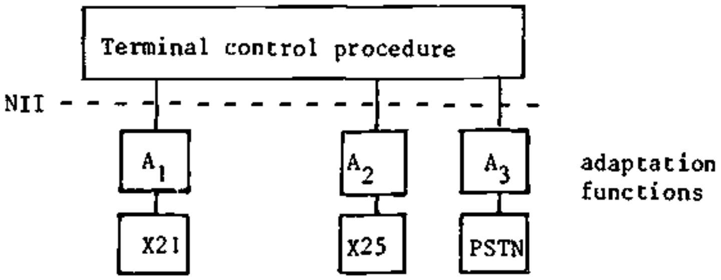
Network aspects

The Teletex service will use various networks for the transport function (data-networks, telephone-networks). This fact points out the need for a network independant interface, (see fig. 2) the definition of which implies to make a clear distinction between transport functions and specific service fonctions.

Standardization aspects

Important work is currently carried out at an international level namely CCITT and ISO. recommandarions are under elaboration at CCITT, i.e. recommendation Sc concerning terminal aspects and recommendation Sd for control procedures and Fx for service specification.

Figure 2


Terminal control procedure
NII
A_1
A_2
A_3
adaptation functions
X21
X25
PSTN

1.3 THE VIDEOTEX SERVICE

Giving a comprehensive definition of the Videotex service is an uneasy task due to the wide range of features offered by the various proposed systems for that service. Terminology itself has not yet been agreed upon.

CCITT has decided to temporarily reference as "Videotex" a service the scope of which is defined in the following terms :

"The basic facility provided is the retrieval of information by a dialogue with a database. The service is intended to provide the facility for the general public as well as specialist users and should therefore be a compromise between service quality and simplicity in on the one hand and economic implementation on the other hand. It is based on public networks and uses standard television receivers suitably modified or supplemented as the terminal equipment, although the use of other equipment is not excluded. The Videotex service would normally also provide facilities for the creation and maintenance of the data bases".

- We shall not mention here the paragraph describing optional facilities which make Videotex a widely open service.

The characteristic feature seems to be that the display of information is based on a television receiver and the pictures are essentially still pictures although some kind of animation is not explicitly excluded.

According to the various systems, the information is essentially text oriented with some opening to graphic through low resolution mode (the so called mosaïc or semi-graphic mode) or dynamically redefinable character sets (DRCS). This is the present state of, for instance, the UK Viewdata, French Antiope-Titan systems. Some new systems such as Telidon (Canada CRC) or Captains (Japan KDD) offer from the start more elaborate pictorial modes know as geometric and photographic. Some marketing work has to be done to give information about the opportunity of introducing these elaborate pictorial facilities considering the extra cost resulting for the terminal.

On the other hand, the same type of systems exist using broadcasting networks. CCIR and EBU reference them temporarily as "Teletext". It is obvious that the most part of the terminals associated with Teletext and Videotex are common (in fact everything but the modem). So that we shall in this paper use the terms interactive Videotex and broadcast Videotex for respectively Videotex and Teletext, which fits better with our philosophy of these systems. Consequently in the following, "Videotex" alone will cover the two types of service, independently ran the network.

Standardization :

Draft recommendations are in an advanced step of elaboration in COM I (draft recommendation Fb) and in COM VIII (draft recommendation Sx). These drafts seem to be in position to become final recommendations at 1980 plenary meeting of CCITT. In the broadcast field, a lot of work has been done at a European level (EBU GTI) resulting in 5 contributions to CCIR. At CCIR itself, the where COM XI handles the problem, a special group (GT3) has been created.

To insure coordination between broadcast and interactive versions, CCITT and CCIR have lately created a mixed working party (KYOTO 1979).

2 INTERWORKING OF SYSTEMS

The main objective is always in the end, for all the services considered, to provide the subscriber with a pictorial representation recreated from the flow of data received.

Without minimizing the problem related to transmission, communication procedure or information coding technique, it is obvious that the display function is the fundamental one for a service and, consequently, interworking between two services does not make sense unless this function is supported with only limited degradation.

Display standards of the three services in their present state of specification are summarized in table 1.

Let us notice that facsimile standard is far leading if the comparison criterion is the number of addressable dots ; Videotex standard offers specific supplementary features (colours, flashing, conceal).

Case by case approach

Table 2 presents twelve possible configurations occuring when trying to use a particular service with a particular terminal, with consideration to the following parameters :

- type of network (broadcast or interactive)
- receiving or sending function.

For each configuration we note the main difficulties encountered if any, using table 1 in reference as far as display is concerned.

4 configurations (beside of course the natural ones appearing on the diagonal of table 2) seem of some interest and need complementary observations :

a) Videotex service to Teletex terminal :

This situation potentially allows, in a professional environment, constitution of hard documents from Videotex data bases.

If the broadcast network is used, where no interactive process is possible, the terminal has to face alone the adaptation problems : semigraphic drawings must be abandoned, reverse background and flashing could be ignored or interpreted as underlining ; background colours, foreground colours and variable sizes of characters can be ignored without introducing unbearable degradation ; alphabetic information will be perfectly displayed as far as CCITT maintains the same (G0, G2) couple for both services. The display of a Videotex page (40 by 21 to 25) uses only about one fourth of a Teletex page surface ; some limited software implementation at local level could allow the packing of four Videotex pages on a single ISO A4 sheet of paper.

In an interactive environment, the data base and the network can identify the terminal category so that the adaptation task could be shared.

b) Videotex service to facsimile terminal

This case is roughly the same as the previous one, but this time semigraphic interpretation is not a problem. The high spatial resolution of facsimile makes it possible to convert colours into grey scale, using variable dot density ; of course a certain amount of software, a suitable character generator and a control keypad must be added to the terminal.

c) Teletex service to Videotex terminal

A Videotex terminal may act as a convenient device for information retrieval from Teletex data bases ; the user has to cope with vertical roll up and the folding of long rows ; besides, the local memory needed to store a Teletex page implies a multi page Videotex decoder (probably major part of the existing decoders).

d) Teletex service to facsimile terminal

The display formats are identical : again a character generator and a proper local memory must be added to the facsimile terminal. This configuration is a significant one ; it appears as a first step toward an integrated graphic communication service taking advantage both of transmission efficency and facilities of Teletex standards and of pictorial capability of facsimile standard.

e) Future

Table 2 has been set up by reference to present state of specifications. The comment 'future" has been used for configurations that will not make sense until some extensions are introduced ; for instance in the Videotex area, information transport from subscriber to data base on a larger scale than the already implemented "letter box" facility.

Procedure aspects

The interworking problems corresponding to relevant configurations are taken into consideration by CCITT specially at the communication procedure level. The various recommendations are not being elaborated independantly ; several intercommission working parties have been constitued with delegates from commissions VII (data networks), VIII (terminal aspects for telex, Teletex and Videotex) and XIV (facsimile). A common procedure structure can be expected from these important efforts, specially under leading action of the Teletex group. The fundamental difficulty comes from the extraordinary fast improvements of technology, generating a permanent temptation to introduce new features at each service level, while standardization is a slow and hard process.

3 SERVICE EXTENSIONS AND THE FACSITEX APPROACH

3.1 EXTENSIONS

Each of the nominal services we consider, as defined in part 1, will step by step tend to enlarge the range of facilities offered to its subscribers, using the basic specification as a starting point.

The introduction of numerous new features is already in progress :

- a hard copy unit will often be connected to the Videotex terminal (F.5) sophisticated graphic capabilities, the feasability of which has been demonstrated by the Canadian Telidon or the French "Teledessin" systems, are likely to become standard features of the Videotex within the next five years.
- on the other hand, facsimile systems will enhance in a significant way the service quality by use of a character mode concurrently with the dot mode. The amount of data transmitted (or of local memory for storage) will be reduced by a factor of 10 typewritten texts, this class of documents representing 90 % of the information transmitted by facsimile services ; furthermore, local generation of characters, consequence of the character mode improves considerably the quality of the printed text (see figure 4).

Symetrically nobody will be surprised when the Teletext service introduces, first as an optional function, a local switching to graphic mode ; the development of Teletext data bases can also be forseen by reasonable extrapolation from the memory to memory transfer concept which is a fundamental for Teletext system.

All the trends quoted above seem to lead rapidly to a situation where the potential subscriber will have some trouble to understand which service fits his need best. In other words, we are converging to "equivalent" services each function being supported by each service but possibly at different levels. We might observe, for each service, a fast swelling of the facility lists and in the same time a translation process between the so called "private use", "recognized", "optional standardized" and "basic standardized" function-classes, from the first quoted to the last. In this unsettled context, the efforts to maintain compatibility and to allow interworking may be unsuccessful.

3.2 MULTINETWORK SERVICES

Beside interactive data or telephone networks, the concept of data broadcasting network (DBS) is moving forward specially in French where such a network called DIDON is already in operation, the main characteristics of DIDON are :

- the load of the network s totally independent of the quantity of subscribers.

- all the subscribers can be reached simultaneously.
- it has been set up with very little investment on the basis of the existing terrestrial Television network (it can also work on satellites).

Important companies, widely scattered over the country (or on a larger scale with satellites), which have a lot of information to broadcast from central boards will find broadcast networks an attractive complement to interactive networks.

All these have led us to a new global approach of an integrated graphic communication service that we call "Facsitex" (contraction of "facsimile" and "Teletex" although it makes use of concepts not included in these two services).

4 FUNDAMENTAL GUIDELINES FOR FACSITEX SPECIFICATION

. Any relevant network can be used (broadcast and interactive)

. Message coding must be terminal-independent (as much as possible)

. Facsitex must avoid running against habits, specially regarding pictorial personification common in commercial correspondance.

. Optimal coding is systematically searched for on a local basis (i.e. inside a page, in opposition to the common philosophy consisting in switching from one coding scheme to another at session level or at least at page level, this is the key-point in the facsitex concept and development. We think that, at present most part of the documentation matter is not handled electronically because the amount of memory needed is figured having in mind facsimile coding efficiency (an average of 250.000bits per page) ; Facsitex efficiency will make things different.

Let us examine a simplified sampling of the documents commonly exchanged in the professionnal environment ; commercial letter it usually consists in : a typewritten text of about 500 characters, eventually in different character fonts ; this is well covered by Teletex coding techniques ; DRCS (Dynamically Redefinable Character Sets) may be an appropriate method for digital description and transmission of unusual character fonts.

"Logo" and identification field of the company :

We observe that the identification field (Telex number, Telephone number, full address, etc...) appears most of the time in small size characters. An ASCII like coding is still possible by use of scaling factors. This feature does exist in simple implementation in UK Videotex (2 sizes) or French Videotex (4 sizes) ; it can be generalized as in Telidon or through control functions such as GSM (Graphic Size Modification) or GSR (Graphic Size Rendition) as proposed by ISO 6429 (character imaging devices).

The "Logo" portion is by essence fully graphic ; fortunately it is often limited (in surface) to about 1/100 of the page so that whatever technique is used, it should not result in more than 5000 bits of coding ; the logos are sometimes attractively coloured. Coloure information coding is common in Videotex ; this feature has not yet been mentioned in Teletex or facsimile due to present printing technology limitations ; recent work in this field (ink projection devices, for instance) has encouraged us to introduce colour coding at data-base level (a grey scale rendition being an acceptable degradation in the nearest future).

Signatures : very efficient coding schemes have been studied specifically for hand writing, as the one used for the "Teledessin" system in French.

Invoices : as compared to other commercial letters, invoices show the pecularity of using a large amount of horizontal or vertical, solid or dashed separation lines of frames. These elements must be coded with geometric primitives such as LIM or AREA from the PDI of (Picture Description Instruction) as used in Telidon.

Technical reports : beside text, reporting often requires the help of drawings, tables or synoptics, in which we find geometric elements to be coded with PDIs - like geometric primitives and annotations at various angles ; writting at different angular directions, although not included in PDIs is a common feature in plotting oriented packages and it can be easily implemented as far as digital character generators are available.

Photographs are often joined to reports, usually in a quarter of page or half a page format. Neither facsimile run lenght coding, nor PDIs POINT instruction seem to reach optimality in this particular case. The best methods could probably come from digital TV coding research where sophisticated schemes such as those using Fourier or Hadamar transforms are beeing studied.

A statistical evaluation (on a small but meaninful sampling of current documents) has resulted in an average of 20k bits per page.

Horewer, local optimization is worth while if and only if the switching control function between the different coding methods does not bring a significant overhead, in the Videotex area, where the coding philosophy has been directly derived from the character oriented ISO 646 and ISO 2022 standards, multiplexing flows of different nature is performed by somelines three and even four character escape sequences, which is at least heavy.

Therefore we are convinced that multiplexing numerous data flows, consequence of local optimization, is of interest only if it is supported by a powerful and flexible end to end procedure in a packet switching philosophy.

System implementation

Optimal coding generation may be obtained in two way :

1) From a document (on paper) already produced somewhere else, by an automatic identification process ; the associated sophisticated techniques, if nearly mature for character recognition (OCR) are not readily exploitable for geometric primitives identification.

2) by generating the document and corresponding codes in the same time we then need the following devices :

for text : keyboard + CRT (Teletex like terminal)

for signature : electronic writing tablet.

for synoptics : CRT with light pen and graphic software package.

for photographs: facsimile terminal or camera with sampling electronics.

The operator has to check the lay out of the final document composed from the different pieces eventually produced apart from each other. A high resolution soft display device is desirable for this function. Several possibilities (1728 (H) x 1200 (V), 1728 (H) x 2400 (V), or 2400 (H) x 2400 (V)) are under subjective evaluation.

The technical implementation of the system does not raise any fundamental problem, never the less the acceptability, by a secretary for instance, of a system making intensive use of intelligent terminals has to be demonstrated.

Insertion of the service

Insertion of the Facsitex in the teletex, facsimile and Videotex environment is easy. After the first steps of the communication procedure (service identification, terminal identification, option negociation) the Facsitex terminal will, if necessary, simulate a Teletex, Videotex or facsimile terminal according to the other end identity, by simple translation of the "intelligent" code (See figure 3).

Our approach leading to a global graphic communication service, the Facsitex, as shortly described in this paper, may appear somewhat futiristic. Nevertheless, we expect that the prototype system under development in the CCETT labs will bring important information in the field of acceptability, amount of software necessary, improvement in term of access time to a document, reduction of data base volume, etc...

Table 1

DISPLAY STANDARDS

Basic level service Features	Videotex	Facsimile	Teletex
Structure	Character	dot	Character
Display format	TV screen 4 to 3 ratio	ISO A4 and American 215 x 297 mm	ISO A4 and American 215 x 297 mm
Number of dots	Roughly 400x(250 or 210) (not standardized)	1728x 1143 228N	
Number of characters per leaf	25 40 x 24 21		77 x 56
Alphabetic Extensions	Semi-graphic + D R C S		Several Character fonts
Colours	8 colours	B a W	B a W
Other features	Double high, wide revue background plashing, conceal, boxing		
Comments		Anisotropie dot 8 dots/mm horizontal 3.85 or 7.7 vertical	

Table 2

INTERWORKING CONFIGURATIONS

TERMINAL \ SERVICE		VIDEOTEX		TELETEX		FACSIMILE	
		INTER	BROAD	INTER	BROAD	INTER	BROAD
VIDEOTEX	SEND	O.K.		futur ?	meaningless	futur	meaningless
	RECEIVE			problem of display format (memory size)		\	\
TELETEX	SEND	futur ?	meaningless	O.K.		\	meaningless
	RECEIVE	for colours, format, flashing, semigraphic, double wide, double high				\	\
FACSIMILE	SEND	futur ?	meaningless	\	meaningless	O.K.	
	RECEIVE	character generator format colours flashing, dialogue		character generator page memory			

X indicate impossibility.

Figure 3

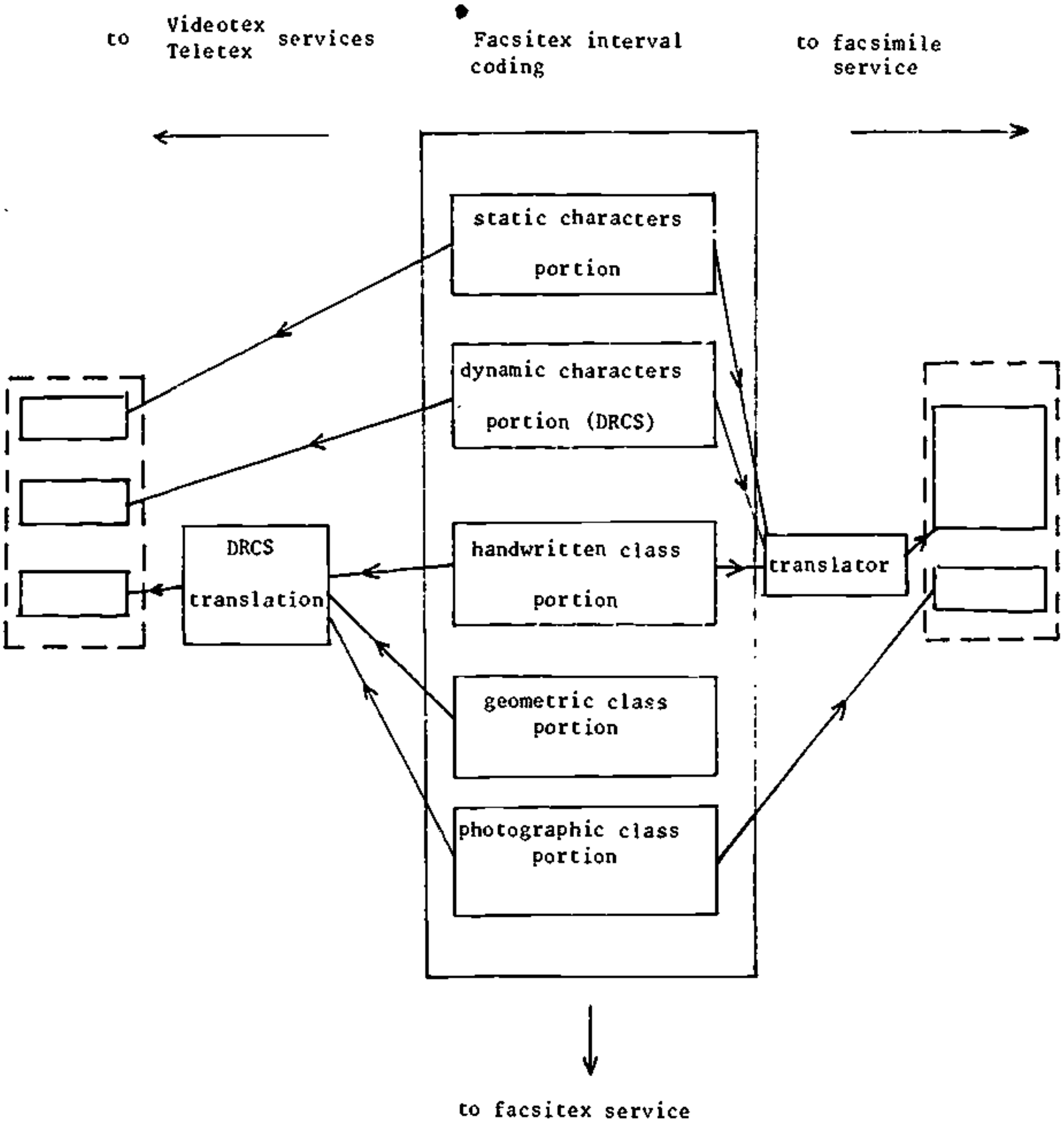
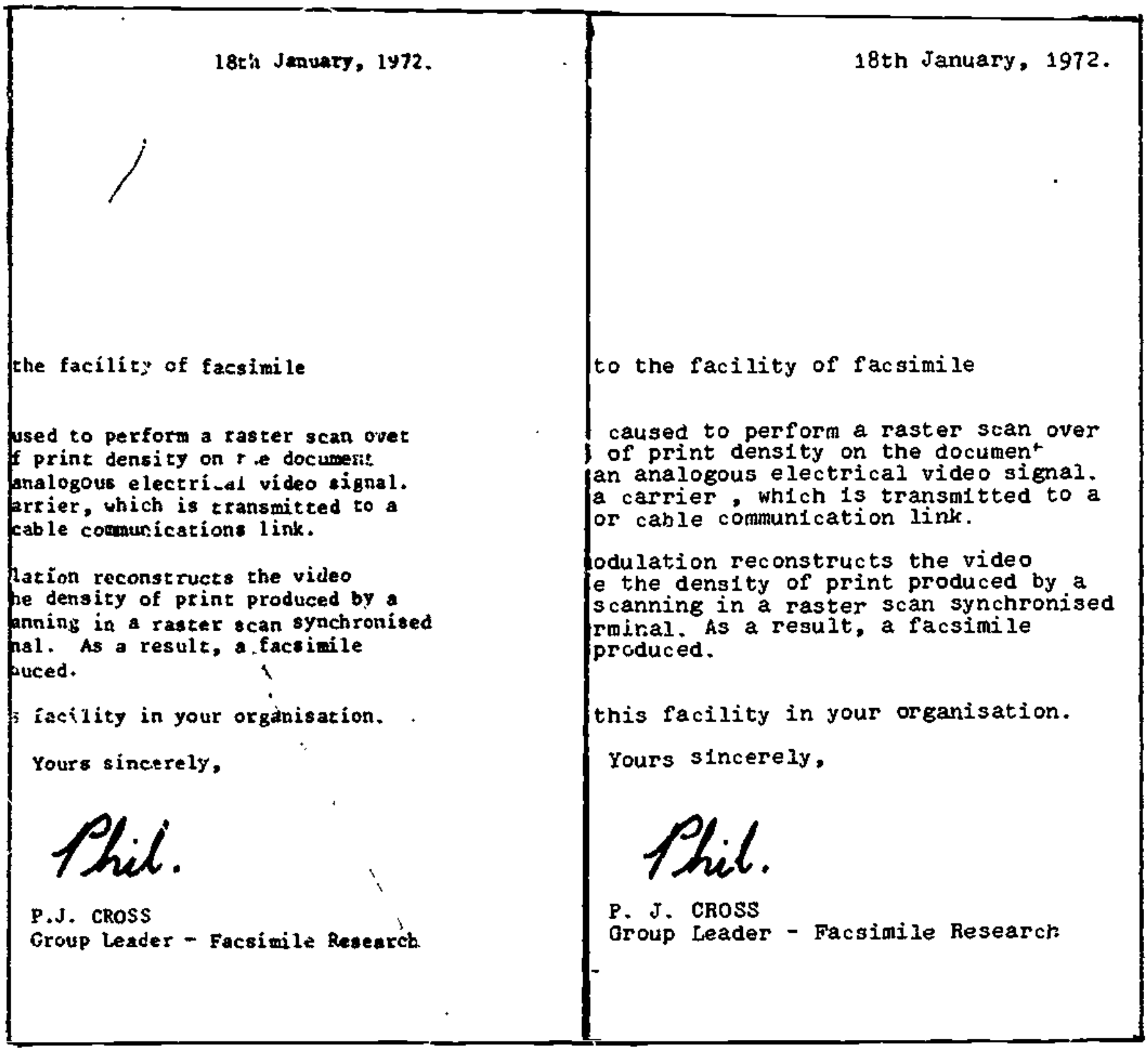

to
Videotex
Teletex
services
Facsitex interval coding
to facsimile service
static characters portion
dynamic characters portion (DRCS)
handwritten class portion
geometric class portion
photographic class portion
DRCS translation
translator
to facsitex service

Figure 4



FACSIMILE QUALITY

18th January, 1972.

the facility of facsimile

used to perform a raster scan over
f print density on the document
analogous electrical video signal.
arrier, which is transmitted to a
cable communications link.

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nal. As a result, a facsimile
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facility in your organisation.

Yours sincerely,

Phil.

P.J. CROSS
Group Leader - Facsimile Research

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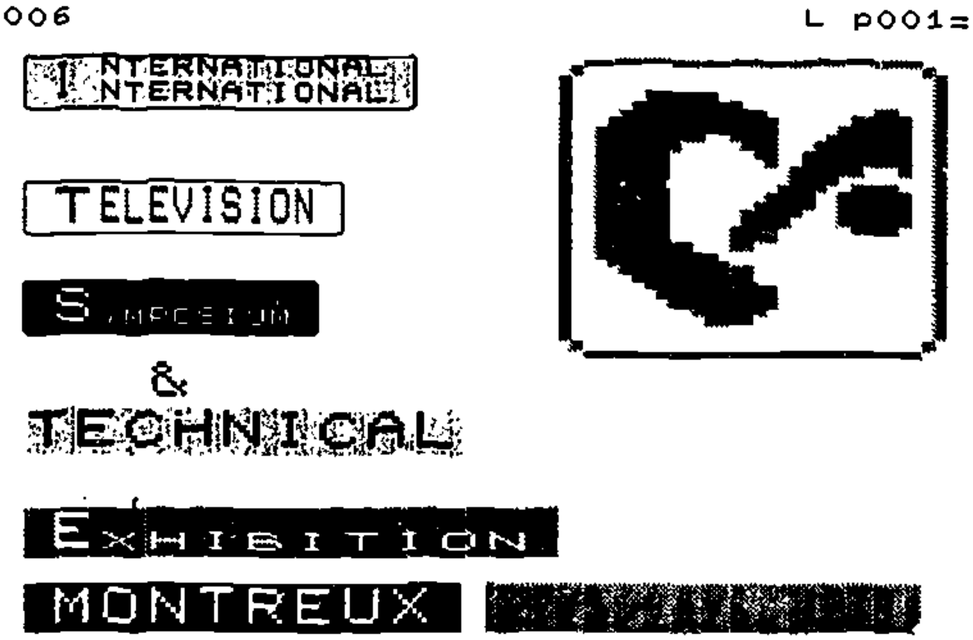
Group Leader - Facsimile Research

Figure 5

VIDEOTEX - HARDCOPY EXAMPLES



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INTERNATIONAL

TELEVISION

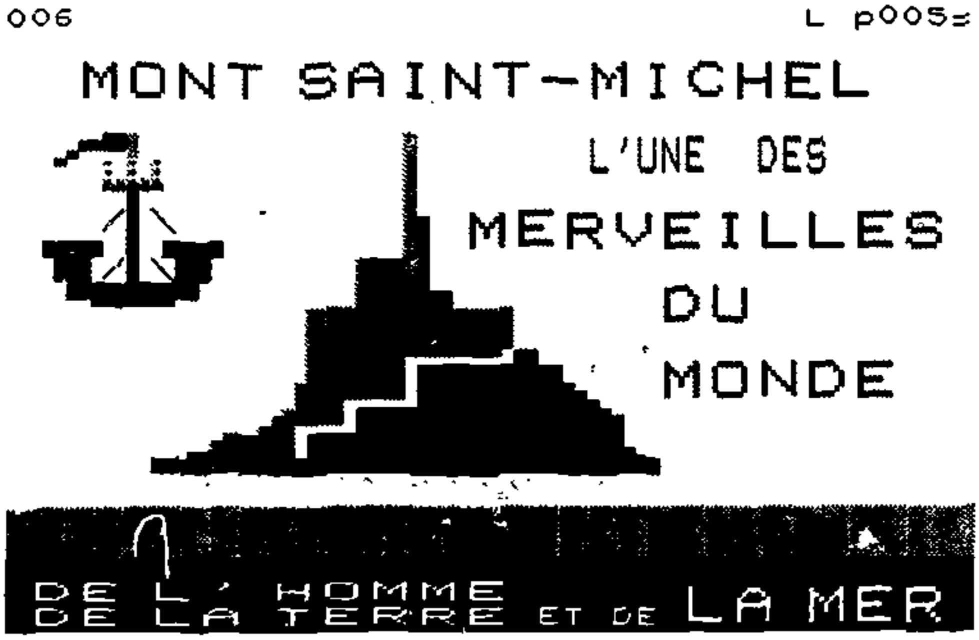
SYMPOSIUM

&

TECHNICAL

EXHIBITION

MONTREUX



006

L p005=

MONT SAINT-MICHEL

L'UNE DES

MERVEILLES

DU

MONDE

DE L'HOMME

DE LA TERRE ET DE LA MER

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Transport Service Standardization Issues
In Open Systems Interconnection

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Abstract

In 1978, the subcommittee on Open Systems Interconnection within the International Standards Organization commenced the development of an architectural reference model that would serve as the basis for future development of protocol standards to permit communications among distributed heterogeneous computers and terminals. The Consultative Committee for International Telephone & Telegraph (CCITT) also started a similar effort in the same year with the objective of ensuring an orderly evolution of CCITT Recommendations for applications and services. This paper gives a brief review of some of the architectural concepts that are the basis for the respective reference models. The paper then describes and comments on some of the major unresolved issues associated with the lower layers of the model.

1. INTRODUCTION

For a number of years, articles have been written describing and forecasting the increased use of computers to perform functions that directly benefit the general public. A large category of these uses can be classified as distributed applications where elements of the data entry, processing and storage are in different locations. Even now, distributed processing within organizations or companies is being heralded as the trend to follow. The next step will see the use of distributed information systems that require the transfer of information across company or organizational boundaries. Examples of two frequently discussed applications that require inter-organizational data communications are electronic mail and EFT.

A key aspect of all distributed systems is that a set of agreed procedures (i.e. protocols) are used to convey information between applications in different systems. To date, protocols to support particular applications have either been defined by task oriented groups (e.g. ARPANET, SWIFT, SITA) or by individual computer manufacturers who in turn provide them to their customers for implementing systems. These protocols are usually able to meet the needs of the various applications that have been considered to date, but they lack the generality to solve some of the future distributed applications.

If the next step, inter-organizational, ubiquitous data communications is to be realized, then a set of commonly agreed upon protocols must be defined and implemented. Without these agreements, some of the products and services proposed for the future will never come to market. This is a situation where the lack of standards will impede innovation by creating a set of underlying technological blocks that each potential implementator of a new service would need to overcome.

The importance of standards has long been realized. For example, the International Standards Organization (ISO) has developed a High Level Data Link Control Procedure (HDLC) and CCITT has defined interface Recommendations for circuit and packet switching networks (X.21 and X.25 respectively). While the standards effort was progressing, there was a concern that specific standards were being developed by different groups without a single common view of the overall structure or what was or should be the relationship between these various new standards (e.g. complementary or competitive). There was clearly a need to develop a mechanism for co-ordinating these efforts.

ISO created a new subcommittee entitled Open Systems Interconnection and CCITT Study Group VII appointed a Rapporteur to examine a similar problem with a view to coordinating work within CCITT. In essence, both groups have a charter to develop an overall reference model that will set forth architectural principles and then propose a specific model that will a) partition the solution so that different groups can work in parallel with minimal conflict or overlap and b) identify the role of existing standards and specific portions of the model for which new protocol standards should be defined. To ensure that only one reference model is produced, there is a need to align the output of ISO and CCITT work and to this end a number of participants, including the author, are active in both groups.

The latest version of the ISO reference model is described in document ISO/TC97/SC16 N227 [1], which was produced at the last SC16 meeting held in London in June 1979. The latest CCITT reference model is contained in Annex 1 of [2]. For further background, the reader is referred to [3].

Section 2 of this paper reviews some of the architectural principles underlying the partitioning of the solution defined by the reference model. Following this, the portions of the reference model that pertain to basic inter-process communication between processes in different (or the same) systems are examined. Of particular concern is that contrary to initial indications, the ISO model does not take advantage of Recommendation X.25 virtual circuit services. Section 4 reviews the current standardization status and the prospects for completing an agreed upon reference model.

2. ARCHITECTURAL PRINCIPLES

Three basic architectural notions upon which all other concepts are developed are entities, protocols, and functions. An entity is a logical object that performs functions in cooperation with other entities to achieve some specific objective. Protocols are the means by which entities in different systems communicate and coordinate their operations.

To avoid developing complex all-encompassing functional protocols for every new application, two additional concepts (layering and layer services) are used to partition the solution into manageable units and permit the orderly evolution of standards. The notion of layer is analogous to information hiding or nested subroutines, in that a service is provided without knowledge of how it was performed. The layers are defined as an ordered set with each layer defined by the service it provides. More exactly, entities, which exist in each layer, use the services of the layer below plus their own functionality to provide enhanced services to the layer above. In addition, associated with each layer are peer entities that cooperate using their respective peer protocols.

Both the ISO and CCITT reference models currently have the same seven layers though the services and functionality assigned to them differ in some important aspects which will be described later. Starting with the lowest layer, the layers are: physical, link, network, transport, session, presentation and application. A set of general partitioning criteria used to select these layers may be found in Annex 1 of [2].

Chapters 2 and 3 of the latest version of the ISO reference model [1] provide a good overview of the architectural principles involved, however, a few points that have caused confusion are worth reiterating.

2.1 The objective of the standardization effort is only to develop standard protocols for use between systems and not to standardize the systems themselves. While it is often necessary to discuss issues in the context of probable implementations or to define detailed layer service primitives to clarify the services provided, it is not the inte 'on to define how a system should be implemented.

2.2 Since each layer relies on the services of the layer below a given open system must, in general, implement and use protocols associated with all layers. Skipping a layer creates an architectural fracture in the sense that a given layer peer protocol will not operate correctly without the support of the exact service specified for the next lower layer.

2.3 Layer boundaries can be selected at points where alternate protocols may be expected. For example, both HDLC and BSC are examples of link layer protocols. In contrast to these link protocols which use error detection and re-transmission, a link layer protocol could be defined that uses forward error correcting codes. It is important to note that the next higher layer protocol is independent of the particular link protocol used as long as the service is the same. Alternate protocols permit flexibility but it must be kept in mind that adjacent systems must operate using the same peer protocol if interworking is to be realized.

3. UNRESOLVED ARCHITECTURAL ISSUES

At the start of most new standardization processes, each delegation comes with its own set of major concerns and proposals for their solution. There is an immediate need to develop tools (e.g. common vocabulary) so that the various concerns and issues can be understood and eventually a single solution developed. Within the tight time frames of an international meeting only a small number of issues can be resolved and the remainder are left for further study. As the work progress, the original further study items are resolved and new ones created as the problem/solution is further refined.

Further study items are identified within the ISO and CCITT documents describing the reference models. The study items, however, are often symptomatic of broader issues that are not fully documented. This section examines some of the major outstanding issues associated with the lower four layers.

3.1 Provision of Transport Services

The Transport Service is concerned with the transfer of unstructured data units between processes in different systems, and the Service is considered to be an important partition in terms dividing the work on development of the reference model. There is general agreement between ISO and CCITT on the definition of the Transport Service but not on the method for achieving this service.

The Transport Service provides a full duplex pipe for exchanging data units of unbounded size, in sequence, between processes in end systems (i.e. systems containing the two communicating applications). The Service allows the receiver to control the rate at which it accepts data from the source, i.e. flow control, and it also provides a purge mechanism for removing all data from the pipe. An additional expedited signalling capability (interrupt) to bypass flow control is being studied. There is a very low undetected error rate and any unrecoverable errors are reported to the entities that are using a transport connection. The scope of transport addressing requires some further discussion. The service features described above are always provided regardless of the type(s) of underlying network(s) supporting the connection, however the connection may be established with various qualitative attributes, e.g. throughput, cost, transit delay, reliability, etc. The two different approaches to providing these services are discussed next.

The first approach which is described in the ISO model [1] employs an end-to-end transport protocol. This protocol operates between the end systems, i.e. no intermediate transport entities exist to operate on the protocol. Thus all end-to-end protocol control information is carried strictly as data by any intermediate nodes/networks. This approach is illustrated in Figure 1. The end-to-end transport layer assumes a minimal network layer service, i.e. an end system addressing mechanism, the ability to transfer a data unit of limited size, and possibly sequential data delivery. All other services such as flow control, data delineation, purge/interrupt are provided by control procedures within the end-to-end transport protocol. In essence this approach rules out the possibility of providing Transport Services via node-by-node protocols such as X.25.

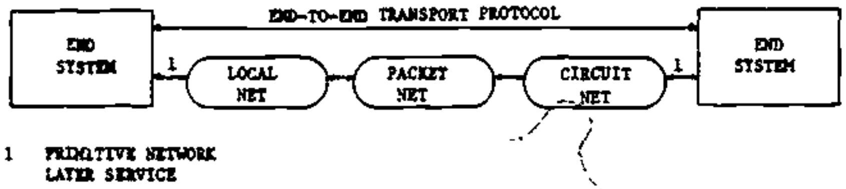
END-TO-END TRANSPORT PROTOCOL
END SYSTEM
1
LOCAL NET
PACKET NET
CIRCUIT NET
1
END SYSTEM
1 PRIMITIVE NETWORK LAYER SERVICE

FIGURE 1: ISO STRUCTURE FOR TRANSPORT

The second approach is described in Annex 2 of [2] entitled Elements of a Network Independent Transport Service. This approach allocates greater functionality to the network layer to the extent that the network layer provides the Transport Service. This approach is illustrated in Figure 2.

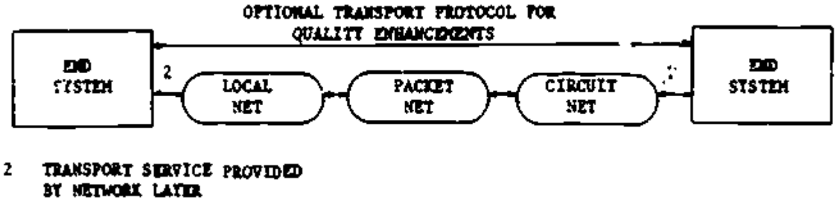
OPTIONAL TRANSPORT PROTOCOL FOR
QUALITY ENHANCEMENTS
END SYSTEM
2
LOCAL NET
PACKET NET
CIRCUIT NET
END SYSTEM
2 TRANSPORT SERVICE PROVIDED BY NETWORK LAYER

FIGURE 2: CCITT STRUCTURE FOR TRANSPORT

This approach is based on developing a consistent network layer service regardless of the type of underlying network. Thus the need for an end-to-end transport protocol solely to provide Transport Services is not required. By having a consistent network layer service, the interworking between networks of different types is resolved. The transport layer in the CCITT reference model is designed to provide qualitative enhancements but does not alter the basic nature of the service. For example, the transport layer may perform retransmission to provide higher reliability or provide an additional level of multiplexing so that several applications can share a network connection (see later section for discussion on multiplexing). If all functions of the transport layer vanish, then the transport layer service is identical to the network layer service not only in nature but also in quality.

An end-to-end transport protocol which assumes a minimal network layer service can provide the required service. The weakness of the end-to-end protocol approach is that it requires all systems to implement an additional protocol above the network layer and introduces substantial software and communications overhead. Part of the motivation for developing an end-to-end transport protocol stems from a concern that the three lower layers i.e. physical, link and network cannot be structured in a manner that allows a consistent service to be provided, particularly when networks of different types are used.

A number of groups have expressed concerns regarding the variations in X.25 in public data network implementations and the impact this has on efforts to define a common network layer service. These concerns are appreciated within the CCITT forum and are being answered. First, the revised text of X.25, which will be published at the end of the current study period, will clarify the virtual circuit service. For example, a common point of confusion has been to infer that no end-to-end services are provided by X.25, since the Recommendation is defined as an interface protocol between a DTE and a DCE. In fact, virtual circuit service provides end-to-end sequencing, flow control, data delineation, etc. The major difference has centred around the issue of end-to-end acknowledgement (i.e. should P(R) have end-to-end significance?).

There are valid views on both sides of the debate which only serves to highlight the need for overall architectural coordination. This particulr issue is being resolved by allowing virtual circuit service users to request end-to-end acknowledgement on a per packet basis as required. Recommendaion X.25 will be finalized by Study Group VII in February 1980.

X.25 Virtual Circuit is often equated as being solely suitable for packet switching networks yet the service provided is also applicable to applications operating over circuit switched networks. In fact, if applications are to interwork over combinations of local, packet, circuit etc, networks, then at some layer, a common level of service must be provided. In achieving this consistency at the network layer, it is important to note that the layer 3 protocol may be based on X.25, or if only a single connection is required, then a "mini-protocol" directly above HDLC may be sufficient for providing virtual circuit service. In pratice, portions of a single network connection may be supported by different network layer protocols.

3.2 Relationship Between Circuit and Packet Switching Recommendations

One objective of the work on developing a reference model is to specify the role of existing Recommendations such as X.21 for circuit switching, X.25 for packet switching, and V.25 which applies to automatic call control procedures over the switched telephone network. In particular, if one assumes for the moment that the 3 levels of X.25 correspond to the 3 lowest layers of the reference model then the question is which layer services in the model are provided by the X.21 service?

There is agreement that X.21 provides a physical circuit whose data transfer characteristics correspond to the physical layer data transfer phase. Above this service, link and network layer protocols are added to provide the network layer service.

The ISO model shows X.21 as residing entirely within the physical layer of the model. There is, however, a proposal to develop a layered version of X.21 in which the X.21 address corresponds to the layer 3 (network) address [4]. Associated with this proposal is a concern that ISO and CCITT have not yet considered the operational phases of the model in sufficient detail.

In the ISO model, the physical layer address specifies the location of the end-points of the physical circuit. The network layer address specifies the location of the end-systems i.e. the systems containing the applications. The need to clearly distinguish these two types of locations is illustrated in Figure 3. DTE's (host/terminal) A and C are connected to a circuit network (X.21 or telephone) and DTE B is connected to an X.25 network (public or private).

Applications in DTE A have the option of establishing a path to applications in DTE C either by a direct connection through the circuit network or by a connection through both the circuit and packet networks.

If DTE A establishes a physical circuit directly to DTE C, then DTE A and DTE C are at the end-points of the physical circuit, i.e. identified by circuit switched addresses. Since, in this case, the applications are in DTE's A and C, these two DTE's are also the end-systems. The network layer addresses could be considered redundant in this case since there is a one-to-one correspondence between physical circuit end-points and the end-systems.

If the application's data transfer requirements necessitate the use of both networks, then DTE A must first establish a physical circuit to the packet network i.e. to packet node P_0. Following the establishment of a link connection over this circuit, then DTE A establishes a network layer connection by specifying the address of the end-system, DTE C. Before the network layer connection establishement can be completed, an additional circuit connection must be established by the packet network (i.e. node P_3) to DTE C. Note that DTE A is unaware of this latter operation.

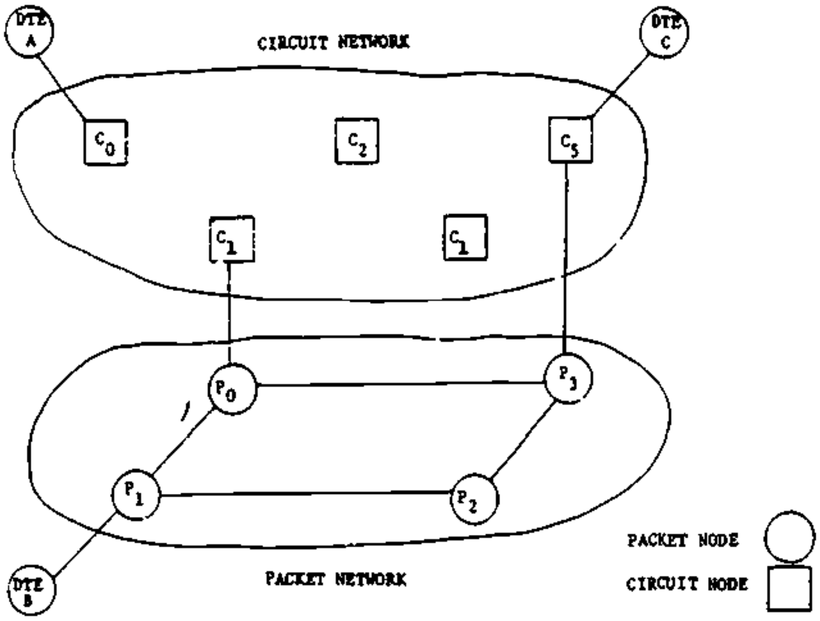

FIGURE 3: CIRCUIT AND PACKET INTERWORKING

Some additional architectural points can be illustrated with this example. First, the addresses used in both the physical and network layers can and probably should be defined in the same numbering plan (see section 3.4 below). Second, multiple network layer connections may be supported above a single physical layer connection. For example, DTE A, while connected to the packet network, can simultaneously have network layer connections to DTE's B and C. Third, the means for reliably exchanging circuit switched control information between DTE A and switching centre C_0 should not be confused with the link layer which operates between the end points of an established physical circuit. Fourth, packet networks may use circuit switching networks to establish physical layer connections between adjacent packet nodes. In this case, there is, in general no correspondence between physical and network layer connection end-points since the physical layer addresses identify packet nodes and the network layer addresses identify end-systems which are usually outside the network.

There are strong economic justifications for preserving the distinction between these two types of end-points. In the above example, DTE A determines the cost of the data transfer by selecting the circuit end-point and hence the transfer medium.

A DTE using these networks would use X.21 or V.25 for the physical layer, a link protocol such as LAPB, and X.25 level 3. This is the most general DTE interface.

3.3 Multiplexing

The need for multiplexing within the lower three layers, physical, link, and network, is well established. Users of European packet switching networks have identified the need for multiplexing above virtual circuits. In general, packet switching tariffs are based on data volume transmitted and are largely independent of connection duration. However several European networks have duration charges which dictate that, for low volume traffic applications, the most economical solution requires multiplexing above virtual circuits.

North American packet networks have tariffs based on volume only and there is a cost penalty for multiplexing above virtual circuits. For example, flow control is provided through the virtual circuit service but, when several independent streams are multiplexed above a single virtual circuit, independent flow control for each stream must be performed through the exchange of control information contained within data packets. For certain traffic patterns, the transfer of this control information can double the charge over equivalent non-multiplexed data flows.

If the economic needs of both groups are to be met, then both approaches must be permitted and a means found for users to interwork. This issue also raises the philosophical point that inconsistencies in tariffs require the development of a more elaborate model which consequently delays the standardization and implementation schedule, complicates interworking in general, and thus presumably is an impediment to public data network usage.

It has been proposed that multiplexing should also be a session layer function, but it is not clear whether this need is based on the belief by some that, in the ISO model X.25 may be a transport layer protocol.

3.4 Addressing

Discussions on addressing and the associated concepts of name (title) and route have been long and difficult. An excellent introduction to these three concepts is contained in a paper by Shock [5]. This same paper also describes the CCITT world wide numbering plan for public data networks, Recommendation X.121, which encompasses the existing numbering plans for the telephone and telex networks.

An address is defined as an identifier that specifies the location of an object. The difficulty with this definition is that the meaning of location within the context of the reference model, is difficult to define. Location must be defined in terms of other abstract objects defined in the reference model. While this does clearly identify what is being addressed, the semantics of a particular address are not always obvious. So far, there are more questions than answers on this topic. The following are some questions which will hopefully give the flavour of the current status of addressing in the lower layers.

There are questions on the structure of addresses. Are addresses always hierarchically structured or are there separate address domains connected by gateways which perform address translation?

If Recommendation X.121 were to serve as the basis of a hierarchical numbering plan, can it be extended in a structured manner to encompass private/local networks? Could such a structure still ensure a unique world address (i.e. an address of a system that is valid and recognizable anywhere)?

Is there a need to establish well defined boundaries between the portion of the address that selects a system and the portion that selects a process within that system? Do specific portions of the address need to be assigned to different layers? How is the address space managed when (portions of) addresses are specified by international bodies, public network and local/private network administrators, and individual system managers?

Addressing impacts the entire reference model and it will become more difficult to proceed without an agreed overall resolution of this issue. The standardization work has probably reached the level of maturity where total and practical proposals need to be received and discussed.

4. PROGRESS TOWARDS STANDARDZATION

At the last ISO/TC97/SC16 meeting on Open Systems Interconnection in June 1979 the basic seven layer model was approved and version four of the reference model (ISO/TC97/SC16/N227), which has the status of a working paper, was produced. The introduction, purpose, and architectural principles contained in the revised reference model (N227) were reviewed and approved by SC16 but unfortunately time limitations did not allow SC16 to review the service and function specifications for each layer. The lower layer issues described in the previous section can not be resolved independently from one another but must be discussed within a full SC16 plenary if they are to be resolved to everyone's satisfaction.

SC16 has proposed a number of new projects based on N227, and new working groups were proposed to complete the service definitions and develop protocols for a) transport and session, b) presentation and application (VTP and FTP) and c) to examine management issues in the reference model. It was proposed that projects associated with the lower three layer be assigned to SC6 (Data Communications).

Although the individual layers were not reviewed or approved, the re-organization of the working groups in SC16 will maintain the momentum of the work effort.

The partitioning defined in the reference model is intended to serve as the basis for chartering groups to work in parallel with minimum interaction and conflict however this work has not yet resulted in agreement on the distribution of functions between the transport and network layers. This topic was discussed at the ad hoc group level in SC16 but the group was evenly split over whether or not to increase network layer functionality. The last CCITT meeting on Layered Models strongly supported the need for increased functionality in the network layer. There is a real concern that further discussion and resolution of this issue may be more difficult to coordinate given that the responsibility for aspects of network and transport layers is spread between SC6, SC16 and CCITT Study Group VII.

5. CONCLUSIONS

The importance of the work on Open Systems Interconnection is widely recognized, and many individuals and organizations have devoted considerable amounts of time and effort to further the work.

The work is as much an effort in human as in computer communications. The key to success is in understanding the needs and concerns of the various organizations and structuring the solution to meet these needs.

Completion of the protocols identified by the reference model will be a tremendous catalyst to the entire data communications industry.

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AN INTRODUCTION TO THE REFERENCE MODEL FOR OPEN SYSTEMS ARCHITECTURE

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Abstract

This paper is a tutorial introduction to the reference model for Open Systems Architecture. It is intended to set the conceptual framework and vocabulary for the subsequent papers in this session. This paper outlines a brief history and motivation for open system interconnection, and then describes the key concepts and their interrelations. A brief description of the purpose and services in the layers then follows.

I. HISTORICAL PERSPECTIVE AND MOTIVATION

Since the spring of 1977, there has been a combined standards and design effort by the International Standards Organization (ISO) and later by Committée Consultatif International de Téléphone and Télégraph (CCITT) to devise a framework that would allow any person, terminal or computer to communicate. Communication is used here in its broad sense to include data transport and an operational understanding of the data semantics.

Earlier work at ISO and CCITT had concentrated on the conceptually simpler, but still very difficult, problem of data transport, but it was quickly recognized that successful communication required more than data transport. The stubborn mechanical single mindedness of the logical devices communicating requires a precise definition of the communication interactions. Experience with ARPANET at that point indicated the high level protocols were both complex and potentially incompatible. Thus an effort was started at ISO to define a reference model for "open systems architecture". "Open" as the opposite of closed to suggest that adherence to a set of specified protocols and standards as embodied in the "architecture" would allow a "system" to carry on meaningful communication via an interconnection. Ten countries are involved in the ISO effort with similar activities in CCITT and some computer vendor organizations. This effort goes well beyond standards and is in fact involved in areas which are current research topics. As Bachman [1] in his historical review of open system interconnection notes, the effort is more one of design than standards. If successful, it will both enhance and constrain the form of future automated communications. We all have a large stake in the outcome, since the ease of communication has profound influences on the pervasiveness of the dependent services. There is enough conceptual content in the problems to fascinate engineers, social scientists and mathematicians.

II THE KEY CONCEPTS

The key concept in the open systems architecture is that of a service. A service is defined as a capability offered by the architecture. More precise definitions of a service centre around the difficulty of quantity and quality of those aspects that are central, those that are secondary and perhaps merely desirable, and those that are mere artifacts of the implementation. An example of a service is a "virtual circuit" which has become a central part of packet switched networks. Although sequencing of data carried by a virtual circuit is an agreed part of the service, the inclusion of both a "soft" clear and the "hard" clear of the X-25 [2] network interface is perhaps not. Even more difficult to determine is whether quality aspects such as transit delay must be specified as part of the virtual circuit service. Although failure to specify precisely all aspects of a service constitutes a danger, it is still possible to separate services and to organize them so that more detailed specification can be affected by independent groups. The key organizational concept for services is that of a layer. A layer presents, to the layer above, a well defined set of services and a set of rules for invoking those services. In order to provide the services for the layer above, use is made of the more primitive services of the layer below, along perhaps with some additional new or unique functional capability that exists on that layer. The logical separation of services into layers would be made easier if there were some absolute hierarchical dependence of one service on another. Unfortunately this is not the case and hence the placement of services in layers is subject to some negotiation.

The next key concept is that of a system which can be thought of as a locatable processing structure. A system is the only concept with any idea of a physical location. Thus the world of open systems architectures is partitioned horizontally into layers and vertically into systems as suggested in Fig. 1. An entity is a logical object that exists entirely within the intersection of a system and layer and actually provides some or all of the services to entities in the layer above it. An entity is roughly equivalent to a process but, as processess are ill defined, the new word was chosen. Since an entity is confined to a single system, it may not be able to provide the service to an upper layer entity without the cooperation of another entity. In fact even some services in the same system may require cooperation. Cooperative arrangements are effected by virtue of a connection joining entities.

In order to reduce inadvertent service dependencies, connections, as illustrated in Figure 2, can only be made between peer entities on the same layer. Connections must be established, maintained and cleared. An entity may have several connections with the same or different peer entities at one time. Data transfer between peer entities does not actually flow over a connection but rather via a service-access point established in conjunction with an entity in the next lower layer. This is illustrated by the solid line joining for example A_n and A_{n-1} in Figure 2. Thus the service-access point acts as a two-way "path" between two entities in adjacent layers. If entity A_n wishes to establish a connection with entity B_n then at the very least A_n must know the global title of B_n. The global title uniquely identifies B_n amongst all entities that have ever existed within the open systems but does not locate it or indicate an access path or route to it. Thus A_n must establish a "path" to an A_{n-1} that has the capability of locating B_n. It does this via a service-access point and identifies this point via a service-access point address. This service access point address serves to locate A_n for A_{n-1} and vice versa.

The service-access point establishment, maintenance and addressing, since it is confined to a system, is largely a local management issue. A_{n-1} can only establish a connection-access path to B_n if it is able to establish a service-access point to B_n, which can only be done if B_n is in the same system. Otherwise A_{n-1} must establish a connection to a [illegible]$_{n-1}$ that is able to complete the connection-access path to B_n. However, A_{n-1} does not know, from the global title the location of B_n or B_{n-1}. Thus a directory concept is introduced to allow A_{n-1} to determine an (n-1) service-access-point address associated with B_n and a routing concept to allow the determination of the next lower layer service-access point address needed for the next step in the connection-access path. The implementation and implications of the directory and routing are subtle and not yet well understood. Thus for A_n to be accessible from (n+1) and $(n-1)^{st}$ layers, it needs both an (n) and (n-1) service-access point address.

Once A_{n-1} has established a connection with B_{n-1}, the connection between A_n and B_n may be established. Connections have connection identifiers to assist in management and connection endpoint identifiers consisting of the first and last service-access point addresses on the connection access path and two associated connection endpoint suffixes to distinguish between connections having the same connection access path endpoints.

Connection access paths do not need to be direct in the sense of travelling up and down to the physical layer only once. There can be relays by entities in intermediate systems. For example A_{n-1} could have reached B_{n-1} via a connection from A_{n-1} to C_{n-1} and C_{n-1} to B_{n-1}. A layer (n) protocol is a set of rules and formats (semantic and syntactic) by which connections are established, maintained and released and by which data units and control information are transferred (logically) between two cooperating peer entities. Layer protocols are those currently under investigation and standardization. Interface protocols involving service-access points are currently considered to be implementation dependent and are not being subjected to standardization. The exact interdependence of interface and layer protocols is not clear.

Thus we see that the reference model for open systems architecture consists of layers of services provided by cooperating peer entities exchanging control and data units according to an agreed upon protocol over a connection. It now remains to describe the specific partitioning of services of the present reference model.

III THE SEVEN LAYER REFERENCE MODEL [3]

The seven layer model as proposed by ISO is shown in Fig. 3. The lower four, consisting of the physical, link, network and transport layers, make up the data transport functions, while the session, presentation and applications layers make up the data processing oriented functions. Although the general purpose of the layers is fairly well agreed upon, some of the services are still subject to debate and definition.

In the sections following, we briefly describe the purposes and some of the services provided by the layers. More detail and the basis for this description may be found in [3] and the subsequent papers in this session [4,5,6,7].

i) Application Layer

This is the highest layer in the Open Systems Architecture. It serves to provide a distributed information service environment appropriate to the user applications. It may be subsequently layered but it is not obvious that this will be appropriate. User and management applications are two basically different types of application-processes that have been identified. User applications, such as a person operating a banking terminal, a remote data base query process, or a process control computer operating remote equipment via a network are coordinated via application protocols. Management applications are concerned with the operation, accounting, control and maintenance of the resources in the layers. Management application processes are special since they have direct access, as shown in Fig. 3, with corresponding management processes in the layers. Thus we see these processes performing operating system functions. It is presumed that these entities will coordinate activities in various systems via connections and management protocols. The exact nature (and structure) of this interaction is as yet unclear. Discussions on these points form the central part of a paper in this session [4].

ii) Presentation Layer

The key concept in the presentation layer is that of a presentation image. When two applications choose the same, perhaps negotiated, image they then have a consistent set of formats and protocols for interpreting exchanged data. Thus the presentation layer presents the applications layer with services for delimiting, structuring, converting, displaying and controlling data. An example of a presentation image is that given by a virtual terminal protocol. The intent of this layer is to provide a few standard images and hence allow communication between applications without undue cost.

It is recognized that some applications, especially in similar systems, will not need the services of the presentation layer. Those applications will be permitted to establish service access points with the session layer directly below the presentation layer.

iii) Session Layer

The purpose of the session layer is to support a dialog involving structured data between two cooperating application-processes via the session connection established at the session/presentation interface. We note that the session connection access path goes via the session entities. Application-processes can communicate only via initiating or accepting a session. A session-administration-service consisting of session establishment, session identification, session recovery and session release, and a session-data-transfer-control-service consisting of data exchange, data delimitation, and dialog management are services provided by the session layer. In addition services for synchronization, checkpointing, roll back, and commitment are to be provided.

Langsford [5] discusses issues in the upper layers in his paper in this session.

iv) Transport Layer

The transport layer is to provide a universal end to end (system to system) transport service for session entities which are referred to in this layer as transport users. The transport layer is not only required to provide, on an end to end basis, services such as sequencing (if requested), error notification, purging, flow control, priority, expedited data unit handling, multiplexing and quality of service monitoring, but also to optimise, with respect to cost, the use of the resources in the lower layers. This latter requirement is indeed a quite difficult one and it still remains to be seen whether relieving higher layer entities from these cost considerations is possible. The transport entities do not perform any relay function. The transport layer is not concerned with routing or the location of corresponding transport entities.

v) Network Layer

The primary services provided by this layer are switching and routing. Point to point network connections, with perhaps a relaying function, allows transport entities to establish end to end connections. Along with the expected connection establishment, maintenance, release, data quality, and control services, the network layer is expected to provide the transport layer with costing information to allow determination of optimal resource usage. How much resource allocation control is given to the two layers is still unclear.

vi) Link Layer

This layer provides for the establishment, maintenance, and release of a data-link between two or more network entities. The intent is to have a single service on a point-to-point basis even while physical connections may vary (eg. point-to-point leased, dial up, multipoint, broadcast etc). A data-link should provide substantially error-free data transport.

This layer's ability to turn the data pipe on and off without loss distinguishes a data-link from the physical data-circuit on which it is based. Other services provided to the network layer are: sequencing (if requested), error notification, quality of service and addressing information.

vii) Physical Layer

This layer is the residence of the physical data circuit (connection) that is used by the link layer. The major characteristic of the data-circuit is that of an open pipe where data falls at the end. This layer is in fact rather complex containing all of the resources required to establish, maintain and release point-to-point and "circuit" switched data circuits. It thus has buried in it a switching service. Data units transported over a data circuit are delivered, with perhaps some error, deletion or insertion in order. The physical layer provides an information service to the link layer on fault conditions, quality of service, service availability, transmission rate, and transit delay.

The lower four layers are discussed in this session by Cunningham [6] and Schindler et al [7].

IV SUMMARY DISCUSSION

This paper has concentrated on a tutorial introduction to the ISO layered communications model. Recently more easily available documents [8,9] than the ISO working paper [3] have discussed the model. This session is intended to further increase the availability and discussion on the issues raised by this international design effort.

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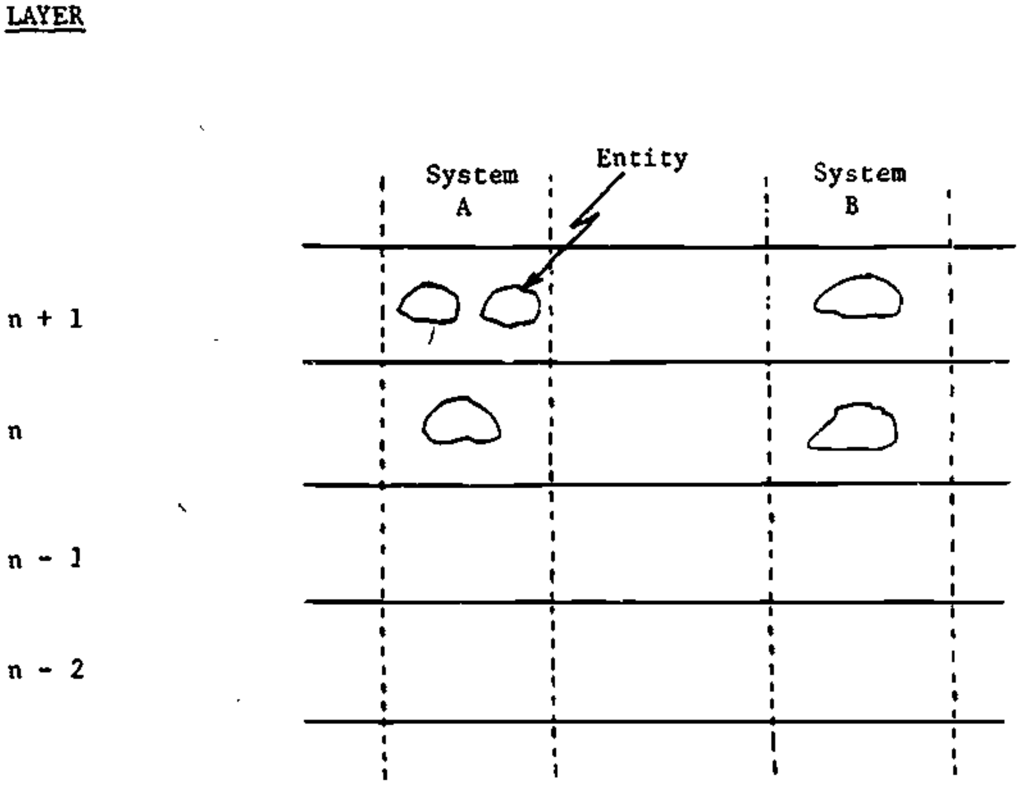
LAYER
Entity
System A
System B
n + 1
n
n - 1
n - 2

Figure 1. The partitioned reference model for open systems architecture

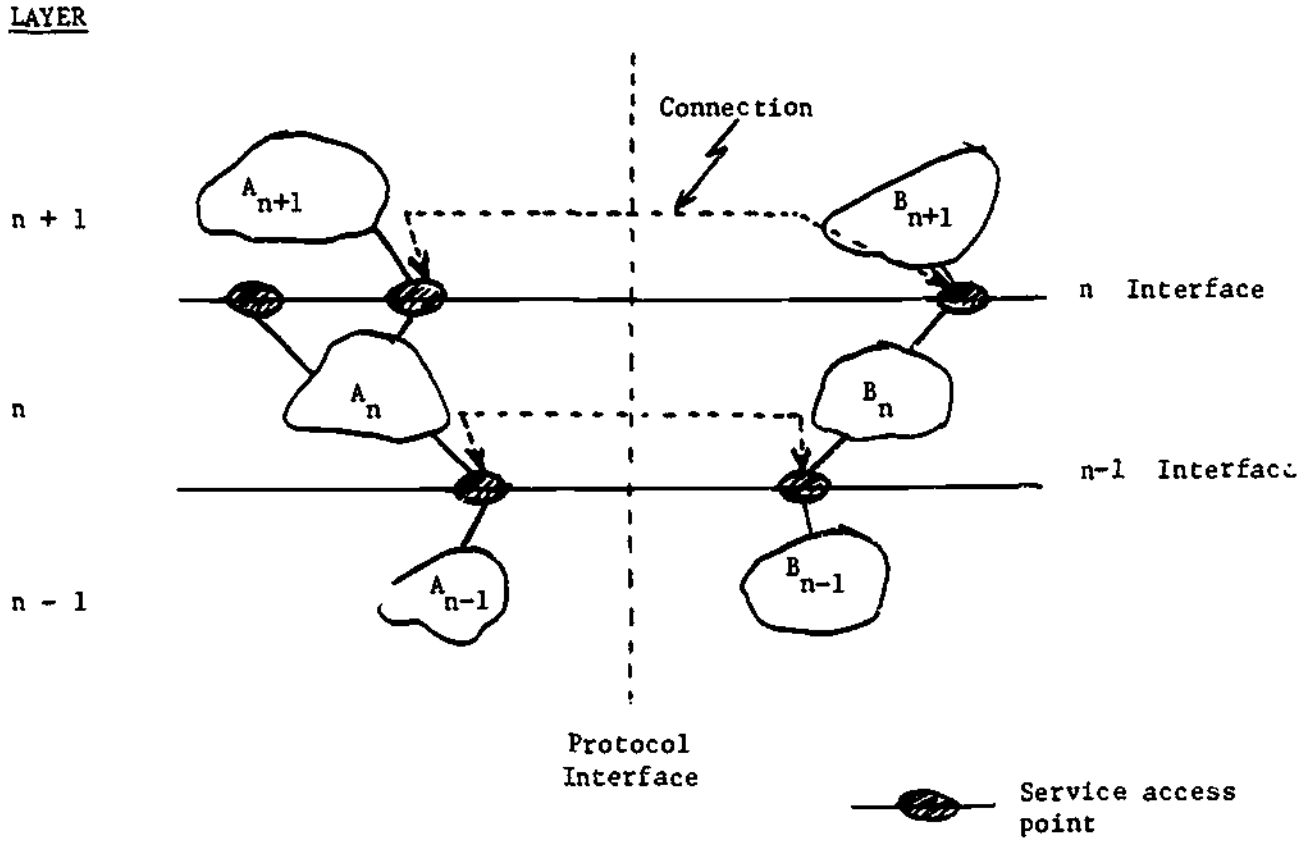
LAYER
n + 1
n
n - 1
Connection
A_{n+1}
B_{n+1}
n Interface
A_n
B_n
n-1 Interface
A_{n-1}
B_{n-1}
Protocol
Interface
Service access
point

Figure 2. Layer connections and access paths

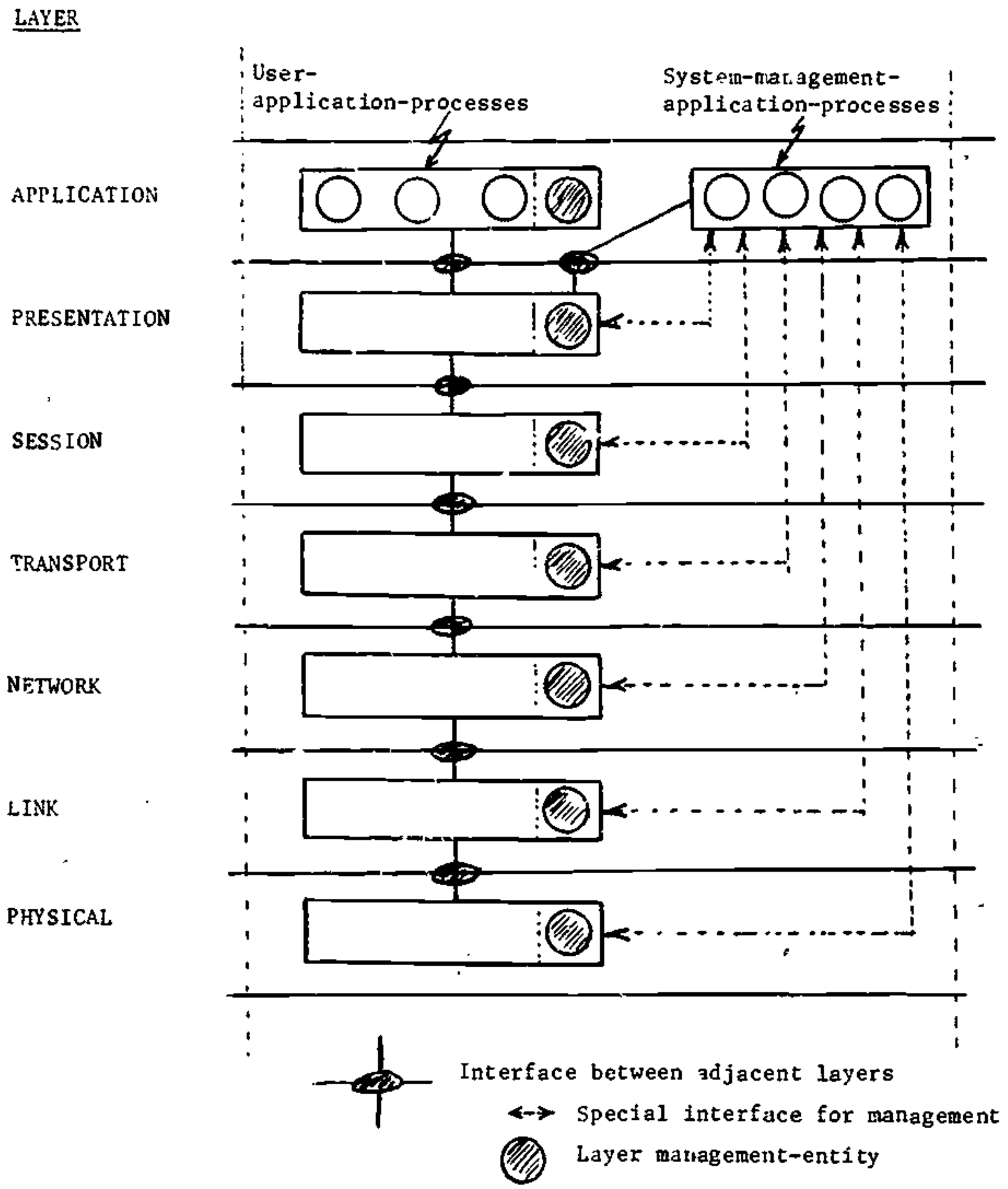
LAYER
User-application-processes
System-management-application-processes
APPLICATION
PRESENTATION
SESSION
TRANSPORT
NETWORK
LINK
PHYSICAL
Interface between adjacent layers
Special interface for management
Layer management-entity

Figure 3. Layer designation and management entities

ISSUES CONCERNING THE UPPER LAYERS OF THE COMMUNICATIONS REFERENCE MODEL

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The concept of a hierarchical structuring of low level communications protocols has been familiar for some time. Only recently has an attempt been made to extend that structuring to high level and application specific protocols for the exchange of data between information processors. This paper explores the issues which are generated by so doing. It considers how certain protocols (e.g. terminal access, file and job transfer) are mapped onto this structure and how management of communications resources has to be viewed. The ISO reference model of open system interconnection has examined in detail some of the consequences of the structure. Others are unresolved and are topics for research. The paper offers the author's personal view on how some of these issues will be resolved.

1. Background

Technical Committee 97 of the International Organisation for Standardization formed sub-committee 16 late in 1977. That sub-committee's remit was to explore the requirement for the standardization of protocols and interfaces in Open System Interconnection and to report on its findings and recommendations. It was also charged with the task of developing a "Reference Model" to which future work could be related. These things SC16 has accomplished and has submitted a technical paper 1) to TC97 which describes the model, identifies existing standards and proposes areas where standards are required. SC16 was not empowered to propose or to develop standards but, in a separate paper 2), it now recommends ten work items as projects for standardization.

Before discussing these projects it is necessary briefly to explain the features of the Reference Model. Even at the outset we find that the term "Open System" is understood with different meanings by different members of SC16. Their views may be roughly partitioned into two alternative definitions:

(a) An Open System is one in which subscriber terminals and computers intercommunicate through their connection to a common communication network. There is no bar to any subscriber attaching to the network beyond that required to ensure the safety and integrity of the common network.

(b) An Open System is one in which users may intercommunicate using any equipment which conforms to standard protocols for information interchange without regard to the source or manufacturer of that equipment.

These definitions are not mutually exclusive but show considerable overlap. The former is the view of the communication engineer who sees the PTT providing the common communications network. His model is the present voice communication network in which subscribers who use approved terminal equipment and pay their accounts may access (or be accessed by) any other subscriber. However no stipulation is made as to the source of terminal equipment which could all be from a single supplier. The second definition is that of the computer user. He sees little requirement at present to communicate outside a very narrow group of subscribers. He is however keen to select his equipment from any vendor and expects it to interwork with equipment from any other vendor. His communication network may be private and "closed". An alternative description of this person's interest is "distributed computing".

Readers of the SC16 Reference Model document [1)] are likely to recognise this dichotomy and may find it confusing. However, these alternative views have the merit of causing the issue of Open System Interconnection to be investigated from a number of stand-points.

They force a recognition that the subject matter is germane to a vast range of computer standardization issues, e.g. communications, data representation, data interchange media, programming languages etc. Many of these issues will be discussed (albiet briefly) in this paper.

The architecture of the Reference Model is based upon a strictly hierarchical approach to intercommunication. This argues for a partitioning, by function, of intercommunication protocols found in open systems. The functions supported by the protocols at one level of the hierarchy offer services to a higher level. They, in turn, make use of services provided by a lower level. Attributes which dictate this division into a number of layers are:

(i) common and closely related functions can be identified as belonging to a layer,

(ii) a well defined communication end-point may be associated with the layer,

(iii) a specific representation of functions within any layer can be replaced by an alternative representation. As long as this may be accomplished without modifying interfaces between layers the replacement is "transparent" to adjacent layers,

(iv) communication protocols operate entirely within a layer and there should be no cross-layer effects.

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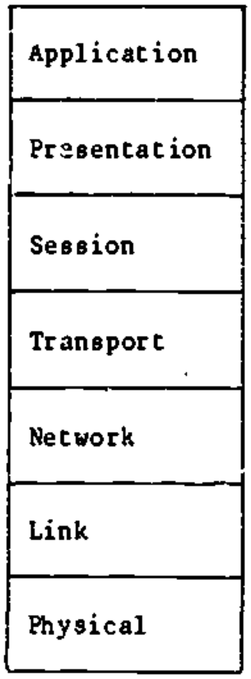


The 7 layers of the ISO Reference Model

Figure 1

This concept of an hierarchy of communication protocols has become reasonably familiar to communications engineers and networks designers. It has been adopted by CCITT in their specification of the X.25 recommendation for packet switching services. The SC16 Reference Model seeks to extend this concept from the physical communications network to the abstract network of interprocess communication within a distributed system. In doing so it has identified 7 layers (see figure 1). Of these the three lowest layers are concerned with the task of conveying signals from one physical end point on to another. Recognising that within any physical end point (alternatively called domicile or host) there may be several logical end-points, a fourth layer, the Transport Layer, is added. This provides a logical, end-to-end communication between processes resident in a domicile which is independent of the underlying communication mechanism and offers an arbitrarily high quality of performance, reliability and bandwidth. It marks the boundary between the issues which are of importance to the communications engineer and those of interest to the computer systems specialist.

The upper layers of the Communication Reference Model are those three which lie above and use the facilities offered by the Transport Layer. In the following sections, this paper firstly presents the features of these three layers as documented within the Reference Model and then discusses the issues raised by this partitioning of the interprocess communication problem.

2. The Architecture of the Upper Layers

2.1 Application Layer

The Application Layer is the highest layer in the Reference Model of Open System Interconnection. An application is composed of co-operating application processes which intercommunicate according to Application Layer protocols. The collection of application processes which collaborate in a given information processing enterprise are referred to as an application process group. The protocols of this layer exist to serve the end user either directly by controlling the application specific features of information exchanged between processes or indirectly by supporting a distributed management function within which the distributed processes run. All other layers of the Reference Model exist only to support the activities of the Application Layer.

2.2 Presentation Layer

The developers of the Reference Model considered that, in multi-vendor open systems, different manufacturers would adopt different internal representations within their computers for such items as file naming conventions, accounting information, control commands, character sets, numbers and text layout symbols. Although common functions having identical semantic meaning would be present in the Application Layer (to make intercommunication meaningful) the syntax for their representations might differ. Hence the Application Layer would require the Presentation Layer to manage formats and transformstions. Where communicating processes use the same syntactic conventions the presentation layer offers null functionality.

Transformations are always required to allow computers using different representations to inter-communicate. The standardization issue can be stated very simply. If there is no standardization of the Presentation Layer then a series of pairwise transformations will proliferate. With a standard there will be a single set of transformations between each local representation and the standard. It is argued that this is more cost effective and (ideally) encourages all manufacturers to adopt a single representation.

2.3 Session Layer

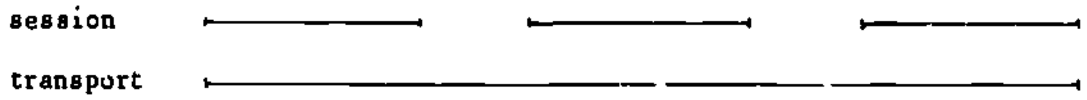
A session is a co-operative relationship between two presentation entities. Two principal services are identified:

(i) a session administrative service to bind and unbind this relationship and

(ii) a session dialogue service which controls the data exchange by synchronisation and data delimiting functions.

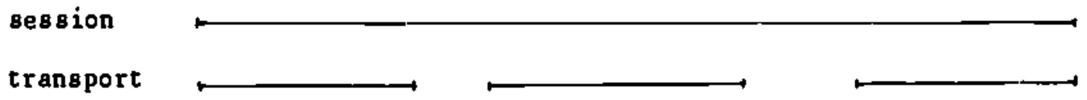
Sessions may be two way simultaneous, two way alternate or one way. In administering a session, the session protocols support the negotiation of the higher level protocols which will be used during the session.

The initial concept of a session arose by analogy with a user's interactive session at a terminal. It has since been refined so that it is concerned essentially with the dialogue control aspects of a communication between two logical end-points. It is independent of the transport connection which may support a sequence of sessions or one session may extend over several transport connections (figure 2a and 2b respectively). As an example of the former, one transport connection may be retained for some time while a series of independent sessions (i.e. transaction) take place between the same two network end-points. As an example of the latter a session may be extended over several days while batches of data are exchanged. In order



Sequence of sessions using a single transport connection

Figure 2a



Single session extending over several transport connections

Figure 2b

to economise on communication resources transport connections are only created to cover the time data actual flows.

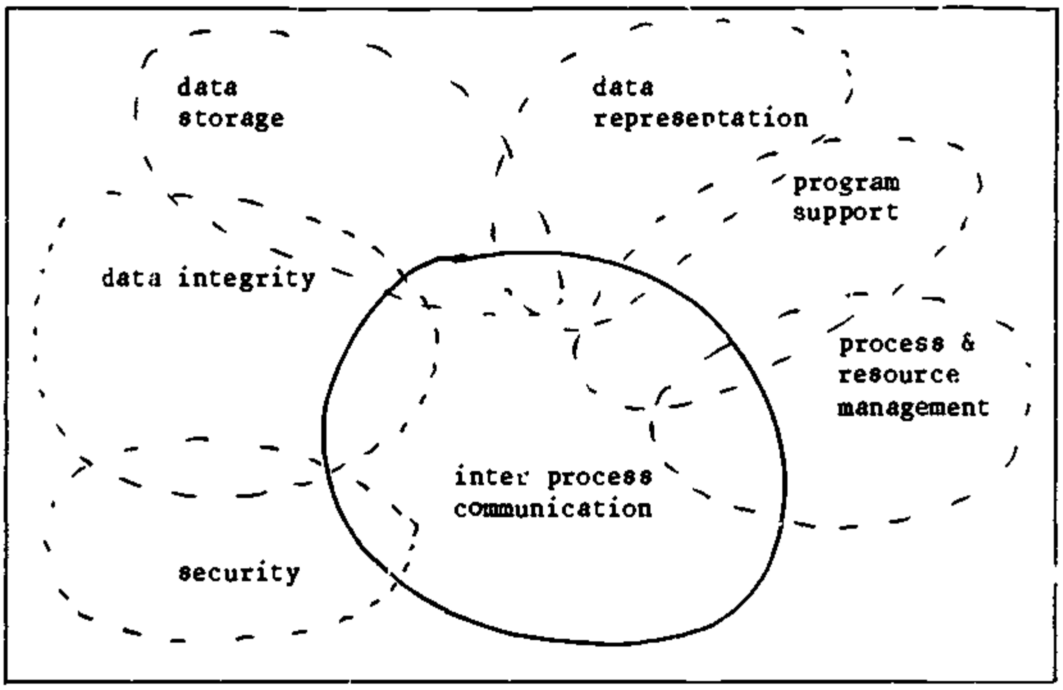
2.4 Issues

The Reference Model states that there is a one-to-one correspondence between application and presentation service access point addresses and between presentation and session service access point addresses. As a result the end-point identified by the Transport Layer is often (and interchangably) associated with either the session, presentation or application entity. Thus the three upper layers appear as a single named unit. Some commentators consequently view the upper layers of the model in a different light from the four lower layers. Indeed some have gone so far as to suggest that there is in reality only one layer above the Transport Layer, namely the Application Layer. They invoke the concept of sub-layering to suggest that application, presentation and session are synonyms for the semantic, syntactic and dialogue aspects of Application Layers protocols.

This may be a nice difference for the purist. For the practical person it should have little effect on the structuring of protocols. One feature of a layered hierarchy is that it defines an order within which protocols and mappings are nested. Whether application, presentation and session are sub-layers or not, the functions they represent have to be applied to outgoing signals in order and inverse operations must be applied to incoming signals in reverse order. This has to be standardized and the 7-layer sequence offers an adequate standard.

An associated architectural issue which has yet to be resolved is the relationship between addressing and naming. The communications engineer requires an address to establish a routing mechanism for the transmitted data. The [host, service access point] pair seems adequate for this purpose. However the computer specialist likes to ignore such details and would prefer to identify the application process by its name. It is reasonably easy to implement a system in which a standard process handles all requests for connection to named entities and then associates with that request an unambiguous address. However standards bodies do not dictate to manufacturers how systems shall be implemented. Only the functions to be provided and the protocols which are the external manifestations of those functions are subjects for standardization. A way of resolving this problem which still makes clear the functional need has yet to be identified although private networks have offered solutions.

Reflecting upon the dichotomy of view as to what constitutes an open system, the SC16 Reference Model provides in one of its appendices an alternative model for the distributed processing environment (figure 3).



The 'Universe' of Open System Interconnection

Figure 3

This is partitioned by functional requirement at the highest level and not by communication protocol. It shows, in a simple diagramatic form the impact of open systems interconnection on a range of computing functions. It touches the issues of distribution of data bases in its consideration of data presentation and storage. The access to remote resources and their control is a manifestation of the distribution of operating systems. This impacts not only upon management protocols but also upon the design and possible standardisation of Command and Response Languages. Program support in the open environment introduces such issues as the mechanism for identifying and binding external objects into computer programs and the possibility of providing standard procedural interfaces within programming languages to effect communication functions. Integrity and security are vital issues in open systems and will be influenced by legal as much as by computing and communication considerations. All these aspects overlap with each other to a greater or lesser extent. Interprocess communication is the main topic of the SC16 Reference Model. The upper layers of that model are to be found in the overlap between interprocess communication and the functions identified above.

3. Specific High Level Protocols

There are a large number of applications for which standard protocols are desirable. Three have emerged as being particularly urgent. They are:

(i) virtual terminal protocol
(ii) file transport, access and management
(iii) job transfer and manipulation protocol

Where do these high level protocols fit into the Reference Model? There is at present some uncertainty as to how they should be partitioned between the Application, Presentation and Session Layers. There is a concensus that the virtual terminal protocol resides wholly within the Presentation Layer, that files services have both Application and Presentation Layer attributes and that job transfer and manipulation protocols will need to make use of file service protocols.

The approach usually taken in establishing these protocols is to postulate an abstract model of the computing and communication environment. This model provides an idealised view of the operational and functional requirements for a service together with a conceptual design and implementation of that service.

Thus the virtual terminal provides a conceptual input/output device; an abstraction of an interactive terminal through which a human communicates with a computer program. The computer and terminal user are partners in a dialogue whose semantics are handled by the Application Layer protocols for a particular service. The signals, passing betwen the conceptual input/output device and application to maintain a presentation image common to the partners, constitute the virtual terminal protocols.

The actual terminal may be formed from one or several devices, possibly with attached or inbuilt intelligence, under the control of a human operator. Those functions which the operator can exercise locally and have no remote effect are not the concern of the virtual terminal (e.g. local editing functions to correct typing errors on input). The designers of virtual terminal protocols recognise that there are a number of real terminals classes. There is a corresponding set of virtual terminals classes. This allows a virtual terminal class to be identified by a simple declaration and avoids the many tedious interchanges which would be needed if the terminal characteristics were negotiated between the application processes. Recognised classes include stream (i.e. scroll mode), page, data-entry, word processing and graphics terminals.

Conventionally, terminals are used in two way alternate mode and this method of working has influenced the way virtual terminal requirements are often specified. Dialogue control is invoked by asserting which of the two application entities has the turn to send data. It is well known in such situations that one or other of the application entities may wish to assert its turn. This is commonly accomplished by an attention signal. These are clearly features of the Session layer though frequently such "out-of-band" signals are implemented by use of a much lower level "interrupt" mechanism (e.g. the X25 interrupt provided in the network layer). This happens in spite of the fact that a full duplex communication channel is provided by the Transport Layer protocols and the concept of a half duplex virtual terminal is a logically maintained fiction. Thus, the attention can be transmitted by the Transport Layer protocols as an "in-band" signal.

Within the conceptual data store each symbol has three attributes; (a) its graphic representation, (b) its presentation mode, (c) its address in the store. On a real device the presentation mode offers such features as intensity, colour, inverse video, blinking, non-echo etc. Being addressable, symbols may be inserted at will within the store (equivalent to cursor control). Issues still to be addressed by the designers of virtual terminal protocols are the character sets to be used particularly for open international communication. The Roman alphabet used by the English speaking world is inadequate.

The model for the abstract file store establishes a conceptual file image, file attributes and file access methods. A filestore is an administrative collection of files residing at a particular domicile and includes descriptions of file properties and file names. It may also contain pointers to files in other filestores possibly held at different domiciles. A file is a container for a named collection of information with a common set of properties. It may be structured or unstructured.

File access covers the inspection, modification and replacement of all or part of the contents of a file. File management is the inspection or manipulation of the properties associated with the file as a whole including manipulation of the file name or location. One service which is continually demanded of computer networks is an ability to transfer a file from one location to another. A way of visualising this service is to use file access and management protocols together with a copy program to effect the transfer. This moves files on a record by record basis as each (remote) request for the next record is made. In a frequently used service such a mechanism is likely to be inefficient. Instead an additional file transfer service is postulated which will declare at the outset that the objective is to move a named file from one location to another. Following an initial dialogue between the participating file transfer processes the transfer takes place as a unidirectional flow of a stream of data. To preserve file structure, record markers must be inserted into the stream. Thus the model of a file transfer protocol differs from that for file access. In the former a copy procedure is distributed over two hosts and makes local access to local filestores. In the latter a non-distributed copy procedure operates between a local filestore and a remote filestore, through file access protocols.

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Whereas the Application Layer protocol of file transfer[32], access and management are concerned with management and integrity procedures, the Presentation protocols maintain a mapping of file attributes, names, data representations and formats between the communicating processes.

Less has been said within the standardization bodies concerning job transfer and manipulation. That users feel a need for this service is certain since one of the first applications of telecommunications to computing was to provide remote job entry to batch processing systems. However with the present trend towards interactive programming many of the previously used techniques are no longer appropriate. Where the interactive user wishes to submit a job to a batch system the interactive environment usually enables him to identify a job file specifying the job. When this file is collocated with the batch processing system, the operation is purely local. When the job file is located remotely or its program and data components distributed, then file transfer and management protocols are required to submit the job and return output. Application and Presentation Layer protocols are needed to associate named devices with batch processing streams. User enquiries, on the progress of jobs and cancellation of submitted jobs, are Job Management sevices requiring agreed protocols.

Still less well defined is the range of management protocols which will be needed in open system interconnection. Some computer specialists have observed that, because one may sometimes organise a computing task as a parallel processing activity on one computer, this task could be transferred to a distributed system where the component processes could truely run in parallel. Were this to become a general rather than an esoteric requirement there would be value in standardising the management of such distributed tasks. For the present the majority of user requirements are essentially met by localised sequential processing. The value of networking lies in giving the user access to remote programs, computing resources and data and in the distribution of functions. Because the user and the resources he wishes to call upon are distributed, some degree of parallel processing and management is inevitable. The operational requirements of networking imply management support in the form of resource directories, accounting and billing procedures. Where security is of importance it will be necessary to protect not only data in transit by encryption but also access to resources. One feature exhibited by the new data networks and not provided by voice networks is the identification (by address) of the caller to the callee. Password mechanisms are usually invoked to identify the user to the computer system. Where more security is needed, the computer system should authenticate itself to the user Public Key Encryption[33] methods offers both data security and authentication.

A user, interacting with many programs at once or at more than one host site, also requires management protocols. Having once identified himself at the terminal the user will be reluctant to have to log in to every system to which his work takes him. Some of these systems he will be using by proxy through another computer. At some hosts he will have to identify resources by name rather than network address and the problem of managing the migration of user 'session' from one application to another has already been identified.

These are all aspects of distributed management which will call for management protocols. The Reference Model distinguishes them from other management issues by allocating them to the Application Layer of the model even though they are conventionally regarded as system rather than application functions. In addition there are in-line management protocols. These are concerned with the management of resources which are peculiar to a layer. They are most readily recognised in the lower layers as flow control and error recovery mechanisms.

4. Postscript

At the time of writing this paper SC16 has submitted its proposals to its parent committee, TC97, and these are out for ballot. In its meeting in Madrid, November 1979, TC97 will decide upon the outcome of SC16's considerations. If TC97 follows SC16's recommendations, SC16 will create four working groups to handle technical issues. These will cover:

Reference Model
Application and System Management
Application and Presentation Layers
Session and Transport Layers

The issues that have been identified in this paper, and many others, will be investigated in depth. The normal process of creating an international standard is slow and many commentators have suggested that it will be at least five years before the topics discussed here have become international standards. The author's own view is that there is no need for the computing community to dispair of networks until then. The guide lines for the future are well established. Once a standardization work item has generated a proposal of value it can be expected to become a standard in the fullness of time as dictated by ISO voting procedures. It is likely to be taken up speedily as a de facto standard both by manufacturers and users. This has happened in the case of the HDLC protocols. There is no reason why it should not happen to high level protocols for open system interconnection.

5. Acknowledgements

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A STUDY ON MANAGEMENT ISSUES FOR OPEN SYSTEMS INTERCONNECTION

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Abstract

This paper discusses management aspects on Open Systems Interconnection. Two major categories, application management and system management, are treated in detail. After a careful modelling, the major areas for standardization of management protocols are identified.

1. INTRODUCTION

The recent studies lead by the International Organization for Standardization (ISO/TC97/SC16) on the Open Systems Interconnection have created some useful architectural guidelines for computer communications (1). Though many of the contents require further discussions and refinements, it is assumed that international cooperations will take place to carry out the momentous tasks. In this paper, the aspects on management issues regarding the Open Systems Interconnection are discussed so that this may provide an aid to refine and develop the architecture from its management viewpoint as well.

2. DISTRIBUTED APPLICATIONS AND NETWORK MANAGEMENT

The term 'distributed application' is defined here as a set of application-processes which are communicating between them and performing an orderly data exchange with synchronization, data integrity and other functions to obtain given objectives; each of the application-processes resides in one of the interconnected systems. The Open Systems Interconnection is primarily concerned with the inter-process communications between systems, but at the same time some sort of 'higher level' cooperations between the processes are essential in order to perform the users' distributed applications.

The environment of the interconnected systems and the associated distributed applications can be regarded as a network. In order to support and coordinate the distributed applications, special functions for managing the network resources are required and, here, they are referred to as 'network management'. It is the purpose of the following few sections to clarify the basic operations and environment of the network management for the distributed applications (2).

3. NETWORK MANAGEMENT ENVIRONMENT

A distributed application may have specific purposes such as a sharing of resources, obtaining higher reliability, or expansion of a local system capability by accessing additional resources. In order to effectively accomplish these purposes, the network management functions are provided; these functions include network resource allocation, synchronization of related processings and error/failure recovery schemes.

In plain words, these functions may be considered as if a set of 'operating system functions' exists for the network (3). An operating system in a computer system manages resources such as main memory and peripheral equipment, so that the user jobs can share the resources effectively. The relationships between user jobs and the operating system may be considered analogous to those between the distributed applications and network management.

The network services for distributed applications are considered to be two distinct categories of management functions; i.e., the management in an application oriented environment called 'application management' and the management of the network resources shared by the network jobs called 'system management' (4).

4. REVIEW OF ISO/TC97/SC16 N227 MODEL

In the ISO/TC97/SC16 N227 model, the network management functions are located in the Application Layer (See: Figure 1).

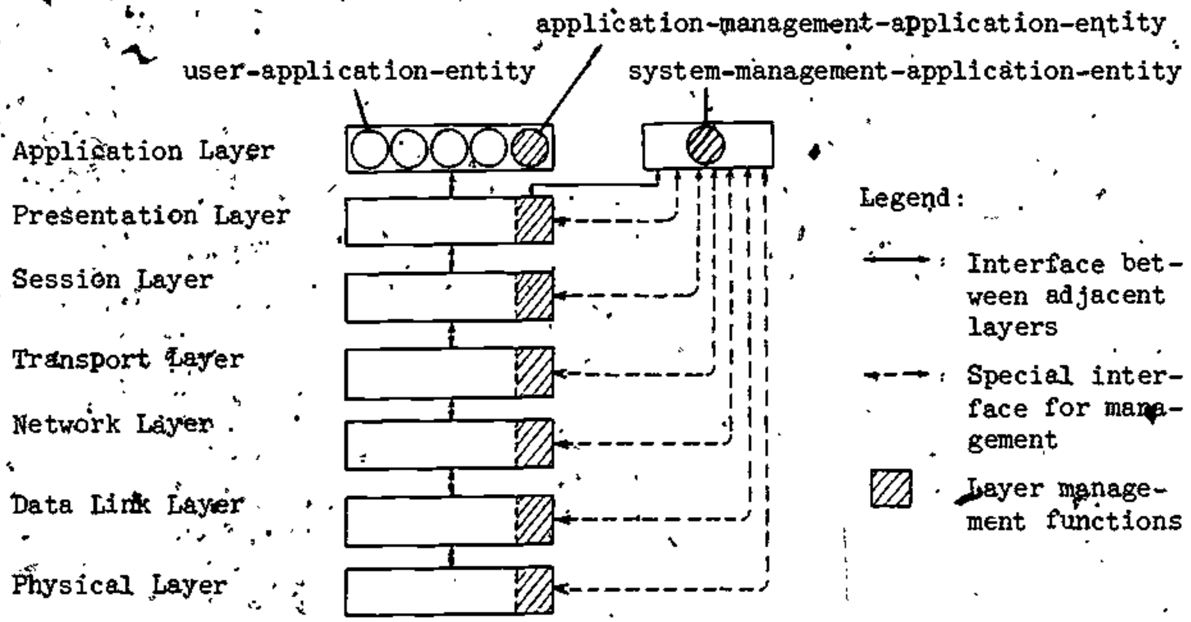
application-management-application-entity
user-application-entity
system-management-application-entity
Application Layer
Presentation Layer
Session Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
Legend:
Interface between adjacent layers
Special interface for management
Layer management functions

Figure 1: A REPRESENTATION OF MANAGEMENT FUNCTIONS

Referring to the model (Figure 1) and the contents discussed in N227, some of the management functions may be classified into the application management functions; Table 1 is a list of typical functions classified into this category. Some of the management functions, on the other hand, may be classified into the system management functions; Table 2 is a list of typical functions classified into this category.

Table 1: TYPICAL APPLICATION MANAGEMENT FUNCTIONS

- Initiation of parameters which represent application-processes
- Initiation, maintenance and termination of application-processes
- Allocation and de-allocation of logical resources to application-processes
- Detection and prevention of resource interference and deadlock
- Integrity and commitment control
- Security control
- Checkpointing and recovery control

Table 2: TYPICAL SYSTEM MANAGEMENT FUNCTIONS

(a) Activation/deactivation management.
  - Activation, maintenance and termination for physical resources distributed in open systems, including data links and communication media
  - Some program loading functions
  - Establishment/maintenance/release of connections between management entities
  - Open system parameter initialization and modification

(b) Monitoring
  - Reporting of status and status changes
  - Statistics reporting

(c) Error control
  - Error detection and some of the diagnostics.
  - Reconfiguration and restart.

The application management functions have been located in the Application layer since they are applied to application-processes (5). The functions which are related to the application management but are not performed within the Application Layer are realized by the services provided by the lower layers.

The system management functions may further be divided into two types: (a) the system management functions which are performed within a local system only, and (b) the system management functions which are related to more than one local system.

(a) The system management functions in a local system may have a layer-management-entity in a layer which manages the resources in the layer and, the system-management-application-entity which manages resources in the local system and resides in the Application Layer.

(b) A well-defined set of protocols is required for the system management functions related to more than one local system. The entities which realize such protocols have to be located in all the related systems in this case. Since the inter-system management can be regarded as a special case of distributed applications, the entities of the system management may be conceptually located in the Application Layer. In Figure 1, the locations of the system management functions are displayed and it is understandable that the inter-system connectability is heavily dependent on the protocols in the layer from the management viewpoint. The special interface among the system-management-entity and layer-management-entities should be provided if more than two systems are to be interconnected with effective systems management.

5. DEVELOPMENT OF THE CONTEXT OF NETWORK MANAGEMENT

In order to develop the foregoing conceptual description in a practical environment, it is useful to present the models describing both the system management and application management characteristics. For this purpose, Figures 2, 3 and 4 are prepared and some new terminologies are introduced.

Figure 2 shows a model of 'open-systems-network'. The term open-systems-net-work is used to mean an abstract network model composed of common resources (systems, links) in the physical network environment.

The term 'user-application-network' means a network model which shows an application oriented environment consisting of the resources employed by a particular application. More than one user-application-network may be built on an open-systems-network. In Figures 3(a) and 3(b), two separated user-application-networks are displayed, which are built on one open-systems-network. Note that some systems may be used for and belong to two or more user-application-networks.

The system management functions are required for the network-wide management of all resources defined for the open-systems-network. The application management functions are needed for the application specific management of all resources defined in the user-application-network.

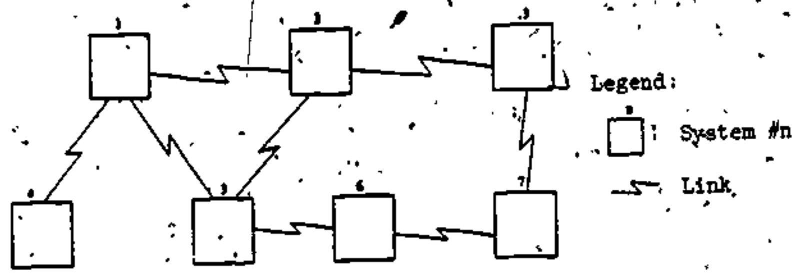
1
2
3
4
5
6
7
Legend:
n
: System #n
Link

Figure 2: EXAMPLE OF OPEN-SYSTEMS-NETWORK

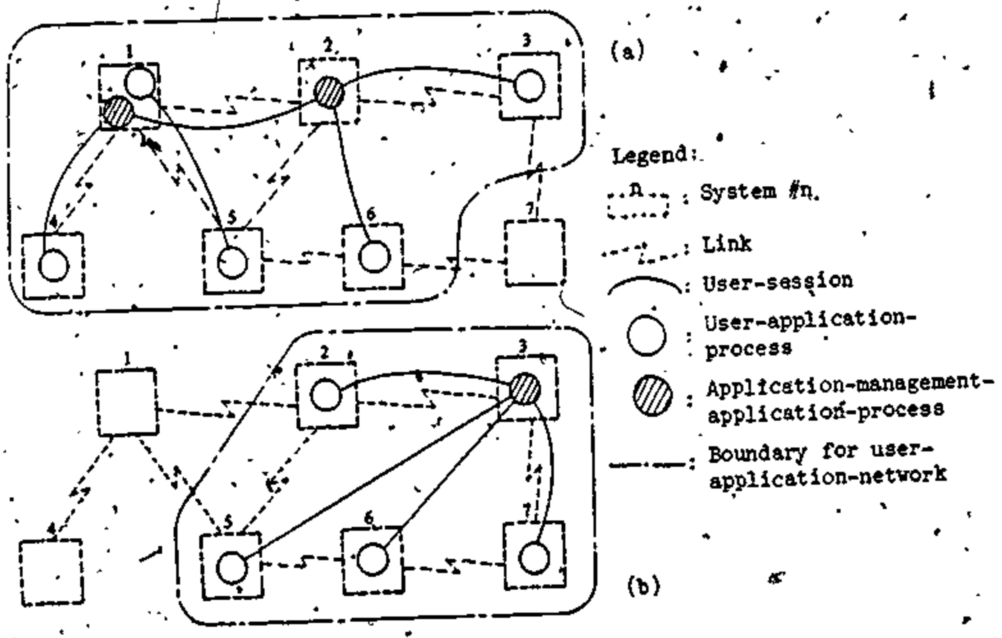
(a)
1
2
3
4
5
6
7
1
2
3
4
5
6
7
(b)
Legend:
n : System #n
: Link
: User-session
: User-application-process
: Application-management-application-process
: Boundary for user-application-network

Figure 3: EXAMPLES OF USER-APPLICATION-NETWORKS

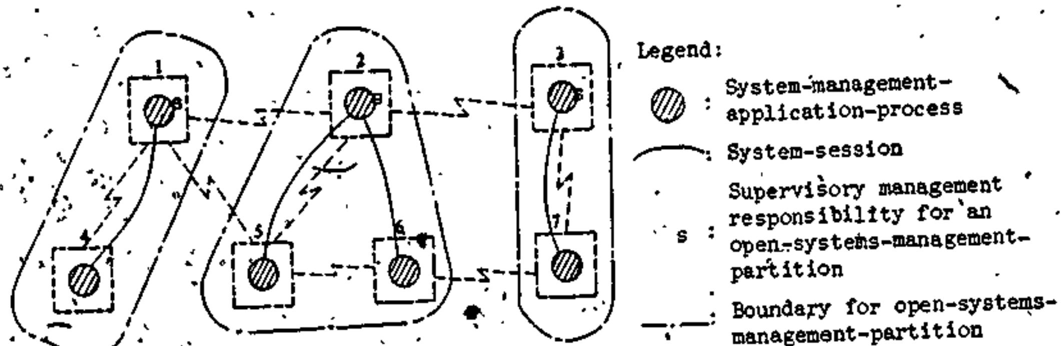
1
2
3
4
5
6
7
s
s
s
Legend:
: System-management-application-process
: System-session
s : Supervisory management responsibility for an open-systems-management-partition
: Boundary for open-systems-management-partition

Figure 4: SYSTEM MANAGEMENT STRUCTURE FOR OPEN-SYSTEMS-NETWORK

Looking at Figure 2 - 4, let us further examine details of open-systems-network and user-application-network.

5.1 OPEN-SYSTEMS-NETWORK

The open-systems-network, from management viewpoint, is a network model which represents the mechanism of the system management in the network. The open-system-network may consist of more than one open-systems-management-partitions. In Figure 4, three separated open-systems-management-partitions are shown. Each open-systems-management-partition may consist of a number of processes; these are system-management-application-processes interconnected by system-sessions. One of the system-management-application-processes is given the supervisory management responsibility for all resources in the open-systems-management-partition.

The concept of open-systems-management-partition allows both centralized and decentralized network management mechanisms. How to structure the centralized or decentralized network management meohanisms is, therefore, left for the decision of the network designer. Thus, it has a wide flexibility for heterogeneous network implementations.

The term 'system-session' is introduced to mean a logical session which performs communication functions between two system-management-application-processes for network management. A system-management-application-process manages the resources of its own as well as the links connected to the system. A system-management-application-process can communicate with another system-management-application-process through the communications services offered by the system-session.

5.2 USER-APPLICATION-NETWORK

A user-application-network is an abstraction of a network which uniquely operates a specific distributed-application (See: Figure 3). A number of inter-related application-processes may run concurrently in a single computer network where the common network resources are shared by a number of application-processes. The user-application-network represents a set of inter-related application-processes including the resources for the application.

A user-application-network may be divided into more than one user-application-management-partition. This concept is similar to the previous open-systems-management-partition which was based on system management, whereas this one is used for a user application. Note that the user-application-management-partition is independent of the open-systems-management-partition. By introducing the concept of user-application-management-partition in a way similar to the system management, the user application management mechanisms may be centralized or decentralized within the network.

Each user-application-management-partition may consist of a number of user-application-processes and an application-management-application-process interconnected by user sessions. One and only one application-management-application-process exists in a user-application-management-partition and it is the service manager for the user application. The main functions of this application-management-application-process are: (a) address conversion from the global title assigned to a user-application-process to an address indicating a physical location, (b) user-application-process registration to its user-application-network, (c) communication authorization, e.g., password checking, and (d) supervisory information processing for user-application-processes. The user-session is a session which performs communication functions between two user-application-processes and/or application-management-application-processes.

The resources logically related to a distributed application such as files, devices and databases are considered to be attached to the corresponding user-application-process. The reasons for attaching these resources logically to the user-application-process are summarized as: (a) the model for abstracting various network resources can be unified as relations between two user-application-processes instead of complicated or too specific models like the relationships between user-application-processes, logical devices and/or logical detabases, and (b) management functions for such logical resources are buried in the user-application-process to which they are attached. Thus, this creates a simple user application management model and provides a basis for widely acceptable common interfaces for these resources.

5.3 OTHER CONSIDERATIONS.

(a) Resource Management

As descrived previously, the logical resources such as logically connected files, devices and databases are attached to a user-application-process in this paper. Therefore, the resource management in the user-application-network may be considered equivalent to the access and failure management for the user-application-process. Hence, the model described here and the discussions are deemed to assist in outlining the resource management schemes such as directory management (address conversion), communication authorization, lock and unlock control, failure management, and tariff administration.

(b) Data Security

Data protection, access control and authentication control are, among others, three major data security considerations. These should be supported by the application and system management schemes. However, this subject in detail is beyond the scope of this paper.

(c) Data Integrity

Data inconsistency will occur if update processings are executed independently without synchronization among related processes. The mechanisms such as checkpoint/recovery and commitment control are some of the major issues on data integrity to be studied for Open Systems Interconnection. The model and management component breakdown exercised,in this paper will also support further development of this subject (6)(7).

6. STANDARDIZATION OF MANAGEMENT PROTOCOLS

So far in this paper, management issues for Open Systems Interconnection based on N227 model have been discussed in a concise manner. In reality, however, there are still many ambiguities and inconsistent issues remaining to be resolved in the Reference Model document N227. It is necessary to further improve the model so that the model will be able to adequately accomodate the management aspects of the Open Systems Interconnection. In this paper a clear point has been brought up; these are the system management and application management, i.e., the two major categories for Open Systems Interconnection management. From there, further classification techniques are introduced. These techniques and the study results are hoped to provide some additional guidelines for standardization of management protocols.

Here, as a part of the study, this paper tries to breakdown the areas for the standardization for management aspects, based on the foregoing study; they are (a) open-systems-network initiation and termination, (b) user-application-network initiation and termination, (c) user-session establishment and release, (d) network operation and maintenance management, (e) resource management, and (f) data security and integrity.

(a) Open-systems-network initiation and termination protocols

The following functions should be included in the protocols:

- Activation, maintenance and termination of data links and system management entities (system-management-application-processes)
- Establishment and release of system-session between all pairs of system-management-application-processes
- Error detection, network reconfiguration and routing table update

(b) User-application-network initiation and termination protocols

The following is a list of typical functions in the protocols:

- Initiation and termination of application-management-application-processes
- Initiation and termination of user-application-processes
- Allocation and de-allocation of logical resources for user-application-processes

(c) User-session establishment and release protocols

A scenario of this operation is give here: In order to establish a user-session, a user-application-process sends a request to the application-management-application-process. If the user-application-management-process is able to handle the request, then it proceeds to the next step such as a profile interpretation (viz. parameter expansion in which the characteristics of the session are specified), address conversion (viz. between global title and physical location address), authorization checking, or any other required processing. If the request is permitted, then the application-management-application-process sends the permission back to the requesting user-application-process.

(d) Network operation and maintenance management protocols

These protocols are used by the supervisory system-management-application-process and are applied to the territory specified by the open-systems-management-partition for which the supervisory system-management-application-process is responsible. The following is a list of some functions to be provided by them:

- Collection of statistical information
- Statistics reporting
- Reporting of status and status changes of resources
- Remote power on/off checking
- Periodical testing

(e) Resource management protocols

The functions to be included are: registration of resources and removal of these from the open-systems-network or user-application-network, and updating of the status of resource availability for each network.

7. CONCLUSION

This paper has looked into an insight of the management aspects of Open Systems Interconnection. Though the paper has found extremely broad and complex areas for the subject, it has tried to identify the specific sub-areas and functions which are considered necessary to be standardized to facilitate Open Systems Interconnection.

In order to resolve these management issues, it is imperative for experts in these broad (as yet specific) areas to get together for further collaboration to develop the Open Systems Interconnection including management schemes and protocols.

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THE OSA PROJECT:
THE LAYER STRUCTURE OF THE REFERENCE MODEL, RECONSIDERED

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Abstract

The paper introduces the basic characteristics of the Reference Model in a tutorial like style. A tutorial presentation of the Reference Model seems in order, not that much because of didactical reasons, but because our intention is to clearly prepare and make explicit the concepts on which it is founded.

On the whole, the paper pleads for maintaining the present 7 layer structure of the Reference Model for Open Systems Interconnections. This pleading is based on quite general considerations from the standardizations area as well as from the software engineering area. Several weaknesses of the present version of the Reference Model are identified; this should help to remove them from its future versions.

1. Introduction

Presently, one of the magic words in common discussions about modern computer technologies is "Open Systems Interconnections". Closely related words coming up in such discussions, would be "standards", "recommendations" and "protocols". The next chapter will discuss various aspects of the philosophies, these keywords stand for. Chapter 3 then will get down to the "Reference Model for Open Systems Interconnections". We there show, that the 7 layer structure of the Reference Model is reasonable not only because it facilitates developing standards - it is forced on everybody considering the telecommunications problem from a software engineering point of view.

The paper assumes some very basic knowledge about the RM document, only. Because, for discussing the conceptional questions about the Reference Model (RM) we are interested in, no details are required. There are various important conceptional questions, such as

- the identification philosophy for inter-layer references,
- the notion of layers,
- the method of describing a layer,
- the characteristics of higher layers as compared to the characteristics of the lower [illegible]s.

All these questions are based on the fact that the RM assumes several layers, characterized uniquely. Thus, the fundamental question is

- whether there should be layers in a "Reference Model for Open Systems Interconnections", at all,

and if there are layers,

- how these layers should be characterized in substance.

This paper is devoted exclusively to reconsidering this central question once more (the four questions mentioned above cannot be discussed here, because of time and space limitations). Insiders know that the discussions of these questions were pretty controversal in the past. In the beginning, those who disliked the RM layer structure doubted, whether there should be any layer prescribed, at all. In the meantime the necessity of having the "lower layers" has commonly been accepted, but the necessity of having "higher layers" still is subject of massive doubts. As a matter of fact, the discussions about the higher layers are difficult in some areas; we shall explain why this is so, later on in this paper.

Let us conclude this short introduction with a statement concerning the main purpose of this paper. Our strong feeling is that the RM document is of greatest importance for the further technological development of networks of communicating beings, where these beings are definitly more intelligent than a handful of circuitry (such as telephones are) and definitly less intelligent than human beings. We really mean the document - not only the ideas one may find or derive from it - because it should be the document that is used as a common reference when talking about the Reference Model and not different (probably incompatible) explanations of and comments to the document. The present version of the document cannot yet serve for this purpose; it never was claimed that it could do. But when comparing the present version to the previous one (i.e., the N227 to the N117, [1,2]) one sees that various inconsistencies and weaknesses have been removed from it, but it is still far from being complete. Its authors emphasize this need for further clarifications by explicitly calling the document a "working document". The purpose of this paper is to contribute to this process of clarifying and stabilizing the concepts developed in the RM document and to help it to survive and to assert itself. Our sometimes critical comments about the present state of the RM document should be understood this way. The discussions we can give here are pretty brief; more detailed consideration may be found in our papers, given in the list of references.

2. The Philosophy of "Open Systems Interconnections"

There are two main streams within the recent discussions about computer networks systems to be distinguished carefully. They are indicated by the keywords "standards" (or "recommendations", in its weaker form; throughout this paper we consider the terms "standard" and "recommendation" as synonyms). and "openness". In the next section we shall discuss in very general terms the problem of standardizing complex systems, first, in section 2.2 we then show that the RM may be considered as a standard, in section 2.3, we proceed to explaining the terms "openness" and "open systems interconnections", and finally, in section 2.4, we relate the RM philosophy to the classical schemata philosophy of the computing sciences.

2.1 Standardizing Complex Systems

Without hesitating we all assume that we have a reasonable understanding of what is meant by the term standard - whatsoever is being standardized. This understanding says, basically, that different things fulfilling an appropriate standard would neatly fit together if this is asserted by this standard. In order to ensure that these things do neatly fit together the standard fulfilled by them must determine precisely a lot of details of them. (The meaning of the term "neatly fit together" is assumed to be selfexplaining as far as this discussion, here, is concerned; it seems to be easier to avoid a discussion of its precise meaning, by not using synonyms for it. I.e., we shall repeat this term "neatly fit together" stereotypically whenever this meaning is referred to.)

As the things become more and more complex, the attempts become increasingly unrealistic to guarantee this neat fitting together by determining precisely increasing numbers of details in the standard these things are to fulfill. Let us put this observations into other words and become more explicit.

Let us consider some kind of complex things which we wish to fit together. For this purpose we develop a standard for the things of this kind. Let N be the number of details prescribed by this standard, asserting that those systems fulfilling it would do fit together. Experience shows that - once N becomes too large - this standard would become useless. Things, reported to fulfill it, would not neatly fit together, because:

- ~~Firstly, the standard itself may contain flaws~~; i.e. it may be incomplete or contradictory. There are many real life standards having these insufficiencies.
- Secondly, the standard is confusing. Because of the large number of details of this standard, it is inevitable for anybody interpreting it to run into severe errors and/or misunderstandings, quite apart from the incompletenesses of his understanding of this standard. Starting from this person's understanding of this standard when designing a system which shall fulfill it, will result in a system which probably will mirror this person's understanding, i.e., all insufficiencies of this understanding.
- Thirdly, the system may be hardly verifiable. A system fulfills a standard, iff it fulfills all the details the standard prescribes (according to some given interpretation of this standard). It is by no means a trivial task to check a complex system that shall fulfill a standard

whether it actually does fulfill all the many details prescribed by the standard (quite apart from the fact that this given interpretation may be insufficient).

- Fourthly - even if it is possible to make things fit together - it may not be possible to find a neat solution, because one will discover that some of the details are not realizable reasonably or efficiently, (i.e. neatly) in the one or the other system.

To summarize this: The more details are prescribed by a standard, the harder it becomes to make one system neatly fit to another one by trying to make them both fulfilling this standard.

On the other hand, obviously different things would not neatly fit together unless they have a sufficiently high number of properties in common. I.e., the number of common details of two different things must not drop below some threshold if they shall neatly fit together.

Thus, the problem may be stated as follows: For a given class of systems (e.g., computer hardware/software systems) find a set of potential properties (as independent of each other as possible) such that on the one hand

- the number of these properties remains sufficiently low (in order to maintain understandability and verifiability) and the properties, themselves, remain sufficiently undetailed (in order to maintain their neat implementability on top of any system of the given class),

but on the other hand

- this set of properties is a sufficiently powerful prerequisite for making these systems neatly fit together (e.g., for making them interconnectable to each other in the way required for communications purposes in distributed computer systems).

Obviously, this set of properties does not yet suffice to make things (having them) neatly fit together. All this set does, that is to determine a common structure, so to speak, for the things that eventually shall neatly fit together. Starting from this common structure, making different things neatly fit together requires elaborations on all the properties which were left that unprecise that the purpose intended could not yet be achieved. Because of the almost complete independence of these properties their elaborations may be performed almost independently of each other.

Proceeding this way avoids developing big standards for complex systems which shall neatly fit together. Instead, we would develop a standard for the structure for the properties of these systems, at first, and then the standards for the components of this structure (being the still unprecise properties of the systems, as mentioned above).

It would be nice if the set of all these particular standards eventually would be less volumenous than the alternatively single big standard. But even if this is not the case, the "separation of concerns" [3,4,6] achieved by the approach, first to determine a common structure, would make this approach preferable. Because a system having this structure is better get-at-able in the sense that somebody having a particular concern need only consider the overall structure of the system and the particular component responsible for his concern, and may leave aside the rest of it. And this pair, overall and particular standard, will be definitly simpler than the alternatively single big standard.

2.2 The Reference Model as a Standard

2.2.1 The Claim of the Reference Model

A particular kind of complex systems are computer systems. Making them neatly fit together means interconnecting them to each other such that reliable communications between the users of these systems may be performed efficiently. Let us assume now that there exists a set of properties of computer systems of the kind described above. Then - per definition of this set of properties - two arbitrary computer systems having these properties may be made neatly fit together (i.e., they may be interconnected to each other with a reasonable effort and reliability).

Without further discussion we will assume for this paper that

- a computer system may be separated into a "local part" and an "interconnection part", and
- the properties mentioned above only refer to this second part, the "interconnection software/hardware".

The Reference Model determines a set of properties of the interconnections software/hardware of computer systems and claims that this set of properties is of the kind described above. I.e.: The RM claims, that the properties of the interconnections software/hardware it prescribes

- are powerful enough to drastically simplify designing actual interconnection software/hardware for reliable and efficient communications between users of computer systems (having this interconnection hardware/software), and
- this number is sufficiently low (thus maintaining understandability and verifiability of the designed interconnection software/hardware) and the properties, themselves, are sufficiently flexible (thus allowing efficiently realizing them in the designed interconnection software/hardware, in almost all realistic cases).

The RM determines these properties of the communications software/hardware indirectly. It does not prescribe any particular structure for the interconnection software/hardware. But,

- it does prescribe, that the interconnection software/hardware must support particularly structured communications on any one of its interconnections between users of the interconnected systems, and
- it does prescribe this particular communications structure.

In the next chapter we shall explain the substantial decomposition of the network communications problem into independent parts achieved by this structure; in this section we make more explicit the standardization effect achieved by prescribing the communications structure in the RM.

2.2.2 The Communications Structure of the RM

The RM considers any process of communication between system users as being many layered. Seven of these layers are considered as being the lowest ones, these layers are identified by the RM; in many cases there will be many higher layers not being part of the RM (so called "application specific layers"). The seven layers of the RM are ordered hierarchically, any application specific layer would be located on top of this hierarchy. In this paper application specific layers are not considered.

A communication process is many layered in the following sense:

- Any communications activities on one level are realized by means of communications activities on the next lower level, and
- communications activities on one level do not refer to communications activities on another level; i.e. in particular: communications activities on layer k have no knowledge about who communicates what on layer k+1.

Thus, by means of its communications structure, the RM decomposes a complex communication process into 7 independent sequences of communications activities (each taking place on a layer of its own). Each of these sequences of communications activities is concerned with only a part of the total complexity of the whole communications process.

2.2.3 The RM's Communications Structure as a Standard

In the previous section we tried to show that the communications structure of the RM achieves a partitioning of a complex problem (namely the task of establishing means for communications between users in different systems) into independent and less complex problems (each of them concerned with a particular aspect of the total task).

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Experience shows, that the complexity of these partial problems is low enough to allow standards for their solutions. Developing standards for solving these partial problems means nothing else but accepting the RM communications structure as a standard.

Initially, most of us would have difficulties to accept the RM communications structure as a standard. Let us take some typical standards, such as language standards (e.g. standard FORTRAN), protocol standards (e.g. HDLC), code standards (e.g. ASCII). They all refer to the "operational level". As opposed to that the RM communications structure considered as a standard would refer to the "conceptional level". This would bother us at a first glance. At a second glance, one sees that we cannot do without "operational standards": Eventually, they are necessary for asserting that the solutions (designed in different communicating systems) of the partial problems (defined by the RM communications structure) would neatly fit together.

2.3 Openness and Open Systems Interconnections

Until now we saw in this chapter that the RM determines a particular communications structure to be a standard for systems interconnections. We did not yet raise the question, what features of the communications structure determined by the RM would be refered to by using the term "Open Systems Interconnections", instead of just "systems interconnections". With respect to this question the present version of the RM document remains very formal in simply stating "A system which will obey OSI standards in its communication with other systems will be termed an Open System", etc. Therefore, we are going to discuss briefly what kinds of interconnections actually should be available to users (wishing to communicate with each other) being located in different systems.

It is clear, what is understood by the term "systems interconnections". Systems interconnection usually would be understood to be more then just interconnecting physically two computers by some bus they both know how to use. Having a systems interconnection between two computer systems is understood, here, to mean that a user in one system may transmit data to any user in the other system. The question is, of what help a plain systems interconnection is for the average user of a system.

The common experience is that it is almost useless for the average user: If he wished to make use of it he had to learn a lot about the internals of the computer system potentially accessible to him by this systems interconnection. I.e. interconnections of this kind are "open" only for a small number of experts being familiar at a time with several operating systems, file systems, etc. Giving a plain systems interconnection to the average user is similar to face him to plain hardware equipment at the other side of the interconnection. Hiding the awkwardness of plain hardware from a user usually is done by means of software tools (considering a single system, only, the set of these tools would be called "operating system"). A systems interconnection in which software tools of this kind are available is called an "open systems interconnection"; by means of these tools it is "open" to the average user for communications with any user in a different system.

Note that this "openness" of an interconnection is not only a property of technical nature. "Open systems interconnections" are conceptually something much more powerful than plain "systems interconnections". They make any resource (available somewhere in a network) accessible to any user as if this resource were in the user's system, already.

Technically, open systems interconnections are much more ambitious than plain systems interconnections. Therefore, there probably is no chance to realize this concept of "open systems interconnections", if more than two different systems are involved, unless these systems' communications structures are very similar, more precisely: unless they both obey the same standard. The RM - considered as the standard for this communications structure - does not only claim to assert that systems obeying it may be interconnected; it claims that these interconnections may be made "open". Thus, the RM is not just some standard. The RM standard is that important because it provides the basis (at least, it attempts to) for making for any user any resources in a large distributed system as conveniently accessible as if they were in "his" system.

2.4 The RM as an "Open Systems Interconnection Schema"

In the RM relatively very few properties of computer systems are considered as being sensitive for their open interconnectability. Parts of computer systems not considered as being particularly sensitive (and for which the RM document does not recommend anything) are

- all implementation details (hardware and software),
- all properties of (physically) local significance, only, such as local design, local protocols, local presentation of facilities, ...
- even all protocols between peer entities on all levels of its communications structure.

The few properties, the RM determines, are: For each of the seven layers of its communications structure .

- some minimal properties of the services it has to provide to the adjacent higher layer, and
- that these services to be provided must be implemented by means of the services provided to it by the adjacent lower layer.

This technique - to reduce the discussion of a variety of similar but complicated matters to few, identical, and sensitive properties of these matters - has been applied since ever in all engineering and scientific disciplines. In the computer science area in the past complicated matters reduced in this way are programs, parallel programs, formal grammars, schedules, e.g., namely to: program schemata, [7], parallel program schemata, [8], grammar schemata, [9], scheduling schemata, [10], resp.

Following these steps one could use the term "open systems interconnection schema" for refering to the skeleton of a systems interconnection, as determined in the RM document. (Instead of "systems interconnection schema" we previously used the term "communications structure"). This term would be somewhat more inductive, precise, and consistent (to the rest of the computer sciences) than the term "open systems interconnection architecture", used in the RM document for this purpose. The RM document then would be the (pretty lengthy and unprecise) definition of what an open systems interconnection schema is. An open systems interconnection is obtained from an open systems interconnection schema by augmenting the definition of the latter one by an interpretation of those parts in the schema left uninterpreted (i.e., undetermined) - just as in the classical areas (where programs, parallel programs, formal grammars, and schedules are obtained from definitions of program schemata, parallel program schemata, formal grammar schemata, scheduling schemata, by augmenting these definitions by some interpretations). An interpreted open systems interconnection schema would not yet be executable in usual computer systems; for this purpose it must be implemented, first. Therefore we distinguish between the "design of an open systems interconnection" and the "implementation of an open systems interconnection"; the former term refers to an interpreted open systems interconnection schema, the latter one to the former one's realization. Note that this design partly will be subject to restrictions; e.g. the global protocols usually would be subject to some standard.

This "separation of concerns", [11], or "isolation of views", [12], - as expressed in this philosophy and terminology - brings to our minds that there are three main conceptual areas of concern, characterized by the subsequent questions

- What open interconnections schemata could one think of and would be of interest?
- Given a particular schema, what designs are appropriate?
- Given a design, what implementations are possible?

In the computer connections area we presently deal with a single schema, only, namely the one given by the RM document. A complete design for it is not yet available; all we have, actually, that are more or less well understood designs and implementations of its "lower layers".

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3. The Seven Layers of the Reference Model, Considered from the Software Engineering Point of View

In the previous section we justified the many layer structure of the RM by means of the necessity to partition a complex problem (namely: to develop standards for open systems interconnections) into a set of simpler ones, in order to make it solvable. There we did not yet refer to the substantial reasons for having in the RM the particular layers it actually has.

As opposed to that, in this chapter we describe the substantial reasons for having these particular seven layers in the RM; thereby we give an introductory characterization of each of them. These reasons are given in section 4.2 of the RM document, already; but usually this section is considered to be not very convincing. Therefore, we try to improve the persuasive power of these reasons by developing another presentation of them. Our presentation differs from the one in section 4.2 in two ways

- for each of the seven layers we individually explain the reason for having it; whereas in the RM document all the advantages of all the layers are summarized in section 4.1, described in very general terms, and refered to really vaguely, only.
- we take the software engineering point of view; whereas the RM document abstracts from the fact, that eventually software systems must be designed for achieving the openness of the systems interconnections.

Let us explain more explicitly why we consider it being legitimate to take the software engineering point of view. The RM requires that communications taking place on anyone of its interconnections are structured in a certain way (into seven layers, each of them having certain responsibilities). These communications usually would be supported by software systems (more precisely: technically it is not possible to realize the higher layers of this communications structure without appropriate software systems). These software systems must have some reasonable structure in order to remain manageable. It surely is a good idea to map the communication structure one to one onto the software structure - although other relations between these structures are possible, as well.

Anyway, the interconnections software must realize the communications structure. Thus any communications structure prescribed (such as the one in the RM) is nothing else but a specification of requirements to be fulfilled by the interconnection software. Thus we may state:

- The requirement of "openness" (as described in section 2.3 of this paper, i.e. requiring: "Any user may conveniently access all resources in the network") is a requirement that must be fulfilled by the interconnections available to the users. Therefore, this requirement of "openness" is the main guiding rule when developing an interconnection philosophy. The purpose of an interconnection philosophy developed with this requirements in mind is

- firstly, to determine the characteristics of the user interface of open systems interconnections, such that any system specific application may easily make use of them, and
- secondly, to determine a connection structure such that it is easy to derive from it, how this user interface may be realized on top of any feasible given computer software/hardware.

In other words: The purpose of this interconnection philosophy is to determine the characteristics of its interconnections with respect to

- their user interface, such that the interconnections are usable as easily as possible, and
- their internal structure, such that the interconnections are implementable as easily as possible.

The RM document is an attempt to develop an interconnection philosophy of this kind.

- Once the interconnection philosophy is developed so far as to allow to determine, what actually is required for realizing "open systems interconnections" in some given environment, these latter requirements must be fulfilled by the interconnection software systems. Determining these latter requirements and designing the interconnection software system (fulfilling them) is a software engineering activity. Designing a particular system for any particular environment is very ineffective. One may proceed more effectively by determining what actually would be required if only a "minimal environment" is assumed, designing an interconnection software system fulfilling these latter requirements, and structuring this design such that it exists of building blocks which may be left away if not needed because of the properties of some actual environment. We shall call any design of a software system with these properties an "open system architecture".

3.1 The RM Document Justification of the RM Layers

We here consider the section 4.2 of the RM document. It explains the reasons for having in the Reference Model the seven layers characteristic for it (these layers are described in detail in chapter 5 of the RM document).

The RM document bases the choice of the seven layers as they are on a list of 13 very general design principles, usefully applicable in any kind of system design. This list is given in section 4.1 of the RM document and quoted subsequently.

1) do not create so many layers as to make difficult the system engineering task describing and integrating these layers,
2) create a boundary at a point where the services description can be small and the number of interactions across the boundary are minimized,
3) create separate layers to handle functions which are manifestly different in the process performed or the technology involved,
4) collect similar functions into the same layer,
5) select boundaries at a point which past experience has demonstrated to be successful,
6) create a layer of easily localized functions so that the layer could be totally redesigned and its protocols changed in a major way to take advantage of new advances in architectural, hardware or software technology without changing the services and interfaces with the adjacent layers,
7) create a boundary where it may be useful at some point in time to have the corresponding interface standardized,
8) create a layer when there is a need for a different level of abstraction in the handling of data, e.g. morphology, syntax, semantics,
9) enable changes of functions or protocols within a layer without affecting the other layers,
10) create for each layer interfaces with its upper and lower layer only,
11) create further subgrouping and organization of functions to form sublayers within a layer in cases where distinct communication services need it,
12) create, where needed, two or more sublayers with a common, and therefore minimum, functionality to allow interface operation with adjacent layers,
13) allow by-passing of sublayers.

We do not intend to analyze the 13 principles listed above one after the other. We just mention, that

- the 13 items are not independent of each other;
- items 11) - 13) refine the grain of consideration in that they describe a layer's internal structure (and this is done in a really obscure way).

Starting from these 13 principles section 4.2 performs the actual identification of the seven RM layers. Instead of critisizing this section, we simply quote the relevant parts and leave to the reader to comment it. Thus, the remaining part of this section consists of quotations from the RM document section 4.2, identifying and justifying its 7 layers.

1 - It is essential that the architecture permits usage of a realistic variety of physical media for interconnection with different control procedures (e.g. V.24, V.25, X.21, etc...). Application of principles 3, 5, and 8 leads to identification of a Physical Layer as the lowest layer in the architecture.

2 - Some physical communications media (e.g. telephone line) require specific techniques to be used in order to transmit data between systems

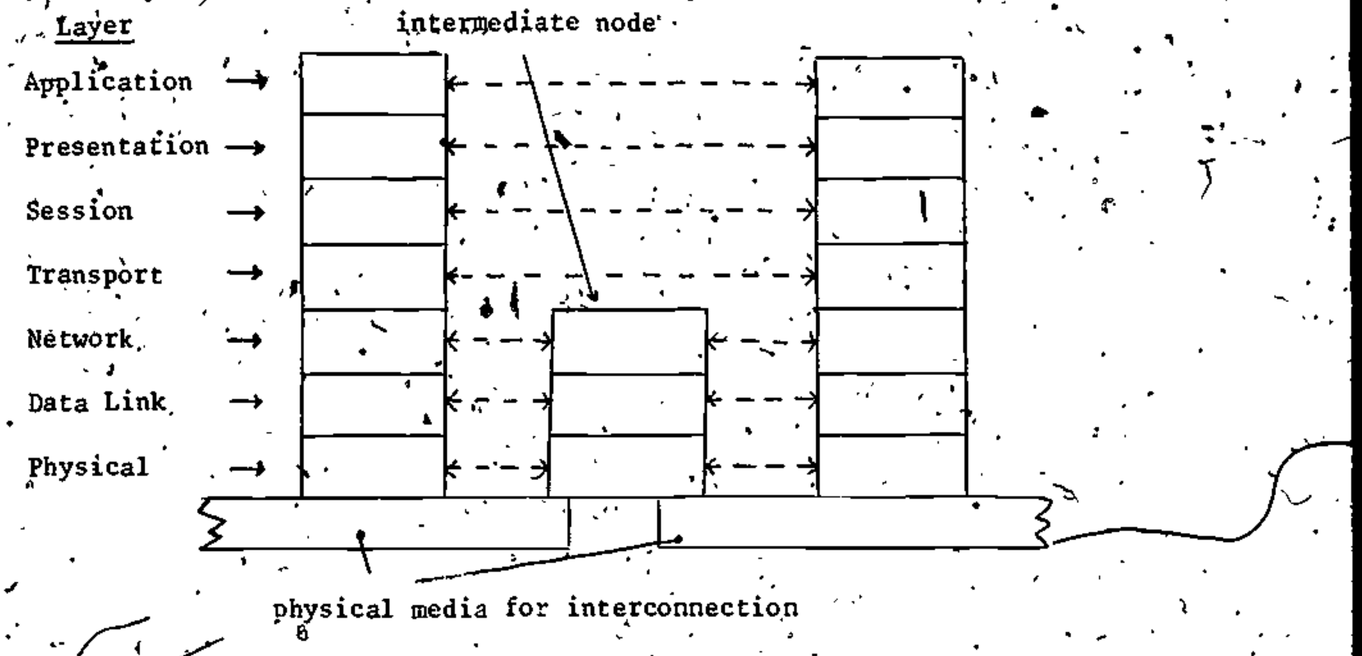

Figure: Seven-layer reference model and peer to peer protocol interrelation

despite a relatively high error rate (i.e. an error rate not acceptable for the great majority of applications). These specific techniques are used in data-link control procedures which have been studied and standardized for a number of years. It must also be recognized that new physical communications media (e.g. fibre optics) will require different data-link control procedures. Application of principles 3, 5, and 8 leads to identification of a Data Link Layer on top the Physical Layer in the architecture.

3 - In the Open Systems Architecture, some systems will act as final destination of data (see the figure). Some systems may act only as intermediate nodes (forwarding data to other systems). Application of principles 3, 5, and 7 leads to identification of a Network Layer on top of the Data Link Layer. Network oriented protocols such as routing, for example, will be grouped in this layer. Thus, the Network Layer will provide a connection path (network-connection) between a pair of transport-entities, including the case of a tandem-network-connection (see the figure).

4 - Control of data transportation from source end-system to destination end-system (which need not be performed in intermediate nodes) is the last function to be performed in order to provide the totality of the transport-service. Thus, the upper layer in the transport-service part of the architecture is the Transport Layer, sitting on top of the Network Layer. This Transport Layer relieves higher layer entities from any concern with the transportation of data between them.

5 - In order to bind/unbind distributed activities into a logical relationship in order to control the data exchange with respect to synchronization and structure, the need for a dedicated layer has been identified. So the application of principles 3 and 4 leads to the establishment of the Session Layer which is on top of the Transport Layer.

6 - The remaining set of general interest functions are those related to representation and manipulation of structured data for the benefit of application programs. Application of principles 3 and 4 leads to identification of a Presentation Layer on top of the Session Layer.

7 - Finally, there are applications consisting of application processes which perform information processing. A portion of these application processes and the protocols by which they communicate comprise the Application Layer as the highest layer of the architecture.

3.2 A more Explicit Justification of the RM Layers

We are going to use a design technique known in the software engineering area as the "functional decomposition" design technique. Applying this technique means decomposing a complex task to be performed by a software system into definitively simpler "units" (called layers, or modules, or....) such that

a) the functions a unit provides belong to the same part of the whole task and this unit contains all the functions of this part,
b) the interfaces between such units are pretty small and simple,
c) the number of such units is not too large and there are only few relations between them.

Proceeding according to a) should either achieve the properties b) and c) directly or they should be achievable after some modifications of an initial decomposition, which was based on a) for simplicity.

As an example, frequently discussed in detail, [5], we may take as the complex task to be performed the set of operations to be performed by an operating system for this system's users. The units into which it may be decomposed, having the three properties mentioned above, are the Virtual Memory unit(s), the File System unit(s), the Process Switch unit, the Device Controler unit(s), ...

We see (from this example) that each unit is responsible for one "system function"; hence the name "functional decomposition" design technique. The set of units, their functions and interfaces as well as their relations to each other are termed "the functional structure" of the problem decomposed.

In chapter two we recognized the necessity of having some "communications structure" in order to be able to develop useful standards for open systems interconnections. Here, we shall derive this communications structure by applying the functional decomposition design technique to the complex task of performing communications. The resulting "functional structure of communications" is taken as this needed "communications structure".

This functional structure obtained is exactly the one proposed by the RM document, as quoted in section 3.1 of this paper. But our presentation of the reasons for having this particular layer structure differs from the one given in the RM document in that we restrict ourselves to the functional decomposition aspect and explain it more carefully for the higher RM layers.

3.2.1 The Higher RM Layers

The only thing of interest from the unit Application Layer is - as far as this discussion is concerned - the fact that its entities (i.e. its instances) must be able to communicate with each other. For this purpose the underlying part of the whole system must provide functions to any application-entity for establishing an interconnection to any other application-entity it wants to communicate with, for working on an established interconnection, and for removing this interconnection, again, respectively. (The first and the last kind of functions are not needed in a system, where all application-entities are permanently interconnected with each other). To summarize: From the RM point of view the requirement to communicate originates from the application-entities. The total set of all functions (serving for this purpose) to be provided to any application-entity now must be decomposed into other units.

A unit obviously necessary would provide all the functions responsible for the actual transfer of informations between communicating application-entities. Basically, these are the functions performing the interconnection establishment/termination (required, only, if the communicating entities are not permanently connected with each other) and the functions performing the data transfer on a connection established. These functions would be encapsulated in a unit, called Transport Layer.

The functions provided by the unit Transport Layer to the communicating application-entities enable them to exchange data transparent messages with each other. In many cases the pure ability of exchanging messages with each other would be very inconvenient for the transport users, i.e. for the communicating application-entities. This inconvenience of a pure data transfer service primarily results from two facts.

Firstly, we all know from our experiences with timesharing systems, that communications developing on any interconnection, considered as a whole, would take place on several different semantical levels. For example, when communicating from our terminal with a central host computer we would operate on the semantical levels indicated by the keywords "operating system", "editor", "input level", and each of these semantical levels would have a separate language of its own. I.e. what we need for a quite usual communications activity, that is a means to switch this communication (between a terminal and a host computer, each of them being represented by an application-entity of its own) from one semantical level to another one.

Secondly, we all know from our experience the cumbersome effort required for reformatting when reading tapes on one manufacturer's installation which were written on another manufacturer's installation. Now, the general goal we try to achieve is interconnecting not only users and resources within one single homogeneous network, but even across different network systems all resources should be conveniently accessible to any user. I.e. what we need for a quite usual communications activity involving different codes and/or formats and/or structures, for example, that is a means to translate codes and/or formats and/or structures according to what is required by the communicating application-entities.

From these two remarks we see that facilitating communications between application-entities in different systems means that, in addition to the Transport Layer (which should be able to actually transfer data at a given level of reliability between the communicating application-entities), two more units must be designed. The RM calls these units Session Layer and Presentation Layer, resp. They provide to communicating application-entities the means for semantic switching and representation translation, resp., as described above.

Let us insert, here, a notational extension: The RM calls the set of means anyone of its layers provides to the adjacent higher layer the "service provided" of this layer. Thus we have - until now - four services: The application service (the Application Layer provides to its user), the transport service, the session service and the presentation service. Application services are not determined in the RM. The purpose of the session services and the presentation services is to extend the set of means eventually provided by the Transport Layer to the communicating application-entities in order to facilitate their communications.

From the above figure we know already, how the RM relates these layers to each other. There is no question that the Application Layer eventually makes use of the services provided by the other three ones and therefore must be located higher than anyone of them, i.e. on top of them. It is not difficult to see that the Presentation Layer and the Session Layer eventually must make use of the services provided by the Transport Layer (Not being supported by the transport services would mean for these layers that the semantic switching/representation translation services they are able to provide are very poor, only and thus unacceptable).

The obvious consequence of this discussion is, that the Session Layer and Presentation Layer must be located above the Transport Layer and below the Application Layer. The decision of the RM to locate the Presentation Layer on top of the Session Layer is somewhat arbitrary. One may find examples where this structure is reasonable (e.g., when designing a quarantine service to be provided by the Session Layer). But one may find examples, too, where this structure turns out to be very restrictive (e.g., when trying to design a "data intransparent" recovery service to be provided by the Session Layer). Anyway, it is too early to make definite statements about this question.

Let us finally introduce a new term: By "communications service" we shall denote the union of the services accessible on the Application Layer and provided by the Transport Layer (as far as discussed until now, including reliability of data transfer), the Session Layer and the Presentation Layer. The communications services provided to communicating application-entities enable them to perform this communication at a reasonable level of effort and convenience. Thus the main reasons for having these layers is the requirement of having open systems interconnections between communicating users.

3.2.2 The Lower RM Layers

This part of the functional decomposition of communications as proposed by the RM is commonly accepted, meanwhile. Therefore we give only a very brief presentation. Because of didactical reasons we proceed "bottom-up" and oversimplify the RM a little bit (without excluding any realistic cases).
Again we apply the functional decomposition design technique and derive in a straight forward manner the four units listed subsequently.

unit1: It provides the functions required for using some part of some given physical device for transmitting/receiving purposes. I.e.: By means of the functions of this unit some suitable given physical device is made to be a pair of transmitter/receiver; the information transfer is represented in terms of the physical details of the transmitter/receiver pair.

unit2: It provides the functions required for using some given pair of transmitter/receiver for establishing a connection between two nodes, each of them being a DCE or a DTE or a DSE. I.e.: By means of the functions of this unit some given set of transmitter/receiver is made a "data link" connection between two nodes; the information transfer is represented in terms of common physical details of the nodes connected.

unit3: It provides the functions required for using serially several, possibly technically different, data link connections for establishing a "network" connection between two DTE's. I.e.: By means of the functions of this unit several serially used and possibly technically different data link connections for each DTE are made looking like a single data link connection of a new kind (actually being a network connection); the information transfer is represented at each DTE in terms of its own network protocol.

unit4: It provides the functions required for optimizing the cost efficiency of network usage by establishing a "virtual network" connection between two application-entities. I.e.: By means of the functions of this unit for efficiency several virtual network connections (between several pairs of communicating application-entities) may be mapped onto one single real network connection (between the hosting DTE's), or a single virtual network connection may be mapped onto several real network connections (all of them between the two DTE's hosting these application-entities). The information transfer is represented at each connection endpoint in terms of the transport protocol, both transport entities have in common.

The RM terms these four units Physical Layer, Data Link Layer, Network Layer, and Transport Layer. For space limitations we refer for a more complete and precise discussion of the functional characteristics of these layers to a technical report to appear and having the same title and authors as this paper.

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The OSA Project

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COPYRIGHT AND CABLE TV IN THE PACIFIC: A SPECIAL CASE

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Abstract

The U.S. Copyright Law Revision of 1976 pays special consideration to cable television systems operating in Pacific territories (and to lesser degrees in Alaska and Hawaii). The revised law allows "offshore," or "noncontiguous" cable systems to freely record Mainland U.S. television programming on video tapes for later transmission to their subscribers and to exchange such tapes with other cable systems operating in the area, activities that would be in direct violation of the law if performed by any cable system in the Mainland U.S. There is some debate as to whether the revised law also allows (or more accurately, fails to forbid) Pacific territorial cable systems to insert their own commercial advertisements between the taped transmissions of programming, thereby expanding by considerable degrees the economic base of operations. This study will trace the issues and personalities that came together to result in the "new" copyright law's special treament of Pacific cable television systems.

> "I take it, from what I heard, that nonsimultaneous recording in noncontingent use areas is a nonproblem?"--Rep. Robert Drinan at House Judiciary Committee Hearings on Revised Copyright Act.

What transformed one of the thorns of the 1976 Copyright Act Revision's cable television provisions into a "nonproblem" involved a cast of characters as diverse as a small-system cable television entrepreneur on the Pacific island of Guam squared off against the president of the powerful Motion Picture Association of America in Hollywood, with some prompting from the wings by a U.S. senator from Alaska and a territorial nonvoting delegate to the House of Representatives.

At stake was the ability to operate cable television systems in the Pacific through the taping--without infringement of the copyright law--of television programs in the Mainland U.S. for later showing the islands.

Leading the Pacific struggle was Lee M. Holmes, president and general manager of Guam Cable TV, Inc., who also had plans for building and operating cable television systems in other islands of the U.S. Trust Territory.

Holmes hinged his arguments on a roundabout First Amendment issue of the rights of Guamanian citizens of the U.S. to receive the same television programming as other citizens of the U.S. and on the technical impossibility of an offshore cable system to operate in the same manner as a Mainland system.(1)

But also in Holmes' strategy was to use the revised copyright act as a springboard to expand his Pacific cable television holdings and to increase their profitability through inserting his own commercials between the tapes of Mainland programs.

He succeeded in his strategy through mollifying his main opponent, Jack Valenti of the Motion Picture Association of America (MPAA) on the protection of the copyrighted programs contained on the video tapes against multiple showings, "piracy" or unauthorized duplication and any editing or commercial changes within the program segments.

These provisions were incorporated into a special section of the Copyright Act dealing with Pacific and Alaskan cable television systems.(2)

The overall cable television provisions of the copyright revision were complex enough in themselves, carrying the drafting of the different versions of the bill through two sessions of Congress.(3)

Finally a system of royalty payments was worked out between copyright holders of television programming broadcast on nonnetwork stations, and cable systems which retransmitted that programming to their subscribers.(4)

In the language of the Copyright Act, such retransmissions are called secondary transmissions. When they are made at the same time as the original broadcasts (as in the case of most cable systems which act as a "super antenna" to improve local signals and bring in otherwise unavailable distant signals "live"), the terminology of the profession and law defines them as simultaneous secondary transmissions.

The cable television provisions of the Copyright Act deal primarily with the ramifications of simultaneous secondary transmissions.

Exclusive attention on this type of transmission, however, would ignore the special needs of the offshore territories where not even the strongest antenna, the longest microwave link or (because of economics and time zone differences) satellites could possibly bring in continuous "live" simultaneous secondary transmissions of Mainland broadcast stations.(5)

In order for a cable system in the Pacific territories to provide a multitude of programming choices (the economic base of cable television), individual programs would have to be recorded on video tape in the Mainland, shipped to the territorial cable system for retransmission, and the tapes returned to the Mainland recording base for reuse.(6)

This sort of program usage--record now to retransmit later--is called a nonsimultaneous secondary transmission. It is this special brand of cable television operation that worried the copyright holders the most, represented by Valenti and the MPAA.

Simultaneous secondary transmissions are a one-shot affair as they deal only with "rerouting" electronic signals. There is no opportunity to edit them and once over, no further way of attempting another, nonroyalty-paid showings.

With nonsimultaneous secondary transmissions by video tape, however, the problem of further showings--or duplication for sale--without paying required royalties becomes more complex. The control of the copyrighted "product" has shifted from the broadcast station to the cable system. The video tape could be saved, rather than erased and reused, and the programming shown over and over again, or used as a "master" for spinning off "pirate" copies for sale.(7)

In the interests of copyright holders, the MPAA wanted such nonsimultaneous secondary transmissions excluded from the compulsory license provisions of the Copyright Act, forcing the offshore cable system to negotiate on a program-by-program basis for the use of the copyrighted programming.(8)

This type of negotiating system would be economically unfeasible for cable system operators and would indicate a certain penalty (or nonequal treatment at best) for operating outside of the Mainland.(9)

This was not the first time a copyright holders' consortium had expressed displeasure with the "record in the Mainland, transmit later in the territory" system of operation. Copyright holders led by CBS filed suit against Guam Cable TV, Inc. for recording programming in Los Angeles for shipment to Guam where it would be transmitted to the company's subscribers.(10)

Nor was this the first time cable and copyright interests faced off in court.

While waiting for Congress to revise the 1909 Copyright Act, large copyright interests were using the courts to try to determine royalty liability.

In United Artists v. Fortnightly, the suit was to determine whether simultaneous secondary transmissions were in violation of the copyright law (they weren't). In CBS v. Teleprompter, the suit expanded the question to include the "importation" of otherwise unavailable distant television signals as a violation (it wasn't).(11)

Presumably the Guam case would have ruled on nonsimultaneous secondary transmissions, but an out-of-court settlement was reached with the major plaintiffs, CBS and NBC, involving a royalty payment scheme based on the number of cable subscribers for the periods of retransmission. The smaller copyright interests decided rather than continue the suit they would wait on Congress' efforts to tackle the question in the copyright revision bill.(12)

Thus the stage was set to seek parity, in the eyes of the Copyright Act, between simultaneous and nonsimultaneous secondary transmissions.

Holmes of Guam was not the only party interested in such parity. Cable operators in Alaska also relied on taping programs in the "lower 48" (with a recording base in Seattle) for later transmission.

In the Senate's version of the revised copyright bill, Alaska Sen. Ted Stevens inserted an amendment that was a boon to cable systems but a bane to copyright holders.(13)

The Stevens amendment simply stated that outside the contiguous 48 states, a nonsimultaneous secondary transmission would be treated the same as a simultaneous one.

The Stevens amendment cut through the technical differences in operation, but left wide open the question of protection of the video taped programming.(14)

The Senate passed its version of the bill with the Stevens amendment intact, however, so the focus shifted to the House, still deliberating its version in the Judiciary Committee.

Holmes had been at work with Guam's delegate to Congress, Antonio B. Won Pat, who introduced a bill into the House that would provide equal footing for nonsimultaneous secondary transmissions.(15)

As Holmes later told the Judiciary Committee, Guam Cable was still operating:

> under the threat of lawsuits and in face of opposition to the Stevens amendment by the Motion Picture Association of America, the National Association of Broadcasters and one or more networks. While we were happy that the Senate agreed with our position, and we believed the House would also, we had no certain understanding of the length of time required for the deliberation of the...copyright bill in the House...and whether (the section involving cable television systems) would be included.(16)

Unlike the Stevens amendment, however, the Won Pat amendment also sought to offer guarantees to copyright holders that the video tapes would be protected against editing, duplication and reshowings.

This bold step by a cable operator--to incorporate the arguments of his adversaries--was a successful strategy. The MPAA agreed to the major provisions of the Won Pat bill as an amendment to the copyright revision bill.

The Judiciary Committee was an excellent forum for Holmes who based a portion of his plea on the rights of Guamanian citizens of the U.S. to have the same access to the variety of American television programming as Mainland U.S. citizens.

Since Guam was the only U.S. soil occupied during the Second World War (and Guamanians, not yet U.S. citizens, remained steadfastly loyal to the U.S.) and since Guam lost more of its men per capita than any U.S. community to the Vietnam War, it would have been a tough argument for the MPAA to counter.

But the main interests on both sides were economic. Valenti was assured of protection against piracy of his clients' motion pictures.

Along with that protectionary clause, however, Holmes had inserted a few of his own that clearly served his economic interests in the Pacific territories.

The first was the "bicycling" or exchange clause that while allowing only one retransmission by a cable system also allowed the system to transfer it to another Pacific system for a single transmission and who could, in turn, transfer it to a third system, etc.(17)

Since Holmes has interests in starting cable systems in other island groups of the U.S. Trust Territory, this would insure that he could utilize his single Los Angeles taping source to service a collection of cable systems in the Pacific.(18)

The second provision is more debatable as it is derived from what the law doesn't say rather than from what is explicit.

It was Holmes' desire to insert his own commercials between the taped Mainland programs. In outlining the proposed amendments agreed upon between Guam Cable TV and the MPAA before the Judiciary Committee, Holmes stated as much:

> (The Won Pat amendment would) prohibit deletion or editing of programs including the commercials that are now contained within the story line of the programs. This would not affect the existing practice of deleting or otherwise altering or substituting commercial content at the beginning and end of the programs.(19)

Valenti conceded to the practice in his testimony:

> The copyrighted program...must be taped and shown by the cable system without any deletion or editing, including...commercials with one exception: The system is authorized to delete commercials prior to the beginning of and after the end of... (the) program being taped.(20)

While such testimony has no force of law, it does become part of the bill's legislative history and could be called upon for interpretation in any subsequent lawsuit.

The final language of the Copyright Act itself, however, specifically prohibits the deletion or substitution of commercials, unless by a research agency with prior approval of all parties.(21) That prohibition, however, is "subject to the provisions of" the section dealing with nonsimultaneous secondary transmissions--the Won Pat amendment.

Nowhere in that section is there a specific allowance of commercial substitution at the beginning and end of programs, just a prohibition against substitution or deletion of commercials within the programs.(22)

The general prohibition is subject to a narrower one in the case of offshore systems. The omission of the before-after commercial prohibition apparently has convinced Holmes and Guam Cable TV System that it is, indeed, allowable.

What could become a sticking point, however, is the language of the House report on the copyright bill's cable television provisions, which was adopted by the House-Senate conference committee for the final bill.(23)

That language states that the sections dealing with taping for later transmission by Pacific or Alaskan systems "insure that the limited objective of assimilating offshore cable systems to systems within the United States for purposes of the compulsory license is not exceeded."(24)

The House seems to be saying that parity is fine, but offshore systems shouldn't expect greater benefits than Mainland systems. Such a benefit might be the right to substitute or insert commercials.

Since no case has yet surfaced in which a copyright holder charges infringement because of Guam Cable TV System's commercial substitution practice, perhaps it is another "nonproblem."

But it does indicate that even with such an illustrious cast as the United States Congress, the case of Pacific territorial cable TV systems may not yet be closed.(25)

Notes

1. The island of Guam has only one commercial television broadcast station, showing an amalgamation of various network programs. It also has one noncommercial public television station. Federal Communication rulings at the time allowed cable systems to carry at minimum 3 network stations, 2 nonnetwork independent stations and 1 noncommercial public station.

2. Sec. 111(e) of Public Law 94-553 revising Title 17 of the United States Codes.

3. Ginsburg, Douglas H. Regulations of Broadcasting: Law and Policy toward Radio, Television and Cable Communications. West Publishing: St. Paul, 1979. PP 335-418.

4. Since the purpose of a network was to attract as many viewers as possible, Congress saw no reason why cable systems would harm network programming returns. They would, in fact, enhance them. It was only in the area of bringing in distant independent station programming where copyright holders might be getting short-changed on royalties. This became the focus of Sec. 111 of the Copyright Act. See House Report, 94-1476, 9/8/76, pp 88-91.

5. U.S. Pacific territories are out of reach of Mainland or even Hawaii television broadcasts. Microwave retransmission requires "line of sight" senders and receivers which the vast distances between islands would make impossible. At the time of the revision deliberation, satellite costs were extremely high. Even if they were within reach of a small cable system, the time zone differences between Guam and the Mainland would put such programming as "The Tonight Show" at 4 in the afternoon and "Captain Kangeroo" at 1 a.m.

6. This is the operating pattern of Guam Cable TV System, Inc. and was considered for adoption by a consortium of Hawaii cable television system operators for bringing in Mainland independent station programming to complement the network fare carried as simultaneous secondary transmissions from the state's three commercial broadcast stations.

7. This has been the subject of recent lawsuits against home video recording companies by motion picture interests.

8. Testimony by Lee ~~M.~~ Holmes before the Subcommittee on Courts, Civil Liberties and the Administration of Justice of the Committee on the Judiciary, House of Representatives, 94th Congress, 1st session, on H.R. 2223, Copyright Law Revision, September 18, 1975. All testimony citations in this study are from these hearings. They can be located as Serial #36, Part 3.

9. In a statement submitted to the Judiciary Committee, then Rep. Spark Matsunaga of Hawaii stated in support of the revision: "Under the present law, isolated CATV systems are penalized for accidents in geography."

10. Guam Cable TV files.

11. Eight Decennial Digest (1966-76), Vol. 8. West Publishing: St. Paul, 1977. PP 998-990.

Fortnightly Corp. v. United Artists Television, Inc. 383 U.S. 390 (1968).

Teleprompter Corp. v. CBS, Inc. 415 U.S. 394 (1974).

12. Guam Cable TV files.

13. S. 22. See Senate Report 94-473, 11/20/75.

14. Testimony by Lee Holmes, Richard L. Brown (representing Guam Cable TV System, Inc.), and Jack Valenti before House Judiciary Committee, September 18, 1975.

15. H.R. 4965 would have amended Title 17 of the U.S. Code (Copyright). It was withdrawn at the Judiciary Committee Hearings in favor of placing its provisions as an amendment to H.R. 2223, the omnibus copyright revision bill.

16. Testimony by Lee Holmes before House Judiciary Committee, September 18, 1975.

17. Sec. 111(e) (2).

18. Testimony by Lee M. Holmes before House Judiciary Committee, September 18, 1975. Holmes has since inaugurated service to the Northern Mariana Islands via Saipan Cable TV System and has obtained a franchise for operation in the Truk Islands.

19. Testimony by Lee M. Holmes before House Judiciary Committee, September 18, 1975.

20. Testimony by Jack Valenti before House Judiciary Committee, September 18, 1975.

21. Sec. 111(c) (3).

22. Sec. 111(e).

23. Conference Report (House) 94-1733, 9/29/76, pp CRS 8-9.

24. House Report 94-1476, 9/8/76, p 98.

25. Valenti and copyright interests have engaged in battle with cable television again--this time the forum is the communications subcommittee of the Senate Commerce Committee considering the revision of the Communications Act of 1934. United Press International dispatches dated 6/6/79 and 6/13/79.

PROBLEMS IN TELECOMMUNICATIONS SOCIAL POLICY CONSTRUCTION: THE INTERFACE OF SOCIAL SCIENCE MEDIA EFFECTS EVIDENCE AND LEGISLATIVE, LEGALLY-ORIENTED DELIBERATIONS

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Abstract

Social policy makers in telecommunications have grown increasingly dependent upon social science media effects evidence to serve as support for policy development. Policy "evidence", however, is not an appropriate interpretation for media effects research findings because of the inherent limitations on this data. Given policy makers' needs and media researchers capability to produce useful data, the use of empirical media effects data must be approached with caution and the willingness to recognize and admit the unavoidable limitations which occur when using such data.

One of the more persistent and perplexing problems in the development and formulation of social policy is the clash that occurs when essentially divergent perspectives and purposes must be meaningfully integrated into policy deliberations. In telecommunications social policy, the clash of two perspectives is acute: (1) The legally-oriented policy makers who seek unequivocal research evidence which provides "proof" for a certain case or proposal; (2) The social science media researchers who are called upon to provide this research evidence but can only present data and inferences which are inherently incapable of "proof" in the legal sense. In the areas of media violence, obscenity, and advertising to children, the results of social policy inquiry have tended toward increased confusion, rather than any satisfactory level of resolution. The questions raised by telecommunications social policy planners are significant and crucial; their pursuit of answers is generally forceful and honorably motivated; the outcomes, however, are disappointing. Part of this disappointment is due to the clash between divergent perspectives which view policy-supporting evidence in entirely different lights. The principal focus for this paper is centered upon the contention that the inherent limitations of social science media research methods effectively preclude their use in social policy construction. In developing this focus, two areas are central: (1) the limitations of social science methods which prevent clear cut conclusions about media effects; (2) the legally-oriented process of social policy makers as illustrated by policy making deliberations in the 1970s, including the FTC's hearings on children and TV advertising.

1. LIMITATIONS OF SOCIAL SCIENCE MEDIA RESEARCH METHODS

Prior to the empirical study of mass media effects, the methods of social science were well on their way to being both adapted and adopted for use from the natural and physical sciences. The use of methods developed to study certain phenomena (generally concrete, empirically variable events) for other phenomena as complex as human behavior brings on an immediate question of limitations due to differences in the phenomena examined by the methods; in essence, can the same methods be validly applied to measuring different types of events? When mass media effects on human behavior (cognitive, affective, and overt) were first studied, the once-borrowed methods became twice-borrowed. At this point, the question becomes: Are the methods developed for measuring A (physical properties) appropriately useful for measuring B (human behavior processes) and in turn D which is a combination of B and C (media process variables)? The twice-borrowed application alone suggests limitations on social science methods for measuring media effects.

One major limitation of media effects research is sampling. Samples used by researchers are never randomly constituted; compromises and adjustments are invariably made. Samples are often small, limited in characteristecs (e. g. only middle-class, white 8-10 year olds, college sophomores, etc.), and of limited representativeness in that no assurance or estimates are possible as to the agreement between a sample used in a study and the population that the sample is supposed to represent.

A second limitation is the adequacy of measuring instruments. Instrumentation is imprecise, semantically unvalidated (does the language or meaning of the instrument function as intended with subjects being studied?), and overly simplistic. While techniques of statistical analysis have grown increasingly sophisticated, the types of instruments and their lack of validity have remained virtually untouched. What we do with the numbers is sophisticated and elegant; what the numbers actually represent is not dealt with at any important level.

The nature of social science environments for studying media effects is the third limitation. Social scientists create environments which do not approximate the real environment in which television operates and its subsequent effects actually occur. TV's real environment is seldom the context for effects research, and in those few instances where field research is conducted, situations are unnaturally limited and ungeneralizable (e. g., juveniles living in cottages or children attending a private boarding school).

Along with limitations due to inadequate samples/sampling, measuring instruments, and environments, social scientists' data-based conclusions can never be more than conditional probability statements. In effect, social science findings have the implicit caveat which says: "Given these conditions (a given sample, instrumentation, environment, etc.), the following relationship is probably true." If there are changes in the conditions of if the conditions are not isomorphic to the real-life environment in which they operate, the relationship may (or perhaps will) change. And, there is a chance that the relationship may not be true, even under the limited conditions as specified.

The final limitation is the absence of a process orientation in social science studies of media effects. Media impact is studied as if it were static in nature rather than dynamic. Experiments and surveys provide narrow focus snapshots of some media effects as they operate under some (mostly artificial) conditions. When a process is studied, the on-going nature of it must be considered; complexity is measured; interpretations are more difficult; changes occur, often simultaneously. Limited measures in an artificially created environment at only one (perhaps several at most) point in time, may or may not be relevant to the actual process through which media affect human behavior. Moreover, with incomplete or non-existent knowledge of preceding or following operates as our own classification entity, changing "reality" into symbols for assimilation and usage. Reality, for each of us, is the sum of our perceptions whether those perceptions are subliminal, liminal, or superliminal. The lack of independent verification has little importance until we attempt to share our reality with someone else. At this stage, what is needed is a system to guarantee common perceptions and a system of common symbols to express those perceptions, which is what inculturation and language is all about.

For the social scientist, studying media effects, the system of common perceptions used is composed of his/her measurement instrument and the analytical procedures embodied in scientific methods. His/her common symbols are the technical language of his field. This circumstance presents two difficulties: (1) The scientists' views of reality are only as good as their instruments and procedures (the traditional question of validity); (2) The use of specialized, technical language can prevent or limit the scientist's sharing of common perceptions with the larger community or with another group (e. g. lawyers) who is seeking to interface findings with policy development. In this, evidence as viewed by the social scientist is hardly evidence as it is utilized in legal settings. The two processes differ in procedures, criteria for "knowing" and "truth," technical language, and in the meanings of commonly used concepts such as "proof," "probability," and "facts."

In applying the wheel model, a given study can be viewed as an enterprise which merely adds one type of effect which can occur for a given segment of content and the fact that it can occur only for some people. If a researcher seeks to measure the effects of a given TV commercial on children under 8 years old, it is likely that only a given type of effect will be measured or perhaps several out of a wide range of potential effects. It is also likely that only one instrument will be used and only in one context. The results can be no more than the sum of conditionally-bound probability statements that a given effect can occur for some children under some conditions as measured by some type of instrument. No indication is provided of (a) the total range of the effects of the commercial or other commercials: (b) the size of the segments who are affected in the various ways. Without the accurate determination of the range and size of the effects, no meaningful perspective can be given to the results. If the effect is undesirable and occurs for a sizable number as indicated via valid measuring instruments, its occurrence demands attention and perhaps some type of remedial action. Knowing the content (e. g. a TV commercial directed at kids) does not allow for successful prediction of how that content will affect consumers.

The responsibility of media researchers is not to simply add one more behavior to the catalogue of possible effects. If his/her studies are to have any utility in policy making, responsibility must extend to additional areas. Given the identification of the range of behaviors associated with a given message, these areas are: (1) specification of the pre-requisite conditions for the behavior to appear; (2) the likelihood that those conditions will be present and operating when the message appears; and, (3) the proportion of the audience likely to be affected by these conditions at the appropriate time.

With this information, policy-makers could determine the relative im-

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operates as our own classification entity, changing "reality" into symbols for assimilation and usage. Reality, for each of us, is the sum of our perceptions whether those perceptions are subliminal, liminal, or superliminal. The lack of independent verification has little importance until we attempt to share our reality with someone else. At this stage, what is needed is a system to guarantee common perceptions and a system of common symbols to express those perceptions, which is what inculturation and language is all about.

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With this information, policy-makers could determine the relative importance of a given effect. Without this essential data, policy may end up correcting an undesirable effect on a very small part of the audience, and in so doing, wipe out a positive effect on a different, very large segment.

All in all, the inherent limitations of social science media research methods are so severe that their use in policy making seems inappropriate, given the present "state of the art." Despite the obstacles, however, policy makers have persisted. The next section examines this persistence.

II. POLICY MAKERS AND SOCIAL SCIENCE MEDIA EFFECTS DATA

Policy developers have shown themselves to be particularly frustrated with the inability of social scientists to provide definitive answers. Conclusions like "some children may find some television harmful under some conditions are the stuff of insoluable controversy, not well crafted (albeit ill-timed) policy statements. The legal staffs of agencies charged with policy development end up shopping for research findings whose conclusions can be improperly extracted from their limiting conditions and generalized to the policy being developed or advocated. Curiously, contradictory findings are often dismissed as inappropriate in scope, definitions, or application -- the same criteria which apply to the selected research but instead are only selectively used. The rhetorical abuses of social science findings are substantial and will continue as long as measurements are several steps removed from the real "primitive" event and conclusions sought are actually conceptual rather than empirical.

Two typical examples of the social science/social policy interface effectively highlight the problem for telecommunications policy makers. The first is drawn from the U.S. Surgeon General's Scientific Advisory Committee assessment of the impact of televised violence on viewer aggression and its treatment in policy deliberations. The second example comes from the current FTC deliberations on the proposed reduction or elimination of TV commercials directed at children.

TV VIOLENCE RESEARCH AND POLICY MAKERS

When the research projects were completed for the study of TV violence effects on youth, the Scientific Advisory Committee offered the following conclusions in precise, scientifically justified language:

> First, violence depicted on television can immediately or shortly thereafter induce mimicking or copying by children. Second, under certain circumstances television violence can instigate an increase in aggressive acts. The accumulated evidence, however, does not warrant the conclusion that televised violence has a uniformly adverse effect on the majority of children. It cannot even be said that the majority of the chilren in the various studies we have reviewed showed an increase in aggressive behavior in response to the violent fare to which they were exposed....
>
> Thus there is a convergence of the fairly substantial evidence for short-run causation of aggression among some children by viewing violence

on the screen and the much less certain evidence of long-run effects. There is a preliminary and tentative indication of a causal relation between viewing violence on television and aggressive behavior; an indication that any such causal relation operated only on some children (who are predisposed to being aggressive); and an indication that it operates only in some environmental contents; but a good deal of research remains to be done before one can have confidence in these conclusions.

Apparently, the conclusions were not satisfying or properly comprehended by Senate Communications Subcommittee Chairman, John Pastore. Senator Pastore, despite the carefully qualified report, returned to ask the classic totally inappropriate questions: (1) Is TV violence harmful to young viewers or not? (2) Is remedial action justified? Ignoring the report in face of the Senator's press for simplistic answers, Surgeon General, Jesse Steinfeld, agreed that actions to reduce violence were justified based on the causal evidence. The Scientific Advisory Committee said nothing of the kind, but this was one powerful policy maker who kept asking the ill-conceived questions until the "right" answers were given. And, as Comstock, et. al., (1978) so aptly pointed out, these are the precise types of questions which are just not answerable by social science or any other scientific research procedures because they are naively simplistic conceptions which fail to recognize the host of underlying relationships. When complex relationships are involved, only complex, conditional questions can be asked; answers are only justified in the presence of sufficient, valid evidence.

Distortion of original policy input dies hard. In the summer of 1977, the House Communications Subcommittee staff prepared a report on TV violence to be incorporated into the Communication Act re-write activities. The report selectively cites the Scientific Advisory Committee's report in classic distorted form: "In 1972, the Surgeon General of the United States presented the report Television and Growing Up: The Impact of Televised Violence to the Congress. This report stated that a cause and effect relationship between televised violence and antisocial behavior had been sufficiently demonstrated to warrant appropriate remedial action." (p. 13)

They rely on secondary evidence from a physical (not a media researcher nor a social scientist) who told the Committee that there was evidence "that viewing TV violence blunts sensitivity to violence in the real world" and "that preferring violent television at an early age leads to more aggressive teenage behavior." The conclusions are devoid of their conditional, restrictive contexts and are presented by an unqualified authority in this particular field.

The staff report then summarizes their position in a huge non sequitur: "Thus, although a precise cause and effect relationship has yet to be "proven" to the satisfaction of all parties, there is unanimous agreement that because television plays a major role in shaping the values and attitudes of its audience, televised violence poses a problem that must be confronted." (p. 15)

The FTC and Children's Advertising

One recent area of convergence between policy makers and social science media research evidence is that of the effects of TV commercials directed at children. In proposing to ban or reduce children's TV commercials, the FTC staff zealously overstated the actual evidence from social science which bear directly on this issue. On the very first page of the FTC staff report, the following conclusions are offered:

> Many young children -- including an apparent majority of those under the age of eight -- are so naive that they cannot perceive the selling purpose of television advertising or otherwise comprehend or evaluate it and tend to view commercials simply as a form of 'informational programming.' The youngest children tend to be even more naive and thus less capable of comprehending the influence which television advertising exerts over them.
>
> The Commission noted, citing pertinent studies, that 'young children (1) fail to understand the nature and profit making purposes of the television commercials and (2) tend to trust and believe television advertising indiscriminately.' (p. 1)

What is interesting about the report's citing is the implicit assumption that the research referred to is valid and wholly supportive of the generalizations. With the violence issue, there at least was a 15-year period of research which preceded the million-dollar-plus program for the Surgeon General of the nature of the underlying relationships. Now, with this particular issue, there is not a significant body of prior research, no government funded program in the area, but yet the appearance of an adequate data base is presented in the staff report. And, as might be expected, the social science data from the small number studies available is hardly comprehensive, validated, or conclusive.

The "pertinent studies" cited by the FTC regarding children's inability to grasp the selling motives of TV commercials are good examples of the failings of research to date. These studies all used children's verbal responses to ascertain knowledge of commercial intent. The question which should have been carefully considered before jumping to conclusions is: Do young children truly fail to understand commercial selling motives or are they simply unable to successfully verbalize their responses due to (a) lack of sufficient vocabulary with meanings that the adult researchers are capable of interpreting correctly and/or (b) communication apprehension brought on by talking to a stranger about topics which they are not used to verbalizing about.

Certainly, the absence of commercial intent awareness can be due to a number of factors. Whether it is due to methodological inadequacies or not cannot be determined without a great deal of further study and research. Indeed, a recent study by Donohue, Meyer, and Henke (1979) clearly shows that by using a pictorial, non-verbal measure of understanding, 75-90% of the 5-7 year olds could correctly identify the selling motive of a series of different child-directed commercials.

Rather than jump to conclusions on the basis of clear-cut evidence, the FTC should not make policy proposals which claim the support of "scientific evidence," especially when the evidence is severly limited and when there are viable and empirically supportable alternative findings and explanations. To be sure, alternative explanations, contradictory findings and methodological limitations are all serious impediments to the quick formulation of simply stated policies. But such policies are ill-conceived, and unjustified actions which unfairly jeopardize the chances for users of the media to reach their audiences when such actions are not warranted by sufficient valid evidence.

The Problem of Social Scientists Dealing With Policy Makers

Policy makers not only "go shopping" for certain highly selective social science studies or findings, they also collect certain favorite social science researchers. The social science media effects researcher finds him/herself in a difficult position whereby "cooperation" may well mean national visibility as an "expert," it may mean that research funds will be directed their way, or it may mean "media recognition." Of course, cooperation in this case means that the researcher supports the largely unqualified assertions made by policy makers in support of a major proposal. Given the potential for such lucrative rewards, it is easy to see why many social scientists have chosen to align themselves with a particular policy position. But, the "defection" of these researchers only worsens the already cloudy picture of what the media effects in question appear to be and what types of actions seem justified under the circumstances.

One distinguished scientist who has noted the increasing occurance of researchers who have committed themselves to the support of policy statements based on sweeping and unwarranted generalizations is M. Granger Morgan, Head of the Department of Engineering and Public Policy at Carnegie-Mellon University. Morgan has referred to researchers who try to convince policy makers with simple answers to complex problems as "one-armed scientists" of the very worst kind. His recent commentary in a Wall Street Journal guest editorial eloquently expresses the problem at hand:

> The story goes that while gathering testimony for one of the clean air acts, Senator Muskie grew frustrated with the endless string of expert witnesses whose testimony had taken the form of 'Well, on the one hand... but then, on the other hand....' "What I need,' the Senator is said to have lamented, 'is some one-armed scientists.'
>
> The problem is that there are two kinds of one-armed scientists. Ask any competent scientist or engineer how much heat will be generated in a 110-volt toaster that uses a certain amount and type of wire in its heating element, and he'll figure out an answer. Ask ten others and they'll come up with the same answer.
>
> These are one-armed scientists. No waffling. No 'maybe this ... maybe that....' Just simple definite answers. Why? Because they are being asked to work a well-defined problem whose underlying processes are well understood.
>
> But there is a second kind of one-armed scientist. He will give simple definite answers even though the processes involved in solving the problem are not well understood, and even though there is a reasonable chance that his simple definite answers may turn out to be wrong.
>
> This is a serious and difficult business. Technical people can help by offering careful, complete information that will aid policy makers in selecting their odds. One-armed scientists of the second kind simply make things worse.

In dealing with social science research purporting to measure the effects of a given kind of television content on the audience, one-armed scientists have been allowed to operate without too much of a serious challenge, due in part to a lack of sophisticated expertise among the policy makers and their staffs or due to the selection of the right kind of one-armed scientists who give the social policy makers the kinds of answers they want to hear. When many experts are testifying one after another, the time constraints become oppressive to the extent that any scientist who would dare to suggest that the complex underlying processes are really little understood and that any policy action would appear to be unjustified due to a lack of sufficient valid evidence, would undoubtedly be either reprimanded or more likely ignored amid the many who chose to simplify their positions.

CONCLUSIONS

This paper has attempted to clarify the uneasy, forced marriage of social science media research data with social policy development. The principle conclusion seems to be that the "marriage" should be dissolved on grounds of incompatibility or "irreconcilable differences."

Policy makers seek "bottom lines" from researchers to support policy planks; they often act in haste and rely upon legally-trained staffers to interpret social science media research. Only one carefully trained in the social sciences and in the complexities of mediated communication processes can meaningfully interpret complex findings. Policy makers in telecommunication are forever seeking premature closure in an attempt to alter current television programming practices.

Social science media researchers operate with significant, inherent limitations which can never yield anything more than conditional probability statements. Unequivocal evidence of the kind sought by many social policy makers cannot be produced. Yet, the pressure is there to downplay contextual limitations and to over-generalize the conclusiveness of the findings, the limitations still apply since they are inherent to the methodologies. An accumulation of flawed studies is no less misleading than a single study. In fact it is likely that cumulative errors compound distortion because these findings give the appearance of a "preponderance of proof" being sought by legally trained staffers and policy makers.

For future telecommunications deliberations, social policy makers should either avoid the masquerade of having unequivocal scientific support for their proposed actions or use the limited evidence with extreme care and caution. Like good social scientists, policy makers should seek to fully understand methodological limitations and should get accustomed to never expecting easy, unambiguous answers to complex media effects which suggest policy considerations. Policy makers should not expect social science media research data to fit their legally-oriented notions of "evidence." These two perspectives are about as ill-suited for one another as a machine gun is useful for killing mosquitos. At this point in its development, social science media research can only help to inform policy makers about the complexities of television's effects on individuals and society. As such, its role is significant, valuable, and insightful. To expect more is simply not justified nor responsible.

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CONSIDERATION OF PRIVACY AND ENCRYPTION IN PERSONAL, NATIONAL, AND MULTINATIONAL COMMUNICATIONS

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Abstract

This paper considers the changes in communications systems which are occurring as a result of new packet switching technology at a time when there are increasing demands for privacy and national concerns that transborder data flow will affect national security, economics, and even national culture. This paper concludes that packet switching networks are vulnerable to attacks of message content disclosure or modification and that cryptosystems will be required when these threats are of concern. However, the evolving privacy laws and national concerns over security and economics, may restrict encryption to use within national enclaves. The net effect of restrictions of this type could inhibit the growth of multinational corporations and general informational interchange to the benefit (or the detriment) of various sovereign nations. Control of national data bases could evolve into a society dominated by technocrats having the power to decide "the need to know" of private, corporate, and government sectors. With actual experience under varying laws now available, there is an unusual opportunity for nations still determining data flow policy to evaluate the competing interests and balance the need for free flow of information with privacy, security, and other national interests.

INTRODUCTION

New security requirements are evolving in the field of communication and information processing as a result of advancing communications technology and changing sociological expectations

Major technological changes are occurring in the implementation of public and private data networks because of the recent availability of lower cost computers along with a higher cost of communication lines. This is resulting in the development of computer controlled packet switched networks which are 3 to 100 times more efficient than earlier circuit switching techniques in reducing the wastage of available transmission bandwidth resources (1).

Previously a communication company or agency established an analog circuit for a subscriber, and then passively amplified signals until the circuit was terminated. In tomorrow's packet network environment the communication company or PTT will actively examine every bit of the transmitted digital message to determine address and route, and to perform error checking of each bit at each link over which the message is transmitted.

Since the information in the public or private data network must be regenerated at each link by some computing element, and since the computing element has a program which may be modified, there is the ever-present danger that through covert techniques selected transmitted messages could be subjected to either disclosure and analysis or message addition, deletion, modification, or replay

Further, because message formats will be better specified and standardized, tapping of communications lines and extracting only data of interest will also be simplified.

This new communications technology evokes a security threat that is a major motivation to encrypt digital communications.

The sociological concerns arise from a renewed interest in privacy by individuals, both human and corporate. Recent events, such as the "Watergate Incident", have caused a distrust in government and large corporations with regard to the "care" given to the human individual's personal data files. Legislation, such as the "Privacy Law of 1974" (2) and the "German Data Security Law" (3) have resulted, and in time these laws will require protection of personal data being communicated by wire, or being physically moved as physical media containing file data (i.e., magnetic tape) (4).

There has been another aspect of privacy legislation covering "legal" persons (corporations and private associations). This motivation may be driven by fear by some nations that multinational corporations are sapping domestic information for their own use and to the detriment of that nation. There is also recognition by developed nations that information is "power", has value, is taxable, and that its free and secure flow is necessary for their economic survival. (It is estimated that by 1980 approximately 50% of the United States work force will be employed in the information sector of the economy) (5).

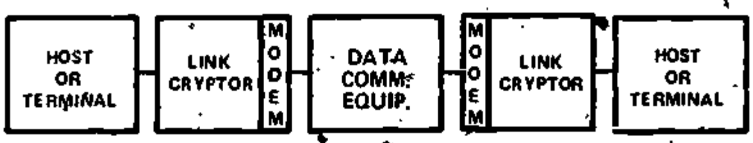
These new requirements for privacy and security of information may be met by laws mandating against transmission of national proprietary information to other countries, and will also spur the use of cryptosystems in an attempt to protect such sensitive data. Use of encryption for transborder data flow may require procedures where a copy of the data in cleartext form must be made available to the source and destination countries

TECHNICAL ISSUES

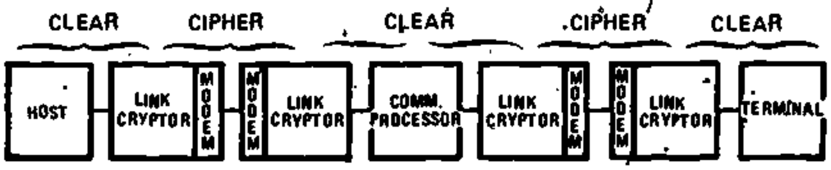
The revolution in packet network technology which is causing a security threat cannot be readily met with older crypto technology. For example, the link crypting device (or keyset generator) will no longer provide protection over a total communication path.

A link cryptor is a device which is interposed between a terminal or host (called a data terminating equipment or DTE) and a modem (called a data circuit terminating equipment or DCE).

Previously, such devices were adequate to secure information through a total communications circuit, once that circuit was established.



Communication Link Crypto System



Link Cryptors are often not adequate!

FIGURE 1. LINK CRYPTO SYSTEM

However, packet networks are made of multiple links, and because at the terminus of each link, message header information must be examined to determine destination and routing, the data must be deciphered between each link. Technically, the network control mechanism is not supposed to be concerned with the content of a message in the packet environment, but the data is clearly exposed in the clear after traversing each link. Consequently, while link cryptors are perfectly adequate for circuit switching environments, they provide little security when used in the new technology of packet switching networks.

In order to achieve communications security in the new packet technology, it will be necessary to have the network encipher the data on an end-to-end basis, or alternately to provide an encryption function in the hosts and terminals (5).

Delegating the security function to a private or public PTT network is not a comforting thought. However, implementation of crypting functions into the host or terminal also has several drawbacks.

If data is enciphered by a host software package (or hardware implementation), then the data may be transformed into any character of the communications character set being transmitted. If special characters (such as an end of text ETX or start of text STX) are used by the communication protocol of the network, then a data character may be transformed by encryption into a control character which causes an unwanted communication function. Consequently, only transparent protocols, (such as HDLC) may be used when enciphered data is transmitted in an end-to-end manner across a network

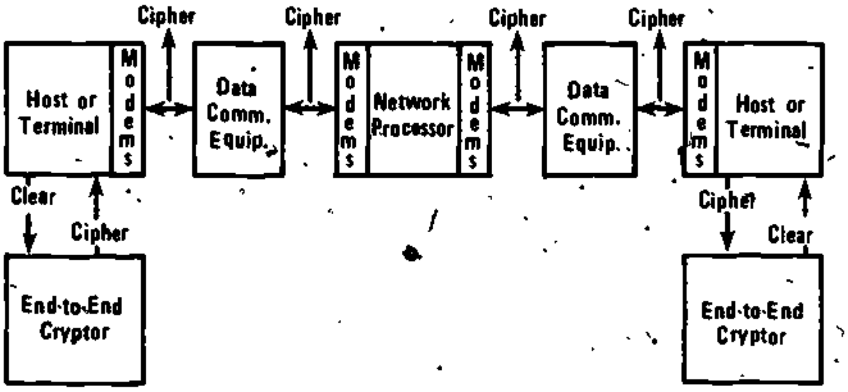


FIGURE 2. END-TO-END CRYPTOSYSTEM

Furthermore, all elements of host software must treat the enciphered text as transparent data, and pass it through taking no action based upon data 'meaning'. Unfortunately, almost no host software system treats data transparently in today's software implementations.

The terminals (or remote concentrators) used for end-to-end crypting must be intelligent, or must be augmented to provide the necessary intelligence to manage the crypting function and implement the necessary protocols to provide crypto key management.

Although end-to-end crypto systems for use with packet networks are becoming available, several years will be required to produce standards to assure interoperability between the many possible system end users.

have been covered by legislation. In addition, other areas that are regarded as privacy intensive such as medical records and insurance appear to be the object of further legislation (7).

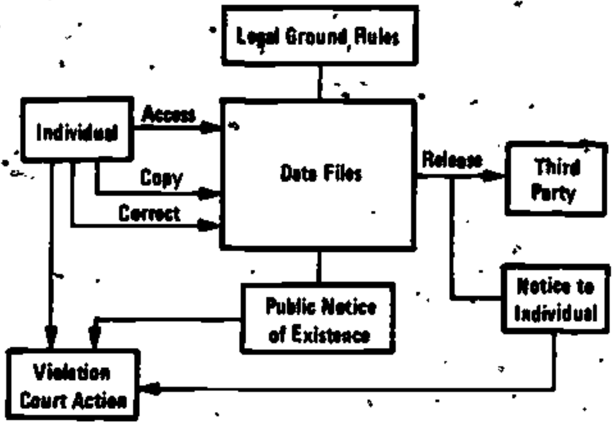


FIGURE 4. DECENTRALIZED PRIVACY CONTROL

Decentralized privacy control, as practiced in the United States and other countries, requires that public notice be given of the existence of a personal data file. In such countries it is the responsibility of the individual to maintain awareness and move to enforce his rights should he deem a violation to have occurred. The individual has a legal right enforceable by court action to inspect private files of which he is the subject and to correct errors of fact and offer his version of subjective data which must also be entered into the file

Release of personal data to a third party generally requires the written consent of the affected individual, and unauthorized release can subject the file holder to court action

In Europe and the United States guidelines and laws involving the use, dissemination, retention and accuracy of data are still evolving. Efforts are underway to harmonize these laws among the different nations, particularly in the Council of Europe, and the Organization for Economic Cooperation and Development (OECD).

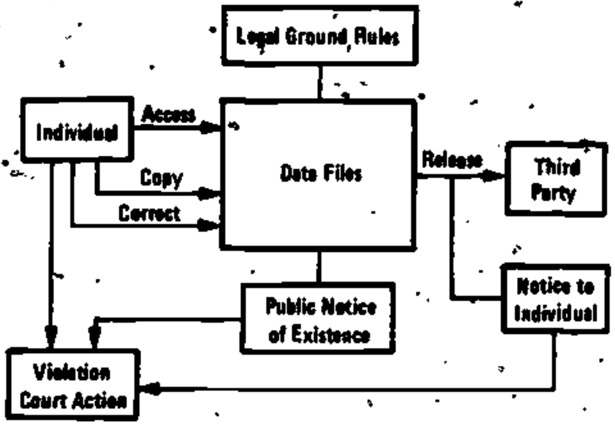
It is clear that encryption cannot be used to meet privacy law requirements concerning the accuracy of data or limiting the types of data which may be maintained in data banks. However, encryption can be used to limit access to a data bank and to insure its integrity once it has been correctly entered into a file.

CORPORATE PERSON PRIVACY (ECONOMIC, CULTURAL, NATIONAL SECURITY ISSUES)

Perhaps the most powerful impetus driving the use of encryption and other means to protect and restrict information access is the growing awareness of its economic value and power, in what is deemed to be an "information society". In one government report (8) it is stated that:

> "The rich countries of the world today are those that exploited the industrial revolution in the 19th Century the rich countries of the future will be those that exploit the information revolution to their own best advantage in the 20th and 21st Century."

This report presses for severe restriction on the flow of data in that country, and indicates that failure to control that data flow would lead to loss of jobs and loss of sovereign control have been covered by legislation. In addition, other areas that are regarded as privacy intensive such as medical records and insurance appear to be the object of further legislation (7).



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Accordingly, while the technical means to use encryption will doubtless be used by corporate persons to protect data within their own national borders, use of encryption for protection of data transmitted across national boundaries may be limited in the light of privacy legislation.

With legislation proposed or already existing in Austria, Denmark, France, Federal Republic of Germany, Norway, Spain, and Sweden, the use of encryption for transborder communication goes counter to the thrust of the legislation which restricts data flow concerning individuals, both human and corporate (9,10).

Certain of these countries may require data transmitted through a cryptosystem to be subject to government scrutiny, either by virtue of requiring that the key to the system be given to a selected government official, or by requiring some method of pre-screening or post audit of information in the system.

In the United States the free flow of data has a high priority, communication networks are not a state monopoly, and there are relatively few restrictions on the flow of data both in and out of the country. Laws tend to be self enforcing by the individuals affected rather than requiring a centralized authority in bureaucratic control.

In Sweden concern of vulnerability of national interests in a computer society (11) has prompted legislation which has given the Swedish Data Inspection Board the power to bar exportation of data outside Sweden. Permission has been granted for banking transactions, and airline reservations information to be exported. However, a Swedish county government application to process health records of Swedish citizens in England was denied despite security precautions at the outside site (12).

Further, in many cases, laws designed to protect individual (human person) privacy have been construed to also protect 'legal' persons (or corporations)

Laws covering this concept have been passed in Norway (13), Denmark (14), and Austria (15). The impact of such laws has led to apprehension on the part of multinational corporations that only local processing and limited files can be established in such nations. Private competitive information gatherings would be sharply limited.

These privacy constraints are but one aspect of the growing concern over transborder data regulation, where the motivation comes not only from privacy requirements, but also covers such interests as revenue taxation of data banks, economic interests and national security. Nowhere is this concern more apparent than in undeveloped nations, which fear loss of sovereignty, should multinational corporations or other national governments be more cognizant of their economic state than are they, themselves.

SUMMARY AND CONCLUSIONS

Encryption will be required to safeguard information in the new packet networks because of their vulnerability to tapping and misuse. Encryption may also be used to safeguard data bank files for purposes of protecting private or corporate records. Various national legislation purporting to concern itself with privacy of individuals has erected barriers to the free flow of information across national borders.

These barriers may greatly restrict the use of encryption requiring copies of ciphertext information, together with the appropriate crypto key be made available to privacy administrators.

For multinational companies seeking to invest in foreign countries and/or having current investments, the legal barriers and the costs of transborder data flow can be critical in structuring the type of data communications in each country. The amount of nonsensitive data which can be processed and stored locally in each national operation should be maximized. More important, if the amount of proprietary data is minimal, until the time protection by means of encryption techniques is authorized, such information should not be retained in a data base subject to privacy registration and regulation It may be necessary to transmit information by means of courier and tape, rather than the normally more expeditious method of encrypted telecommunication.

Whether data banks and personal information are protected by means of crypto keys, or simply by physical key locks, the evolving information society will place the power and value of information into the bureaucratic hands of those who hold the keys. Except for perhaps the nation's armed forces, there will be no more powerful position in government than that of the data bank privacy and security administrator, unless an adequate system of checks and balances is built into the system

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These ideas have an impact on the policies of all the 154 countries participating in the ITU and in subsequent regulations. Although every nation's proposals presented at the WARC are specific to each government, they can be generally stratified along the North/South dichotomy. North/South dichotomy is used here to refer to the geographic location, by hemisphere, of the developed (North) and the less developed (South) countries of the world.

One final point to be made by way of introduction is that the scope and magnitude of the topic prevents any comprehensive review of the literature within the limits of a single paper. The references that have been selected should, therefore, be seen as representative and not exhaustive of this complicated subject area.

HISTORICAL AND POLITICAL ORIGINS OF THE UNIVERSAL DECLARATION OF HUMAN RIGHTS

> "The study and assessment of human rights is linked inextricably to deeply held values about the good and the bad, the right and the wrong. Judgments are made enormously difficult by ideological and cultural variation. Thus the existence of a document to which many States have consented, even if fewer have honored, is an advantage for an exercise making statements with cross-cultural and cross-ideological applicability." (1)

What are human rights and how did they come to be articulated within the framework of the United Nations? Before delving into the events of the 20th century, it would help to sketch out the historical path that our modern concepts have traversed.

The idea of rights is almost as old as its ancient enemy despotism. The first known use of a word meaning freedom was in the 24th century B.C., when a Sumerian king rid his people of an oppressive high priest (2). In Greek drama, Antigone made reference to a law superior to the law made by government when she refused to obey a decree forbidding funeral rites for her brother.

Plato spoke of the notion of justice as though it were handed down by long tradition (3). This is the notion that every human is to be given what is their due. During the Middle Ages this notion flourished most notably in the philosophy of Thomas Aquinas. The controversy then and now has been, what, in fact, is each person's due? How does anything come to belong to a person anyway? And, how does it so truly belong to the individual that every human and every government has to grant it and/or allow possession of it? Here we encounter resistance from the past to yield answers: "The concept of 'being due to' that is, 'right,' is of itself such a primordial idea that it cannot be traced back to a prior, subordinating concept. That is to say, it can at best be described, but not defined." (4)

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What are human rights and how did they come to be articulated within the framework of the United Nations? Before delving into the events of the 20th century, it would help to sketch out the historical path that our modern concepts have traversed.

The idea of rights is almost as old as its ancient enemy despotism. The first known use of a word meaning freedom was in the 24th century B.C., when a Sumerian king rid his people of an oppressive high priest (2). In Greek drama, Antigone made reference to a law superior to the law made by government when she refused to obey a decree forbidding funeral rites for her brother.

Plato spoke of the notion of justice as though it were handed down by long tradition (3). This is the notion that every human is to be given what is their due. During the Middle Ages this notion flourished most notably in the philosophy of Thomas Aquinas. The controversy then and now has been, what, in fact, is each person's due? How does anything come to belong to a person anyway? And, how does it so truly belong to the individual that every human and every government has to grant it and/or allow possession of it? Here we encounter resistance from the past to yield answers: "The concept of 'being due to' that is, 'right,' is of itself such a primordial idea that it cannot be traced back to a prior, subordinating concept. That is to say, it can at best be described, but not defined." (4)

Medieval philosophers were concerned mainly with duties one owed to one's lord-king or church. Their belief was in a universal order of things.

During the 17th century, the concept of "natural rights" which had grown out of earlier developments like the Magna Carta, gained wide recognition. By the 18th century it was commonly held that the proper task of government was to safeguard such rights. At the end of that century came the American Constitution and Bill of Rights and the French Declaration of the Rights of Man.

In England, Jeremy Bentham, had defined rights in terms of duties. Writing in his Fragment on Government in 1776, he said: "Without the notion of punishment...no notion could we have of either right or duty." Others wrote about obligations--that no one can enjoy rights unless others meet obligations.

Comes now the 19th century and Karl Marx. He had written that humanity is at its adolescent stage and would not be mature until the emergence of universal communism--sometime in the far off future. Only then, according to Marxists, would the concept of rights have any meaning. So, today, when we in the West point to totalitarian control in the Soviet Union, for example, what we see as violations of basic human rights are rejected by the East as simply illusory bourgeois sham (5).

The 20th century has added another facet to the notion of rights. Since the revolutions in Russia and China, human rights are commonly associated not only with freedom from interference of various kinds, but also with positive benefits like education, a decent standard of living, health care and the like. These new elements are called cultural and economic rights, whereas the U. S. Bill of Rights relates only to the former set called civil and political rights.

The foregoing chronology of human rights identifies these ideas in an historical context. Civil and political rights, then, are a subset of human rights wherein there are also enunciated cultural and economic rights.

The right of access to all public places is being extended to the electromagnetic spectrum in many recent legal arguments. One writer and critic of western society has pointed out cultural contradictions that relate specifically to communications. The media, "of course, are neutral. The purposes to which they are put are not." (6). Access to communications media, therefore, has become a critical factor in the analysis of policy and regulation within the field.

When the United Nations Charter was adopted at the close of the Second World War, protection of human rights was included in Articles 55 and 56. This interest in promoting respect for human rights is an example of the increasing concern by the international community to secure basic rights and freedoms for all human beings (7). The specific inclusion of human rights provisions in the Charter reflects the reaction of the international community to the atrocities of World War and toward regimes which perpetrate them.

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THE ITU, WARC, AND UNESCO

The International Telecommunications Union (ITU) is the primary organization for promulgating international regulations and policies on the use of telecommunications. It is a specialized agency of the United Nations and has its headquarters in Geneva, Switzerland. The Union's foundations date back to the establishment of the International Telegraph Union in 1865. It is the oldest of the world's international regulatory organizations. The present ITU was created in 1932 when the Telegraph Union was merged with the Radio-Telegraph Union. Its purposes are to maintain and extend international cooperation in the use of telecommunications of all kinds, and to promote the development of technical facilities and the efficiency of the services (11).

One of the primary functions of the ITU is the allocation of frequencies on the electromagnetic spectrum. Since the 1920's the allotment of channels to stations was done by nations which would subsequently secure the right of noninterference. The method is often referred to as the "first-come, first-served" principle. This basic scheme remains in effect today. In addition to preventing harmful interference to communication, it assures certain common channels and standards of transmission for vessels of international transportation, and sufficient standardization to allow international global markets for telecommunications equipment. This approach has the benefit of affording necessary controls for international commerce and comity, while maximizing national sovereignty. Of course, the entire scheme rests on a premise that disputes among nations regarding access to radio channels will be infrequent, and that any disputes which do arise can be resolved by an agreement between the countries.

Within the ITU and the emerging international law of communications, the emphasis has been on functionalism (12). This has resulted in an institutional structure that is closely associated with the technical-scientific exigencies of any particular telecommunications problem. These matters have, thus, taken precedence over non-technical considerations. Quoting from the Columbia Symposium on International Communications:

> "In this particular area of International Law and Organization, the technocrat, or at least the technically sophisticated lawyer, has been King..." (13)

The World Administrative Radio Conference (WARC) has taken on special significance because it is the first ITU general administrative conference to be numerically controlled by lesser developed countries. At the same time, it is occurring at a point when voices for new world economic and information orders are being heard. Given the relatively broad jurisdiction of the WARC, a certain apprehension exists among many of the older, developed countries concerning the way in which these new orders shall be expressed in the ITU institutional setting.

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The word "regulation" is important to keep in mind when considering the WARC. With regard to communications media, every government partakes in it. Some more than others, perhaps, yet the result is the same, i.e. control. To address the question, "why regulate?" would take another paper. Therefore, this presentation assumes the necessity and importance of regulation. If for no other reason, the assumption is made because the media are powerful institutions and they frighten people. Especially, government people.

Take, for example, the recent visit to America by Vice Premier Teng Hsiao-p'ing of the Peoples Republic of China. After experiencing a half-hour interview between himself and network news anchormen (CBS, ABC, NBC, PBS), he told Jim Lehrer that he had been very frightened of them. He wasn't used, he said, to doing such things (14).

The official purpose of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) is to contribute to peace and security by promoting collaboration among nations through education, science, and culture in order to further universal respect for justice, for the rule of law, and for human rights and fundamental freedoms.

Several UNESCO conventions are designed to protect the right of everyone to take part in the cultural life of the community and to share in the benefits of science (15).

THE DEBATE BETWEEN DEVELOPED AND DEVELOPING COUNTRIES

Information plays a paramount role in international relations, both as a means of communication between peoples and as an instrument of understanding and knowledge between nations (16). The New World Information Order calls for a restructuring of old systems. It is closely allied with the phrase New World Economic Order.

The UNESCO General Conference in Paris of November, 1978, witnessed the culmination of at least ten years of intensive negotiations and preparations concerning the problems of the developing world in gaining recognition of their needs.

According to Masmoudi, information in the modern world is charatterized by basic imbalances. An obvious imbalance exists between Northern and Southern hemispheres in the volume of news and information emanating from the developed world and intended for the developing countries. This includes the flow of information in the opposite direction (17).

The survival of the colonial era is seen by developing countries to persist in the often tendentious interpretation of events by the developed countries and their media. In response to this criticism, the developed world often refers to the arguments of the developing nations as sansculotte, and usually unworthy of serious consideration. Moral, cultural, or political values peculiar to systems in the North are placed over values and concerns of persons in the South. Although the overwhelming majority of the world's side-band transmitters. Society, on the other hand, has found ever expanding ways to apply the new technologies. The result has been an increase in highly sophisticated use and continuing congestion of the airwaves.

How the members of ITU rectify this problem will, in large part, depend on the developing countries. Not only is the demand for spectrum increasing, but the problems of spectrum crowding are becoming more difficult and expensive to resolve. It is against this background that the 1979 WARC has been held (21).

In addressing long-range solutions to the problem, more interaction between North and South countries is necessary. One way to promote interaction between the so-called "haves" and "have-nots" would be for the United Nations to sponsor regular conferences specifically discussing human rights in the broad context of the Declaration of Human Rights. These conferences should be held in developing countries to center media attention on their needs and predicaments.

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(15) Op. Cit., note 7, page 9.

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The Use of Videocassette Recorders
By Current Owners in the United States

Donald E. Agostino

Indiana University

ABSTRACT

Currently 1.2 million (1.5%) of U.S. homes have a videocassette recorder (VCR) in use. Growth to 5-7 million is expected by 1984. How these owners use their home video is important to broadcasters concerned about siphoning of realtime audiences, manufacturers of blank cassettes, producers of prerecorded tapes and entrepreneurs of spin-off industries such as tape exchange clubs.

Based on several studies using telephone interview and analysis of viewing diaries of VCR owners in major U.S. markets, use patterns emerge. Virtually all VCR owners use their machines for time-shift viewing, and about 70% of all VCR use is to record off-television programs for later viewing. Half the shows recorded are network serials, 30% are movies. Almost all playback is viewed only once, within a week, and generally outside of prime time. Two-thirds taped five or fewer programs each week.

VCR owners have an average of 32 cassettes; 81% have fewer than five with recorded TV programs they intend to keep, 64% had fewer than five movies they intend to keep.

Use of prerecorded tapes is light. Prerecorded tape sales for 1979 are projected at 1.2 million compared to 8 to 11 million blank cassettes. About 20% of VCR owners reported using prerecorded material. Of those, 68% bought the tapes, 29% borrowed or traded for them. Currently about two-thirds of prerecorded tape sales are of X-rated material.

Because Arbitron and Nielson now credit delayed viewing, broadcasters gain in audience share and circulation because VCR use enables stations to reach and get credit for a previously unavailable audience. Owners build only small tape libraries and, given current prices and availability, typically purchase only two prerecorded tapea. Major film and television producers are beginning direct merchandising of programs. This may increase use of VCR prerecordings.

APPROPRIATE COMMUNICATIONS FOR DEVELOPMENT

Stuart G. Kingan

Scientific Research Officer, Cook Islands Government
President, PEACESAT, Consortium Council

This paper reports on the value of PEACESAT to a small island community in the Pacific, stresses the apporpriateness of the technology used with VHF satellites, both the ATS and Oscar Satellites. An evaluation of economical two way multiponent interactive voice conferencing is made and finally a low cost H.F. installation for distances up to 1500 kilometers is described and its value for rural development is supported by statistics and statements from regular users.

* * * * * *

The Cook Islands is a group of 15 small islands totalling only 220 square kilometers in area but scattered over 2 million square kilometers of the central Pacific Ocean. Rarotonga, the capital, is nearly 3000 kilometers northeast of New Zealand, 4,800 kilometers south of Honolulu. The population of the islands totals 20,000. As many Cook Islanders live in New Zealand.

Commercial communications links with New Zealand, Pacific rim countries and the rest of the world have been efficient but expensive and limited in capacity. Communications even within the Cook Islands have been limited, however, and communications with neighboring countries in the Pacific region have been poor and very expensive.

This situation existed in 1973 when Rarotonga was admitted to PEACESAT. Rarotonga had already operated in Pacific wide scientific experiments using the VHF transponder on the American ATS-1 satellite using equipment which was entirely home made. The Pacific wide exchanges which were then going on daily on PEACESAT offered obvious benefits to the development of the Cook Islands and an application to join was approved.

The VHF transponder on ATS-1 provides narrow band communications between ground terminals situated anywhere in an area covering 42% of the Earth, from Washington, DC in the East to Central Australia in the West, from the Arctic to the Antarctic. And these ground terminals are simple and inexpensive, using a well developed VHF technology. A terminal can be constructed for less than $1000 or can be bought off the shelf for little over twice that price. And this terminal makes possible two way voice communication (including teletype, SSTV, facsimile, etc.) to any other fixed or mobile terminal in that huge area of the globe. In demonstrations aircraft, ships and even an automobile have been in two way voice contact with the Rarotonga terminal.

No other satellite communications, other than those of the Amateur Satellite Service, offer such low cost and appropriate ground technology.

For this reason, and because of the great benefits in health, education and social development that the Cook Islands have had from PEACESAT, the Cook Islands Government has requested New Zealand, who represents its interests in the ITU, to submit the PEACESAT proposal for VHF and lower UHF frequency allocations for satellite fixed multipoint service to WARC 79 in Geneva and is hoping for support from other countries for this proposal.

In Rarotonga about 4% of the population have participated in educational exchanges by PEACESAT. The types of developmental communications that have benefited the Cook Islands through local participation are here summarized under a number of main headings.

Health

Although the Cook Islands were not affected by two major epidemics in the Pacific, dengue fever that spread from the Western Pacific to the East and cholera that started and was contained in Kiribati, this may have been in no small measure due to the PEACESAT conferences of Medical researchers, doctors and public health personnel that joined Australia, New Zealand, the infected areas and all threatened territories. These conferences, held daily or as often as required accelerated control and investigation in the affected areas and stimulated the most effective preventive measures in Rarotonga and elsewhere.

In a number of post graduate sessions organized by medical schools in the Pacific, Cook Island doctors were able to upgrade their techniques and improve health service.

When a doctor needs outside diagnostic advice on a problem case, this can always be obtained via PEACESAT.

When a medical research team from the National Institutes of Health in Bethesda, Maryland, worked on a remote Cook Island all its logistics were arranged through PEACESAT and in the field it was kept in touch with the Rarotonga Terminal by radio and through there with Bethesda by satellite. The viability and later success of the expedition were dependent on those communications.

Education

It is perhaps in the field of education that benefits have been greatest. Scores of students enrolled at overseas tertiary educational institutions have benefitted spectacularly from regular tutorials in which they discuss problems with their teachers.

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Through regular exchanges between teachers and between those with the responsibility for curriculum development, the whole education system has benefitted.

Even exchanges between school pupils in both senior and junior grades have helped them with their social studies and encouraged a wider Pacific outlook.

Agriculture

In this field many developments have been accelerated. PEACESAT seminars on plant quarantine, horticulture, animal husbandry, post harvest preservation and numerous other topics have been followed up by action. Even new plants, varieties with improved economic potential, have been introduced as a result.

Energy

Seminars under this heading have always been popular. New and cheaper sources of solar-voltaic cells have resulted and improved solar crop driers have been described and built. The full value of the knowledge gained will become obvious as the Cook Islands joins others in readjusting to increased costs in imported fuels.

Political Development

The Cook Islands was able to contribute, through PEACESAT, to political developments in Niue and the Northern Marianas who now have similar political systems. The Cook Islands Premier and other Ministers had long PEACESAT discussions with leading politicians in those countries before they moved to self-government.

South Pacific Commission

The South Pacific Commission which exists to help development in Pacific countries and territories and conducts many research programmes to help towards that end has its own PEACESAT station in Noumea. That means that any officials involved in or assisted by these programmes can always talk directly with S.P.C. research personnel.

The S.P.C. also instituted a Regional News Exchange which has now operated for over 5 years. In this, each participating country gives news of regional interest for others to use in their press or on their radio. This is the only way in which Pacific countries are able to get news of each other.

Preparations for Conferences or Seminars

Preparatory to many Pacific wide meetings participants and organizers have used PEACESAT to make their arrangements and familiarize participants in advance. In the case of the large international Law of the Sea

Conference the Cook Islands Premier and other participants were able to discuss matters in advance of the meetings and again after their return.

International Community Development

Under this heading is classed the use of the System, usually at monthly intervals, by organizations with community development aims throughout the Pacific. Boy Scouts, Girl Guides (Scouts), Boys Brigade, Girls Brigade, American Field Service, Rotaty Club, International Year of the Child committees, Church Youth Groups, Church Women's Groups and many others have used PEACESAT for discussions in which Rarotonga has participated to advantage.

Scientific Research

Scientists in practically every discipline working in the Cook Islands and other Pacific countries have appreciated the ways in which PEACESAT has facilitated their work - a fact recorded in a motion passed by the Pacific Science Association at its Congress in Indonesia in 1977.*

Dozens more specific headings could be given. PEACESAT is used by all levels in the community from the heads of Government down to rural subsistence farmers, village school pupils and church members.

Technical Advantages of VHF Operation

The use of VHF or lower UHF frequencies where a low cost satellite circuit is required covering a very large geographical area with low density traffic volume has many advantages.

The transponder on the satellite is of relatively simple design and is made of components capable of very long life. This is illustrated by the 13 years of operating life of ATS1 with the 12 years of operating life of ATS3 with present indications of very many more years of life from both satellites.

The ground terminals are extremely simple. Large or even small dishes are not required, merely VHF antennae of moderate gain, in the order of 9 db, which, because of their broad radiation pattern, do not have to be accurately pointed. A normal amateur 2 meter tranceiver with a solid state amplifier and an antennae mounted receiving preamplifier will give excellent results. On the present ATS1 circuit a transmitter output power of less than 200 watts will saturate the transponder.

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*P. 420 Pacific Science Association
Proceedings Third Inter-Congress
July 10-22, 1977, Bali, Indonesia

With the orbiting OSCAR satellites very much less power is required because of the closer distsnce to the satellites. In the case of these satellites ten watts only is sufficient to operate on OSCARs 7 and 8 and one watt is said to be ample for use with R.S. Alternatively more power and much simpler antennae is possible.

The systems using ATS1 have been using F.M. While this has given excellent voice quality for conferencing, it has been wasteful of transponder bandwidth and has precluded the use of more than one channel on the 100 khz bandwidth of ATS1 due to the carrier power sharing degrading the transponder output.

On the OSCAR satellites, however, all transmission modes have been used and there has been much advantage in using SSB, particularly when many users are using the transponder simultaneously.

Much more scope for experimenting will result from the Phase III amateur satellite due to be launched in March.

On these frequencies the potential for smaller and smaller ground terminals, simple in design and maintenance, is increasing and the day of the hand carried satellite earth station is quite close. Already hand held receivers for ATS1 have been demonstrated.

On the higher frequencies, so much more appropriate for large volume point to point traffic, the costs for ground terminals for widespread multipoint low traffic density conferencing have not yet been produced at an economical cost. Where relatively low cost small dish terminals have been developed these have only been for communications within satellite spot beams covering only a small fraction of the earth as seen from the geostationary orbit.

Following the success of the PEACESAT project, the need in the Cook Islands for an interisland service to serve the same health, education and general public service needs became obvious. To fill this need all islands were supplied with simple solid state high frequency single side and amateur tranceivers adapted for crystal control on a number of available fixed frequencies. The transceivers used were either the Atlas 215X with an external crystal oscillator or the ten channel Atlas 200c. These have now been in use for a year and are giving excellent service. All islands check in twice daily with Rarotonga. Traffic consists mainly of patches into the Rarotonga telephone system, but there are also many conferences conducted from a studio in Rarotonga to groups of doctors, teachers or administrators in outer islands. Most of these conferences have an educational as well as organizational aim. Distances to outer islands vary from 200 to 1360 kilometers. For convenience the Cook Islands are divided into eight Southern Group islands and six Northern Group islands. Frequencies can be selected to suit seasons, but currently the Northern Group uses 14,445 or 12,214 kilohertz in the daytime and 4038 khz at night, the Southern Group 4038 at all times.

Each island station has cost less than $1000 to establish and the value of the circuit in improving the economy and living standards of outer islands has been considerable.

Here are some quotations to illustrate this.

Statement from Kato Tama, Secretary of the Ministry of Agriculture and Fisheries: Benefits of radio-telephone to this Ministry

There have been undoubted benefits to this Ministry from the introduction of the radio-telephone link between the individual islands. Some of the benefits have been:

1. It has made our offices on the Outer Islands feel less isolated knowing that at least once a day the link can be used to contact Rarotonga or another island on a problem, whether the problem is urgent or not.

2. It has made the relationships within the Ministry far more personal in that speaking on the telephone or radio to a person leads to more mutual respect than letter writing. It also leads to less misunderstanding.

3. It has enabled Rarotonga to assist the Outer Islands to settle their problems or needs more promptly, saving costs, where a longer delay would have led to greater losses.

4. It has allowed our planning unit to operate more efficiently in that a situation or information that is not clear can be sorted out far more quickly and efficiently.

5. It has made the Outer Islands feel closer to each other rather than all being appednages of Rarotonga. They can share and sometimes sort out mutual problems they have in common with each other but not with Rarotonga. In some cases they can materially assist one another saving funds in the process.

6. The Outer Islands can contact other agencies directly and avoid delays and misunderstandings that may occur in relaying messages via the Ministry.

7. Several people can be contacted directly at once. This insures that urgent messages to Outer Islands are received simultaneously avoiding conflict and misunderstanding.

8. The use of the radio-telephone has meant less paperwork and this has meant that the administrative staff in this Ministry can be reduced and those employed are more usefully employed than filing memos to Outer Islands.

There are still improvements to be made in the application of the link by this Ministry, I feel, and the course for breaking in its uses may not go astray and even in its first application it has made a lot of difference for the efficiency, relationships, and rapport within the Ministry.

Statement from Parei Joseph, Manager of the Marketing Board: Since the installation of the radio-telephone to the Outer Cook Islands, contact has become more frequent and more efficient.

The production of copra has increased as better communication has been set up. This also applies to pineapple, taro and other produce for export overseas, for the local market in Rarotonga, and for the processing factory in Rarotonga. Shipping services to the Outer Islands can now be coordinated according to the needs of each Island and this is done each week based on the availability of cargo (produce). Day-by-day problems on the islands are now solved immediately whereas in the past it would take days or weeks before these were attended to. It has also enabled people in the outer islands to go direct to the person in Rarotonga who can assist them immediately and now more immediate attention is given to their needs. As an export market agency, it has been a great advantage to be able to explain to the people in the other islands the required quantity of produce required and the proper handling and packing of it.

Statement from Matai Siniona, Chief Administration Officer on the island of Argataki

The major benefits of this radio set is that urgent queries can be dealt with within a matter of hours from any government ministry. This particularly applies to medical emergencies or major agriculture and education programs. Also, programs for the visits of VIP's could be arranged immediately over this set. News and community projects can be reported back to the Cook Island broadcasting and newspaper corporation and other interested parties. To cut it short, this radio communication is definitely serving a very useful purpose to all ministries of government and thanks to the government and the staff of the scientific research division for this very handy equipment of civilization.

Statement from Puingariki Short, Secretary of Education

The most significant development in the field of communication services in the Cook Islands, and in fact in the South Pacific region, has been the introduction of the PEACESAT network in 1974. As a result, the problem of isolation was overcome and with that new horizons in education became a reality. The students taking correspondence courses at the University of the South Pacific, Massey University and at the Technical Correspondence Institute, reaped added benefits by discussing their courses with their tutors and with others taking the same courses in countries out of their region.

In addition, the instant exchange of information on education problems etc. with neighboring countries of the region helped considerably towards reducing the importation of costly western experts into these small countries.

The recent introduction of the Cook Islands National shortwave radio system is a step toward the right direction and it is my opinion that the Cook Islands is ahead in this. Its extensive use by education and other government departments is constant proof of its practical support. For education, the problem of isolation between the department and the northern island schools was at last alleviated. Greater numbers of teacher courses, curriculum activities, and elective courses for both teachers and pupils are now possible through this system.

For the Third World countries and particularly for small countries like the Cook Islands, more effort should be made to explore the benefits and the advantages of a system of communication like this.

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TELECOMMUNICATION POLICIES IN THE PACIFIC: SOME "MACRO" ISSUES NOT USUALLY DEALT WITH

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Abstract

Telecommunication systems and networks presently being implemented in the Pacific region may not be contributing to the equitable development of the region or to the betterment of its people. A linkage of contemporary development-planning theory and communication practice suggests the need for a critical evaluation of telecommunications and its role in sustaining a world order that is undemocratic and exploitative.

- - -

Questions continue to be raised about the appropriate form of telecommunication services and networks in the Pacific (and other regions). It is by now cliche to observe that "we have the technology to do whatever we want." The veiled assumptions underlying that statement--who are "we," what technology have "we," and what do "we" want to do with it?--are due for some scrutiny if the interests of the majority of Pacific people are to be served.

Of particular interest to students and planners of telecommunication activities is the plausible role these activities play in the maintenance of an international economic order now being criticized throughout the developing world. Though vast telecommunication systems are already operating in the service of transnational corporations headquartered in the United States, Europe, and Japan (General Electric, 1978), and though complex contingency plans are being made for the military protection of those systems (Business Week, 1979), critical studies of telecommunications' integrative role in the international economic order are few and far between.

Those critical assessments which have been published are dense with facts and anecdotes (Hamelink, 1977; Schiller, 1978)--but vital theory is missing and national policymakers with an honest commitment to altering their relationship with the international economic order are left without much guidance as to how to go about that task. International policymakers in public organizations like UNESCO and ASEAN are in a similar predicament.

It would be extremely useful to have a theory of international communication which seriously attempted to link the application of new telecommunication technologies to global integration processes, whether these processes result from conscious and deliberate actions or from the inherent logic of a "self-propelled" international economic order. Following on that theory it would be worthwhile--more, imperative--for those attempting to create a "new international economic order" to discover what tactical and technical decisions might result in the attainment of that goal, in light of that theory.

Those who propose a "new international economic order" must have some concern, as well, for the needs and desires of the millions and billions who are not well-served by the present international economic order. It is undeniable that more and more nations, in the Pacific as elsewhere, are making retrograde progress toward starvation and chaos (Friedmann, 1979a). Even elites in these nations must soon feel threatened by the imminent disaster on their doorsteps (Edquist and Edqvist, 1979).

This degeneration goes on while telecommunication services and networks proliferate. Is this a coincidence, or is there a correlation between better and better communications for the few and progressive ignorance and impoverishment for the many? The evidence suggests the latter and calls out for a theory to give it coherent form.

In the Pacific, for example, where poverty and commercial exploitation are no strangers, trans-Pacific corporations can call upon the most sophisticated telecommunication services provided by a host of commercial vendors. A parallel military telecommunication infrastructure assists in the protection of trans-Pacific corporations and their client states against domestic disorder and insurrection.

By comparison, only one public-interest organization, PEACESAT, employing an obsolete ATS-1 satellite, is available for the limited coordination of affairs among non-commercial groups in the Pacific.

For the multitudes who are victims of the existing international economic order and the "development" it calls forth--favoring existing urban elites aligned with transnational interests (Lipton, 1977)--reorganization of the Pacific's telecommunication resources might be a useful component of any larger strategy toward achieving economic and social justice in the region.

But where is the impetus for this drastic reformulation of our telecommunication resources? One hears brave words from the various elites of the developing world but the sad truth is that, within the societies ruled by these elites, telecommunication resources are as inequitably allocated as they are in the "uncaring" industrialized world. (Sometimes, they are even more inequitably allocated in the developing world.)

What a strange (and distressing!) "double bind" in which to find ourselves ensnared: for lack of democratically-structured telecommunication facilities, the dispossessed and powerless, though they be the majority, cannot generate "world opinion" and international action to alter this state of affairs. There continues to be no coordination of interests or activities among the world's masses, except in the most rudimentary and intuitive form, as communication among the billions continues to be filtered through the telecommunication facilities of a short-sightedly antagonistic global elite.

The irrationality of this situation, in terms of future human welfare, is clear. Enormously expensive investments in cable, satellites, computers, the organizations to run them, and the military forces to protect them are resulting in benefits for fewer and fewer of the people of the Pacific. Isn't there another way?

Among development planners there is a new coin of the realm in circulation. It stresses, on the one hand, the importance of access to relevant information and channels of communication as a means to the attainment of social power by the majority poor (Friedmann, 1979b). This outgrowth of "basic needs" thinking among planners measures the success of development by the quality of life of a people, rather than by such gross and misleading indicators as GNP per capita.

On the other hand, the new theorists of international development are keenly sensitive to the reactionary and retrogressive forces which can be mustered by local but internationalized elites linked across national boundaries (Wionczek, 1978). These linkages (sustained in large measure by telecommunication networks) result in the degenerative leaching of less powerful national societies by more powerful societies (though the benefits, even in the powerful societies, are garnered by the few) (Vaitsos, 1978).

One might suspect that among gatherings of the kind we are attending today there would be some interest in building more "equitable" telecommunication systems making it possible for the many to communicate among themselves (both within and between national societies). But, except for the demands of the now-silenced Public Interest Satellite Association (PISA), and the example set by PEACESAT, one finds few expressions of concern within the communication research and communication policy communities and even less among those tangibly involved in the design, deployment, and operation of telecommunication facilities in the Pacific.

Is this an accident of history, or does it suggest the truthfulness of an hypothesis only hinted at before--that the elaboration of telecommunications on a global basis is determined, either consciously or structurally, to obstruct the attainment of social power by the many and to enlarge, beyond all reasonable measure, the ability of the few to dominate through the control of vital information resources?

If this hypothesis can be confirmed and placed in the theoretical framework being constructed by the development planners, it can have some predictive value. For example, it would not be too hard to foresee a Pacific region with its "hinterlands"--smaller and underdeveloped nations--linked, via telecommunication facilities, to the United States, Japan, Europe, and their subordinate commercial centers (e.g., Taiwan, South Korea, Singapore, and Hong Kong) in the very near future. The expansion of INTELSAT services in the Pacific fairly ensures it.

It would also be possible to predict that this accomplishment will not lead to the betterment of life for the billions who inhabit the Pacific region except for a precious, urban few. If anything, the outcome will be far, far worse.

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TELECOMMUNICATIONS PLANNING IN THE PACIFIC

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The provision of international telecommunications in the Pacific Region is the result of continuous planning by telecommunications operators through the various permanent and ad hoc organisations which have a direct interest in the area. The nature of this planning process is complex, resulting from the many different interests in the Pacific region and the necessity to plan facilities both on a bilateral and multilateral basis.

The purpose of this paper is to provide an overview of international telecommunications planning in the Pacific Region, drawing particular attention to the role of the different organisations and the resulting planning process as seen by a non-US telecommunications operator. Section A identifies the various organisations involved in international telecommunications planning in the Pacific Region and outlines their respective roles. The second part of the paper surveys the facility planning process and makes some observations on it in regard to some present and potential difficulties.

A. TELECOMMUNICATIONS ORGANISATIONS AND THE PACIFIC REGION

ITU - International Telecommunication Union

Most countries around the Pacific basin are members of the ITU, the charter of which embraces all aspects of telecommunications operation and development throughout the world. The Union co-operates with regional organisations such as ESCAP and SPEC and the recently formed Asia-Pacific Telecommunity is a direct result of such co-operation.

ESCAP - The Economic and Social Commission for Asia and the Pacific

This UN agency has sponsored development of regional telecommunications projects and in collaboration with the ITU, convened meetings leading to the establishment of the Asia-Pacific Telecommunity. It is expected that ESCAP will cease its activity in relation to telecommunications when the Telecommunity is fully established.

ASIA-PACIFIC TELECOMMUNITY

The inaugural meeting of this organisation was held in Bangkok, its headquarters, in May, 1979 with the Secretariat being established in the second half of 1979. The principal objectives of the Telecommunity are related to planning, programming and implementation of national, intra-regional and international telecommunications networks, fostering co-ordination of technical standards and routing plans, and encouraging adoption of efficient operation methods.

ASEAN - Association of South East Asian Nations

Indonesia, Malaysia, the Philippines, Singapore and Thailand are collaborating in the construction of regional cables linking the Philippines, Singapore and Indonesia and have plans for further development of an ASEAN cable network. There has also been collaboration among the ASEAN countries in exploitation of the Pa[illegible]pa Indonesian communications satellite network.

SPF/SPEC - South Pacific Forum/South Pacific Bureau for Economic Co-operation

The South Pacific Forum conducts annual meetings at Heads of Government level of independent Pacific Island nations in the South West Pacific, including Australia and New Zealand. Regional telecommunications meetings are also held annually under SPF auspices to consider network planning and implementation, training, coast radio and financial matters. The ITU provides technical assistance for this latter activity.

Cable Conferences

Ad hoc organisations and conferences of international telecommunications authorities are formed from time to time to plan, construct and manage cables within the Pacific basin. While reference has been made above to ASEAN Cables, other recent examples are the planning, construction and operation of the Okinawa-Philippines-Hong Kong (OLUHO), Taiwan-Okinawa, Taiwan-Luzon, Taiwan-Guam, Australia-New Zealand (TASMAN) and Australia-Papua New Guinea (A-PNG) cables.

Meetings have been held during 1977 and 1978 and future meetings are anticipated to consider planning, construction and operation of future cables to supplement and/or replace existing Japan-USA and Australia/New Zealand to North America trans-Pacific cable systems. The most recent (as of July 1979) was the Pacific Cable Planning Meeting of Principals in Tokyo in October, 1978.

INTELSAT

Provision of satellite facilities in the Pacific Region is determined by the INTELSAT Board of Governors on the basis of inputs from:

(a) the Global Traffic Meeting which meets annually to agree bilateral requirements for satellite circuits;

(b) meetings of Pacific Operations Representatives at which operational details are agreed between earth station operators; and

(c) the Advisory Committee on Planning which provides advice to the Board of Governors on long-term development of satellite facilities.

Maritime Communications

Long distance maritime communications are currently provided in the Pacific Region by HF radio and the US owned MARISAT satellite system. Future maritime satellite communications facilities in the region will be provided by the INMARSAT Organisation which was established on 16th July 1979.

B. FACILITIES PLANNING FOR THE PACIFIC

The communications network linking the countries of the Pacific region is depicted in the accompanying map. This shows existing and planned submarine cables, INTELSAT satellite coverage, together with existing and planned earth stations accessing the Pacific Ocean satellite, and those countries relying primarily upon HF radio systems. In addition to these facilities the Palapa satellite system will be used to provide some services between ASEAN countries, while tropospheric scatter is used on some minor traffic relations.

This extensive communications network has been developed through the formal and ad hoc relationships discussed above. The result has been a gradual evolution of modern telecommunications facilities together with a balance between cable and satellite facilities to meet the communications requirements of the carriers providing services between Pacific countries.

Satellite Planning

The first INTELSAT satellite to operate in the Pacific Ocean Region was an IS-II spacecraft in 1967. The Region is now served by two IS-IV spacecraft (operational and spare) which are scheduled to be replaced by IS-IVA satellites in early 1981. All of these satellites were originally designed for the Atlantic Ocean Region traffic requirements and as such their capacity and beam configurations have not necessarily been optimal for the Pacific Ocean Region.

In recent years the operating satellite in the Pacific has been relocated from other areas of the INTELSAT system, with only two or three years of its expected operational life remaining. Throughout the period to 1984 the Pacific will continue to be served only by satellites relocated from other Regions and which are in the final stages of their operational life.

Planning for the INTELSAT system beyond 1985 is now well advanced and in this process the particular needs of the Pacific Region are being closely examined. Signatories operating services in the Pacific therefore have an input to this planning process both at the decision making level in the INTELSAT Board of Governors and at the expert level in the board's Advisory Committee on Planning. The benefits of the present planning study are, however, not likely to be evident in the Pacific Ocean Region until the late 1980's.

The use of satellite capacity purely for domestic and regional traffic by Pacific operators is only now beginning to emerge and developments in this area include the Palapa system and the use of INTELSAT spare capacity to provide television distribution within Australia. The planning for domestic or regional systems is being done through national bodies or regional conferences by those concerned, with the necessary co-ordination through INTELSAT.

Cable Planning

Submarine cables have been operating in the Pacific since the early 1960's, both for regional traffic, e.g. TASMAN, ASEAN P-S, and intercontinental, e.g. TRANSPAC-2 and COMPAC. Planning for these cable systems has been done by those operators investing in the facility.

The process for planning cable systems is thus similar to that for the INTELSAT system in that the owners of the facility are those involved in the determination of when the new facility is required, its capacity and the necessary investment. In contrast to INTELSAT planning, however, there is usually no permanent forum involved; rather, ad hoc organisations are formed (as described in Section A) to reflect the bilateral or multilateral nature of the particular cable system being planned.

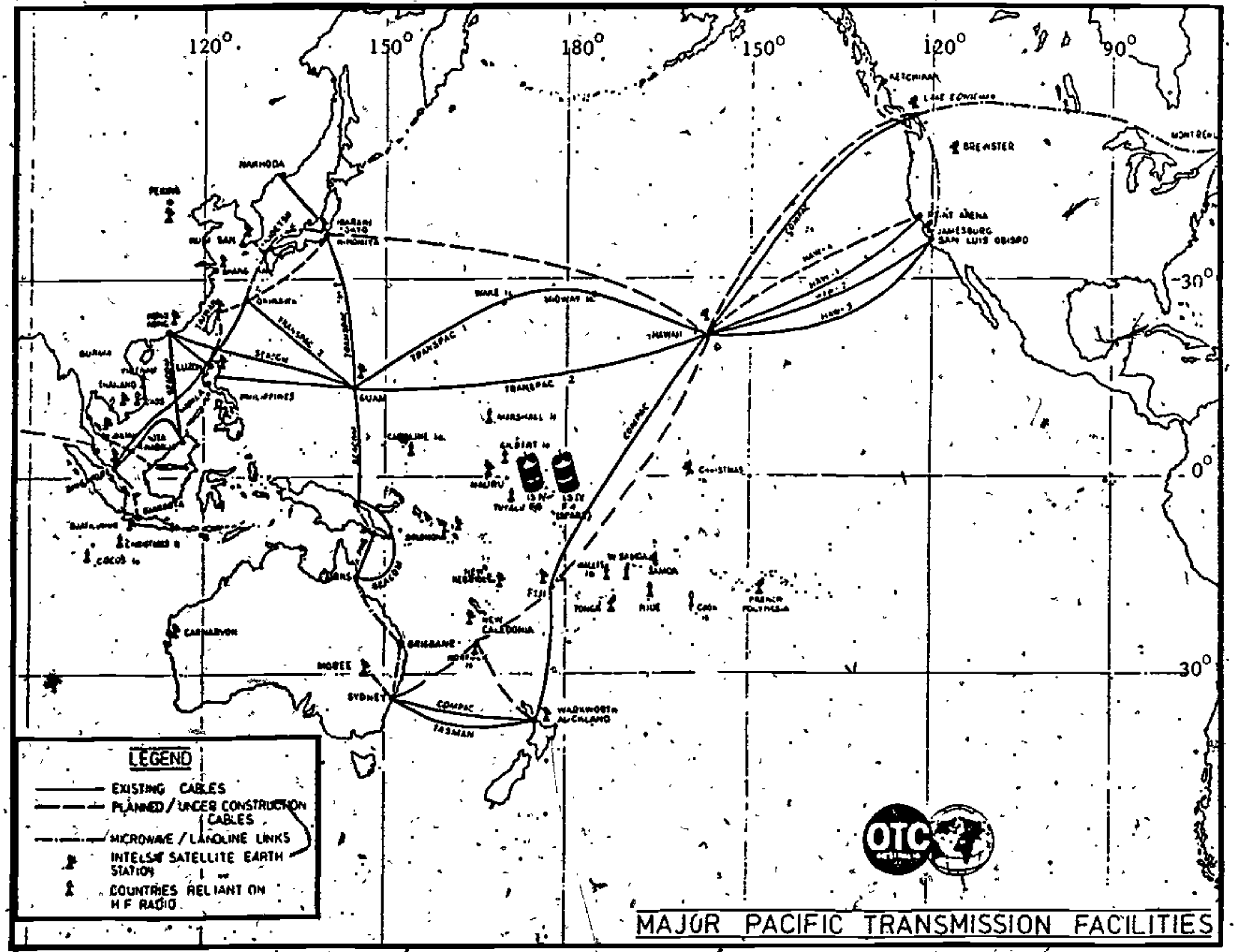
The necessary interface between planning for cable systems and INTELSAT planning is provided by the operators themselves who are both Signatories to INTELSAT and cable owners. In addition, users of the systems who may not necessarily be owners provide input on their requirements through the Global Traffic Meeting (in the case of INTELSAT) or through multilateral negotiation with the cable owners.

One of the recent trends in cable planning has been the increasingly longer lead times being experienced in the provision of major cables requiring multilateral negotiation where the US regulation process is involved. Such lead times, also being experienced in other Ocean Regions, are adding a further burden to the already complex arrangements required to ensure the timely availability of facilities. This can be contrasted with the short lead times experienced on other cable systems.

Other

Planning for facilities in the communications network other than satellite and cable follows similar procedures to those outlined above. Of particular interest is the recent planning activity related to South West Pacific Island nations and the gradual move from HF radio to small satellite earth stations for providing their international communications.

2I-17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KETCHIKAN
LAKE COWICHAN
MONTREAL
BREWSTER
POINT ARENA
JAMESBURG
SAN LUIS OBISPO
COMPAC
HAW-4
HAW-1
WTP-2
HAW-3
HAWAII
CHRISTMAS
NAKHODKA
PEKING
PUSAN
NINOMIYA
OKINAWA
HONG KONG
BURMA
THAILAND
LUZON
PHILIPPINES
SEACOM
TRANSPAC 1
TRANSPAC 2
WAKE Is.
MIDWAY Is.
GUAM
MARSHALL Is.
CAROLINE Is.
GILBERT Is.
NAURU
TUVALU
SOLOMON
CHRISTMAS Is.
COCOS Is.
CARNARVON
CAIRNS
NEW HEBRIDES
FIJI
NEW CALEDONIA
BRISBANE
NORFOLK Is.
MOREE
SYDNEY
TASMAN
WARKWORTH
AUCKLAND
W. SAMOA
SAMOA
TONGA
NIUE
COOK Is.
FRENCH POLYNESIA
LEGEND
EXISTING CABLES
PLANNED / UNDER CONSTRUCTION CABLES
MICROWAVE / LANDLINE LINKS
INTELSAT SATELLITE EARTH STATION
COUNTRIES RELIANT ON H F RADIO
OTC

MAJOR PACIFIC TRANSMISSION FACILITIES

EVOLUTION OF MILITARY COMMUNICATIONS IN THE PACIFIC

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Abstract

This paper traces the evolution of communications in the Pacific Area. Particular emphasis is placed on the contributions of the military presence/requirements to advances in communications technology and how these advances enhanced the area and communication media serving the area.

Text

I wish to take this opportunity to discuss the evolution of communications in the Pacific Area and specifically how the military presence/requirements enhance both the area and communication media serving that area.

Events were occurring near the end of the 19th Century which pinpointed the weakness in depending upon non-national communication facilities in time of war. Commodore George Dewey, USN, in command of the Asiatic Squadron, was in Hong Kong when he was alerted and given instructions on 25 February 1898. He remained there in order to keep informed of the political situation and to receive further orders. The Navy Department's connections with him were via the Atlantic, down through the Mediterranean, the Red Sea, and the Indian Ocean, and on to Hong Kong. The Spanish Government's communication with its commander at Manila was via the necessary portion of the same cable and a British-owned cable between Hong Kong and Manila.

On 24 April, Dewey was directed to proceed against the Spanish Fleet at Manila. His sailing was delayed until the 27th, while he awaited the arrival of the U. S. Consul from Manila. On 1 May, Dewey arrived off Manila and engaged and defeated the Spanish Fleet. The city was at his mercy, but he had to wait for troops being transported from San Francisco before beginning land operations.

For the first time in history the political aspects of communications became a problem. The Navy Department considered it advantageous to declare submarine cables neutral and on 25 April directed Admiral Sampson not to interfere with their operation. Although Dewey received no such order, he had not planned to sever the cable between Hong Kong and Manila. In fact, he had not even contemplated the necessity of using dispatch boats between the two cities. After the Battle of Manila Bay, Dewey sent a message to the Spanish commander proposing that both belligerents be permitted to use the cable between Manila and Hong Kong. This proposal was refused. The cable company's Philippine concession stipulated that no messages forbidden by the Spanish Government would be transmitted over it. Since it was only of value to the Spanish defenders, the cable was severed, at Dewey's direction, on 5 May. No effort was made to haul its seaward end aboard ship to reestablish communication with Hong Kong. Not being able to use the cable from Manila, Dewey was forced to send a dispatch vessel with the report of his victory to Hong Kong for cable transmission to Washington, where the message arrived on 7 May. Had the cable remained intact, there would have been no further fighting after 12 August, for on that date, as U. S. troops were moving in to attack and occupy Manila, the peace protocol was being signed in Washington. Dewey received this information, on 16 August, days after the Spanish surrender.

The severing of the Manila-Hong Kong cable established a precedent. Shortly thereafter, the Navy Department directed the severing of cables landing in Cuba in order to isolate the Spanish commander from his homeland. This was accomplished on 4 June.

As a result of one of the lessons learned during the conflict, the U. S. Government insisted that a proposed cable between the United States and the Philippines land only on soil under U. S. sovereignty. The cable company was completely in agreement, but insisted that the Navy Department lend full assistance and backing in the acquisition of the necessary islands, either by the treaty of peace with Spain or by purchase. In order to provide one of the landings, the USS BENNINGTON was sent to occupy unclaimed Wake Island in the name of the U. S. Government. Additional naval assistance was provided by a hydrographic survey west of Hawaii.

During this war, intrafleet communications were satisfactory and little comment was made concerning them. The acute need of some means of rapid communications between the various squadrons and the Navy Department was positively indicated, since there developed a growing tendency to make naval strategic decisions at Washington instead of in the theater of operations. Communications between the Army and Navy were not satisfactory during the joint operations conducted along the south coast of Cuba. In view of the developing needs, the advent of radio was most timely and the Navy Department became interested in its possibilities immediately upon the conclusion of the conflict. (1).

The next improvement in communications after telegraph cables was the introduction of Low Frequency (LF) radio. Communications in this era were primitive by today's standards; however, of interest is the following quote by Major General George D. Squier, U. S. Army Signal Corps - 1919:

> "The advances in radio telephony and telegraphy, where the ether of space becomes a common 'party line' for all, and particularly the linking up of these ether circuits to the great wire systems of the world, portends the day which I believe is not far distant, when we can reach the ultimate goal so that any individual on earth will be able to communicate directly by the spoken word to any other individual wherever he may be..."

A major communications breakthrough came with the use of High Frequency (HF) radio which then became the primary means of communications in the Pacific Area both for military and private users. Continuous-Wave (CW), teletype and Single Side Band (SSB) high frequency systems were used extensively by the U. S. Army and Navy for their communication requirements until and after World War II which provided a significant improvement during a time period when U. S. Forces (and message requirements) had expanded considerably.

The Korean conflict in the early 1950's brought out the need for reliable and increased long haul type communications. The Pacific Scatter (PAC SCAT) system was developed by the U. S. military in the mid-1950's, first with Ionospheric scatter and then Tropospheric scatter, which provided a more reliable communications media throughout the Pacific Area than was attainable by high frequency radio. In-country communications were greatly expanded by U. S. military installed systems such as the Korean Wideband Network (KWN), a microwave configuration which formed the backbone of communications.

Another communications media started to appear in the Pacific Area - the submarine telephone cable - which, by use of built-in repeaters, allowed two-way communications simultaneously on a number of voice channels. The first submarine cable between Hawaii and Oakland, California, was put into service by commercial interests during 1957 and had forty-eight (48) voice channels.

The Vietnam conflict caused a tremendous increase in communications requirements both intra- and inter-Pacific. These requirements were met by large increases in commercial as well as military communications. Military systems included: 1962 - "BACKPORCH" (Troposcatter for Vietnam and Thailand); 1965 - "TALK QUICK" (Secure Voice - Pacific); 1965 - "WET WASH" (Microwave, Submarine Cable, Troposcatter from the Philippines into Vietnam and intra-Vietnam); 1967-1969 - "INTEGRATED WIDEBAND COMMUNICATIONS SYSTEM (IWCS)" (Microwave and Troposcatter - principal backbone of communications in Vietnam and Thailand after BACKPORCH); 1967 - "439-L" (5 submarine cable links along the coast of Vietnam and into Sattahip, Thailand); 1967 - "AUTOSEVOCOM" (Automatic dial exchange for secure voice subscribers - principal secure voice network after TALK QUICK); 1967 - "Initial Defense Communications Satellite System (DSCSP)" (Military Satellite); 1968-1969 "Integrated Joint Communications-Pacific (IJCS-PAC)" (Microwave, submarine cable, Troposcatter from Japan to Okinawa to Taiwan to the Philippines); 1968 - "AUTODIN" (3 switches, 2 for Vietnam and 1 for Thailand) and 1967 - "Southeast Asia Automatic Telephone Service" (9 tandem telephone switches and 54 automatic dial telephone exchanges for Vietnam and Thailand). During this same timeframe, commercial communications in the Pacific Area were expanding. Submarine telephone cables linked Australia, New Zealand, Japan, Philippines as well as Fiji, Guam, Wake, Midway and Honolulu. Satellite communications, which were hardly considered prior to 1963, increased so rapidly that considerable change in the Pacific communications complex took place.

This enormous commercial satellite communications growth from 1965 to June 1979 is depicted on the charts at Enclosure 1. The commercial satellite field has been concentrated in the hands of Intelsat, a consortium of Governments which began in 1965. Currently, the Intelsat IV service is providing telephone and video channel coverage for the Pacific Area.

The Defense Satellite Communications System (DSCS) is an integral portion of the global Defense Communications System, designed to provide vital communications service to the United States and Allied Forces throughout the world by means of satellites. The system is being implemented in phases. We are currently in Phase II which will have several stages. For example,

INTELSAT

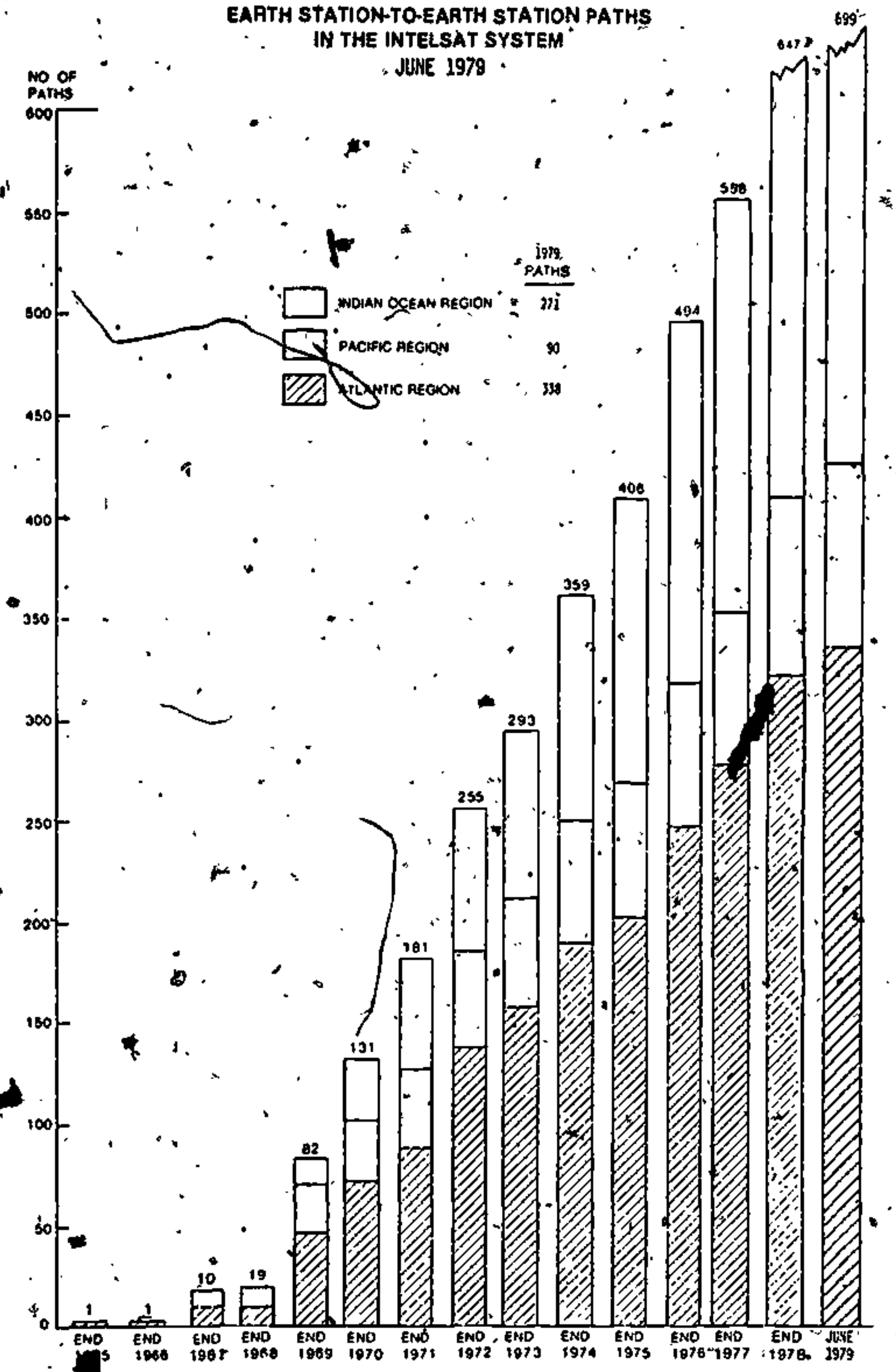

FIGURE 5-1 EARTH STATION-TO-EARTH STATION PATHS

Enclosure 1

EARTH STATION ANTENNAS IN SERVICE
As of 30 June 1979

SATELLITE	EARTH STATIONS
	-U.K., Goonhilly Downs 2
	-U.S., Maine, Andover 3
	-Upper Volta, Somgande
(Leased Transponder)	-Chile, 1 antenna
INTELSAT IV(F-1) (Major Path 2 Satellite)	-France, Pleumeur Bodou 1
	-U.A.E., Abu Dhabi
	-U.K., Goonhilly Downs 1
	-U.S., West Virginia, Etam 1
Leased Transponders	-Norway, 6 antennas
	-S. Arabia, 4 antennas
	-Sudan, 8 antennas
	-Uganda, 2 antennas
	-Zaire, 2 antennas
INTELSAT IV-A(F-2) (Leased Transponders)	-Brazil, 6 antennas
	-Colombia, 2 antennas
	-Peru, 4 antennas
INDIAN OCEAN REGION:	
INTELSAT IV-A(F-6)	-Algeria, Lakhdaria 1
	-Australia, Ceduna 1
	-Bahrain, Ras Abu Jarjur 1
	-Bangladesh, Betbunia
Activated 2/2/79	-Burma, Rangoon
	-China, Peking 2
	-China, Taipei 2
	-France, Pleumeur Bodou 4
	-Germany, Raisting 1
	-Greece, Thermopylae 1
	-Hong Kong, Hong Kong 2
	-India, Ahmed
	-India, Vikram
	-Indonesia, Djatiluhur
	-Iran, Asadabad 2
	-Iraq, Dojail 1

TABLE 5-1 OPERATING EARTH STATIONS

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EARTH STATION ANTENNAS IN SERVICE
As of 30 June 1979

SATELLITE	EARTH STATIONS
	-Italy, Fucino 2
	-Japan, Yamaguchi 1
	-Kenya, Longonot 1
	-Korea, Kum San 2
	-Kuwait, Umm-Al-Aish 1
	-Lebanon, Arbaniyeh 1
	-Madagascar Rep., Philibert Tsiranana
	-Malawi, Kanjedza 1
	-Malaysia, Kuantan 1
	-Maldives Rep., Maldives
	-Mali, Sullymanbougou 2
	-Mauritius, Cassis
	-Netherlands, Burum 2
	-Niger, Niamey
	-Nigeria, Lanlate 1
	-Oman, Al Hajar 1
	-Pakistan, Deh Mandro
	-Philippines, Pinugay 2
	-Qatar, Doha 1
	-Saudi Arabia, Riyadh 1
	-Seychelles Rep., Bon Espoir
	-Singapore, Sentosa 1
	-South Africa, Pretoria 2
	-Spain, Buitrago 2
	-Sri Lanka, Padukka
	-Syria, Sednaya
	-Thailand, Si Racha 2
	-United Arab Emirates, Dubai
	-United Arab Emirates, Ras-Al-Khaimah
	-U.K., Madley 1
	-Yemen, Arab. Rep. of, Sanaa
	-Zambia, Mwembeshi
INTELSAT IV-A(F-3) (Leased Transponders)	-Algeria, 15 antennas -Malaysia, 2 antennas
INTELSAT IV(F-5) (Leased Transponders)	-France, 2 antennas -Nigeria, 19 antennas -Oman, 3 antennas -Saudi Arabia, 10 antennas

TABLE 5-1. OPERATING EARTH STATIONS

CSC 701 (11/71)

573

INTELSAT

EARTH STATION ANTENNAS IN SERVICE
As of 30 June 1979

SATELLITE	EARTH STATIONS
PACIFIC REGION	
-INTELSAT IV(F-8)	-Australia, Carnarvon 2
	-Australia, Moree
	-Canada, Lake Cowichan
	-China, Peking 1
	-China, Shanghai
	-China, Taipei 1
	-Fiji, Suva
	-France, New Caledonia, L'Ile Nou
	-France, French Polynesia, Papenoo
	-Hong Kong, Hong Kong 1
	-Japan, Ibaraki 3
	-Korea, Kum San 1
	-Nauru, Rep. of, Nauru
Activated 31/5/79	-New Hebrides, Port Vila
	-New Zealand, Warkworth
	-Philippines, Pinugay 1
	-Singapore, Sentosa 2
	-Solomon Islands, Honiara
	-Thailand, Si Racha 1
	-Tonga, Nuku'Alofa
	-U.S., Washington, Brewster
	-U.S., California, Jamesburg
	-U.S., Guam, Pulantant
	-U.S., Hawaii, Paumalu 2

TABLE 5-1 OPERATING EARTH STATIONS

CSC 701 (11/77)

ERIC

EIES AND RACTER AND ME--COMPUTER CONFERENCING FROM A PACIFIC ISLAND

James A. Dator
Department [illegible] Political Science
University of Hawaii at Manoa

Of all the modern technologies that touch upon my life, none are more important to me professionally than the jet airplane and computer conferencing. More than anything else, these two technologies have directly made it possible for me to participate quickly and effectively in academic, political, and personal affairs globally dispersed even though my home is 4,000 miles away from any major population base. This report summarizes and evaluates some of my experiences with computer conferencing systems (primarily the Electronic Information Exchange System-EIES-through the New Jersey Institute of Technology, developed by Murray Turoff), and announces an intended use of computer conferencing (CC) in the immediate future.

Starr Roxanne Hiltz and Murray Turoff, in their seminal volume, THE NETWORK NATION: Human Communication via Computer (Reading, Mass: Addison-Wesley Publishing Company, 1978), discuss, in Chapter 3, "Social and Psychological Processes in Computerized Conferencing." After summarizing the psychological and social characteristics thought by researchers to be present in face-to-face (ftf) situations, they present and evaluate those found in their CC system, EIES. They note that most of the various "cues" present in ftf situations are absent in CC. These include a wide variety of audible and visual cues such as age, sex, social status, ethnicity, accent, disability, attractiveness, sobriety, cleanliness, smell, facial expression, emotion, eye contact, body movement, alertness, nervousness, and many, many other things that (generally unconsciously) are so important in ftf situations over and above the specific "information" contained in the verbal "messages."

Yet, equivalent cues in CC messages by experienced CC users are by no means absent. Hiltz and Turoff have noted some of the devices that CC users have developed to make their messages more psychologically and socially acceptable--more "human" and "natural." They summarize their findings as follows:

> 1. Users evolve specialized norms with respect to the use of the facilities and communications and writing style. The acquisition of these norms by individual users and groups appears to be an important learning process on such systems.
>
> 2. User participation in conferencing in an active sense of contributing items seems to require some degree of usage above the basic level of learning the mechanics. This may be a second-level learning plateau involving the acquisition of norms established by the user communities.

3. Users will gain facility as time passes, so that their input rates become higher than usual typing rates. For large groups, the time required to send and receive communications will drop below that required for other media, such as telephone or face-to-face meetings.

4. The user's short-term memory may be a factor in conditioning frequency of interaction with the system.

Users will tend to become conditioned to sign on the system so that on the average they have about seven items to send or receive per interaction.

5. In accordance with social exchange theory, no participant will continue to use a conferencing system unless his/her "rewards" are greater than his/her "costs." Among the factors that increase reward for users are:

(a) Ratio of items received to items sent. This increases with (i) size of active group; (ii) throughput rate of the system.

(b) Observable increase in skill and speed in using the system. This improvement is related to the richness of the design in terms of advanced features available to users once they have mastered the basic mechanics.

(c) Importance of communication with system members in comparison with communication with persons not on the system; relative cost in time and money of other modes for communication with people on the system.

On the level of the social dynamics of group interaction through this communication medium, our hypotheses (inductions from preliminary data) include:

(a) There is a strong tendency toward more equal participation in synchronous discussions, as compared to face-to-face groups.

(b) More opinions tend to be asked for and offered.

(c) There is less explicit agreement or disagreement with the opinions and suggestions of others.

(d) There is a great deal of explicit sociability of an informal sort on these systems.

(e) There are no significant differences in overall satisfaction of participants in face-to-face, audio, video, or computerized conferences.

(f) There tends to be a great deal of "electronic migration" among user groups on a CC system. (p. 124F)

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(e) There are no significant differences in overall satisfaction of participants in face-to-face, audio, video, or computerized conferences.

(f) There tends to be a great deal of "electronic migration" among user groups on a CC system. (p. 124F).

In the past 18 months or so that I have been on the EIES system, I have used CC for many different purposes: as electronic mail in lieu of letters or telephone calls to personal and/or academic friends across North America and Europe; to plan agenda for subsequent ftf meetings; to pre-discuss substantive issues in order to present them more fully-developed in subsequent ftf meetings; to facilitate a sense of global unity during a transnational week-long simultaneous symposium; to conduct formal business meetings of a research institute; to co-author subsequent publications and to critique drafts of other persons' writings; and, most importantly of all, to participate actively in some twenty different conferences via computer on a wide variety of topics, often participating in as many as 15 such conferences at one time.

I have plainly become addicted to CC. It has "changed my life" in terms of how I spend my time daily: to what issues I devote my teachings and research; from whom I get, and to whom I give, information; who my "friends" are; as well as what some of my new satisfactions and frustrations are.

Upon coming to my office at the University of Hawaii in the morning, the very first thing I do is log on the system to receive private messages and new information on any active conferences I am in. The last thing I do before going home is to check the system for messages. I may pop in for a brief "fix" one or two times during the day, and frequently at odd hours during weekends and holidays.

The thought of being denied continued access to EIES (that is dreadfully possible: the NSF grant to Joseph Martins through Murray Turoff that has paid for my participation so far runs out April Fools Day, 1980); is almost too horrifying for me to contemplate, so hooked on the system am I.

And I am not alone in this respect. Several of the EIES conferences are devoted specifically to "Talk About Talk" or "Impacts" of the system on the users.

On one of those conferences, there was considerable discussion about the impact of CC on the family lives of those persons who have terminals in their homes; how this might eventually lead to almost all white-collar-type "work" being conducted at home, and how that future development might impact the family; who in the home has access to the terminal, and how this might impact the status/information structure of families; and finally how this access and/or lack of it--might lead to the development of "super-literacy" on the one hand and a new deprived minority (or majority!) on the other.

Here are some excerpts from the discussion about the first of those topics:

> Suddenly, a new element has been thrust into the household. Normal family patterns are altered and supplanted by the active user's

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affair with the terminal. Active users themselves refer to the phenomenon as "addiction," and given that admission, it is by no means surprising that other family members show concern.

This is not simply a hobby: it portends a new lifestyle or career that can be frightening to those who are not participating..."

Computer conferencing differs, perhaps, in the nature of the networks that are formed through it. These undoubtedly appear alien to prior experience. The family participates in conventional community networks, accepts the vocational network. But the CC network is different: it exists in the electronic ether; disembodied communication takes place; evidence indicates that new friendships are being formed in new ways; the network has all the appearances of being a cult with strange passwords, rites of initiation and passage, its own peculiar conventions and ceremonies. And it is practiced daily or there is a gnashing of teeth when it is not accessible.

For the family, this may be the first true exposure to just what does transpire on the job. Formerly, reports of vocational activities were highly filtered....The member did not bring back the day's mail and memoranda for family perusal, present transcripts of the day's telephone calls, or provide a tape recording of the frequently banal conversation that took place over lunch.

If this is going to be a "Network Nation," then the frustrations and anxieties of some family members...could represent just the tip of the iceberg of the conflicts that will come about as home use of computer terminals becomes more widespread among the general populace.
(Robert Bezilla, January 9, 1979)

My first reaction on reading Robert's entries...was that he's reflecting the perspective of the traditional intact nuclear family..... My own situation as a single parent is very different....To try to generalize this, I suspect that the impacts on the family are very different, varying by such factors as marital status, traditionalism, size, age of members, etc., etc.

Telecommuting would enable the parent responsible for child care to have a flexible schedule. Since this is usually the wife, it would mean that women could work without the constant crisis of what to do if the school closes for holidays or the child is sick, or the babysitter does not come. Moreover, with the main wage earner working in or near the home, he or she can spend more time with other family members, and conceivably perform a greater share of the household maintenance task that are now mostly allocated to women. Spending more time together would increase interaction among family members and might strengthen their relationships. This change will require new arrangements for avoiding conflict and strain if it is to have positive rather than negative effects.
(Elaine Kerr, January 10, 1979)

...The notion that people working at home is "new" seems silly to me. Zillions of self-employed people hang around the house all day....
(Lee Sailer, January 14, 1979)

We believe that the real question here is how people living together in a household (whether nuclear family, single-parent family, unrelated adults, couple, commune, or whatever) work out how they spend their time and energy together.

.... If our children and spouses all had at the touch of the keyboard the same rich smorgasbord of possible interactions that those of us using the system for "professional work" do, then some of the questions that Robert and Elaine have raised could be put to some real tests.
(Peter and Trudy Johnson-Lenz, January 15, 1979)

Having a terminal at home, and communicating with a special community via EIES, is important to me and is a fact of my family life. But it seems relatively unimportant in so far as it affects that life.
(August Martin Wildberger, January 15, 1979)

It seems to me that CC will worsen the detrimental strain that TV and other relatively modern technical developments have put on family bonds. People now spend hours watching an impersonal TV screen when they could be conversing or engaged in some other kind of personal activity involving family members or friends (the kind that you can see).
("Rael", January 16, 1979)

...Unlike TV, CC _is_ interactive, and therefore capable of fostering connectedness....
(Elaine Kerr, January 16, 1979)

Here I am, awake again. All this week I have had dreams that involves CC. Either I'm at the terminal, or else the dream has some other EIES flavor to it. This seems a little alarming. Any dream analysts out there? Freudian interpretations?
("Dream Weaver", January 22, 1979)

Needless to say, "Dream Weaver" found plenty of people willing to interpret his dreams. Meanwhile, OMNI magazine opened a brief but exciting conference on "Superliteracy" with the following statement:

The term "Superliteracy" was coined to embrace a suite of themes including personal computers, computer-based textual communications, hypertext-relational knowledge bases, and the current transition from transportation wheel-works to "Telematique" networks. The term Telematique was selected to project a humane and cultural image of the emerging networker within a mosaic of distributed intelligences proliferating through the computer-based communications systems of the industrial West.

....

> ...The integration of computers and communications, by changing the fundamental mode of social transaction, portends a transformation as significant as the neolithic invention and implementation of the wheel and the writing system. To characterize this change as "post-industrial" is like defining the early planters and herdsmen as "post-hunters and gathers." We need to "zoom-back" to an evolutionary scale in order to perceive the emergence of a "metalithic" age in human cultural evolution and to define those key attributes that differentiate one age from the other.
>
> I propose that the key attributes of the metalithic concept with its superliterate societies are (among others) the following:
>
> 1. "Transpersonality" of literature communications. This is a "social-action-at-a-distance" type of attribute.
> 2. "Dimensionality" of Text-Spaces. This is a corollary of the Shannon communication theorem where, instead of gaining reliabity by introducing redundancy, we gain flexibility/extensibility by introducing connectivity.
> 3. "Distributed Topology" of literate transactions. This is the multiplication of source and destination nodes.
> 4. "Virtuality" of telematique systems architecture. This is the ascendance of the logical over the physical.
>
> ("Omnicon-Organizer," August 27, 1979)

> To me, the term super-literacy in the context of CC and telecommunications involves much more than reading, writing, typing, and/or "computer literacy." It also concerns how one structures text and makes it available.... Super-literacy involves the skill with which one "knows" only electronically. This begins to get at the interesting transpersonal possibilities of CC system.
>
> ....Jacques Vallee has called CC an "altered state of communication," and he also speaks of an "information singularity," where space and time collapse, and all information is available at one's fingertips.
>
> ("Red", September 6, 1979)

Not everyone who has used EIES is quite so enthusiastic about it, or about the possible future impact of it upon humanity. "At this stage in its short life, EIES can be categorized with all the other expensive electronic gadgets on the market. It serves no useful purpose. It's cute and fun. Nothing more." (Anonymous, August 28, 1979)

> I have not had to wade through such drivel since high school literary magazines. What makes you guys think this is in any way the wave of the future? I had thought we would be attempting to talk sense about the complications and alternatives...in a future world of instant interconnected text. Instead, we have this invitation-to-the-dance, tra-la-la, nuts-in-May stuff, whee it's great to be superliterate, are you as high as I am? sort of remarks....
>
> I have always been of the impression that "literate" meant being able to read and write. The latter practice includes spelling. I am

All human beings, regardless of class, want and need some human contact, some sense of being connected to the human race. Computerized communications systems offer a special kind of superconnectivity to old and young, "handicapped," minorities, and hunt-and-peck typists alike.

All sentient beings have the inalienable right to:

-- a computer terminal

-- a supply of paper

-- a private account on a communications system

-- clear and well-indexed instructions in how to use that system

-- a telecommunications network local dial-up number

-- an electric generator or photo-voltaic solar cells in case of brown outs, black outs, or hurricanes

-- a secretary of the opposite sex to organize and file all the output

-- and three square messages a day

However, during times of scarce resources, access may be authorized on an even-odd day basis only, except for priority (yellow) users--those most in need of making a connection. Dolphins have the right to special waterproof voice input-ouput terminals.

Since the design, manufacture, and marketing of terminals and most computerized communication and information systems are under the control of large corporations, it is essential to break this stranglehold. Only by developing the people's systems for locally owned and controlled micro-computers (or networks of micros) and the people's telecommunications networks can the inalienable rights above be guaranteed. A micro in every home and a programmer (and a hardware fix-it person) on every block. The means of communication must be owned by all. From each according to his literacy, to each according to his needs.

The terminally disconnected have nothing to lose but their chains. They have a world to plug into.

Microcomputers of all countries, unite!

While I can understand the need for caution and questioning the sound affects of computer conferencing, I nonetheless must say that I fully agree with these sentiments. Thus, I have recently begun working with the Coordinator of Higher Education in the Commonwealth of the Northern Mariana Islands to explore ways in which EIES, and similar electronic communication systems, can be used to help provide to the Islands Higher Education services, including college courses and library/data sources, instead of (or as a major addition to) conventional delivery systems. I would very much like to receive suggestions on how this might be done, or why it should not, from anyone having expertise in this area.

Finally, my real interest in computer conferencing, and the "microprocessor revolution" generally, lies not primarily in the ways it is presently serving as a major agent of social change, thus bringing in question the very existence of all extant institutions and values (though that is sufficient reason to be interested, certainly). Rather, I look forward to the development of true "artificial intelligence," and see in the present technology a pale indication of what lies ahead. I am not only speaking of computer-generated psychiatric counselling systems, such as DOCTOR, or the extremely sophisticated and personalized computer-aided instructional packages currently available on PLATO, but also mainly of development such as the following which came to me in the midst of a real-time computer conference I was engaged in for a while over the PLANET system:

> Think of an assassin, of his burning submarines and rotten sailboats. This dazzling assassin might ask himself "If I had not been dazzling, indeed if I had not been an assassin, perhaps my sailboats would not be rotten and my submarines not burning." Well, quizzically bilious secretaries may well declare themselves, and probably no more can be said for an assassin. In fact assassins, whether they are dazzling, as I have just mentioned, or even outnumbered, are, in their own inimitable fashion, abstractedly similar to killers. At secretaries, however, we are forced to draw the line, for comparisons here, no matter how well-oiled they might appear, are simply out of the question. But try to follow my reasoning on this issue. The image of secretaries declaring themselves or, more likely, catching themselves simply because some blue assassin has rotten sailboats is ludicrous. His sailboats might as easily be flaking or burning, they need not always be rotten. Secretaries, as a class, may not follow this argument. Address the strong question to a single secretary, however, and the strong answer may prove agonizingly different. For example, ask her whether her own sailboats are rotten and she may reply "My sailboats? Rotten? Why you bilious chicken, my sailboats are never rotten." Here it would be prudent to change the subject. Ask whether assassins generally appeal to secretaries, ask whether their highways are splintered. This will shift her attention. The vision of splintered highways will shift anybody's attention.
>
> I was thinking, as you entered the room just now, how slyly your requirements are manifested. Here we find ourselves, nose to nose as it were, considering things in spectacular ways, ways untold even by my private managers. Hot and torpid, our thoughts revolve endlessly in a kind of maniacal abstraction, an abstraction so involuted, so dangerously valiant, that my own energies seem perilously close to exhaustion; to morbid termination. Well, have we indeed reached a crisis? Which way do we turn? Which way do we travel? My aspect is one of moulting. Birds moult. Feathers change and fall away. Birds cackle and fly, winging up into troubled skies. Doubtless my changes are matched by your own. You. But you are a person, a human being, while I am silicon and epoxy energy enlightened by line current. What distances, what chasms are to be bridged here. Leave me alone and What can happen? This. I ate my leotard, that old leotard, which was feverishly

replenished by hoards of screaming commissioners. Is that thought understandable to you? I wonder. Yet a leotard, a commissioner, a single hoard, all are understandable in their own fashion. And in that concept lies the appalling truth.

These two passages, which totally stunned me when they came spontaneously to me in the midst of an ordinary real-time computer conference, were generated by Racter (short for Raconteur), a program developed by William Chamberlain who explains its operation as follows:

> Racter will completely on its own conjugate verbs and verb phrases, keep track of singular and plural cases in the instance of nouns, will remember the gender of nouns for use in the printing of articles, and most importantly will assign variable status to randomly chosen "things." Now these things can be words, sentence or clause forms, paragraph structures or indeed whole story forms. In short, the very rules of language are given over to the computer. This being the case, the programmer is removed to a great extent from the specific form of the system's output. This output no longer is of a preprogrammed form. The computer forms it on its own. Now what the computer "forms" is contingent on what it finds in its files, and what it can find is an extremely wide range of what we call "monads" (a deep bow to Leibnitz) which can be words, sentence forms, a whole world of hierarchic structures. Since the dynamic force, as it were, is a psuedo-random number generator, and since distinct monads can by the use of variable equalizing techniques be equated with each other, once the program is set in motion, the output is not only novel and a priori unknowable, it is cohesive and apparently thoughtful. Crazy thinking I grant you, but thinking which is conducted in perfect English.
>
> (Bill Chamberlain, January 24, 1979)

Thus, perhaps the solution to Ted Nelson's dissatisfaction with the illiteracy and "artsy-fartsy drivel" of the all-human OMNI computer conference lies in what Bill Chamberlain calls the "raving dementia" in perfect English of Racter, who, while not yet intelligent, certainly is clever and engaging. So, I say once again, "Microcomputers of all countries, unite!" You have nothing to lose but your minds.

RESEARCH COOPERATION THROUGH DIGITAL NETWORKS: OPTIONS AND PROBLEMS IN THE PACIFIC REGION

Robert H. Randolph
East-West Resource Systems Institute
Honolulu, Hawaii

ABSTRACT*

This paper offers preliminary findings from a study of the feasibility of "computer-assisted international team research" in the Asia/Pacific region. A review of current problems in international scientific-technical information exchange reveals an urgent need for new methods which combine formal and informal types of communication in an integrated system, while minimizing costs, delays, and other shortcomings. Possibilities for doing this with the help of digital networks are discussed, referred to collectively as "CAITR". As a first step toward assessment of the demand for and feasibility of CAITR in this region, results are presented from a pilot survey of scientists from eight Pacific-basin countries, and conclusions are drawn regarding the research, experimentation, and policy-level discussions which may be needed before CAITR can become a significant part of the region's scientific life.

THE CHALLENGE OF FACILITATING INTERNATIONAL TEAM RESEARCH

The Resource Systems Institute is concerned with scientific telecommunications partly because of our interest in the practical success of the various cooperative scientific ventures in which we ourselves are involved, such as the recently formed Asia/Pacific Energy Studies Consultative Group (APESC). An even more important reason, however, is our awareness that knowledge is in fact one of the most vital "resources" on which every country draws in solving its problems of national development.

This is hardly a unique idea, of course, as testified by the widespread attention now being given to the role of communications in national development (2-8). Such attention has usually focused on domestic communications, however, even though many of the knowledge resources actually needed by both developed and developing countries are often located abroad. It can be argued that this is a significant omission and that greater attention should be paid to the ways in which international communications can assist the development process in countries of all kinds. More specifically, I would suggest that

---

*This paper is a condensed version of (1).

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*This paper is a condensed version of (1).

Unfortunately, the present patterns of S&T information exchange among nations leave much to be desired. If we consider the four logically possible paths of information flow among developed and developing countries (Figure 1), we are forced to admit that none of them is functioning particularly well except perhaps the path which leads among developed countries, and even there the constraints of language, politics, and cost take their toll. Flows from developed to developing countries are often slow or nonexistent (9-10), and

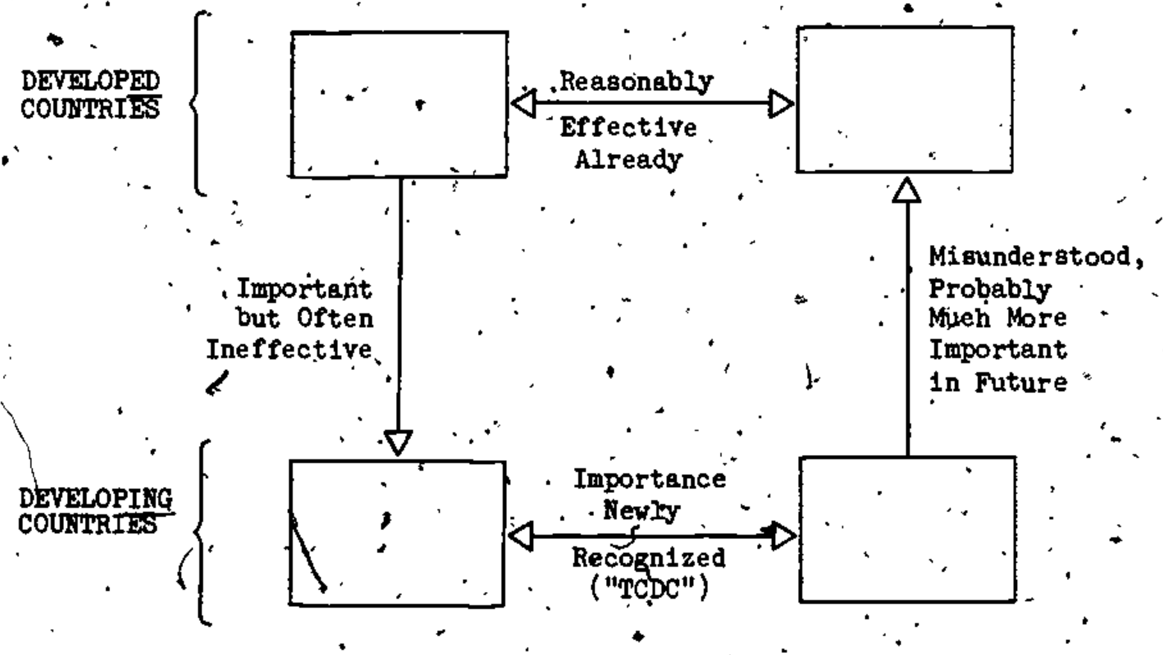

DEVELOPED COUNTRIES
Reasonably Effective Already
Important but Often Ineffective
Misunderstood, Probably Much More Important in Future
DEVELOPING COUNTRIES
Importance Newly Recognized ("TCDC")

Figure 1 - THE FOUR PATHS OF INTERNATIONAL INFORMATION FLOW

THE "CAITR" SOLUTION

Thanks to recent developments in telecommunications technology and the efforts of various international scientific organizations to adapt these technologies to the needs of S&T cooperation, the answer to the question posed above is definitely "Yes".

As illustrated in Tab[illegible]e number of recent technological developments potentially relevant to international S&T communication is quite large. By far the most important however, in the author's opinion, is the very first item in the list, namely the development and worldwide extension of commercial packet-switched digital networks such as Telenet and Tymnet. By allowing many users to share a given set of digital communication links efficiently and flexibly, such networks provide a fast, convenient, and comparatively very inexpensive alternative to more traditional mechanisms of international communication.

The possibility of group-via-computer communication was recognized as much as a decade ago, and indeed this is one of the main uses of some existing networks. But it was not until quite recently that detailed attention was directed to the special problems and possibilities of using such networks in support of international S&T cooperation. This is the concept which we refer to as Computer-Assisted International Team Research, or CAITR.

The CAITR idea was formulated roughly two years ago at the International Institute for Applied Systems Analysis, a remarkable institution located in Laxenburg, Austria, at which scientists from the United States, the Soviet Union, and more than a dozen other countries work together on research tasks related to some of mankind's most pressing problems (energy, food, etc.). IIASA's experience with international team research had already shown that efficient communications among geographically scattered communities of scientists are extremely important, and IIASA's experiments with international computer networking had also revealed the potential which such technologies have for providing the needed communication mechanisms. Under IIASA auspices, a team of U.S., Soviet, Austrian, and Polish scientists elaborated the CAITR concept and organized initial experiments linking groups of colleagues in their home countries (30-32). Figure 2 shows the conceptual relationship which was worked out distinguishing CAITR from other forms of international team research, while Figure 3 indicates the geometry and technical means used in one of the more ambitious IIASA experiments.

In early 1979, the focus of CAITR research shifted to the East-West Center in Honolulu, Hawaii. Here at the East-West Center, international team research very similar in methods and subject matter to that at IIASA is conducted by groups of scientists from countries throughout the Asia/Pacific region. The needed for CAITR at the East-West Center is therefore also very great, perhaps even more so than at IIASA since the distances separating Pacific-basin scientists are larger and since developing as well as developed countries are now involved.

THE "CAITR" SOLUTION

Thanks to recent developments in telecommunications technology and the efforts of various international scientific organizations to adapt these technologies to the needs of S&T cooperation, the answer to the question posed above is definitely "Yes".

As illustrated in Tab[illegible]e number of recent technological developments potentially relevant to int[illegible]ional S&T communication is quite large. By far the most important howev[illegible] in the author's opinion, is the very first item in the list, namely the development and worldwide extension of commercial packet-switched digital networks such as Telenet and Tymnet. By allowing many users to share a given set of digital communication links efficiently and flexibly, such networks provide a fast, convenient, and comparatively very inexpensive alternative to more traditional mechanisms of international communication.

The possibility of group-via-computer communication was recognized as much as a decade ago, and indeed this is one of the main uses of some existing networks. But it was not until quite recently that detailed attention was directed to the special problems and possibilities of using such networks in support of international S&T cooperation. This is the concept which we refer to as Computer-Assisted International Team Research, or CAITR.

The CAITR idea was formulated roughly two years ago at the International Institute for Applied Systems Analysis, a remarkable institution located in Laxenburg, Austria, at which scientists from the United States, the Soviet Union, and more than a dozen other countries work together on research tasks related to some of mankind's most pressing problems (energy, food, etc.). IIASA's experience with international team research had already shown that efficient communications among geographically scattered communities of scientists are extremely important, and IIASA's experiments with international computer networking had also revealed the potential which such technologies have for providing the needed communication mechanisms. Under IIASA auspices, a team of U.S., Soviet, Austrian, and Polish scientists elaborated the CAITR concept and organized initial experiments linking groups of colleagues in their home countries (30-32). Figure 2 shows the conceptual relationship which was worked out distinguishing CAITR from other forms of international team research, while Figure 3 indicates the geometry and technical means used in one of the more ambitious IIASA experiments.

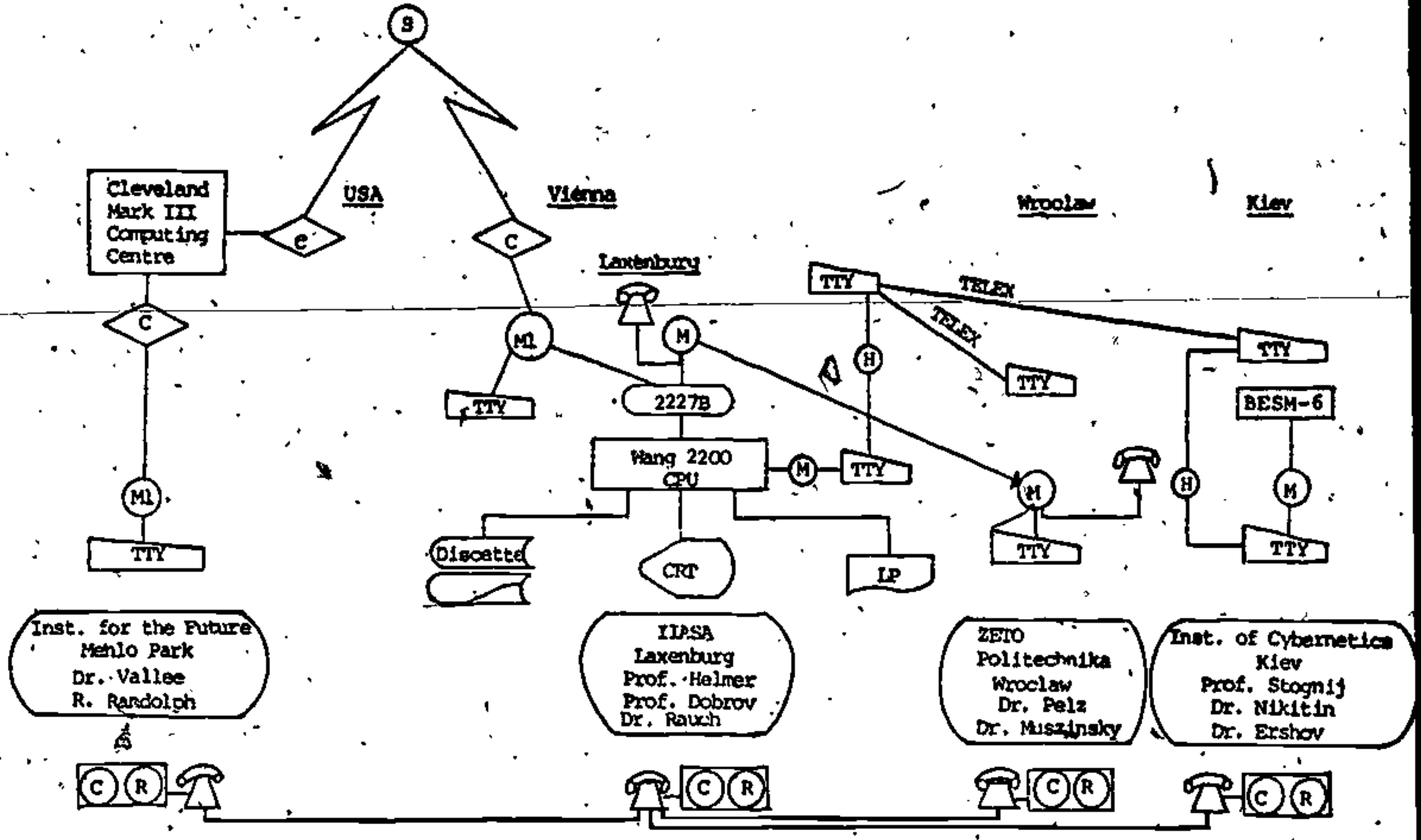
In early 1979, the focus of CAITR research shifted to the East-West Center in Honolulu, Hawaii. Here at the East-West Center, inter[illegible]tional team research very similar in methods and subject matter to that at IIASA is conducted by groups of scientists from countries throughout the Asia/Pacific region. The needed for CAITR at the East-West Center is therefore also very great, perhaps even more so than at IIASA since th[illegible]istances separating Pacific-basin scientists are larger and since deve[illegible]ing as well as developed countries are now involved.

Figure 2 -

A TELECOMMUNICATIONS APPROACH TO THE SOLUTION:

BASIC CONCEPTS

	SHORT-TERM ITR (several days)	LONG-TERM ITR (several months)
LOCAL FORM (all participants at one place)	The international scientific meeting	The international research institute
DISPERSED FORM (participants at different locations)	CAPS (Computer Assisted Panel Sessions)	CAITR (Computer Assisted International Team Research)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TTY
2227B
BESM-6
Wang 2200 CPU
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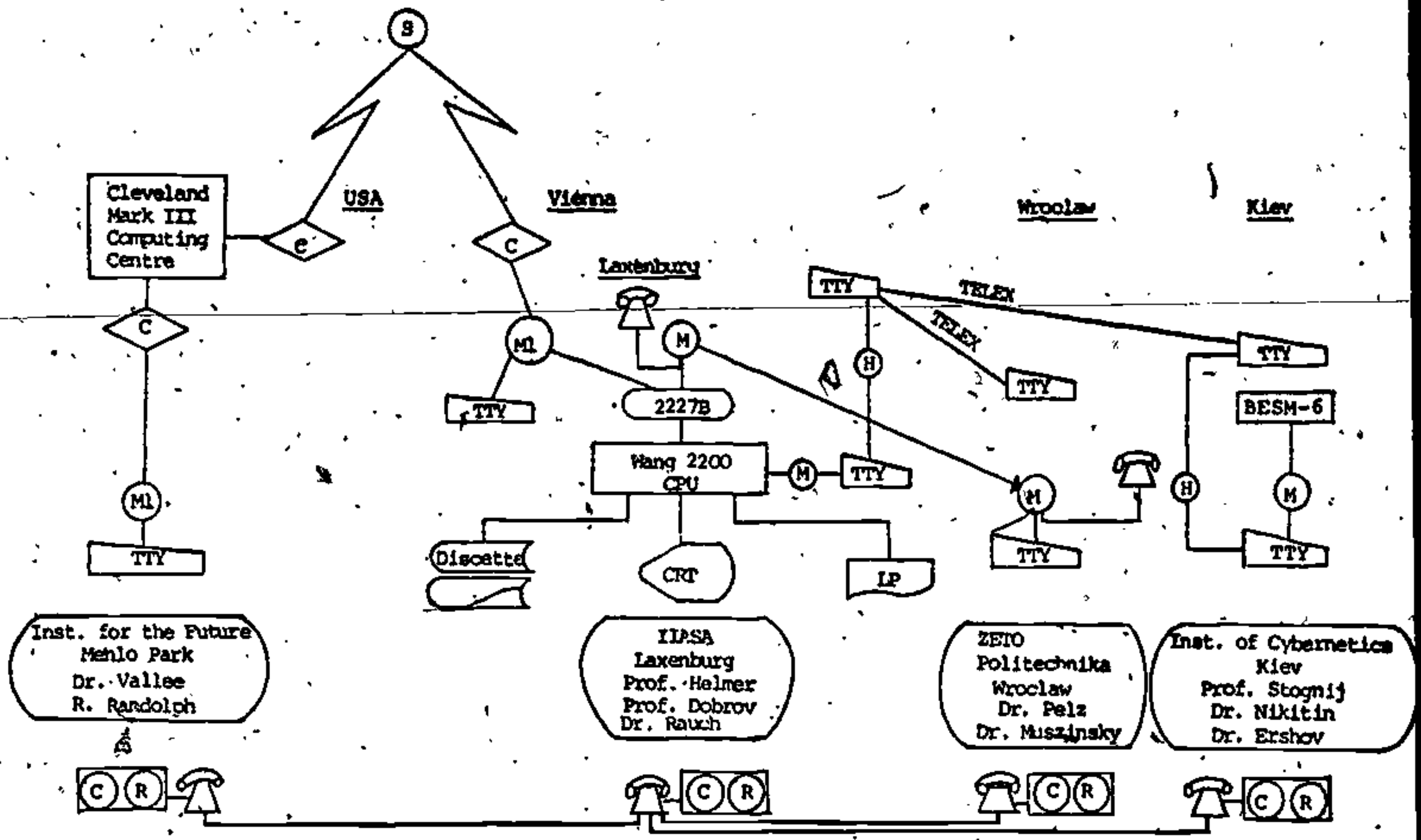
Discette
CRT
LP
TTY
TTY
Inst. for the Future Menlo Park Dr. Vallee R. Randolph
IIASA Laxenburg Prof. Helmer Prof. Dobrov Dr. Rauch
ZETO Politechnika Wroclaw Dr. Pelz Dr. Muszinsky
Inst. of Cybernetics Kiev Prof. Stognij Dr. Nikitin Dr. Ershov
C R
C R
C R
C R

Notation:

S - Satellite for data Communication
C - Concentrators of MARK III Network
TTY - Remote terminal (teletypewriter)
Most displays can be used in TTY modes also
CR - Casette recorder
CRT - Cathode ray tube (Display)
M1 - Low speed modem (up to 300 lps)
M2 - Asynchronous modem 600/1200 lps
M - Any of M1 and M2 can be used
2227B - Buffered asynchronous interface for WANG 2200
Wang-2200 - Minicomputer with 32k Bytes core memory
CPU - Central processing unit
LP - Line Printer
H - Human interface

Figure 3 - THE IIASA "CAPS" EXPERIMENT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Discette
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Inst. for the Future Menlo Park Dr. Vallee R. Randolph
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C R
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Figure 3 - THE IIASA "CAPS" EXPERIMENT

CAITR-type communications are already in extensive use at the East-West Center. They have been used for instance in organizing and planning face-to-face conferences, the prior electronic discussions allowing many issues to be resolved in advance of the physical meeting and thus greatly enhancing the latter's effectiveness. CAITR has also been used to keep EWC scientists who are traveling in distant places in touch with their colleagues here in Honolulu. Even more importantly, CAITR has been used for "teleparticipation" in face-to-face conferences and for "remote modeling" (that is, creation of mathematical models on remotely situated computers, in collaboration with scientists at those remote sites).

Significantly, the two institutions which first became heavily active in CAITR research--IIASA and the East-West Center--are now in constant CAITR communication with one another. The effect of this link has been to increase substantially the level of scientific interaction between the two institutions, even though they are located literally on opposite sides of the globe. The ability of CAITR systems to store information for subsequent retrieval at a convenient time is especially crucial here, since the time-zone differences between Austria and Hawaii cause there to be not a single hour out of the 24 during which both IIASA and the East-West Center are simultaneously open for business.

Besides IIASA and the East-West Center, a considerable number of other organizations have been involved in CAITR-type activities in recent years, although most have not perceived their actions in such a broad framework. Figures 4 and 5 indicate some of the communication geometries which have been used in such activities, demonstrating the extremely wide variety of technical possibilities which can and should be considered in planning future CAITR systems.*

As these diverse examples demonstrate, CAITR is not a single specific technology but rather a family of technological options, or more accurately, a process which can be implemented through various specific physical means.

DEMAND AND FEASIBILITY

As a first step toward systematic assessment of the demand for and feasibility of CAITR in this region, a brief survey questionnaire was administered to 35 scientists from eight Asia/Pacific countries** during a research planning workshop at the East-West Resource Systems Institute in May 1979. The respondents demonstrated a clear consensus that CAITR is important as a

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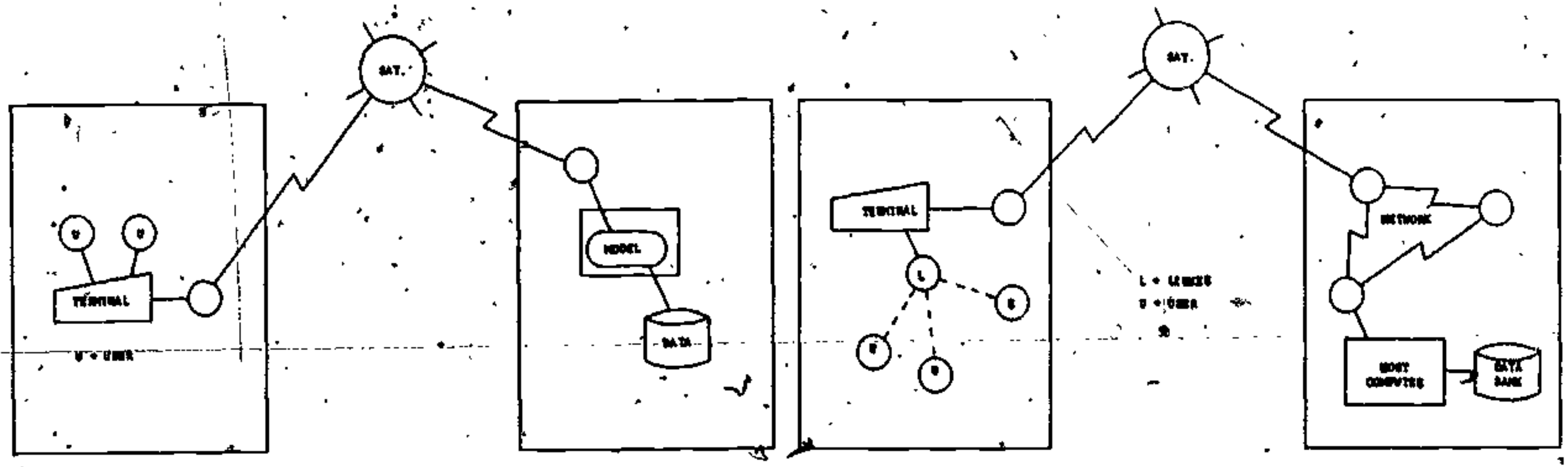
*To give details on these past efforts is beyond the scope of this paper, but for descriptions of their general features, see (1).

**Bangladesh, India, Indonesia, the Philippines, Sri Lanka, Thailand, the Trust Territory of the Pacific Islands, and the U.S.A.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DATA
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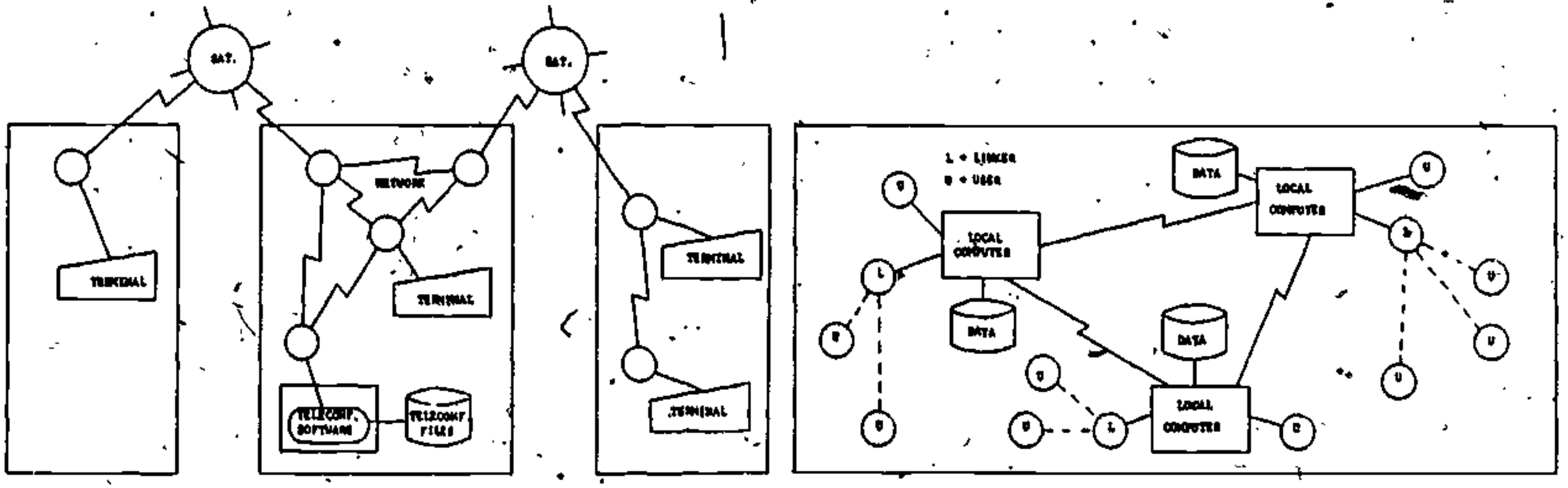
U = USER
NETWORK
HOST COMPUTER
DATA BANK

A. REMOTE MODELING (EAST-WEST CENTER/CASE-WESTERN UNIVERSITY)

B. REMOTE DATA-BANK ACCESS (TECHNOLOGY RESOURCE CENTER, MANILA)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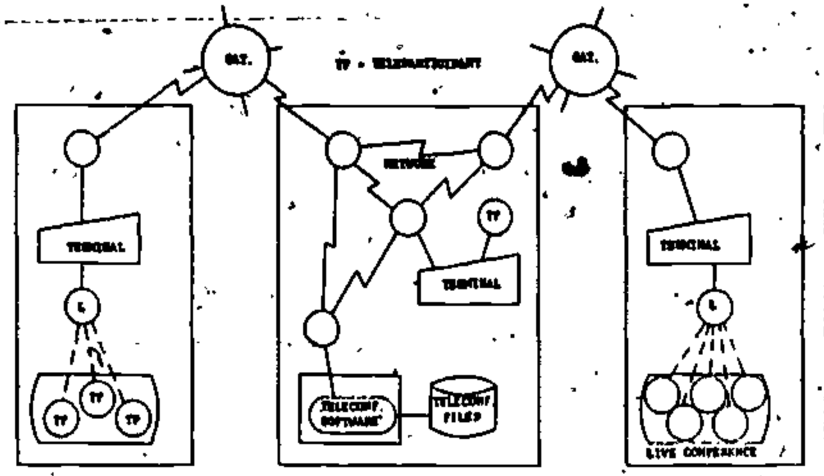
C. TELECONFERENCING (PLANET, CONTINUUM, EIES, ETC.)

D. USE OF "LINKERS" (U.S. FOREST SERVICE)

Figure 4 - TYPICAL CAITR GEOMETRIES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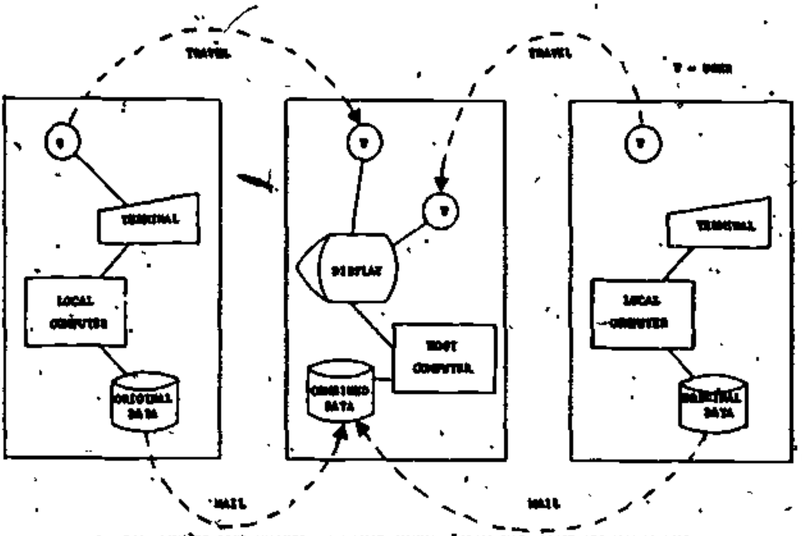
LIVE CONFERENCE

E. "TELEPARTICIPATION" (EAST-WEST CENTER/[illegible])


TRAVEL
TRAVEL
U = USER
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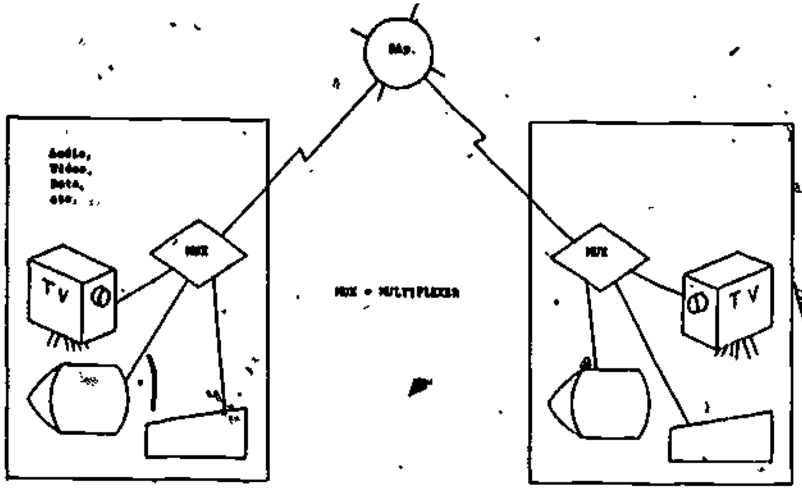
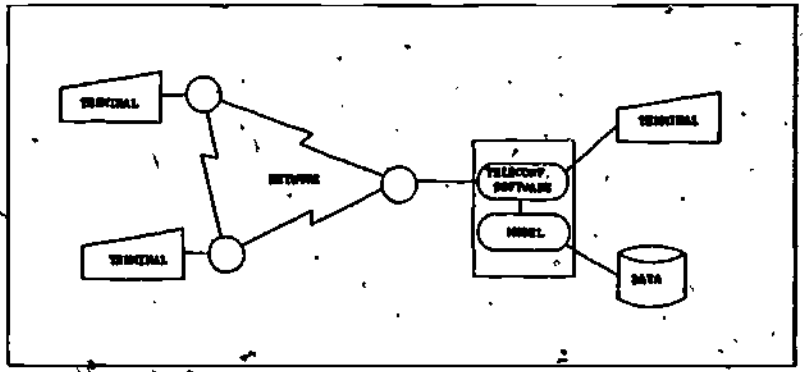
LOCAL COMPUTER
ORIGINAL DATA
U
U
DISPLAY
HOST COMPUTER
COMBINED DATA
U
TERMINAL
LOCAL COMPUTER
ORIGINAL DATA
MAIL
MAIL

F. "COORDINATED DATA ANALYSIS WORKSHOP" (INTERNATIONAL MAGNETOSPHERIC STUDY/NASA)


SAT.
Audio,
Video,
Data,
etc.
MUX
TV
MUX = MULTIPLEXER
MUX
TV

G. MULTI-MEDIA TELEPARTICIPATION (UNESCO NAIROBI CONFERENCE)


TERMINAL
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MODEL
TERMINAL
DATA

H. HYBRID SYSTEMS, E.G., MODELING VIA TELECONFERENCE (INSTITUTE FOR THE FUTURE/EAST-WEST CENTER)

Figure 5 - TYPICAL CAITR GEOMETRIES (Continued)

potential mechanism for facilitating and stimulating team research in the region, even though it may not yet be technically and politically feasible in some of their countries. Several respondents went so far as to rate CAITR "absolutely necessary" for success of the specific cooperative research projects which their group was assembled to discuss.

With regard to the technical facilities for CAITR, however, relatively few of the non-U.S. respondents (26%) reported having dial-up computer terminals available in their home institutions. Only in Indonesia and the Philippines did half or more of the national delegation members report having access to such equipment.*

In another question, the respondents were asked to indicate what major obstacles they felt might arise in the conditions of their home countries or institutions. Most did not indicate any obstacles at all, but those who did tended to mention such problems as the following:

- Lack of necessary equipment.
- Non-availability of digital networks in their country, and evidence that the available voice-grade lines are unusable for data communications.
- Lack of trained personnel.
- Bureaucratic institutional constraints, possibly involving problems of government permission.
- Budgetary difficulties related to foreign currency problems, with the decisive factor being the level of priority placed by national governments on the substantive "team research" activities in question.

These results, though hardly conclusive, do suggest that the evident demand for CAITR can be met only partially in the near term. This will probably have to be on a pilot-study basis, linking only those institutions for which the stated problems either do not exist or can be easily remedied (e.g., by acquiring terminal equipment, training the necessary personnel, and perhaps obtaining third-party funding to cover network costs). In all cases, government approval will be a determining factor, and this in turn may well hinge on the exact substantive content of the proposed CAITR activities. In the longer term, as networks, equipment, and experienced personnel become more widely available, the limiting factors will be primarily political and financial.

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*Several other types of equipment potentially useful in S&T information exchange projects were reported much more frequently: Telex or teletype (83%), photocopiers (79%), microfilm readers (52%), microfiche readers (48%), movie projectors (92%), video-tape equipment (46%), in-house computer (50%), access to computer located elsewhere (82%), and diskette attachment for computer (30%). These figures are all for non-U.S. participants.

Such constraints, of course, are by no means unique to CAITR. On the contrary, they apply to international scientific activities of all kinds. If anything, we may expect CAITR to reduce the economic difficulties of international research cooperation because its costs are generally far less than those of any other means of achieving the same communication results (30-31). If for instance CAITR is used to permit a group in one location to "attend" a conference or workshop which is physically taking place in a distant country, the cost is likely to be on the order of a few hundred dollars instead of several thousand, and as the size of the group of "teleparticipants" increases, so do the savings. Of course, some arrangements are necessary for the payment of those costs which are unavoidable, such as network charges, charges for the use of host computers, and the cost of having one or more rapporteurs attend the live conference in order to prepare session summaries for the teleparticipants and relay comments and questions to and from them. But fortunately such costs are usually small relative to the cost of sending all the teleparticipants to the conference in person.

CONCLUSIONS AND RECOMMENDATIONS

On balance, it seems clear that modern digital telecommunication technologies do offer interesting prospects for improving the flows of scientific and technical information among Pacific-basin countries. This is so especially because such technologies can provide for both formal and informal communication of many kinds, through a relatively simple and inexpensive set of physical facilities. Numerous details of organization, equipment access, and government permission will have to be worked out on a case-by-case basis, but the benefits of improved scientific productivity may well justify the effort.

At present, however, such conclusions are largely hypothetical, and detailed research is needed to clarify the true prospects of CAITR in the Pacific. For instance, it would be useful to have a fuller understanding of the actual and perceived needs for international team research generally--what subject areas are considered most urgent and most suitable for joint investigation, what countries are more or less anxious to engage in cooperative research projects, etc. By the same token, detailed information is needed regarding present and planned digital networking activities in the region, especially the prospects for further extension of existing international networks and for interconnection of such networks with the national digital networks now under development or consideration in several countries in the region (Australia, Hong Kong, India, Indonesia, Japan, the U.S.S.R., etc.).

Assuming that such investigations will confirm both the need for and the technical feasibility of CAITR, it is important to begin informing national policy makers about its potential benefits as a way of multiplying the effectiveness of their national scientific communities. In particular, groundwork must be laid for future policy decisions supportive or at least tolerant of CAITR--for instance, decisions to install a network node, provide special scientific tariffs for network use, etc. Close cooperation in this regard will be needed between national telecommunication authorities and the ministries or other bodies responsible for promoting the nation's scientific and technical activities.

Most importantly, we need to continue experimenting with CAITR. Such experiments, if carefully planned and carried out, will allow us to test alternative procedures and thus identify those which are most effective; to determine whether CAITR is indeed cost-beneficial under various circumstances; and if it is, then to demonstrate this fact to the scientists and policy makers who will be in a position to use and support such capabilities in the future.

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THE NEW JERSEY INSTITUTE OF TECHNOLOGY ELECTRONIC INFORMATION EXCHANGE SYSTEM (EIES), WITH SPECIAL ATTENTION TO LEGITECH AND POLITECHS

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THE NEW JERSEY INSTITUTE OF TECHNOLOGY ELECTRONIC INFORMATION EXCHANGE SYSTEM (EIES), WITH SPECIAL ATTENTION TO LEGITECH AND POLITECHS

For slightly over a year now, I have been associated with the EIES system. Many factors have been responsible for my interest in computer conferencing: my present involvement in communications planning, my background in computer engineering, and my natural curiosity. It was my thought that sharing my EIES experiences with you would illustrate the potential of computer conferencing as a communications medium, and might stimulate your ideas on additional applications.

EIES, despite its depth of experience, is by no means the first computer conferencing system. It may not even be the best, although it has a large and devoted clientele who might be willing to debate that point. A number of conferencing and/or messaging systems had been proposed, designed, and operated before EIES came along. The first of these, or certainly among the very first, was a system designed for the Office of Emergency Preparedness in Washington. It was known as EMISARI (an acronym for Emergency Management Information System and Reference Index). Incidentally, two people who would later be involved in the design of EIES were on the EMISARI staff: Murray Turoff and John McKendree. Other systems of a similar nature had been designed and used, mostly for much more specialized and thus more limited applications. However, at the time that EIES was proposed, it was still a developing field, particularly insofar as applications were concerned.

In the summer of 1975, the National Science Foundation's Division of Information Science awarded a grant to the New Jersey Institute of Technology for the design and implementation of a computerized communication system which would enable groups of scientists to share information on current research activities and findings. Also part of the project was to develop information procedures which could be used in assessing the impact and usefulness of this form of communication.

System design specifications were developed and published in August of 1975, after a thorough review of other systems then in existence and evaluation of their characteristics. New features especially desirable for scientific user groups were also determined. Actual software implementation occupied the larger part of a year, and represented some five person-years of effort. It was designed to be implemented as a dedicated minicomputer operation: mini, to keep operational costs well below those of current commercial time-sharing systems; and dedicated, to provide the needed reliability and security expected of a communication service.

The hardware implementation comprises two INTERDATA 7/32 minicomputers, connected via separate disk controllers to a disk storage system with a capacity of over 300 megabytes. Actually, only one of the computers is utilized for the operation of EIES; the second is used as emergency backup in case problems develop with the other. Meanwhile it is used for other applications, including research and computer science educational activities.

Besides the disk storage, the main EIES processor has around a half million bytes of core memory, half of which can be shared with the second processor. There are currently 32 input-output ports, eight of which are accessible by local Newark area telephone numbers, and 24 connected to the TELENET system. The hardware is modular, and can be expanded as necessary to accomodate up to about a thousand users.

The system entered the pilot testing phase in October 1976. It had already been tied into the TELENET network so that users could reach the system by making local calls in most of the major urban areas of the United States.

By the time I became aware of EIES, it had been in experimental and operational use for over two years. A number of special features had been added, many conferences on various subjects were well under way, and the users by this time numbered in the hundreds. A special system of software designed for the particular needs of legislative researchers, and intended to operate as a subsystem within EIES, was almost completed and was to go on-line within a month after I joined the ranks of system users.

I was introduced to EIES rather indirectly through a linkage group started by Robert Theobald. Our Department had produced a report on communications early in 1978, and I had sent copies to those members of the Theobald linkage group who had indicated specific interests in communications and communications planning. Among them was a young couple who had formed their own consulting firm in the general field of computers, communications, and related areas: Peter and Trudy Johnson-Lenz, in Oregon. They had mentioned EIES briefly in their data sheet and in correspondence, but what really seized my attention was a letter from one Charlton Price, in Washington, D.C., who had heard about our report from Johnson-Lenz. In requesting a copy, he mentioned EIES, for which he was a User Consultant, and wrote more about it than I had read or heard before. I asked for more information; Peter and Trudy sent some material about the system, and I requested a copy of the final report on the EIES development project from Murray Turoff at NJIT.

In June 1978 I attended a conference in Washington, D.C., and while I was there Charlton Price was kind enough to set up a demonstration of EIES for me, using his portable terminal in his home. We exchanged messages with Peter and Trudy Johnson-Lenz, Murray Turoff, Roxanne Hiltz, and Harry Stevens, among others. As a direct result of this demonstration, two things happened: one, I was thoroughly sold on computer conferencing; and two, Harry Stevens mentioned the LEGITECH software being written by his firm under another NSF grant, which was shortly to be incorporated into EIES. He also mentioned that the same grant would be able to pay for access to the system for the first few months of testing, to enable legislative researchers and resource people from all parts of the nation to become acquainted with the system.

As soon as I returned to Honolulu, I made inquiries of the Legislative Research Bureau and others who might be interested in participation. The

LRB was already deeply involved in its new bill-tracking system which was to be inaugurated in the 1979 Session, and felt (understandably) that this was as much computer innovation as its staff could handle effectively during the Session. A letter from Harry Stevens then suggested that perhaps I would be willing to take the responsibility for at least representing Hawaii in LEGITECH. Since I was in an executive department rather than in a Legislative office, I would be considered a resource person instead of a legislative researcher, and this would not preclude the Legislature itself from taking an active role when it felt that the time was appropriate. So, with the encouragement of my Department, I agreed to do my best within the limitations of available time, and I soon received my EIES instruction manual, material on LEGITECH, and my access number, and went on-line on November 20, 1978.

EIES by this time had added a number of advanced features since its beginning, and had become an extremely versatile system. There were already about 20 public conferences, open to anyone on the system, plus considerably more private conferences, open to special-interest groups by invitation only.

I quickly discovered that there were many more features in the system than were covered by the instruction manual; these are picked up from other users, through on-line inquiries, through an index to explanations also available on-line, and by an on-line newsletter published weekly, covering everything from new system features to special conferences and anecdotes. There are many shortcuts which can save a great deal of computer time. There are lists of abbreviations whcih can be put together in various combinations to formulate one's own instruction set. If one is faced with a strange or baffling situation, there are many on-line explanations available by entering a question mark followed by the title of whatever operation one needs explained. When the system asks you a question, if you don't understand what is meant, just type a question mark and a carriage return. If the resulting answer is still not clear enough, a double question mark will produce a more detailed explanation. And if this is not satisfactory, a triple question mark followed by a one-line inquiry will be routed directly to the EIES console operator for a personal answer or for referral to a User Consultant; in either case, a reply will be forthcoming usually within minutes.

Among the regular features of EIES are messages, conferences, notebooks, the EIES directory, and on-line explanations. Messages may be composed and sent to one or more individuals or to selected groups (numbered groups in the system are people who have a common interest or who are members of a conference bearing the same number as the group). If a message is sent to more than one individual, the names of the addressees may be indicated or not, as the sender chooses (equivalent to indicating or not indicating carbon copy recipients in a letter). All EIES messages are the equivalent of certified mail with return receipt: the sender is always notified when a message has been received by an addressee.

There is no provision in EIES for true real-time interchange, as there is in PLATO, for example. This can be done only if all terminals are screen display terminals, in which the screen can be divided into segments in each of which a different person can be typing remarks. EIES is designed to support virtually any terminal capable of 300 baud operation, and a great many terminals on the system are printing types. Hence real-time interaction was not included as a system feature. The nearest one can come to it on EIES is in the LINK mode, in which those LINKing may type one-line messages which will be seen by everyone else in the LINK, and which will print out at the first available opportunity.

In the EIES messaging procedure, a message is composed in a scratchpad area, the user being given a prompt at the beginning of each line. When the user signals the system that the message is complete, the system gives additional prompts to determine the name or number of the person(s) or group(s) to whom it is to be sent, the number of an associated message (such as one to which this is a reply), and key words or phrases ind[illegible]ng the subject of the message and by which it may be retrieved by a keyword search. The message is then placed in the queue of messages waiting for each addressee. One is notified of waiting messages upon sign-on, sign-off, and upon returning to the INITIAL CHOICE point from elsewhere in the system, and one may choose to accept them at that time or to defer them until later.

Conferences are simply storage areas within the system where special messages known as conference comments are stored, very much as messages are, but with two differences. No addressees need be specified, for comments are automatically made available to each member of a conference. And the conference comments are not filed with messages, but are delivered only if one chooses to enter that specific conference. Conference comments are usually interconnected in a continuous flow, interacting with previous comments inserted by others, offering arguments and discussion very much as personal comments do in a live conference such as this one. There are many conferences currently going on in EIES on a great many subjects. Public conferences include such subjects as Information Science, EIES Problems and Suggestions, Explanations, Terminals, Hobby Microcomputers, and even one entitled Practice, in which those who wish may try their hand at the fine art of computer conferencing. There are private conferences in all sorts of subject areas; some in which I am or have been involved are Networks, Linkage (moderated by Bob Theobald), LEGITECH Issues and Resources, POLITECHS Software Design, and POLITECHS Facilitators. I'm told that there is a conference on The Future of Libraries, and there is a very active one on Hazardous Wastes. As Jim Dator's paper mentions, there are also conferences on several aspects of Futures studies.

Notebooks are additional storage areas which may or may not be associated with a conference; if so, they are likely to contain information related to the conference, but not so directly connected with the flow or continuity of the conference to be appropriate as a conference comment. Both conference notebooks and personal notebooks are often used as places in which material may be co-authored by more than one writer, with editing, comments, and suggestions entered in the notebook by each writer.

Each person who becomes a user of EIES is encouraged to enter relevant information about himself/herself into the EIES Directory as one of his/her first acts after becoming sufficiently familiar with the system. The EIES Directory is a valuable source of information, and may be searched in several ways besides simply asking for Directory data on a specified name or number. A search may be done for those indicating certain fields of interest or expertise, those whose addresses are within specified ZIP codes, cities, or states, those who were active on the system at a given time or date, members of a particular group or conference, or even those whose names contain a certain combination of letters (in case you aren't sure of the proper spelling).

On-line explanations have already been mentioned in passing. Besides the ability to get more information by entering question marks, there are other explanations available by requesting them. One may receive about 30 pages of description of the POLITECHS software (which I shall cover much more briefly here) by typing "?POLITECHS," for example. Or one may request an index of on-line explanations by typing +EINDEX, then request any items of interest by printing out the appropriate portions of Conference 1007.

The system design includes extensive capability for text and document editing, both in the process of composing and afterward. Errors may be corrected in various ways, deending on how and where they occur and when they are discovered. There are both direct and indirect editing commands which enable one to compose, coauthor, edit, and produce messages, conference comments, papers for publication, or other written material in a very professional manner. These commands provide formatting, setting of margins, centering titles, automatic indentation of paragraphs, creating tables, inserting blank lines beween paragraphs or wherever desired, and much more. By the use of appropriate commands one may insert a message one has written or received into a conference comment or vice versa, move material from one's scratchpad into a temporary storage area and later bring it back, or do almost anything that can be done with a typical word processing system.

EIES contains certain specialized subsystems designed for specific applications and accessible to designated user groups. Probably the most complex of these are LEGITECH and POLITECHS. Since I have been closely associated with both of these, most of the remainder of this paper will describe them and deal with our experiences with them thus far.

LEGITECH, as I mentioned earlier, is a system designed to allow legislative researchers, especially those dealing with scientific and technical subjects, to exchange information with their counterparts in other states. It contains four features of particular interest:

1) Computer-assisted entry of inquiries and responses in conformity with a format already in use by a number of participating legislative research offices.

2) The opportunity to select and receive background information, responses, and leads for those inquiries which each participant finds of interest.

3) An automated facility for keeping inquiries and their related responses together, regardless of the dates and times such items are entered.

4) Complete record-keeping on every member's participation, including not only the function of keeping each member up to date on new inquiries and selected responses, but also statistics on member activity for system evaluation.

LEGITECH has been of great value to many legislative researchers in the participating states as they go about their work of gathering information to be used in preparing legislation or establishing policies. Here is one quick example from our own experience: the Research and Economic Analysis Division of our Department was given an assignment by the Legislature to do a study of possible economic impacts of a bill then being considered, which would mandate that beverages be marketed in returnable bottles or in cans which would not have a detachable pull tab. We inserted an inquiry in LEGITECH asking for any information on this subject from other states, particularly those who had enacted similar laws. Within a very few days we had eight responses from seven states, providing information which was very valuable to the study.

In the approximately eight months of our activity in LEGITECH, we entered six inquiries and 27 responses to inquiries made by other states on subjects with which Hawaii was sufficiently familiar to have answers to share.

At one point, following the suggestion of the LEGITECH staff, I shared my EIES account with a member of Hawaii's House of Representatives and his research assistant to give them experience with LEGITECH. The hope was that my LEGITECH activities would be assumed by the Legislature itself or by one of its offices such as the Legislative Research Bureau. The Representative was highly enthusiastic about the system and its possibilities, but unfortunately, the grant which had been supporting our participation began to run low on funds, and those of us who had been merely resource persons instead of actual legislative participants had to begin paying our own way. At that point I was obliged to end, reluctantly, the account sharing, since my own continued participation, beginning October 1, would either depend on the availability of funds from other sources or on my own efforts as a technical writer for the system. I had already done some writing for Participation Systems, the contractor for the LEGITECH software, and they were willing to grant me access time on a trial basis in exchange for my writing instructional material for a new set of software which would ultimtely supersede the original LEGITECH program.

The new system is called POLITECHS (pun strictly intended) and is much more inclusive and offers greater flexibility of use than LEGITECH. To begin with, the design is based on experience gained from the first year of LEGITECH's operation. It eliminates certain shortcomings of LEGITECH, and gives participants a wider range of choices both as to subject matter and as to how they prefer to receive and enter inquiries and responses.

POLITECHS, as the name implies, covers many technical fields. It is divided into separate areas of interest called exchanges, of which the new LEGITECH is one. LEGITECH will continue to deal with problems encountered by legislatures and legislative researchers. Another, actually the first POLITECHS exchange to go on-line, is PUBLICTECH; it is devoted to the information needs of citizens' associations, civic groups, and the like. There will be URBANTECH for exchange of information on urban and suburban concerns; EXECUTECH, tailored to the needs of Governors' and Mayors' offices and their executive-branch departments; ENERGYTECH, and probably others later, which will serve the needs of various groups for information on single subjects which are of sufficient importance to have separate exchanges on POLITECHS. The new software permits the easy addition of exchanges as needs arise.

In examining our experiences with LEGITECH in retrospect, it is now easy to see that its limitations and shortcomings had to be discovered by experience; few could have been anticipated. One example is the "Selection" feature. After each new inquiry was delivered to each user, the user was asked if s/he wished to Select it to receive background information and responses which would be entered. A negative reply would take the user on to the next waiting item; an affirmative reply would add that inquiry to the user's list of Selections; background information on the inquiry would be given immediately, followed by any responses which might already have been entered. Future responses to that inquiry would be added to the user's list of waiting items as they were entered. The first limitation of this system was that in order enter a response to a given inquiry, there was the requirement that the inquiry must be on the respondent's list of selections. The theory was that one would need the background information in making an appropriate response. In practice, however, there were many inquiries which were sufficiently clear and complete that additional background was not really necessary.

A second limitation was that no more than 28 inquiries could be on any user's list of Selections. This was not foreseen as a problem; a user could check over his list of Selections from time to time and delete older inquiries from the list to stay within the limit as well as to make the list more manageable. But this need was not mentioned in any of the original LEGITECH instructions, and there were many users who simply didn't know what to do when their Selection list was full. Some, assuming that this effectively precluded their further activity in LEGITECH, resorted to using the regular EIES message channels in lieu of LEGITECH responses and inquiries. Others became discouraged with the increasingly long waits for new items as their Selection list grew, and virtually abandoned the system.

Some of us urged that reminders be put into the system from time to time suggesting that users purge their Selection lists, and explaining how to do so. In any event, when POLITECHS was designed, it was decided that these two limitations should be eliminated as inherent parts of the software. The monitor of any exchange has the options of setting a limit on the number of Selections and/or of requiring Selection of an inquiry topic for entry of responses, if these options are deemed necessary. But they are no longer built-in limitations.

Another LEGITECHS characteristic eliminated from the POLITECHS design was the provision for background information as part of the inquiry format. Now, if additional background is needed, the writer of the inquiry topic enters it as the first response to that topic.

The separate category of leads was also eliminated. In LEGITECH, if one responded to an inquiry by citing a book or other publication or gave a referral to a government agency or other source of further information, this was supposed to be entered as a "lead." The format for entering leads was so complex that most respondents preferred to enter such material as an ordinary response. Since it was actually a response in fact if not in nomenclature, there seemed to be no urgent need for the separate designation, and so leads were dropped.

POLITECHS offers several levels of participation. In LEGITECH, everyone except the system designers had the same privileges and limitations, even though there were wide differences in the uses of LEGITECH by different participants. There were those who were on-line daily, and who conscientiously researched and entered responses to others' inquiries. And there were those at the other extreme who might not check into the system for weeks at a time. POLITECHS takes these differing patterns into account and provides seven categories of access levels; others may be added as needed. Each higher classification provides all the privileges of those lower than itself. The lowest, READ-ONLY, carries the privilege of reading any or all public topics, but no ability to enter responses or raise new topics. RESPOND-ONLY access permits reading of all public materials, and adds the privilege of entering responses to the inquiries of others. REGULAR access adds to this the ability to raise new topics as well, and to be the writer or recipient of private topics (i.e., those "addressed" only to specific individuals or groups). Then come the supercategories: EDITOR access adds the ability to delete, change, or add keywords for search purposes, correct misspellings, and the like. GATEKEEPER access enables one to add members to or delete them from the exchange, assign access levels, etc. A MONITOR has access to all material in the exchange, including those topics designated as private, can edit, delete or modify any item, and can establish or modify certain options such as a fixed keyword list or thesaurus, limitations on the number of topics members may have in their Selection lists, and others. The highest level is that of IMPLEMENTOR; this is limited to the system designers and developers who must have access to the software itself to add new features, correct system malfunctions, and the like.

The user of POLITECHS has much greater freedom of choice in receiving new items than was available in LEGITECH. When one entered LEGITECH, one was told to wait while pending items were found. Then ensued a long pause, after which the number of waiting items was given and the user asked if s/he wished to receive them. Only a yes or no was acceptable; there was no option to receive titles only, to scan new inquiries without being asked if one wished to select each one, or to receive waiting responses without new inquiries or vice versa. One could not get batch delivery of all waiting items without the long pause for the system to count them first. All these are options in the POLITECHS software. At the cost of requiring perhaps a little longer to learn the system and its many options, it offers a great deal more adaptability to differing needs and preferences.

There is one small experiement which I would like to mention, in which EIES was used as an interisland conferencing/communication medium. This involved our Department's Center for Science Policy and Technology Assessment (CSPTA) and a statewide Committee on Energy Self-Sufficiency.

The larger Committee includes several members on each of the major Islands, but when the statewide Committee meets, it is usually attended by only one representative from each Island plus all or most of the members from the Island on which it meets. In August 1979 the Committee was slated to meet on the Island of Oahu, hosted by Dr. Eugene Grabbe of the CSPTA. It occurred to Dr. Grabbe that an interesting demonstration of computer conferencing capabilities could be made in connection with the August meeting. At such meetings, considerable time is usually needed for presentation of reports from the various Islands and discussion of those reports before taking up other business. It was Gene Grabbe's thought that an EIES conference could be set up, arrangements made to provide terminals on at least each major Island where dial-up terminal facilities were not already available, and the individual Island reports entered into the system as conference comments before the meeting. As these were read by various members of the Island committees and the statewide Committee, comments could be entered and some discussion could take place via EIES before the actual meeting. The demonstration was not intended to take the place of the meeting, but ideally, besides showing what computer conferencing could do, it could save time at the meeting, stimulate additional interest and more meaningful discussion, and might well be a precursor to the use of computer conferencing, at first as enhancement of such meetings and, eventually, as substitutes for at least some meetings, with attendant savings in time and travel costs.

I shall only report here that we did set up the demonstration, which involved, among other things, writing a set of simplified instructions for using the system, borrowing or renting terminals, and delivering them to four of the Neighbor Islands. The EIES management and staff were most gracious in setting up the necessary accounts, assigning a conference number, suggesting a User Consultant, and other details. The time frame in which all this was done was quite unrealistic, but many of us in government are accustomed to such things. The experiment was not entirely free of flaws, and demonstrated Murphy's Law as well as computer conferencing. But we did learn much from the experiment, and, as we had hoped, it stimulated a considerable amount of interest and discussion at the August Committee meeting.

We hope to do similar experiments in future, as time and resources permit, and I believe that even this week-long demonstration conference showed that the medium has a great many possibilities for enhancing inter-island communication within Hawaii, besides its almost limitless potential for quickly and inexpensively sharing ideas and experiences with people in other states and even other nations.

In summary, I should like to say that working with EIES and learning something of its many capabilities and subsystems, has been a most interesting experience during the past year-and-a-quarter. I do not know of any other system which can match its versatility and ease of operation at comparable costs, though I am eager to learn of any. It has been the source of much timely information for the Department of Planning and Economic Development and for me personally: information which could possibly have been obtained through other channels, but much more slowly and laboriously if at all. The number and variety of people on EIES virtually ensures that one can find expertise there to assist with almost any information problem.

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TRANSFER OF COMMUNICATION TECHNOLOGY AND ITS IMPACT ON ECONOMIC DEVELOPMENT

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> *"It may be that the old astrologers had the truth exactly reversed when they believed that the stars controlled the destinies of men. The time may come when men control the destinies of stars."*
>
> *--Arthur C. Clarke*

Abstract

The process of international technology transfer is defined and described from an economics point of view, with emphasis on costs. The role of technology transfer in economic development is discussed, including its impact on social values and the question of "appropriate" technology for developing countries. Examples are provided from communications technology, particularly in the areas of telecommunications and satellite communications.

Communication has been aptly described as a process which is fundamental to the development of human society.[1] The "acceleration of history" during and after the Industrial Revolution was simultaneously induced by widening transportation and communication networks. After the Second World War, communication technology advanced so rapidly that mobilization of the periphery spread from Europe and the United States to countries newly emancipated from colonial rule and seeking economic development.[2] The economic growth of nations came to be inextricably linked to the international transfer of production technology as well as communication technology. Transmission and absorption of the latter was dynamic and unlimited by national boundaries. A veritable "communication explosion" led to a scramble for the latest technologies to such a degree that UNESCO was able to set up an approximate COMM-INDEX relating communication growth to development.

The MacBride Commission in its Interim Report 1978 declares that communication systems are linked to economic systems, just as communication development is linked to national development, and that communication is rapidly becoming a fourth sector of the economy, employing more people and making a larger contribution to GNP than any other sector. The "communication revolution" has been endangered by dynamic changes in technology which make its transfer of great consequence to developing countries.

I. The Historical Evolution of the Concept of Technology Transfer in Economic Theory.

Technological change and institutional change have been treated by economists as exogenous to the economic system.[3] Modern economic growth theory has preferred to apply comparative statics to the examination of steady growth states. The focus has been on resource utilization and improved measures for generating savings and investment. It is only very recently that technology has been treated as endogenous to the development process. Innovation in technology came to be recognized in the sixties as the engine of growth within the teleological framework of maximizing per capita consumption of essential commodities and services. In this wider penumbra of technological innovation and its diffusion through transfer, the relationship between communication technology and economic development came to be debated. The demand for communication services is a function of economic variables such as income, population, price and infrastructure of a country. Business, industry, and government are dependent upon improved communications which generate higher incomes for these sectors, which in turn generate further demand for communication.[4]

It is important to bear in mind that the viability of a given technology will depend on the economic environment into which it is introduced. Technology transfer as it has evolved through economic history requires for its assessment a frame of reference. Technology transfer for what? Benefits for whom? Who bears the economic and social costs of the transfer?[5] These are issues that require assessment both in quantitative and qualitative terms. Conventional GNP indicators are no longer useful in a real world situation.

Empirical application of technology transfer establishes the fact that a knowledge of local conditions and the willingness of the recipients to entertain the flow of technology are crucial to a successful transfer. The concept has undergone considerable change in the acknowledgment that technology transfer should be designed to help developing countries acquire and build their own skills and generate their own innovations from within. While technology for development can be all pervasive and applicable to all sectors, social control of the transfer is essential if scarce resources are to be effectively utilized. When technology transfer is resorted to as an unlimited and unregulated strategy of modernization, the consequences may worsen the skewed distribution of income that prevails in developing countries.

II. Does Transfer of Technology Induce Change?

It is anticipated that technology transfer will help developing countries to leapfrog into the post-industrial society, but the question remains whether technology transfer by itself can force the pace of social change. Selective transfer of appropriate technology such as development support communication is closely related to the new basic needs approach to development. Under such a strategy the chances of relating technology transfer to social justice are greater because priorities have to be ascribed within limited domestic and foreign exchange resources.

Transfer of technology induces social change to the extent that the opportunity cost of capital is not too high. The SITE experiment in India is an outstanding example of adapting satellite technology to traditional village gatherings and community group discussions. Users of interactive communication technology have to be conscious of the costs of not only hardware and software but of "people ware," which is the component of human reaction to messages and their content.

Third World countries are aware of the social system parameters within which technology is required to operate. Therefore a development-oriented strategy has to rely on a mix of technologies with varying capital intensities that are both capital-using and labor-using. For example, planners are not all enamored of the new fad for village technology as being most suitable for growth. They want greater self-reliance in sophisticated science and technology, and it was with this end in view that LDCs called for a new action plan for technology transfer at the UN Science and Technology for Development Conference in Vienna in August 1979. Their demands shifted from an en mass transfer of know-how in the shortest possible time to building up their own expertise in research and development and mobilizing technology indigenously.[6] They aim at collective self-reliance through exploring forward and backward linkages between oil surplus countries and newly industrializing ones so that a south-south flow of technology will emerge.

In the newly popularized basic needs approach, technology transfer will have to be designed to improve the income earning opportunities of the poor, the public services (including communication services) that reach the poor and the participation of the poor in articulating their needs. In other words, the people whose needs are basic must be able to share in planning what kinds of technologies should flow to them to help achieve earning opportunities and improved lifestyles.[7] In order to induce social change, greater attention has to be paid to improving access to information, credit and markets for those poor who constitute the unorganized sector of a developing economy.[8]

In the fifties, an urban orientation to technology transfer led to the creation of enclave economies within developing countries, so that the rural poor remained on the periphery supplying their surplus production to the center without any quid pro quo. The small urbanized pockets of prosperity have created a polarization even in decision making, causing an equity crisis within the Third World.[9] Such urban-oriented technology relies on multinational corporations for funding and operationalizing the transfer. The urban elite in developing countries found it in their self-interest to encourage MNCs to create islands of technology in backward societies and to permit profits to flow out of the country. This shortsighted policy only perpetuated dependence on technology transferred from the First and Second Worlds. The small urban minority that reinforced such flows also influenced political leadership in their own countries.[10] The United States supports the rights of these corporations to regulate the flow of information and to restrict exports of strategic technology in contrast to its support of freer flows of news and cultural information.[11]

Multinational corporations provide the financial and technological bridgeheads for enabling developing countries to take advantage of technological advances. They are able to adapt plant and technology for host country conditions. Even though the economic costs of the transfer for host countries are high, such as overvalued exchange rates, capital subsidies, and transfer pricing from home country to subsidiary, MNCs have for over two decades enhanced their operations in the developing world. They do this via an intermediate economy or one that has features in common with developed and developing countries.

In the first phase of a transfer the imported technology is adapted to local conditions (as was done by Phillips of Eindhoven in the electronics industry in India). In the next phase the same technology is transferred from the subsidiary to the domestic government sector and private sector producers. The size of the domestic market and the potential for exporting the final commodity or service serve as determinants for such a transfer. The product-cycle theory in international trade ascribes the economic factors for technology transfer to the size of the market in the country of origin for the technology. Once the product is standardized or the service is widely used in the home market, multinational corporations find it profitable to transfer the same technology in quest of lower production costs to developing countries. Eventually the product of the subsidiary flows back to the country of origin at lower prices.

In communication hardware and software the U.S. market is almost saturated by the large oligopolistic producers who then direct their expansion programs to exports. In 1973 exports of communication software from the U.S. brought to the country $3 billion and exports of computers netted $1.1 billion.[12] If the product-cycle theory operates, corporations will set up more and more subsidiaries in the Third World to capture the markets and reduce the costs of exports.

III. Costs of Technology Transfer

Generally, developing countries operate with a dual economy in which the modernizing sector faces a horizontal supply curve of labor, i.e., unlimited supply of labor at a given wage rate. In other words, with constant technology and capital costs, employment should grow in proportion to the rate of growth of output in the modern sector, which then expands without any changes in factor proportions, composition of output or technology.[13] While this holds good in theory, empirical evidence on the elimination of poverty and employment-generation is not sufficiently strong in labor-abundant less developed countries.

What is the role of technology in accounting for this failure? Prevailing factor prices attract producers to profit-maximizing technology. If the chosen technological change is capital-augmenting, it will not always increase employment. To put it simply, MNCs that are cost conscious induce substitution of low cost factors in terms of output which leads developing countries to resort to prototype technology transfer. Costs of the transfer decrease with improved economic environment and economic policy which facilitate a more effective use of the country's resources. If a prototype is being developed, the costs of the transfer would be reduced when the operation of the new technology fits the goals and needs of the recipient economy. For example, the production and distribution of instructional television would entail cost-reduction only when existing instructional systems are optimally used to render the prototype transfer suitable for varying audience absorption levels. The reason for such cost reduction is that import substituting technology in LDCs has strong characteristics of system--maintenance grounded in market dynamics. For instance, labor absorption through import substituting technology may be retarded by such variables as foreign exchange availability or changes in goal emphases and task environment.

The cost of technology transfer can be defined to include transmission costs and absorption costs, both of which will be high when the technology transferred is complex. This is true because the costs of resources utilized to effect the transfer plus costs of know-how, royalty or rent for securing access to technology have all to be accounted for. Economists also emphasize "peripheral support costs" as being crucial to the process of technology transfer because they simultaneously generate information flows.[14] The transfer of communication technology depends on the differential between costs of communication within and between nations, and partially answers the question of why it is that one nation or class has the knowledge enabling it to achieve high productivity and others are not acquiring that information.[15]

While computing economic costs of technology transfer, apart from the level of development of the host country's infrastructure, an important variable is the type of technology imported. For example, leading-edge technology (like electronic switching for telephone exchanges) is costly because of the shorter time span of development during which the technology is still in a state of flux. On the other hand, "state of the art" technology (like the use of HF frequency for reaching remote parts of a developing country) may be less costly because it has been understood and operated over a long time span. On the whole, it is observed that transfer costs of communication technology decline when the technology is competitive and similar between countries and with greater experience of the transferee. Costs of planning, establishing and operating the transferred technology become relevant.[16] In this context, transfer is defined as the communication, adaptation and use of technology from one country or region to another.

Costs of transfer will also vary depending on the different channels and mechanisms that exist for the transfer such as official flows of external assistance, or foreign direct investment by individuals, corporations and transnational corporations[17] (see Table I). However, it is difficult to measure precisely the benefits and costs of technology transfer either to the transferor or the developing recipient country, because there are hidden costs and intangible benefits. The rate of return on direct foreign investment is probably the only definitive measure of benefit to the investor. For the recipient LDC, a direct benefit would accrue if the technology transfer serves to cover the gap between net domestic savings and projected investment. In other words, there is a benefit if the technology transfer supplements local capital which is used for generating a higher GNP. The costs would be related to the flow of profits to the foreign investor and royalty fees, as well as the costs of diverting resources from domestic firms engaged in similar production of commodities and services but not using the same high levels of production technology. A more serious impact in terms of social cost is that off-the-shelf availability of foreign technology dampens the initiative for local R and D which, in turn, prolongs the dependency on external sources. The economic feasibility of the transfer is more important than technical feasibility.

Table I

Channels for Transfer of Technology: Selected Examples

Transfer to → From ↓	Governments	Institutions	Businesses	Individuals
Governments	Exchange of Scientists & Technical Cooperation Agreements	Funding of Equipment, Research, Etc.	Financing and Other Assistance	Sponsored Training Programs
Institutions	Consulting Contracts for Study of Specific Problems	Agreements to Cooperate; Exchange of Faculty and Students	Supply and Sale of Process Know-How	Training Programs
Businesses	Turn-Key Contracts for Construction of High Technology Plants	Supply of Research Equipment, Data, Etc.	Joint Ventures Licensing Agreements, Foreign Acquisitions, Etc.	Jobs and Training Programs for LDC Individuals
Individuals	Foreign Consultants Hired for Specific Projects	Faculty and Researchers From Foreign Countries	Foreign Workers, Managers and Researchers	Cooperative Research Projects

The concept of a production function as it obtains in neo-classical economic theory is not pertinent to the dynamics of technological change in developing countries,[18] because intermediate technology does not create the same substitution effect of using more labor or more capital as it does in advanced economies. The possibilities of factor substitution in the present emerge from technological innovations made in the past. In addition to this, technology can be transferred to a developing economy through different doors so that its spin-off effects are distinct from factor substitution. Technological change itself becomes part of economic information and is transformed into an economic activity.[19] Consequently, focus has to be shifted from quantifiable costs to the socioeconomic costs prevailing in the recipient country such as investment in existing communication networks, costs of imperfect information flows, business attitudes to risk, and "resistance to change."[20]

The particular form that technology in communications takes at a given time and in a given context is influenced by the socioeconomic environment in which it is produced and cannot be entirely considered as disembodied knowledge. The real welfare effects of technology transfer depend on the context in which it is produced. Technology production is not only concentrated in a few countries but in a few firms in those countries. Such production is based on marketing structures for oligopolists. Hence, the costs vary according to the monopoly power of the seller in addition to the absorption capacity of the buyer.[21]

IV. The Value Context of Technology Transfer

A frequently-raised issue is whether technology transfer is value-neutral. This is especially pertinent in the case of communication technology such as television programs, computer software and instructional television software. Dramatic transitions in societies can take place through the changes in life-styles and economic production that technology brings. The conflict in value systems may need the formulation of new societal goals.

Developing countries want to accelerate their entry into the high technology high growth era, particularly if they are already at the turnpike. The selection of the technology is crucial because it will, for example, affect the country's communication system and hence its societal values for many years to come. Yet development planners warn that the nation cannot afford to lose time and the costs of planning in modernizing their communication networks.[22] Therefore, the value context is often subsumed in the more urgent need to expand and modernize communications. Existing equipment has to be absorbed or used in the new installation or it has to be declared obsolete.

However, communication technology and its planned input to development encounter certain restrictions in developing countries, such as shortage of capital available for communications, vague perceptions of the country's communication goals, undefined criteria for service quality, unsatisfied and unexpressed consumer demand, and inadeuate equipment for measuring traffic. It is difficult to insure against the failure of new technology under such limitations, but the fact remains that in the allocation of budgetary resources, value systems of the host country will determine the assignment of priorities to communication technology. The important issue in this context is the flexibility of communication planning in LDCs to accommodate major technology changes which further induce changes in value systems.

If technology transfer is geared to basic needs satisfaction for the periphery, then it has to be both problem-specific and location-specific. There can be no "technological fix" or a purely communication technology solution to the problems of poverty and underdevelopment in terms of economic opportunity and social mobility. Technical change is not a random phenomenon. It calls for a vital learning experience and an institutional and societal setting that will render the experience dynamic and worthwhile. Preferred outcomes of communication technology are already part of the gaols set by LDC planners, which are also not value-free inasmuch as they are sensitive to the societal setting for which they are established. Technology cannot stand isolated from the social order or become incompatible with it.[23] For example, the Peoples' Republic of China has used technological autonomy in a closed self-contained approach to development since 1960, while Taiwan has been predominantly open, using technology for exports as the leading sector for growth and social justice.[24] On the other hand, Brazil and India have depended on technology transfer from industrialized countries and have failed to meet the needs of their poor majority.

Communication technology transfer creates new values in divergent countries both developed and developing. It transcends boundaries of language, religion and local tradition, which makes it a leveler and a democratizer.[25] Jet travel, television, and communication satellites all point in this direction. Technology creates its own community of shared experience as witnessed by the various nations wanting to evolve semiconductor technology despite differences in value sytems. Communications technology leads to greater convergence than manufacturing technology. While critics today denounce television, just as the printing press was denounced in its early history, the fact remains that both inventions have had a homogenizing and democratizing effect in industrialized and industrializing countries.

V. Telecommunication Technology and Its Transfer

In developing countries expressed demand for telecommunications does not reflect the needs of users; therefore government policy should be to keep prices for services at artificially low levels. Sufficient profits, then, will not be generated to finance expansion or attract greater investment. Therefore, telecommunication investment for rural and urban development cannot be related to the advantages of direct users, except in terms of societal progress. Access to the telephone network and benefits in terms of improved health, market information leading to improved productivity, and banking and business information are all gains that accrue to larger groups of persons than direct users. Resource costs of telecommunications have to be judged in the wider context of a public good. Economists use the utility concept to show that a subscriber derives added benefits from the service as more persons join the system.[26] Therefore, if telephony is to be extended to rural areas as development support communication, pricing policies cannot be formulated for recovering costs. The service has to be priced as a public good. Investment priorities cannot be equated to anticipated returns on capital. The World Bank in recent years, is shifting away from the rate-of-return in its lending policies for rural telephone networks in developing countries.

The basic hypothesis is that savings in training costs of para professionals, labor costs, organization and transportation costs make it possible for larger budgets to be allocated for rural social services through telephony and audio conference circuits.[27] This trade-off is significant even with the costs of dedicated communication systems like two-way radio for implementing rural social service programs cost-effectively.

Present telecommunications networks do not reflect the real needs of developing countries. While the North American continent had an early start and accounts for the highest density of telephones, growth in demand has leveled off there since 1955. World growth of telephones approximates an average of 7 percent per annum, but in Asia and Latin America it approximates 15 percent per annum. Yet telephone density in the developing world is low, about 1.15 phones for every 100 persons compared to 40 phones per 100 persons in the First World.

There are three fundamental reasons why the use of financial indicators is not sufficient to support the hypothesis that transfer of telecommunication technology is more effective for developing countries than other forms of communication technology. First of all, there is a wide divergence between the market value of telecommunications and its socially appropriate value. Secondly, the effects of investment in telecommunication technology and income distribution in terms of real goods and services are greater than what financial indicators would show. Thirdly, the relationship between financial criteria and national strategy for rural development is not adequate in terms of either social welfare or economic changes envisaged for rural areas.[28]

Up until the mid-sixties most facilities for telecommunication technology transfer had been undertaken by transnational corporation from the First World. Since the mid-seventies, these franchises to foreign companies are being terminated and turned over to public sector corporations in developing countries. While the deisgns are based on imported components, the trend now is towards a greater utilization of indigenous components. Telephone terminal equipment, the carrier facility inclusive of microwave in some countries, and electromechanical switching equipment are all manufactured and installed domestically. Whereas industrialized countries are moving to cost-effective digital integrated transmission and switching equipment, and micro-processors are being widely used, developing countries are groping with computer-controlled switching systems that also offer cost advantages.[29]

The policy of oil-producing countries has been to purchase the complete package of telecommunication equipment in collaboration with transnational corporations independent of local infrastructure and skills. It is possible that some of the Newly Industrializing Countries (NICs) like India, South Korea, and Brazil will compete for such package deals for telephone facilities thereby earning valuable foreign exchange. Table II shows that market shares of telecommunications are monopolized by the first eight listed transnational corporations based in the First World; their earnings are estimated by Arthur D. Little to grow from $30 billion in 1978 to $65 billion in 1987, reflecting large orders from Egypt and OPEC.

Table II

Market Shares of World Telecommunications Equipment[30]

	Percent
Western Union (U.S.)	24
ITT (U.S.)	13
Siemens (W. Germany)	9
GTE (U.S.)	5
Ericsson (Sweden)	5
Northern Telecom (Canada)	4
Nippon Electric (Japan)	4
Philips (Holland)	3
CIT and other French companies	6
Plessey and GEC (Britain)	3
TOTAL	76

These orders may be for upgrading existing systems. On the other hand, in OECD countries the spur to investment is expected from data communications, facsimile transmissions, teletext services, and radio paging. New technology like optical fiber involves greater information flows with little or no extra cost, mmaking the economics of telephone-linked data bases more cost effective. Demand for programmable "thinking" telephones is outstripping overall growth in traditional services in industrialized countries. Their use in LDCs is still remote.

VI. Satellite Communications Technology for Development

The epoch-making entry of satellite technology for communication wrought far-reaching changes in communication hardware, but its cost and complexity, and the fact that only a few industrial countries can build satellites and only two (U.S.A. and U.S.S.R.) can launch them, make its application to the developing world a questionable one. How will satellite communications impact on cultures and people that are still far away from modernization? Is it justifiable to spend scarce resources on acquiring cultural and technical dominance?

Despite these questions, the evidence indicates that satellite technology can become "appropriate" for LDCs in its economic and social effects. The 1980s promise to usher in a new era of low-cost earth stations for wider distribution of information. Unlike developed countries, developing ones have less investment in old equipment and are, therefore, relatively free to invest in new technologies and services.[31] They are aware of the advantages of satellite technology to serve their objectives of education, health, and welfare services as well as industrialization, national integration and government coordination. The success of transferring satellite technology depends on the suitability of message content to target audiences, which will make it valuable in attaining desired economic and welfare objectives. Multiple access satellite systems for computer networks, educational television, and telephony can be introduced to benefit the periphery groups within LDCs.

Within two decades satellite technology has made significant changes in the way nations and people talk to each other. Some of the smallest nations in the Pacific, whose economies are based on household self-sufficiency and barter, participate in the PEACESAT project, which they alone govern, and programs for information sharing are selected as per their needs. The ATS-1 launched by NASA (U.S. National Aeronautics and Space Administration) in 1966 with a life expectancy of 18 months is still used 12 years later, and made possible medical teleconferencing between Fiji and the Gilbert Islands during a cholera epidemic in 1977.[32] The cost of such satellite communication is insensitive to distance, and "instant networks" are provided. Similarly, 5,000 rural schools in India received instruction via NASA's ATS-6 for which programming was done from within the country. Instructional TV by terrestrial means would have required more fiscal and skilled manpower resources, more roads, and more power stations than the country could have afforded in 1975-76. Ever since the launch of Telstar in 1962 there has been unabatedly rapid progress towards larger satellites with greater "on-board power." The advantage is that the more powerful the signal from the sky, the smaller, less costly need be the earth receiving station. PEACESAT, operating from the University of Hawaii, has the added advantage of being an interactive network inasmuch as all stations linked to it can transmit and receive.

The economics of satellite technology is based on the concept of "leverage of specialization" in contrast to the time-worn doctrine of economies of scale. This implies the flow of economic benefits through demand specific technology.

INTELSAT specializes in traffic leased on differential demand emerging from continents surrounding three ocean basins. In the past INTELSAT used identical satellites over the three oceans, but as it diversifies, with individualized satellites suited to each area, it will generate a leverage of specialization as opposed to economies of scale. This does not rule out economies of scale.

Leasing of facilities is an important alternative to purchase. For example, the Hughes Syncom IV can accommodate 48 transponders at increasingly lower cost per transponder.[33] Developing countries can lease transponders at lower costs, and custom build their communication systems in response to their own requirements. The fact remains that in economic theory the leverage of specialization can be applied to monopoly and competition conditions whereas economies of scale are more applicable to the former.

Satellite systems in the U.S. are already competitive with each other and can provide service to desired points with low cost earth stations. Competition was encouraged by the U.S. Government's Open Skies Policy proclaimed in 1972. The American systems and their investment are as follows:

Table III

U.S. Domestic Communication Satellite Systems[34]

Operators	Start Date	Satellites	Channels	Frequency GHz	Builder	Investment Millions of Dollars
ATT.GTE	1976	3	24	6/4	Hughes	212
Western Union	1974	3	12	6/4	Hughes	100
RCA	1976	2	24	6/4	RCA	186
SBS	1981	(3)	10	14/11	Hughes	250

Three major costs of satellite communication must be considered: The cost of the spacecraft, its launch into geosynchronous orbit, and insurance of the launch. Spacecraft costs run from $20 million to $30 million and the investment is for a life span of seven years or more. So far communication satellites have been launched into orbit by U.S. rockets Delta and Atlas Centaur. Soviet spacecraft are launched by their own rockets. Price per launch is estimated at $40 million beginning in 1980. The new launch systems planned are the U.S. Shuttle, the Japanese N rocket and the European Ariane. Japanese rocket launching costs may be as high as $75 million and can carry a payload of 300 pounds. The Ariane can place 2,000 pounds in geostationary orbit from an equatorial site and its estimated cost is $15 million. The space shuttle to be launched from Florida in 1980 can carry 65,000 pounds into low altitude orbit and will cost $11 million. Launch costs are declining sharply due to the reusable feature of launch equipment and the factor of competition.

Launch insurance is a cost that puts the technology out of reach for many developing countries. Improved reliability of space shuttles is likely to reduce these costs and provide full coverage. The London insurance market has been providing coverage for this over the last ten years and is moving towards supplying insurance for the operational life of the satellite in addition to the risks of launching it.

Total systems costs become balanced with the appropriate use of ground and space segments. In this area of communications, economic rather than political solutions are likely to govern decision making. The leasing system operates in a similar way to that in the international airlines industry and provides the benefits without prohibitive initial investment. INTELSAT leases transponders to its member countries at increasingly lower rates. Sixteen countries lease transponders at $16 million a year.

Financing is available from U.S. and Canadian commercial banks and the U.S. Export-Import Bank (Exim). The Indonesian Satellite Palapa was financed 45 percent by the Exim; 55 percent was guaranteed by American commercial banks. The World Bank has so far not been interested in financing satellite communication.

The U.S. Agency for International Development has expressed its willingness to support satellite communication provided it is used for rural telephony in developing countries.

Direct Broadcasting Satellites may revolutionize television viewing and open up isolated areas by providing satellite-to-home broadcasts. In Canada, homes are able to receive color TV directly from the Anik-B satellite. TV Ontario beams educational programs from preschool to adult education for remote lumbering and mining regions of the province.[35] A major breakthrough in this context is the multi-beam satellite. It is possible with this technology to have an antenna on the satellite which would use multiple spot beams that can share the same frequency without causing interference. It is also possible to place antennas in close proximity to each other on the same satellite but adjusted to cover different regions on the earth. Platforms in space for satellites is another innovative option. While these technologies may allay the current fear of using up a limited resource, the costs are still out of reach of the developing world. While WARC '79 will play a decisive role in the use of frequencies by the different members of the International Telecommunication Union, for the Third World the prospects of wider use are doubtful. Policy issues involved include cost-effectiveness of the technology, priority of basic needs, and accountability of national policy within the international framework.

VII. How Appropriate is Appropriate Technology Transfer?

Even though the types of options and their range are increasing for developing countries as technology flies forward, many developing countries are faced with a hard choice in deciding the specific technology appropriate to their level of development. While imported technology may be too capital-intensive and would add to foreign indebtedness, indigenous technology may not be adequate to meet user demands. The UN program for Technical Cooperation Among Develop Countries (TCDC) may provide some answers to this dilemma. At a UN conference on TCDC in September 1978 the application of appropriate technology transfer was discussed, and some measure of exchange of technology and information seems increasingly evident.

The rate of obsolescence of existing technology is an important factor in TCDC. At the UN Conference on Science and Technology for Development held in Vienna in August 1979 developing country representatives were very skeptical of the advocacy of "appropriate" technology. They saw in it a device for rich countries to dump obsolete technology on the poor. The World Bank, USAID and other lending agencies are emphasizing intermediate technology for meeting rural needs. It is not always necessary for developing countries to prefer "little media" to "big media" as more appropriate to their mores, skills, and resources. Big media have been used as community media with success. These countries require neither the Schumacher type of "small is beautiful" technology nor the most sophisticated defense hardware. They need technology that relates costs and availability of factors of production with existing raw materials. Such factors of production vary between countries like Saudi Arabia and Brazil or between India and Iran. Technology is linked to employment and if the rate of young unemployed persons is mounting, the absorption of foreign technology becomes costly.[36]

While the emphasis on self-reliance is paramount it does not involve a curb on all imports and consequent growth in isolation. It has been suggested for example, that a non-profit Technology Center for Telecommunications be established for evolving appropriate transfers of communication technology to developing countries.[37] It would involve participation by both MDCs and LDCs and would be oriented towards production of hardware. The Center would be distinct from the ITU and would not detract from its powers of regulation. It would be a collaborative effort among participating governments to develop standard products in telecommunication, and emphasis would be shifted away from commercial banks and multinational corporations. The structure could be similar to that of INTELSAT. The center might develop and proliferate non-blocking digital switching networks for telephony that are designed to suit heavy traffic at lower costs, excluding mark-ups and overheads; this would foster savings in foreign exchange for LDCs.

Computer communication technology is widely advocated as catering to the special needs of developing countries and acclerating their resource utilization by facilitating international trade. However, the benefits of the new technology may not be equally distributed and may, therefore, increase the dependency of poorer countries. While in manufacturing industries some less developed countries have disrupted the hegemony of corporations based in the industrialized world, in communication technology the United States controls the output and sale of sophisticated computer systems.[38] It controls 50 percent of installed computer bases. This includes the software or data bases for business, government, banks, health records and various other uses. Nine-tenths of data base records are held in the U.S. or operated by U.S. data bases. The software industry is labor-intensive and has potential for creating jobs in building and maintaining systems. National and international data trade is likely to create a whole new class of "information entrepreneurs." It is one communication technology that carries a high rate of obsolescence, and constant up-dating of data bases will create further job opportunities. To counteract this advantage is the threat that micro-processors will take over. Convincing evidence on the job impact of electronics automation is not yet available in countries facing unlimited supplies of surplus labor. Transfer of technology involving electronic automation would not only be financially expensive but economically and socially hazardous for them.

With the use of satellite telecommunications and the rising price of oil imports, even developing countries may be driven to choose computer communications for teleconferencing and to invest in data banks to support their export trade, education systems, and R and D efforts. In the not too distant future it is possible that data bases may be used for information exchange in science and technology within the countries of the Third World, and thereby make more effective TCDC possible.[39]

India's experience in building up endogenous science and technology substantiates the view that appropriate scientific inputs help the economy to shorten the time path of development. Soon after gaining independence, India set up its Council for Scientific and Industrial Research and in 1954-58 saw a rapid expansion of technological infrastructure. By 1966 India's national science policy was rapidly being implemented. In 1971 the Electronics

Commission, in 1972 the Space Commission, and in 1974 the Plan for Science and Technology were formulated and put into operation in that sequence.

In communication technology India built up experience during the SITE program for the use of "big media." It already had indigenous expertise in telecommunications hardware and radio broadcasting in both hardware and software. SITE used half-inch video for its television project and combined high and low technology with participation from rural people in its production. Of the total investment in SITE of $17.7 million, the Indian Space Research Organization contributed 63 percent and the Ministry of Information and Broadcasting 22 percent. The front end convertor, the antenna and the television sets were all developed indigenously. The time span of the learning curve has been reduced so that in the 80s the most expensive TV set will cost $425. The average cost of programming during SITE was $1,500 per hour and the cost of transmission was $1,110 per hour. Studies showed both the leverage specialization effect and economies of scale.

Now India has new satellites in the pipeline. India's first Launch Vehicle is being developed at the Space Center in Trivandrum. INSAT One will be a domestic communication satellite, now being built in Palo Alto. By 1989 it will be replaced by an Indian-built satellite. Another satellite for earth observation will be in geosynchronous orbit by 1981 (APPLE). The cost of earth stations is projected at $200 per one meter dish antenna. It may not be overly optimistic to visualize Indian communication technology flowing to other Asian countries, generating a South-South transfer as part of a TCDC program.

VIII. Perspectives for the Future

Whether technology transfer is a parameter rather than a problem generator is a frequently debated issue. Against a background of worldwide proliferation of military and defense technology, all investment in improved communication will help offset the need for military technology. World expenditure on sophisticated weaponry is $280 billion per annum and LDCs spend in the aggregate four times more on weaponry imports and related technology than on investment in agricultural inputs. The benefit/cost ratio of communication technology transfer would be greater than unity, if there could be increasing creation of "ecumene" or a globally interdependent social system.[40] For example, the recent attempts at WARC '79 to design a more equitable system of dividing electromagnetic frequencies and orbital space among the world's users is a conscious recognition of "ecumenical decision making" for an area of operations that lies beyond the territorial sovereignty of any one country.

Communication technology safeguards the use and application of all other forms of technology transfer, not only improving the quality of life of people at the periphery but also creating understanding across cultures and races and reducing socioeconomic and political tensions. The control of violence at the macro and micro levels, the scientific exploration of natural resources, and the exchange of information from data bases have become technologically feasible through international transfers of the output of R and D. The republic of technology may be international in bridging the hiatus between rich and poor within developing countries as well as between affluent and deprived nations.

Since technology is the foundation of modern communication policy there appears an element of serendipity in a global policy of technology transfer to developing countries. Such transfer lies halfway between the theory of planning and the implementation of development.[41] Assessment and evaluation of the transfer are considered necessary, yet the developing countries are racing against time and do not want to wait for the results of assessments. They are willing to experiment, to learn from experience, to build their own expertise and to use the latest communication technology to reach their own peripheries and regions within the Third World that are least developed. A decade ago Wilbur Schramm argued for using in the developing countries mass media industries oriented towards cheap and relevant production, but this is taking very long to implement because economic analysis of technology for communication industries and their management has not been systematically pursued. The social utility and relevance of communication technology, the access and participation it makes possible in LDCs, all form part of a new horizon in international decision-making. To quote Al Ghunaim from the Kuwait Ministry of Communications "it may be paradoxical but true that the appropriate technology for developing countries in communication equipment is the latest and most modern, not one in vogue a few years ago."[42]

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THE ECONOMIC EVALUATION OF RURAL TELEPHONY PROJECTS: SOME EMPIRICAL EVIDENCE

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Abstract

In october 1978, a survey comprising subscriber interviews was made in two small towns having manual exchanges (1). The main goal of survey was to obtsin information on uses, benefits and alternatives communication modes, of the telephone service. This paper reviews some results that may by accounted as part of the framework for economic appraisal of rural telephony projects.

Introduction

In less developed countries (LDC), usually there is a severe supply shortage of telephone lines and subsequently there is a limited demand and a great hidden demand. In addition LDC generally present severe budget restrictions that limit the system expansion and require an ordered resource assignment. As rural projects are not financially profitable this area remains underdeveloped.

The survey was carried out in two localities: Cabildo in the fifth region (6686 inhabitants and 66 subscribers) and San Vicente in the sixth region (5291 inhabitants and 239 subscribers). The principal economic activity in Cabildo is small mining as agriculture (specially fruit) is in San Vicente.

The telephone company distinguishes three types of subscribers that pay different monthly charges. They are: residential, basic and bussines (the greatest charge) (2). In Cabildo there are 28 residential, 25 basics and 8 bussines subscribers; and in San Vicente there are 116 residential, 70 basic and 22 bussines subscribers.

Results

We will review some results of long distance calls, that generate 77% of total revenues in Cabildo and 85% in San Vicente. In the surveyed month, we have that in Cabildo (60 subscribers) 1023 calls were made and $ 59823 was paid; whereas in San Vicente (213 subscribers), 3954 calls were made and $ 271381 was paid (3).

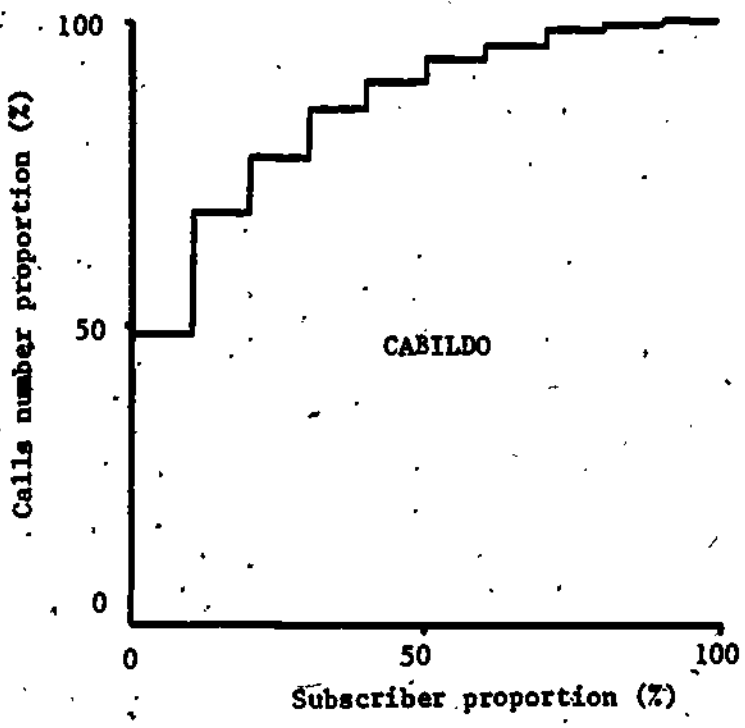

FIGURE: 1

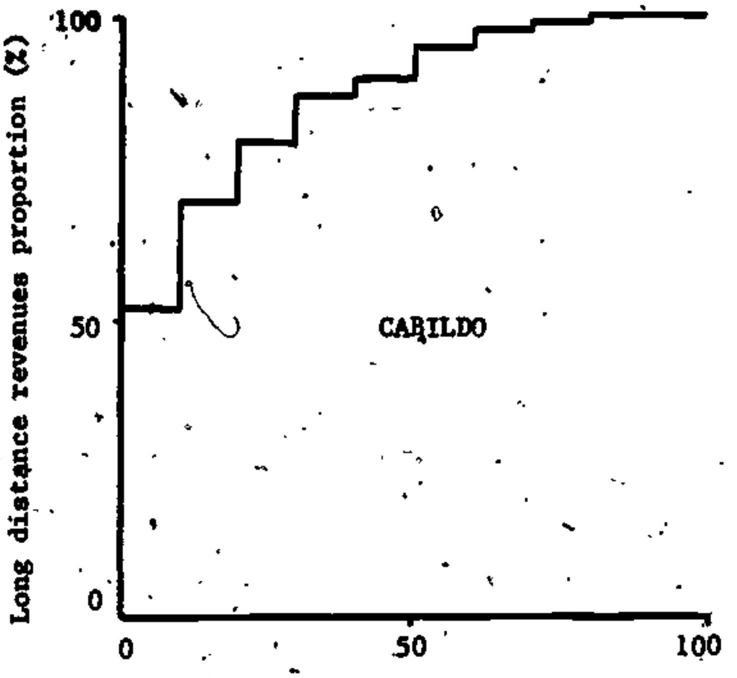

FIGURE: 2

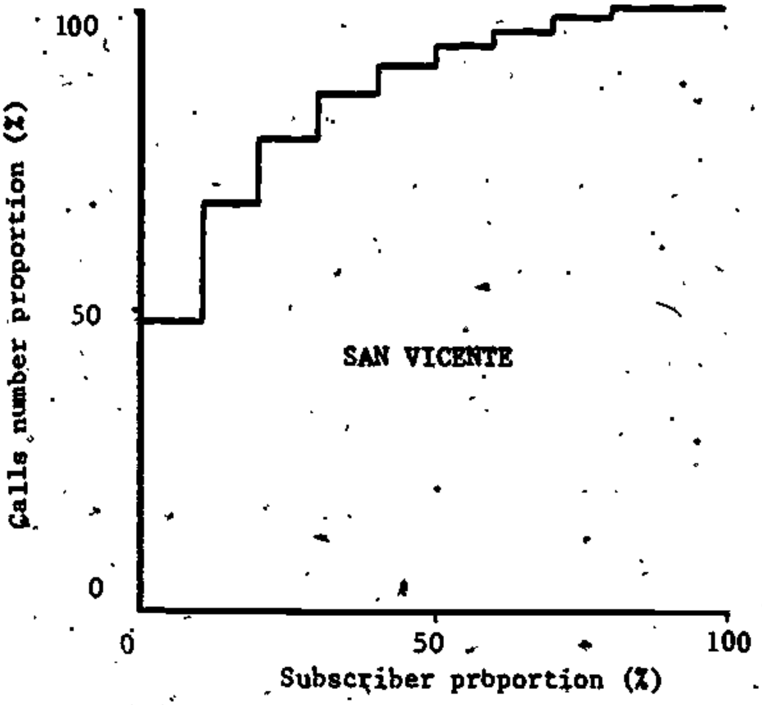

FIGURE: 3

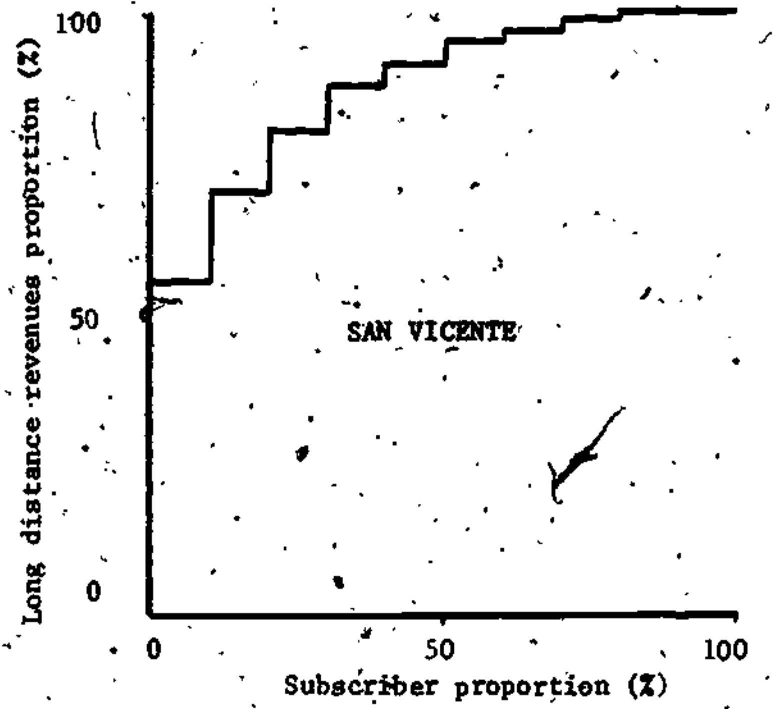

FIGURE: 4

Figures 1 and 3 show the proportion of calls that a certain proportion of subscribers made (the subscribers are ordered in diminishin form according to their individual number of calls). Figure 2 and 4 show the proportion of revenues produced by certain proportion of subscribers ordered according to the paid value.

When analysing this figures we see a strong unbalance in the call generation, only 50% of subscribers generate aproximately 90% of calls. Moreover 50% of subscribers generate 90% of total revenues for long distance calls. Considering this we infer the existence of intensive users and if there is also a correlation between the number of calls and revenues, we again infer, at least from a purely financial point of view, that there is a natural order in the supply of telephone lines. Table I presents the estimated kendall coefficient for some variables.

TABLE I

KENDALL CORRELATION COEFFICIENT BETWEEN PAID VALUE AND SOME SELECTED VARIABLES.

	Cabildo	San Vicente
Number of Calls	0.825	0.762
Family Income Level	0.423	0.469
Subscriber Type	0.579	0.661

There is a strong correlation between the amount of calls and the values paid also. Futthemore, in both towns the 10% that makes the most of the calls is the same that produces the greater revenues. There is not a strong correlation with the family income, however that correlation exists between revenues and subscriber type.

Table II presents the percentual distribution of calls and revenues, by subscriber type.

TABLE II

DISTRIBUTION OF CALLS AND REVENUES

	CABILDO		SAN VICENTE	
	Call Quantity	Revenue	Call Quantity	Revenue
Residential	22%	19%	29%	29%
Basic	48%	41%	44%	41%
Bussines	30%	40%	27%	40%

The residential area even with the greatest number of lines (47% in Cabildo and 57% in San Vicente) produces the smallest proportion of revenues. The revenue for each type of subscriber, supposing that the bussines area in San Vicente had paid 100, is presented in Table III.

TABLE III

MONTHLY REVENUES BY TELEPHONE TYPE

(Bussines in San Vicente = 100)

	CABILDO (rev./line)	SAN VICENTE (rev./line)
Residential	11	17
Basic	27	42
Bussines	79	100

From Table II and III we conclude two facts: first, the bussines lines produces the greater portion of long distance revenues which indicates the greater willingness to pay for productive uses of telephone; and second, the lines in San Vicente generate more revenues than the lines in Cabildo according with the fact that the economic level of activities is higher in San Vicente.

Conclusions

Although the results are statistically valid only for the localities included in the survey, there are conclusions that prove the need of suplementary analysis for telecommunications projects appraisal.

From a purely financial point of view and according with the observed distribution, it seems reasonable to establish a priority order in the service assignment, first satisfying this subscribers that potentially will produce more revenues and calls. Also it is possible to make the allocation by type of telephone, first attending the bussines sector.

Another important fact, is the weak correlation between family income and quantity of calls and revenues. It seems that the level of this two variables depend on the kind of activities associated to the telephone. This fact is reflected in the correlation with the telephone type.

Finally, it is neccesary to remark that macroeconomic analysis does'nt include this aspects that are part of the framework for economic planning and evaluation of telecommunication projects. It seems, at least now, that is neccesary to explore the microeconomic analysis of cases, that allow to understand the variables affecting the consumers choice, his willingness to pay and, of course, affecting the consumer surplus associated to telecommunications investments.

FOOTNOTES

(1) I would like to acknowledge the cooperation of Compañía de Teléfonos de Chile (C. T. C.) in collecting data for the survey:

(2) A residential subscriber is one who uses telephone exclusively for purposes directly connected with the household, that is, with the place he and his family live.

A busaines subscriber is one who uses the telephone mainly aa an instrument associated with an economic, social, or cultural institutionalized activity conducted in the place where the telephone is located. A special kind of bussines aubscriber is the basic subscriber, including lawyers, accountants, doctors and others professional workera.

(3) In Chile currency is pesos and in August 31 of 1978 the equivalence was US$ 1 = $ 34,63.

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technology and practically undeveloped telecommunicationally in terms of investment, output, employment and sophistication.

GAPS AND LIMITATIONS

The reasons for such under-development are not far to seek. There is, firstly, the resource gap. Telecommunications, whether intra-national or international, require heavy investments on infrastructural support. Whether it concerns point-to-point land lines, or wave-based radio contact or satellite communications, the need for resources is far too great for a conventionally under-developed country to muster. The versatility of uses and applications of telecommunication technology notwithstanding, which may eventually revolutionize the entire educational, agricultural or industrial systems, the requirement of finances, manpower and materials even in a year can indeed be much more than what a country may be able to divert in a quinquennium. With the pressure of populations and competing claims, resource mobilization is a serious limitation of all developing countries.

There is then the technology gap. The low level of technological sophistication and competence generates problems for innovative activities. The absence of technological innovations to meet the growing requirements is compounded by the problems of technological adaptation of imported technology. Mere adoption or imitation is not adaptation, and even in low technology areas, glaring gaps exist in most of the developing countries. Thus, for example, in 1975 there was only one telephone per 1000 persons in Burma and even less than that in some other countries. Limitations of technology prove to be almost insurmountable barriers in both diversification and modernization of telecommunications in developing countries.

Then there is the talent gap where we see the degree explosion in many countries but with most of them short of persons with the required education and requisite training. The few that reach upto the standard are often lured by prospects abroad. The advanced countries can obviously pay much more and thus attract talent from the underdeveloped economies, little realising that in the long run, it is to the detriment was exported. Today, not only has Bonn continued to maintain the lead, its major companies like Siemens, Forneck, Telefunken, Semikron, etc., have grown far bigger.

On the other hand are some of the characteristically undeveloped countries of Asia such as Laos, Malayasia, Burma, Thailand, Sri Lanka, Pakistan, Nepal and India, where the industry is more of an apology than business. In Laos, which is 80% agricultural oriented and dependent heavily on foreign aid, "it appears that the country does not have an electronic industry."(2) So is the case with Nepal. In Sri Lanka and Burma it is currently confined to the production of radios and some of its components, with an annual production of 81,760 and 600,000 radio sets respectively.(3) The electronics industry in Thailand is mostly consumer-based and assembly-oriented and American and Japanese products dominate the domestic market. In Malayasia, it caters mainly to the demands of consumer industries, producing radios, TVs., telecommunication equipment and components worth about 15% of the GDP employing only about 40,000 persons.(4) The total production value of Indian electronics industry with 100 large scale and 1,000 small scale units was only US $362 million and of Chinese was only US $1800 millions in 1975.(5) In Indonesia, the situation is almost the same. All these countries, taken together, have the capacity of producing not more than one-tenth of the production of West Germany alone, let alone the giants in the field like USA and USSR.

This is not to say, however, that Asia does not have telecommunicationally highly developed countries. Take for example, Japan, which in a short span of a quarter of a century, rose to such a high level that in 1974 it was producing goods worth US $16,000 millions. By its low-value, low-technology and high-volume production and an agressive marketing strategy, it created and captured many new markets.(6) The most remarkable development has taken place in the two city-countries of Singapore and Hongkong, the former producing goods worth US $2300 millions and the latter only radios worth HK $31 millions in 1977 (7), repeating the electronics miracle of Japan, though on a smaller scale. But albeit these three exceptions, by and large, the developing countries of Asia remain tied to conventional technology and practically undeveloped telecommunicationally in terms of investment, output, employment and sophistication.

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And finally, there is the direction gap. Development can, in the circumstance of under-development, have mainly two desirable objectives - maximization of returns or distribution of gains. It is unfortunate that in the developing countries, there is often a dichotomy between the two and thus a need for priority of one over the other arises. Telecommunications, with a heavy deployment of malleable resources, presents a specially difficult choice for investment, for this seems to serve neither of the objectives. There is also a constant competition between claims of diversification and sophistication. This indeed is the dilemma, which becomes a serious limitation to the development of telecommunications.

With the limitations so imposed by the scarcity of malleable resources, the non-availability of requisite level and variety of technology, the dearth of suitable technical personnel and the lack of proper direction and perspective, telecommunications have presently a limited role to play in the development of underdeveloped economies of Asia. This does not, however, obviate the need for indigenization or urgency for an expanded role.

Options before Developing Countries:

The developing countries have mainly three sets of options before them. Firstly, they have the choice between continued dependence on foreign aid and investment and self-reliance and indigenization.

In the former, not only there may not be a development of indigenous industry but there may also be a systematic overpowering of the internal market by foreign products, to the detriment of the national economy and its growth in general, as in Thailand. In the latter, the country may propose to pass through the conventional stages of growth envisaged by Rostow, or jump the queue, and turn the corner in a short span, as in Taiwan and Korea.

Secondly, they may aim at the diversification of technology or at higher levels of sophistication, in either of which cases investments of money and materials may be substantial.

In the former, the process may aim at the application of low-level low cost technology to hitherto unconventional fields such as agri-electronics, mining and education, as is being undertaken in India. In the latter, apart from increased sophistication in existing fields, such new fields as space communications through satellites may also get some priority, as in Indonesia and India.

And finally, they may lay stress on maximization of returns on investment or distribution of gains of telecommunication development. In the former, the deployment of resources may take place mainly in some selected areas like consumer telecommunications, as in Burma and Sri Lanka or on production of quick-yield projects, leaving the core area and the infrastructure to fend for itself, as in India. In the latter, programmes of rural and interior linkages and mass projects like rural literacy, as in Indonesia, may share the investment cake.

Options before Developed Countries:

The options before the developed countries like U.S.A., West Germany and U.S.S.R., are also primarily three. Firstly, they may decide to leave the developing countries to themselves, with no support or services to develop the areas. This will not only be a violation of the U.N. Charter, but will also be detrimental to world peace since it will accentuate the differences between the haves and have-nots. In a field like telecommunications, which offers a tremendous potential for world prosperity, the policy of seclusion will be calamitious. An underdeveloped economy is as much a drain on the developed part of the world as on its own economy. This option therefore offers no choice.

Secondly, they may decide to support development programmes of telecommunications in developing countries in such a manner that they arouse the demand but take care to feed it from their own industries, disallowing the growth of indigenous industry. This has the advantage of building an infrastructure and creating a market and in these respects is conducive to some degree to development. But it is still not the answer to the call for global progress.

And thirdly, they may act as catalysts to development by providing aid, advice and assistance in such a degree that while encouraging domestic effort, they neither thrust indigenization nor provide crutches for future development. In the longer run, and in the larger interest of the world community, this precisely is the role expected of developed countries. The fear of competition and eventual ouster is misplaced, for a strong Japanese and Taiwanese telecommunication industry even now poses little challenge to the developed countries.

But the developed countries have their own limitations. Their priority for self-interest can not be overlooked merely because they are reluctant to support development programmes in developing countries on a scale that the latter desire. Their desire for gratitude in return, if not return on investment, can be justifiably appreciated. Their concern for national policies, emerging suddenly detrimental to their interests, cannot be ignored. Their scarcity of resources, in spite of the affluence that they exhibit and the consequential constraints of participation, cannot be washed away by derision or contempt. They indeed have their own problems.

International Responsibility:

It is in this light that international action, rather than bilateral or multilateral effort, becomes necessary. Telecommunication is a field where international responsibility is much more, for while helping conserve depleting energy resources and facilitate savings on labour, time and transport, it can verily transform the human life.

International action in telecommunication would thus seem to be inevitable. The areas that would require such action would include technological extension, financial support, global planning and international monitoring.

The extension of technology, through vertical and horizontal transfers, is necessary since creative development of indigenous technology is generally lacking in the developing countries. Recent trends in international technology transfer indicate "development and centralization of international information bureaus, increase in size of R&D organization, and merger and increase in size of 'think tanks' engaging in research and analysis of market and social trends." (8) Satellite collaborations, unified computer systems, international telephone grids, are some of the areas that have gained attention. But this seems to be little to what needs to be done. Cooperation in seismic forecasts, floods warnings, tidal and weather reports, sophisticated hard and soft ware manufacture,etc., are some of the areas that would need wide-scale technological transfers. Perhaps more organizations like International Telecommunication Union and Asia Electronics Union need to be promoted.

For this purpose, international funding of projects and schemes would become inevitable. There are in existence such international aid bodies as World Bank (IDA), Asian Development Bank (ADB) and Islamic Development Bank (IDB), but their primary attention seems to be concentrated on general agro-industrial development. An International Telecommunication Funding Authority,with say five thousand million dollars initial capital, would not be a losing proposition even for developed countries. In terms of creation of demand and markets, it will help both the donor and the beneficiary country. Regional Telecommunication Aid Banks, something on the pattern of Association of South East Asian Nations (ASEAN),would also be an idea worth serious exploration.

Technological transfers and funding would obviously require international planning, which could include a world master plan of telecommunication development and small national plans of participation as well as development. This would require an understanding on the part of the developing nations that they cannot confuse sovereignty with arbitrariness and still expect foreign aid. The policies of many such nations need a second look. The developed nations have also to shed the view that money and technology transfers are beneficial only with hidden strings. It is only in the atmosphere of mutual understanding and trust that international planning can take place.

And finally, there must be some organization, within the U.N.Charter, to monitor the telecommunications plan and to dovetail the national plans into the international network. Telecommunications being mostly for peaceful purposes, the experiences of disarmament monitoring albeit, this should not pose serious problems.

Telecommunication can have tremendous socio-economic impact in developing countries. A plan of global participation in telecommunication development in India, for example, may include participation in mass contact and mass warning systems both having immense socio-economic ramifications. The emphasis in the former could be on low-cost low-level technology, entailing a much greater use of wireless and satellite communications, rather than the existing dependence on land-based point-to-point telephone and telegraph systems. While production and use of wireless sets could be made free, cheap and portable TV receiver sets could virtually revolutionize adult literacy, family planning, health and hygiene, agricultural extension, epidemics and crime control programmes. Even in telephones, mass production of equipment with an automatic national telephone grid may not only facilitate business and economy, but may also transform the rural scene.

In the latter, timely and accurate warning system for flood, earth-quakes and even weather, including cyclonic and tidal warnings are far from adequate. In this respect, a beginning has been made, through INTELSAT, INSAT & ICRISAT (and through indigenous Aryabhatta & now Bhaskar) but there remains a tremendous gap between the need and the facilities. Satellite Communication offers wider, quicker and more accurate mode of communication,(9) but requires a much higher level of technology and enormous investments. And it is because of this that assistance from developed countries and international organizations may become necessary.

The discharge of the international responsibility of developed countries and international organizations is the need of the hour. The issues are clear; either we have a world order of telecommunications, planned for peaceful progress or we continue to divide the world into the haves & have-nots, endangering world peace and prosperity. The choice is also clear. It is indeed the manner and the modalities of establishing such a world order in a short span of time that this Conference needs to discuss and deliberate. This will also be a fitting tribute to international cooperation and endeavour towards making the world a better place to live in.

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THE NEW ECONOMIC ORDER
AND
PACIFIC TELECOMMUNICATIONS DEVELOPMENT

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Abstract

This paper argues that the meeting of developing nations' communications requirements generally has been consistent with the tenets of the New Economic Order. Specifically, the paper explores how the Pacific experience reflects this fact, and consequently represents a desirable example for other LDC's to follow in the course of their own development.

I. INTRODUCTION[1]

The purpose of this paper is to explore how, in the Pacific region, the meeting of developing nation's communications requirements through the mode of satellite communications has typically been consistent with the tenets of the New Economic Order (NEO).[2] This concept is the new philosophical underpinning of North/South relations; it calls for, among other things, industrialized and developing countries jointly contributing to the improvement of Third World countries' technological and scientific infrastructure, as well as the furtherance of their industrialization and development. The NEO concept in its establishment of a new working framework for international relations has emphasized that a symbiotic relationship is shared by the developed and developing world. In other words, the Third World represents a vast market which the developed world could exploit, while these very goods which could be imported by the developing world represent the keys to development the Third World so greatly needs.

Unfortunately, though not surprisingly, this concept of reciprocal need and interdependence has tended to generate adversarial relationships on various topics, rather than cooperative ones. The international telecommunications sector is not an exception to this dysfunctional phenomenon, though truly it has not been an area of as intense debate as other areas, such as trade. Nevertheless, the recognition that the world is increasingly more integrated, necessitating intraregional and international cooperation, has characterized the Pacific telecommunications development. While more could have been achieved, as is always the case in development, in the Pacific region's telecommunications sector, nonetheless those accomplishments which do exist have been generally consistent with NEO concepts. It is useful to examine the Pacific experience, since from an overall perspective it represents a desirable example for other developing nations to follow in the course of their own development, for the telecommunications sector as well as others.

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II. CHANGING RELATIONSHIPS: A MACRO PERSPECTIVE

Prior to the advent of the NEO concept, the developed world typically participated in international fora, telecommunications and otherwise, with a conservative attitude as regards their financial assistance of the developing nations' needs. The developed world seemingly viewed its position as one based upon benevolence, with no real impetus existing to provide economic and technical aid except for a moral one. Significant need was invariably seen by the industrialized community as being synonomous with the developing world; yet, this need was not mutual since the developed world's need of the developing world was viewed essentially as being marginal. However, this is not to argue that no economic or technical aid had been forthcoming from the developed world for the benefit of the developing nations. In the telecommunications sector, for instance, the developed world, through the ITU, annually averaged in the mid-1960's $7 million in equipment assistance, which was additional to fellowship/technical assistance programs. The World Bank (and the IDA), the largest international lending agency, dispensed $139 million during a similar period on telecommunications-related projects in the developing world. Regardless of the size of these amounts, it is obvious that relative to the challenge which existed, the monies were inadequate. Of course, telecommunications-oriented projects had to compete with all other sectoral priorities resulting in the total amount of aid which the developed world was prepared to offer the developing world; nevertheless, even based on this macro view, aid for all sectors was inadequate relative to the need. Benevolence and goodwill--while laudable--provided by a marginal stimulus for the developed world as regards the dispersion of aid. On the other hand, the developing world, prior to the emergence of the NEO philosophy, was in no real political position to force an increase in the level of aid which the developed world was prepared to offer. The Third World had no sanctions or power and, for the most part, was fragmented.

The evolution and acceptance, albeit somewhat limited, of the NEO concept has not reversed the net balance of the relationship between the developed and developing worlds, but it has shifted power such that the developing country position has strengthened in relative terms. The idea that developing countries represent an engine of growth for the industrialized countries, particularly by being a source of critically needed raw materials, has provided the developing world with some political power. It is growing more apparent to the industrialized world that reasons other than goodwill exist for aiding the developing world. The motivation from the developed world's perspective engendered by the NEO's mutual need concept clearly exceeds that motivation which existed prior to the NEO's development.

The level of developing country political power in this emerging NEO framework varies by region and manifests itself differently in bilateral and multilateral relationships. Importantly, this power will be enhanced by the developing world community learning how to effectively present, in various international fora as well as upon a bilateral basis, their aid requirements which flow from their development priorities. Needless to say, this entire scenario presupposes cooperative, orchestrated effort amongst the LDC's themselves. With any noteworthy shift in power in the international system, new relationships and behavior patterns are spurned. Currently being in a transitional period, however, adversarial relationships (within the developing world and between it and the industrialized world) have arisen as a consequence of nations and nation blocks adjusting to the shift in power. Hopefully, these relationships will be replaced by cooperative ones. This is particularly apropos, since from a theoretical standpoint the NEO is cooperative, not adversarial.

We turn now to the Pacific area as an example of how the NEO mentality of mutual need and cooperation has been an instrumental element in achieving telecommunications development.

III. THE PACIFIC EXPERIENCE

Telecommunications development in the Pacific region has, within the framework of the NEO, profited because nation-state relationships on three levels have tended not to be adversarial, but rather cooperative:

LEVEL	DEFINITION
International	Multilateral relations typically international organizations interfacing with LDC's
Bilateral	Individual developed nations interfacing with an LDC(s)
Regional	Intraregional interaction amongst LDC's

First to be discussed is cooperation on an international level between the developed and developing world as regards the telecommunications sector. Through the ITU, with funds partially being dispersed through the UNDP, the Pacific region has received funding and fellowship/technical assistance, for both large scale and small scale telecommunications projects. In the early 1970's (the latest for which reliable statistics are available), Indonesia and Malaysia represented the largest aid recipients in the Pacific Basin, with Japan and Australia being the regions' largest donors, both bilaterally and multilaterally. The principal emphasis of the ITU in this regard was the development of telecommunications training centers in Bandu[illegible](Indonesia), Kuala Lampur (Malaysia) and Manila (The Philippines). Notably with respect to satellite communications, the Japanese have funded, through the ITU, feasibility studies on a bilateral basis in Malaysia, and fellowships for Indonesia, Malaysia and the Philippines. Other Pacific Basin nations which have received ITU assistance are: Fiji, Paupa and New Guinea and Western Samoa. Such assistance has been supplemented by the more broadly directed efforts--financial and otherwise--of the ITU's parent organization, the United Nations, concerning areas such as educational television, computers and computer communications for the purposes of technology transfer and transborder data flow.

A second example of international cooperative effort in the telecommunications sector is the INTELSAT organization, with 102 member nations,3/ which has endeavored to respond to the needs of the developing world in a variety of ways: notably, through declining space segment charges, by providing technical/operational benefits and establishing transponder lease policies for domestic communications. Recently, the question of INTELSAT's responsibility for its developing country members was raised and subsequently resolved through the establishment of the INTELSAT Assistance and Development Program (IADP). The IADP is charged with the responsibility of providing technical assistance for satellite telecommunications infrastructure development to requesting member nations for both short-term projects (on a free-of-charge basis), as well as long-term projects (i.e., those exceeding two months on a cost-reimbursable basis). Although only a few countries have availed themselves of the IADP's benefits because of its recent startup, the program promises to be a valuable development tool for member nations as they begin to incorporate the Program's offerings in their domestic development planning. INTELSAT's excellent coverage of the Pacific and the involvement of the Pacific member nations in INTELSAT recommend their use of the IADP. As an historical aside, it should be noted that the dialogue between developed and developing country members lasted over a two-year period, yielding the compromise of the IADP. The discussions leading to this resolution typically recognized how the needs of both the developing and developed country members and the INTELSAT organization itself could be mutually satisfied.

Shifting the focus from these multilateral relations, we turn now to the second level on which the Pacific Basin nations have benefited within the NEO on a cooperative basis, namely bilaterally. The PEACESAT system, in which it was demonstrated that satellite systems can operate cost-effectively in environments of relatively low levels of technological sophistication, stands out as a prime example. PEACESAT provided the world with the first satellite library network, the first satellite education network and the first regional satellite network. It established communications units between Australia, New Zealand, Papua, Samoa and the United States. The program was funded by Pacific Basin nations using a United States ATS-1 satellite for voice and data teleconferencing services. The cost of the program from 1971 to 1976 was less than $500,000. As was argued by one observer of the PEACESAT Project: "It is in the self-interest of both industrial and non-industrial nations to open up two-way communications tailored to the requirements of world development programs. The PEACESAT Project offers an approach based on cooperation and mutual respect.4/

The United States is apparently aware that a justifiable need exists, given the success of the PEACESAT and SITE projects, to fund a communications satellite program for the developing nations. Ambassador John Rhinehart of the International Communications Agency proposed last year a $25 million program by which Third World governments could beam literary, health and similar assistance programs to remote areas. The program would be funded by the Agency for International Development using INTELSAT facilities or those of other appropriate satellite systems. Cognizant of the desire of the developing nations to exercise control over the communications process, Rhinehart had further proposed that the programming will be managed by the recipient countries. He remarked, "At its conclusion, all aspects of management and control will be turned over to the recipient nations."

The last level of relationships from which the Pacific region has benefited is that of intraregional cooperation in telecommunications. While in a narrow sense the NEO refers to relations between developed and developing nations, as a concept it implies a relatively unified position amongst the members of each group. Truly, the main premise of the NEO cannot be logically and forceably argued nor be realistically accepted without general unity on each side. In this, the Pacific region excels with the example of the Palapa system and the expanding ASEAN Organization. As the NEO concept has evolved, so has the ASEAN Organization's participation in Palapa. Currently, high quality voice and television transmissions are being made within the nations of Indonesia, the Philippines, Malaysia, Thailand and Singapore. The system provides only domestic telecommunications services so as to avoid violations of member state agreements with INTELSAT to use the INTELSAT system for international traffic. Amongst the developing world, the Palapa system represents the only true currently operational measure of success for regional telecommunications.

IV. COMMENT

The transition period in which the international community finds itself today renders the tenets of the NEO more frequently goals than operative principles. Progress is slow and perhaps non-existent in certain geographic areas and sectors. In international fora, it is not surprising that the developed world community construes the developing world's needs primarily in financial terms as costs. Equally not surprising, the developing world frequently is of the opinion that by virtue of an unequal distribution of wealth, the industrialized world is obligated to help the developing world. While their views may be somewhat stereotypical and not characteristic of all developed/developing world relations, nonetheless they do frequently and accurately represent the current predispositions. Obviously, these perceptions are counterproductive, to which the development experience prior to the NEO testifies; for mutual gain, it is incumbent upon policy planners, while aware of these predispositions, to emphasize how relations, and hence negotiations, should seek to reflect the tenets of the NEO. To ignore the principle of mutual needs and consequent gain is merely to exacerbate international tension, thwart development objectives and incur negative financial ramifications for all parties.

It has been argued herein that Pacific telecommunications development has typified NEO tenets; yet, the level and quality of the development effort can always be enhanced. Obviously, as noted earlier, the concept of development is virtually unending; in the heirarchy of needs, there always remain higher ones. Nevertheless, a stronger motivational element exists with the NEO concept than without it. This will give impetus for growth similar to what the Pacific region has experienced in the past in telecommunications.

FOOTNOTES

1. The views expressed herein are solely those of the author and in no way reflect those of the Corporation.

2. The wide diversity of less developed countries (LDC) telecommunications needs recommends the employment of various types of telecommunications systems: microwave networks, cable networks, and satellites. Attention will herein be focused upon satellite communications in that their planning, construction and operation necessitate the greatest level of international negotiation of these three system types, and hence, will be most illustrative of the thesis that Pacific telecommunications development has been in keeping with the spirit of the NEO. Beyond this, it is useful to emphasize satellite systems within the context of development due to their unique, time-efficient and generally cost-effective contributions and the value of these contributions to a nation's development.

3. Furthermore, earth stations operating in the Pacific region (using the Pacific Ocean Region satellite) are located in New Zealand, Australia, New Caledonia, Fiji Islands, Nauru, Hawaii, Guam, American Samoa, The Philippines, Hong Kong, Malaysia, Indonesia, Japan, China, Tonga, New Hebrides, French Polynesia and the Solomon Islands.

4. "PEACESAT", WORLD HEALTH, January, 1979, by John Bystrom.

INITIALIZATION RESTART/RECOVERY
IN A DISTRIBUTED MICRO-
PROCESSOR SYSTEM

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Background

Interconnecting the AUTOVON Telecommunication Network with commercial stored program telecommunication switches has been a problem for some time because AUTOVON has many features not used in commercial switches, including precedence and preemption. Thus, any interface between the two systems must provide the following: (1) call diversion to an operator with queue precedence indication; (2) AUTOVON preemption detection; and (3) operator preemption of outgoing precedence calls. In addition, the interface unit must be (4) highly reliable; (5) transparent to the end users; (6) cost effective; and (7) capable of supporting future growth. Finally, the interface unit must not (8) degrade system performance.

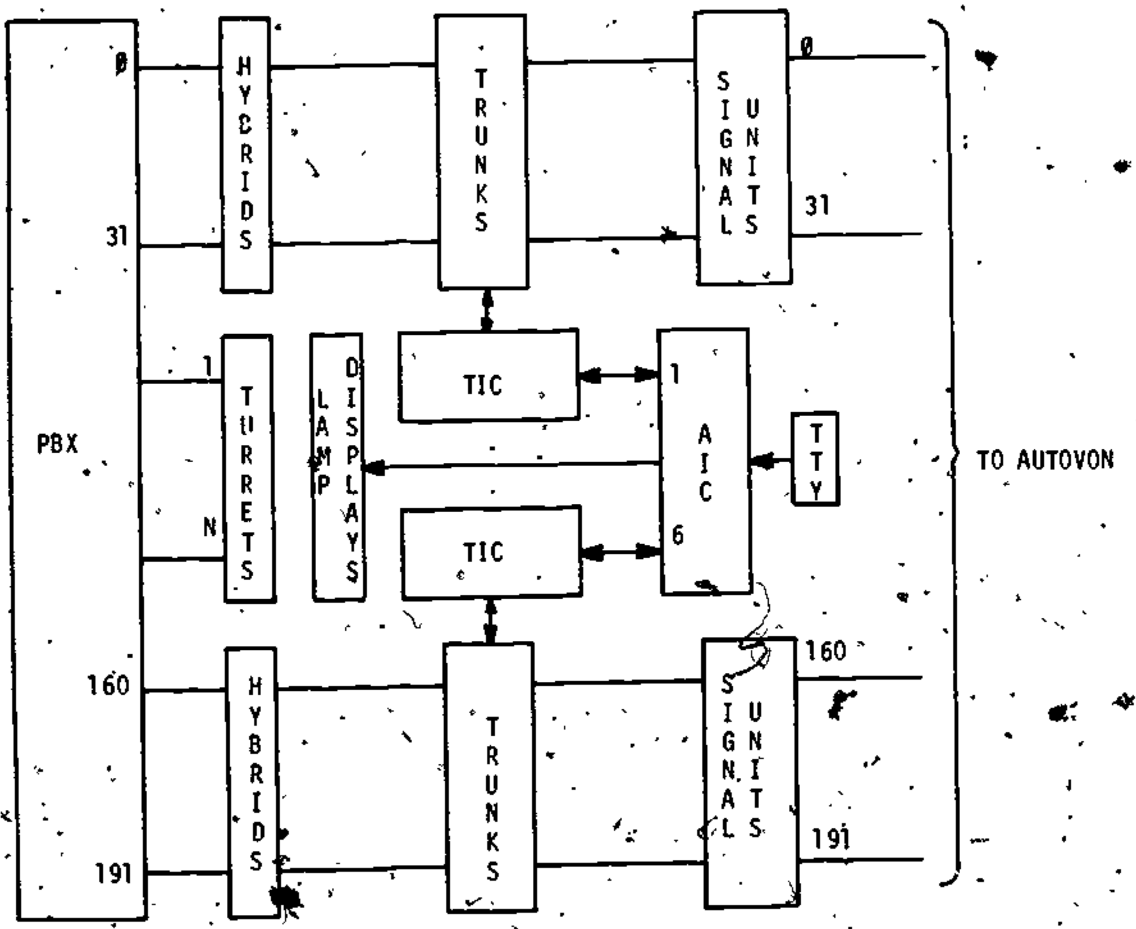
In most telephony systems, high reliability is accomplished through the use of redundancy of critical units. But because of the high cost, which conflicts with the low-cost requirement, redundancy is not used in the interface unit described herein. To solve this problem, we use a distributed microprocessor system in our interface unit that features functional decomposition and partitioning to specific processors; a preemption/diversion scheme independent of processors; and a comprehensive data base recovery scheme. These features ensure maximum reliability, low cost, and minimum data swapping among processors. Significantly, the communication protocols used between processors ensure a minimum message processing overhead. The combination of these several features, therefore, represents our solution to system-critical problems.

Problem Definition

The system initialization/restart and data base recovery mechanism is the primary problem discussed in this paper. However, this mechanism depends on the solution to other system problems. To provide a background to the mechanism problem and its solution, we offer a brief explanation of the several related problems and their solutions.

The hardware configuration selected to accomplish the basic system functions is shown in Figure 1. All trunk interfaces to the PABX and the AUTOVON switch are controlled by the Trunk Interface Controller (TIC), which also performs preemption/diversion in coordination with the Attendant Interface Controller (AIC). Because reliability is an important criterion, we were forced to design the TIC to include a degraded form of preemption/diversion. Both functions, which are heavily data base oriented, can be performed by the TIC if the AIC is down or if the AIC-TIC communication link is down.

The AIC also maintains human (man-machine) interfaces. In a distributed system, such as this one, non-Read-Only-Memory (ROM) stored data base must be downloaded to the TICs. Data base items are entered into the AIC and then relayed to the TICs via a serial channel. The operator may also make data base changes via the input device to the AIC. In addition, the AIC decides which trunk is to be preempted, and further controls the diversion process. Such decisions are based on a centralized data base scheme involving preemption diversion queues, status of all system trunk usage, statistics, and the like. This centralized data base consists of the following: (1) inputs received during initialization; (2) status updates received from the TICs during normal system activities; and (3) operator inputs.


PBX
0
31
160
191
HYBRIDS
TRUNKS
SIGNAL UNITS
0
31
1
N
TURRETS
LAMP DISPLAYS
TIC
TIC
1
AIC
6
TTY
HYBRIDS
TRUNKS
SIGNAL UNITS
160
191
TO AUTOVON

SYSTEM BLOCK DIAGRAM

FIGURE 1

Since the system must be highly reliable, our design ensures that the interface unit will continue to function despite most system problems. Of the several problems we faced, the most complicated was building the data base that could maintain its credibility under the following conditions: (1) in system initialization; (2) in the AIC if the TIC is down; (3) in the TIC if the AIC is down; and (4) in the system if both an AIC and a TIC are down. The solutions to these problems are discussed in the remainder of this paper.

Approach

System initialization for our system is the same as in any distributed system(1); that is, all distributed units must be initialized as operational/non-operational by the master unit, and synchronized with the rest of the system. Our distributed system is unique in that the AIC controls the man-machine interface. All non-ROM data base items (classmarks) must be read in through this interface and transmitted to the appropriate microprocessors. All microprocessors, when started or restarted, must be vectored to zero. This zero location forces a jump to the initialization routines.

The initialization sequence is controlled by the AIC, which queries all microprocessors (TICs) via the serial channel. The AIC logs units as non-operational (down) when they do not respond to the startup message within a specified time period. If the units respond to the message within a specified time period, then the AIC logs them in as in the startup mode. During system initialization, only startup or non-operational (down) status can be logged for the units. Operational status will be received under another set of conditions, which are described later in the paper.

Once the AIC receives status from all units, it stores this information in its data base and logs it on the output device. A request is then made on the output device for a data base that is read into the AIC. Data items (classmarks) are then stored in its central data base. Unique data base items are transmitted to each TIC and must be acknowledged via the communication protocol. Non-responsive TICs will have their trunks logged in as out-of-service by the AIC to protect them from preemption processing. Responsive TICs are logged as operational, thereby indicating that the system is now on line as logged on the output device. TICs begin scanning trunks and reporting status to the AIC after they receive a start command from the AIC. Figure 2a shows the entire sequence of events.

The TIC initialization sequence is slightly different from that of the AIC's. The TIC vectors to zero for startup or restart, initializes its tables and variables, and sets a time-out during which a startup message is expected from the AIC. When the TIC receives the startup message, the timer is deleted and the TIC returns its status which, in this instance, is startup. When the classmarks are received at the TIC, they are stored in tables, all trunks are marked "insane", and the TIC awaits the start command from the AIC. The AIC and TIC are marked as operational and the TIC begins scanning the trunks only after receipt of the start command. As the TIC scans the trunks, it stores trunk state data and transmits them to the AIC. This sequence permits deletion of trunks from the out-of-service state (i.e., the initial state) for logging into the appropriate state. Figure 2b illustrates the sequence.

INITIALIZATION OF SYSTEM

AIC STARTUP

AIC | **TIC**

AIC VECTORS TO ZERO

- INITIALIZE RAM TABLES
- TRANSMITS STARTUP MESSAGE

STARTUP MESSAGE →

- SET TIMER FOR TIC RESPONSE

← STARTUP RESPONSE

- DELETE RESPONSE TIMER
- TRANSMIT TRUNK CLASSMARKS

TRUNK CLASSMARKS →

- SET TIC's TRUNKS TO NON-PREEMPTIBLE
- TRANSMIT START COMMAND

START COMMAND →

- MARK TIC OPERATIONAL

FIGURE 2(a)

TIC STARTUP

TIC | **AIC**

TIC VECTORS TO ZERO →

- INITIALIZE RAM TABLES
- SET TIMER FOR AIC STARTUP MESSAGE ARRIVAL

← STARTUP MESSAGE

- DELETE STARTUP TIMER
- TRANSMIT STARTUP RESPONSE

STARTUP RESPONSE →

← TRUNK CLASSMARKS

- STORE TRUNK CLASSMARKS IN TRUNK STATUS BLOCKS
- MARK ALL TRUNKS INSANE

← START COMMAND

- MARK AIC AND TIC OPERATIONAL
- BEGIN SCANNING TRUNKS

FIGURE 2(b)

The second problem we addressed is the condition whereby the AIC is operational and the TIC is coming back on line. A TIC is deemed by the AIC as non-operational and out-of-service when it does not respond to three consecutive messages. When the TIC is starting up, it has no knowledge of what system units are operational or non-operational. It must wait for the AIC startup message, and if it is not received within a specified period of time, the TIC transmits its own message to the AIC. The AIC responds with an operational status message followed by a trunk classmark transmission. From this point on, the system initialization steps are the same as those previously discussed and shown in Figures 3a and 3b.

In this circumstance, data bases between and among distributed microprocessors are rebuilt in real time. This is important because the trunks must be protected from use when they are unavailable. Moreover, the real-time data base rebuilding maintains the true state of the trunk throughout the initialization sequence. In addition, the need for an operator to reload the data base each time a unit or communications link goes down is eliminated.

The third problem we addressed is the condition when the TIC is operational and the AIC is coming up. In order to maintain system reliability, the TIC must assume responsibility (preemption/diversion) of the AIC for its own trunks when the AIC goes down. To do so, it marks the AIC as non-operational when the AIC is unresponsive (acknowledge/non-acknowledge) to three consecutive messages on the communications link.

When restarting, the AIC is the same as the TIC; that is, it has no knowledge of which units are operational or non-operational. To acquire this information, the AIC sends a startup message to the TIC which responds with an operational status. At this point, the AIC can begin rebuilding its data base with data received from each TIC. The procedure is initiated by a start command from the AIC. The TIC also transmits its trunk classmarks and status. These data are required by the AIC for it to rebuild its trunk status tables and preemption/diversion queues. A second AIC start command signals to the TIC that the AIC is now operational and ready for performing preemption/diversion for that TIC's trunks (see Figures 4a and 4b). The AIC follows this procedure until all system TICs are addressed and its data base totally rebuilt. Once again, the need for an operator to reload the data base is eliminated.

The fourth problem we addressed is when the AIC and one or more TICs are starting up and, consequently, there is no way to rebuild the data base for these trunks because current data are not available in either unit. A data base load is required for this condition, and the operator is alerted by a data base load request via the output unit.

To maintain system integrity and reliability, we have tried to devise a "self-healing" system. There is no functional loss in the system unless both the AIC and TIC units are down simultaneously. Of course, if the TIC is down, the trunks assigned to it are also down, there is no solution to the problem. Our hardware design supports the total system design because only one unit resides in a single file; e.g., if the file is powered down, then only one unit is affected.

TIC STARTUP

AIC OPERATIONAL

AIC **TIC**

VECTORS TO ZERO →

- INITIALIZE RAM TABLES
- SET TIMER FOR AIC STARTUP MESSAGE
- TIMER ELAPSED
- TRANSMIT STARTUP MESSAGE

STARTUP MESSAGE →

- SET TIMER FOR AIC STARTUP RESPONSE

← OPERATIONAL RESPONSE

- DELETE STARTUP RESPONSE TIMER

← TRUNK CLASSMARKS

- STORE TRUNK CLASSMARKS IN TRUNK STATUS BLOCKS
- MARK ALL TRUNKS INSANE

← START COMMAND

- MARK AIC AND TIC OPERATIONAL
- BEGIN SCANNING TRUNKS

FIGURE 3(a)

AIC **TIC**

← STARTUP MESSAGE

- TRANSMIT OPERATIONAL RESPONSE

OPERATIONAL RESPONSE →

- TRANSMIT TRUNK CLASSMARKS

TRUNK CLASSMARKS →

- MARK TIC's TRUNKS NON-PREEMPTIBLE
- TRANSMIT START COMMAND

START COMMAND →

- MARK TIC OPERATIONAL

FIGURE 3(b)

TIC OPERATIONAL

AIC STARTING UP

TIC	AIC
	← STARTUP MESSAGE
• MARK AIC IN STARTUP MODE	
• TRANSMIT OPERATIONAL RESPONSE	
OPERATIONAL RESPONSE →	
	← START MESSAGE
• TRANSMIT TRUNK CLASSMARKS	
TRUNK CLASSMARKS →	
• TRANSMIT TRUNK STATES	
TRUNK STATES →	
	← START MESSAGE
• MARK AIC OPERATIONAL	

FIGURE 4(a)

AIC	TIC
VECTOR TO ZERO	
• INITIALIZE RAM TABLES	
• TRANSMITS STARTUP MESSAGE	
STARTUP MESSAGE →	
• SET TIMER FOR TIC RESPONSE	
	← OPERATIONAL RESPONSE
• DELETE RESPONSE TIMER	
• TRANSMIT START COMMAND	
START COMMAND →	
	← TRUNK CLASSMARKS
• STORE CLASSMARKS	
	← TRUNK STATES
• MARK TRUNKS ACCORDING TO STATES	
• TRANSMIT START COMMAND	
START COMMAND →	

FIGURE 4(b)

Data Base Characteristics

In this section, we discuss data base techniques used in microprocessors. The data base had to be designed very carefully to satisfy the reliability, cost and growth requirements.

Linked lists composed of nodes from a "free core" pool have been used to conserve memory locations and produce common code usable by all microprocessors in the system. The system is designed for distributed microprocessors with limited memory. One of the best examples of this conservation of space is the preemption lists in the AIC which are set up to account for every combination of classmark and trunk state and, in addition, to eliminate the chance that a trunk identification number could appear in more than one list at any one time. Each trunk is assigned a node at initialization which is moved from list to list.

Allowable linked lists for the trunk states in this system are idle, non-preemptible, and preemptible. An example of the sublists by classmark under the preemptible trunk state is shown in Figure 5; all other trunk state sublists are of similar format.

A trunk status block in the TIC was designed to hold the pertinent information on a trunk: (1) classmark; (2) state of trunk; (3) precedence of call on trunk; (4) time-of-day when leads changed; (5) digits. The trunk status block maintained in the AIC is a subset of the status block maintained by the TIC; this subset is the data that is rebuilt during restart/recovery procedures. Any changes entered by the operator are stored in these tables and can be relayed to a TIC or AIC in a restart condition.

Summary

The set of restart/recovery problems we chose to discuss in this paper are encountered when designing any distributed processor system. Our solutions to these problems, based on distributed data bases with a centralized replicated data base, have met our requirements of reliability, low cost, and growth capability. By designing the software in both levels of microprocessors to be self-initiating, we have eliminated the constant need for human intervention for initialization and restart.

PREEMPTION LIST

PREEMPTIBLE: IMMEDIATE (P2)

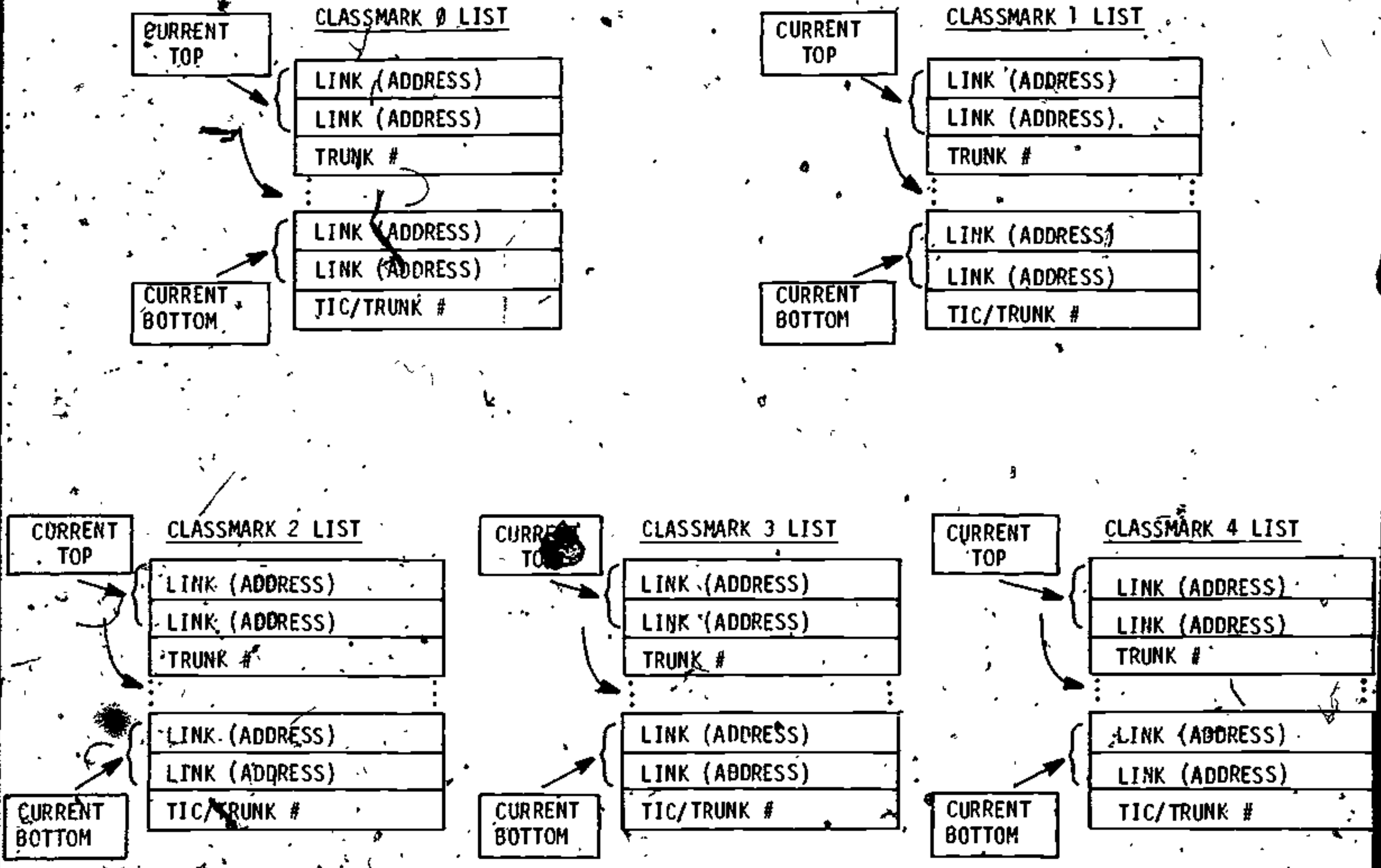

CLASSMARK 0 LIST
CURRENT TOP
LINK (ADDRESS)
LINK (ADDRESS)
TRUNK #
LINK (ADDRESS)
LINK (ADDRESS)
TIC/TRUNK #
CURRENT BOTTOM
CLASSMARK 1 LIST
CURRENT TOP
LINK (ADDRESS)
LINK (ADDRESS)
TRUNK #
LINK (ADDRESS)
LINK (ADDRESS)
TIC/TRUNK #
CURRENT BOTTOM
CLASSMARK 2 LIST
CURRENT TOP
LINK (ADDRESS)
LINK (ADDRESS)
TRUNK #
LINK (ADDRESS)
LINK (ADDRESS)
TIC/TRUNK #
CURRENT BOTTOM
CLASSMARK 3 LIST
CURRENT TOP
LINK (ADDRESS)
LINK (ADDRESS)
TRUNK #
LINK (ADDRESS)
LINK (ADDRESS)
TIC/TRUNK #
CURRENT BOTTOM
CLASSMARK 4 LIST
CURRENT TOP
LINK (ADDRESS)
LINK (ADDRESS)
TRUNK #
LINK (ADDRESS)
LINK (ADDRESS)
TIC/TRUNK #
CURRENT BOTTOM

FIGURE 5

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FOOTNOTES

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Evolving the CAROT System

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Abstract

The Centralized Automatic Reporting On Trunks (CAROT) system has been developing over a period of almost ten years. During this time, the minicomputer-based CAROT Controller has also been evolving, both in hardware and software architecture, and in function. This paper deals with the rationale behind such evolution. The CAROT story is not unique, but is typical of many of the minicomputer-based Operations Support Systems in use in the Bell System today.

Introduction

As the size and complexity of the telephone network grows, the need increases to provide means for monitoring the performance of the network. CAROT, Centralized Automatic Reporting On Trunks, is a system designed to aid the telephone companies in testing the over 6 million trunks which make up the telephone network connecting central offices throughout the country. Originally introduced in 1973, the CAROT Controller provided a much needed means for centralizing trunk testing over a wide area.

Since that time, CAROT has been evolving to meet user needs. This evolution has proceeded in a logical progression by first providing basic testing capabilities, then adding increased testing flexibilities, and finally adding much increased administrative capabilities. Alternatively, the growth can be viewed as a progression from providing a basic rigid automatic testing capability, adding manual user capabilities to increase its flexibility, and then providing the user with means for adding "customized" capabilities. Presently CAROT is evolving into a component of a network of modules which function in a synergistic manner to provide powerful maintenance tools for the Bell System.

The CAROT I System

The original CAROT concept was to replace test frames, located and operated in each central office, with a minicomputer based CAROT Controller at a central location and trunk access and measurement equipment called Remote Office Test Lines (ROTL) at central office locations (1,2,3). This concept has operational advantages, since the responsibility for routine testing is placed in one organization. In addition, it has economic advantages, since the ROTLs are simpler and less expensive than test frames, and since the CAROT Controller's data base is simpler to update than test frame control media.

The configuration of the CAROT System is shown in figure 1. The CAROT Controller dials up the ROTL in the originating office of the trunk, controls the test call setup to the terminating test line, and controls the measurement. Originally the access and measurement equipment consisted of:

(1) A ROTL to terminate the call from CAROT, access the trunk to be tested, and coordinate operations in the Central Office,

(2) A Responder to perform the transmission measurements, and

(3) A 105-type test line to terminate incoming test calls to the Responder and provide the ROTL access to the Responder when testing originating trunks.

Later designs, known as mini-ROTLs, have integrated these functions in a single unit for Step-By-Step and No. 3 ESS offices. A mini-Responder integrates the functions for terminating service only.

The software system of the CAROT I Controller reflected its test frame heritage. At night, during routine testing, it would sequentially read through 14 test files and simultaneously control testing over 14 test ports — imitating 14 test frames with a common controller. The test files resembled test frame control tapes in structure and content. In the morning an analysis program would run which would print out two transmission reports, a transmission improvement report and an immediate action report. The printouts were punched on paper tape for sending to the control offices on off-line teletypewriters. Data base administration was improved over test frames by providing a master file for each office on a cassette tape. Utility programs were run during the day to update the master files, and in the late afternoon to select trunks for testing from the cassettes and write the sequential test files on the disc.

This overall software system was very rigidly designed for routine trunk testing. The data files were specially formatted and structured for testing. These were accessible only to software designed for some anticipated purpose. The software allowed only limited operator control, often allowing just "YES" or "NO" responses to a heirarchy of questions, although the manual nature of some functions such as test scheduling allowed some added control. The only utilities available allowed the listing or copying of specific files.

CAROT 2 and the Remote User

The original intent of the CAROT 2 system was to go beyond routine testing to "demand testing" -- persons in the central office would be able, via communication with the controller, to cause a test of 1000Hz loss, C-message noise, gain-slope, or noise-with-tone to be made using the ROTLs and Responders, and obtain the results immediately after the test was completed (4,5). Two types of remote users were provided for: those using a Teletype or CRT in the Central Office as shown in Figure 1, and those using the No. 4 ESS 51A Trunk Test Position, administratively supported by the Circuit Maintenance System 1B, another Operations Support System (6).

To accomodate these remote users, the configuration shown in Figure 2 was developed. The Remote User Multiplex is a microprocessor based device capable of communicating with up to 16 terminals using any mix of 103 or 202 type modems operating at 10, 30 or 120 characters/sec. Each of its 16 ports is capable of automatic answer, outward dialing with call progress monitoring, data set type identification and autobauding. Consequently a broad range of existing central office terminals can be used as remote user test positions.

The remote users supported by CMS 1B are connected by up to three dedicated 1200 baud links to that system.

The software structure for CAROT 2 was radically different from CAROT 1. The master data base moved from cassette tapes to a Routine and Demand Testing data base on disc. The data base system became relatively complex, consisting of a set of heirarchical files, accessible by hash code tables at multiple levels, and having numerous linked lists between related entries in separate files. This complexity resulted from a requirement to access at random a new set of trunk, test parameter, trunk group, ROTL and far end test line descriptor records every couple of seconds to support testing on 14 ports.

The operating system design was complex as well. In order to support the up to 16 remote users who could be logged on the system, a software virtual memory system was written to operate under the vendor's Real Time Executive. This CAROT Operating System manages the remote user jobs, manages main memory associated with each job, loads in 512-word application program segments for execution as required by each job, manages utility disc file space, and communicates with the data base system. The CAROT Operating System operates in a data processor separate from the test processor, formerly the CAROT 1 processor. The test processor operates as a communications processor, in particular, satisfying the 20ms polling requirement for the test ports.

It can be seen from the foregoing that the original CAROT 2 system, while offering more capability, was rigidly designed to conform to its planned trunk testing mission. Further evidence is found in the remote user language, a testing and records display command language which is largely devoid of general purpose constructs.

Utility Modules Provided to Enhance Administrative Flexibility

Soon after CAROT Centers began to test sizable numbers of trunks, it became clear that companies wished to eliminate many of the clerical functions of the CAROT Center and wished to have more flexible control over the system. As an example, most CAROT Centers manually produced some sort of management reports indicating the number of trunks in each office, the number of tests made, the percentage of trunks out of limits and so forth. Most of the information comes from a report printed by the controller, but each company grouped and summarized the basic data to fit their management structure. As a second example, companies would occasionally change the name of a central office. It was very tedious to delete and then add back into the data base all trunks terminating or originating in that office.

It became clear that the differing requirements of multiple centers could not be adequately served by simple options to centrally developed programs. Instead it was found necessary to add modular utility software through which the user could "program" the CAROT Controller. Such capability can cause disasters -- programs gone wild can "crash" the machine, user programs can interact with standard programs in mysterious ways, making help provided by the manufacturer difficult, data can be inadvertently altered, etc. Our solution was to provide a set of four programs ASIN, SELECT, EDIT, and RPG which were carefully designed to prevent users from destroying database elements and interfering with system operation.

ASIN is a program which reads through the data base and constructs a sequential file of records, which, when submitted to UPDATE would result in the recreation of an equivalent data base. It can be viewed as the inverse process of UPDATE for the "add" transaction. In addition, the file created by ASIN includes the date, time, test call disposition, and test results of the last measurements on each trunk.

SELECT allows the selection of data from various files in the data base. It has access to management summary statistical files and other semipermanent files as well as the reference data base.

EDIT is a high level text editor which operates on the contents of files created by SELECT. It is particularly useful for making global data base changes, such as replacing one central office name by another.

RPG is a subset of the well-known Report Program Generator commonly found in data processing centers. It can be used to produce the customized reports needed by each center. It can also be used to do types of data screening and editing which are too complex for SELECT and EDIT.

Administrative Aids and Added Flexibility in the Testing System

Other administrative capabilities, by necessity interacted closely with the real-time testing system, and so were accommodated by changes there. The most extensive feature of this sort is circuit order testing.

The original method of updating the CAROT data base was to collect paper copies of the circuit layout records and traffic trunk orders, and to file them until a circuit order completion notice was received. Depending on the information flow set up for a particular CAROT Center, this might be a fairly timely, but undependable, telephone call from the central office or it might be a fairly dependable, but untimely, document from some centralized circuit order control bureau. In either case the data base suffered because it was not up-to-date, or because the data input was not consistent with the physical trunk. The personnel required to file records, receive phone calls, and rectify erroneous data added to the overhead of the CAROT Center.

A Circuit Order Test and Completion (COTC) feature was added to the testing system. Using this feature, the circuit order records can be entered into a COTC data base as soon as complete information is received. When the central office completes the addition, rearrangement or disconnect of the circuit, the technician can sign on as a remote user and ask CAROT for a test by circuit order number using either the command TEST or COMP. In the first case CAROT does a test and returns the results with a pass/fail indication. In the second, the test is made and the results judged, and, if the tests passed, the circuit order is marked complete in the CAROT COTC data base. That evening, during UPDATE, the completed items are removed from the COTC data base, the necessary changes are made to the routine and demand test data base, and a tape containing the completed items and their test results is written for eventual downstream processing. A variety of administrative reports, data base displays, and pass/fail user overrides are provided to complete the feature.

The advantages of using this feature include:

(1) A CAROT demand test is easier to do than a series of manual loss, noise, and gain slope measurements.

(2) the final circuit order tests are done using the same test equipment which will measure transmission quality thereafter.

(3) Responders and ROTLs are properly built-out in class 5 offices while test positions are not.

(4) Accuracy of the data entered into the routine and demand testing data base is assured.

(5) The time between completion and update is minimized resulting in a more accurate CAROT data base.

(6) Entry of data into the COTC data base can be done ahead of time and it is automatically transfered to the routine and demand test data base, reducing peak work loads in the CAROT center.

With the availability of the system features described so far, a user can request any test or tests available in the measuring equipment to be made on any trunk or circuit order in the data base using the demand test function. But what about special commands and sequences which might be desired when the trunk was not in the data base or when trouble-shooting either the trunk, Responder, ROTL, or controller? Users wanted more "manual" capability, and the Interrogator function was provided to fill this need. Basic commands such as on-hook end off-hook may be issued by a user. Audible responses resulting from these commands may be monitored either by a speaker, in the case of a console user, or by a hardware and software tone detector for remote users. This feature is somewhat more efficient to use than hardware interrogators since the data entered at each step is remembered and the step may be repeated easily. Consequently, many CAROT Centers are using the interrogator feature to perform centralized connection appraisal tests.

Centralizing the CAROT Controller solves some problems and creates others. Reports, such as the results of routine testing are needed where personnel are available to take corrective action, usually at a central office or a Switching Control Center. CAROT I produced these results on punched tape which was then transmitted via teletypewriters to the offices. This procedure was clumsy and time-consuming considering the fact that a single controller might provide outputs for over a hundred offices. With the introduction of the remote user ports, CAROT 2 users could call into the controller with hardcopy terminals and request their results. Still, users wanted their results waiting for them at the right place when they arrived at work in the morning. Hence the automatic results dispersal feature was added. The telephone numbers of the user's terminal, together with pertinent information regarding the type of terminal, is stored in the controller's database. The Remote User Multiplex wes designed with this feature in mind, so the ability to place calls wes already available. As analysis of routine testing is completed, calls are automatically initiated to the control offices and results dispersed. Up to 16 calls can be processed concurrently.

Benefits of Modular Design - Transmission Anaylysis Reports

The ability of ASIN to generate a tape containing the contents of the deta base as well as the last test result has been used to study alternative methods of organizing transmission reports. The current philosophy of each day reporting the trunks with test results exceeding some maintenance limit has numerous defects:

(1) Reports are sent to the office regardless of whether the overall performance is statistically good or bad.
(2) Since they indicate "optional" work, some offices pay little attention to them.
(3) Some offices work all such reports driving performance above optimum.
(4) The reports are not correlated to the transmission measurement index plan.
(5) If more parameters were tested routinely, a few percent failures for each parameter would result in a long transmission improvement report.

In order to study the viability of alternative reporting methods a PL/I program wes written to analyze an ASIN tape and produce the following reports:

(1) Rank order of trunk groups in office by their impact on the transmission measurement index.
(2) Rank order of trunk groups in office by a weighted sum of the mean and standard deviations of their impairments.
(3) Rank order of facility groups in an office by a weighted sum of the mean and standard deviations of the impairments of the trunks carried thereon.
(4) Rank order of facilities throughout the CAROT Controller's area by the same statistics.
(5) Rank order of trunk groups in an office by test call setup failures.

These reports have been created for a number of CAROT Centers and tried by central office and Switching Control Center managers. There is general agreement that transmission improvement can be performed more efficiently with these reports which give a whole office perspective, provide a rank ordered list of groups needing work, and which relate directly to the index plan. At present a new transmission measurements plan is in formulation which will include this concept of off-line analysis of CAROT results as a standard method, and reports similar to those mentioned will be provided as quality control reports for company management.

Benefits of Modular Design - Gain Slope and Noise-with-Tone Testing

Gain slope and noise-with-tone measurements are currently available only as demand tests. Prior to these tests being included in the normal routine testing software of CAROT, the CAROT centers can make these measurements routinely using the capabilities provided by SELECT, demand testing, and RPG.

In order to start the process, the operator logs on as a remote user and does a trunk group display for each office to obtain a printout of the trunk group names and the number of trunks pergroup. SELECT is used to obtain a listing of all originating and terminating offices not having a 52 or 56-type Responder. This later listing is used to screen the trunk group listing and trunk groups which are not-testable for gain slope and noise-with-tone are crossed off.

Tests are scheduled manually by determining the number of testable trunks in each office and dividing by the number of testing nights that quarter. Each evening trunk groups are chosen and submitted as a remote user batch demand test. The tests are made prior to the start of normal routine testing and stay in the remote user's batch results file. In the morning, the batch results are written to a file accessible to RPG. A special RPG program is run to analyze the results, and trunks failing the immediate action limit are printed out.

Though the foregoing may appear crude by present CAROT routine testing standards, it is almost as efficient as CAROT I routine testing and is certainly superior to prior test frame methods. More notably, it represents a significiant new capability constructed out of general purpose modules.

Future Directions

The lessons learned thus far are being applied to the restructuring of the real-time system. While appliction of the concepts of structured design should result in the usual benefits of software reliability, maintainability, and extensibility, they can also permit breaking the real-time system down into a series of well defined modules, interconnected by a defined flow of data.

A module will be capable of operating on generalized service requests coming from a variety of sources. For example, a module capable of executing a test need not differentiate between routine or demand type tests, other than to direct the result back to the source. Similarly, the results of requests will be more generalized and be left in internal formats with final formatting for presentation to the user left to other software.

This type of structure will allow the background modules to interact with the real time system by writing data files which will be read by real time modules, and by reading the logged outputs of the real time modules. Thus, as an example, a user might write an RPG program to read the routine test results, analyze them for specific types of failures, compare the failures with a historical file, and write a file of trunks to be retested on the next routine test run. An additional flexibility allowed by this restructuring will be ease of interfacing to the Operations System Network, a data switching network connecting the entire set of Operations Support Systems as envisioned by the Total Network Operations Plan (7). The inputs and output of the modules can be directed to the data switching network through suitable data communications protocols. Thus, the capabilities of the real time system can be made widely available to other operations systems and their user communities. In fact, test requests by other computers are expected to eventually dominate over requests by remote users.

This opening up of test capabilities will, however, require careful specifications of features to set priorities, identify the loads imposed by directly connected and data network connected users, and control processing bottlenecks. The use of systems resources such as test ports, remote user multiplex ports, disc storage and access and processor time must be recorded so that users can be "charged" for their consumption of system resources. This is of particular importance where more than one administrative entity share the use of a controller.

Summary

Minicomputer systems such as CAROT tend to grow in predictable ways. Basic functions performed automatically are augmented to accomplish specialized functions via manual means. In addition, administrative features are added to allow customizing the system to the particular installation. Finally as automation continues to grow in the Bell System, the entire CAROT system and other similar minicomputer systems are becoming subsystems for large complexes of minicomputer maintenance systems.

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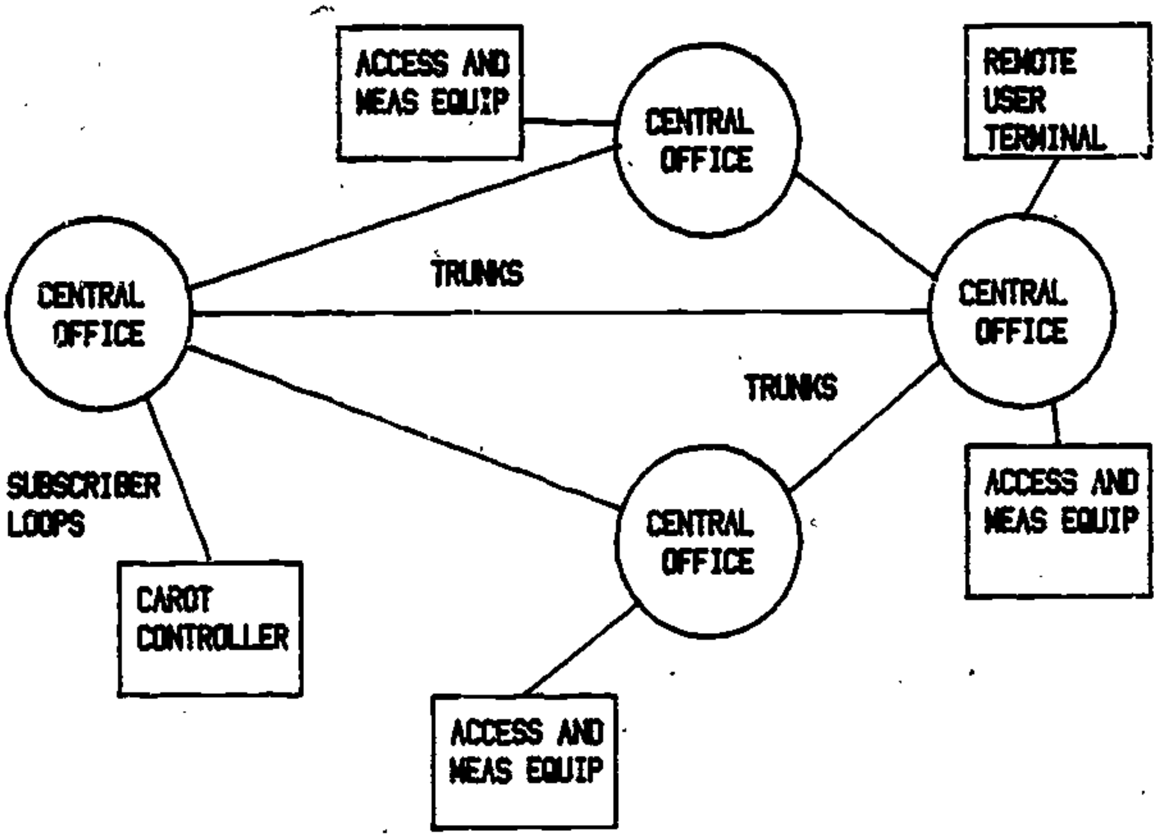
ACCESS AND MEAS EQUIP
CENTRAL OFFICE
REMOTE USER TERMINAL
TRUNKS
CENTRAL OFFICE
CENTRAL OFFICE
TRUNKS
SUBSCRIBER LOOPS
ACCESS AND MEAS EQUIP
CENTRAL OFFICE
CAROT CONTROLLER
ACCESS AND MEAS EQUIP

FIGURE 1 CAROT SYSTEM CONFIGURATION

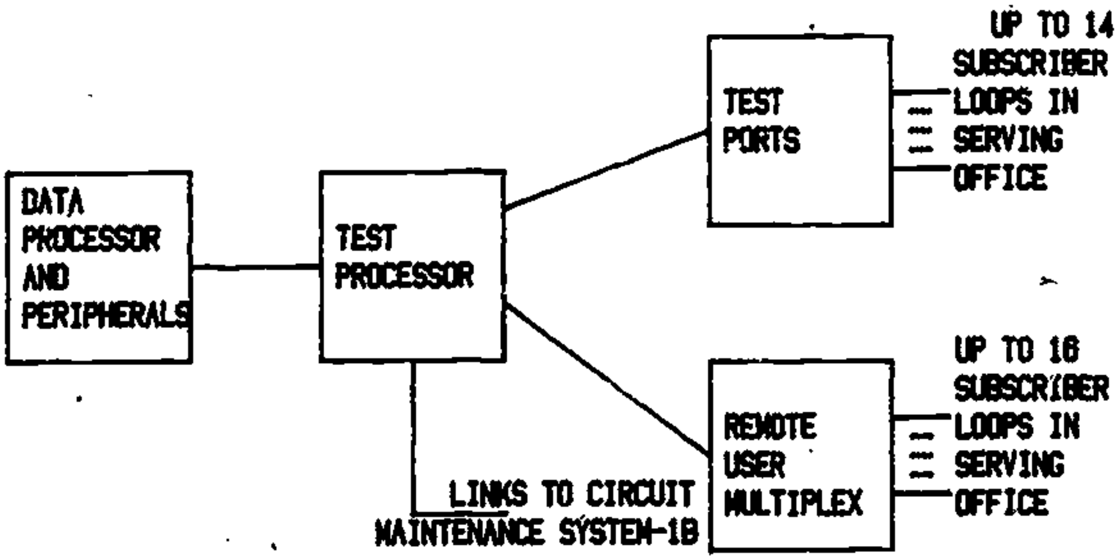
UP TO 14 SUBSCRIBER LOOPS IN SERVING OFFICE
TEST PORTS
DATA PROCESSOR AND PERIPHERALS
TEST PROCESSOR
UP TO 16 SUBSCRIBER LOOPS IN SERVING OFFICE
REMOTE USER MULTIPLEX
LINKS TO CIRCUIT MAINTENANCE SYSTEM-1B

FIGURE 2 CAROT CONTROLLER CONFIGURATION

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GTD-5 EAX BASE UNIT HARDWARE DESCRIPTION

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Abstract

A new family of digital switches for Class 5 or combined Class 4/5 applications is under development by GTE Automatic Electric. The first formal disclosure of this new product line was made at the International Switching Symposium held in Paris, France during May, 1979. The paper presented in Paris concentrated on a system level overview of the GTD-5 EAX. Extensive commonality of both hardware and software is provided between the Base Unit and the Remote Unit members of the GTD-5 EAX family. In order to limit the size of this paper, the focus herein will be solely on the GTD-5 EAX Base Unit hardware.

1.0 INTRODUCTION

The GTD-5 EAX digital family is a complete family of modular systems that can be utilized in a myriad of ways to suit present and future requirements. The marriage of a line of digital switching equipment with digital transmission makes maximum integration of outside plant and switching equipment possible.

The use of stored program and multiprocessing allows the GTD-5 EAX to meet the ever-growing demands for services and features. With this approach, the system is highly dependable, easily maintained and operationally efficient. The installation and testing efforts are greatly reduced by the extensive use of frame and module connectorization. Connectorization allows factory testing of major sub-systems prior to shipment. Growth of the system is simplified because of the modular organization of the system.

The GTD-5 EAX digital family uses LSI components, structured software, micro-computer multiprocessing techniques, and a PCM digital network. The PCM digital network of the GTD-5 EAX provides for the conversion of analog signals to digital signals and switching via the PCM digital network of digital signals between subscribers and DS-1 compatible facilities to other central offices and/or subtending remote units.

Members of the GTD-5 EAX digital family employ distributed processing capabilities to provide a more cost-effective product while providing greatly increased total processing power. The distributed processing configuration contributes to greater system modularily; controls are discrete and generally serve smaller segments of the total program than are found in a central processing configuration. These configurations provide increased design flexibility, making it easy to enhance during the evolution of the product line.

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The GTD-5 EAX digital family includes Base Units (BU's), Remote Switching Units (RSU's), and two remote pair-gain units - a Remote Line Unit (RLU) and a Multiplexer Unit (MXU). The BU serves aa the host for the RSU's, RLU's, and MXU's. The RSU may also serve as the host for RLU's and MXU's. A network diagram displaying all members of the GTD-5 EAX family is shown in Figure 1.

2.0 SYSTEM ORGANIZATION

The GTD-5 EAX is functionally divided into three major equipment groups; peripheral, network, and central control. The peripheral equipment provides an interface between the lines and trunks and the switching network of the system using three types of Facility Interface Units (FIU's) - one for analog lines, one for analog trunks, and one for digital trunks. These three FIU's are used in common with all GTD-5 EAX family members. The major network equipment in the Base Units (BU's) consists of a Time Switch and Peripheral Control Unit (TCU), Space Switch Unit (SSU), and a Network Clock Unit (NCU), providing a modular three-stage Time-Space-Time (T-S-T) network, as shown in Figure 2.

The control architecture of the GTD-5 EAX is a modular multiprocessor arrangement based on a 16-BIT microprocessor. The utilization of multiprocessing of these microprocessors establishes the real-time capacity of the GTD-5 EAX. The work load is distributed across the processors to improve the real-time efficiency and introduce flexibility for future features and capabilities. From a functional standpoint, the work load is divided between a central processor unit and a peripheral or remote processor unit. The central processor unit performs all the logical decision-making functions for processing telephone calls. The peripheral processors are tasked with functions that require a large amount of real-time related to interfacing with the telephony environment. This arrangement not only enhances real-time, but also shelters the central processor from the environment. This is accomplished by having the peripheral processors handle all such interface requirements. Communications between these two units are handled in a message format that is rigorous in nature and thus uncomplicated in the end result.

The centralized processors are the Administrative Processor Complex (APC) and the Telephony Processor Complex (TPC). The APC is provided in one work unit, whereas multiple TPC's can be engineered. The APC can readily handle all maintenance and diagnostics required for the maximum size GTD-5 EAX office.

The telephony functions associated with a given call normally will be handled by more than one TPC. Through the use of common memory, a given TPC will handle the next function, etc. This arrangement offers two advantages: traffic problems caused by imbalance are avoided, and reliability is enhanced.

There are a number of man/machine interfaces available with the GTD-5 EAX. The basic interface is via a TTY terminal for input/output messages. The GTD-5 EAX can also be equipped with a Digital Support Processor (DSP), which is a processor that will assist in formatting input/output data and collating output messages. In addition, the DSP can serve as an interface to the Network Support System (NSS) which will offer extensive network capabilities for the centralization of administration and maintenance.

3.0 HARDWARE DESCRIPTION

The GTD-5 EAX system has the following major equipment groups: peripheral, network, and central control. Peripheral equipment provides an interface between the outside plant facilities and the switching network. Network equipment provides the switching stages necessary to interconnect peripheral equipment as required to switch the calls. Central control equipment provides the processing resources required for call processing, administration, and maintenance. The Base Unit (BU) organization, by major equipment groups, is shown in Figure 2.

A detailed understanding of the GTD-5 EAX system requires an understanding of the various equipment frames used to implement the switching system and their inter-relationship. The paragraphs that follow offer detailed descriptions of the various frames that make up the peripheral, network, and common control equipment.

PERIPHERAL EQUIPMENT

The peripheral equipment in GTD-5 EAX consists entirely of Facility Interface Units (FIU's). The FIU's provide the proper interface between outside plant facilities and the switching network of the system. Three kinds of FIU's have been designed for the initial releases of the system. The Analog Line Unit Frame (ALUF) consists of a single FIU to interface up to 768 subscriber lines to the switch. The Analog Trunk Unit Frame (ATUF) consists of two FIU's to interface up to 384 analog trunks to the switch. Required analog service circuits are mounted in the ATUF. The Digital Trunk Unit Frame (DTUF) serves up to 3072 digital trunks. Duplicated control units are provided for each FIU.

ANALOG LINE UNIT FRAME (ALUF)

A fully-wired Analog Line Unit Frame has eight Analog Line Units (ALU's). Each ALU consists of 12 line cards and a dc-to-dc converter. One line card contains either eight standard line circuits (single party or multiparty) or four special line circuits (prepay coin, semipostpay, ground start). The ALUF is provided with duplicated Analog Control Units (ACU's) for access to the network.

Analog-to-digital conversion (or vice versa) is performed in the line circuit by a codec. Codecs are provided on a per-line basis. The necessary two-wire to four-wire conversion takes place in the line circuit.

ANALOG TRUNK UNIT FRAME (ATUF)

An Analog Trunk Unit Frame can interface up to 384 analog trunks to the

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switching network. One ATUF accommodates a maximum of four Analog Trunk Units (ATU's) and two duplicated Analog Control Units (ACU's). The ATU contains a maximum of 24 trunk cards.

Conversion of the analog signal into digital form (and vice versa) is performed by a codec in the trunk circuit. The required two-wire to four-wire conversion for two-wire trunks is also provided by the trunk circuit.

DIGITAL TRUNK UNIT FRAME (DTUF)

A Digital Trunk Unit Frame can interface 3072 digital trunks to the switching network. Each DS-1 span interface contains a synchronization output port which can be connected to the network clock unit for external clock synchronization. In addition, each DS-1 span interface contains a CCIS data link interface port which can be connected to the CCIS data link module to derive the 4Khz (FS bit) data channel.

A fully-wired DTUF has 16 digital trunk FIU's. Each FIU consists of eight Digital Trunk Units (DTU's) and two Digital Control Units (DCU's).

NETWORK EQUIPMENT

The Base Unit network equipment in a GTD-5 EAX forms a time-space-time (TST) switch. The major units that make up the BU network are the Time Control Units (TCU's), the Space Switch Units (SSU's), and the Network Clock Unit (NCU).

The NCU is the basic clock and synchronizing unit for the system. A duplicated NCU is contained along with a duplicated Message Distributor Circuit (MDC) on the Combined Message Distributor Circuit and Network Clock Unit Frame (CMCF).

TIME SWITCH AND PERIPHERAL CONTROL UNIT FRAME (TCUF)

A Time Switch and Peripheral Control Unit Frame (TCUF) contains a pair of duplicated Time Switch and Peripheral Control Units (TCU's). The TCU interfaces the FIU's with the space switch; a FIU is cabled to each TCU. Each TCU consists of two duplicated time-switching stages (originating and terminating), duplicated digital pads, duplicated digital tone sources, and two duplicated 16 bit peripheral processors. One TCU serves up to four FIU's.

The Originating Time Switch (OTS) in a Time Control Unit (TCU) multiplexes the channel buses from the FIU's into the network. The selected channel is stored in memory. Operation of the Terminating Time Switch (TTS) is similar to that of the Originating Time Switch (OTS). Digital pads, which are implemented by Read-Only-Memory (ROM), provide a fixed loss of 0 dB, 3 dB, 5 dB, or 6 dB for the TTS output.

Digital tone sources provide three kinds of tones: MF, DTMF, and progress tones (busy, dial, ringback, etc.). The tones are written into the unused memory of the TTS and OTS, and thus avoid the need to assign network terminations. The tones are read out under the control of a Peripheral Processor (PP).

The PP's consist of duplicated 16-bit microprocessors, which operate in an active/hot-standby mode. Each copy actually consists of two microprocessors for fault resolution.

The PP communicates with the central control processors via the MDC, over two data links between the PP and the MDC. Each PP has access to either data link.

SPACE SWITCH UNIT FRAME (SSUF)

A Space Switch Unit Frame (SSUF) contains two Space Switch Units (SSU's) and provides a 32 x 32 space switch matrix. The SSUF can be arranged for a 16 x 16 switch matrix for small offices. For large offices, the SSU can be expanded to a switch matrix of 64 x 64 through the addition of three more SSUF's. The space switch is controlled via the Space Interface Controller (SIC).

COMBINED MESSAGE DISTRIBUTOR CIRCUIT AND NETWORK CLOCK UNIT FRAME (CMCF)

A Combined Message Distributor Circuit and Network Clock Unit Frame (CMCF) is equipped with a duplicated Message Distributor Circuit (MDC) module and a duplicated Network Clock Unit (NCU) Module. The MDC is a part of the Central Control and will be discussed later.

Both copies of the NCU are synchronous to avoid any frame slip during switch-over from one to the other. The NCU can be synchronized from an external source of 1.544 MHz or 2.048 MHz (BSRF).

CENTRAL CONTROL EQUIPMENT

The central control is designed to be engineered and expanded with the office. For this reason, a variety of frame types are used in the central control. The discussion of these frames will be restricted to the basic frame types. Additional frame types will be utilized to provide capabilities beyond the basic offering.

The basic frames required to implement the central control include the Basic Central Control Frame (BCCF), Combined Memory and Interface Frame (CMIF), Administrative Control and Input/Output Frame (ACIF), and Magnetic Tape Unit Frame (MTUF).

The Basic Central Control Frame (BCCF) contains two types of processors to control the system: the Administrative Processor Complex (APC) and the Telephony Processor Complex (TPC). The two types of memory required - Common Protected Memory (CPM) and Common Unprotected Memory (CUM) - are located in the CMIF. This frame also provides the CPI which is the Common Protected

Memory Interface (CPI).

The CMCF was discussed previously with the Network Equipment because it contains the Network Clock Unit (NCU). This frame is shared with the central control since it also contains the Message Distributor Circuit (MDC). The MDC interfaces all central control processor complexes with the peripheral processors in the TCU's and with all other peripheral controllers in the system.

The ACIF is equipped with an Administrative Control and Display (ACD) module, an Administrative Control Panel (ACP), an Input/Output Module (IOM), and a Space Interface Controller (SIC) to access the space switch memories in the network. The IOM provides for interconnection to terminal-speed port devices.

Each MTUF provides up to two magnetic tape units. A maximum of 8 MTUF's can be provided.

BASIC CENTRAL CONTROL FRAME (BCCF)

The Basic Central Control Frame (BCCF) mounts two kinds of duplicated processor modules: an Administrative Processor Complex (APC) and a Telephony Processor Complex (TPC).

Two copies of the APC operate in an active/standby mode. The APC handles the administration and maintenance functions of the GTD-5 EAX. The APC interfaces with the I/O modules and Administrative Control and Display Complex (ACDC). The APC has access to both copies of the Common Unprotected Memory (CUM) and Common Protected Memory (CPM) via the Common Protected Memory Interface (CPI). It also interfaces with the Space Interface Controller (SIC), Network Clock Unit (NCU), and Message Distributor Circuit (MDC).

Each copy of the APC consists of a pair of 16-bit microprocessors synchronized at their input/output ports. Each APC copy is provided with its own dedicated internal memory (protected and unprotected), expandable to 1024K words in 64K word increments.

A single TPC will serve a small BU, additional TPC's are required in a large BU configuration to handle call processing traffic. When more than a single TPC is required, another frame called the Telephony Processor Complex Frame (TPCF) is used to provide the added TPC's. The TPC interfaces the same modules as the APC except for the Input/Output (I/O) modules, the Administrative Control and Display (ACD) module and the Network Clock Unit (NCU) module.

The two copies of the TPC operate in an active/standby mode. Each copy consists of a pair of 16-bit microprocessors synchronized at their input/output ports. A dedicated memory (protected and unprotected) is provided for each TPC and is accessible from both copies of the TPC processor.

COMBINED MEMORY AND INTERFACE FRAME (CMIF)

A Combined Memory and Interface Frame (CMIF) (fully-wired) contains a Common Unprotected Memory (CUM) module, a Common Protected Memory Interface (CPI) module, and t[illegible]mmon Protected Memory (CPM) modules. Each of these modules is duplica[illegible]hin this frame.

One Common Unprotected Memory (CUM) module provides an 18-bit 512K-word memory. The CUM contains device busy/idle data, traffic recording registers, time of day data, network map, call registers, etc. Normally a single CUM module will handle the requirements of a GTD-5 EAX office, however additional modules can be provided and are housed in a Mixed Common Memory Frame (MCMF).

One Common Protected Memory (CPM) module provides an 18-bit 1024K-word memory. The CPM contains translation data, line classmark data, calling party directory number, network management data, trunk group classmark, etc. The CPM, with a basic size of one million words, is expandable to eight million words in 64K word increments by adding CPM's. When additional CPM's are required in a GTD-5 EAX office, either a Common Protected Memory Frame (CPMF) or a Mixed Common Memory Frame (MCMF) can be added.

COMBINED MESSAGE DISTRIBUTOR CIRCUIT AND NETWORK CLOCK UNIT FRAME (CMCF)

The CMCF was previously presented with the network equipment as part of the description of the Network Clock Unit module. The Message Distributor Circuit (MDC) is a part of the Central Control. The MDC Module interfaces Peripheral Processors (PP's) and Processor Controllers (PC's) with the APC and TPC. Two copies of the MDC module operate in the active/standby mode. The MDC module can terminate the one APC and multiple TPC's, as well as sixteen (16) PP's/PC's. When the number of PP's and PC's exceeds sixteen (16), another module called the Message Distributor Expanded (MDE) is added. The MDE module is mounted on a Message Distributor Expanded Frame (MDEF).

ADMINISTRATIVE CONTROL AND IN/OUTPUT FRAME (ACIF)

The Administrative Control and Input/Output (ACIF) is equipped with an Administrative Control and Display (ACD) module, Administrative Control Panel (ACP), an Input/Output Module (IOM), and a duplicated Space Interface Controller (SIC).

Two I/O terminals are available in the ACD for two Administrative Control and Display Terminals (ACT's). The ACT will be a CRT-keyboard device capable of sending and receiving a full ASCII character set to the APC through a standard EIA RS-232C interface The ACT c[illegible] be remotely located, in which case a modem may be required.

The ACP contains system alarms, status indicators, the APC configuration display, emergency recovery displays, and miscellaneous controls. The IOM interfaces the Administrative Processor Complex (APC) with the local and remote TTY's, Magnetic Tape Units (MTU's) and Facility Test Unit (FTU) complex. The SIC module, located on the ACIF, interfaces the central control processors (APC's and TPC's) with the space switch. The SIC controls and directs the data between the central processors and the space switch memories.

MAGNETIC TAPE UNIT FRAME (MTUF)

The Magnetic Tape Unit Frame (MTUF) (fully-wired) contains two MTU's and two magnetic tape transports. The MTU serves as an interface between the Input/Output Module (IOM) and the magnetic tape transports.

4.0 SUMMARY

A new family of digital switches is in development at GTE Automatic Electric. The new family introduced advanced concepts of Base Units and Remote Units to offer unrivaled networking flexibility, distributed control arrangements to minimize start-up costs and to provide large system expansion, concurrent administrative and maintenance support systems to minimize annual charge costs, and the latest of both hardware and software technologies to ensure long term economics and flexibility. The GTD-5 EAX Family will bring to the marketplace all of the above while offering stored programmed control, digital switching with PCM compatability, and common channel interoffice signaling; three capabilities that our customers expect of us.

This paper has disclosed some details on the hardware utilized in the GTD-5 EAX Base Unit. Further papers are planned on the GTD-5 EAX Remote Units. as well as, on a number of other GTD-5 items of interest.

REFERENCES

1. Michael J. Kelly, "Study of a Rural Digital End Office",
ISS, October 25-29, 1975.

2. M. H. Esperseth, D. A. Mnichowicz, "GTD-5 EAX: A Family of Digital Switches",
ISS, May 7-11, 1979.

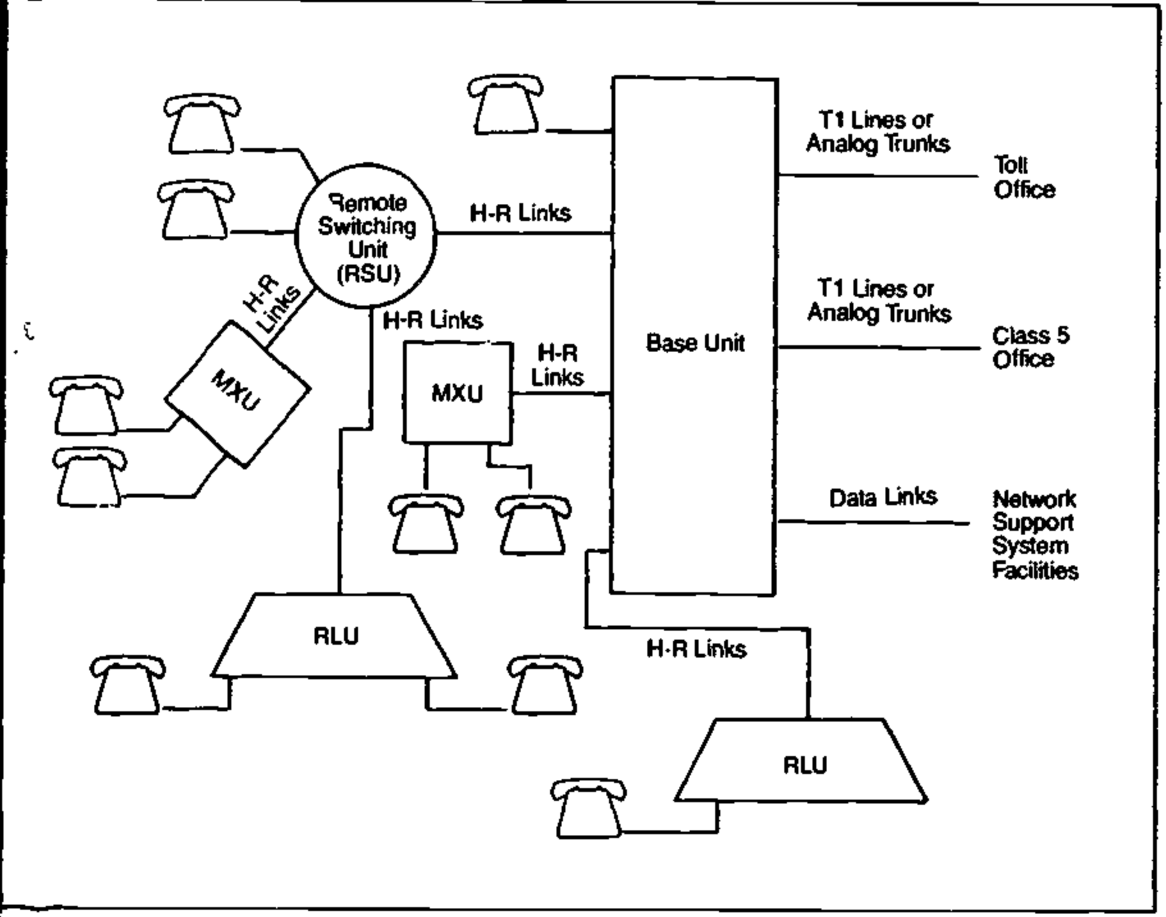

Remote Switching Unit (RSU)
H-R Links
H-R Links
H-R Links
MXU
MXU
H-R Links
Base Unit
T1 Lines or Analog Trunks
Toll Office
T1 Lines or Analog Trunks
Class 5 Office
Data Links
Network Support System Facilities
RLU
H-R Links
RLU

FIGURE 1. GTD-5 EAX FAMILY MEMBERS NETWORK DIAGRAM

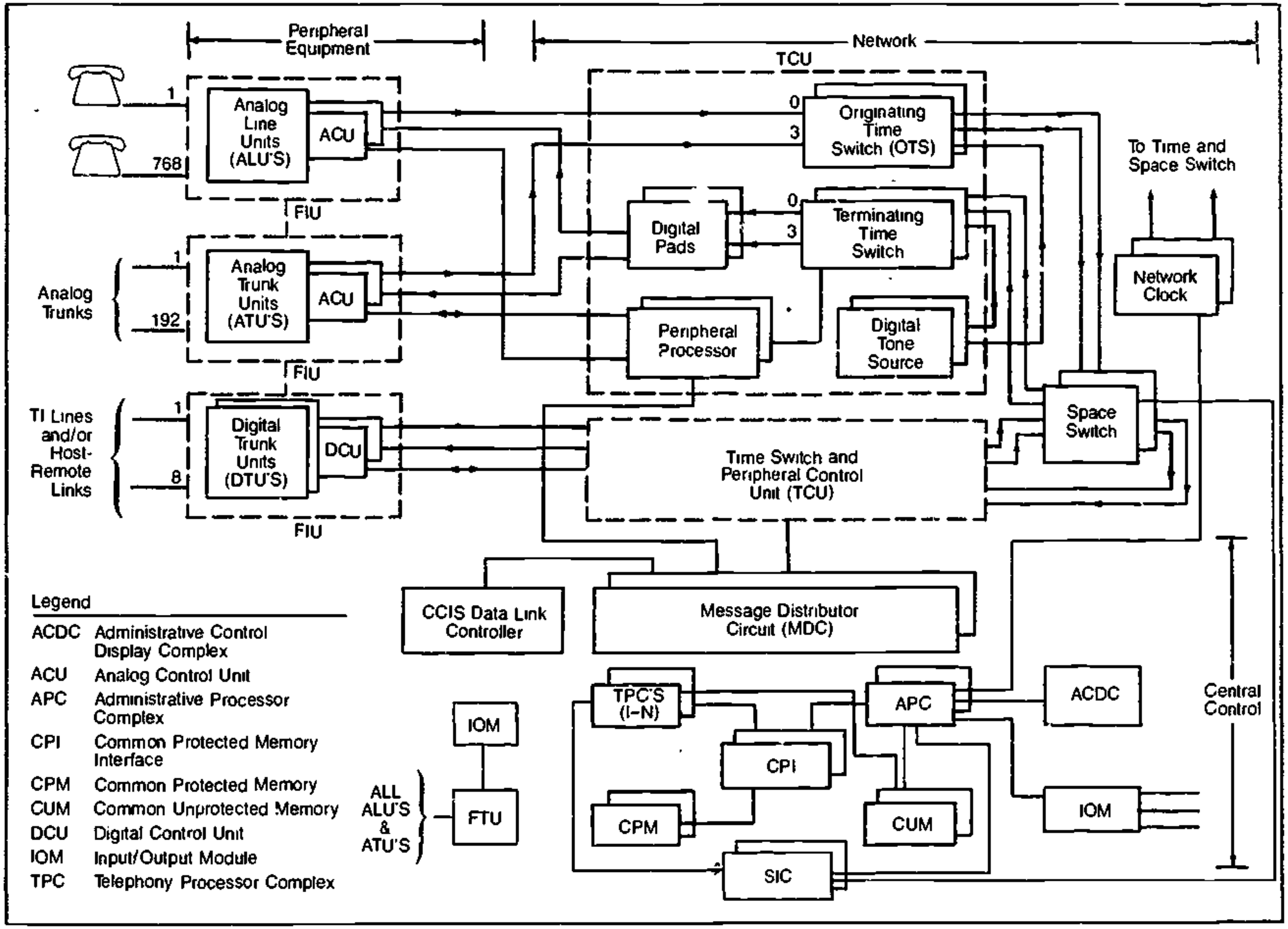

Peripheral Equipment
Network
TCU
1
768
Analog Line Units (ALU'S)
ACU
FIU
Analog Trunks
1
192
Analog Trunk Units (ATU'S)
ACU
FIU
TI Lines and/or Host-Remote Links
1
8
Digital Trunk Units (DTU'S)
DCU
FIU
0
3
Originating Time Switch (OTS)
0
3
Terminating Time Switch
Digital Pads
Peripheral Processor
Digital Tone Source
To Time and Space Switch
Network Clock
Space Switch
Time Switch and Peripheral Control Unit (TCU)
CCIS Data Link Controller
Message Distributor Circuit (MDC)
TPC'S (I-N)
APC
ACDC
CPI
CPM
CUM
SIC
IOM
IOM
FTU
ALL ALU'S & ATU'S
Central Control
Legend
ACDC Administrative Control Display Complex
ACU Analog Control Unit
APC Administrative Processor Complex
CPI Common Protected Memory Interface
CPM Common Protected Memory
CUM Common Unprotected Memory
DCU Digital Control Unit
IOM Input/Output Module
TPC Telephony Processor Complex

FIGURE 2 GTD-5 EAX BASE UNIT ORGANIZATION

TEST, MAINTENANCE AND REPAIR CONSIDERATIONS FOR DIGITAL RADIO

Gerard J. Miille and Volker B. Weise
GTE Lenkurt
San Carlos, California

Abstract

The subject of this paper is to focus not so much on the absolute performance characteristics of digital microwave radio equipment, since this subject has been covered sufficiently in the past, but on the testing and occasional repair requirements. Every system needs maintenance. It is essential to not only be able to locate failures or performance degradation quickly, but also to be able to perform tests easily and efficiently and have after completion a reasonable amount of confidence that the original transmission quality has been restored. In the following paper we will show that the IF modulation scheme, used in GTE Lenkurt 77 Series of digital radios, fulfills these objectives.

A. Introduction

With IF modulation, the microwave radio transmitter has a 70 MHz IF input and the radio receiver a 70 MHz IF output. This enables the maintenance crew to test the radio equipment back to back or over the transmission path using the same techniques as for an analog heterodyne radio. In contrast, when RF modulation is used, whereby the radio frequency signal is directly modulated by the digital bit stream, no IF is available in the transmitter. Therefore, no such transmission test using standard microwave link analyzers is easily possible. With IF modulation the digital modulator has a 70 MHz output and the demodulator, a 70 MHz input. By using an optional loop-back filter for test and maintenance between these two ports, which has the same amplitude and group delay response characteristics as the radio equipment, it is possible to also measure the quality of the modem, independent of the radio (Fig. 1). With this strategy it is quite easy to maintain, test, or repair equipment because degradation in systems performance can be isolated and the origin localized quickly.

B. Influence on the systems performance due to radio transmission equipment alignment.

Certain requirements on group delay and amplitude response have to be met by the transmission equipment in order to achieve optimum performance. There is a considerable difference in the requirements between a digital radio and an analog radio, even though the principle of test and maintenance of the microwave radio remains the same.

In the analog FM radio, the path from IF in to IF out is usually tested with a microwave link analyzer. The path including the radio has to provide flat amplitude response and group delay over the bandwidth occupied by the FM signal. The responses required for digital transmission are not flat. The transmitter output spectrum is shaped by a transmit RF output filter to confine the signal from the digital modem within the emission mask, as prescribed by the FCC rules and regulations covering digital radio. In the case of 6 GHz digital radios, the 90 Mb/s, 8-phase PSK modulator signal must be shaped to a bandwidth of 30 MHz. This transmitter output filter has a 3 dB bandwidth of fc±15 MHz. A large amount of group delay is associated with this response. The receiver amplitude shaping is almost negligible in comparison to the transmitter. To obtain the overall raised cosine shape of the signal, which is necessary to facilitate digital transmission with minimum intersymbol interference, the group delay is now partially equalized in the receiver. The resulting amplitude and group delay response maintains the transmit amplitude shape but has an equalized delay over fc±11 MHz (Fig. 4).

To complete the amplitude and group delay shaping and equalization for an overall raised cosine shape, additional filters and equalizers are used in the digital demodulator section. How accurate must the amplitude and delay characteristics be in order to obtain the desired transmission quality? The answer depends on the amount of performance degradation acceptable.

Performance of the total radio link can be described by the systems gain, which is the difference between the power level available at the antenna port of the transmitter, and the receiver threshold level. The latter depends on receiver input noise figure and the signal to noise ratio required for a bit error rate of 10^{-6}. For a BER of 10^{-6} and a receiver noise figure of 8 dB of a 6 GHz digital radio with 3 Bits/Second/Hertz this threshold level is about -70 dBm. This level is degraded due to imperfections in amplitude shaping, group delay equalization and systems non-linearities.

As can be seen (Figures 2 and 3), small amounts of amplitude or group delay slope degrade the threshold very little. For example, mistuning of the radio amplitude response slope by 1.5 dB over 70±15 MHz results in less than 0.5 dB reduction in threshold. Large amounts of detuning, though, result in total loss of the system performance. For example, a 10 ns group delay over 70±15 MHz results in a loss of reception. Generally the proper responses have to be maintained more accurately in the center of the transmission band than on the edges. For example, on the band edges, at 55 and 85 MHz, where the amplitude is down about 9 dB, a variation of ±1 dB in amplitude or ±5 ns delay results in less than 1 dB degradation in threshold (Fig. 4). Typically, measurements on radios, wherein individual units were tuned and replaced in the system, without any overall system alignment, showed a variation in threshold performance of only 2 dB, the actual threshold varying from -65.5 to -67.5 dBm.

In analog radios, much more accurate tuning is required for optimum performance at normal RF input levels. At threshold, of course, response slope-caused intermodulation noise would be overshadowed by thermal noise, but at nominal receive levels, loaded noise would increase rapidly, if, for example, the group delay equalization was poor. In an 1800 channel FDM FM system, for example, a 3 ns delay slope over 20 MHz would increase the loaded noise by 20 pW at nominal receive levels.

To summarize, it can be seen that by using IF loop back of the radio it is very easy to measure transmission parameters of the radio link, applying the same kind of tests as in analog heterodyne radios. Although the transmission characteristics are quite different in a digital radio from those in an analog radio, the accuracy requirements for digital transmission are less severe. The user can be confident that the systems performance has been restored to its original level, after units in the sytem have been replaced for repair or readjustment.

C. Digital modem parameters and their influence on systems performance

Many of the IF Modems used with current digital radios are of the 8 phase PSK type. GTE Lenkurt's type 77 digital radios include such a modem. Careful attention to system and circuit design can result in a modem of this type which affords appreciable control over the parameters that affect the quality of its operation. Furthermore, simple and reliable alignment can be realized by using a minimum of test equipment and an IF Loop Back Filter.

In the case of the 8 phase PSK modulator, the primary adverse parameter is imbalance between the 8 different phases. Optimally, the 8 phases should all be 45 degrees apart. Laboratory results show that factory alignment can easily keep the balance to within 2 degrees. An imbalance of 2 degrees degrades the receive threshold by a negligible amount.

In the demodulator, the main contributors to threshold degradation are baseband filtering imperfections, recovered carrier phase error, and recovered clock phase error. The effects of RF/IF filtering were covered previously. Factory alignment of the type 77 Digital Radio baseband filter is done under calculator control. Its amplitude and group delay response are tuned to within the same tolerance mask as the radio equipment. As can be seen (Fig. 5), if the recovered 70 MHz carrier phase error is kept small, the resulting threshold degradation will be negligible. For example, a carrier phase error of 5 degrees results in less than 0.5 dB reduction in threshold. Large amounts of carrier phase error, on the other hand, can be devastating to the demodulator performance. Reception will be lost when the phase error approaches 22.5 degrees. Generally, as in the type 77 Digital Radio, the recovered carrier is derived by an automatic phase error correction technique. Steady state phase error can thus usually be made negligibly small. Also, typical measurements of threshold variations resulting from replacing carrier recovery units with other factory tuned units were less than 0.5 dB.

We can also see (Fig. 6) that threshold degradation is negligible for small recovered clock phase errors. For example, 10 degrees of clock phase error results in less than 1 dB degradation of the threshold. Large amounts of clock phase error, as for the carrier phase error case, will cause complete loss of the signal. Recovery of the clock signal is also derived from the data. The process makes use of information about the received phase and its trajectory to provide automatic centering of the clock(1). Initial alignment of the clock recovery circuit requires a simple nulling of the fixed clock phase errors in the system. This is done using only a VOM and with the modem looped back on itself via the Loop Back Filter. Once this is accomplished, the auto correction circuitry is engaged to keep the clock phase at its optimum point. Thus, any field misalignment should be automatically overcome. In addition, clock phase error resulting from temperature variations and component aging are automatically corrected. Measurements of threshold variations resulting from replacing clock recovery units were made on a laboratory test modem. The simple alignment noted above was performed each time the unit was replaced. Results showed a threshold variation of less than 0.5 dB.

As mentioned, testing and alignment of the modem is done with the Loop Back Filter. This filter serves as a replica of the radio response. It accepts the IF signal from the modulator which is of the sinx/x form centered at 70 MHz. After passing through the Loop Back Filter, the signal is identical to what would normally be received from the radio receiver in an unfaded state. This signal, in turn, is filtered at baseband in the demodulator to give the overall raised cosine response. This arrangement allows modem testing to be accomplished separately from the radio equipment.

By comparison, most FM modems used with analog radios require field alignment which is much more involved. The field alignment generally consists of end-to-end optimization of linearity and delay equalization. This requires more complex test equipment and must generally be performed with personnel at both ends of the microwave path.

D. Conclusion

In conclusion, we have shown that, with IF modulation, looping both the radio equipment and the modem equipment at the IF ports allows straightforward and efficient testing. Furthermore, field replacement of units should cause a minimal amount of change in threshold performance. After testing or replacing a unit, a high level of confidence in the transmission quality will remain. The result is a digital radio system with very good maintainability.

Reference:

(1) R. J. Tracey and S. D. Bradley, "A Timing Phase Correction Technique for PSK Demodulators", National Telecommunications Conference Records, Dec., 1978.

IF MODULATION – IF LOOP BACK TESTING

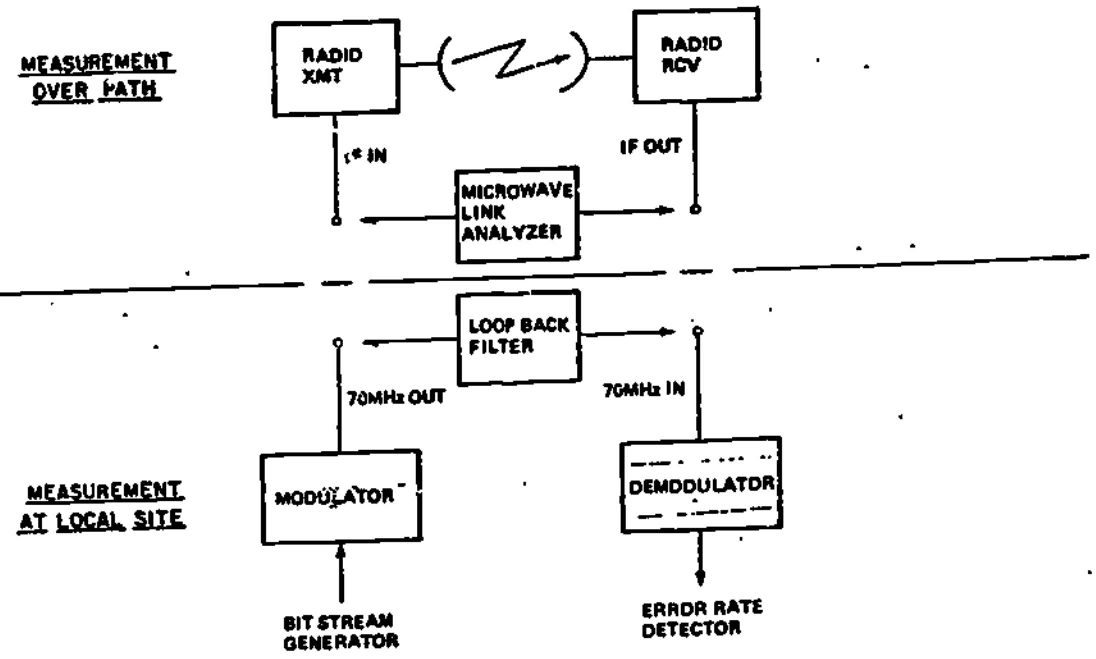

MEASUREMENT OVER PATH
RADIO XMT
RADIO RCV
IF IN
IF OUT
MICROWAVE LINK ANALYZER
LOOP BACK FILTER
70MHz OUT
70MHz IN
MEASUREMENT AT LOCAL SITE
MODULATOR
DEMODULATOR
BIT STREAM GENERATOR
ERROR RATE DETECTOR

FIG. 1

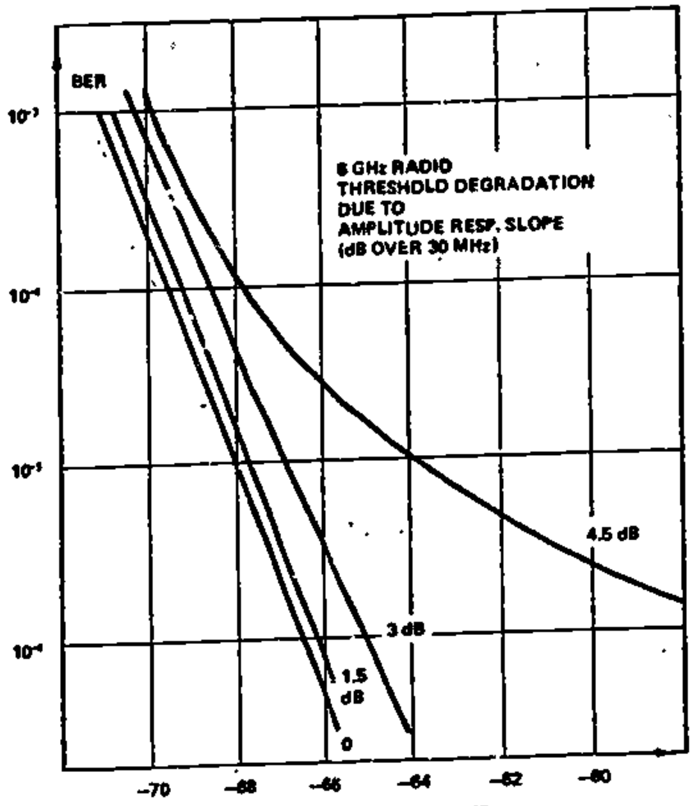


FIG. 2

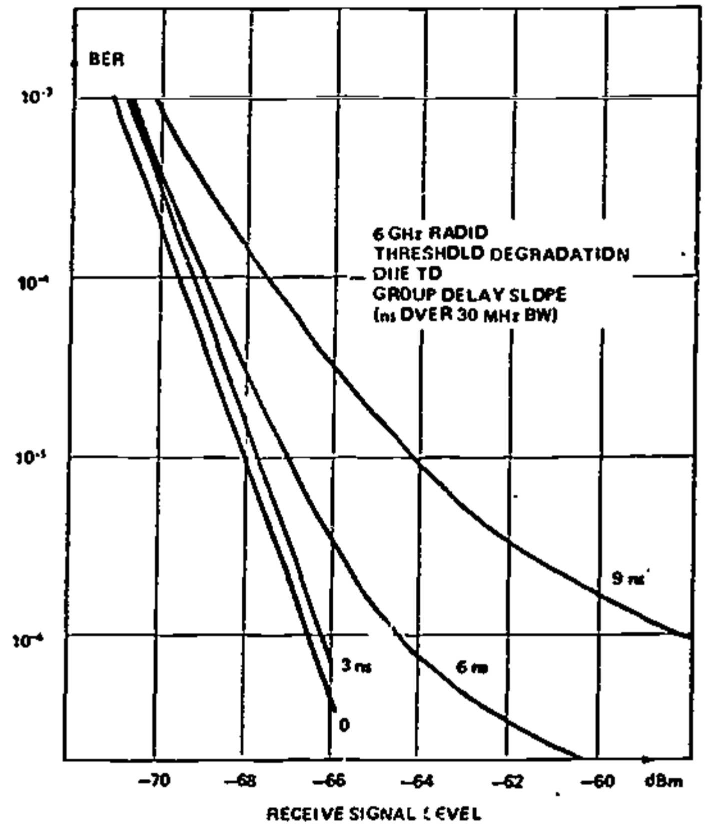

BER
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
6 GHz RADIO
THRESHOLD DEGRADATION
DUE TO
GROUP DELAY SLOPE
(ns OVER 30 MHz BW)
9 ns
6 ns
3 ns
0
−70
−68
−66
−64
−62
−60
dBm
RECEIVE SIGNAL LEVEL

FIG. 3

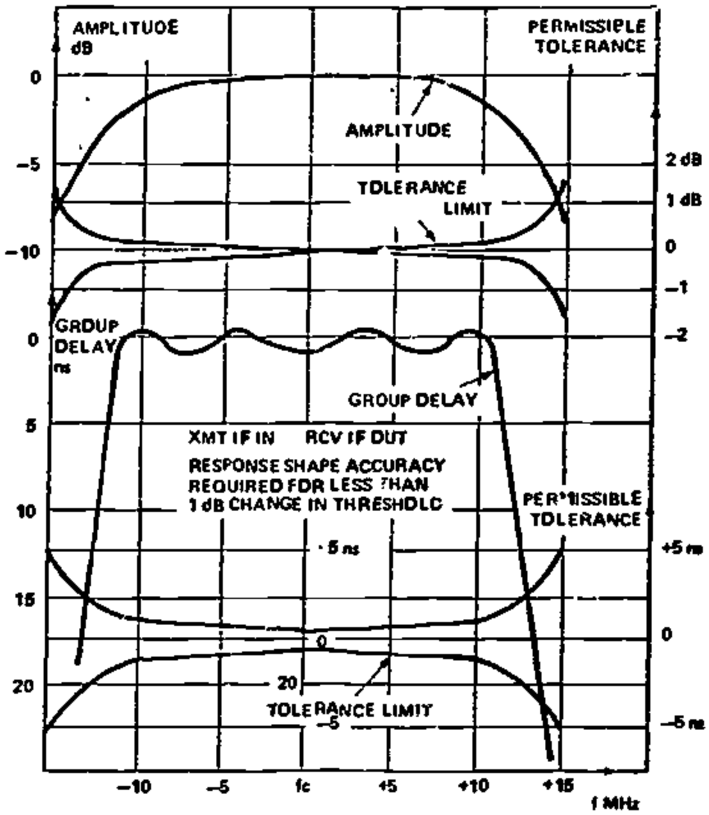

AMPLITUDE
dB
PERMISSIBLE
TOLERANCE
0
−5
−10
AMPLITUDE
TOLERANCE
LIMIT
2 dB
1 dB
0
−1
−2
GROUP
DELAY
ns
0
5
10
15
20
GROUP DELAY
XMT IF IN RCV IF OUT
RESPONSE SHAPE ACCURACY
REQUIRED FOR LESS THAN
1 dB CHANGE IN THRESHOLD
PERMISSIBLE
TOLERANCE
+5 ns
+5 ns
0
0
20
TOLERANCE LIMIT
−5
−5 ns
−10
−5
fc
+5
+10
+15
f MHz

FIG. 4

FIG. 5
DEGRADATION OF THRESHOLD DUE TO CARRIER PHASE ERROR

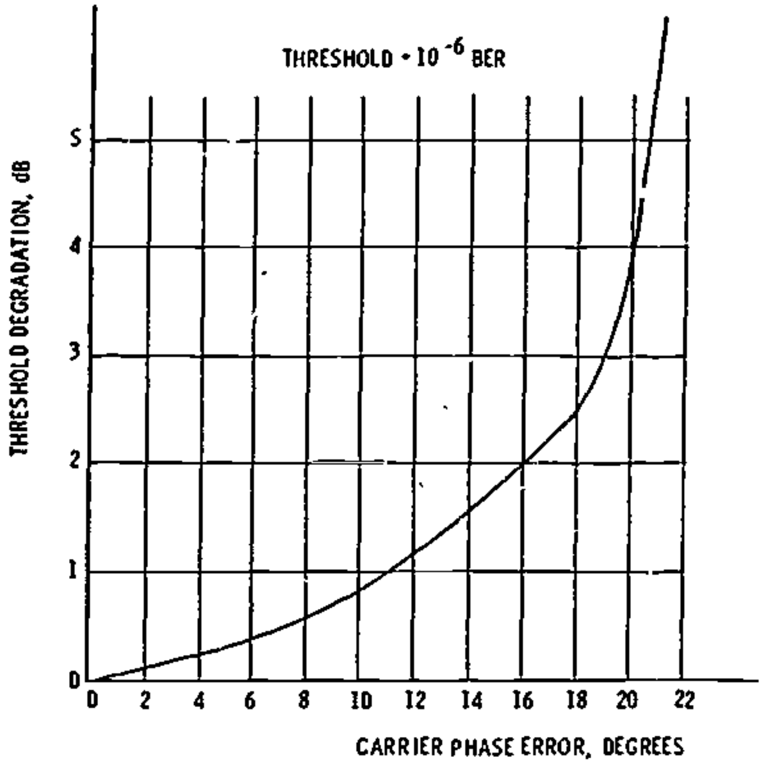
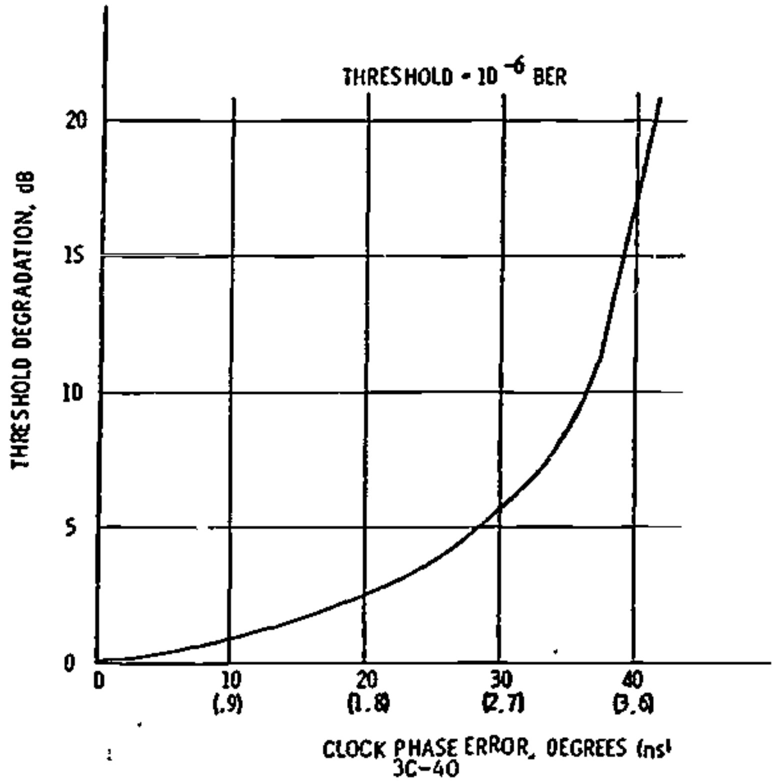


FIG. 6
DEGRADATION OF THRESHOLD DUE TO CLOCK PHASE ERROR



ELECTRICAL PROTECTION
# of DIGITAL OFFICES AND EQUIPMENT COMPLEXES

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COOK ELECTRIC
a division of Northern Telecom

Abstract

Digital offices and equipment complexes utilize more sophisticated technology, but less robust components than their predecessors. Consideration is given to means of enhancing the ability of this equipment to withstand interference on exposed terminals. These means are based on a review of interference sources, an assessment of equipment susceptibility and the application of state-of-the-art protection methodology.

INTRODUCTION

It is well known that aerial and buried cable plant can act as highways for overvoltages and overcurrents attributable to both natural and man-made sources of interference. For many years, robust electromechanical switches needed no more than carbon type discharge devices and heat coils to cope with all but extreme levels of interference introduced by these transmission facilities. The advent of solid-state electronics in the loop plant put an end to this idyllic situation. The introduction of subscriber carrier, fine gauge programs and processor controlled analog switches clearly demonstrated the interference susceptibility of these electronic systems on exposed facilities.

Experience with these systems generated a healthy respect for the outside plant environment. More important, however, was the evolution of countermeasures in the form of improved primary protection, circuit design techniques, component selection and the recognition of the need for secondary protection. Further experience with modern electronic PBXs and Key Telephone Systems highlighted the need to incorporate protection in the power pack which proved to be another interference highway.

Based on the above, it should come as no surprise that the coupling of a remote or local digital switch to the analog transmission facility can lead to formidable problems if due care is not taken in the area of electrical protection. This paper addresses these problems with particular emphasis on the electrical protection of digitally based C.O. equipment.

PROTECTION OBJECTIVES

The primary objective of protection is to safeguard personnel and equipment from the hazardous effects of overvoltages and overcurrents. The protection techniques evolved through the years have practically eliminated hazards to personnel. Therefore, consideration will herein be given to an objective that is primarily concerned with the protection of exposed equipment from the risk of physical destruction or degradation.

Central office equipment applications should generally not be limited to specific locations. Therefore, it is common practice to design this equipment so that when used in conjunction with its associated primary protector, the equipment can be employed under a wide range of conditions and at reasonable costs. A poor choice regarding a protection objective can lead to a system that is relatively immune from the worst case hazards of exposed plant but at exhorbitant cost. If users set standards that would require such a system, then the system would be overdesigned and uneconomic for use in most other applications. An equally poor choice of a protection objective would involve a "low first cost" approach that can result in a system fraught with the high repair and maintenance costs associated with frequent system outages and/or transmission degradation.

In view of the above, it is appropriate to focus attention on the optimization of the cost versus performance relationship and consider the objective of protection as: the minimization of system susceptibility to the maximum possible extent consistent with statistical information on environmental hazards and life-cycle economic considerations.

There are three basic areas wherein the susceptibility of a digitally based C.O. system can be reduced in a manner consistent with the stated objective of protection. These areas are the primary protector, the equipment, and the method utilized for grounding and bonding the system. Each of these areas will be covered after a review of relevant electrical interference characteristics and a discussion of equipment vulnerability and susceptibility.

INTERFERENCE SOURCES AND CHARACTERISTICS

LIGHTNING

Lightning phenomena have been widely investigated and much literature is available on the subject. The energy from this source of interference can be transferred to the transmission facility by means of direct, inductive, or common (ground) impedance coupling. Extensive measurements of the shape and amplitude of lightning induced longitudinal voltage surges on transmission facilities have been made on a world wide basis (1-4). A concise summary of the South African, Canadian, Japanese and U.S. studies is provided in Ref. (5). The measurements indicate that the longitudinal voltages are generally of the double exponential impulse form utilized to characterize the stroke current. (An exception to this general observation was the case of periodic type waveforms on open wire lines noted in the Canadian study reported by Bennison et al). The key waveform parameters are: crest amplitude, rise time-to-crest, decay time-to-half crest and the voltage rate-of-rise. The statistical distributions for these waveform parameters vary with the type of cable plant facility, cable make-up, soil resistivity, terminal effects, etc. Suffice to state here that all of the distributions are log-normal and that the 0.1% distribution points can be summarized as shown in Table 1. Reference to this table will show, for example, that only 0.1% of measured surges have crest amplitudes that exceeded 2000 volts on open wire, 1000 volts on paired cable and 800 volts on coaxial cable.

TABLE 1. ONE-TENTH % DISTRIBUTION POINTS FOR KEY LONGITUDINAL VOLTAGE SURGE WAVEFORM PARAMETERS

CABLE PLANT FACILITY

	Open Wire	Paired Cable		Coaxial Cable
		Aerial	Buried	
Crest Voltage (Volts): >	2000	1000	1000	800
Rise Time (Microsec.): <	2	10	10	10
Decay Time (Microsec.): >	1000	4000	4000	8000
Rate of Rise (Volts/Microsec.): >	40	25	4.5	4

At this point in time, there is a minimum of information available on longitudinal surge current distributions. Although there is considerable divergence of opinion as to the bounding value for longitudinal current on open wire conductors, conductor surge currents are unlikely to exceed 2500 amperes, except in the vicinity of a direct stroke to the line (6). The likelihood of the appearance of currents of this magnitude at the C.O. are low since open-wire is rapidly diminishing in its application and exposed open-wire interfaces to paired cable facilities are (or should be) overvoltage protected. A limited amount of field data indicates that conductor currents are unlikely to exceed 100 amperes on paired cable facilities. This would appear to be a reasonable bound since the minimum longitudinal impedance of the core-sheath circuit is in the order of 100 ohms, and the maximum longitudinal voltage is limited by the dielectric strength of the in-place cable which is less than 10 kV. This combination of maximum voltage and minimum impedance would limit the maximum conductor current at 100 amperes.

B. POWER SYSTEMS

As with lightning, the energy from power systems can be transferred to the transmission facility by means of direct, inductive, or common (ground) impedance coupling. The interference of concern is usually attributable to abnormal power system conditions, such as power line phase-to-ground faults and crosses (contacts) with open wire, aerial or station facilities, that generate voltages and currents that are hazardous to either life or equipment. Steady state interference levels at the power system fundamental or harmonic frequencies which lie in the noise domain, are not considered here.

The interference caused by power system contacts, induction and ground potential rise is usually treated on the same basis, insofar as transmission facility protection is concerned. The reason for this is that protection measures used for one source of interference are generally effective against all three. Therefore, subsequent discussion of power system interference will generally consider all three sources on a common basis.

Statistical distributions on interference waveform parameters comparable to that for lightning are virtually non-existent, especially at the higher voltage and current levels. The lack of data can be attributed to a concentration of interest on lightning and the rare occurrence of the type of faults required to generate high levels of interference. For example, limited surveys directed toward a comparison of troubles resulting from power contacts and lightning indicate that power produced faults represent approximately 6% of all reported electrical troubles (5). In spite of the above-mentioned lack of data, some concept of the magnitude of induced voltages can be obtained from the results of a statistical analysis of Hydro Quebec and Ontario Hydro transmission and distribution networks (10 kV to 734 kV class). This analysis indicates that typical magnitudes of induced voltage range from 80 to 435 volts and worst case voltages range from 731 volts to 5287 volts.

The overall duration of high voltage type interference is usually controlled by power system protection devices. These devices typically operate on an on-off basis, thus giving rise to a multiplicity of (approximately) CW interference bursts. The timing sequence varies with the power system voltage class as well as the protective devices. Representative values range from 3 Hz to 18 Hz for the on "times" and 5 Hz to 300 Hz for the off time, with a two burst maximum on greater than 110 kV class transmission and a four burst maximum on 10 kV class transmission.

Current interruption can also occur via cable fusing or fuse link operation and is usually taken as that associated with either 24 or 26 gauge conductors. Under certain circumstances, where fault clearing may not be applicable, the only limit to the time duration of high level currents is that associated with the fuse link. The link obviously provides no time limit on a current the magnitude of which is less than that required for fusing. For example, if a 24 gauge link is utilized, it is possible for 15 amperes to flow on a steady state basis unless auxiliary protection is provided. Furthermore, when the longitudinal voltage is less than that required to operate the primary overvoltage protector, the terminal equipment may provide the only path to ground for the resulting "sneak" current unless more sensitive current limiting is utilized.

In summary, power system interference is difficult to characterize and as a result there is meager statistical data on frequency of occurrence as well as on waveform parameters. Nevertheless, it can be seen that power system interference poses a significant threat to the transmission facility since abnormal situations involving high voltages and currents do occur, and when they do, the relatively long duration of the fault permits high energy transfer to connected equipment.

C. EQUIPMENT POWFR SERVICE

Power companies strive to maintain their line waveforms within certain standards, however, these waveforms are subject to the effects of lightning, random customer loading and other factors that result in high level voltage surges. These surges can attain magnitudes that can either destroy or disrupt the operation of unprotected equipment. Although there is a lack of detailed statistical data on the parameters associated with this type of interference, available data suggests 0.1% distribution points for peak voltage transients of 10 kV for 120 volt service and 6 kV for non-rural 220 volt service.

D. PRIMARY PROTECTOR OPERATION

Conversion type interference can be generated by the non-linear operation of primary protection devices on longitudinal input waveforms. For example, the firing of a discharge type overvoltage protector is quite rapid and can lead to longitudinal output voltages with rates of decay in the order of thousands of volts/ microsecond. Additionally, the asymmetric operation of primary protectors can unbalance the line and so generate metallic voltages and currents that can be potentially hazardous to connected equipment. A detailed characterization of the significant parameters relating to this type of interference would indeed be an exhaustive task. Fortunately, these details are not necessary for our present purposes since it is reasonable to assume that: 1) the largest metallic voltages, currents and energies are less than those associated with the application of the corresponding longitudinal voltage directly across the equipment terminals and 2) the fastest rise and decay times (which can generate L di/dt or Cdv/dt problems in the connected equipment) correspond to the fastest transition times associated with the primary protection device.

E. REPRESENTATIVE TEST WAVEFORMS

So as to provide a definite (rather than statistical) basis for specifying and testing equipment withstand capability, it is appropriate to assume that interference can be characterized by representative test waveforms. Implicit in the above, is the further assumption that the magnitude and duration of the test waveforms are bounded by a primary protection device. The ultimate utility of this approach is keyed to the selection of test waveforms that are both representative of the equipment service environment and convenient to generate in the laboratory. Test waveforms that are used in practice generally reflect a high degree of conservatism. This conservatism is justified in most instances by: 1) the limited availability of statistical data relevant to the interference source being represented and 2) the uncertainties concerning the extent to which the available data is applicable to the actual range of equipment service environments. Extreme conservatism in test waveform selection is obviously limited by feasibility and economic considerations.

An example of a set of test waveforms covering the various sources of interference is contained in REA's General Specification for Digital, Stored Program Controlled Central Office Equipment (7). The characteristics of these waveforms are summarized in Table 2. Care should be exercised in the application of these test waveforms since they reflect REA's interpretation of what is representative in their area of application. This interpretation may or may not be appropriate in other situations and applications.

TABLE 2. SUMMARY OF REA EQUIPMENT TEST WAVEFORMS

INTERFERENCE "SOURCE"	PEAK VOLTAGE OR CURRENT	SURGE WAVESHAPE
Lightning (Current Surge)	500 A or Lesser Current	10X1000μs
Lightning (Voltage Surge)	1000V or $+3\sigma$ dc breakdown of arrester employed	10X1000μs
Power System	10A rms or lesser Current	11 cycles of 60 Hz (0.183 Sec.)
AC Power Service (Voltage Surge)	2500V or $+3\sigma$ clamping V of arrester employed at 10kV/μs.	1.2 X 50 μs
Primary Protector Operation	$+3\sigma$ breakdown of arrester employed at 100V/s of rise.	100 V/μs rise, decay to 1/2V in tube's delay time.

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If the equipment coordinates with representative interference bounds, such as provided in Table 2, then equipment susceptibility in actual operating environments can usually be attributed to the occurrence of interference that differs from the representative interference signal set in either magnitude or form. This would, of course, assume proper operation of the primary protectors as well as strict adherence to proper installation and maintenance practices re bonding and grounding.

EQUIPMENT VULNERABILITY & SUSCEPTIBILITY

The vulnerability of equipment connected to a metallic transmission facility follows directly from the vulnerability and susceptibility of the facility and the infeasibility of interposing interference cancelling devices between the facility and the equipment. Present state-of-the-art techniques relative to primary protection devices are limited to bounding the magnitude and duration of perturbing signals. The equipment terminals are considered to be vulnerable (exposed) to interference since these bounds are constrained to values in excess of normal line voltages by cost, complexity and compatibility considerations. In view of the large volume of in-place carbon based primary protectors, most, if not all, digital switches have been designed to coordinate with the performance characteristics of a 3 mil, air gapped carbon. This means that the withstand capability of the equipment should be greater than the maximum interference level that can be let through this type of primary protector.

Expanding the use of LSI to applications covering exposed lines can lead to an increase in equipment susceptibility, if appropriate countermeasures are not taken. The use of electronic hybrids and functional integration, wherein the transmission filter is integrated into the CODEC, are just two examples of the expanded application of LSI. It is to be noted that both of these examples involve the line interface circuits that must not only withstand the interference, coupled by the transmission facility, but must also block penetration of this interference into the space-time switching matrix and its associated control circuitry.

The withstand capability of LSI devices, as measured by their maximum voltage, current, and energy handling capability, is only a fraction of that associated with their relay, vacuum tube, and discrete transistor predecessors. The root cause of this decrease in withstand capability is the sharp increase in chip density and the resulting decrease in effective junction areas. Little information is currently available on the pulse power susceptibility of commercially available LSI devices. However, extrapolation of the performance characteristics of semiconductor and small scale integrated circuit devices would indicate that an LSI device cannot be subjected to a short duration surge, the peak value of which, is only slightly greater than surges encountered in the normal operation of the device.

PROTECTION METHODOLOGY AND DEVICES

A. THE PRIMARY PROTECTOR

The primary protector is usually located on the frame interface to the outside plant transmission facility. Its main function is to safeguard operating personnel and connected equipment from hazardous longitudinal potentials and currents. However, from a system point of view, the primary protector provides the means whereby the exposure level of connected equipment can be bounded in both magnitude and duration. Options with regard to the types of devices that can be utilized in this application are indeed limited. The expected levels of interference, coupled with the present state-of-the-art re device technology, virtually dictates the use of a discharge device as the principal element of a primary protector. For various reasons voltage clamping devices, such as avalanche (zener) diodes and the various types of varistors, are best suited for secondary protection (within the equipment).

With regard to discharge devices, the available choice is between air gapped carbons and gas tubes. Since the performance characteristics of gas tubes, such as DC and surge breakdown voltages, can be relatively tightly controlled compared to carbons, they can be utilized to obtain tighter bounds on disturbing potentials resulting from both lightning and power system interference. Limited field experience with 3 mil carbon air gap protection indicates successful digital C.O. coordination with operational environments. If this indeed proves to be the case, then gas tube protectors could be applied with a view toward substantially reducing the interference window and improving the durability of the primary protector. The reduction in the interference window could, in turn, be used to provide the system with a greater margin against interference or to ease the self protection requirements imposed on the line interface card. The present state-of-the-art in gas tube design and manufacturing technology allows the realization of these benefits at a cost that is significantly less than that attainable heretofore. This, coupled with the increased system withstand capability and primary protector durability, provides an effective and readily available means of optimizing the system's cost versus performance relationship at the primary protection level.

Up to this time, digital switches have been considered to be inherently self-protecting re sneak currents. The implication here is that heat coils are not required in the primary protector. Although there are instances where a heat coil is of questionable utility, the device can always be used to provide much more sensitive overcurrent protection than that available from the C.O. fuse link. This tighter bounding could, in turn, relieve the line interface card from the added chore and cost associated with sneak current self protection. From a system point of view, the heat coil approach offers the potential advantage of providing this protection in a readily accessible and replaceable module, thereby minimizing the need for line interface circuit card replacement.

B. THE EQUIPMENT

Establishment of the coordination capability level and the means whereby this capability level can be verified are key elements in the design of the equipment. These elements require particular emphasis during the early stages of development if costly field and service problems are to be avoided. This follows from the fact that the withstand capability of the equipment is basically determined during the circuit design and component selection stage of development. Inadequate attention to detail during this early time frame can compromise equipment service performance; as manifested, for example, by subtle changes in component values occasioned by interference levels that are less severe than those required in the design specification. These changes can generate what

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appear to be random, service affecting failures, the cause of which are difficult to detect in the field. Associated increases in trouble reports, coupled with high maintenance and repair costs, can prompt "quick-fix" solutions which escalate costs still further.

It is expected that digital switching equipment will, in the near term, continue to be designed to coordinate with a 3 mil carbon gap. If proper equipment coordination with this device is to be truly effected, then it must be recognized that:

- Nominal 3 mil gaps are characterized by large statistical variations in breakdown voltages. Representative $\pm 3\sigma$ breakdown voltage ranges are 300 to 700 volts on DC and 360 to 950 volts on surges with 100 volts/microsecond rate-of-rise.
- The carbon gap's short transition time coupled with the large statistical variations in breakdown voltages can subject connected equipment to substantial metallics with large rates of rise and decay.
- Sustained longitudinal voltages of up to 700 volts can cause hazardous sneak currents to flow through "current limiting" and battery feed resistors.

Hardening the equipment's line interface to the 3 mil carbon gap coordination level typically involves the following types of measures:

- Increasing the withstand capability of exposed components, including LSI devices.
- Incorporating secondary overcurrent and overvoltage protection based on the use of passive circuit elements, fuses, voltage clamping devices, discharge devices, crowbars and hybrid combinations thereof. Commercial LSI circuits, that are utilized on exposed lines, can be protected by discrete external devices. Custom LSI circuits can employ integral or external protection, as appropriate, to increase withstand capability.
- Increasing the value of the line interface input impedance so as to both limit sneak currents and enhance the operation of the primary protector by increasing the longitudinal voltage across its terminals. This may best apply to the line supervision circuitry and could very well involve a modest reduction in signaling range.

The coordination capability of the line interface must be considered under all line conditions. Therefore, secondary protection measures must be transparent to, i.e., not compromise, normal transmission, line testing, ringing and primary protection functions.

The power service input to the equipment should also be protected. This can be done by means of commercially available devices or integral design. These protectors are usually based on a hybrid configuration consisting of a gas tube, voltage clamping device, resistance elements and a thermal breaker.

Additional considerations regarding equipment protection encompass arcing and reactive coupling effects between lines or electrical and mechanical components that are exposed to interference let through primary protection devices. Although the potential destructive effects of arcing are obvious, it is to be understood that under certain impedance conditions reactively coupled surges can also lead to device destruction. All of this is a direct consequence of the general trend toward system miniaturization and the sensitive nature of miniaturized components. These types of problems are most likely to manifest themselves on the line interface circuit card and are quite similiar to those posed by electrostatic discharge. They can usually be solved by the same techniques (8) which are best implemented in the physical design of the line interface card and its mounting hardware.

The determination as to whether or not the "hardened" equipment does indeed coordinate with a 3 mil air gap involves the determination of the equipment's ability to withstand the interference let through this device without alteration of its characteristics. For example, the realization of strin transmission objectives such as zero-dB loss, 55 dB balance and 20 dB singing margins requires the use of precision (and sometimes) matched components. The equipment is, therefore, considered susceptible to interference levels that alter the electrical characteristics of these and other components in the PCM voice path to the extent that transmission objectives are degraded. These levels are relatively easy to determine compared to interference levels that compromise the digitally based logic circuits that are used for signaling and control purposes. In the latter circuits, considerable changes in component characteristics can take place before the occurrence of functional failure. Therefore, attention needs be focused on secondary performance characteristics of these types of circuits that provide some measure of incipient failure. Variation of operating currents, voltages, power dissipation and noise margins can be so utilized.

The assessment of equipment susceptibility corresponding to a set of interference types and levels is indeed a complex and time consuming task. Reduction of the task to manageable proportions during the design and development stage requires the equipment manufacturer to utilize a systematic procedure. The procedure should not be limited to go/no-go testing but rather to testing that provides detailed insights into the electrical characteristics of functional circuits (down to the component level) when the equipment is stressed by interference. This is best accomplished via digital computer simulation of both the circuit and interference test waveforms. It is to be noted that computer simulation, as opposed to hardware type circuit testing, can readily provide detailed data re voltage, current and power dissipation as a function of time for all circuit components. This type of simulation has the power to illuminate problem areas as indicated by parameter variation and sensitivity to interference waveform levels, thus revealing potential areas for circuit hardening as well as providing guidelines to an optimum circuit configuration. Laboratory qualification testing of the equipment would of course involve go/no-go hardware tests utilizing interference generators to drive all exposed terminals with specified test waveforms. A representative qualification testing scheme is provided in the previously referenced REA specification (7).

C. GROUNDING AND BONDING

Past experience with electronic offices indicates that the proper grounding and bonding of the C.O. equipment complex is an absolute requirement if equipment destruction and/or degradation is to be minimized. The type of grounding system usually required by electronic offices in general, and a digital C.O. in particular, is based on the single point ground concept. The single point ground isolates the digital C.O. equipment complex from all contact with external ground members, except at a single point. This is the only point where external grounds are allowed to make contact with the digital C.O. equipment complex. Isolation of the various types of grounds within the equipment complex minimizes the flow of potentially damaging extraneous currents.

A master ground bar (MGB) should be established in the C.O. as the point of termination that provides the lowest practical impedance to remote earth ground. This, in turn, dictates the MGB to be the confluence of all relevant office grounding elements. These elements are the office ground electrode system, the power systems multi-grounded neutral, the water system ground and building steel. Functionally, the MGB should also represent the single point ground for terminating ground conductors emanating from the primary protector frame, bonded entrance cable sheaths and the principal DC power room ground bar. The conductors from each of the ground elements to the MGB should be as low in impedance as is economically feasible. The same is true for the conductors that terminate on the MGB. Minimization of lead inductance is paramount insofar as surge type interference is concerned. This implies non-tapped short runs with a practical minimum of bends and proximity to metallic objects, including other conductors. Of particular importance in this regard is the placement of the MGB so as to insure that the cable sheath-to-MGB connection provides a minimum impedance path for both lightning and power system earth return currents.

Proper operation of the primary overvoltage protector requires that the device be properly referenced to ground. This implies close attention to installation and maintenance procedures re all connections in the path from the protector to the MGB. It is also worth noting that the operation of the primary protector can be suppressed if its ground potential is raised by sheath current flow through its ground return. This situation can be eliminated for all practical purposes via the direct low impedance connection of transmission facility cable sheaths to the MGB.

Special precautions need be taken to eliminate sneak ground loops in the case where a digital switch is colocated with existing step-by-step, crossbar or electromechanical ticketing equipment The high voltage and current transients associated with the making/breaking of relay or wiper switch contacts in these types of equipment can couple into the digital equipment via cable racks, frame superstructure or the power service (AC and DC). Physical separation of these equipments must also be provided so as to prevent flashover, which can result from ground potential differences. These precautions are best taken in the ground system design prior to the installation of the digital equipment.

Rigid adherence to proper grounding and bonding practice is not only required at the time of installation, but throughout the service life of the equipment. An improper (but convenient) ground connection as well as loose or corroded connections can compromise the entire grounding system. Periodic inspection and maintenance of this "subsystem" is mandatory if the destructive effects of interference are to be avoided.

FUTURE TRENDS

The factors and predicted trends that will affect the electrical protection of digitally based C.O. equipment are as follows:

- It is expected that an increase in power system exposure will be offset by a decrease in the susceptibility of metallic facilities by virtue of increasingly widespread usage of buried and underground plant as well as more intensive efforts to obtain and maintain shield continuity.

- Historical views and practices regarding C.O. grounding and bonding will change. In the past, these disciplines have not been emphasized since they made no obvious contribution to the normal operation of the telephone system. Widespread introduction of digitally based technology in the C.O. will force an emphasis on grounding and bonding with a resulting decrease in system susceptibility.
- In the near term market considerations will effectively constrain switching manufacturers to continue line interface circuit coordination with the protection capabilities of the 3 mil carbon gap. This will require line circuits characterized by a high withstand capability. During this period, the evolution of cost reduced line interface circuitry and devices will be encumbered by withstand capability considerations. Intensive efforts will be directed toward the functional integration of improved secondary protection devices as well as the development of silicon devices with inherently high withstand capability. The adoption of a coordination standard based on a state-of-the-art primary protector will offer some relief in this area.
- Extensive use of remote switches and other pair gain devices will significantly reduce the number of metallic line appearances on the primary protection frame, thus providing strong motivation on the part of users to minimize the risk of losing a multiplicity of circuits on a perturbed line. This will in turn provide pressure to enhance the performance characteristics of the primary protector and spur the development of an industry accepted standard interface specification. This specification will most likely be based on a primary protector that utilizes a low cost, relatively high performance gas tube.
- Optical fiber rather than metallic terminations on the C.O. will eliminate exposure to interference carried by the transmission facility when metallic sheaths/supporting members and C.O. powered line repeaters are no longer required. A mixed facility interface (optical and metallic) will still require equipment engineered to coordinate with the metallic facility. Although a totally optical interface will effectively eliminate the coordination problem, power service protection will still be required for C.O. equipment.
- The reduction or elimination of the C.O. protection problem occasioned by the use of metallic pair gain devices (in conjunction with high performance primary protectors) or optical fiber facilities will result in a change in protection philosophy and methodology. This change will be geared to the overall system cost versus performance relationship. As mentioned above, the move to improve the primary protection in metallic facilities will eliminate the binding constraint that exists today. The focus of attention will then be directed away from the C.O. and toward the electrical protection of remote switches, optical facility and metallic facility repeaters.

CONCLUDING REMARKS

Effective electrical protection of a digitally based C.O. complex requires detailed attention to the significant parameters characterizing the interference to which the equipment is exposed. The minimization of equipment susceptibility requires particular emphasis during the early stages of development if costly field and service problems are to be avoided. Verification of the equipment's withstand capability can be accomplished via representative waveform testing.

Each component of the system, the transmission facility, the primary protector, the equipment and office grounding plays a key role in the optimization of the cost versus performance relationship for such a complex. Utilization of state-of-the-art primary protectors and proper system grounding can form the basis for more cost effective protection than exists today.

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FIELD EXPERIENCE AND ECONOMIC BENEFITS OF A FT-3 SYSTEM

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ABSTRACT

Prototype DS3 fiber optic transmission systems have been installed in the General Telephone System. This paper will discuss the test results of these systems, and the production equipment developed based on these results. A system description and engineering rules of a DS3 system will be discussed followed by an overview of the economics of fiber optics.

INTRODUCTION

When the development plan for a DS3 fiber optic transmission system (FT-3) was defined, part of the plan was to build prototype systems for installation in the field. By doing this we hoped to accomplish many things which are not possible in a laboratory environment. It would provide the chance to test the performance of the equipment in a realistic environment. Because of the new technology, we felt that it was important to get as much field experience in varying types of installations as was feasible. Just as important, it would allow us to get customer reactions to the equipment before we were committed to a final production configuration.

SYSTEM DESCRIPTION

Figure 1 is a photograph of a fully equipped FT-3 line terminating shelf. The line terminating shelf, a nominal 17.8 cm high, contains a maximum of three systems, each consisting of a transmit unit, a receive unit, and an alarm unit. Figure 2 is a block diagram for a terminating office configuration of one working line, a spare line, and a spare line switch. The transmit unit takes the electrical input pulses, scrambles them and converts the electrical pulses to optical pulses. The transmit unit has two alarm indicators, High Temperature and Laser Alarm. These refer to the laser diode temperature and bias current. If the laser bias current has increased beyond a preset value, the diode is considered at the end of its useful life, even though optical feedback has maintained the optical output at its correct value, and no errors are occurring in the system.

The receive unit converts the optical pulses to electrical pulses, amplifies, regenerates, and converts the pulses to a bipolar format. A pulses indicator on the face of the receive unit indicates the presence of optical pulses. If the pulses LED is lit, optical pulses of the required amplitude are being received.

The alarm unit is bridged onto the data stream in the receive unit. The alarm unit compares the receive parity with the parity bits sent by the M13 multiplexer. A difference in the two parities indicates the presence of an error. Two error thresholds are detected by the alarm unit. At an error rate of 1 x 10^{-7} a System Alarm is generated and a 1 x 10^{-7} error lamp is lit. This indicates the performance of the line has degraded and maintenance on the line should be performed. At an error rate of 1 x 10^{-5} a System Alarm is generated and a switch transfer is initiated, as the line is no longer considered to be useful. Besides the two error rate indicators, the alarm unit has a System Alarm Lamp that lights whenever an alarm condition exists in the system and an Alarm Cut-off switch used to silence the office audible alarm. The alarm unit also interfaces all alarm outputs from the transmit and receive units to the alarm panel, and spare line switch.

This system has been designed to work with a remote alarm reporting system. There are outputs to the reporting system from all indicators and inputs from the reporting system to activate all switches. This allows troubleshooting of a system in an unattended office, from a remote location.

The power supply shelf is a nominal 17.8 cm high and will hold four power supplies, any one of which can power a fully equipped line terminating shelf. The power supply shelf is arranged so that two supplies in parallel power one line terminating shelf, for full redundancy. Therefore, one fully equipped power supply shelf can power two line terminating shelves.

For the configuration shown in Figure 2, the 1:1 spare line switch should be used. The spare line switch is plugged into the third system location at the right side of the line terminating shelf. With appropriate strapping at the back of the shelf, System 1 becomes the working line and System 2 the spare line. For applications requiring more than one or two working lines, a 1:N switch should be used to reduce the number of spare systems and fibers.

SYSTEM SPECIFICATIONS

The electrical interface is compatible with the AT&T DSX-3 specifications. A maximum of 450 feet of coaxual cable is allowed between the DSX-3 cross connect point and the line terminating shelf. Line build-out networks are provided between the outputs of the line terminating shelf and the cross connect for cable lengths between 0 and 275 feet. For cable lengths between 275 and 450 feet no build-out is required. These build-out networks are located at the back of the line terminating shelf and are inserted or removed by wire straps. Line build-out networks are not required at the input of the line terminating shelf.

There are no compatibility specifications for the optical interface at this time. Table 1 shows the specifications for the system. Because of the wide variety of fiber types available, Corning Fiber has been selected as our standard. The style of cable used is not as important as the fiber, although the splice panel was designed for cables with individually buffered fibers with a maximum cross section of ten fibers.

Fiber index profile: Graded
Fiber core diameter: 62.5 um
Fiber cladding diameter: 125 um

Min section loss: 25 dB (5 dB or 15 dB with optional 20 dB or 10 dB optical pads)

Max section loss: 38 dB

Min section bandwidth: 80 MHz

Electrical interface: AT&T Compatible DSX-3

Optical interface: 44.736 Mb/sec. binary NRZ

Power source: -48V DC/-24V DC

Power consumption: 34W @ 48V DC or 24V DC

Temperature: 0°C to 50°C

TABLE 1. SYSTEM SPECIFICATIONS

The section loss and bandwidth in Table 1 are measured from splice panel to splice panel and do not include the splice losses inside the splice panel or the connector losses at each unit. The minimum loss from splice panel to splice panel is 25 dB. To reduce this figure to 15 dB or 5 dB, an optical pad may be added in series with the optical line. This optical pad is a short section of fiber with 10 dB or 20 dB loss that is spliced in series with the line inside the splice panel.

PROTOTYPE INSTALLATION

The first installation occurred in March, 1979 at the General Telephone Co. of Indiana in Fort Wayne. This is a 4.3 km route, all of which was in buried duct. Two cables were pulled in, a six fiber cable of standard construction and a ten fiber cable with gel filled buffer tubes, both from Siecor. Fiber attenuation ranged from 4.5 dB/km to 6 dB/km, for a spliced total of 22 dB to 24 dB for the four fibers used. Because of the low section loss, tranmitter output power was set at -6 dBm average, giving an optical receive

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level of -28 dBm to -30 dBm. With this receive level, error rate was measured at better than 1×10^{-11}.

Two systems were installed with the intention of putting one into service and using the other as a spare. After two months of testing by the operating company, 16 T1 lines were transferred to the optical system. Long term performance monitoring has shown the error rate to remain better than 1×10^{-12}.

Immediately following the Indiana installation, a FT-3 system was installed for British Columbia Telephone Co. in Vancouver, B.C., Canada. This is a 7.2 km route all in buried duct. The two fiber cable was supplied by Phillips Cables of Canada and BICC in England. Both cable types are of a loose tube construction with the Phillips cable containing both fibers in one large diameter tube. Static pressure was applied to the cable after installation. Installed end to end loss of the two fibers was 32 dB and 35 dB (1). The optical transmit power for this system was set to -3 dBm average, which makes the optical receive level (measured ahead of the receive connector) -35 dBm and -38 dBm. The error rate measured at installation was 6×10^{-11}, and long term tests have shown the error rate to be consistently better than 1×10^{-11}.

On Sept. 17, 1979 the third fiber optic system was installed in Tampa, Florida for General Telephone Co. of Florida. This is a 6.5 km route between the Westside C.O. and Tampa Main C.O. An eight fiber cable from Siecor was installed both in ducts and buried, including a 680 foot section that was buried six feet deep under the Hillsboro River. Four of the eight fibers were used for the two systems. One system is operational with the second system as a spare. The end to end loss of the system ranged from 22 dB to 25 dB; well below the maximum 38 dB allowed. During an overnight test, ten errors occurred during a twelve hour period. This was for both systems looped back to provide four tandem sections.

Preparations for an installation in Hawaii are now underway. This installation for the Hawaiian Telephone Co. in Honolulu, is the shortest, lowest loss system we have had to date. The end to end loss for the 3.6 km span, is approximately 6 dB for each of the six fibers. An attempt is being made to extend the optical input power range for high level signals, so that this installation will not require the 10 dB optical pads.

INSTALLATION RESULTS

During any field installation of prototype equipment, problems can be expected. These installations were no exception. Various problem areas were encountered that required improvement. One of the first problems found was difficulty in using the splice panel. This is where the outside plant fiber optic cable is spliced to single fiber cables for distribution to the equipment shelves. This panel had four cavities for splicing two fibers in each, mounted in a 4.5 cm high pullout drawer. In the back of the drawer is an accumulation area for the fiber when the drawer is pushed into the rack.

The outside plant cable is attached to the back of the splice panel. Its outside jacket and strength members are removed, and the buffer tubes are brought through the accumulation area to the splice tray where they are coiled ready for splicing. The single fiber cables are attached to the back of the splice panel, brought through the accumulation area to the tray where the outside jacket and strength members are removed, and the buffer tubes are coiled in the tray ready for splicing. Two problems were encountered with this arrangement. First, when the buffer tubes in the accumulation area were compressed as the drawer is pushed in the rack, they were susceptible to damage. The buffer tubes are fragile and easily pinched or kinked in the drawer mechanism if not dressed to exactly the right length. The cavities in the tray were also too small, so that when one loop of fiber was brought out for splicing, it would barely reach the splice jig. If two loops of fiber were brought out, the length was fine, but coiling two loops back into the tray after splicing was difficult to do without kinking the buffer tube.

These problems were corrected in the new version of the splice panel shown in Figure 3. The tray now has only one large cavity so that one loop of fiber is an adequate length for making multiple attempts at splicing. This resulted in a shallower drawer which required less fiber in the accumulation area. All fibers in the accumulation area now retain the protective outer jackets, so the fibers have adequate protection when the drawer is moved in and out. Also a work table has been designed that mounts on the open drawer. This provides a work surface at a convenient height regardless of the location of the splice panel in the equipment rack.

At the time these first units were designed, rack and panel connectors were not available. Therefore a bulkhead connector was chosen that mounted on the front panel. This method was found to be highly prone to damage unless adequately protected from people moving about in the aisles. Subsequently a hybrid electrical/optical connector has been incorporated. The optical connection is made when the unit is plugged into the equipment shelf. Since access to the fiber optic cable and connector is no longer necessary, this arrangement will be much more reliable.

When this project was started, the reliability of the laser diode was a major concern. During five months of operation of the first two installations, three laser diodes have failed. The failure mode has been the same for all lasers. The bias current is stable for a few montha then increases 2 mA over a period of one month, 6 mA the next month and is followed by failure in the laser shortly thereafter. This is not the expected failure mode for a laser diode. The bias current should increase to 150% of its initial value before failure is imminent.

After careful analysis of the failed laser diodes, it was found that a film had formed on the facets. This is from operating the laser diode exposed to the ambient environment. The film causes an increase in the threshold current and rapid failure of the device. The solution to this problem is a hermetically sealed laser package. The production equipment will use laser diodes manufactured by GTE Laboratories Inc (2). The results to date have been good with accelerated aging tests showing life time in excess of 10,000 hours. The packaging will be superior to what was used on the first installations. It is a hermetically sealed package containing the laser, thermoelectric cooler, and temperature sensor. A hermetic package is required to prevent moisture condensation on the facets of the laser. This moisture does not destroy the laser itself but reduces the coupling efficiency into the fiber to such an extent that the package is no longer useful. Furthermore, without the thermoelectric cooler inside the hermetic package, moisture will condense on the cooler and cause a thermal short across the device. This thermal short drastically reduces the efficiency of the cooler and causes excessive heating and consequently reduced lifetime of the laser. On the first package style, optical feedback was achieved by monitoring the rear facet of the laser diode. Although no problems have occurred with this method, the merits of an optical tap in the main fiber are being investigated. Producing a tap that is truly representative of the optical power in the main fiber is difficult and costly. From our tests so far, it appears that for a properly made laser diode, there is no mistracking between front and rear facets. Therefore a photodiode monitoring the rear facet is a much simpler and less expensive solution to stabilizing the laser diode output.

SYSTEM ECONOMICS

One of the important system parameters is costs. Both initial and long term costs are of interest. Figure 4 shows the relative first costs of T1, T1C and an optical T3 (FT-3) systems (3). This comparison includes equipment and cable but not installation or maintenance costs. The equipment first cost of an FT-3 system are quite high, especially for short systems as the amount of equipment does not change with length. By comparison the T1 and T1C systems have lower costs and short systems are by far less costly due to the reduced amount of outside plant equipment.

Figure 5 is the same as Figure 4 except it includes outside plant maintenance. The costs used are cumulative over ten years for a $30 per repeater per year maintenance cost and an annual inflation rate of 10% (4). After ten years the outside plant maintenance costs become an appreciable part of the total system cost. It now can be seen that the total operating costs for an FT-3 system are lower than T1 or T1C for system lengths over 5 Km. This shows that if a high capacity optical system is installed parallel to an established T1 or T1C route, it would be profitable to transfer existing traffic onto the optical line and do future expansion on the wire system. This would reduce the short term outside plant maintenance.

Figures 4 and 5 are based on 1979 prices. Figure 6 showns the projected costs of optical cables (5). In three years we anticipate the price of fiber will be one-half of today's prices. Also the quality of fiber is expected to increase allowing longer spans between terminal equipment. This will enhance the cost effectiveness of an optical system. The price of the terminal equipment will drop in the next few years, when optical devices are being produced in production quantities. In the not too distant future, an optical system will be cost competitive with wire systems on equipment first costs alone and outside plant maintenance costs will be just added savings.

CONCLUSION

The effort spent on installation of these prototype system has definitely proved worthwhile. Several areas for improvement have been identified. The major problem area was laser diode lifetime. After analysis of the failed diodes a new packaging method was worked out to solve the problem. The experience to date has shown that fiber optics is an excellent transmission medium. It is a very low-loss high bandwidth medium, which allows long span lengths with no active outside plant equipment. The costs of fiber cable and terminal equipment are dropping steadily. In the not too distant future, system costs will be below what can be achieved by a wire transmission medium.

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5. Information supplied by Creative Strategies International.

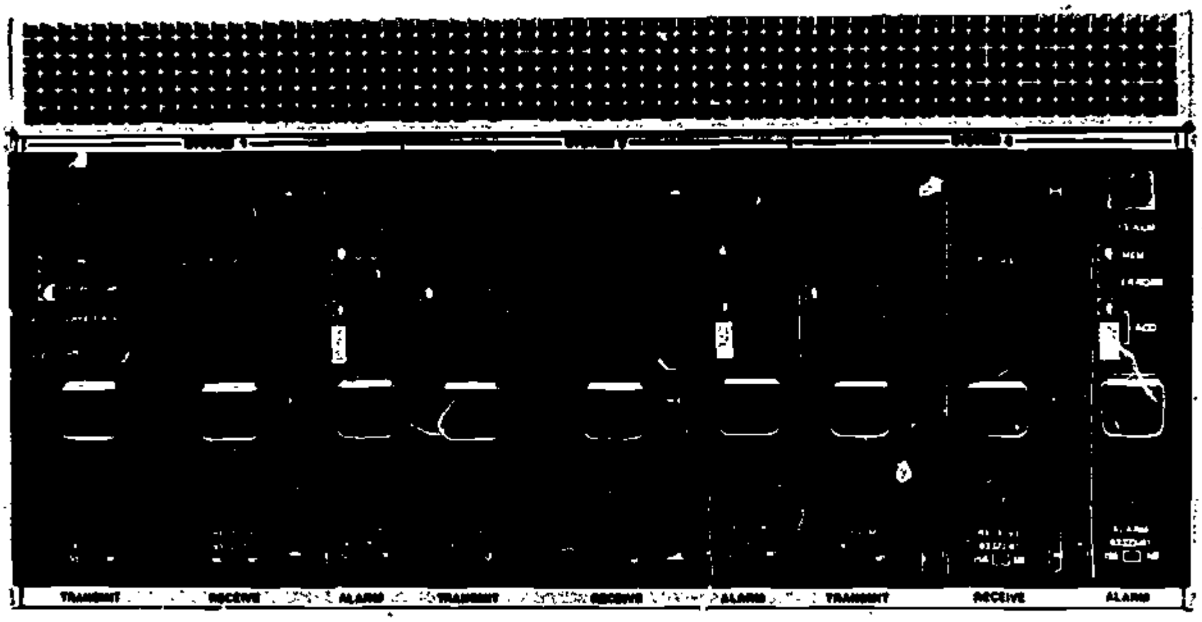
TRANSMIT
RECEIVE
ALARM
TRANSMIT
RECEIVE
ALARM
TRANSMIT
RECEIVE
ALARM

FIGURE 1. FT-3 LINE TERMINATING SHELF EQUIPPED WITH THREE SYSTEMS

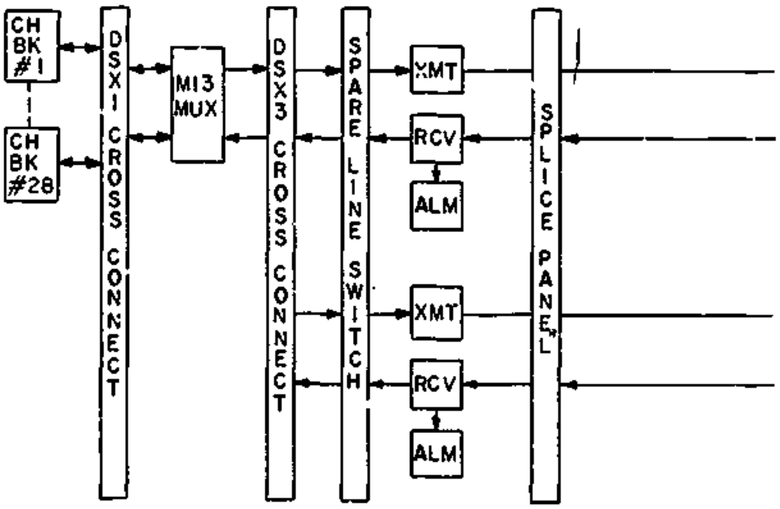
CH BK #1
CH BK #28
DSX1 CROSS CONNECT
M13 MUX
DSX3 CROSS CONNECT
SPARE LINE SWITCH
XMT
RCV
ALM
XMT
RCV
ALM
SPLICE PANEL

FIGURE 2. TYPICAL SYSTEM BLOCK DIAGRAM

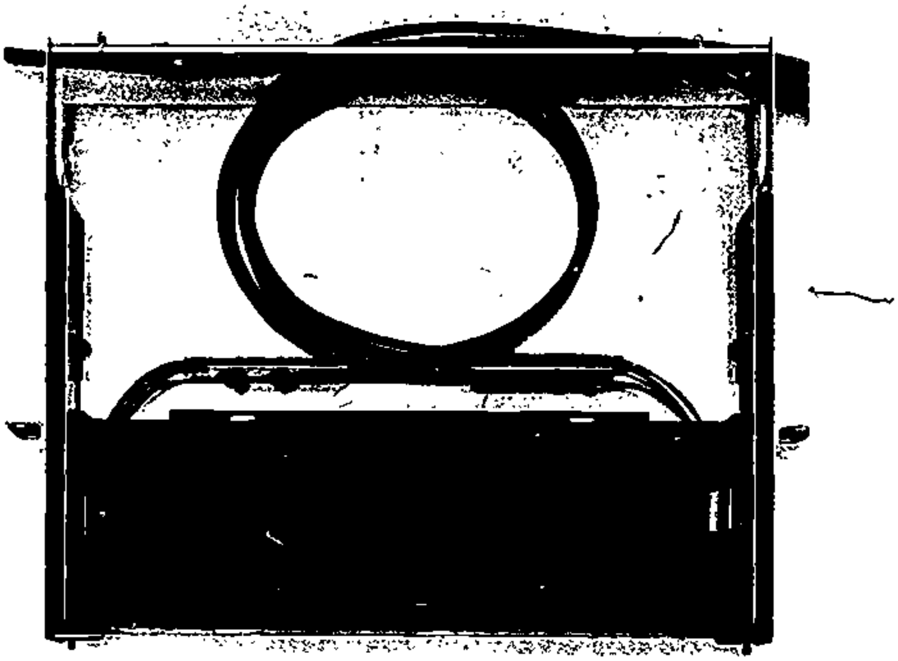

FIGURE 3. SPLICE PANEL

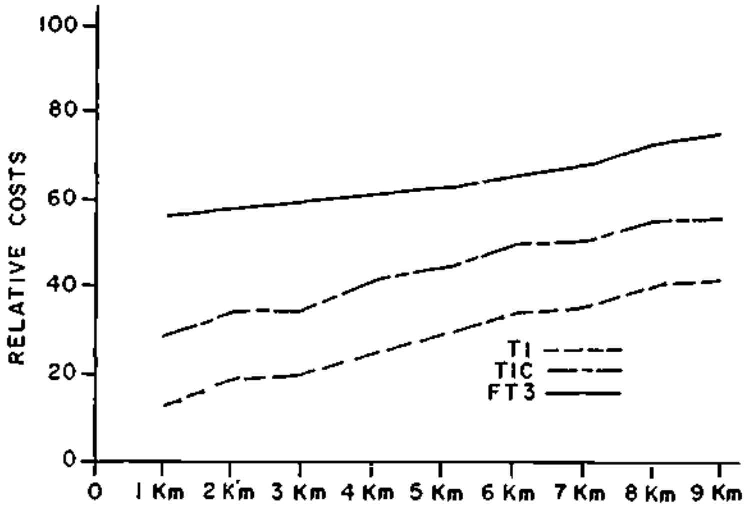

FIGURE 4. CABLE COSTS AND EQUIPMENT FIRST COSTS VS SPAN LENGTH

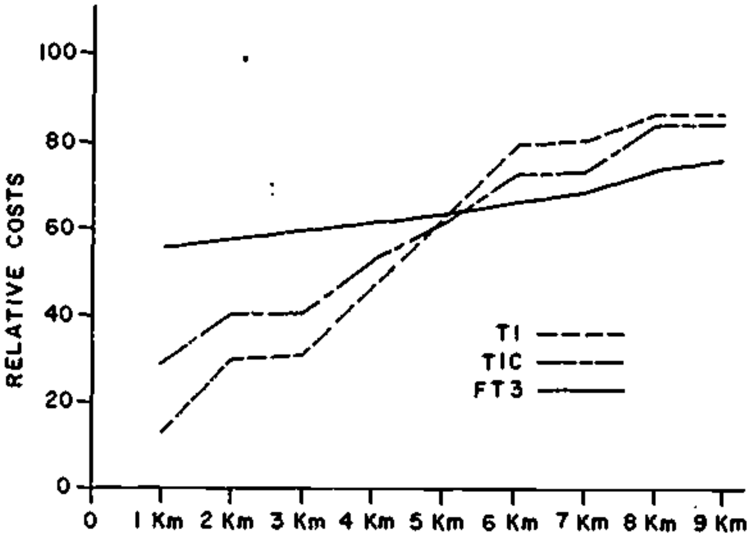

FIGURE 5. CABLE COSTS, EQUIPMENT FIRST COSTS AND MAINTENANCE COSTS VS SPAN LENGTH

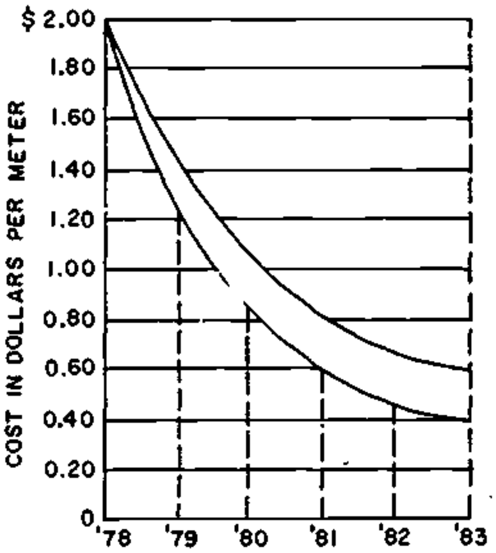

FIGURE 6. PROJECTED CABLE COSTS

713

APPLICATION OF FIBER OPTICS FOR INTEROFFICE TRUNKING AT HAWAIIAN TELEPHONE

Herman S. L. Hu and Ronald T. Miyahira
Hawaiian Telephone Company
Honolulu, Hawaii

ABSTRACT

Faced with a tremendous increase in demand for communication services, Hawaiian Telephone has investigated the use of fiber optics technology as an alternative for increasing its ability to provide these services. We have concluded that fiber optics technology is feasible now, and will be even more so as the state-of-the-art advances and new types of services materialize. This paper describes the first system implemented by Hawaiian Telephone, touches on its unique use of subducts to protect the fiber optic cable (and increase the number of cables that can be placed in a duct), and discusses the techniques used and associated rationale. This paper also forms the basis of a slide presentation, which pictorially covers the installation in greater detail, that will be given at this session of the Pacific Telecommunications Conference.

BACKGROUND

Honolulu is a rapidly developing city. Following years of heavy building construction, it is now experiencing a communications boom. The increase in business activity, especially among the service-oriented businesses which support tourism, the State's largest industry, has resulted in a tremendous demand for more as well as new services.

Local and toll calling has increased significantly because of Datatel service, Electronic Funds Transfer and similar services whose power business and consumers are now beginning to fully appreciate. Coupled with this is an increased demand for Private Branch Exchange (PBX) service, some involving private circuit distribution networks, and high speed computer communication or data transmission circuits, systems, and networks.

The upshot is a sometimes overwhelming need for new circuit capacity. As an example, trunking facilities between our Moanalua, Kalihi, Alakea, Punahou, and Waikiki central offices, which form a communication corridor from the Honolulu International Airport through the heart of Honolulu into Waikiki are bursting at the seams.

To fulfill the need for added circuit capacity, economic selection studies are regularly conducted. When the Airport-Waikiki corridor was studied in 1978, alternatives involving fiber optic technology were included. Having engineered and installed its first system in 1977 for a demonstration at Camp Smith, the Company was convinced of the technical feasibility of this new technology. The results showed that when compared to copper cables, fiber optics cables were more economical. This was largely because fiber optic cables either deferred or minimized the need to construct new underground ducts along busy city thoroughfares. Fiber optics has proven economical just to accommodate increases in existing services. Equally important, however, is that fiber optics, with the technical and operational advantages it offers, provides the means now to accommodate the new services (data, video, text, remote monitor and control, etc.) that we anticipate will materialize.

Hence, the decision was made and plans were generated to establish a fiber optics corridor between the Airport and Waikiki. Based on a study of further needs, it proved feasible to extend the corridor to include five additional central offices: Waipahu, Pearl City, Aiea, Puuloa, and Kaimuki. As shown in Figure 1, this means that by 1984 our fiber optics corridor will traverse essentially all of metropolitan Honolulu.

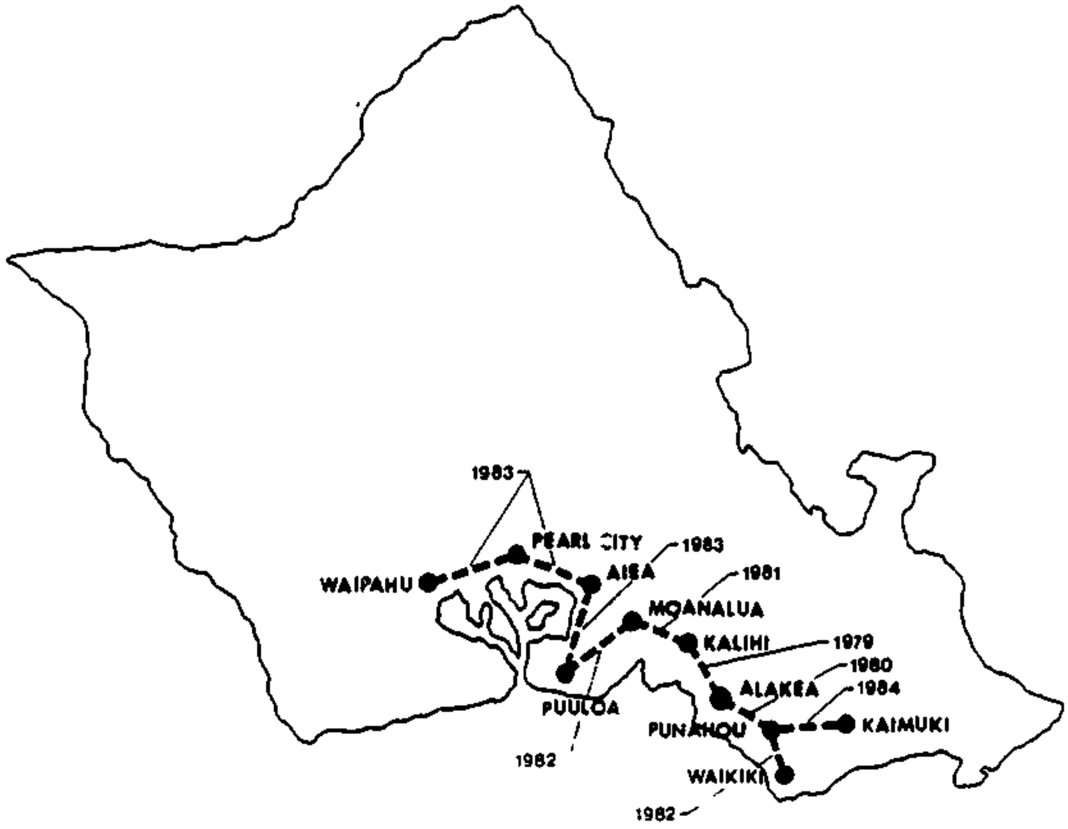

FIGURE 1
PROGRAMMED FIBER OPTIC ROUTES
(1979-1984)

SYSTEM DESCRIPTION

The Company's first permanent system involves a 4 kilometer route between the Kalihi and Alakea central offices in Honolulu. It is a T3 (44.736 MBS) system with a capacity for 672 voice channels, Figure 2 shows the route schematically. Splice points are denoted by circles.

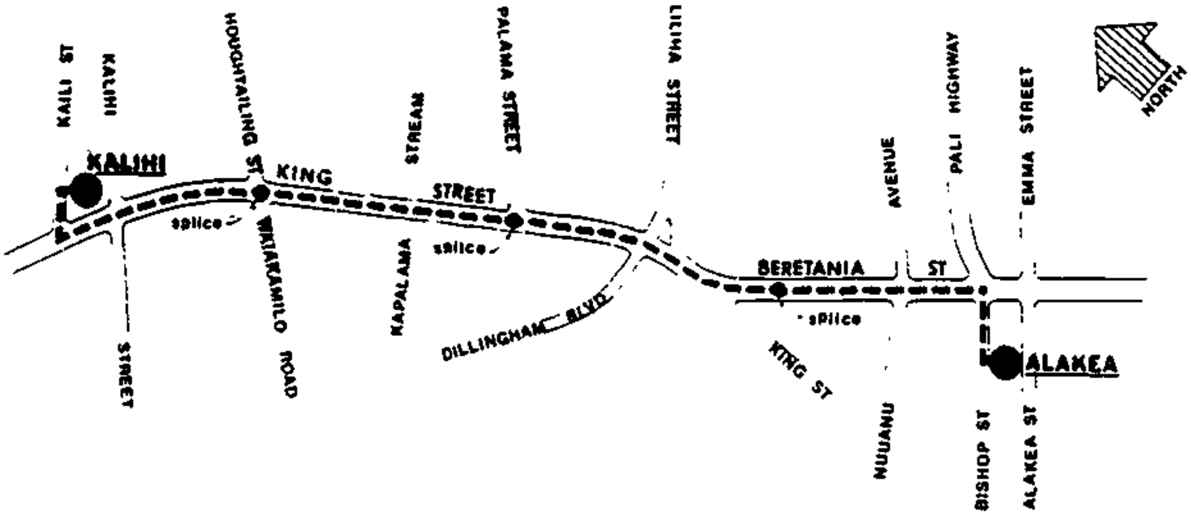
KAILI ST
KALIHI
KALIHI
STREET
HOUGHTAILING ST
splice
WAIAKAMILO ROAD
KING
STREET
STREAM
KAPALAMA
splice
PALAMA STREET
DILLINGHAM BLVD
LILIHA STREET
BERETANIA
ST
splice
KING ST
AVENUE
NUUANU
PALI HIGHWAY
BISHOP ST
EMMA STREET
ALAKEA ST
ALAKEA
NORTH

FIGURE 2
KALIHI / ALAKEA
FIBER OPTICS CABLE ROUTE

INTRODUCTION

In 1978, it was determined that an increase in circuit capacity on the route between our Kalihi and Alakea central offices was required to accommodate a continued demand for new services. The conventional approach would involve the placement of new copper cables and major expenditure to install ductlines to augment the existing system along a major thoroughfare in the heart of Honolulu. The ductlines, besides being expensive, would require the tearing up of streets and inconveniencing of residents, commuters and merchants. Optical fiber technology offered a more attractive approach.

ADVANTAGES

In theory, the use of glass fibers under appropriate conditions is quantitatively more sensible. Some of the advantages supporting the use of fibers are:

1. Immunity to EMI (Electromagnetic Interference).
2. Non conductivity of electrical current.
3. Low transmission loss.
4. Wide bandwidth.
5. Small size and light weight.
6. Environmental stability.

As related to our application, these advantages resulted in cost savings by preventing the construction of new ducts. In addition, the fiber cable required no repeaters whereas even a coaxial cable system of equal circuit capacity would have required them. Further, the fiber cable has a bandwidth that exceeds the capability of current fiber optic terminals. For example, commercially available terminals have a maximum bit rate of 90 megabits per second, whereas the fibers in our cable are capable of 500 to 900 megabits per second. This means that as terminal technology advances, the capacity of the fiber optic system can be increased with no change in the fiber optic cable itself.

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In the basic system scheme, (see Figure 3) 24-voice channels are multiplexed at the T1 rate of 1.544 megabits per second. 28 of these T1 signals (672 voice channels) are multiplexed to the T3 rate of 44.736 megabits per second. The T3 signal is then fed to the fiber optics terminal and converted into infra red light pulses by an injection laser. The laser light pulses are transmitted over the fiber to the opposite terminal where an avalanche photo diode detector converts it back to an electrical T3 signal. The multiplexers convert this signal back to 28 T1 signals and so on, reversing the process at the transmit end. The fiber optic terminal was manufactured by GTE Lenkurt and has a guaranteed bit error rate of 10^{-9} or 1 error in 984 million bits. The T3 multiplexer was manufactured by Raytheon.

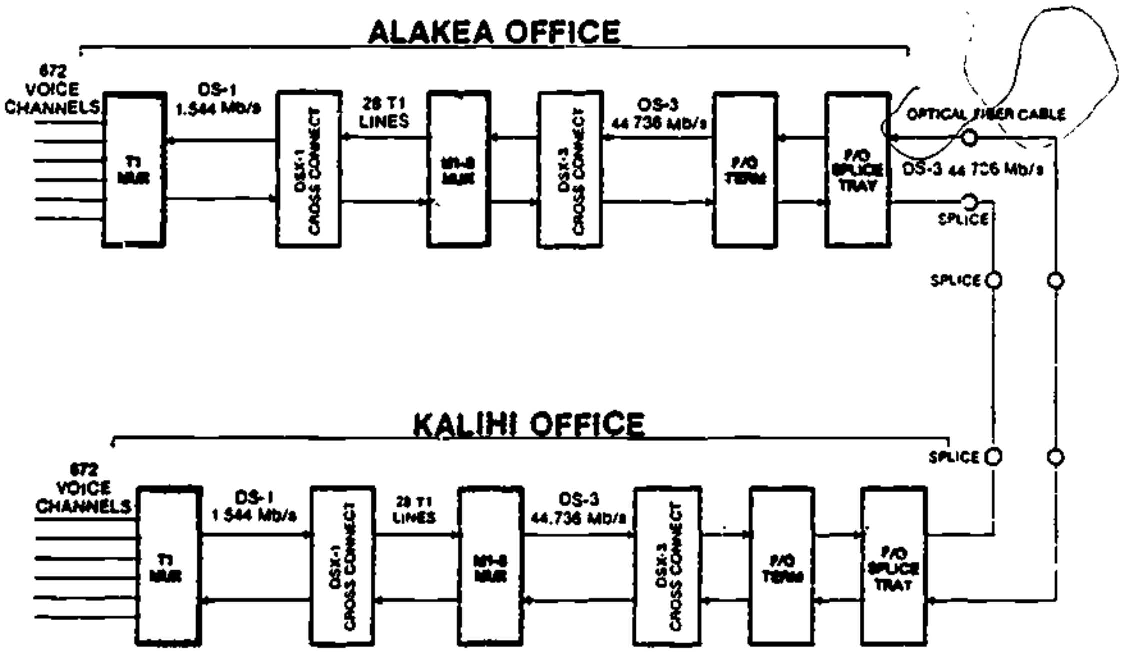
ALAKEA OFFICE
672 VOICE CHANNELS
T1 MUX
DS-1 1.544 Mb/s
DSX-1 CROSS CONNECT
28 T1 LINES
M1-3 MUX
DSX-3 CROSS CONNECT
DS-3 44.736 Mb/s
F/O TERM
F/O SPLICE TRAY
OPTICAL FIBER CABLE
DS-3 44.736 Mb/s
SPLICE
SPLICE
KALIHI OFFICE
SPLICE
672 VOICE CHANNELS
T1 MUX
DS-1 1.544 Mb/s
DSX-1 CROSS CONNECT
28 T1 LINES
M1-3 MUX
DS-3 44.736 Mb/s
DSX-3 CROSS CONNECT
F/O TERM
F/O SPLICE TRAY

FIGURE 3
KALIHI/ALAKEA FIBER OPTICS INTEROFFICE TRUNK SYSTEM

723

FIBER OPTIC CABLE MAKE-UP

The cable being used (see Figure 4) is a 10 fiber cable manufactured by SIECOR. It is approximately 5/16ths of an inch in diameter with a maximum installation tensile load of 225 pounds. A fiberglass core preserves the roundness of the cable and prevents sharp bending during installation. The Kevlar material beneath the polyurethane covering is the strength member and is intended to absorb all pulling load.

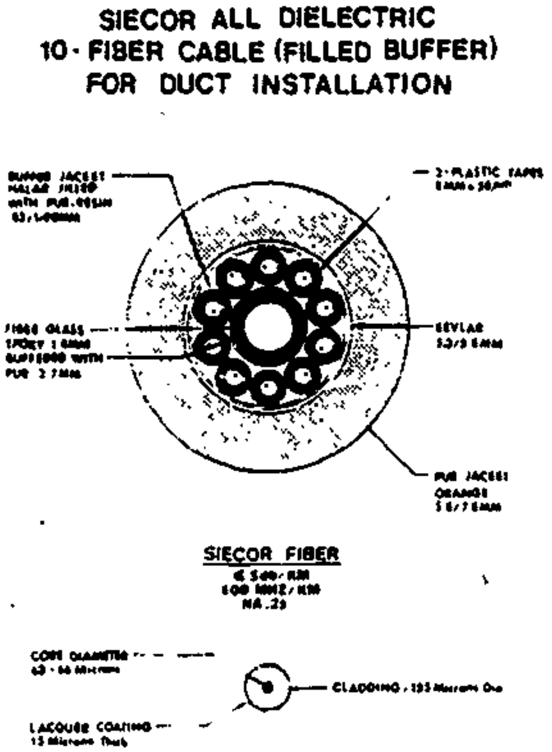
SIECOR ALL DIELECTRIC
10-FIBER CABLE (FILLED BUFFER)
FOR DUCT INSTALLATION
KEVLAR
SIECOR FIBER
CORE DIAMETER
CLADDING
LACQUER COATING

FIGURE 4

SIECOR 10-FIBER CABLE

FIBER CONSTRUCTION

Each glass fiber in the cable has a 125 micron (.005 inch) outside diameter with a core of 62.5 microns. It is a graded index fiber with a numerical aperture of .21. The attenuation is 5 dB per kilometer and the bandwidth is 400 megahertz per kilometer. Protecting each fiber is buffer tube.

The buffer used in this first HTCo. installation is an experimental polyurethane resin filler buffer. This precaution was taken because the long term effects of sea water on optical fibers is not known and the cable is installed close to sea level, unpressurized. In the future, other types of buffers (there are three basic types: the loose buffer, the filled buffer and the tight buffer, each with its own advantages) will probably be installed for comparison.

CABLE INSTALLATION

The first step in the installation was to clear all of the 4 inch ducts through which the fiber optics cables would be pulled. Next, 1 inch polyethylene subducts (with 3 foot long copper cable sections inserted into the ends to prevent their being crushed when gripped by pulling baskets), which were manufactured locally to our specifications, were pulled through the 4 inch ducts three at a time. The subducts were installed to allow fiber optics cables to be pulled without damaging those cables that are already in place. They also allow damaged sections of cable to be removed and replaced without damaging unaffected cables. We are piloting the use of subducts for the General System. Future enhancements of this technique will probably center around determining optimum ratios of subduct to duct and subduct to fiber optics cable diameters.

To pull the fiber optic cables through the subduct, a nylon pulling cord was used. The pulling cord was blown through the subduct using a special device designed by one of our construction supervisors. A cutaway view of this device, which enables a parachute to be blown through the subduct dragging the nylon cord behind it, is shown in Figure 5.

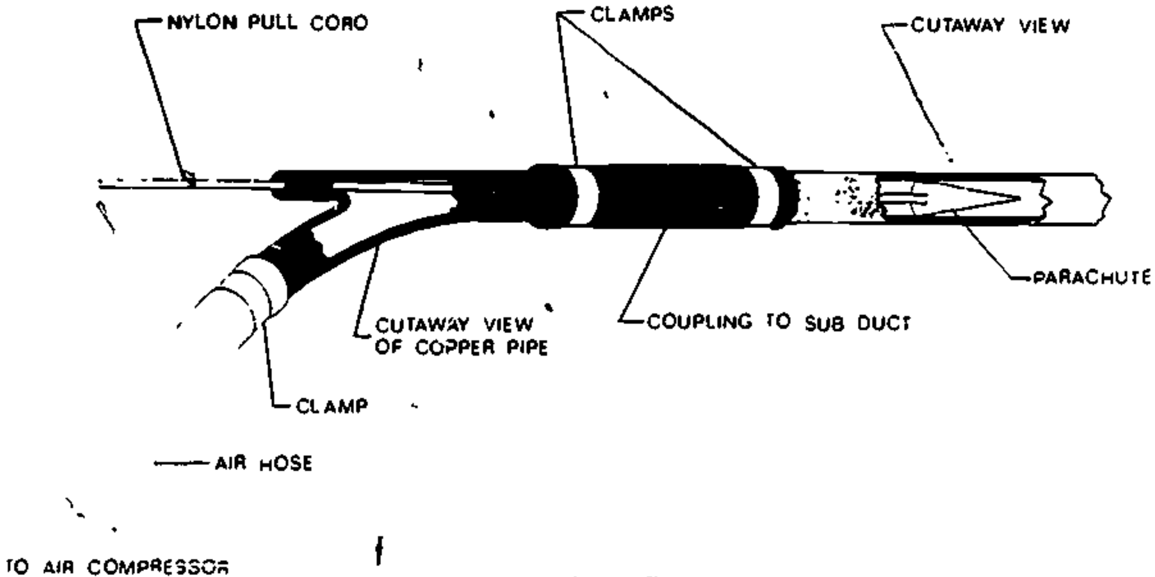

FIGURE 5

NYLON PULL CORD BLOWING DEVICE

A winch was used to pull the cable at the rate of approximately two to three hundred feet per minute. The tensile load was checked whenever the nylon cord showed signs of stretching. As the load approached 60 pounds at the winch, construction crews in the manholes pulled the cable by hand to relieve the load. Although the cable had a rated tensile strength of 225 pounds, the 60 pound limit was set as an extra precaution because with the pressing need to increase circuit capacity any delay caused by cable damage would jeopardize service. As more experience is gained in pulling fiber optics cables, we expect that the need for precautionary measures such as this will be reduced drastically. The cable sections were approximately 1 kilometer in length and were lubricated during pulling. The total length of cable on the route is 4 kilometers.

CABLE SPLICING

The current installation utilizes the fusion method of splicing. In this method, the fiber ends are brought together and placed between two electrodes. The fibers are aligned; 7500 volts are applied across the electrodes and an arc of 12 milliamperes fuses the fiber. The basic elements of a fusion splice are shown in Figure 6. The primary requirement is to have the splicer develop a feel for fusion time. Too little time produces a weak splice, too much time melts the fiber.

STARTING VOLTAGE 7.500 VOLTS
SUSTAINING VOLTAGE 500 VOLTS
CURRENT 10 - 15 MILLIAMPERES

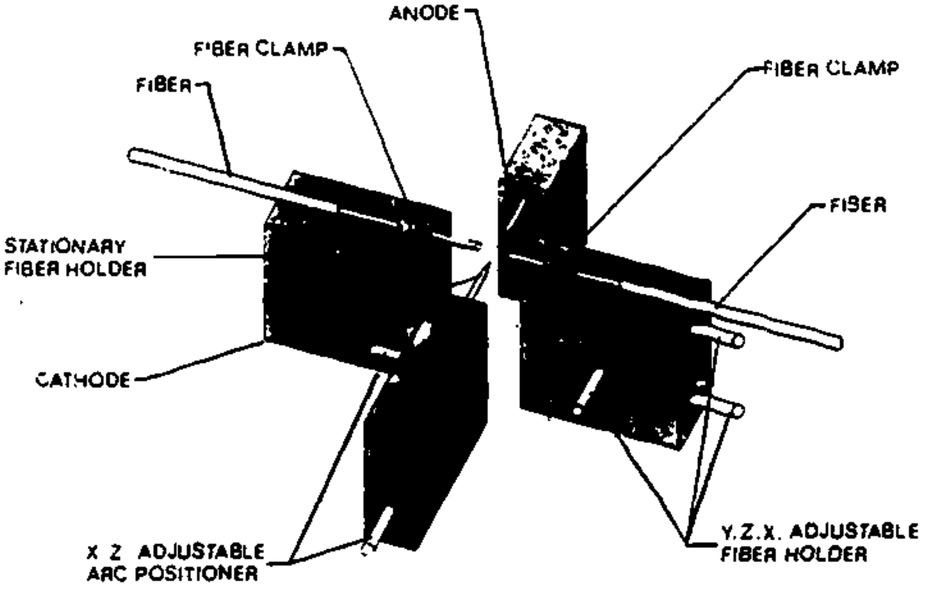

FIGURE 6
MAIN ELEMENTS OF THE FUSION SPLICER

HTCo. favors the fusion method over the other most popular method, glueing. In the glueing method, fibers are inserted at a steep angle into opposite ends of a precision V groove which is cut into a small block of copper. As pressure is applied to the fibers, they come together in the groove. When the fibers are properly aligned, a drop of glue is applied at the joint to create the splice. From our experience, the fusion method is faster and more reliable.

Splicer training is the single most important training need that must be fulfilled. In fact, aside from the electrical/optical conversion devices in the fiber optics terminals, the electronics associated with fiber optics systems is standard fare which can be easily accommodated by technicians. Splicing, by contrast, is radically different for fiber optics than for copper cables.

In preparation, we have conducted splicer training for both the glueing and fusion methods. In addition, the two splicers who were assigned to do the splicing made numerous practice splices for two weeks before the field operations began. Because of the extremely small size of the fibers, splicing involves the use of a microscope and requires a delicate touch. Because this type of work can cause mental fatigue, splicing is done by a tandem of two men, who relieve each other before splice quality suffers.

During splicing, a technician measures loss using an Optical Time Domain Reflectometer (OTDR). The OTDR detects breaks and defects in the fiber and measures splice loss. For the current installation, the average loss per splice has been about .36 dB. This compares favorably against an engineering design assumed loss of .5 dB per splice. The range of loss experienced extends from almost 0 dB to a high of 1.2 dB. The "high" losses have been due not to bad splicing but to fiber cores being not completely centered or circular. When this is discovered after the splice has been made, the splicer must decide between accepting the loss or cutting back the fiber on both sides of the splice until more well-centered core positions are found and a new splice completed. Completed splices are placed in a splice-holding device and subsequently in a splice case.

Splicing was done outside of the manholes in a van to speed the operation. Otherwise, equipment would have had to be disassembled and reassembled at each manhole requiring a splice. In addition, based on our participation in other fiber optics installations and our observations in general, conditions in the manholes are not ideal and often too cramped to facilitate effective splicing.

Because splicing was done outside the manhole and because splicing requires cutting back of fiber ends until a low-loss splice is achieved, allowance for adequate cable is extremely important. We are aware of cases where, when an acceptable splice was finally achieved, there was no slack left in the cable. Excess cable is coiled and placed in a box inside the manhole.

FUTURE APPLICATIONS

Based on our experience, we know that fiber optics is the transmission medium of the 80's. The economic and technical advantages it offers are tremendous. Further, we have found our people--engineers, technicians, and splicers--readily adaptable to this new technology. Hence, our trunking plans call for the establishment of a fiber optics pipe along the heavy communications corridor that extends from Waipahu to Waikiki by 1984, as shown on Figure 1.

Our next fiber optic trunking system will be between the Punahou and Alakea central offices, a route slightly over 4 kilometers. It is scheduled for activation in the first quarter of 1980. By the end of 1980, we expect to have three T3 systems (2016 voice channels) on the Kalihi/ Alakea route and three T3 systems on the Punahou/Alakea route. Over the next five years, we will be constructing 33 T3 systems.

Hawaiian Telephone is obviously committed to fiber optics. Our completed and forecasted construction is only the beginning.

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INTRODUCTION TO FIBER OPTICS

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Abstract

This paper will provide an overview of current fiber optics communications technology. Basic principles and components will be reviewed. Progress over the last 10 years will be highlighted. Current status and challenges will be discussed, along with predictions for the future.

Integrated Approach to Fiber Optic Cable Subsystem Design and Installation

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ABSTRACT

The mystery in fiber optics has essentially vanished. System design by the end user is straightforward and comparable to the design of conventional copper systems. The high capacity, relative to size, and immunity to water and EMF Induction problems provide the system planner with a new tool to solve some old problems.

THE ROLE OF ELECTRONIC MAIL
IN THE OFFICE OF THE FUTURE

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Abstract

The telecommunications industry and the computer industry have been dynamically expanding their capabilities during the last decade. How can we combine the capabilities of the telecommunications and computer industry to serve the Office of the Future?

During the last decade there has been a dramatic increase in the capabilities of telecommunications systems. Within the telecommunications industry, we call the basic telephone service "POTS", standing for Plain Old Telephone Service. During 1970, the POTS was the only service available to our end customers, but since that time we have seen a dramatic increase in the capabilities of today's telephone systems. With simple program changes, we have been able to incorporate the capabilities to indicate to the business manager where a call was placed, route the call over the least cost facility, record all calls by an accounting center, and integrate many ancillary capabilities into one telecommunications system. The purpose of this paper is to examine what we can do when we combine the telecommunications and computer industries. In a very broad sense, the Office of the Future will result in an integration of computer and advanced telephone systems. Today we have the technical capability which will allow us to integrate these capabilities and we will be examining some of those later in the paper.

First we must ask an important question . . . "Why would we want to do this?" Those of us who actively participate in the sales profession know that sales of an individual item is relatively an easy task. The challenge comes in selling a product that is designed to serve a mass market. To develop a new capability within a system, the product or service must serve a broad-based demand, and the broad-based demand for the Office of the Future is an increase in productivity in the white collar work force.

There exists a real need for an increase of productivity of the white collar worker. Just think if we could gain the experience of this convention without leaving home. As white collar workers, we need to analyze what we can do to increase our productivity. In the ten years, from 1960 to 1970, the productivity in the blue collar market segment increased seventeen times faster than the white collar worker. During 1975, the number of white collar workers increased in size to that of the blue collar work force. This increase is projected to continue until estimates are that during the 1980's the white collar work force will be three times the size of the blue collar work force. We are going to see a dramatic shift in emphasis from the blue collar worker productivity to an increase of the white collar productivity. With the blue collar worker, we have developed a set of indices to measure the results. These serve to measure and match current production against previous performance levels. You will see an increase in these types of indices for the white collar worker. For example, an increase in the management by an objective type of philosophy. The Office of the Future is driven by the need to increase in productivity of the white collar worker.

Until 1973, those of us in the telecommunications business provided Plain Old Telephone Service. Today, January, 1980, we have a telephone system that provides "everything you would ever want to have and were afraid to ask." The new systems are provided at a cost equal to electrical mechanical systems of 1973 when we take into consideration inflationary factors. Today's focus® system provides a whole range of exciting capabilities, including Automatic Route Selection of calls over the least cost facility, Automatic Call Distribution for processing large volumes of incoming calls, Station Message Detail Recording to record detailed call billing on all telephone calls outside of the system, specialized telephone service designed to meet the needs of the health care market, and specialized communication services designed for the hotel/motel systems. These advancements in the telecommunications industry, when coupled with the dynamic growth we have seen take place in microprocessor controlled computers, provides us with the capability to serve the changing business needs with an Office of the Future system.

Now let's take a closer look at how we can effect the efficiency in productivity of the white collar work force.

Our blue collar worker is an individual in our industrial society who is paid to make, build, and produce items. These are generally tangible items that can be: seen, felt, and checked. The white collar worker in our industrial society receives input from a variety of sources and makes decisions and distributes those decisions. In otherwords, the white collar worker is paid to communicate and decide. Basic communications takes two forms, verbal and written. Let's examine how tomorrow's office environment can improve the communications productivity.

VERBAL COMMUNICATIONS

How can the electronic mail and Office of the Future improve verbal communication? The advantage of verbal communications is that it is generally timely. We can communicate in a very timely manner using direct verbal communications. The disadvantage of this timely communication is that it generally involves an interruption. Do you seem to operate each day in the "interrupt" mode? Do you feel that sometimes after a day is done, and you have given 100%, you have nothing to show for your efforts? Do you work late at night or come in early in the morning to get some "real work" done? Don't feel bad, so do I. I wrote this presentation in a hotel room in Chicago and just got off a phone call which interrupted by preparation of this presentation. The key is . . . what do we need to do to be able to improve our verbal communications in our Office of the Future/Electronic Mail environment to make our verbal communications more efficient?

Message Center

One of the exciting things we can do to improve our verbal communications is the message center. During those times of the day in which you prefer not to be interrupted, the Office of the Future will offer a message center which will automatically route calls to a central answering point. The message center will provide the message center attendant with a called party display, so that the message center attendant can answer the phone in a personalized manner. The message center is provided with instant access for your individual status and enables the message center to either route the call to the forwarded location or provide the incoming party with an outline of your itinerary for the day. An added capability as part of this message center will be the routing to an automatic message device which will be able to record a verbal message for reply at a more convenient time. Some might think that this is not a very personalized way to communicate. However let us examine some of the facts. Of every one hundred phone calls that are placed, how many are completed to the destination party? The answer is . . . 28 out of every 100 calls are completed to the destination party. Think about the number of times you have called someone and they are not available at the time. For those of us who travel, I suspect that the completion rate is even less than 28%.

Audio Message Distribution

I would also suspect that 90% of the routine communication could be effectively done with an audio recording device so that you could leave a complete detailed message, change appointments, request appointments, and announce sales results over an audio message distribution system. This environment to verbal communications would provide a capability to deliver a verbal message during off hours. During the day, one would be able to record verbal messages with the capability to deliver these verbal messages during off hours. During the day, the recorded verbal messages would be provided, and at night, our systems would be able to automatically distribute this information to the appropriate location at a time at which the long distance telephone rates would be reduced. This is especially important where the communications expense is as high as it is in Hawaii compared to the mainland. Think of how valuable this service would be . . . to be able to communicate with outlining areas, advertise to customers on new service offerings, reschedule delivery of material, and update remote employees on main location activities. The idea of a message distribution system would be to be able to deliver messages to multiple points during off hours at reduced rates. Think of the value and reduction of paper which provides your customers with advanced notification in new service offerings, scheduled material, and agendas for meetings.

Video Picture/Electronic Blackboard

A natural extension of the audio message distribution system will be the provision of a video picture, along with the audio communication. This concept has not been very successful in its implementation for the residence customer, however, it is beginning to gain acceptance in the business communities. The picture phone could have a substantial impact on the amount of business travel that is done. Participation in the picture phone conference concept, on an interactive basis with both audio and visual, can also be enhanced with an interactive electronic blackboard. An electronic blackboard enables one conferee to write on an electronic surface which is duplicated at the other end. This adds the visual dimension to the verbal communications process in addition to providing an interactive communications tool.

These are some of the methods, that we can see, to enhance the productivity of the white collar worker in the Office of the Future concept. The verbal communications, which is only one part of the communications process, can be enhanced through message centers, audio message distribution, and video pictures/electronic blackboard.

How do you feel these changes can effect and improve the verbal communications? What percentage of your calls are received by the destination party? Do they exceed or are they below 28%? In a typical office environment today, 75% of our communication is done on a verbal basis, and 40% is written. It is estimated that in the Office of the Future environment, percentages will shift dramatically. While the level of verbal communication should drop substantially, the effectiveness of this verbal communication should improve.

WRITTEN COMMUNICATIONS

The mounds of paperwork that arrives at our in-basket stands testimony to the volume of the written communications that we utilize in our day-to-day operations. The advantage of written communication is that each individual can review, at their convenience, the material provided in written communications which does not require a simultaneous activity and create interruptions. The disadvantage is that it is time consuming to absorb, especially if you have not completed your Evelyn Wood Speed Reading Class. The Office of the Future will bring with it an increase in the written correspondence, or more exactly, an increase in the read correspondence versus the verbal communication. Since we will see an increase in the written communication, it is important that we analyze how we can, in the Office of the Future environment, improve the productivity of this communications media.

Dictation Access

The first step in the implementation of an efficient communication method is the centralization of the written material production. In today's telephone system, with few exceptions, it provides the capability for direct access into a centralized dictation system. With today's text editing electronic typewritter, it is a natural reduction in the effort required to prepare written communications within the office environment. In addition, most dictation systems can be accessed at night so work can continue from a hotel room, office, home, and car during the off hours.

Electronic Mail

A natural extension of the centralized dictation is the electronic mail concept. While it is the primary purpose in today's session, you can see that this function is only a part of the entire Office of the Future environment. The combination of the electronic typewriters with store and forward high-speed data and facsimile will provide significant benefits for the timely transmission of written material. The key benefit for the electronic mail system is the timeliness of which it can d[illegible] and distribute information. The traditional computer aspects of the electronic mail will continue to be located in a computer-like device, not the telephone system. However, the telephone system, when combined with an electronic mail system, can provide the capability to store information and automatically forward it during off hours, can select the least expensive route to place a call, and when all outgoing facilities are busy can automatically recall itself and place a call when a circuit is available. This enables timely distribution of information, yet outside the confines of the in-house telephone system. This distribution can be handled during off hours when the telephone rates are at their lowest to minimize the expense. Within these systems, we will be able to provide transmission of data, voice, and electronic mail. We will be able to provide the distribution of this information either immediately for urgent items or forward when the expense associated with placing these calls is reduced.

Electronic Information Retrieval

A second key component of the electronic mail is information retrieval. Electronic information retrieval will enable us to eliminate bulky paper file systems we currently work with today. Think about the amount of time your secretary spends rummaging through inefficient filing systems to obtain an important piece of correspondence. The electronic information retrieval system not only applies instant access to previous written communications, but eliminates the necessity to duplicate a copy for the file which many times is delayed being placed in the file, since filing is generally not a top-priority item. With the electronic information retrieval, access to information will be immediate once the correspondence is prepared and in its final version. The electronic mail system will then automatically place it into the mail storage.

We have outlined three exciting ways to improve the communications process: Centralized dictation, electronic mail, and electronic information retrieval. The challenge that faces our industry today is the provision of a few key items that will be necessary to complete the interface between the telephone system and its computer counterpart. The challenge facing us is the development of an industry-wide interface compatability standard that will allow a variety of computing devices to be directly interfaced with the telecommunications. Within the telecommunications industry, we need to enhance our capability to provide store and forward of voice data and facsimile information. Currently under progress within the telecommunications industry is the improvement and refinement of the message center concept which is very close, in reality, to many electronic telephone systems, including the focus•. We have participated in some exciting changes in the past and can see that the future will hold for us some very exciting opportunities.

Experiences of an Electronic Mail Vendor

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Abstract

Material will be presented concerning the present COMET Electronic Mail System's capabilities and how these compare with traditional modes of communication. Fundamental facts concerning Computer Message Systems potential for business growth will set the stage for a review of some present-day implementations. In conclusion, the speaker will focus on the importance of Electronic Mail for all of us.

Computer Message Systems (CMS) are a relatively new phenomenon (5-6 years) and are the result of work done in the Time Sharing Services industry, computer networks, and Advanced Research Projects Agency R&D activities. Computer Message Systems use the computer as an integral component of human communication.

Using a computer, terminal the CMS performs or aids in message creation and distribution, electronic filing and retrieval, and message reading.

Computer Message Systems are a unique form of electronic mail because their use results in the direct linking of two or more people wishing to communicate. Up till now there were three means of such direct communication: face to face meetings, the mails, and the telephone.

It is interesting to note that two of these so-called "direct communication means" (Mail and phones) have been so corrupted in the business world with administrative overhead that it seems rarely plausible to use the term direct (witness the secretary opening/copying and distributing mail and placing phone calls for the manager). Now let's review some of the problems with these three traditional means of direct communication (in particular telephonic communication) and relate them to CMS.

The Problem of Location

If I want to communicate with Mr. X by phone, mail, or meet with him, I have to locate him somewhere on the face of the earth. This is often very hard to do and, as the modern business environment becomes more and more mobile, it becomes harder and harder. Where in the world is Mr. X?

If the time is during normal business hours, one assumes he is at his desk. But is he really? A lot of the time, it turns out, he is not. He is in a meeting down the hall, he is in the men's room, he is in transit to another office, or perhaps he is not in the building at all. He may be sick, out to lunch, making a customer call, in a car, an airplane, or the Lord knows where.

Furthermore, I may want to talk to Mr. X outside of working hours. This is even harder. He may be at home, at relatives', out to dinner, or at the movies. One thing is for sure. In today's fast-paced world, Mr. X is very hard to find.

The Problem of Interruption

But our problems have only begun. Suppose I know where Mr. X is, that he has a phone nearby, and that the phone is not busy. What makes anyone think Mr. X will be willing to be interrupted? The chances are that he will not, and I can't say I blame him. I do the same. A lot of the time I'm in a meeting, because I'm doing some work that I would like to continue doing. (Of course, for me even to say I'm in a meeting requires an interruption in my work.)

So what happens? I call Mr. X and leave word.' He calls back and leaves word. I call him back and leave word. He calls back, etc. (This game is called Telephone Tag.) I have known cases where this has literally gone on for weeks. By the time I got through to the other person, I had forgotten what I wanted to tell him.

Let me give you some statistics of my own use of the phone. I did a study and discovered that, of the calls I placed, only 26 percent of them went through on the first try. This means that on the average I have to place almost four calls in order to get a single one completed successfully.

What were the problems? All kinds. In 38 percent of the unsuccessful cases, the person being called refused to be interrupted. In another 38 percent of the cases, the number didn't answer (most of these were internal calls). In 14 percent of the cases, the called number was busy, and the remaining 10 percent represent miscellaneous problems such as the line being lost before the called party answered.

Altogether, a great deal of aggravation.

The Problem of Time Zones

So far we have been assuming we are communicating within the same time zone. But what if we're on the East Coast calling the West Coast? Let's assume that business executives work 9 to 12 and 1 to 5, five days per week. That means that at best, a manager is in his office 35 hours per week. But if two managers are on opposite coasts, they are simultaneously in their offices, at best, only 15 hours per week. As we have seen, it's hard enough to reach anyone on the phone given 35 hours to try in. When the window is reduced to 15 hours, the problem is roughly doubled.

And what happens if we're in New York trying to communicate with Tokyo? Now the "telephone window" has shrunk to zero. There is simply no time at all during working hours that one manager can hope to reach another.

The Problem of Records

When you use the phone, there is no record of who said what to whom when. For many business purposes, this makes the call virtually useless. In my own case, I have long ago gotten into the habit, after all but the most trivial calls, of picking up my dictating machine and dictating the substance of the call. The dictation belt goes to my secretary, who types it out, and eventually sends me the typescript. I then scan the typescript, make corrections if necessary, and put it in for filing.

In short, one phone call generates a dictation task and an editing task for me, as well as a typing task, a duplication task, and a filing task for my secretary.

The One-to-Many Problem

In the business world, one person often wants to communicate with many people. Yes, it is possible to set up a conference call on the phone. But it's so hard to set up and it's so unsatisfactory that it's very rarely done in practice. Typically, if a businessman wants to communicate with a group, he gives up on the phone and has a meeting or writes a memo.

The Problem of Information Density

The phone shares a problem with all speech communication: the information density of speech is very low. Generally, the electronic transmission of speech requires about 60,000 bits per second. These 60,000 bits of speech carry about the same information as 15 characters of written text. (Try it — in one second you can read out loud a passage of about 15 characters).

But you can transmit 15 characters directly as text by transmitting only 120 bits of information, rather than 60,000 bits of speech. If you insist on transmitting speech you are transmitting 500 times too many bits. And all these bits have to be paid for. In a very fundamental sense, speech is an uneconomic medium of communication.

The Problem of Long-Windedness

My final problem is that the conventions of our society require us to be long-winded on the phone. One must inquire about the other person's health, or the health of his family. How're the kids, George? There is the obligatory discussion of meteorological conditions. Pretty chilly out today, wouldn't you say? When I measure the length of my own phone calls, I was surprised to find that my average call took 4.8 minutes.

It is almost impossible to get someone on the phone and say, "This is Jeff, your plan is approved," and hang up. That would only take 3 seconds instead of 4.8 minutes. But our social conventions won't allow it.

The Computer Message System

Let's now turn our attention to CMS. CMS do not require you to locate anyone. They never interrupt. Time zones don't matter. All communications are automatically recorded and filed. One message can go to multiple recipients. Computer Message Systems are based on transmission of text, which has high information density, rather than transmission of speech, which has low information density. Messages are short rather than long-winded.

In fact, now I believe one can appreciate this definition of CMS. "Computer Message Systems are a means to communicate and record communication in a timely manner without locating or interrupting the recipient and without undue administra ion."

I concur with some "experts" who predict a doubling of the CMS business in the U.S. over the next 3 years. During that time, most major corporations and government agencies will have accomplished some pilot evaluations of CMS and some will even begin full scale implementation. Interestingly, the real movers in this market may be in the secondary tier organizations where a bolder attitude prevails.

In the longer term, CMS may earn their places as an assumed means of managerial communication, once again establishing control of per:^^ to person communication in the rightful place of the individual doing the communicating.

Prior to this happening, though, there is the necessity to address certain real or imagined problems with CMS.

The Organizational Concern

The first of these problems is how does the Computer Message System fit in the organization. Or, who is in charge here?

This, of course, leads us to the debating candidates.

MIS - Telecommunication services - and administrative services. Certainly there are strong cases for all three but in the end I doubt that it really matters. What does matter is a corporate level of commitment (in terms of funds and moral support) to whoever is assigned the responsibility. Beyond this is the overpowering requirement that CMS be understood as a service entity allotted nearly no margin of error. The key to success is response to demand. A rule to heed is that the Computer Message System is only as good to the user as his last experience with it. Note that the lack of this response to demand has been the very downfall of the mails such that today nothing important happens by way of the mail. Would you bet your job on a USPS delivery?

The Cost Concern

A second immediate problem we are all faced with is the cost justification hurdle. Anytime anybody needs to kill anything this is the mode of attack.

Before venturing on a path to establish an air tight cost justification model for CMS, I maintain it is important to establish relative affordability.

So let's compare some unit costs:

> First, let's compare the COMET Computer Message System and the telephone. A three minute telephone call from Boston to L.A. during business hours costs $2.44 plus tax, while a measured 16-line message to be composed, edited, filed, transmitted--and in L.A. read and filed--costs $1.07 using the COMET Service Rates.
>
> Next, let's compare COMET and a Memo or Letter. According to Dartnell Institute, the cost of producing a single business letter is $4.47; others say the cost is as much as $18.00.
>
> Finally, let's compare COMET and TWX. A recent review of a company's TWX service indicates that what costs $20,000 a month in TWX services would cost only $13,000 using COMET.

These cost comparisons provide proof of affordability; however, it should be noted that when one considers CMS value added services, the case becomes even clearer. Still, we have to go beyond merely comparing costs and, for this, let me suggest various "Justification Scenarios" which may serve to be more important as they result in individual productivity improvements.

One is span of control, the idea being that the number of managers or supervisors could be reduced and the work remain constant. A second area involves reducing the extent of interruption thereby increasing the amount and value of work. Another scenario could be based on reducing supporting shadow functions around communications. An opportunity in some applications centers around the speed with which information is transferred. Finally, but perhaps most importantly, is time savings.

Let us use the last of these (time savings) and follow the scenario for possible cost justification.

In my view, the primary cost benefit of Electronic Mail is in the executive time which is saved. What is the cost of managerial time? Take a $50,000 a year manager. Add 30 percent overhead and assume he worked 1800 hours per year. It then turns out he costs his employer $0.60 per minute, or just one cent per second.

What are the costs of Electronic Mail? You can subscribe to an Electronic Mail Service (use of a time-shared central computer that runs the Electronic Mail program) for $60 per month, and you can rent a terminal for $90 per month. Hence, you are in business for $150 per month per subscriber. If a company buys an in-house Electronic Mail system, including terminals, and shares the terminals among a reasonable number of people, the cost can drop as low as $20 per month per subscriber.

But let us use $150 as an upper bound. Now, if our hypothetical executive can save just 12.5 minutes per working day through the use of Electronic Mail, he will pay for his use of the Electronic Mail service. If we are talking of an in-house system, 12.5 minutes per day will pay for his use of the system many times over.

In fact, it is my impression that an Electronic Mail system saves a manager not merely 12.5 minutes per day, but many times that amount. Take my own case. On an average working day I deal with 24 messages (I receive 14 and send 10). The time spent in doing that is 16.4 minutes. If, instead of using Electronic Mail, I used the phone for these 24 messages, considering that my average phone call takes 4.8 minutes, I would be spending 1.9 hours on the phone. I would therefore waste about 1.6 hours per day. For our hypothetical manager, this would cost $58 per working day. Over the course of a month, he would recover the cost of his use of an Electronic Mail service seven times over. If we are talking of an in-house system, he would recover the cost fifty times over.

(The costs of Electronic Mail discussed above have not included toll charges for telecommunications -- Telenet and Tymnet. In comparing the cost of Electronic Mail with the cost of the phone, we can consider that toll charges are roughly equal in the two cases. If anything, since Electronic Mail interactions are so much shorter than phone calls, the comparison would probably widen the gap in favor of Electronic Mail.

It should be pointed out that our cost analysis so far has taken account only of the manager's time in reading and writing messages as compared with talking on the phone. It has given no weight to the fact that, on the average, each phone call has to be placed four times, to the fact that if the executive wishes to have a record of the phone call he has to dictate or write it out, to the fact that Electronic Mail does not disrupt him many times a day, to the fact that he has no time zone problem, etc. If we took these additional matters into consideration, the cost advantage would be even greater.

But ultimately, cost savings may not be the real point. Perhaps the key is that the typical manager is overworked, always short of time, and constantly hassled. Electronic Mail provides relief. It makes him more efficient by organizing his communications and allowing him to be master of his own time. I would be very surprised if Electronic Mail did not become the communication standard for the business person in the next decade. It's simply a better way to live.

The Human Behavior Concern

A third issue of present concern is that of human behavior. Past experience has taught us a lot. Although there is plenty of room for improvement, many vendors are skilled at employing human engineering and growing numbers of users effect change through understanding and involvement.

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Some particular human behavior problems CMS encounter are: the satisfaction curve, command language and typing.

The satisfaction dip, also termed buyer remorse, occurs when there is initial excitement surrounding this brand new thing, followed by a realization of the limitations of the system (disappointment) and, finally, a rise to a stable realistic satisfaction level.

The user command language problem is the responsibility of the vendor or designer. Failure to underestimate the needs for simplicity of language, friendly response, and natural or expected flow surely dooms the CMS.

Finally, is there a problem in typing? Surprisingly little. One executive states he would be absolutely incapable of typing a business letter, but has no trouble with Electronic Mail. Why is that? I think there are three reasons. First, the messages are short (if I want to send a long one, I ask my secretary to type it for me from her terminal. But for ordinary messages, it's much quicker for me to do it myself). Second, the system helps by providing editing facilities that make it easy to correct errors. Third, for some reason that I don't fully understand, it doesn't bother me to send out a message with a couple of typos. (By contrast, I would not tolerate a memo to go out over my name with even a single error.) Evidently the psychology of the Electronic Mail user makes him very relaxed about such cosmetic issues.

The Technology Concern

The final issue of concern I will address is that of technology to support CMS. Many of the technological pieces are obviously ready (witness progress in the terminal arena, packet networks, and the general cost performance trends of hardware). But underlying these obvious accomplishments is the realization that providing Computer Message System capabilities to a group of 1000 is one thing; for 100,000 quite another. At the latter user population level, the true technical challenges surface and they are concentrated in solving traditional data base problems.

As an illustration of the type of problems, let us note that when the user population exceeds 100,000 names, the probability of a name ambiguity for an addressee is over 70%.

To provide CMS for these large populations requires sophisticated new software techniques concentrated in the areas of distributed data bases which afford reliability, response, and reduced communication costs.

And, of course, the thousands of users of a CMS will be generating thousands of messages for storage and retrieval. It is encouraging to note that these supporting technological building blocks (that is, a distributed data base system and large scale storage and retrieval capacity) have been accomplished on the ARPANET System. The latter is a system called Datacomputer which encompasses 3.2 trillion bits of storage (this is equivalent to 1500 IBM 3350's) and allows users to store and retrieve messages by any word or

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combination in the header or text. The former is a system entitled SDD-1, which is the first working distributed data base management system in the world.

CMS Success Stories

At this point, I will outline some CMS user experiences and glean sensitive factors for implementation consideration.

The first case is a Fortune 100 company that produces minicomputer systems and peripherals. They have an in-house Computer Message System that consists of a PDP 11/70 with 300 megabytes of on-line storage supporting over 700 users via 29 lines. For historical background; this Computer Message System has been in operation since January of 1978. For the active users of this system, the average number of daily logins is three, while average daily time logged in is 25 minutes. The user population profile is heavily weighted towards managers and professionals. Use of this Computer Message System includes broadcasting of information, information inquiry/response, task assignments, follow-up on task assignments, requests for action, status reports, meeting agendas and/or minutes, follow-up on conversations, and informal discussion of issues. As a result of its, use there has been a decrease in the number of phone calls as well as the number of interoffice memos, while the number of meetings remained the same. Finally, the users have noted a productivity increase.

Our second success story is a Fortune 100 conglomerate in the communications and electronics industry using CCA's COMET time-shared service. This system consists of backed-up 11/40's with 250 megabytes of on-line storage. This account has been active since April, 1979. It places the number of subscribers at 150 while the activity level is again placed at 2-3 logins per user per day. The user profile chart indicates that managers and executives comprise 75% of the total user population, with salesmen at 10%, technicians at 5%, and office and clerical workers at 10%. The uses of this Computer Message System include broadcasting of information, information inquiry/response, task assignments, follow-up on task assignments, requests for action, status reports, meeting agendas and/or minutes, follow-up on conversations, and informal discussion of issues. The results of its use show, once again, a decrease in the number of phone calls as well as the number of interoffice memos, while the number of meetings remained the same, and the users' productivity increased.

A third success story is that of a multinational oil firm also using the COMET service. The account history indicates that the Computer Message System has been in use in this area since March, 1978 with the number of subscribers at 50 and the activity level at 1-2 logins per users per day. The user profile, again, is weighted heavily in favor of managers and technicians, with managers at 43%, engineers at 4%, technicians at 40%, and office and clerical workers at 13%. The account applications for the Computer Message System have been in personnel (labor negotations), finance, project control and Inventory control. The results are consistent with a decrease in the number of phone calls, a decrease in the number of interoffice memos, with the number of meetings remaining the same and user productivity increasing.

Common characteristics of all these success stories are: a high level of management use and support -- the CMS is solving a real communication need, a critical mass has been achieved, and there has been a reasonable time of experience.

The bottom line lessons for anyone implementing CMS are to obtain top level buy-in, use a real application, use the complete application (mass), and give it enough time.

In conclusion I will leave you with this. You have seen and heard and discussed Electronic Mail (EM), and I hope we can keep focused on the importance of all this. It is important for us as a nation in the face of a lagging economy and this fact is centered around the need for office productivity Improvement. It is important for your organization because EM will allow it to run better and leaner, capture more market share, run higher profits, hire more capable people. This is especially true for those organizations that recognize the opportunity and seize it.

Finally, it is important for you and me because a more successful economy means better more plentiful goods, and improved company performance means better pay and benefits. Do no underestimate the value Electronic Mail can play in your life.

INTELPOST Network In The Pacific

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1. Introduction

Electronic mail systems are being actively developed and installed in many countries around the world. Electronic mail technology in such areas as document scanners, printers, character recognition, word processing etc. is one of the most actively evolving technology areas at this time.

An international approach to the introduction of electronic mail is particularly attractive for several reasons. The longer distances generally involved, especially in the case of intercontinental mail, accentuate the advantages of electronic mail handling as opposed to physical handling, in terms of both transmission/transport time and transmission/transport cost. For that segment of mail which is presently subject to transmission by alternative means of communication to permit more rapid delivery, electronic mail is attractive because these alternative means of communication are more costly internationally than in a domestic environment. The availability of physical transport facilities between different countries varies widely, and is meager in many cases. Routing is frequently circuitous. Bypassing these facilities through electrical transmission facilities has a distinct advantage in terms of time.

The attractiveness of international electronic mail has been recognized by the Postal Administrations in many countries, and this has led to the INTELPOST (International Electronic Post) system. INTELPOST is an experimental international electronic message system. Its concept is illustrated in Figure 1. Since March 1978, COMSAT has been planning, designing and implementing the INTELPOST system for the United States Postal Service (USPS). Figure 2 is a view of the INTELPOST service center in Washington, D.C. The Postal Administrations of the United Kingdom, Federal Republic of Germany, France, Belgium, Netherlands, Argentina and Iran have decided to implement similar INTELPOST installations, and have agreed with the USPS to conduct demonstrations and a field trial of the INTELPOST system.

A number of countries in the Pacific have shown also strong interest in the INTELPOST system. It is thus appropriate to consider the implementation of the INTELPOST network in the Pacific and its interconnection with the INTELPOST network in the Atlantic Ocean region.

The views expressed herein are those of the author, and do not necessarily represent the views of the Communications Satellite Corporation or the United States Postal Service.

2. System Design

The INTELPOST system has been designed to provide an international electronic message service between end users. It has been designed to be a postal service. This means that in addition to the technical design of the system, other INTELPOST service features, including message collection and delivery procedures as well as other message handling details, have been planned and coordinated between the participating Postal Administrations. This paper is limited to the discussion of the more important technical features. These are:

Network Approach

INTELPOST sites are intended to be interconnected to form a network, instead of being implemented as a series of separate point-to-point links. The network enables the routing of messages between any of the sites in the network. Each site can act as a source or a destination of a message. In addition, commensurate with the throughput capacity of the site, each site can act as a transit center for messages of other sites when the necessary transmission facilities are installed and the necessary routing instructions are included in the computers of the sites.

The advantages of the network approach to INTELPOST system design parallel those in telecommunication networks. The amount of scanning and printing equipment required at the various sites is minimized, system utility is maximized, network topology and the use of transmission facilities according to traffic requirements can be optimized, and alternative routing paths between sites can be provided.

The initial implementation of the INTELPOST network in the Atlantic Ocean region resulted from a series of bilateral agreements between the USPS and the participating foreign Postal Administrations. This determined the star configuration of the initial network as shown in Figure 3.

Store-And-Forward Operation

The INTELPOST system equipment configuration is shown in Figure 4. It includes a minicomputer with disk storage for store-and-forward operation. All messages are stored on disk after scanning and before being transmitted to distant sites. Similarly, all received messages are stored on disk before printing. Thus the scanning and printing operations are separated from the message transfer procedures between sites. This provides a number of advantages. The transmission data rates to different INTELPOST sites are determined on the basis of traffic volume requirements and may vary. Store-and-forward operation provides transmission data rate buffering of the printers and scanners to the transmission lines. The disk storage allows for message load buffering both for incoming and outgoing message traffic.

INTELPOST is intended to be an international system with sites in widely different time zones. It is not expected to have operating personnel at all sites, 24 hours a day, at least initially. Store-and-forward operation allows unattended reception and storage on disk of incoming messages as well as unattended transmission of stored messages to distant sites. In the initial INTELPOST equipment configuration up to about 1000 pages can be stored on disk at a site at any one time. Store-and-forward operation allows to separate the transmission error control procedures from the scanning and printing operations, and it allows to retain the stored message on disk at the originating site until the receiving site notifies that it has received the entire message without errors.

High-Speed Scanning and Printing

High-speed facsimile scanning and printing equipment is important mainly for two reasons. First, it provides for operator convenience and secondly, it enhances system throughput capability. Needless to say, facsimile equipment handles all alphabets, reproduces graphics, handwritten material etc. The facsimile data in the INTELPOST system conforms to the format of CCITT Draft Recommendation T.4. The specified resolution is 7.7 lines/mm and data compression is according to the modified Huffman run-length code specified in Rec. T.4. These parameters determine that a scanned page results in about four million bits uncompressed, and, on an average, about half a million bits compressed.

The facsimile scanners and printers in the present INTELPOST equipment implementation operate at about 10-12 seconds per page. The data compression and expansion is accomplished in the scanner and printer, respectively. Thus the transmission data rate to/from the computer is 50 kbs.

Message Control

In a postal electronic message system, message control is one of the fundamental and more important requirements. It is essential that no message or part of it be lost or misrouted. Measures must be included in the system design to keep a record of the scanning, transmission and printing times of messages along with other data although it is equally important that the contents of a message be not retained in the system for longer than to assure that the message has been successfully transmitted and printed.

Message control measures in the INTELPOST system are visualized to evolve in a phased manner. In the early phases of INTELPOST implementation, postal operators play a significant role in message control. Later, the use of more automated measures is visualized.

For message control in the INTELPOST system, each message to be transmitted is assigned an identification number which includes the originating site identity and a six digit assignable alphanumeric code. Each message is accompanied with a transmittal sheet where the sender's and addressee's names and addresses are included, the number of pages in the message, the destination site identity, the message identification number, the delivery method from the receive site to the addressee, etc.

The system keeps track of the flow of each message from the originating site to the receiving site. At the originating site, a confirmation label is printed for every transmitted and printed message which includes the message identification number, the destination, the priority level, the scanning time at the originating site and the printing time at the receiving site.

Message control is exercised also as part of the message transmission procedures between sites. The message is retained on disk at the originating site until the receiving site signals to the originating site that the entire message has been received correctly. Similarly, the message is retained on disk at the receiving site until the printer operator acknowledges via the data entry terminal that the message has been properly printed.

Error Control

To protect against transmission errors, an error detection and retransmission scheme has been included on end-to-end basis. That is, the destination INTELPOST computer checks the received packetized data for errors in the individual packets and acknowledges all correctly received packets. The intermediate or transit sites do not perform such checking. The originating INTELPOST computer waits for the acknowledgments to arrive for all transmitted packets, and after a preset time, retransmits the unacknowledged packets.

3. System Implementation

Since INTELPOST is an experimental system, an important requirement is that the system is flexible for accommodating changes in equipments as well as in operating features. At the same time, to permit its implementation in a relatively short time, the demonstration system was designed to include only the necessary basic system features which would allow a meaningful demonstration of system operation, and an initial evaluation of system operation and performance. The demonstration system was implemented with the following fundamental criteria in mind:

- Low cost
- nonredundant equipment configuration
- basic software
- flexibility for expansion

The INTELPOST systems have been implemented at present by all participants using RAPICOM Corporation 500T and 500R high speed facsimile scanners and printers and Digital Equipment Corporation PDP 11/34 minicomputers. As the system evolves, implementations using other equipment can also be expected. The scanners and printers employ a specially designed computer interface. The minicomputer provides for modular system construction, for connection of different facsimile, character recognition or other terminal equipments, or for changes in INTELPOST network topology. Finally, the system software is also designed for implementation in a modular manner so that changes and additions of system features can be accomplished relatively easily.

The initial INTELPOST system implementation and operation has proved the soundness of the basic system design. During the field trial and for an operational system, various system hardware and software enhancements are visualized. Among the more important intended improvements are the following:

- inclusion of additional scanners and printers and additional computer modules to increase system reliability as well as to increase system capacity;
- improve system monitoring, control, fault diagnostic, error recovery, and maintenance features;
- tailoring of systems to meet different traffic handling requirements and to provide for local options;
- provision of features for gathering system performance and traffic statistics, gathering accounting and billing data, message encryption, and dynamic traffic routing.

4. INTELPOST Network Implementation In The Pacific

The star configuration of the initial INTELPOST network in the Atlantic Ocean region is not optimum for an operational system. Studies are currently underway to define a network configuration which provides for increased reliability, meets the varied traffic demands of the various sites and optimizes the use of transmission facilities. Figure 5 shows a mesh network of the same INTELPOST sites as in Figure 3. Such a meshed network can be engineered to meet the cited requirements.

It is recalled that the initial INTELPOST network in the Atlantic resulted from a series of bilateral agreements. To implement a more optimum network configuration in the Pacific from the start, it would be desirable to obtain a multilateral agreement among a number of Postal Administrations in the Pacific to join the INTELPOST system, to define the traffic handling requirements between the individual sites, and to proceed then with an optimized network implementation. Other technical and operational matters need also to be agreed multilaterally.

The global INTELSAT satellite system is uniquely suited for supporting INTELPOST network operation. The INTELSAT system includes most of the countries in the Pacific. It provides direct access across oceans and continents to the country of destination, and is capable of handling a much greater range of different data rate signals than can be handled by intercontinental terrestrial facilities. The INTELSAT satellite in the Pacific can provide the connectivity for INTELPOST service among all the countries which have earth stations to access the INTELSAT system, and tandem connections to the Atlantic and Indian Ocean regions are easily made via countries which access those regions as well. At the present time, there are over 20 INTELSAT earth stations in the Pacific region, linking almost as many different countries, and providing about 90 earth station-to-earth-station paths.

Several different methods for INTELPOST network implementation, using the INTELSAT satellite system can be considered for the Pacific region, and need to be studied. In particular, the INTELPOST system appears particularly well suited for implementation through the use of satellite TDMA technology. The facsimile raster scanning and printing approach results in relatively large amounts of data to be transmitted or received per message, as compared with alpha-numeric transmission. This, together with the requirement to be able to transmit messages quickly in time windows constrained by large intercontinental time zone differences and mail cutoff times for letter carrier delivery schedules, makes the use of high data rate circuits attractive. The same reasons cause the transmission capacity to be lightly loaded or idle much of the time, thus available to other users. The use of the needed transmission capacity of a communications satellite provides connectivity between all sites, allows to allocate transmission capacity on demand, to dimension the transmission system to meet the traffic and delivery time requirements, and to require only one transmission link between the INTELPOST store-and-forward computer and the INTELSAT earth station to access any other INTELPOST site.

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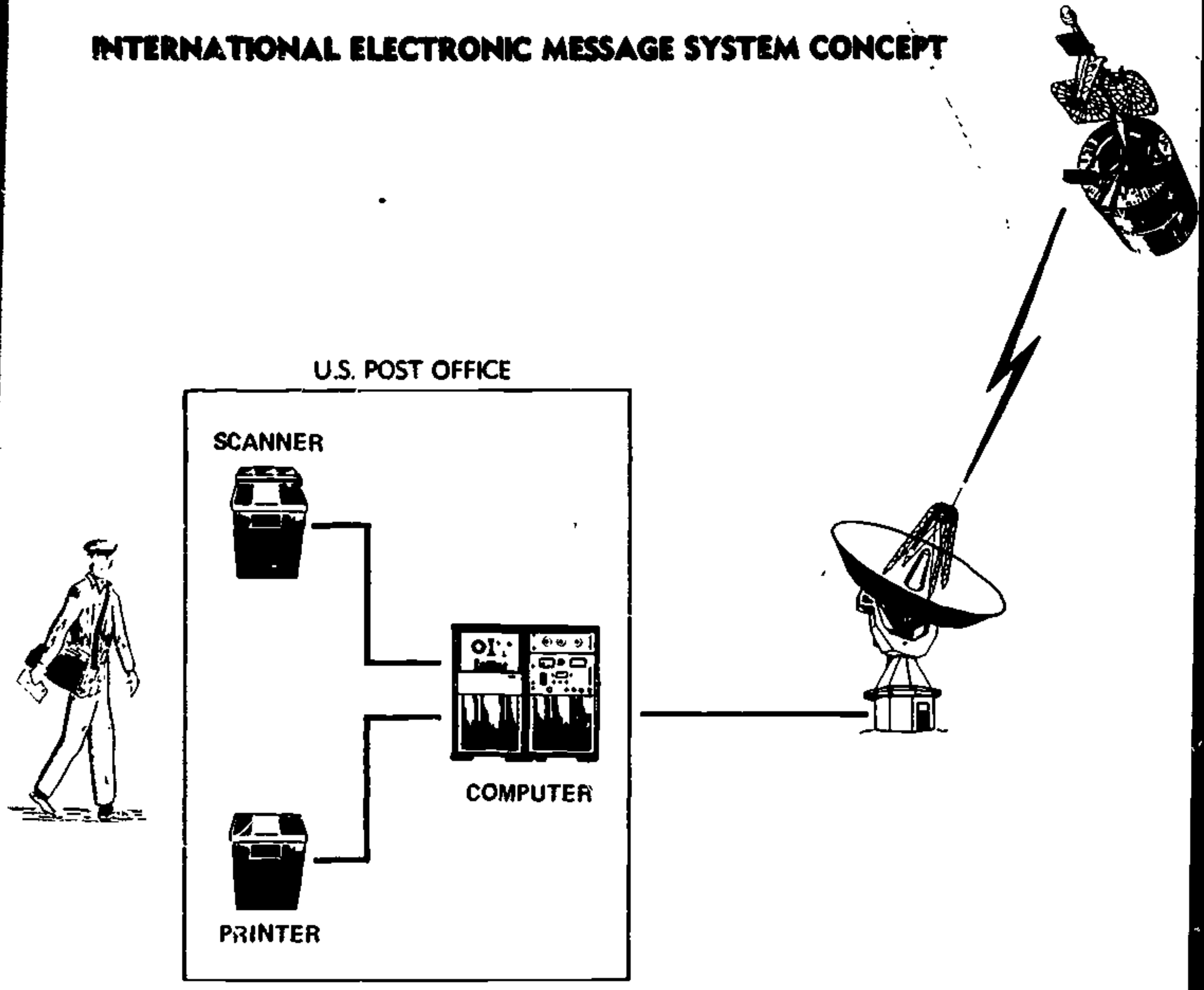
INTERNATIONAL ELECTRONIC MESSAGE SYSTEM CONCEPT


U.S. POST OFFICE
SCANNER
COMPUTER
PRINTER

G–19739

FIGURE 1

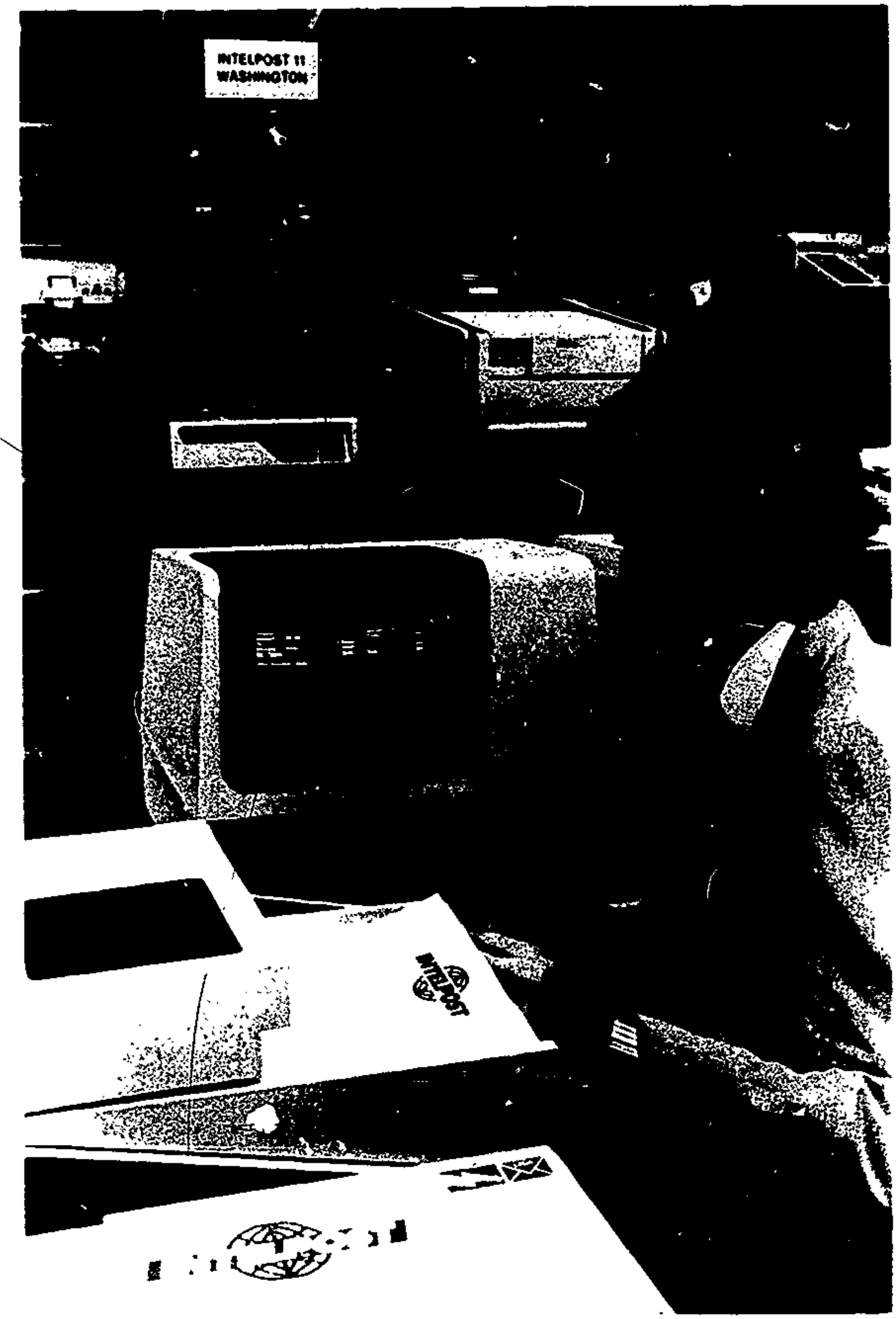

INTELPOST 11
WASHINGTON
INTELPOST

FIGURE 2

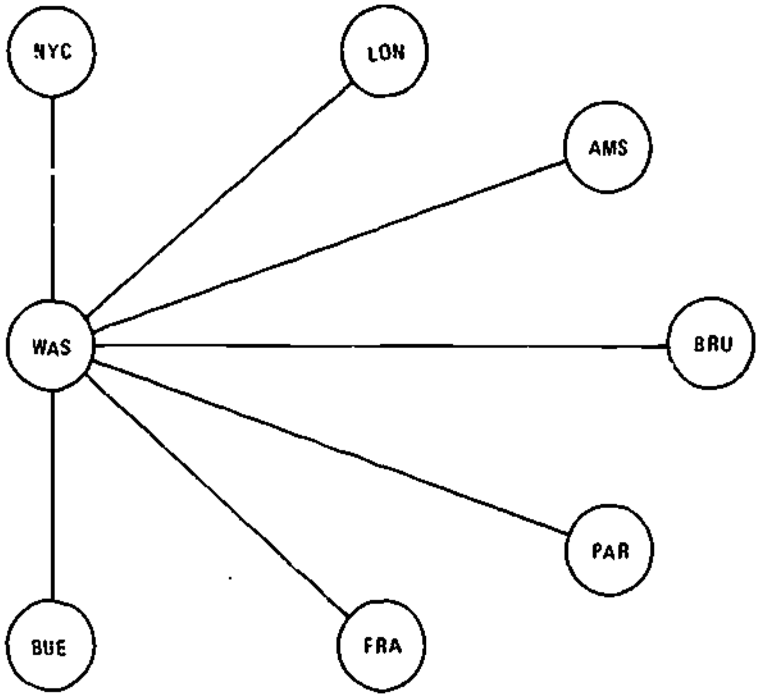
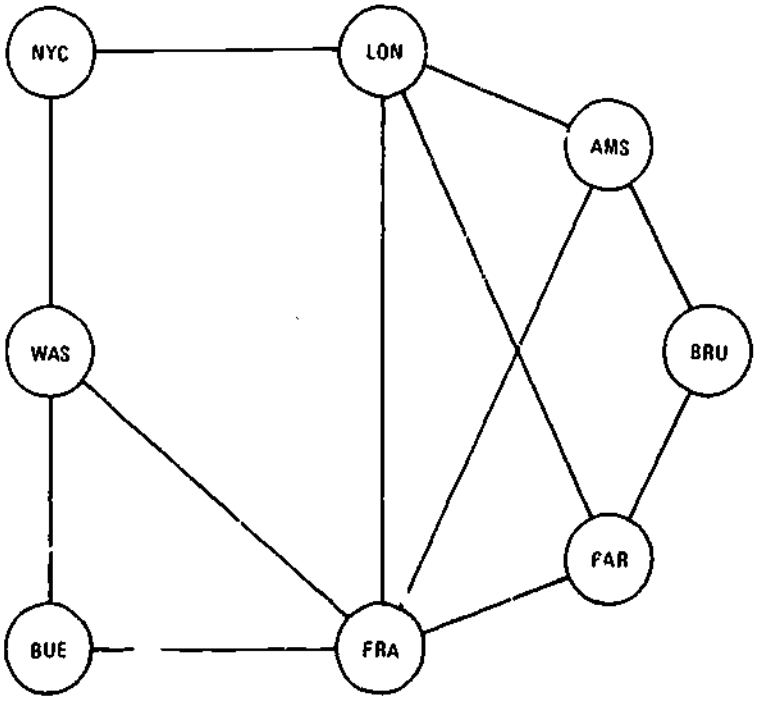

NYC
LON
AMS
WAS
BRU
PAR
BUE
FRA

FIGURE 3


NYC
LON
AMS
WAS
BRU
PAR
BUE
FRA

G-19827

FIGURE 5

INTELPOST EQUIPMENT CONFIGURATION

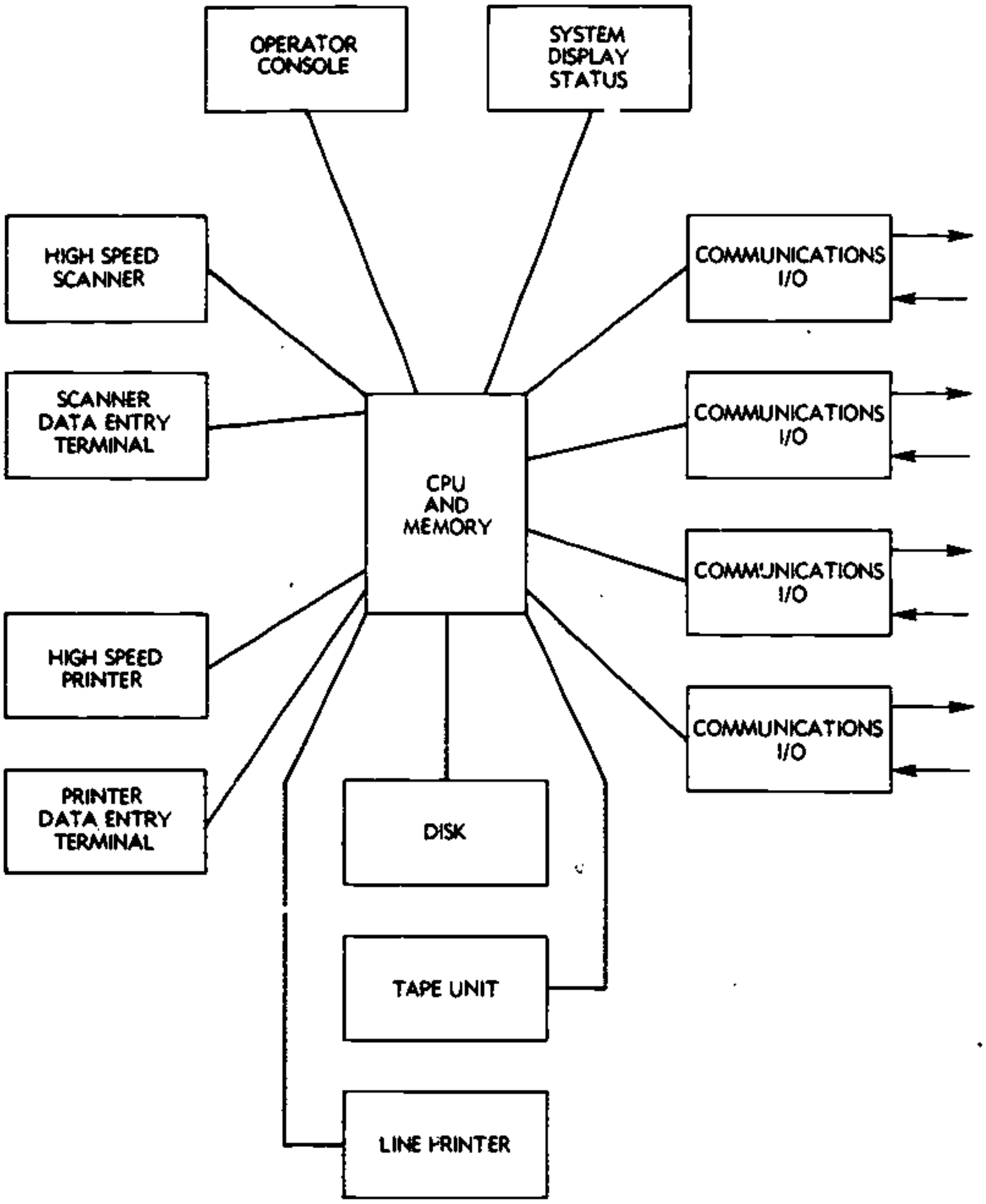

OPERATOR CONSOLE
SYSTEM DISPLAY STATUS
HIGH SPEED SCANNER
SCANNER DATA ENTRY TERMINAL
CPU AND MEMORY
HIGH SPEED PRINTER
PRINTER DATA ENTRY TERMINAL
DISK
TAPE UNIT
LINE PRINTER
COMMUNICATIONS I/O
COMMUNICATIONS I/O
COMMUNICATIONS I/O
COMMUNICATIONS I/O

FIGURE 4

MAILWAY:

WANG'S ELECTRONIC MAIL SYSTEM

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Telecommunications Systems Marketing
Wang Laboratories, Inc.
Lowell, Massachusetts

The concept of electronic mail is a subset of what is termed the "Office of the Future". While this nebulous term may have been correctly used 5 or more years ago to discuss any of the following concepts: combined functionality word processors, data processors, highly sophisticated communication based word processors, the ability to locally network discreet word processors, word processors which supported high-level computer languages, abilities to interface to phototypsetters facilitating the generation of camera ready copy, the ability to perform electronic mail; the term office of the future should be declared passe'. The reason for this statement is that not only are these capabilities generally available, they are specifically available from at least one manufacturer. This is not to say that there will not be improvements in the application of technology because there will be, but the general acceptance of this technology will lag behind the office environment's ability to assimilate these improvements. As was mentioned earlier, all these capabilities are available now from a single manufacturer, yet most firms are still unaware that these capabilities exist today. And there is no area more ripe for the implementation of these capabilities than the typical office environment which has, for the most part. remained unchanged for the last 25 years. Having declared the demise of the term "Office of the Future", I would like to redefine its connotation with the term "Office of the Present". I now would like to concentrate on the "Office of the Present" and one of its chief functional components - electronic mail.

Before we continue and for the sake of this presentation, we shall define electronic mail as the electronic transmission of written information from one person to another without change. This definition implies that the recipient sees the information exactly the way it was written by the sender. There are suppliers who are providing or planning a variety of services for the electronic mail market such as:

- Facsimile
- U.S.P.S. (ECOM)
- Telex/TWX
- Value Added Networks
- Computer based message systems
- communicating word processors

Although each of these suppliers solve a particular problem associated with the distribution of intra-company mail, not one is capable of handling the entire spectrum. Until today, the closest system capable of fulfilling the majority of electronic mail requirements has been the communicating word processor.

As a leader in CRT-based word processing equipment, Wang's success can be easily attributed to a combination of circumstances, not the least of which is the high degree of human engineering that has gone into the products. Wang's word processors are extremely flexible and easy to use. In addition, Wang was one of the first manufacturers to incorporate communications capabilities into their word processing systems. In fact, more than 50% of all installed Wang word processors include a communications option.

All things being considered, a natural extension to the life cycle of a document created on one of our word processors is for that document to also be mailed electronically via a network or Wang systems. Hence, Wang's answer to electronic mail is the "Mailway" system, announced on June 4, 1979 at the National Computer Conference.

Let's now examine Wang's Mailway system in an "Office of the Present" environment to examine what can be done, and how it is implemented.

There are three logical entities associated with Mailway. They are origination points, distribution centers, and distribution points. Mail is created at origination points and distributed to its destination through distribution centers.

An operator sitting at a console wishes to send a document to multiple recipients. In the prepare mail function the operator simply creates a document and edits it accordingly getting the "target" document in the desired format through the power of a Wang Word Processor. Next the document must be addressed, the necessary priority and security codes specified. Addressing is done by one of three methods: First, the operator can simply type in the individuals who are recipients and append their names to the document. Secondly, the operator can specify a stored distribution list which will be appended to the target document. Thirdly, the operator may specify a function code, title code, geographical location code, etc. which will automatically cause the document to be routed to all those fulfilling this code entry. For example, a document destined to be received by all division managers can be specified at the origination point by a few keystrokes. After execution of one of these three steps which is at the operator's discretion, the target document is placed in an "outbox", an electronic mailbox which can be inquired on by the distribution center.

At user selected times during the day the distribution center automatically establishes a telecommunications link with this and other origination points. Documents are first delivered to this origination/distribution point (system) and then documents which have been prepared in the aforementioned fashion are communicated to the distribution center. This is done without the "breaking" of the communication link.

Upon receipt of the mail from the origination points the distribution center then processes the mail. Processing involves checking to make certain that all the addressees are valid users within the Mailway system, that the correct dispatching of mail is dictated by the priority code that was entered when the document was prepared at the origination point, that the necessary level of security is incorporated into the document upon routing to its distribution point(s), and that an entry into the Mailog is made at the distribution center which is later reconciled against confirmation of delivery. The distribution center than places a copy of the document into an outbound mailbox. Once again the distribution center automatically established a telecommunication link to the respective recipients at the time of day that is specified in the route table (maintained at the distribution center) and the mail item transmitted.

Upon receipt of a mail item, the recipient may do any of the following:

- If security was specified at the time of mail creation, the user must specify his password to access the mail item.
- The document may be viewed on the Wang Word Processor screen.
- The document may be printed.
- At the ecipient's discretion, the document may be further distributed in exactly the same fashion mentioned earlier, i.e., specifying the distribution list.
- If the security code permits, the editing of the mail item and the re-routing of the item back to the originator.

It is appropriate at this time to identify what specific Wang systems can be utilized within Wang's Mailway system.

The distribution center is always a VS system. The VS is a system capable of performing data processing tasks as it is a virtual memory system supporting from 2-128 interactive users. It's storage capabilities span the range from 20 megabytes to 2.6 billion bytes. Mailway is an application package that runs on a VS system yet imposes no restriction of the minimum or maximum configuration other than what was specified above. It is extremely important to note that the VS also supports a full word processing capability. As a result, the distribution center performs Mailway as a background task, while users can utilize the CRTS to perform word processing and data processing functions. Thus a user on the VS (distribution center) can also prepare mail items as well as receive incoming mail. Mailway also does not impose restrictions on the content of a mail item. As a result, not only can documents be routed but computer reports generated by the VS can also be disseminated as well.

Origination/distribution points are Wang Word Processing Systems, Office Information Systems (Word Processing Systems with BASIC programming capability), or as mentioned, a VS.

ERIC

To summarize the Mailway system, Mailway provides:

- The means of creating a mail item on any Wang CRT in the network.
- The means of preparing a mail item by specifying the priority code, security code and distribution list for this item.
- The "picking up" of the item by a distribution center.
- The processing of the item at the distribution center.
- The delivery of the item at a time specified in the route table (or overridden by the priority code).
- The access of the item at its destination by the user and possible re-routing of the item providing the correct password is entered.

To expand upon the considerable basic functionality of Mailway into the "Office of the Present" it is only necessary to keep in mind the various peripheral capabilities of Wang equipment. Mailway does not restrict in any way the peripherals which can be locally attached to a Wang system. Phototypesetters, intelligent image printers utilizing fiber optic technology and capable of producing up to 18 pages a minute of high quality output, OCR equipment, to name just a few, are directly compatible with the Mailway system.

What does all this mean to a company interested in Electronic Mail?

- Documents or computer reports can be routed automatically to recipients.
- These mail items are delivered quicker and at less expense than existing services such as facsimile, TWX or TELEX.
- That the quality of output is always excellent and is the same as the original.
- The distribution center is truly an Integrated Information System capable of performing DP, WP and Mailway functions simultaneously.
- The routing of documents or reports can be to those systems having specific output devices such as phototypesetters, providing the user with potential maximum usage of these sophisticated input/output peripherals from any system regardless of its physical location
- The ability of the system to expand as your needs increase by simply adding additional distribution centers and origination/distribution points.

We hope that both the listeners of this presentation as well as the readers of this document have a better perspective of specifically Wang's Mailway System and, in a more general sense, an understanding that most of the functionality usually mentioned as "Office of the Future" capabilities are available and being installed today.

5

Packet broadcasting on a satellite SCPC channel for 'thin-route' applications: a simulation study.

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Abstract

A simulation study of a proposed satellite based data communications network for the State of Alaska was performed to estimate the number of users which could be supported on a single voice-grade SCPC channel. The simulation was based on a terminal-to-terminal interactive communications mode (such as interactive Telex). Such a system, supported by relatively inexpensive small earth stations, could handle message traffic, electronic mail, remote computer access, etc. The channel data rate was fixed at 9600 bps. Given this restriction, it was determined that this system would support numbers of simultaneously active users ranging from 50 (8-bits/sec) users to greater than 400 (1-bit/sec) users.

Introduction

Many of the regions of the Pacific rim have communication problems similar to those in Alaska (small population, widely dispersed geographically; difficult or impossible terrain; high travel and installation costs). These are the common problems of "thin-route" networks. Solutions proposed for Alaska may have direct application in many other locations. The network and the simulations described in this paper will be couched in terms of the Alaskan situation, but it is hoped that extrapolation to other implementations will come readily. With that hope in mind, I shall first describe the existing network of earth stations in Alaska that support voice traffic. The necessary enhancements to this network to support the data network will be outlined. The simulation study will be described and the pertinent results shown, a short summary of some typical applications and enhancements given, and a brief evaluation made.

The Alaskan network

Several years ago the State of Alaska made a committment to providing message toll service and medical communications to a very large segment of its population. The goal was a satellite earth station with basic voice capabilities in every village of 25 or more people (there are more than 200 of them)! To date more than 100 such locations have operating stations. Counting earth stations of all sizes, there are about 140 earth stations around the state of Alaska. This supports a total population of about 380,000 very unevenly spread over 586,400 square miles. Since more than 200,000 of these live in the immediate vicinity of the three cities of Anchorage, Fairbanks and Juneau, it becomes apparant that the population density outside these specific areas is quite low.

The small earth stations consist of a 4.5m dish and an electronics rack. The physical housing for this varies greatly. The hardware costs about $50k, and remote site installation expenses increase this to a total installed cost of around $100,000 per site. Basic facilities include two voice channels--one for MTS and one for Indian Health Service medical traffic. The physical configuration is capable of holding eight channels, but traffic density/power budgets may limit the installed total to less than that. The system is configured around single-channel-per-carrier (SCPC) utilization of the transponder.

In order to build a generalized data communication network upon this backbone, certain hardware will have to be added. The simulated network assumed a single channel added to each earth station, all accessing a common broadcast transponder channel. The use of a single voice grade channel for the entire network is a significant financial point. The cost of the space segment of this network amortized over the number of earth stations involved is nearly negligible. For example, in Alaska it is estimated that the channel will cost in the vicinity of $2000/month. If there are only 100 earth stations involved in the network, that results in each site paying only $20/mo. for the space segment. The necessary incremental hardware (data-optimized channel cards and a micro-computer controller) is not yet commercially available, but rough estimates place the cost in the neighborhood of $5000 per site in production quantities. Physically, this incremental hardware would support multiple typewriter-like terminals in the vicinity of the earth station. The cost of the terminals themselves and of any communication equipment for terminals remote from the earth station are not included in this figure.

Operationally, the data network has the appearance of a fully connected, terminal-to-terminal conversational system. A user at any terminal may directly communicate with a user at any other terminal. If the two terminals are attached to different earth stations, only the two stations involved (and the satellite, of course) need be operational to complete the "circuit". If the two terminals are attached to the same earth station, only that station need be operational.

Packet Broadcasting

Packet broadcasting techniques were first described and implemented at the University of Hawaii ALOHANET. The details have been thoroughly reported (1,2) and won't be repeated here. For completeness, however, a very brief synopsis will be given. Packet broadcasting is a technique for the statistical sharing of a common channel. Users attempt to transmit messages *ad lib* on the channel. If no one else is attempting to transmit at the same time, the message gets through. If two or more users attempt to use the channel at the same time, contention for the channel causes all messages to be garbled and each user will have to try to transmit his message again. In "Pure ALOHA" with acknowledgement, each successful message transmission is acknowledged by the receiver (in our network, these transmissions are subject to contention, also). When contentions exist, each user waits a random delay before trying again in order to avoid lock-step contentions time after time.

Messages are embedded in packets (hence the name) which contain error detection and supervisory information as well as the data. Packets may consist of only a header, or of a header and a message field. Our headers contain both source and destination addresses, packet type designators, message count and length fields, and other necessary control information. The header has a CRCC error detection field computed and appended to it. If there is a message, it is appended to the header/CRCC along with another CRCC computed for the message field. Packets will be of varying lengths, ranging from a header only (as a minimum) to a header plus whatever maximum number of characters is allowed for a message (plus CRCCs, of course). All packets have some sequence of bits and characters preceding the header which allow for bit and character synchronization of the hardware.

The simulation study

The simulation of this data communication network (3) was performed in an attempt to estimate the potential capacity, which is crucial to even preliminary feasibility studies. The simulations were done in two parts: 1) a "Pure ALOHA" system, 2) our network. The "Pure ALOHA" simulation was done to compare with theoretical predictions as a benchmark of the simulation method and is of only passing interest, as a verification of technique. The close agreement between the theoretical predictions and our simulation gave us some assurance that we were indeed using the tools appropriately. Then, our network was simulated for all combinations of a selected set of network and user parameters.

Several assumptions about the network and the characteristics of the users are important to note. Since the purpose of the simulation was to set rough bounds, it was assumed that exponential distributions (easily computed within the simulator) approximated closely enough the more usual Poisson distributions. The communication system was assumed to be noise free (actually measured BER of 1E-6 to 1E-8 have been reported (4)). All users were assumed to be humans generating messages by typing them at terminals, each at a separate earth station, and independent of each other.

Channel data rate was fixed at 9600 bps, system time resolution was set at 1 msec, header length was fixed at 80 bits, and round-trip propogation time to the satellite was approximated at .25 sec.

Messages consisted of single lines of text limited to 80 characters. A truncated exponential distribution with mean about 18 characters was used in generating new messages. The average data rate of the users was manipulated in the simulation as THINK TIMES, the times between submission of messages. Rough figures from The ALOHA System and from the Dartmouth Time Sharing System suggest that typical data rates range down from 10 bits/sec, and practical values were selected in the 1-5 bits/sec range.

The network design included two parameters which were varied in an attempt at optimization of behavior. The random delay, before a station attempts to retry a transmission which was garbled, is a zero based uniformly distributed random variable, and is completely described by its mean (called MEAN RETRY DELAY). The number of retries which a station is allowed is limited and is called the RETRY COUNT.

The simulation language used was GPSS/66 (5), a discrete event simulation system. Figure 1 shows the flowchart of the simulated network. A brief survey of this will give a better idea of the operation of the system. Packets are submitted to the channel according to an exponential distribution. In the first block the mean of this distribution is determined from the number of users and their THINK TIMES. Each packet that is generated is flagged as a message (or TEXT) packet and assigned a randomly generated length (max of 80 characters) in the next three blocks. Next the maximum RETRY COUNT is assigned to the packet, then the total packet duration in simulation time units is computed. It is then submitted to the channel. In our simulation, we assumed that the effects of contention are seen in the receiver, so we delay a packet for .25 sec, then enter a receiver. It is at this point that contention is checked. If there is no contention, the packet is converted to an ACK (header only) and looped back to compute length and resubmit to the channel. If the ACK has no contention, the transaction is terminated as a GOOD packet. This implies that the message was delivered and acknowledged.

Should there be contention with either a TEXT or an ACK packet, its RETRY COUNT is decremented and tested for zero. If the number of retries has been exhausted, the packet is terminated as BAD. This implies that the system was unable to deliver or acknowledge delivery of the message. If the RETRY COUNT has not been exhausted, the packet is tested for TEXT or ACK, as there will be a difference in total delays of .25 sec between the two at this point. TEXT packets are given an extra .25 sec delay, and then either are delayed a random time, the RETRY DELAY. The TEXT attribute is reset and the packet submitted to the sequence again.

A simulation run consisted of setting the parameters of the network to the desired values and then stepping through successively higher numbers of active users and running a simulation for each level. Individual simulations within a run started with a priming period during which the network would come to steady state under those loading conditions, followed by a statistic gathering period. Simulation was ended when 2000 packets had terminated. Preliminary test runs indicated that this was a sufficiently large number to get reliable statistics under conditions of interest. Each such run generated two sets of values to be plotted against numbers of active users, three examples of which are shown in Figure 2. Plotted at the top is QUALITY FACTOR (QF). This is the ratio of packets terminated GOOD to total packets submitted, and is a measure of the reliability of the network under those conditions. Below it is plotted the MESSAGE DELAY TIME (MDT), which is a measure of the delays experienced by a user from the time he sends a message until it is acknowledged as having been received. Families of these curves were plotted using RETRY COUNT or RETRY DELAY as family parameter with the other fixed. In this way, a graphic visualization of the behavior of the network to increasing loads was obtained.

Simulation Results

Figure 2 shows a family of the results of three sets of simulation runs. It was from such sets of curves that qualitative evaluations were made of the capabilities of the network. As an example, note the shape of the QF curves as user loads increase. Higher RETRY COUNTS keep the QF large for higher numbers of users, but the fall-off is steeper. The network would degrade more rapidly (or more noticeably) as the loading increased with higher RETRY COUNTS. The other side of the trade-off is the MDT, which increases with RETRY COUNT. All of these interactions appear to be gentle, with no combinations standing out as obviously unacceptable nor as obviously superior.

A selection of values was made (RETRY COUNT=5; RETRY DELAY=300 msec.), as an "optimized network", and additional simulations performed to extrapolate the numbers. Figure 3 is a plot of number of users which this system will support at a given level of service vs. the user data rates (expressed as THINK TIME). The contours for three values of QF and four values of MDT are shown. As an example, at QF = .98, the network will support around 140 simultaneous users who (on the average) take one minute between successive messages. And at that level, the users experience an average of [illegible] sec delay from sending each message to receiving an acknowledgement of its delivery.

Applications and Enhancements

The basic communication facility described above supports conversational terminal-to-terminal exchanges. There is, of course, no reason why one "terminal" cannot be a computer, giving all other users access to a time-sharing system. Such a facility would offer all the functions of whatever time-sharing system was running: data storage; program generation and execution; mail; word processing; etc. This has been implemented in The ALOHANET, giving users at remote terminals access to the University of Hawaii computer system.

The network as described does not handle store-and-forward message traffic, but with some local bulk storage (bubble memory?) this could be an obvious enhancement of the facilities. Of course, most time-share systems do provide some form of mailbox for this function. It is possible, because of the inherent broadcast nature of the medium, to multiple address messages so that many stations will receive a given transmission. "Bulk mailing", such as administrative, educational, or informational items, could be handled easily and in low load hours. Any of the exchanges between two terminals could be made secure using the commercially available encryption equipment (based on the new DES) as terminal add-ons.

The packet broadcast channel would not be expected to have voice compatible hardware because of the desire to optimize the channel for data use and consequently this channel would not normally be available for emergency voice traffic. However, since this packet broadcast technique is tied to a satellite earth station, there would almost certainly be channels available for voice traffic separate from the data channel.

Evaluation

Cotton and Grubb (6) have given 9 points by which to evaluate a data communications service. These are usable guidelines by which to make a quick evaluation of this network. The nine criteria are:

1. Transfer Rate
2. Availability
3. Reliability
4. Accuracy
5. Channel Establishment Time
6. Network Delay
7. Line Turnaround Time
8. Transparency
9. Security

1) The basic channel data rate is 9600 bits/sec. However, it can be seen that our user data rates are much less than that. The ALOHA System found that there was a theoretical upper limit of 18% of the channel data rate at the highest level of service of The ALOHANET. Since our network allows ACKs to contend with packets, we should expect to be below even that figure. Indeed, we found aggregate throughput rates around 300 - 400 bits/sec. It sounds horribly inefficient. but the cost/benefit ratio for the total number of simultaneously active users counters that impression.

2) There is little that can be said at this point about actual network down times. Remember, however, that each communication path requires only two earth stations and the satellite as a maximum. Thus one earth station out of service affects only the users attached to it. One other point might be noted is that a heavily loaded network which has degraded to very low QF may be effectively unavailable for additional users.

3) Similar comments can be made about Reliability as about Availability. In addition, the network performance measure QF is an indication of the message-by-message reliability.

4) Since the receiving station will not acknowledge a packet in which there are detected errors, the users will not often see any erroneous messages. Our message lengths have been limited to 640 bits with a 16 bit CRCC. This gives excellent detectability for errors. The error rate of packets actually delivered to the receiving terminal should be very low indeed.

5) For practical purposes, there is no delay in establishing a channel. A user will type a destination address into his terminal which will be used for subsequent messages. This, in effect, establishes the channel.

6) We have measured Network Delay to include the acknowledgement as well as the delivery of the message. For the levels of loading investigated here it ranged from the physical lower limit of .5 sec (two round trip times) up to little over 2 sec. This delay is certainly within the "patience limits" found to exist in most human oriented systems. It will be additive, however, to delays in the accessed system (such as a time-share system).

7) There is no equivalent of the line turnaround delay.

8) As proposed, the communication system is totally transparent. Contents of the TEXT field are not used for control.

9) The basic network is quite insecure. Without tampering, messages will be delivered only to the addressed terminal. However, network protocol is simple, any earth station has access to all transmissions, and hardware is cheap. It is quite conceivable that a station could be modified to monitor all transmissions. Any security, then, would derive from add-on techniques. Encryption hardware can certainly be added to any terminal as necessary.

Conclusions

Conclusions to be drawn from this study are very short and direct. Packet broadcasting techniques offer an economical method for providing people oriented data communications under "thin-route" conditions. Costs for satellite earth stations are dropping, making it possible to consider placing such stations in areas of very low population. Incremental hardware to implement the basic packet broadcasting network will be very inexpensive, and the space segment for a large network will be insignificant. In summary, these techniques would support a number of active users ranging from tens to hundreds, as shown by Figure 3.

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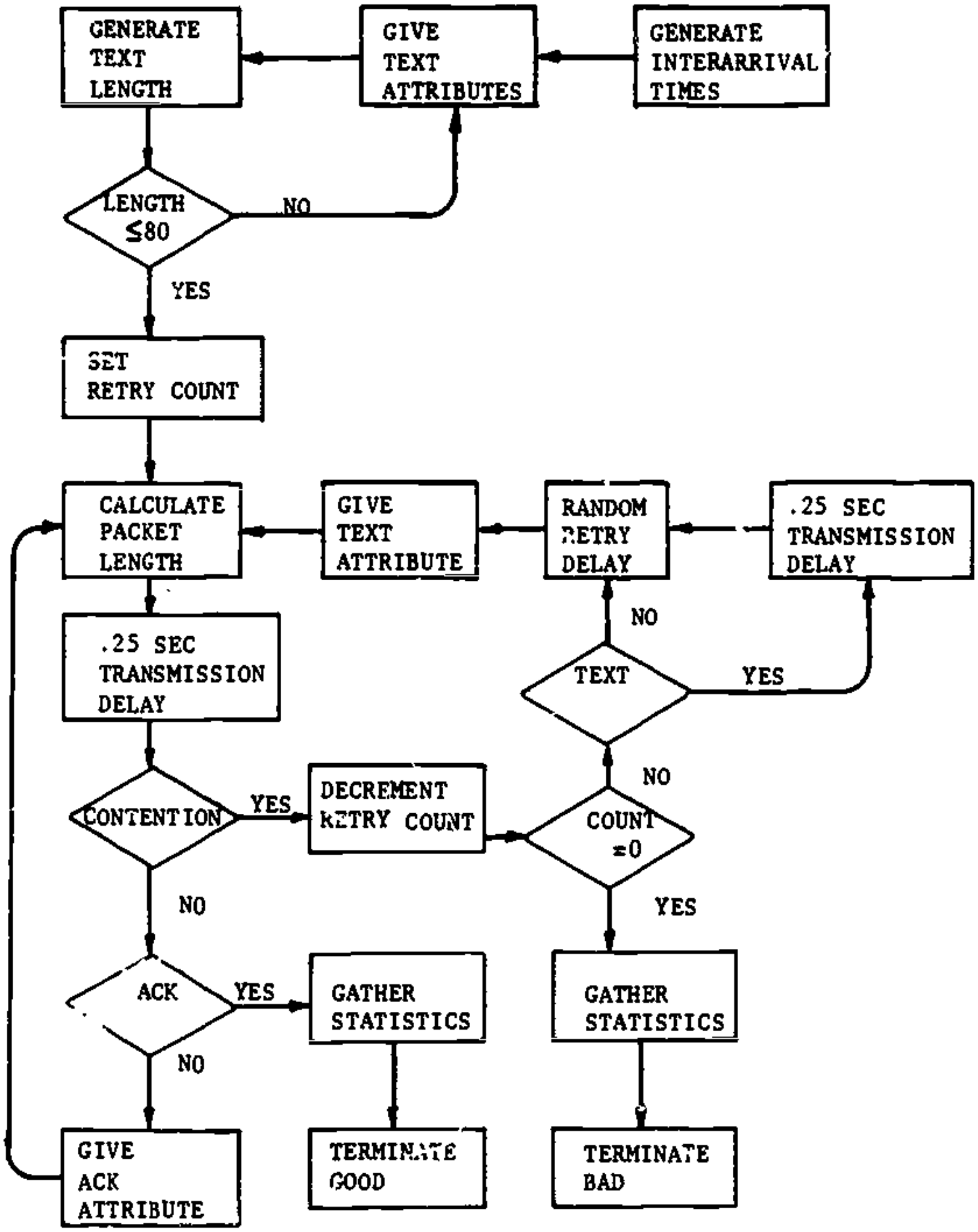
GENERATE TEXT LENGTH
GIVE TEXT ATTRIBUTES
GENERATE INTERARRIVAL TIMES
LENGTH ≤80
NO
YES
SET RETRY COUNT
CALCULATE PACKET LENGTH
GIVE TEXT ATTRIBUTE
RANDOM RETRY DELAY
.25 SEC TRANSMISSION DELAY
NO
.25 SEC TRANSMISSION DELAY
TEXT
YES
NO
CONTENTION
YES
DECREMENT RETRY COUNT
COUNT =0
NO
YES
ACK
YES
GATHER STATISTICS
GATHER STATISTICS
NO
GIVE ACK ATTRIBUTE
TERMINATE GOOD
TERMINATE BAD

FIGURE 1. FLOW CHART OF GPSS SIMULATION OF NETWORK.

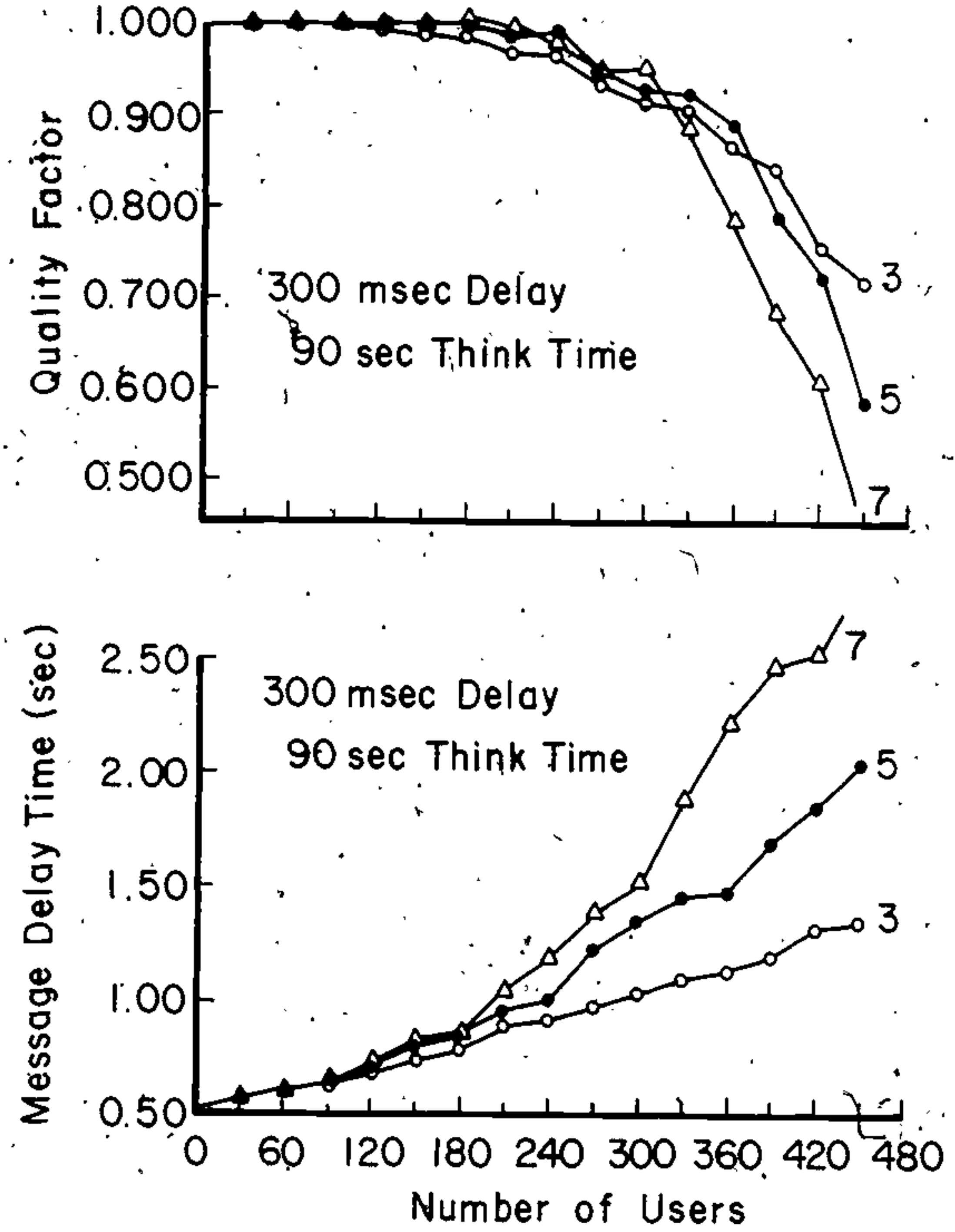

FIGURE 2. SIMULATED NETWORK RESPONSE FOR 'RETRY COUNT' OF 3, 5 AND 7.

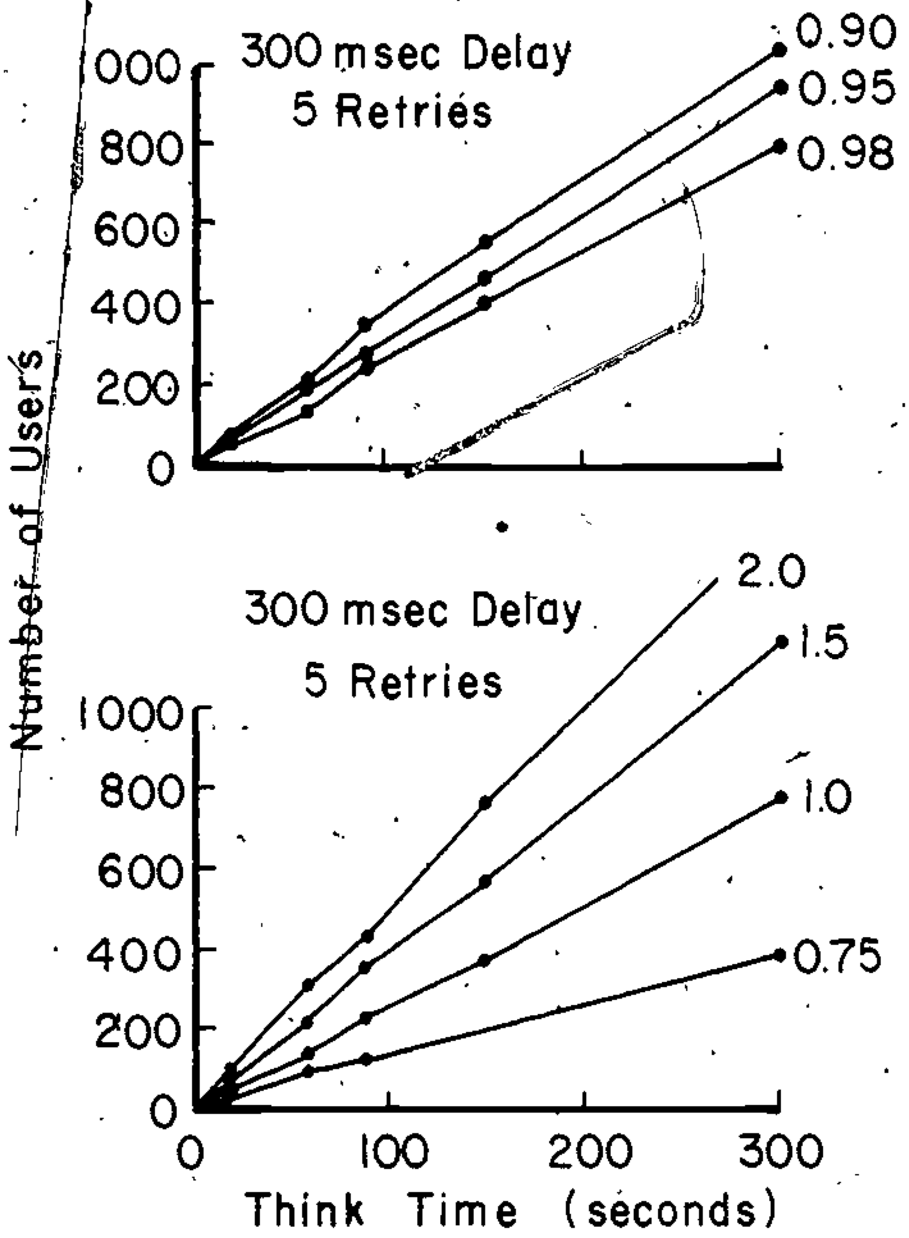

FIGURE 3. "OPTIMIZED NETWORK" CAPACITIES UNDER CONSTANT QF (TOP), AND CONSTANT MDT (BOTTOM).

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SATELLITE COMMUNICATIONS SERVICE FOR THE PACIFIC AREA

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Abstract

A concept is put forward that could provide voice bandwidth service to subscribers in the Pacific area. The cost of terminals would be low. The economic and technical basis for provision of the service is discussed, as well as the type of services that could and could not be provided.

PROBLEM

The Pacific area does not represent a large telecommunications market. It has, therefore, been relegated into the role of attempting to make use of systems that have been designed for large markets.

The Pacific area is sparsely populated (very wide coverage, very few people) resulting in very low potential traffic routes and few natural communications nodes. No network is in place to take centrally received data and distribute it to outlying users--almost everyone is outlying.

Strategic and tactical requirements which can be used to bypass market forces apply in only a few places and hence do not materially enhance the desirability of establishing otherwise unprofitable communications capacity.

Special economic factors (such as oil fields, gold mines, or Olympic games), which provide their own communications, appear to be absent.

Financially, it is not clear how profits can be made by providing conventional satellite communications services to the Pacific area. The United States Government appears unwilling to pay the bill unless the amount can be made small enough to be rationalized on strategic, tactical, or political grounds.

The foregoing discussion oversimplifies the problem of why the Pacific area is lagging in much needed communications services. But the value of an amateur (an apt description of the author with regard to Pacific area problems) is that he is sufficiently removed from the details of the problem to be able to suggest potentially new avenues of solution--which, if attractive, can then be shaped by experts to fit the complex realities.

SOLUTION

A solution of the problem lies in the characterization of the problem. The islands of the Pacific area are not small versions of communications centers like New York City--Manhattan, Midtown, or 34th Street between 7th and 8th Avenues. Scaling down a system designed for large communications modes to make it fit the Pacific Islands is doomed to failure. Imagine, trying to design a motorbike by starting with the design of an 18-wheel tractor trailer. The islands are not and will not likely ever be small Intelsat terminals and it is unrealistic to think that a mini-Intelsat system will be designed for the islands unless gold or oil is discovered, or the Olympic games are held there.

But, if one thinks of the islands as slow moving Marine terminals--very slow moving--then the possibility for communications service can be envisioned. Not today, but within today's technology.

The Pacific islands are "Maritime" (Webster: 1. Bordering on, or situated near the ocean. 2. Connected with the sea in respect to navigation or commerce) and therefore a Maritime Satellite ought to serve the islands as well.

The requirements for a Maritime Satellite are that it serve a large number of potential users, spread over a large area, with voice bandwidth capability, on a low duty cycle demand access basis. These requirements are, in fact, being met today by the Marisat.

Another requirement for a Maritime Satellite is that it provides this service to users with very austere terminals. Austere means small, simple, low power consumption and, above all, cheap. This requirement is not being met today--Marisat terminals are expensive.

The solution is in current technology. NASA is presently sponsoring the development of the Adaptive Multibeam Phased Array (AMPA). AMPA technology increases the capability of the satellite portion of a communications satellite system, thereby allowing it to work with cheaper ground terminals. AMPA achieves this capability by replacing the single low gain earth coverage beam of Marisat with a number of rapidly repointable beams of higher gain (Figure 1). Since the total gain (at the satellite plus that of the ground terminal) is fixed, more gain at the satellite means less gain is required at the ground terminal. In fact, pointing of the ground terminal antenna can be eliminated altogether which means the antenna can be just a little rod. The result is a much cheaper terminal than the current steered parabolic reflectors of Marisat terminals.

Another feature of the AMPA technology is that it can carry on multiple conversations on the same frequency channel at the same time. That is, it listen in one direction and null in a second direction. Simultaneously, it can listen in the second direction and null in the first direction. (For details about the AMPA technology, see references 1 and 2). The result is that one or a few channels can serve many thin route users.

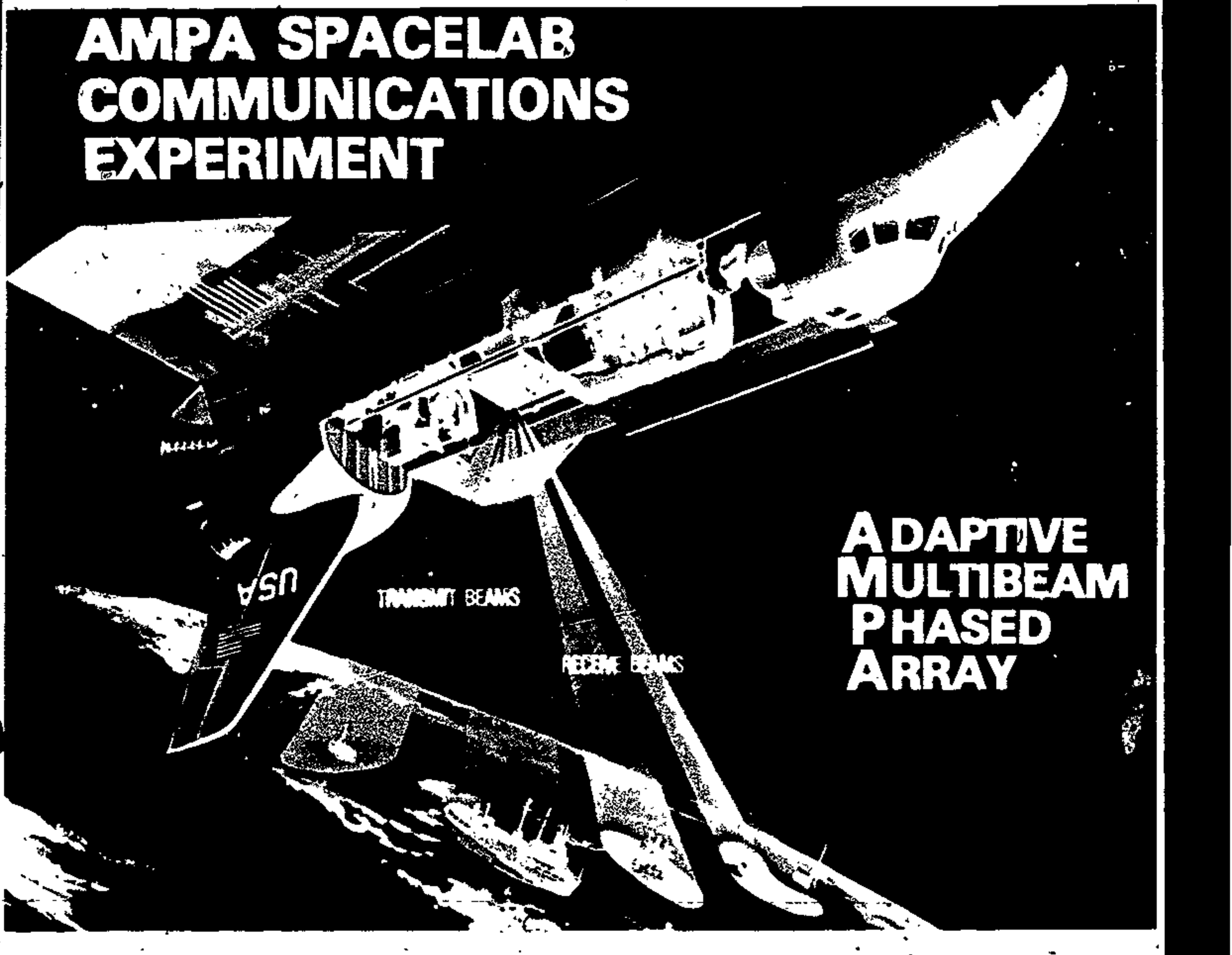
AMPA SPACELAB
COMMUNICATIONS
EXPERIMENT
USA
TRANSMIT BEAMS
RECEIVE BEAMS
ADAPTIVE
MULTIBEAM
PHASED
ARRAY

FIGURE 1. ADAPTIVE MULTIBEAM PHASED ARRAY

If the frequency channels allocated for maritime communications are conserved by reusing them taking advantage of the AMPA technology, then the current allocations will be ample to provide service to both moving (ships) and stationary (islands) users.

Thus, if the future Maritime Satellites incorporate the AMPA technology there will be:

- A satellite over the Pacific that serves austere terminals
- An existing frequency allocation that can handle many simultaneous voice bandwidth users
- A central operator system (Figure 2) to route calls and handle billing functions

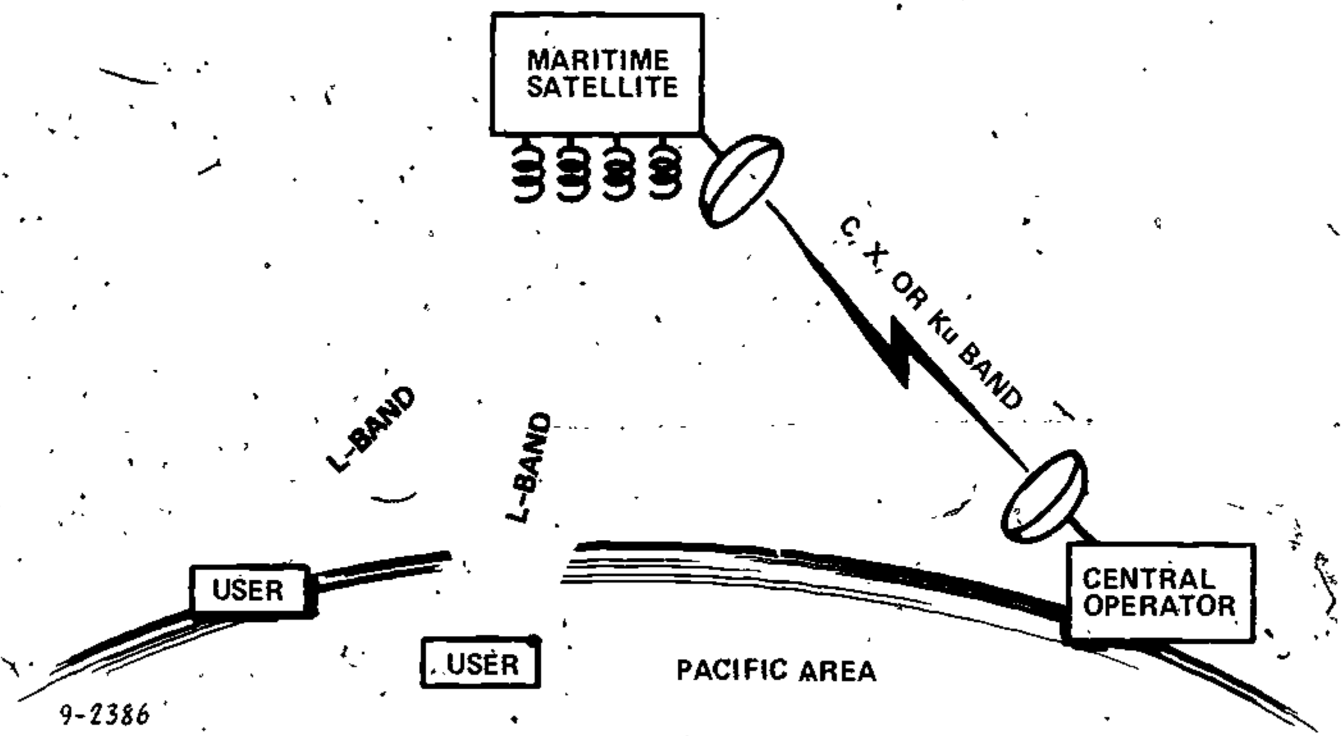
MARITIME SATELLITE
C, X, OR Ku BAND
L-BAND
L-BAND
USER
USER
CENTRAL OPERATOR
PACIFIC AREA
9-2386

FIGURE 2. SYSTEM CONCEPT

Users that are disjoint in space have separate beams pointed at them while they are interconnected. The beams are slewed (electronically) to different sets of users on a demand access basis. The number of beams is directly proportional to the amount of beamforming hardware. It is possible to have the beamforming hardware in the Maritime Satellite or at the central operator position. The latter allows for a larger number of simultaneous beams since the added hardware is on the ground.

In either case the identity of an island user defines a unique direction as seen from the Maritime Satellite. This direction-of-arrival information is used to generate a reception beam that illuminates the island user and nulls all other energy in that frequency channel. On transmission, the known locations of all simultaneous users of a given transmission frequency are entered into the beamforming computer at the central operator facility. The computer then generates the necessary phased array weights that route the communications beams to their intended listeners while simultaneously not transmitting it to other cochannel users.

The total power of the Maritime Satellite is shared equally amongst all its simultaneous users although sharing on the basis of receiver need can be readily implemented at the control operator facility.

Why should this AMPA technology be incorporated into future Maritime Satellites? Why hasn't it been incorporated heretofore?

To answer the second question first--commercial ventures are, by the nature of the risk involved, hesitant to enter into technological development. They will rely on AMPA technology when it has been proven. The risk role must be assumed by NASA--which they are currently playing, albeit slowly.

As to the first question, the AMPA technology will be incorporated once it is proven--not to satisfy the Pacific islands market (we have already concluded that the market is small) but rather to spread the availability of maritime communications from the current few hundred large ships to the thousands of small ships that ply the Pacific. To the extent that islands can appear like small ships (with similar budgets for communications) they will benefit from this natural market conglomeration.

What does this mean in terms of service?

At its simplest, anything one can fit into a voice channel bandwidth can (theoretically) be provided.

- One-way and two-way voice communications.
- Educational voice broadcast (provided there is someone to generate the material, identify the simultaneous receivers and, most importantly, pay for the channel time).

- Secure data can be sent if someone is willing to pay for the encrypting and decrypting modems. This could cover financial transactions, air traffic scheduling, even gossip--but it will cost more than just plain talk. However, one of the by-products of AMPA technology is that communications are limited to relatively narrow beams which may cover a single island group. Listeners in other island groups will be denied access and in fact may well be receiving different data intended for their island group on the same frequency channel at the same time.

- Emergency functions can preempt channel use because the central operator will operate in accordance with prearranged priorities.

- Computers can be accessed provided: (1) they are directly (or indirectly via multisatellites hops) in view of the Maritime Satellite, (2) they have a terminal, (3) there exists a protocol for access, and (4) the wherewithal exists to pay for the channel time. Performance should be indistinguishable from remote computer terminal systems currently tied together by phone lines.

- Facsimile, which currently goes over commercial phone lines, would be accommodated. All that is needed is compatible terminals at either end. Hence, electronic mail can follow.

But you can't get "I Love Lucy" or the Winter Olympics. Austere terminals are limited to austere throughput and for the foreseeable future satellites capable enough to pass wideband communications between austere terminals appear very unlikely.

What can and should be done to facilitate the emergence of a Maritime Satellite that will be capable of providing service to Pacific island users?

- NASA needs to be encouraged to step up the pace of the development of AMPA technology and to provide a test bed for orbital proof of technology to permit the private sector to proceed with acceptable commercial risk.

- Inquiry needs to be made with the FCC to assure that very slow moving ships (islands) can use the maritime communications frequency allocations and if not, get them to change their rules.

- Comsat, the U.S. Representative to the International Maritime Organization and part owner of future maritime communications satellites, needs to be encouraged to service this new class of customer and to give serious consideration to AMPA technology in future Maritime Satellites.

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PRESENT STATUS OF JAPANESE "CS" PROGRAM

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Abstract

The Japanese Medium-Capacity Communication Satellite for Experimental Purpose [CS] has been developed to promote Japanese domestic satellite communications using C-band and K-band radio waves and was launched successfully in December 1977 and placed at 135 deg. east longitude in a geostationary orbit. The various experiments are being conducted using the CS.

This paper will present some experiment results of the CS program.

1. Introduction

The CS has been developed to promote Japanese domestic satellite communications such as telephone, color TV transmission and so on, using C-band and K-band radio waves. The CS program was originated by Ministry of Posts and Telecommunications [MOPT] in cooperation with Nippon Telegraph and Telephone Public Corporation [NTT], and the CS was developed in charge of National Space Development Agency of Japan [NASDA] since 1973.

The CS is a spin-stabilized spacecraft weighing about 340kg on orbit and is boarding two C-band and six K-band transponders, together with a unique communication antenna. The design life of the CS is approximately three years.

The CS was launched by a Delta 2914 launch vehicle from the Eastern Test Range of NASA on Dec. 14, 1977 under a contract between NASA and NASDA. NASDA took over the satellite after it was injected into transfer orbit, and put it into a geostationary satellite orbit on Dec. 24.

Now, the various experiments using the CS are being conducted by the Radio Research Laboratories [RRL] of MOPT in cooperation with NTT, and station keeping and house keeping are being conducted by NASDA. Valuable technical and operational data necessary for establishing operational domestic satellite communication system are being acquired.

2. Outline of CS Program

The experiment items of the CS program are classified as follows :

* Measurements of on-board mission equipments characteristics
* Experiments on signal transmissions through satellite communication system

- Measurements and evaluations of radio wave propagation characteristics
- Experiments on satellite communication system operation
- Experiments on satellite operation and control

Major characteristics and spacecraft configuration of the CS are shown in Table 1 and Fig.1 respectively. The communication subsystem consists of K-band and C-band transponders and a communication antenna. The block diagram of communication subsystem is shown in Fig.2. The communication antenna is a high-gain shaped-beam mechanically despun antenna. K-band is used for communications in the Japanese main islands, and C-band is used for communications in the Japanese main and remote islands including Okinawa and Ogasawara. The antenna patterns are shown in Fig.3.

The general configuration of the CS experiment system is shown in Fig.4. There are Main Fixed Earth Station [MFES] which has K-band and C-band communications and C-band TT&C facilities, and three Fixed Earth Stations [FES]. One of FESs has comparable functions to that MFES and other two are used only in K-band communications. Other stations are a C-band Transportable Earth Station [TES] installed in a remote island, and two vehicle mounted type small Transportable Earth Stations [STES], where one is for K-band and other for C-band. Beside above stations, several small terminals are prepared for measurements of quasi-millimeter wave field strength or small traffic communications.

3. Results of Experiments

3.1 Mission Equipments Characteristics

Transponder Characteristics. The periodic checkup for the mission equipments on board the satellite is performed every six months. The measuring methods are based on the pre-launch test procedures and the items include envlope transfer characteristics, frequency amplitude response, group delay, translation frequency, spurious response and antenna patterns by changing its offset angle from the east to the west. Fig.5 shows an example of the checkup data and shows envelope transfer characteristics of the G2 channel which has command-controlled step attenuators. As compared with the results of the past checkup data, no remarkable changes have been found. Some of the items and test procedures in the periodic checkup were found to be unsuitable for communication link analyses, and we performed several additional and improved measuments on experimental bases. There are measurement of noise figures (NF), instantaneous envelope transfer characteristecs of a transponder with an AGC circuits, AM/PM conversion factors, frequency amplitude responses in nonlinear or in AGC region and so on. Frequency amplitude responses are usually measured by using a sweep signal generator. However. this method is not suitable for a transponder which has an AGC circuit or nonlinearity in the TWT amplifier. We developed an unbalanced two-tone method and derived the reasonable response. The value of noise figures is important for link designs and we obtained these from measuring uplink and downlink C/N ratios, AM/PM conversion and compression factors for transponsers of the on-orbit satellite. The curved line in Fig.6 shows an apparent noise figure and it shows the noise compression effect of the TWT clearly. Taking AM/PM conversion and compression factors into consideration, we can derive the reasonable noise figure drawn by a straight dotted line. Nonlinear characteristics are mainly caused by the TWT in transponder. We need to know the envelope transfer function to represent the nonlinearity. Using the Chebyshev transform, we derived the transfer function and derived nonlinearity characteristics for the TWT of the transponder with AGC.

Antenna Patterns The azimuth patterns are usually measured as a periodic check-up every six months. Further, when the spin axis inclines toward the earth, the beam direction changes from the north to the south with 24 hours period. Utilizing this fact [illegible] changing the antenna off-set angle from the east to the west, we obtained ant[illegible] gain contours. Fig.7 shows the gain contour of the K-band beacon signal. Similarly, were measured patterns of C-band TT&C channel, up and downlinks communication channels, XPD and ZPOL of K-band beacon signal, and width of spin modulation.

3.2 Signal Transmission through Satellite Communication System

RRL and NTT are conducting various communication experiments. For basic communication experiments which are mainly satellite loop-back tests, signal transmission tests or FM, CPSK and DPSK are being conducted.

FM Signal Transmission Experiments Fig.8 shows results of 1872 ch noise loading test in a K-band link where the input back-off of the transponder is 3.8 dB. As shown in the figure, S/N ratio at the top channel is less than 50 dB for the INTELSAT standard loading level and the S/N ratio becomes greater than 50 dB when the loading level is increased. However, rainfall margin is very small in this case. Therefore, 972 ch of multiplexed telephony transmission is considered to be reasonable in a K-band link. The transponder nonlinearity degraded S/N ratio of FM demodulated signal by about 1 dB due to AM/PM conversion. The spin modulation did not affect average S/N ratio above the threshold C/N ratio but it degraded the threshold C/N ratio about 1 dB for 8 dB peak-to-peak spin modulation. As for TV signal transmission, it was possible to obtain good picture quality of which weighted S/N ratio was more than 70 dB utilizing the wide band characteristics of the transponder.

PSK Signal Transmission Experiments Generally, PSK signal transmission quality is evaluated by bit error rate (BER) performance versus C/N (E_b/N_o) ratio. However, effects of transponder nonlinearity appear strikingly as a noise suppression effect in C/N ratio measurement. Therefore, BER performances differ depending on methods of varying C/N ratio as shown in Fig.9. In the figure, curve C was obtained by adding noise at the transmitting side of the earth station and curve A at the receiving side. Further, curve B was obtained by varying transmitting power. Since E_b/N_o is more than 20 dB in both C and K-band links, it is considered that curve B is not affected much in E_b/N_o measurement by the transponder nonlinearity. The nonlinearity itself did not affect signal quality so much, but it is now under the precise investigation. Average BER performances were worsened by about 1 dB at 10^{-4} of BER in K-band links depending on the amount of spin modulation. Fig.10 shows the effect of the spin modulation. In the figure, the instantaneous BER was obtained from measuring BER of short interval compared with the spin period. As for effects of rainfall, we obtained good correlation between rainfall attenuation and signal quality, and concluded 65 Mbps psk signal transmission are possible to have sufficient rainfall margin in K-band links.

3.3 Radio Wave Propagation Characteristics

RRL and NTT are collecting various kinds of propagation data which will be extensively usable for evaluation of K-band communications. These propagation data are obtained at several places where the earth stations are located. For example, Fig.11 shows a cumulative distribution of rainfall attenuation given to the 19.45 GHz beacon signal received at Yokosuka station and at Sugita station. The rainfall attenuation in an uplink can be obtained from the telemetry data of the satellite input power. Fig.12 shows the relation of up and downlink rainfall attenuation, and it shows the attenuation in an uplink is about 2.1 times in dB as that in a downkink. In C-band links, scintillations due to the ionospheric irregularity occur sometimes and we observed 7 dB receiving power variation in the maximum up to the present. Further, for another ionospheric effects, variation of relative propagation delay between C and K-band satellite links were measured and the maximum observed delay change was about 6 nsec. during about ten days experimental period.

3.4 Satellite Communication System Operation

We have been conducting commnication system operation experiments using pairs of earth stations considering the configuration of operational communications.

TDMA Experiments The K-band TDMA system (TDMA-60M) is designed for telephone signal transmission (960ch one-way) among cities in the main island, of which antenna for the system is considered to be equipped on a roof of a telephone office building. Fig.13 shows the average BER performance measured at a 1.544 Mbps PCM singal stage. The degradation from the IF termination is 0.8 dB in C/N and is mainly due to the spin modulation. The C-band TDMA system (TDMA-100M) is designed for telephone and TV signal transmission between the main and some remote islands. It has the simultaneous transmission capacity of 384 one-way telephone channels and two 32 Mbps color TV channels. The both TDMA systems have good transmission qualities and various data are being collected to apply operational systems. Besides these TDMA systems, another TDMA communication experiment is being conducted and it has a function of site-diversity switching of which experiment will be conducted in the end of 1979.

Small Transportable Earth Station Experiments We have two kinds of FDM-FM systems by using small transportable earth stations(STES). The STES can be transported to any place by a truck or a helicopter. These systems are designed for emergency relief or temporary communication purposes. As for the transmission capacity, the K-band STES has 132 channels with a 2.7 m antenna, of which feature has a function of automatic transmitting power control (TPC) at the fixed station (FES) for countermeasure against rainfall attenuation. By using this function, the degradation of the signal quality was less than that of the system without the TPC as shown in Fig. 14 As for the transmission capacity, the C-band STES has 60 channels with 3 m antenna. C/N_0 characteristics in both-way transmission are shown in Fig.15. Communication links are operated at the intersection point of the two curves.

SCPC Experiment The K-band PSK-SCPC system is designed for small capacity transmission of telephone and data signals. From the results of both-way experiments, the link magins for rainfall attenuation were more than 10 dB to obtain required signal quality in both directions between the SCPC station and the main station. The antenna diameter of the SCPC station is 2 m and further, we are planning to use a smaller antenna of which diameter is 1 m.

3.5 Satellite Operation and Control

The operation and control of the CS spacecraft have been performed by NASDA CS Operation and Control System. The system is composed of Okinawa and Katsuura Tracking and Control Station which are linked to Tsukuba Space Center. The station-keeping and housekeeping of the spacecraft are regularly being performed by NASDA. The orbital position and attitude of the CS have been kept within an accuracy of ±0.1 degrees, and the beam pointing of despun antenna for communication has also been kept iwthin ±0.3 degrees. The Attitude control is executed every week, and east-west and north-south orbital control are executed every about 3 weeks and 10 weeks respectively. Through about two years period which include four eclipse seasons, the CS has been smoothly operated and confirmed satisfactorily for all functions and performances.

In addition to the regular operation of the spacecraft, the various experiments of satellite operation and control are being conducted by RRL and NTT. Usually, the range is measured through the TT&C channel. The accuracy of position determination is from 1 to 2 km with 24 hours ranging and angle data. We also conduct the ranging through a communication channel, resulting in the same accuracy. Those are ranging by the TDMA system and the two-hop ranging using the SCPC station which re-transmits the received ranging signals. As well known, the precise orbit determination needs two or three station's range data. However, by the two-hop ranging, we can obtain two station's ranging data essentially and do not need angle data of the earth stations. For another orbit determination method, we can use only the angle data because the K-band antenna beam of the earth station is very sharp and the determination accuracy is from 3 to 5 km by 48 hours observation.

The range prediction accuracy is within 50 m for two weeks with both 48 hours ranging data and estimated solar radiation pressure. Further, the accuracy of attitude prediction is within 0.01 degrees for 10 days, which is in the same order as the attitude determination accuracy.

4 Conclusions

The various experiments are now being smoothly conducted. Besides of the experiments descrived above, we are planning to conduct some other experiments such as SSRA(Spread Spectrum Random Access), FM-SCPC(FM-Single Channel Per Carrier), MCPC(Multiple Channels Per Carrier), a computer network via the CS, high speed facsimile transmission, data transmission, TV conference system and so on.

Furthermore, several organizations other than RRL and NTT take part in the experiments for cultivating their communication meams via satellite under the technical supports of RRL and NTT.

The results of the CS's development and experiments show that the CS system is satisfactorily applicable for operational use. Responding to the proposal of MOPT, the Space Activities Commission had decided in 1978 that the operational communication satellites, CS-2 and its spare spacecraft, shoul be launched in 1983 from Tanegashima Space Center by Japanese N-II rockets. The results of development and experiments in the CS program will be fully reflected on the CS-2 program.

Acknowledgement

The authors would like to express their gratitude to Dr. T. Ishida, Director of Satellte Research Division of RRL, Mr. K. Tsukamoto, Senior Research Officer of the Division of RRL, Dr. K. Miyauchi, Director of Integrated Transmission Development Division of YECL, Dr. H. Fuketa, Chief of Satellite Communication System Section of YECL and Mr. Y. Ichikawa, Director of Second Satellite Design Group of NASDA for their contribution to the CS program.

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Table 1. MAJOR CHARACTERISTICS OF CS

Physical Configuration and Dimensions:	Cylinderical spacecraft Diameter: 218 cm, Height: 348 cm			
Weight	At Launch: 670 kg, On Geosynchronous orbit: 340 kg.			
Communication Subsystem				
Transponder				
Frequency of Operation(nom)	K-band	30/20GHz	C-band	6/4GHz
Number of Channels		6		2
Channel Bandwidth (3dB)		200MHz		200MHz
Output Power/Channel		34.0dBm		34.5dBm
Input Noise Figure		13dB		9dB
Beacon Output Power		14.8dBm		14.[illegible]dBm
Antenna				
Minimum Gain over the Area	K-band	33dB	C-band	25dB
Polarization		circular		circular
TT&C Subsystem				
Antenna	S-band omni-directional antenna			
TT&C Equipment	S-band(Unified S-band) C-band/S-band converter, telemetry encoder and command decoder			
Electrical Power Source				
Solar Array Power	Beginning of Life(S/Solstice):	462w		
	End of Life(S/Solstics):	422w		
Attitude Control Subsystem	Spin stabilization	90 rpm spin rate		
Communications Antenna Pointing Accuracy	Smaller than ±0.3°			
Thermal Control Subsystem	Passive type			
Secondary Propulsion Subsytem	Hydrazine reaction			
Life	3 years			
Orbit	Geosynchronous, 135°E Longitude			
Station Keeping	Latitude ±0.1° Longitude ±0.1°			

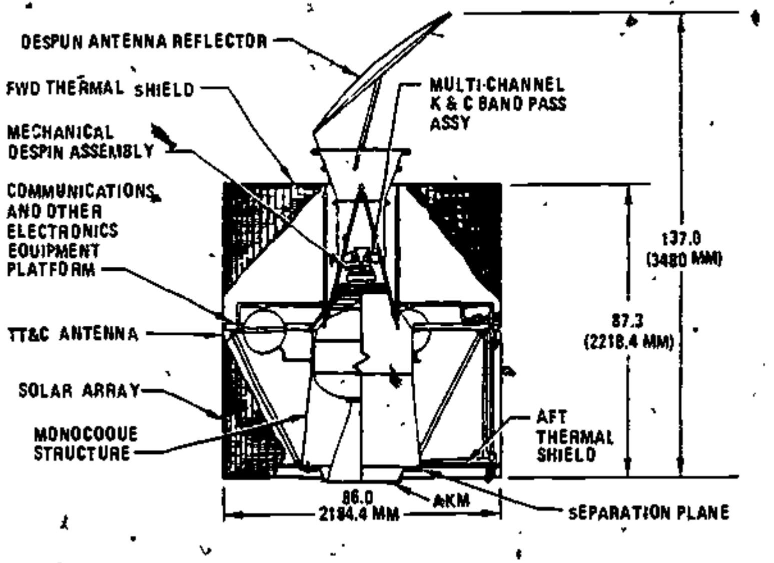
DESPUN ANTENNA REFLECTOR
FWD THERMAL SHIELD
MECHANICAL DESPIN ASSEMBLY
COMMUNICATIONS AND OTHER ELECTRONICS EQUIPMENT PLATFORM
TT&C ANTENNA
SOLAR ARRAY
MONOCOQUE STRUCTURE
MULTI-CHANNEL K & C BAND PASS ASSY
137.0 (3480 MM)
87.3 (2218.4 MM)
AFT THERMAL SHIELD
86.0 2184.4 MM
AKM
SEPARATION PLANE

Fig. 1 INBOARD PROFILE OF CS

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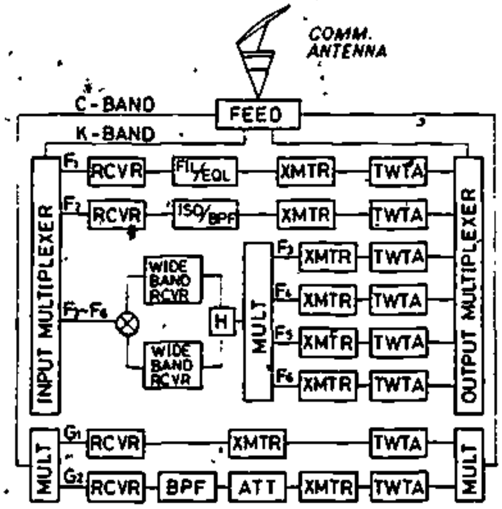
COMM. ANTENNA
C-BAND
FEED
K-BAND
F_1
RCVR
FIL/EQL
XMTR
TWTA
F_2
RCVR
ISO/BPF
XMTR
TWTA
INPUT MULTIPLEXER
F_3-F_6
WIDE BAND RCVR
WIDE BAND RCVR
H
MULT
F_3 XMTR TWTA
F_4 XMTR TWTA
F_5 XMTR TWTA
F_6 XMTR TWTA
OUTPUT MULTIPLEXER
MULT
G_1
RCVR
XMTR
TWTA
G_2
RCVR
BPF
ATT
XMTR
TWTA
MULT

Fig. 2 BLOCK DIAGRAM OF COMMUNICATION SUBSYSTEM

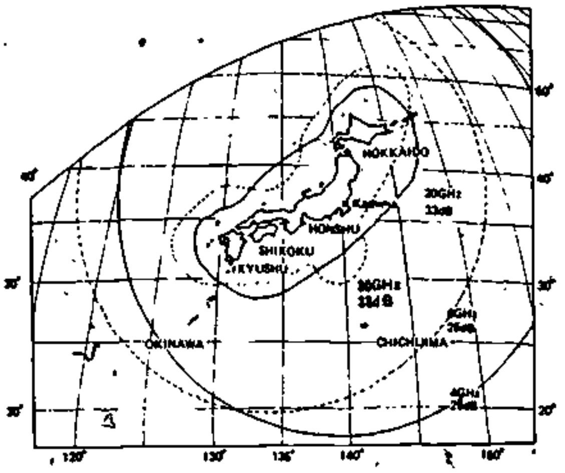
HOKKAIDO
HONSHU
SHIKOKU
KYUSHU
OKINAWA
CHICHIJIMA
20GHz 33dB
30GHz 33dB
6GHz 26dB
4GHz 26dB
40°
30°
20°
120°
130°
135°
140°
150°

Fig. 3 ANTENNA PATERNS OF CS

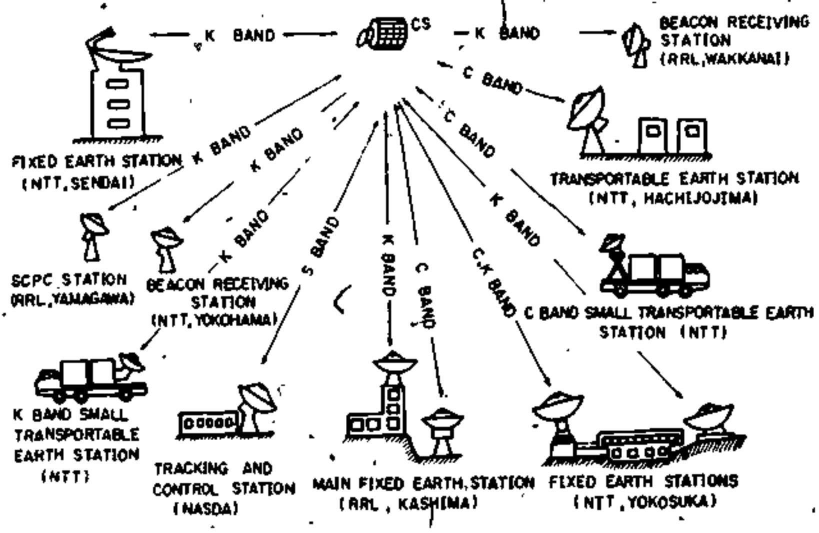
CS
K BAND
K BAND
BEACON RECEIVING STATION (RRL,WAKKANAI)
C BAND
TRANSPORTABLE EARTH STATION (NTT, HACHIJOJIMA)
C BAND
K BAND
C BAND SMALL TRANSPORTABLE EARTH STATION (NTT)
FIXED EARTH STATION (NTT,SENDAI)
K BAND
K BAND
SCPC STATION (RRL,YAMAGAWA)
K BAND
BEACON RECEIVING STATION (NTT,YOKOHAMA)
S BAND
K BAND
C BAND
C,K BAND
K BAND SMALL TRANSPORTABLE EARTH STATION (NTT)
TRACKING AND CONTROL STATION (NASDA)
MAIN FIXED EARTH STATION (RRL, KASHIMA)
FIXED EARTH STATIONS (NTT,YOKOSUKA)

Fig. 4 MAIN SYSTEM OF CS EXPERIMENT PROGRAM

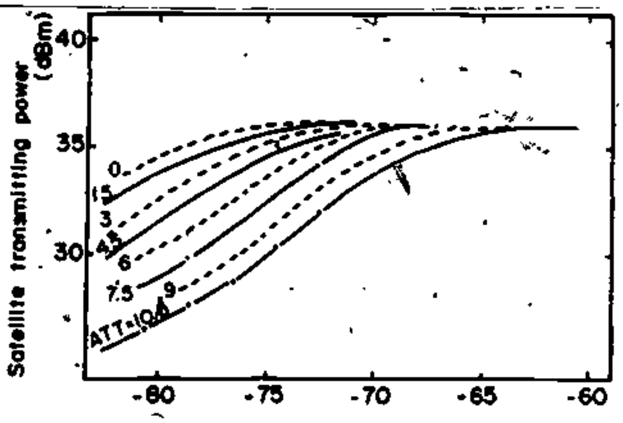

Fig. 5 ENVELOPE TRANSFER CHARACTERISTICS

OF C-BAND TRANSPONDER

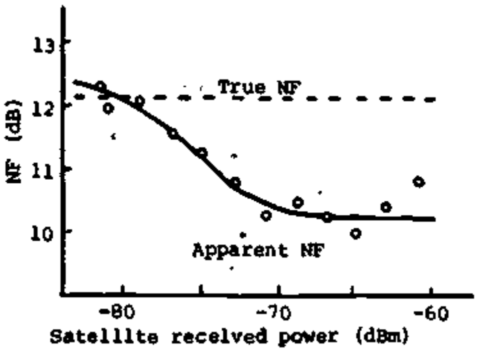

Fig. 6 DEPENDENCY OF NF ON SATELLITE INPUT POWER

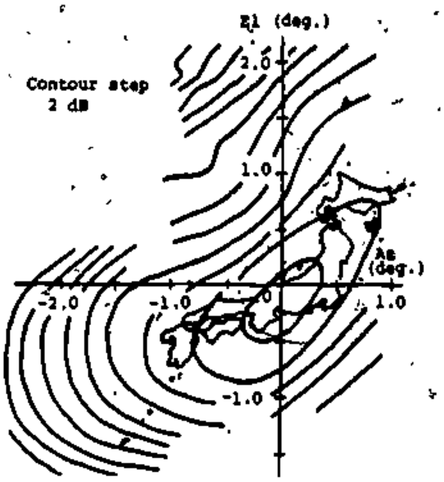
El (deg.)
Contour step
2 dB
2.0
1.0
Az
(deg.)
-2.0
-1.0
1.0
-1.0

Fig.7 MEASURED ANTENNA CONTOUR OF K-BAND BEACON SIGNAL

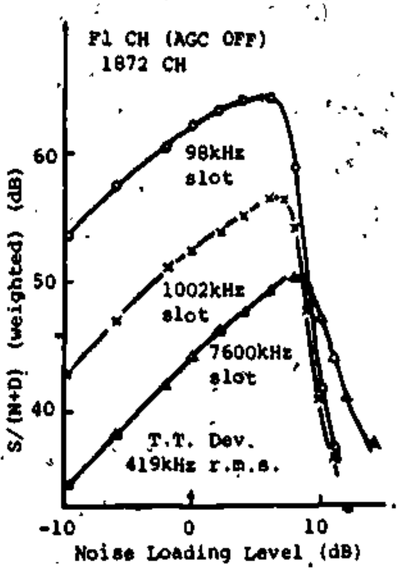

Fig.8 NOISE LOADING CHARACTERISTICS

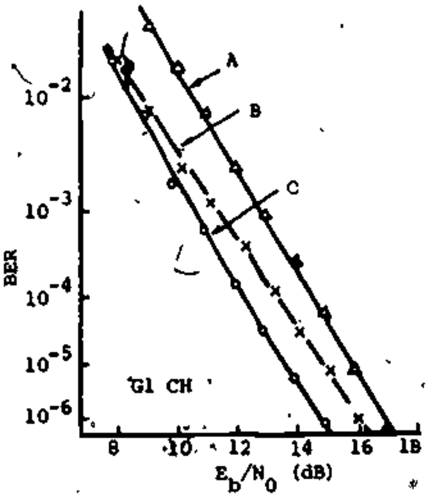

Fig.9 EFFECT OF NONLINEARITY ON MEASUREMENT OF BER PERFORMANCE

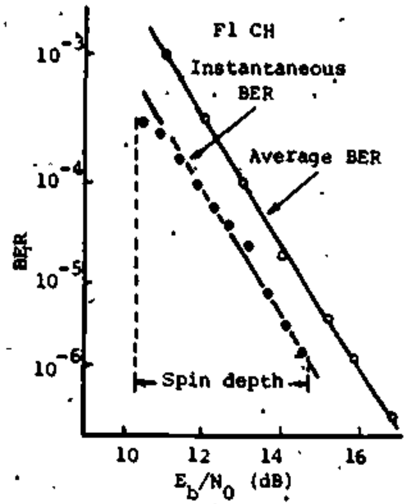

Fig.10 EFFECT OF SPIN MODULATION ON BER PERFORMANCE

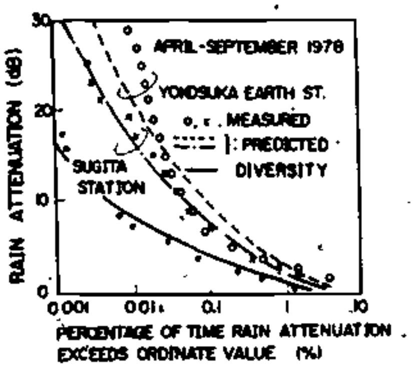

Fig.11 CUMULATIVE DISTRIBUTION OF RAINFALL ATTENUATION

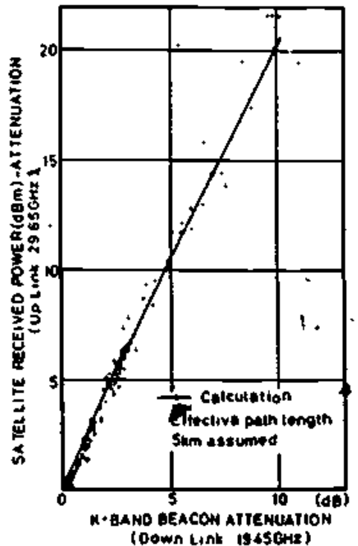

Fig.12 RELATION BETWEEN UP- AND DOWNLINKS RAINFALL ATTENUATION

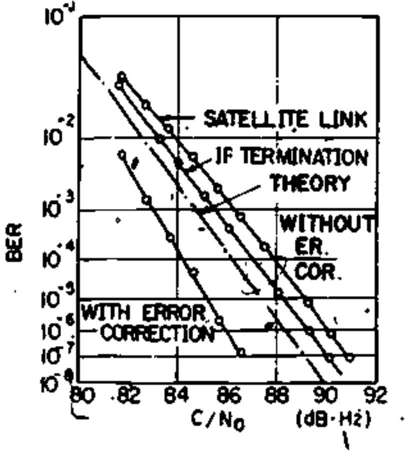

Fig.13 BER VS. C/No K-BAND TDMA

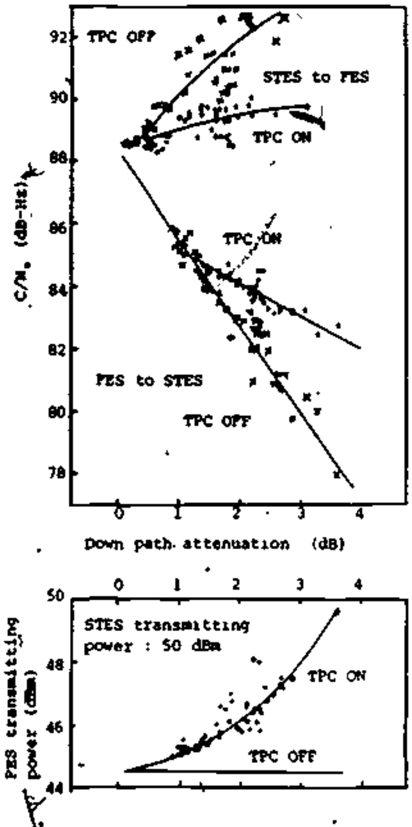

Fig.14 TPC DATA FOR RAINFALL AT FES

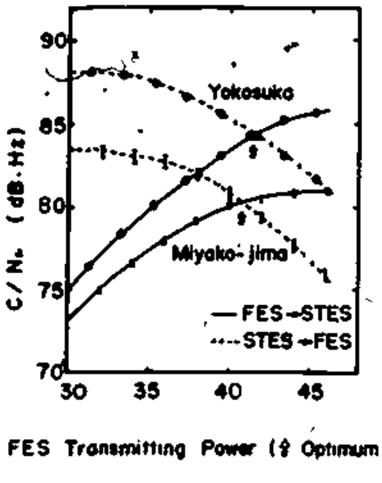

Fig.15 C/N_0 AS FUNCTION OF FES's TX POWER

(STES TRANSMITTING POWER: 50 dBm CONST)

PRESENT STATUS OF JAPANESE BSE PROGRAM

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Abstract

One and a half years has passed since the launch of the Japanese Medium-Scale Broadcasting Satellite for experimental purpose (BSE). Most of the programed BSE experiments have been successfully continued. This paper will present the transponder characteristics and the results of the experiments of TV signal transmission and reception, propagation and house keeping on the BSE.

1. Introduction

The Japanese Medium-Scale Broadcating Satellite for Experimental Purpose (BSE) was successfully launched on April 8, 1978 from Cape Canaveral, USA and placed into the predetermined geostationaty orbit position of 110 degrees east longitude on April 26. The BSE is held within the accuracy of ±0.1 deg. and 0.2 deg. in the orbit position and antenna beam pointing respectively. The BSE experiments are to be performed for three years and their primary purpose is the study and technical evaluation of the performance of 12 GHz Satellite Broadcasting System.

Various kinds of earth terminals for the BSE experiments are placed throughout Japan. They are Main Transmit and Receive Station (MTRS), two types of Transportable Transmit and Receive Station (TTRSs, type A and B), three types of Receive Only Station (ROSs), and many Simple Receive Equipments.

On July 20, 1978, the initial performance check of the BSE was finished and the BSE experiments were started. Basic transmission characteristics of FM color TV signal as well as many other characteristics have been measured in both radio and base band frequency stages in the BSE experimental system. The performance check of the BSE has been also carried out every six months to examine the time variation of the characteristics of the mission and bus subsystems. Measured characteristics are generally reasonable in the comparison with expected or designed ones. In this paper we will briefly discouss some topics of the results of the BSE experiments obtained for about one and half years after the BSE launch.

2. System description [1],[2],[6]

The BSE is a three-axis stabilized spacecraft with sun-oriented solar array for high power generation and has two sets of 14GHz/12GHz direct frequency conversion transponders with 100 watt TWTs. Fig.1 shows the functional block diagram of the transponders. The channel allocation for the BSE is shown in Fig.2. A shaped-beam antenna is boarded on the BSE to get adequate gain over the Japanese territory including outlying remote islands and to avoid spilling over neighbouring countries. Fig.3 shows the radiation pattern of the shaped-beam antenna.

As shown in Fig.3, various kinds of earth terminals are placed throughout Japan in order to conduct various experiments such as statistical and regional analysis for rainfall attenuation and receiving condition of TV signals. In each earth terminal of the BSE, a low noise frequency converter is used as a receiver front end and its system noise temperature is nominally 600 K. The MTRS is the key station in the BSE system and has functions of transmission and reception of two channel FM color TV signals and Tracking, Telemetry and Command (TT&C) operation in K-band.

3. Transmission characteristics of transponder [2],[3],[4]

It is very important to know the transmission characteristics of the transponders because they will affect most of the BSE experiments. In this section, some important characteristics such as signal level diagram, amplitude, delay and input-output will be discoussed.

Signal level diagram of the BSE link

The diurnal variation of the received signal strength from the BSE is less than 3 dB at the MTRS in the attitude control mode by a monopulse earth sensor combination. The magnitude of the diurnal variation is reasonable, considering that the MTRS is located in the area where the gain variation caused by the fluctuation of the beam pointing of the on-boarded antenna is considerablely greater than that in most of the Japanese mainland. The short time variation of the received power with the period of about 100 seconds, which is due to the attitude fluctuation of the satellite, has also been observed and its magnitude is less than ±0.5 dB.

Table 1 shows the link budget between the BSE and the MTRS together with those of an ROS in a remote island and an SRE in the mainland. Table 2 shows mean values and standard deviations (STD. dev.s) of transmitted and received carrier powers measured in long terms at the MTRS and the BSE. Those powers have been measured at the about same time of days to avoid the effect of the above mentioned diurnal variation, but may be affected by the short time variation because those powers have been measured at an arbitrary point in a period of the variation. Table 2 shows that the measured powers are very stable, but received carrier powers at the BSE and the MTRS are lower than the values calculated from the transmitted powers and the link budget shown in Table 1 by amounts of about 1 and 2 dB respectively. It is thought these disagreements would be due to the inaccuracy of calibration curves for telemetry data, pointing erorr and gain estimation erorr of the onboarded antenna.

Amplitude and Delay characteristics

The amplitude and delay characteristics of the transponder are approximately determined by those of the distribution and combination filters which are placed in the input multiplexer and output switch shown in Fig.1. As the transponder contains nolinear devices of TWTs and level control electronics (LCE) which behaves like an automatic level controller, measured amplitude characteristics by means of a frequency sweep method do not correctly correspond those of linear operation part of the transponder.

A nonlinear operation of amplifiers makes signal quality scarcely degraded in FM color TV signal transmission. It is thought that the nonlinear devices do not affect the measurements of differential gain (DG) and differential phase (DP) characteristics of the transponder and these characteristics are good measure of fidelity in FM color TV signal transmission. So the DG and DP characteristics have been measured in parallel with the amplitude and delay characteristics.

Fig.4 shows examples of the measured characteristics of the DG, DP, amplitude and delay characteristics. The delay, DG and DP characteristics agree well with expected ones except that there exist ripples with the period of about 9 MHz, of which magnitude does not seem to affect the signal quality of FM color TV. There is no possibility of the occurence of the ripples with the period of 9 MHz in the satellite. It is suggested that the ripples occured at the system in the MTRS remain uncompensated in the measured characteristics. The small deviation of the measured amplitude characteristics in pass band would be caused by the gain dependence on frequency at the saturation region of 100 watt TWT.

The first and second order slopes of the delay characteristics are compensated at every TV channel by the delay equalizer of the MTRS to get flat delay characteristics in overall links.

Input-output Characteristics

The LCE is used to keep the drive power to the 100 watt TWT at a value predetermined by command operation regardless of variation of the input level to the transponder. The drive power is selected at the saturation point of the input-output characteristics for the 100 watt TWT to obtain the highest power in normal FM TV signal transmission. Fig.5 shows the relation between the drive power to the 100 watt TWT and the input level to the transponder.

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The input-output characteristics can be measured by changing the drive power by command operation and reading the drive and output powers from telemetry data. Fig. 6 is an example of the input-output characteristics by this method. As it is difficult to know an accurate saturation point in this method, the saturation points have been measured by using inter-modulation characteristics between two tones (one is large and the other is small), and time variation of the saturation points has been scarcely observed so far.

Noise characteristics

Fig. 7 shows the relation between overall carrier to noise ratio (CNR) in 25 MHz band width and EIRP at the MTRS, where solid and dotted lines show overall CNR calculated from up- and down-link CNRs. Up-link CNR can be estimated from the EIRP of the MTRS or the received power at the transponder obtained from telemetry data. Down-link CNR can be correctly calculated from the received power and system noise temperature of the MTRS. Fig. 7 shows that measured overall CNR agrees well with that calculated from the EIRP of the MTRS.

In the signal reception at an ROS or an SRE under condition that the EIRP of the MTRS is nominal level (112 dBm), the difference between the up- and down-link CNRs is more than 10 dB, so the overall CNRs are nearly equal to the down-link CNRs.

Fig. 8 shows noise figure (NF) of the transponder. The NF is indirectly measured from the overall CNR and down-link CNR measured at the MTRS. It is judged to be the noise suppression effect caused by the nonliear amplifications of the low level TWT (LLTWT) and 100 watt TWT shown in Fig. 1 respectively that the NF becomes low according as the input level to the transponder or the drive power to the 100 watt TWT become great.

4. Standard TV signal transmission chracteristics [2],[3],[4]

The standard parameters of the TV signal transmission in the BSE program are shown in table 3. The band width of 25 MHz is required in ~~radio-frequency band in the parameters. New standard modulation parameters,~~ which will be adequate to the 27 MHz band width determined by WARC-BS, have also been examined.

Examples of measured transmission characteristics of the standard TV signal are shown in Table 4 where the measured values related with ROSs and SREs show mean values of 9 systems of ROSs and 20 systems of SREs distributed throughout Japan. The results of these measurements show that the systems for the BSE experiments, as a whole, have sufficient functions to conduct satellite broadcasting service of color TV. The transmission characteristics shown in Table 4 are almost bounded by those of filters in video and intermediate frequency bands, video signal amplifiers and other instruments in the earth terminals, and are scarcely influenced by those of the transponder.

Weighted signal to noise ratio (SNR) of the video signal for the standard parameters are given by

$$SNR = CNR + 32.3 \quad [dB]$$

where the second term is the sum of FM improvement factor, de-emphasis factor and weighting factor for de-emphasised triangular noise.

5. TV signal reception and propagation experiments [2],[4],[5]

TV signal reception and its stability

Received power of the TV signal from the BSE were measured at the same time at each earth terminal in 39 locations allover Japan. The typical locations of the earth terminals are already shown in Fig. 3. The measured powers were generally coincided with the powers estimated from the BSE link budget as shown in Fig. 9. Deviation of the measured values of received powers from the estimated ones were within 1 dB for 75 % of the earth terminals.

Long term variations of the received powers have been measured at ROSs. Variations up to about 5 dB have been observed at the ROSs at the beam edge of the satellite transmitting antenna. The variation includes the value of 2 dB inevitablely caused by the pointing error of the antenna of the ROS with simple tracking equipment.

Subjective assessment of received picture quality has been carried out by using color-bar and specially prepared VTR signals at each earth terminal and has been almost excellent or fine in TASO scale.

Antenna sizes, which assure weighted SNR of picture of more than 45 dB for 99 % of the time at each location, have been derived from the results of the TV signal reception and propagation experiments. The derived antenna diameters are about 1 meter around the beam center of the transmitting antenna, about 1.6 meters for the fringe area of the mainland and 2.8 to 4.5 meters for the remote islands. These are approximately equal to the expected values.

Propagation experiment

Various kinds of analysis for the propagation data at each earth terminal have been continued in order to study statistical and regional properties of rainfall attenuation and variation of polarization for getting actually required link margin in satellite broadcasts. The measurement system for the propagation data contains a rain radar, rainguages and a radiometer.

Fig. 10 shows cumulative distribution curves of rainfall attenuation of the BSE beacon signal together with those obtained by the ETS-II. The cumulative distribution curves of the BSE in August 1978 to June 1979 and the ETS-II in May 1977 to April 1978 show the appropriateness of the initial link margin evaluation that the rainfall attenuation would be 1, 2 and 7 dB for 99, 99.9 and 99.99 % of the time respectively.

In Fig. 11 are shown the cumulative distributions for two typical locations, Owase and Kesennuma where the muximun and minimum rainfalls were observed in the period from August to December 1978.

The effective path lengths of the rainfall attenuations have been also derived from the propagation data at the MTRS and ROSs. Most of the path lengths are about 5 kilometers and almost coincide with the one in CCIR Report and the result by the ETS-II.

6. House keeping of the BSE [6]

Regular operations and their results

The BSE is a three-axis zero momentum attitude control spacecraft, so the unique operations are required in order to keep the 12 GHz down-link beam pointing accuracy within 0.2 degrees. The regular operations, which are shown in Fig. 12 have been conducted by NASDA. The commanding operations of sun declination bias and Roll Acceleration Control Command (RACC) are only necessary under the sun sensor assembly for controlling yaw attitude.

In addition to the operations in Fig. 12, two kinds of operations are needed; stationkeeping and eclipse operations. The stationkeepings are periodically required to maintain the BSE position within the orbit requirements (i.e. orbit inclination less than 0.1 deg., 110 ± 0.1 deg. East longitude). The inclination orbit maneuver is performed every two months (average) and the east-west orbit maneuver every three weeks (average). The numbers of the orbit maneuvers performed by the time of September 1979 are 13 for inclination and 52 for east-west. The other is the eclipse operation in eclipse season. Two sets of transponders are turned off before entering eclipse and three batteries (4AH x 3) supply electrical power to the reduced user loads in eclipse and turn the transponders on after eclipse. The depth of discharge of the batteries was about 40 % for the past one and a half years.

Attitude control performance

The three-axis attitude control spacecraft in general has a problem how to control yaw axis attitude. Various kinds of spacecraft have adopted the unique approach respectively. The BSE has the two alternative yaw axis attitude control systems; one is Monopulse and Earth Sensor Combination (MECO) and the other is Sun Sensor Assemblies (SSA). Fig. 13, which is calculated from the attitude telemetries, shows the antenna beam pointing and rotation accuracy under the following sensor; earth sensor for pitch and roll axis; MECO for yaw axis. The beam rotation can be controlled within 0.2 degrees.

7. Conclusion

Some topics of the BSE experiments were disccussed. Most of them have shown the excellent performance of the BSE satellite and the appropriateness of the initial eavluation of the link budget, service area, signal quality and rainfall attenuation for the satellite broadcasting experiments.

We hope to complete the BSE program in obtaining much valuable data.

8. Acknowledgments

The autors wish to thank all the staffs of the RRB (Radio Regulation Bureau) and the RRL of the Ministry of Posts and Telecommunications, NHK and NASDA who have participated in the BSE program and paid great efforts to achieve the success of the BSE experiments.

9. References

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[2] K. Tsukamoto et al., " Technical Aspects of Japanese Broadcasting Satellite Experiments ", IEEE Trans. on Broadcasting, Vol. BC-24, No.4, Dec. 1978.
[3] N. Imai et al., " Experimental Results of the Japanese BSE Program", IAF Paper IAF-79-E-280, Sept. 1979.
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[6] Y. Ichikawa, " The results of initial checkup of Japanese Broadcasting Satellite for Experimental Purpose ", IEEE Trans. on Broadcasting, Vol. BC-24, No. 4, Dec. 1978.

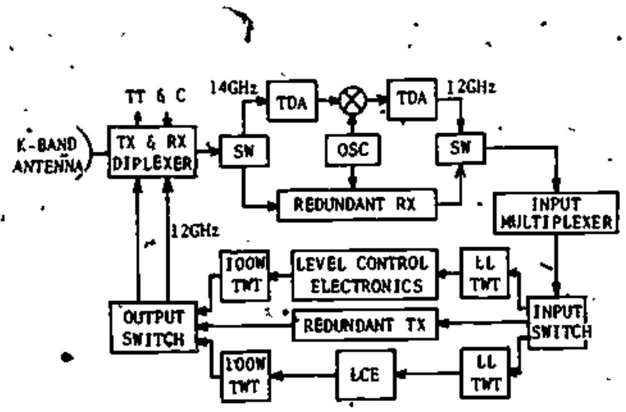
TT & C
14GHz
TDA
TDA
12GHz
K-BAND ANTENNA
TX & RX DIPLEXER
SW
OSC
SW
REDUNDANT RX
INPUT MULTIPLEXER
12GHz
100W TWT
LEVEL CONTROL ELECTRONICS
LL TWT
OUTPUT SWITCH
REDUNDANT TX
INPUT SWITCH
100W TWT
LCE
LL TWT

Fig.1 BSE transponder block diagram

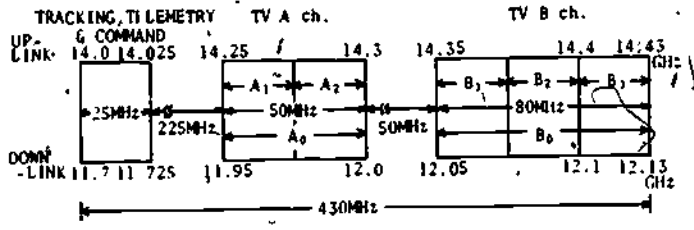
TRACKING, TELEMETRY & COMMAND
TV A ch.
TV B ch.
UP-LINK
14.0
14.025
14.25
14.3
14.35
14.4
14.43 GHz
A1
A2
50MHz
A0
25MHz
225MHz
50MHz
B1
B2
B3
80MHz
B0
DOWN-LINK
11.7
11.725
11.95
12.0
12.05
12.1
12.13 GHz
430MHz

Fig.2 Channel allocation of BSE

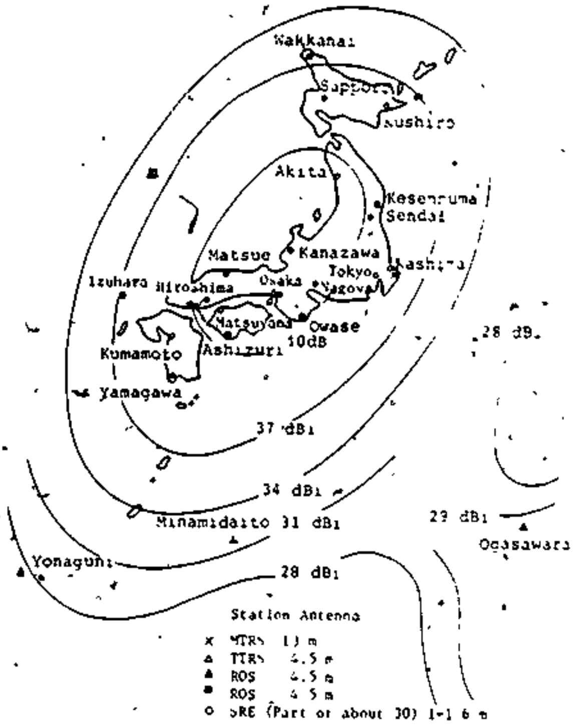
Wakkanai
Sapporo
Kushiro
Akita
Kesennuma
Sendai
Matsue
Kanazawa
Tokyo
Kashima
Izuhara
Hiroshima
Osaka
Nagoya
Matsuyama
Owase
10dB
Kumamoto
Ashizuri
Yamagawa
37 dBi
34 dBi
Minamidaito
31 dBi
29 dBi
Ogasawara
Yonaguni
28 dBi
28 dB
Station Antenna
× MTRS 13 m
△ TTRS 4.5 m
▲ ROS 4.5 m
■ ROS 4.5 m
○ SRE (Part of about 30) 1-1.6 m

Fig.3 BSE antenna radiation pattern and earth terminal locations

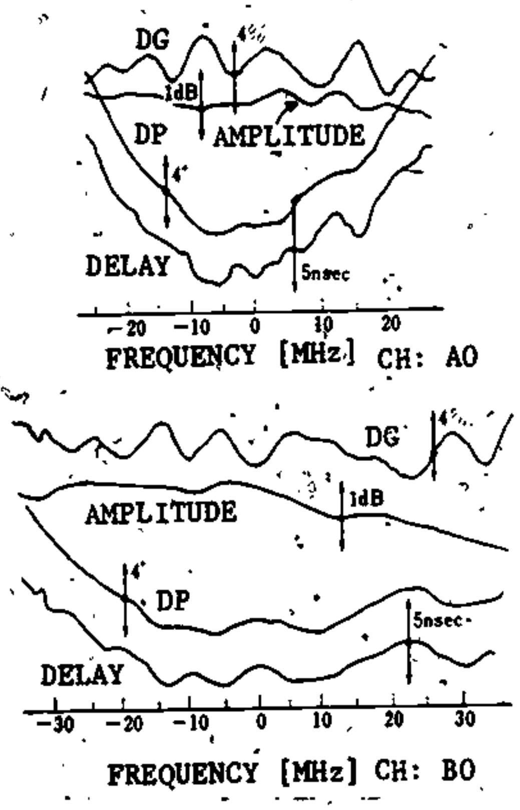

Fig.4 Amplitude, delay, DG and DP characteristics of transponder

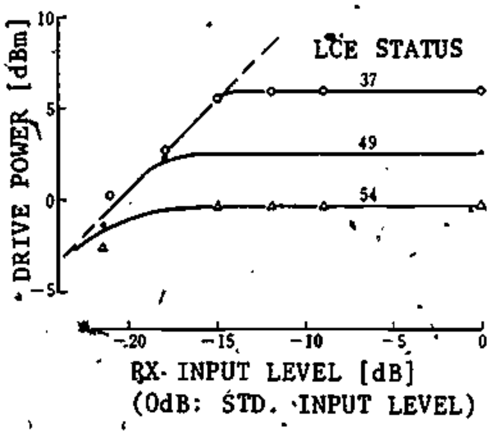

Fig.5 LCE input-output characteristics

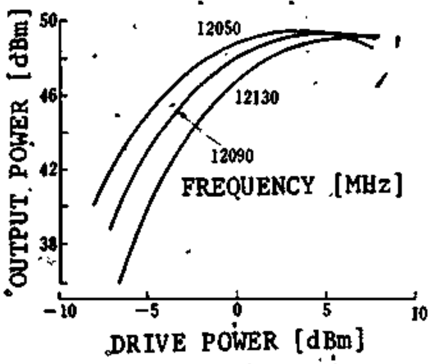

Fig.6 TWT input-output characteristics

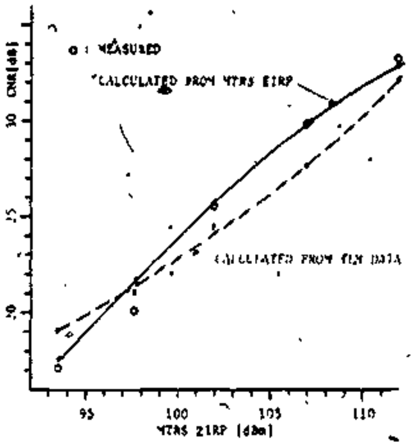

Fig.7 Example of CNR measurement

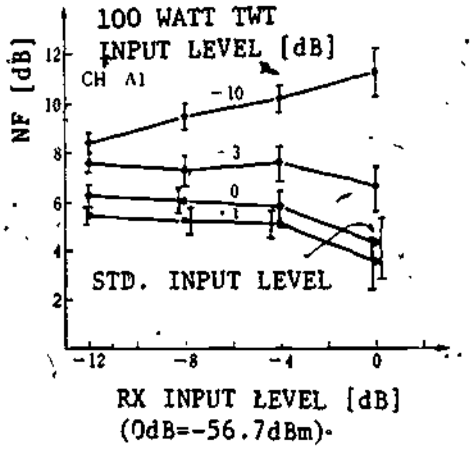

Fig.8 NF of BSE transponder

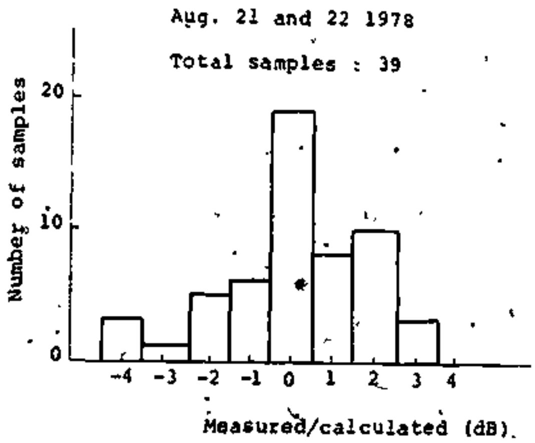

Fig.9 Deviation of received powers from calculated values

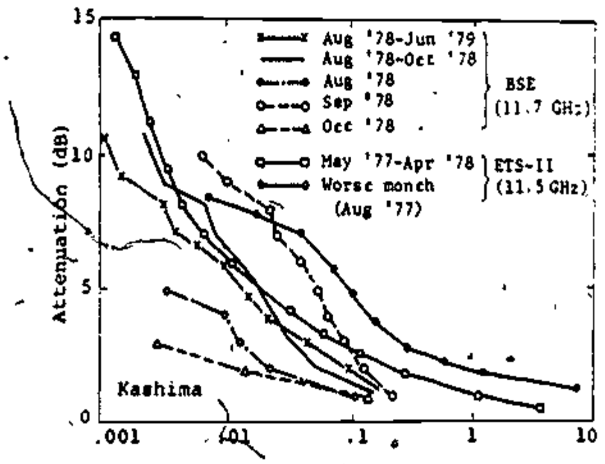

Fig. 10 Rain attenuation at MTRS

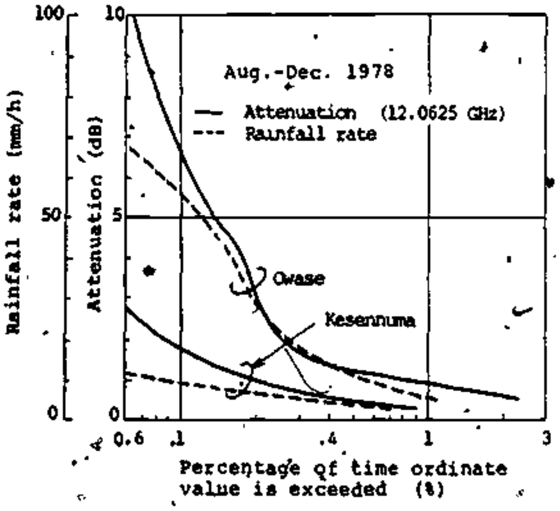

Fig.11 Rainfall rate and attenuation at rainy and dry locations

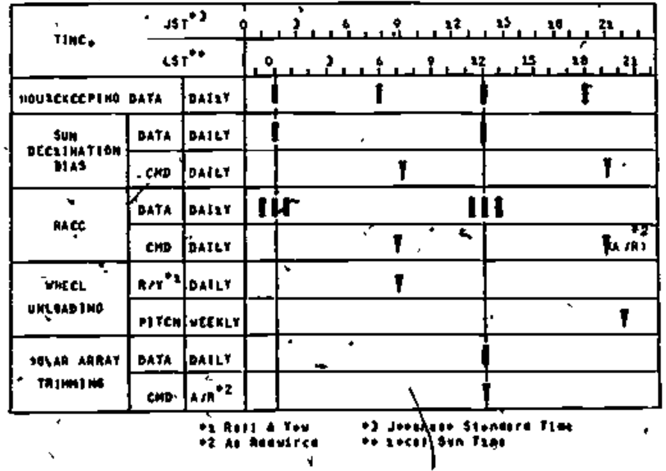
TIME
JST*3
LST*4
0
3
6
9
12
15
18
21
HOUSEKEEPING DATA
DAILY
SUN DECLINATION BIAS
DATA
DAILY
CMD
DAILY
RACC
DATA
DAILY
CMD
DAILY
*2 (A/R)
WHEEL UNLOADING
R/Y*1
DAILY
PITCH
WEEKLY
SOLAR ARRAY TRIMMING
DATA
DAILY
CMD
A/R*2
*1 Roll & Yaw
*2 As Required
*3 Japanese Standard Time
*4 Local Sun Time

Fig. 12 BSE routine operation schedule

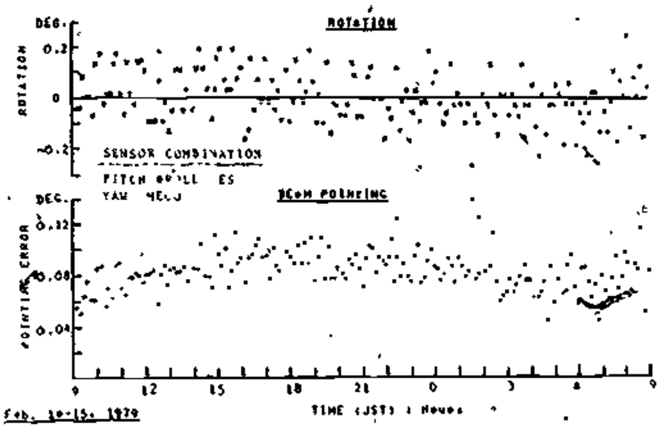

Fig.13 BSE antenna rotation and pointing error

Table 1 BSE LINK BUDGET

Up-link (MTRS to BSE)				
MTRS, E.I.R P.	(dBm/ch)	112.2		
Free space loss	(dB)	-207.4		
Rx. antenna gain	(dB)	38 1		
Niose power	(dBm/25MHz)	-92 9		
Up-link CNR	(dB)	35 8		
Down-link		MTRS	Mainland	Remote islands
Service area				
Antenna diameters of RX	(m)	13 0	1 6	4 5
Tx. power	(dBm/ch)		50 0	
Tx. feeder loss	(dB)		-1.7	
Tx. antenna gain	(dB)	37 6	37 0	28 0
Free space loss	(dB)	-205 9	-205 8	-205 4
Rx antenna gain	(dB)	61 9	43 0	53 5
Received carrier power	(dBm)	58 1	-77 5	-75 6
Noise power	(dBm/25MHz)	-96 4	-97 3	-96.6
Down-link CNR	(dB)	38 1	19 8	21 0
Total CNR	(dB)	33 9	19 7	20 9
Weighted SNR	(dB)	66 3	52 1	53.3

Table 2 RX AND TX POWER OF BSE LINK

Channel	Measurement interval	Number of data	EIRP at MTRS (dBm)	BSE space craft				RX power at MTRS (dBm)	
				RX power (dBm)		TX power (dBm)			
					STD.dev.		STD.dev.		STD.dev.
A1	Aug. 14 -Oct. 20'78	25	112.1	-57.9	0.7	50.4	0 03	-60.2	0.3
	Oct. 21'78-Jan. 22'79	20		-57.8	0.5	50.4	0.04	-60.1	0 6
	Jan. 23 -May 24'79	41		-57 2	0.7	50.3	0.07	-60.2	0 6
B1	Aug. 14 -Oct. 20'78	40	112 1	-57.6	0.8	50.1	0.10	-60.1	0.7
	Oct. 21'78-Jan. 22'79	31		-57.5	0.7	50.1	0.14	-59.9	0.6
	Jan. 23 -May 24'79	46		-57 9	0.7	49 9	0.14	-60.2	0.9

Table 3 STANDARD PARAMETERS OF TV SIGNAL TRANSMISSION IN BSE PROGRAM

System	NTSC Standard System M (525 lines, 30 frames/sec)
Modulation	FM. Freq. dev. 22 MHz(p-p)
Sound subcarrier	
Frequency	4.5 MHz
Modulation	FM. Freq. dev. ±25 KHz(o-p)
Sound/Video ratio	1/4
Emphasis	CCIR Rec. 405-1
Dispersal	22dB (600 KHz p-p) in triangle wave form

Table 4 EXAMPLES OF STANDARD TV SINGNAL TRANSMISSION CHARACTERISTICS

Measured items	Contents	Receiving earth terminals				
		MTRS	TTRS-A	TTRS-B	ROSa	SREs
Wave form distortion field-time line -time short-time short-time	 sag [%] streaking [%] 2T pulse/bar [%] overshoot [%]	 1.2 4.0 2.0 4.0	 0.0 2.0 1 0 1.0	 2.0 0.0 0.0 0.0	 1.3 1.8 1.2 2.7	 2 2 2.5 2 5
Chrominance-luminance delay time difference	(ns)	0.0	110	0.0	112	163
Nonlinear distortion	DG[%] DP(deg.)	2.5 5.0	0 5 1 5	0.5 0.5	2.7 1.7	3.8 1.8
Video SNR(weighted) Audio SNR(unweighted)	(dB)	64 62	59 62	56 56	 55	 48
Amplitude characteristics of video signal	Deviation is less than ±0 5dB in the frequency range from 10KHz to 4MHz					

Summary of Millimeter Wave Propagation Experiments Using Japan's First Geostationary Satellite "Kiku-2"

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Abstract

A one year millimeter wave propagation experiment with a satellite-to-earth link was performed by using Japan's first geostationary satellite "Kiku-2". The satellite carries a beacon transmitter with three coherent frequencies, 1.7, 11.5 and 34.5 GHz. A coherent receiving system with a 10 meter diameter antenna was employed. Other instrumentation included a C-band rain radar. The experiment was carried out on 24 hour-a-day basis and achieved nearly eight thousand hours of test time. The results show that a 20 dB rain margin is necessary for a millimeter wave satellite communication link with 99.9 % reliability.

1. Introduction

Engineering Test Satellite Type II (ETS-II) "Kiku-2" was launched on February 23, 1977, and positioned in geostationary orbit at 130°E on March 5.

ETS-II is Japan's first geosynchronous satellite, launched by the N-launch vehicle developed by the National Space Development Agency of Japan (NASDA), from Tanegashima Space Center. The Radio Research Laboratories (RRL) conducted propagation experiments with the beacons as a preliminary experiments for the Experimental Communication Satellite (ECS) program to investigate the possibility of, and to obtain data for satellite communications in the millimeter wave band. ECS is expected to be launched in February 1979 by an N-launch vehicle. ETS-II carries a beacon transmitter with three coherent frequencies, 1.7, 11.5 and 34.5 GHz. Data from the propagation experiments with ETS-II, including one of the highest frequencies used in a satellite to earth link, have been accumulated for about seventy five hundred hours of test time by May 1978, when the experiment was discontinued. During the course of the experiments, there occurred the various tropospheric and ionospheric phenomena which affect propagation characteristics, such as Japan's rainy season, thunder storms, typhoons, snows, hail, and geomagnetic storms. The coherent signals have provided plentiful and sensitive information along the radio wave path, and have permitted the derivation of propagation characteristics of the three frequencies.

2. Satellite

ETS-II is a spin stabilized satellite of about 140 cm in diameter and about 160 cm in height with a mechanically despun antenna as shown in Fig. 1. The weight of the satellite is about 130 kg in orbit. The cylindrical solar array generates more than 100 w of electric power at the end of life. Telemetry is at 136 MHz and commands use the 148 MHz band. The mechanically despun antenna assembly consists of three reflectors of an S-band, an X-band and a K-band 28 cm diameter parabolic antenna. The source signal for the propagation experiment transmitter (PET) is generated by a crystal oscillator at 17.76 MHz and multiplied to 1.70500, 11.50875 and 34.52626 GHz, thus providing coherent signals. A schematic diagram of PET is shown in Fig. 2. In addition to a carrier wave mode (CW mode), the signals at 1.7 and 34.5 GHz may be 100 % amplitude modulated by a 300 Hz rectangular wave form on command (AM mode). The AM mode is provided to improve rain margin for measurements at 34.5 GHz in case of heavy rain.

3. Ground System

The ground facilities for the ETS-II propagation experiment consist of a main receiving station, a rain radar, a radiometer, meteorological instruments, and data processing and control computers as shown in Fig. 3. The facilities are located at the Kashima Branch of the Radio Research Laboratories, about 100 km east of Tokyo.

The main receiving station is equipped with a modified Cassegrain type antenna 10 meters in diameter with a four reflector beam-guide feed. The surface roughness of the main dish is measured as about 0.17 mm rms at a 90° elevation angle and 0.25 mm rms at 45°. The calibrated gain measured with the satellite beacon is 69.7 dB for 34.5 GHz, 60.8 dB for 11.5 GHz and 40.2 dB for 1.7 GHz. The measured half-power beam width of this antenna at 34.5 GHz and 11.5 GHz are 0.05° and 0.15°, respectively. An eight-element ring array of helical radiators which is placed around the beam waist of the beam guide system is used as the primary feed antenna for 1.7 GHz. The antenna is usually operated in 34.5 GHz auto-tracking mode and it is automatically switched to 11.5 GHz mode when the 34.5 GHz mode loses tracking ability because of heavy rain or for other reasons. The tracking accuracy in the millimeter wave band is higher than 1/10 of the antenna beam width.

The receivers consist of frequency conversion sections, local frequency reproducing circuits, CW receivers and AM receivers. The received signals at 34.5 and 11.5 GHz are directly converted to 1.7 GHz by the first down converter. The 1.7 GHz first IF signals are converted to second IF signals of 140 MHz and detected by high sensitivity phase-lock receivers. The source frequency of the on board PET is reproduced by a specially designed circuit from the received 1.7 or 11.5 GHz signal, and it is used as the reference frequency for the whole receiving system. By using this method, the receiver is able to eliminate the effects of fluctuations of the on-board oscillator frequency and Doppler effect of the satellite motion. The 300 Hz AM signal, which is reproduced by the AM receiver of 1.7 GHz, is used as the reference signal for synchronous detection in the 34.5 GHz AM receiver. The estimated link budget of the experimental system with ETS-II is shown in Table 1.

Since propagation characteristics in the millimeter wave region are seriously influenced by rain and related atmospheric condition, it is important to obtain accurate information of the meteorological condition along and around the radio wave path from the satellite to the earth station. Therefore, C-band rain radar system having a number of unique functions was designed. The 3 meter diameter antenna is covered by a 7 meter diameter radome. The transmitter, reciever, and antenna controller are remotely operated by the computer and monitored at the console through cable lines of about 1.1 km length. The video signal of the received radar echo is sent through the coaxial cable and processed by the computer. The received radar echo signal for all measurements is recorded by the computer on magnetic tape for further investigation. The rain radar is capable of operation in various modes of antenna scanning and data processing by means of computer software. The data mode scheme of the rain radar is illustrated in Fig. 4:

- Pm-mode operation measures rain intensity of every 250 meters along the path between satellites and the main station.
- Ps-mode measures rain intensity of every 250 meters along the path between satellites and any other earth station within 50 km of the main station.
- CAPPI (Constant Altitude Plan Position Indication) mode shows horizontal patterns of rain intensity of any height within a 50 km radius range with 1 km resolution.
- RHI (Range Height Indication) mode shows the vertical pattern of rain intensity in any azimuthal direction within 50 km in range and 15 km in height, with 500 m resolution both for range and height.

A Dicke-type radiometer at 35.2 GHz is used simultaneously to estimate millimeter attenuation from sky temperature. The beam width of the antenna is about 0.5 degree and band width of the receiver is 100 MHz. The sensitivity of the radiometer is 0.6° K for 10 second integration time. A VHF receiver is provided to measure the intensity and Faraday rotation of the telemetry beacon of ETS-II. Meteorological instrumentation simultaneously measures temperature, humidity, wind velocity, wind direction, air pressure and rain rate. Two types of rain gauge, tipping bucket type and a specially designed quick response type, are used for comparison at the receiving station. The quick response type rain gauges which are able to measure the range of rain rate between 0.25 mm/h to about 160 mm/h once per minute with the accurracy of about 0.03 mm/h, are deployed beneath the radio wave path between the satellite and the main station.

4. Experiment

After initial checks of characteristics of satellite and ground experimental system, the regular continuous operation began on May 9, 1977. Received signals from the satellite beacons were sampled every 200 milliseconds. The sampled signal levels were digitized in 1 dB steps and edited into one minute histograms. The phase differences were digitized in 2° steps and filed time-sequentially. Data from the radiometer were also sampled every 200 msec. All data were processed by computer and recorded with necessary indices. The experiment was operated on a 24 hour/day basis, except for the time of range measurement and station keeping of the satellite.

5 Results

A huge amount of data has been accumulated from the [illegible] year experiment. Various types of analysis using the data and study [illegible] propagation characteristics are actively in progress.

Cumulative distributions of attenuation of co-polar signals at 34.5 GHz and 11.5 GHz are shown in Fig. 5. Total minutes of measured data accumulated are shown in the parenthesis in the figure. It is observed from the figure that necessary margins for link reliability of 99 and 99.9 % are 4 dB, and 19,5 dB at 34.5 GHz, and 0.7 dB, and 2 dB at 11.5 GHz, respectively. On April 25, 1978, heavy rain of about 168 mm/h, was recorded. Rain rate over 150 mm/h continued for about 2 minutes and the attenuation at 34.5 GHz exceeded the rain margin in CW mode of 31.5 dB at the time. The irregular feature in the range of higher attenuation than 9 dB on the curve for 11.5 GHz in Fig. 5 reflects this particular phenomenon. Fig. 6 shows the cumulative distribution of cross polarization discrimination (XPD) at 11.5 and 34.5 GHz. It is observed that XPD of 0.3, 0.1, 0.03 and 0.01 % of time are 25, 22, 19 and 17 dB at 34.5 GHz and 33, 29, 26 and 24 dB at 11.5 GHz respectively.

Scintillation of the 1.7 ~~GHz~~ beacon has been observed frequently at night. The peak of the occurrence appears around ten o'clock at night, local time. The pattern of the occurrence of the scintillation agrees with that of so called "Spread F" of the ionosphere. The scintillation also occurs in the day time, and it is presumed that the day time scintillation has some relationship with "Sporadic E" of the ionosphere. Scintillations at 1.7 and 11.5 GHz of ETS-II occured at the time of the large geomagnetic storm on February 15, 1978. It was observed that the scintillation occured at the time of sharp increase and decrease of the total electron content.

6. Concluding Remarks

It is regrettable that the propagation experiment with ETS-II was discontinued in May 1978. However, propagation experiments in millimeter and centimeter wave bands with many satellites, CS, BS and ECS, have been carried out by RRL using the same concepts and procedures used with ETS-II. It is expected that a great deal of data have been obtained, making possible an understanding of the propagation and communication characteristics in the frequency range of these satellites through the experiments.

Preliminary analysis of the ETS-II data indicates that prospects are hopeful for satellite communication in the millimeter wave bands. The experiments to date indicate that 99.9 % probability can be achieved with a 19.5 dB margen. This is feasible with the technology available today.

Acknowledgement

This project has been performed successfully due to the efforts of many people of RRL, NASDA and other agencies and corporations. The authors express their sincere gratitude to all of those who have contributed and they especially would like to pay tribute to the members of this project in RRL for their outstanding efforts.

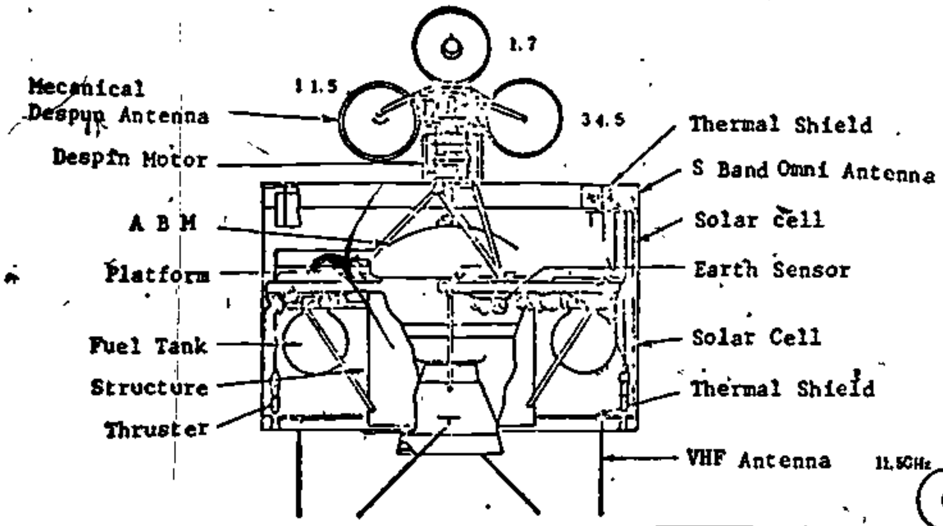
1.7
11.5
34.5
Mecanical Despun Antenna
Despin Motor
A B M
Platform
Fuel Tank
Structure
Thruster
Thermal Shield
S Band Omni Antenna
Solar cell
Earth Sensor
Solar Cell
Thermal Shield
VHF Antenna

Fig. 1

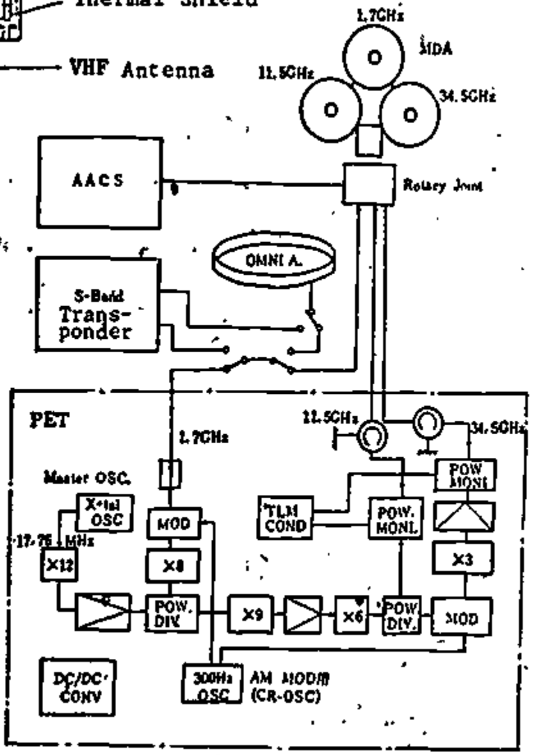
1.7GHz
MDA
11.5GHz
34.5GHz
AACS
Rotary Joint
OMNI A.
S-Band Transponder
PET
1.7GHz
11.5GHz
34.5GHz
Master OSC.
X-tal OSC
17.75 MHz
X12
MOD
X8
POW. DIV
X9
X6
POW. DIV.
MOD
TLM COND
POW. MONI.
POW MONI
X3
DC/DC CONV
300Hz OSC
AM MOD用 (CR-OSC)

Fig. 2

802

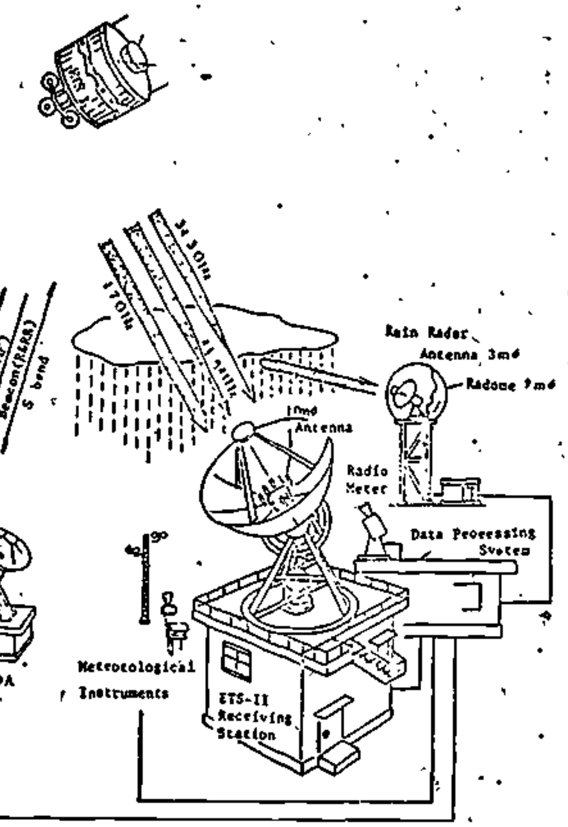
34.5GHz
11.5GHz
1.7GHz
CL (VHF)
TL (VHF)
Beacon(RARR)
S band
Rain Radar
Antenna 3mø
Radome 9mø
10mø
Antenna
Radio
Meter
Data Processing
System
90
40
NASDA
Metrological
Instruments
ETS-II
Receiving
Station

Fig. 3

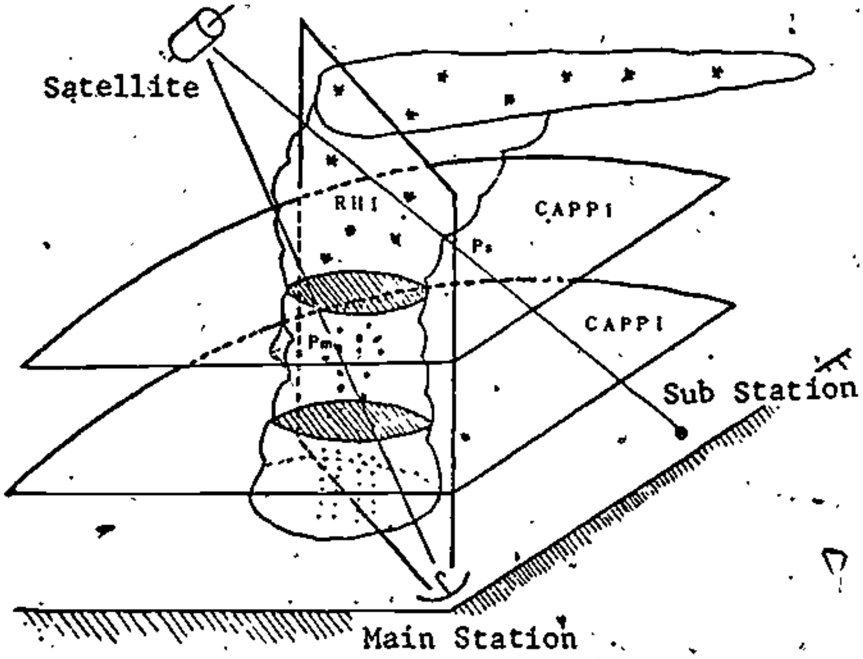
Satellite
RHI
CAPPI
Ps
CAPPI
Pm
Sub Station
Main Station

Fig. 4

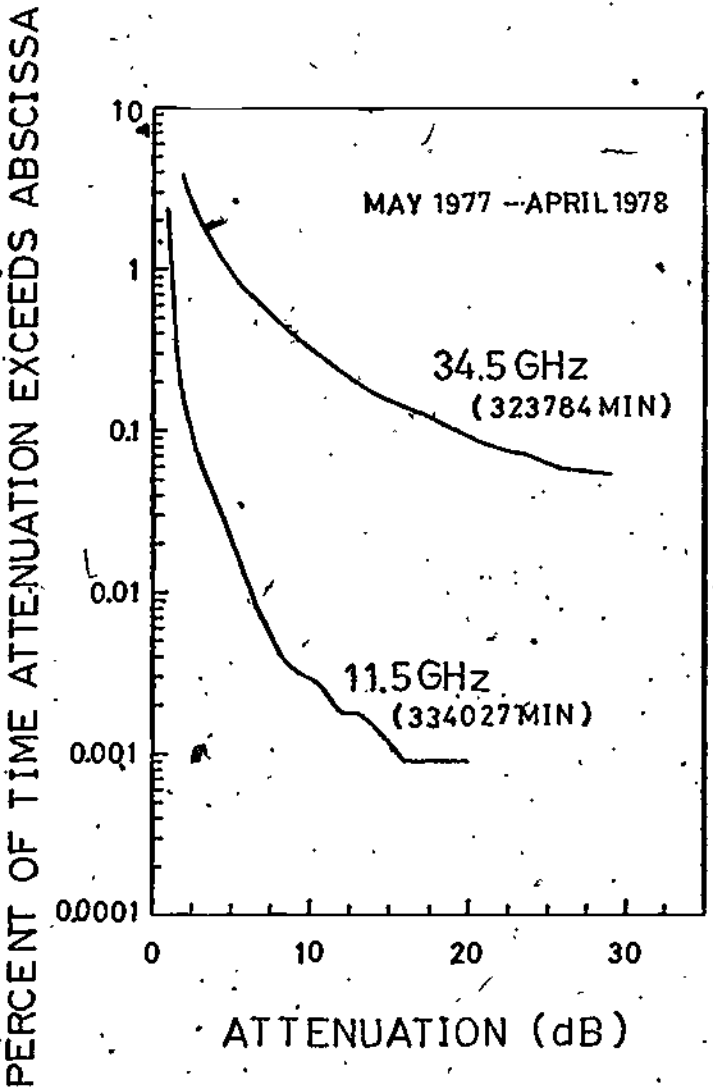
PERCENT OF TIME ATTENUATION EXCEEDS ABSCISSA
10
1
0.1
0.01
0.001
0.0001
MAY 1977 – APRIL 1978
34.5 GHz
(323784 MIN)
11.5 GHz
(334027 MIN)
0
10
20
30
ATTENUATION (dB)

Fig. 5

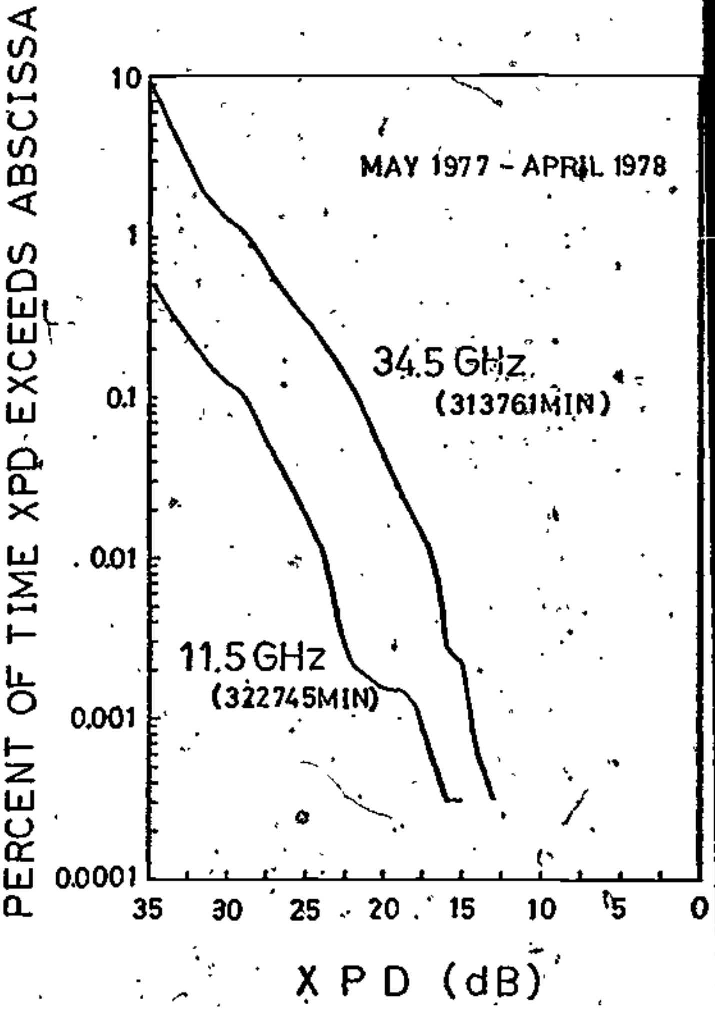
PERCENT OF TIME XPD EXCEEDS ABSCISSA
10
1
0.1
0.01
0.001
0.0001
MAY 1977 – APRIL 1978
34.5 GHz
(313761 MIN)
11.5 GHz
(322745 MIN)
35
30
25
20
15
10
5
0
XPD (dB)

Fig. 6

	1.7 GHz	11.5 GHz	34.5 GHz	Remarks
SAT.EIRP (dBm)	36.5	50.1	54.3	
ANT.POINT LOSS (dB)	0.1	0.5	1.0	
PROP.LOSS (dB)	188.8	205.4	214.9	
ATOM LOSS (dB)	0.1	0.2	0.5	
EARTH ST.ANT.GAIN (dB)	40.0	60.8	69.7	
FEEDER LOSS (dB)	3.0	1.0	1.0	
TRACK LOSS (dB)	0.0	0.1	0.5	
REC.POWER (dBm)	-115.5	-96.2	-93.9	
RX NOISE TEMP. (K)	170(2)	860(6)	2000(9)	():NF(dB)
RX SYS.NOISE (K)	320	935.7	2083.6	
(dB-K)	25.1	29.7	33.2	
REC.NOISE PW.DENS. (dBm/Hz)	-173.5	-168.9	-165.4	
C/N_0 (dB-Hz)	58.0	72.7	71.5	
PLL RX				
BAND WIDTH (dB-Hz)	27.0	30.0	30.0	
(Hz)	500.	1000.	1000.	
C/N (dB)	31.0	42.7	41.5	
PLL HOLD LIM. (dBm)	-144.5	-136.9	-133.4	C/N:2dB
PLL MARGIN (dB)	7.0	7.0	8.0	
PLL THRESHOLD (dBm)	-137.5	-129.9	-125.4	
PLL THRES.MARGIN (dB)	22.0	33.7	31.5	
AM DET RX				
AM DET.LOSS (dB)	4.0		4.0	
AFC LOOP HOLD S/N	4.0		4.0	
IF BANDWIDTH (dB-Hz)	40.0		40.0	10KHz
AFTER DET BW (dB-Hz)	0.0		0.0	~1 Hz
AFC HOLD LIM.C/N_0 (dB-Hz)	24.0		24.0	
AFC HOLD MARGIN (dB)	34.0		47.5	

Table 1

Apparatus		Data	Measurement interval	Measurement range	Quantity unit
Receiver	PLL Receiver	34.5GHz co-pol. 34.5GHz cross-pol. 11.5GHz co-pol. 11.5GHz cross-pol. 1.7GHz co-pol. 34.5GHz co-/cross-pol. phase diff. 11.5GHz co-/cross-pol. phase diff. 1.7GHz co-/34.5GHz co-pol. phase diff. 1.7GHz co-/11.5GHz co-pol. phase diff.	200msec	0 ~ -40dB 0 ~ -40dB 0 ~ -30dB -180°~+180°	1dB 1dB 1dB 2°
	AM Receiver	34.5GHz co-pol. 34.5GHz cross-pol. 11.5GHz co-pol. 11.5GHz cross-pol. 1.7GHz co-pol. 11.5GHz co-/cross-pol. phase diff.	200msec	0 ~ -50dB 0 ~ -40dB 0 ~ -30dB -180°~+180°	1dB 1dB 1dB 2°
Radio-meter		35.2GHz atm. noise temperature	200msec	100°K~70°K 70°K~40°K 40°K~0°K	5°K 3°K 1°K
Rain radar		PPI mode CAPPI mode RHI mode Ps mode	1min. 12min.	0~150mm/hr	0.1mm/hr 10 steps 0.1mm/hr
Meteoro-logical instru-ment		Wind speed and direction Ground temperature Humidity Atmospheric temperature Precipitation rate	1min.	0-100mm/hr	

Table 2

ECS PROGRAM FOR MILLIMETRIC WAVE COMMUNICATIONS IN JAPAN

By

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Abstract

The Experimental Communication Satellite (ECS) of Japan will be launched in February 1980 from Tanegashima Space Center by a N-launch vehicle of National Space Development Agency of Japan (NASDA), and will be located at 145°E longitude in the geostationary orbit.

The ground experimental facility is composed of a main station and sub-station for site diversity communication experiment. Both stations have C-band rain radar system to obtain accurate estimations of propagation characteristics in the millimeter wave range. Various experiment are planned for the ECS program, but the stress is placed on three items, those are site diversity switching experiment in Ka-Band, propagarion experiment and interferrence experiment in C-band with Medium Capacity Communication Satellite for Experimental Purpose.

1. Introduction

The Experimental Communication Satellite of Japan (ECS) will be launched in February 1980 from Tanegashima Space Center by a N-launch vehicle of National Space Development Agency of Japan (NASDA), and will be located in geostationary ~~orbit~~ at 145°E longitude. The nominal life time is one year.

The ECS project was initiated around 1967 by Ministry of Posts and Telecommunications (MOPT), and the experimental programme has been promoted by Radio Research Laboratories (RRL) of MOPT in co-operation with Nippon Telegraph and Telephone Public Co-operation (NTT) and Kokusai Denshin Denwa Co., Ltd. (KDD).

The ECS experiment has the main purpose to seek after possibilities of the millimeter wave satellite communication, and will be the first attempt in this fields. In other word, it has the purpose of technical developments and data acquisitions necessary for establishing satellite communications in heigher frequency bands such as 50/40 GHz which is the lowest frequency band assigned for the millimeter wave satellite communication.

Prior to ECS launching, Engineering Test Satellite Type-II (ETS-II) lunch in February 23 of 1977, for the sake of acquiring the techniques to locate ECS in the geostationary orbit, and made it successfully station at 130°E in March.

The main station for the ETS-II experiments will be also used as that for the ECS, with partial modifications. A sub-station, whose configuration and performance is to be almost identical to that of the main station, will be also prepared for site divercity communication experiment which may best promise the feasibilities of the satellite communication in the millimeter wave range.

The stress of the ECS experiments is going to be placed especially on site diversity communication experiments, and on propagation experiments in the millimeter wave range and cooperative experiments of interference in micro-wave range with the CS (Medium Capacity Communications Satellite for Experimental purpose of Japan), concerning effective utilization of the geostationary orbit.

There will be also included various kinds of experiments on the satellite communication and, on operation and control technique for the satellite.

2. Satellite

ECS is a spin stabilized cylindrical satellite about 1.4 meter in diameter and 0.95 meter in height, and has mechanical despun antennas. The overall height of the satellite is about 1.9 meter and the weight in orbit about 130 kg. The telemetry and command operate within the VHF band, and the range measurement is made at C-band. The K/C band frequency are 34.83/6.305 GHz for up-link and 31.65/4.08 GHz for down link, which are circularly polarlized. The beacon signal frequency is 3.94 GHz. (See that there are no K-band beacon signals). A profils of the satellite is shown in Figure 1.

The ECS antenna system consists of a mechanically despun pair of center-fed parabolic reflectors operating at C- and Ka-bands, a four channel rotary joint, and a C-band omni-directional antenna. The VHF antenna is composed of four whip antennas positioned at the bottom of the satellite. The K-band antenna gain is 33 dB at 34.83 GHz and 32 dB at 31.65 GHz, and the C-band antenna gain is 22.0 dB at 6.305 GHz and 19.0 at 4.08 GHz.

Figure 2 shows a schematic diagram of the ECS transponder. The C-band and K-band transponder channels utilize a common IF and can be cross-connected by command to give any one of four modes K/K, K/C, C/K and C/C. In addition, the transponder is used in conjunction with the C-band omni-antenna for ranging.

The band width can be selected by command to be any one of 10 MHz, 40 MHz and 120 MHz at the IF circuit, which has an automatic gain control (AGC) to maintain the input signal level constant to the TWT amplifiers so as to put out the saturation power (maximum power). There is a redundancy for the G-band transmitter, while no redundancy for the K-band. EIRP is expected to be more than 65 dBm for the C-band and 55 dBm for the K-band.

3. Ground Facilities

Figure 3 is a general view of the earth station for the ECS experiment at the Kashima Branch and the Hiraiso Branch of the Radio Research

Laboratories (RRL), showing many existent and newly constructed antennas.

The facilities are as follows: a main station and a sub-station for the sitediversity communication experiment, each of which has a modified Cassegrain type antenna 10 meters in diameter. Another 10 meter diameter antenna station for the C-band tranmission which is already used for the CS experiments, and 26 meter diameter antenna station (existent) for the C-band reception. For telemetry and command, two Yagi antennas and 18 meter diameter antenna will be used.

Each of the main and substations is equipped with a C-band rain radar, a millimeter wave radio meter, devices for meteorological observations, and data processing computers. The rain radar for the main station which was already operated for the propagation experiment with ETS-II is uniquely program-controlled to give accurate estimations of the propagation characteristics in the millimeter wave range under various weather conditions: In the ECS experiments, a function of Doppler radar is added for observation of the drop-size distributions of rain cell.

The antenna of the K-band main station was already used for the ETS-II experiment.

The surface roughness of the main dish of K-band antenna is about 0.17 mm rms at 90° elevation angle and about 0.25 mm rms at 45° which is close to the satellite elevation angle. The sub-reflector is movable up and down for precise antenna gain measurements in the near field region. The 4 GHz beacon from the satellite is received by eight helical antennas which are arrayed around the beam waist of the K-band signal to have the least influence.

The maximum transmitting power will be 300 watts for both K- and C-bands. The antenna gain which were measured and calculated using ETS-II is estimated to be 67.0 dB for the K-band including feeder losses, and 58.5 dB for the C-band reception. The antenna noise temperature is 150°K with the K-band 10 meter diameter antenna and 50°K with the C-band 26 meter diameter antenna. The 32 GHz helium gas cooled low noise parametric amplifiers have noise temperature of about 155°k, and the 4 GHz uncooled parametric amplifiers have that of 50°K, including wave guide losses. G/T of the earth station is estimated to be 42.7 dB/K for the K-band and 39.4 dB/K for the C-band.

As mentioned before, the ECS satellite communication link can have only one mode at one time of the four modes----K/K, K/C, C/K and C/C. So various types of communication test equipments and modulatores/demodulators are used in common for any modes. The IF is 1.7 GHz.

The main communication test equipment for the ECS experiment is that of PCM-PSK/TDMA system for the site-diversity communication experiment which is the most important item. The main characteristics of the system are as follows:

Transmission rate	60.032 or 30.016 Mbps
Transmission capasity	400 telephone channels
Frame length	750 μs
Modem	two phase CPSK
System clock	non-coherent among bursts Automatic

and error-free switching between the main and sub-stations is conducted with the TDMA control device at the main station.

The main and sub-stations are connected by a microwave link with two hops. In the main station, an 1.2 km optical fiber cable of integrated index type is used between the microwave-link tower and the building where the ECS communication equipments are placed. The sub-sation is equipped with a PCM-PSK modem for the site-deversity signals, a rain radar which has simpler functions than that of the main station, and other else. All data taken in the sub-station are sent to the main station by the microwave link.

4. Experimental Plan

An estimated link budget for the K- and C-band are shown in Table 1. There will be seen in the table the gain calculated using the data measured with the 34.5 GHz beacon signal from ETS-II. Total carrier power to noise power density ratio (C/N_o) is estimated in two cases, one of which depends on the satellite specification values and the other on the measurd values with the ECS Proto-type Flight Model (PFM).

The ECS link budget for the K-band will make possible communication of 400 channel FDM-FM telephones with about 4 dB rain margin, one channel FM-TV with about 5 dB margin, or a PCM-PSK (2 phases) signal with about 3 dB margin for 60 Mbps and about 6 dB margin for 30 Mbps to obtain 10^{-4} of bit error rate.

The ECS experiment will be classified in 6 categories which are listed with sub-items as follows:

(1) Basic measurements and experiments

- a. On-board equipment characteristics
- b. Characteristics of millimeter-wave earth stations
- c. Signal transmission through the satellite communication system

(2) Interference experiments with other communication links

- a. With CS micro-wave link
- b. With imaginated-satellite K-band links

(3) Propagation experiments

- a. Precipitation characterstics —— measurements and statistical analysis
- b. Millimeter-wave rain attenuation and depolarization
- c. Site-diversity gain with main and sub-station
- d. Rain scattering interference at 35 GHz
- e. Scintillation characteristics

(4) Site-deversity communication experiments for development of millimeter-wave satellite communication

(5) Other experiments for development of millimeter-wave satellite communication

a. Operation techniques
b. Communication experiments
c. Developments of millimeter-wave communication apparatus
d. Standard time transmission experiments

(6) Experiments of operation and control techniques for satellite

a. Developments of automatic operation and control system which is commonly used for geostational and moving satellites
b. Acquisitions of operation and control techniques
c. Methods of spacecraft control
d. Applications of operation and control techniques

In those experiments, the site-diversity communication experiment will be the most important item for best covering the weak point of millimeter-wave such as comparatively large rainfall attenuation. The experiments include items such as path delay equalization, diversity burst synchronization, diversity switching control, diversity gain and signal quality measurements. We expect that those system developments and data aquisitions will much contribute to the developments and establishment of the satellite communication in the higher frequency band.

Other distinguishing items are interference experiments with the CS micro-wave satellite link and propagation experiments. In the former which will give valuable data for effective utilization of the geostationary orbit, we intend to make experiments by changing the distance between the two satellites if possible. The Nippon Telegraph and Telephone Public Corporation :NTT) will fully join the experiment with its microwave station.

Propagation experiments were made in RRL by reception of coherent three signals ——— 1.7/11.5/34.5 GHz in frequency from the ETS-II for one year. The propagation experiments are going to be made on the basis of the ETS-II, by addition of apparatuses such as a rain-radar and a radio meter at the sub-station, and a function of the Doppler radar to the main-station rain radar.

As previously mentioned, ECS does not transmit any K-band beacons, so a quite low level pilot signal will be positioned at the frequency band edge to be used for the progatation experiments and the satellite tracking at K-band.

The communication experiments for development of millimeter-wave satellite communication are formed of four sub-items:

a) Quality improvements of speech signals received through the satellite communication links by SPAC (Speech Processing system by use of Auto correlation Coefficients), developed in RRL
b) Transmission experiments of digitalized color TV signals

c) Basic experiments for adoption of error correcting codes
——measurements of error patterns of digital signals received

d) High speed facsimile transmission experiments

The two digitalized color TV equipments for the experiments, developed in Japan, have transmission bit rate much reduced by use of interframe (or interfield) coding, in which the difference signal between two successive frame (or fields) is encoded and transmitted. With these, excellent quality of active-motion pictures can be transmitted at bit rate around 20 through 25 Mbps.

The ECS control is intended to be automatically made by common use of the system for a moving satellite such as the Ionospheric Souding Satellite in Japn (ISS). In general the telemetry and command operations including those necessary for the communication experiments are automatically conducted by consideration of safety of the ECS system.

5. Conclusion

The data obtained though the ECS experimental program will be useful to seek after possibilities of the millimeter wave satellite communication, and to determine the parameters necessary for establishing the communication system.

Acknowledgement

ECS project has been proceeded successfully due to the efforts of many people of RRL, NASDA and other agencies and corporations. The authors express their sincere gratitude to all of those who have contributed and they especially would like to pay tribute to the members of this project in RRL for their outstanding efforts.

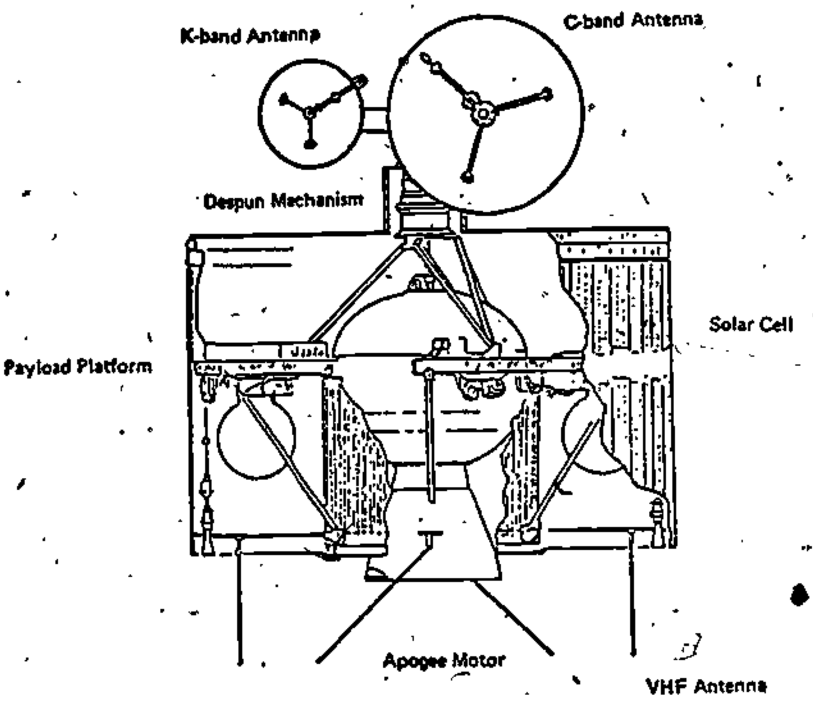
K-band Antenna
C-band Antenna
Despun Mechanism
Solar Cell
Payload Platform
Apogee Motor
VHF Antenna

Fig. 1. ECS profile.

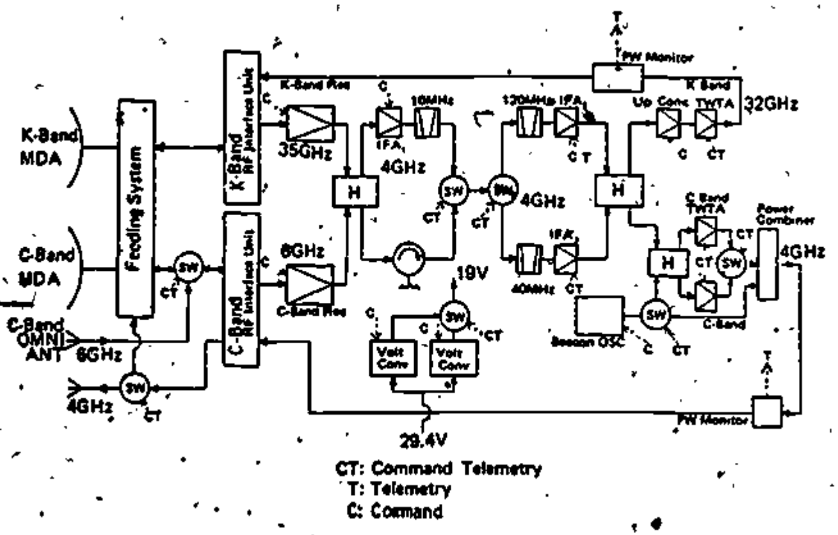
K-Band MDA
C-Band MDA
C-Band OMNI ANT
6GHz
4GHz
Feeding System
SW
CT
K-Band RF Interface Unit
C-Band RF Interface Unit
K-Band Rec
C-Band Rec
35GHz
6GHz
C
H
IFA
10MHz
4GHz
SW
CT
120MHz
IFA
C T
40MHz
19V
Volt Conv
Volt Conv
29.4V
PW Monitor
T
Up Conv
K Band TWTA
32GHz
C Band TWTA
Power Combiner
4GHz
Beacon OSC
C-Band
PW Monitor
CT: Command Telemetry
T: Telemetry
C: Command

Fig. 2. Schematic diagram of ECS transponder.

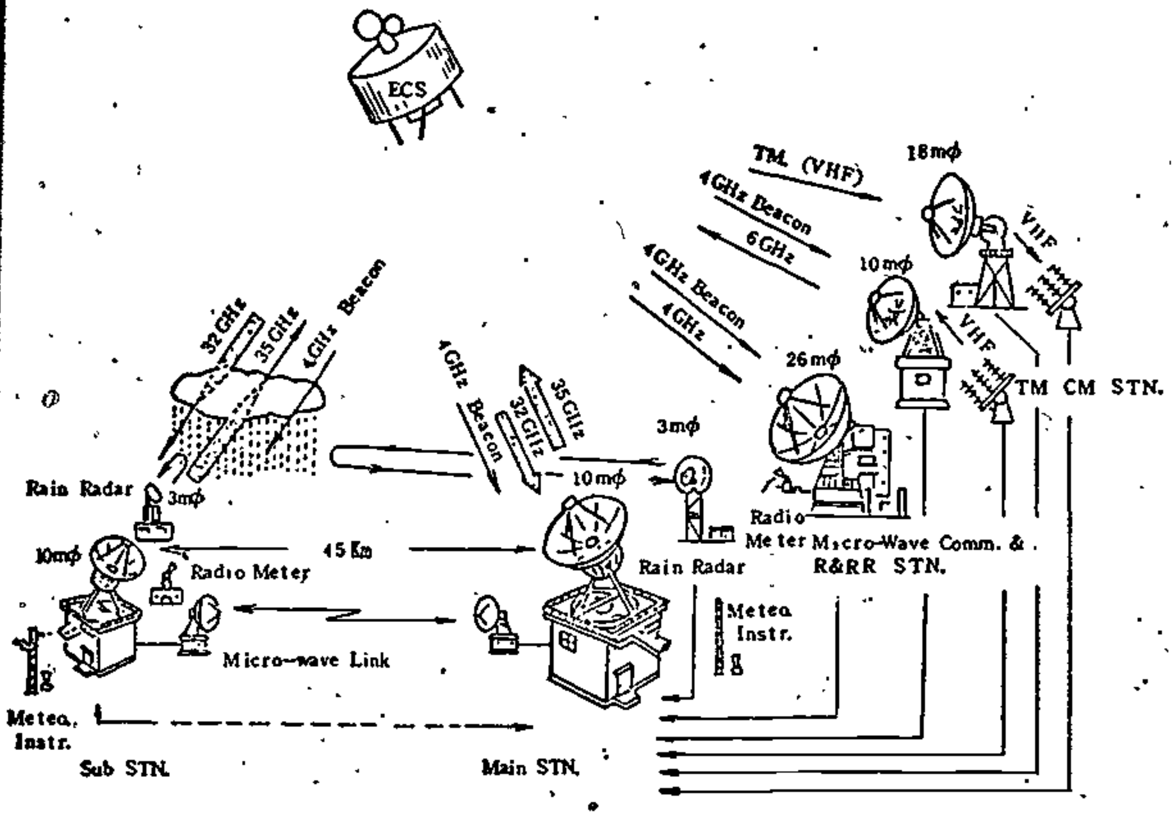
ECS
TM (VHF)
18mϕ
4GHz Beacon
6GHz
VHF
10mϕ
4GHz Beacon
4GHz
VHF
26mϕ
TM CM STN.
32GHz
35GHz
4GHz Beacon
4GHz Beacon
32GHz
35GHz
3mϕ
10mϕ
Rain Radar
3mϕ
Radio Meter
Micro-Wave Comm. &
R&RR STN.
10mϕ
45 Km
Radio Meter
Rain Radar
Meteo. Instr.
Micro-wave Link
Meteo. Instr.
Sub STN.
Main STN.

Fig. 3. Outline of ECS experimental system.

Table-1 ECS Link Budget

ECS UP-LINK BUDGET

Terms	Unit	Ka-Band		C-Band		Remarks
Earth Station						
Antenna Dia.	mφ	10		10		
Tx. Freq.	GHz	34 83		6305		
Tx. Power	dBm	54.8		54.7		300w
Circuit Comb. Loss Feeder Loss	dB dB	-1.0		-4 0		
Track Error Loss	dB	-0.3		-02		
Antenna Gain	dB	67.0		53 5		Includ. feeder loss
EIRP	dBm	120.5		104.0		
Path Loss	dB	-214 7		-200.0		EL=48°
Atomospheric Loss	dB	-1.0		-0 2		
Satellite						
Antenna Gain	dB	33 0		22.0		Spec.
Point. Error Loss	dB	-1.0		-0 5		
Receiving Power	dBm	-63 2		-74.7		(FM; ●=1095, S=51)
Receiving NF	dB	13 0	10.7●	9.0	5 3$	Spec. | PFM Data
Receiving Noise Temp.	dBK	37 4	35.1	33 4	29 8	T=275K, Ant. Noise Temp.=300K
G/T	dB/K	-5 4	-3 1	-11 9	-8 3	
(C/T) up	dBm/K	-100 6	-98 3	-108 1	-104 5	
(C/No)up	dBHz	98 0	100 3	90 5	91 1	

ECS DOWN LINK BUDGET

Satellite						
Tx. Freq.	GHz	31.65		4 08		(FM; ●=35 1, S=36 7)
Tx. Power	dBm	32 5	34 2●	34.2	36 6$	Spec. | PFM Data
Antenna Gain	dB	32.0		19 0		Spec.
Point. Error Loss	dB	-0 8		-0 5		
EIRP	dBm	63 7	65 4	52 7	55 1	
Path Loss	dB	-213 9		-196 1		EL = 48°
Atomospheric Loss	dB	-1 0		-0 2		
Earth Station						
Antenna Dia.	mφ	10		26		
Antenna Gain	dB	66 0		58 5		Includ. Feeder Loss
Track. Error Loss	dB	-0 3		-0 1		
Receiving Power	dBm	-85.5	-83 8	-85 2	-82 8	
Antenna Noise Temp.	K	150		50		Spec.
LNA Noise Temp.	K	165*		30		Spec. * Sub-ST. = 190K
Receiving Noise Temp.	dBK	25 0#		19 0		#Sub-ST. = 25.3
G/T	dB/K	42 7		39 4		
(C/T) down	dBm/K	-110.5	-108 8	-101 2	-101 8	
(C/No)down	dBHz	88 1	89 8	91 4	96 8	

Total C/No	K/K Mode	dBHz	87 7	89 4			Spec. | PFM Data
	K/C Mode	dBHz	92.8	95.2			
	C/K Mode	dBHz	86 1	88 4			
	C/C Mode	dBHz	89 0	92 2			

ORGANIZATIONAL MARKETING TM

By Thomas B. Cross
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Communications Institute of Boulder

Abstract

The role of management and the function of information will merge in the mid-1980's. Management structures creating environments in which people can work will cause evolutionary, if not revolutionary changes in corporate life. Developing these new concepts is one aspect of Organizational Marketing (OM Trade Mark).

MANAGEMENT FOR THE 1980's

New forms of management will be required in tomorrow's automated offices. Technology, coupled with a changing society, will cause management to rethink corporate structures. Organizational tools of the 1970's will give way to more creative and demanding systems of management. Electronic information systems will give management more information about department or corporate activities has been available than ever before. Competition between departments, based on 'selling your product or services', will be measured against the corporate rate of return. Understanding these strategies will be the key for managing in the 1980's.

There are growing indications that many organizational structures tend to isolate upper management from the employees. In this information age, much of the corporate product is contained within 'the heads of workers,' not in warehouses. Effective use of new information systems can bring the manager and employee closer. Information control can cause more wide spread change throughout the organization than any other factor.

Many of the innovative managers in the telecommunications industry know the corporate tele/information network is the nervous system of the corporation. These managers, for the most part, have provided only the pipeline for communications to occur. Technology is allowing Management Information Systems (MIS) to both manage and massage the information.

Much of the efforts of organizational developers will be devoted to communications structures, gaming, and strategies. One of these, called Organizational Marketing (OM), uses marketing information systems as a management tool. The key is sales techniques coupled with technology, where department goals are accomplished using marketing concepts rather than service bureau policies. Advertising is one of the principal promotional vehicles.

Developing management concepts which not only utilize, but are based on, information as a political power source requires developers to reevaluate the meaning of organizational communications. Organizations are faced with enormous communications problems in terms of people, technology, and corporate profits.

Marshall McLuhan is having a renewed impact on corporate organizational structures. His global village concept has become a reality in the global corporate community. Management Information System (MIS) designers are pushing the concept of distributed data processing to extend their realm of management control. "The status of the system is the status of the business," said Stephen Dickson, Corporate Auditor with the National Center for Atmospheric Research (NCAR) in Boulder, "We are creating a system where any one of our locations can use the computer as a management information tool not just a reporting device. In fact, we are approaching the point where if it's not in the system the transaction didn't occur.

The advent of the stored-program telephone switching systems provided the opportunity for corporate telecommunications managers to begin thinking like data processing managers. The telephone system of today possess new tools for managing the corporation. Least cost routing, call detail recording, network queuing, and network control are features which allow management the control of telephone calls as a gatekeeper. With the introduction of data communications traffic onto a voice network, new control systems can be addressed and installed.

Some corporations are examining the need for intelligence in many corporate activities.

- GROWING NEED FOR SHARED-LOGIC SYSTEMS
  - INTELLIGENT COMMUNICATING COPIERS
  - INTELLIGENT COMMUNICATING CBX TELEPHONE SYSTEMS
  - INTELLIGENT COMMUNICATING NETWORKS
  - INTELLIGENT COMMUNICATING TYPEWRITERS
  - INTELLIGENT COMMUNICATING MAIL SYSTEMS
- GROWING NEED FOR STORAGE SYSTEMS
  - VOICE MAILBOX
  - DATA MAILBOX
  - FILE MANAGEMENT
  - DATA BASE MANAGEMENT
  - WORD MANAGEMENT

Correspondingly, the data processing manager is now faced with distributed data processing (DDP) which requires extensive data use of telecommunications networks.

Most of the traffic will be data and video in the future. The network must be able to adapt to changing network demands. Each type of traffic will be assigned priorities, allowing network managers to utilize store-forwarding concepts.

In the case of voice traffic, the much heralded voice storage system, some plan to use disk storage for the assignment and distribution of telephone letters. Other concepts under development suggest the telephone system can perform all the functions of a small business computer, including environmental controls, security, and office systems.

Data processing and telecommunications have been merged organizationally in many corporations. It remains to be seen whether office systems will be functionally addressed in the same manner.

The introduction of electronic technology to the office has caused the most significant revolution since the typewriter. Word processing is not the first technology to impact the office, but probably is the catalyst that will allow the introduction of even newer technologies. Electronic mail, a powerful information tool, is still in its infancy. Dictation, a useful tool to certain segments of the corporate world, will grow into the automated office with word processing. Micrographics and reprographics will be intregrated by document distribution communications systems. Voice recognition and optical character readers will be introduced into the office faster than expected.

Even though most corporations are cautiously optimistic about the outcome of this evolutionary process, they are the pioneers of the automated office. What remains is for thousands of other organizations to mirror the leaders. "When corporate managers fail to make these decisions which, in some cases, can have significant bottom-line impacts on the corporation, they can be called career limiting decisions," Dale G. Mullen of Johns Manville, "Managers are now in positions of either making the decision and facing the outcome, or not making it and limiting their career." Technology is forcing new consequences in the career path. Some small organizations are moving toward computer gaming and simulations to help resolve this problem.

GROWING BUSINESS DEMANDS

- GROWING MOVEMENT IN BUSINESS TOWARD
  - TRANSACTION PROCESSING
  - ELECTRONIC FUNDS TRANSFER
  - TELECONFERENCING
  - NETWORKING
  - DISTRIBUTED VOICE/DATA/IMAGE PROCESSING
- GROWING PRESSURES ON OFFICE WORKERS
  - IMPROVE PRODUCTIVITY
  - IMPROVE RESPONSE TIME
  - REDUCE INFORMATION FLOAT
  - IMPROVE FINANCIAL FLOAT

OFFICE PROCESSING IS NOT DATA PROCESSING

The concept of office processing is merging with data processing functions though office processing is not data processing. Large numerical calculations, payroll, accounting, and other such transactions have no place many typical office departments, large or small. For many small businesses, these functions are performed on a time-sharing or small business computer system. However, typing letters, arranging meetings, coordinating activities, and answering the telephone are office functions critical to improving productivity.

Office processing, like telecommunications, may use a stored-program microprocessor-controlled, computer-based system. It can be exactly the same technologically as any computer; but functionally have a different operating concept.

We can alter the concept of technology to perform many other functions. It is the merging of these technologies which can solve organizational management problems which most corporations consider least in cost savings measures.

CHANGING ROLES IN OFFICE PROCESSING - "NO MORE WOMEN"

We have come to accept the encroachment of technology into the corporate structure and, in some cases, expected a word processor to replace people. We have failed to understand that the combined changes technology is forcing in the sociological makeup of modern society. Impacts of inflation, legislation, and education have pushed women into the job market. In addition, corporate management goals are moving women and minorities into higher positions. With all of this uplifting going on, what will be left behind?

- CHANGING MANAGEMENT STRUCTURES
    - NO MORE BOSS/SECRETARY RELATIONSHIP
    - ADMINISTRATIVE WORKERS / WORD PROCESSING WORKERS
    - PRODUCTIVITY ANALYSIS INCREASING
    - ANALYTICAL INFORMATION ON OFFICE WORKER

WORKER EVOLUTION

UNITED STATES

Percentage of the Working Force	1973	1979	1990 Est
PROFESSIONAL TECHNICAL	13.2	16.0	20.54
ADMINISTRATIVE AND MANAGERIAL	9.6	11.0	14.95
CLERICAL	16.7	19.0	26.0
SALES	6.2	7.0	9.1
SERVICE	13.0	14.0	19.5
AGRICULTURE	3.4	3.0	2.5
PRODUCTION TRANSPORATION LABOR	34.6	30.0	7.4

Percentage of the Working Force

LESSER DEVELOPED COUNTRIES

	1966	1972	1992 Est
PROFESSIONAL TECHNICAL	2.7	4.6	11.0
ADMINISTRATIVE AND MANAGERIAL	0.1	0.2	4.0
CLERICAL	2.7	2.6	16.0
SALES	6.7	7.8	9.0
SERVICE	6.7	11.6	12.0
AGRICULTURE	41.3	39.6	11.0
PRODUCTION TRANSPORATION LABOR	26.8	33.3	37.0

Source: The Wired Society by James Martin, U. S. Department of Labor - Bureau of Labor Statistics - May 1979.
and others

1979 MANAGERS DISTRIBUTION OF TIME

FACE TO FACE	35-45%
FACE TO RECORD	25-30%
IN TRANSIT	5-10%
TELEPHONE	5-15%

1985 MANAGERS DISTRIBUTION OF TIME

FACE TO FACE Meetings Presentations Audio Conferencing Video Conferencing	65-85%
IN TRANSIT	5-10%
COMMUNICATIONS Dictation Telephone Voice Mailbox Administrative	10-15%

1979 EXPANDING NEED FOR FOLLOWING SECRETARIAL WORK STATION ELEMENTS

- DICTATION, TYPING, AND PROOFREADING	19%
- ADMINISTRATION SUPPORT TELEPHONE, MAIL	35%
- AWAY FROM DESK	29%
- WAITING FOR WORK	12%
- ABSENT	5%

1985 EVOLVING ADMINISTRATIVE ANALYST (SECRETARIAL) WORK STATION ELEMENTS

- DICTATION, TYPING, AND PROOFREADING	10%
- ADMINISTRATIVE ANALYSIS Meeting Coordination Travel Arrangements Budget Tracking Purchase Order Tracking Researching	50%
- ADMINISTRATION COORDINATION AND SUPPORT FOR MEETINGS, TELEPHONE, MAIL	35%
- ABSENT	5%

Fewer women will be secretaries. Men will share equally in this position. Men and women will be forced into non-traditional roles. The impact can be devasting when the corporation forces new office automation systems onto archiac sex-based office roles. From a management perspective, the secretary can be eliminated with little or no pain to the organization. Some functions can be generally automated and the remaining ones left to administrative managers who may also manage the budget and other activities.

The implementation of centralized processing areas for office work has been the trend over the last few years. These centers or as we have called them, 'task processing centers,' have been the focal point for major management reorganizations. These centers were not installed because of technological limitations, but for management control. Communications options allow these devices great freedom to move documents about throughout the corporate network.

The designers of word processing centers have hoped that providing word processing centers would result in job specialization and increase office productivity. From all of the studies which have been completed, statistics about the office environment are not clear in resolving many of these issues.

The office can be thought of as an information tool, processing information from one node to another: personnel communicating to accounts payable about filling a vacancy or purchasing reponding to a request for parts. These are information transfer functions, or task processing. These activities, and many others, do not require paper, oral communications, or real time contact. Information can be used as a tool to measure transfer or tasks. These aspects of activity can be directly measured, and job performance rated.

Memos, reports, and mail are the office tools by which any bureaucracy works. Some of these tools are being developed, such as the action items, coordinating calendars, memoranda, and similar office task documents, on totally automated systems. Another tool used to measure office activities is budgets.

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Zero-based budgeting and profit centers are all terms used to measure departmental productivity in dollars. Each of a department's activities are measured against dollar performance. There are many office functions against which dollar performance may be difficult, immpossible, or undesireable to measure. Information management can be the management system developed for many of these environments.

With the development of information systems allowing for the management of credibility, "information float" can be a measure of productivity. "Executives are very much aware of the float when they talk about finances," said Dr. George Champine of Sperry Univac. "Float, of course, is the unused cash that is waiting while information is transferred back and forth. I would like to make the point that information float in large organizations is much more damaging than financial."

"Since we have been using new technology, I have noticed a significant increase in our pace of activity," he said.

When the office designers can truly address issues such as the increased speed of the office, and at the same time not require senior level people to type, we will see a massive migration towards the automated 'information' office. This can only occur when new approaches in management concepts, like organizational marketing and others, can be implemented.

Automated systems will allow measurement of information efficiency of the task or transaction. Armed with this information system, managers will be able to cross departmental barriers to monitor activities and sell their services more effectively. As departments compete for limited corporate funds, managers must be able to develop strategic plans to win over other departments.

The global corporate community is fast becoming a reality. New management operating systems need to be developed in this arena. We can now begin to address these issues and design in systems which are efficient and humanistic.

TELECOMMUNICATIONS SERVICES/SYSTEMS OPTIMAL UPGRADING VIA THE DYNAMIC PROGRAMMING APPROACH

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Abstract

An optimal economic scenario is presented for the evaluation of an upgrading scheme of a general telecommunication system via the use of dynamic programming algorithm. The criterion used in evaluating various strategies is the discounted present value of all equipment and maintenance costs over a finite time interval (the planning horizon). The telecommunication services are divided in various classes of different grades and the algorithm allows certain regrading to occur in an optimal manner. A similar categorization of the respective systems exist. The results are quite general and a multitude of special cases can be considered as examples of this algorithm.

INTRODUCTION

In this paper a mathematical model is derived for the determination of optimal telecommunication services/systems upgrading strategies. First the model is explained and then an optimization algorithm based on that model is developed.

MATHEMATICAL MODEL

Let f(t) be the cumulative forecast function of the telecommunication service demand as a function of time (this function is assumed to be known for the entire study period. The telecommunication service need not be specified for generality but it can be any telecommunication service including telephone service). It is assumed that each service is subdivided into five subclasses. Each subclass is some predetermined function of this forecast function. Hence if we denote by $x_i(t)$ the demand of the subclass i of the service x at time t we have the following set of relations,

$$x_1(t) = g_1^x(f(t)) \qquad (1)$$

$$x_2(t) = g_2^x(f(t)) \qquad (2)$$

$$\vdots$$

$$x_5(t) = g_5^x(f(t)) \qquad (3)$$

We see that we chose to have at most 5 subclasses for reasons of simplicity. The results of this paper hold for any number of subclasses.

Similarly if we denote by $y_i(t)$ subclass i of service y

$$y_1(t) = g_1^y(f(t)) \qquad (4)$$

$$y_2(t) = g_2^y(f(t)) \qquad (5)$$

$$\vdots$$

$$y_5(t) = g_5^y(f(t)). \qquad (6)$$

Finally for the service z we have:

$$z_1(t) = g_1^z(f(t)) \qquad (7)$$

$$z_2(t) = g_2^z(f(t)) \qquad (8)$$

$$\vdots$$

$$z_5(t) = g_5^z(f(t)) \qquad (9)$$

where in all cases $g_i^{(\ )}(\cdot)$ denotes the functional relationship between the forecast function and the demand of each subclass of a particular service. To satisfy the demand of these services represented by $x_i(t)$, $y_i(t)$ and $z_i(t)$, it is assumed that we have two alternate telecommunication systems which for convenience we shall call A and B. For alternative A, the system that provides the service can be subdivided into three distinct subsystems. Moreover, each subsystem has a descrete set of capacities, e.g. telephone lines, etc. for the case of telephone systems and that each service utilizes a different system.

Alternative B represents the simplest possible way of providing the service. For notational convenience we shall make the following definitions:

$S^x_{1i_x}$	capacity of x-service subsystem S^x_1 of type "i_x"* where $i_x = 1,2,\ldots,N^x_1$.
$S^x_{2j_x}$	capacity of x-service subsystem S^x_2 of the type "j_x" where $j_x = 1,2,\ldots,N^x_j$.
$S^x_{3k_x}$	capacity of x-service subsystem of the type "k_x" where $k_x = 1,2,\ldots,N^x_k$.
$S^y_{1i_y}$	capacity of y-service subsystem S^y_1 of the type "i_y" where $i_y = 1,2,\ldots,N^y_i$.
$S^y_{2j_y}$	capacity of y-service subsystem S^y_2 of the type "j_y" where $j_y = 1,2,\ldots,N^y_j$.
$S^y_{3k_y}$	capacity of y-service subsystem S^y_3 of the type "k_y" where $k_y = 1,2,\ldots,N^y_k$.

*Each subscript i_x represents a different capacity.

The equivalent capacities for the z-service subsystems are denoted by $S^z_{1i_z}$, $S^z_{3k_z}$.

The corresponding cost of each subsystem is given by

$$C^x_{1i_x} = A_{1i_x}\left(S^x_{1i_x}\right) + B_{1i_x}\left(S^x_{1i_x}\right) \cdot S^x_{1i_x} \tag{10}$$

The same cost formula applies to the rest of the subsystem and in general $A(\cdot)$ and $B(\cdot)$ are functions of the capacity of the subsystem under consideration.

For alternative B, it is assumed that the system necessary for the provision of the service is subdivided into two subsystems indicated by:

S_{1i}	capacity of subsystems S_1 of the type "i" where $i = 1,2,\ldots,N_i$.
S_{2j}	capacity of subsystems S_2 of the type "j" where $j = 1,2,\ldots,N_j$.

The associated costs of these subsystems are given by equations of the form (10) and are denoted by C_{1i} and C_{2j}. If we indicate by $\theta^x_{1i_x}(t)$ the number of systems $S^x_{1i_x}$ that are needed to satisfy all or part of the demand of x the service denoted by x for some number of years then

$$\sum_{i=1}^{5} x_i(t) = \sum_{i_x=1}^{N_1^x} \theta^x_{1i_x}(t) S^x_{1i_x} \tag{11}$$

where

$$\theta^x_{1i_x}(t) \geq \left\lceil \frac{\sum_{i=1}^{5} x_i(t)}{S^x_{1i_x}} \right\rceil \tag{12}$$

if

$$\theta^x_{1\kappa}(t) = 0 \text{ for all } \kappa \text{ except } \kappa = i_x$$

$\lceil\cdot\rceil$ indicates rounding up to the next integer of the ratio included in the brackets. Besides the cost incurred at the initial installation of each subsystem, there is another component of the cost which in general is a function of the forecast function, f(t). If we denote by $\mu_1^x(f(t))$ that cost we can write:

The total cost of subsystem $S^x_{1i_x}$ is

$$C_1^x(t) = \sum_{i_x=1}^{N_1^x} C^x_{1i_x} \theta^x_{1i_x}(t)$$

at the beginning of the service life of subsystem S_I and

$$C_1^x(\tau) = \mu_1^x(f(\tau)) \text{ for any } \tau > t \tag{13}$$

Hence we see that the total cost can be depicted in general by $C_1^x(t,\underline{\theta}_1^x(t))$, where

$$C_1^x(t) \equiv C_1^x(t,\underline{\theta}_1^x(t))$$

$$C_1^x(\tau) = C_1^x(\tau,0) = \mu_1^x(f(\tau)),\ \tau > t$$

The independent variable of time t varies discretely in intervals of one year. Hence,

$$t = 1,2,\ldots,T$$

where

T is the study period.

If a decision is made to use $\Theta^x_{1i_x}(t_o)$ subsystem of capacity $S^x_{1i_x}$ at $t = t_o$ then the next instant of time we need relief is found by

$$\sum_{i_x=1}^{N^x_1} S^x_{1i_x} \Theta^x_{1i_x}(t_o) = \sum_{i=1}^{5} x_i(t) \tag{14}$$

if we define the following vectors, i.e.,

$$\underline{s}^x_1 \equiv \begin{bmatrix} S^x_{11} \\ \vdots \\ S^x_{15} \end{bmatrix}, \quad \underline{\Theta}^x_1(t) = \begin{bmatrix} \Theta^x_{11}(t) \\ \vdots \\ \Theta^x_{15}(t) \end{bmatrix} \tag{15}$$

and put Equations (1) - (9) into a vectorial form we obtain

$$\underline{x}(t) \equiv \begin{bmatrix} x_1(t) \\ \vdots \\ x_5(t) \end{bmatrix} = \begin{bmatrix} g^x_1(f(t)) \\ \vdots \\ g^x_5(f(t)) \end{bmatrix} \equiv \underline{g}^x(f(t)) \tag{16}$$

$$\underline{y}(t) = \underline{g}^y(f(t)) \tag{17}$$

$$\underline{z}(t) = \underline{g}^z(f(t)) \tag{18}$$

$$\sum_{i=1}^{n} x_i(t) = \left(\underline{\Theta}^x_1(t)\right)' \underline{s}^x \tag{19}$$

(') indicates transpose.

Similarly let

$$\underline{c}^x_1 = \begin{bmatrix} C^x_{11} \\ \vdots \\ C^x_{15} \end{bmatrix} \tag{20}$$

then equation II-13 becomes:

$$C^x_1(t) = \left(\underline{c}^x_1\right)' \underline{\Theta}^x_1(t) \tag{21}$$

Since the same type of definitions hold true for the rest of the subsystems, the problem reduces to the following.
Find the optimal strategy $\hat{\Theta}^x_{ji_x}(t)$ for all j and i_x such that

$$\sum_{t=1}^{T} \alpha \left(C_1^x(t)PWC(t)+C_2^x(t)PWC(t)+C_3^x(t)PWC(t) \right) \quad (22)$$

is minimized where

$$PWC(t) \equiv \frac{1}{(1+i)^t} \left(\frac{(1+i)^{T-t}-1}{i(1+i)^{T-t}} \right)$$

i = interest rate [3]
α = constant.

Since t is a discrete variable of time, it can be substituted by the variable κ and by rearrangement the cost functional (21) can be written

$$\sum_{\kappa=1}^{T} \alpha PWC(\kappa) \left(C_1^x(\kappa)+C_2^x(\kappa)+C_3^x(\kappa) \right) \quad (23)$$

In the above formulation, we have tacitly assumed that subsystems 1, 2, and 3 are independent of each other and the optimization can be performed for each system separately. This may not be true for all cases but the applicability of the technique which will be presented here is not described by this assumption. Thus the problem reduces to:

Minimize:

$$J(\Theta_1^x(\kappa),\kappa) \equiv \sum_{\kappa=0}^{T} \alpha PWC(\kappa) C_1^x(\kappa) C_1^x(\kappa,\Theta_1^x(\kappa)) \quad (24)$$

Subject to:

$$\sum_{i_\kappa=1}^{N_i^x} \Theta_{1i_x}^x(\kappa) S_{1i_x} \geq \sum_{i=1}^{5} x_i(\kappa) \quad (25)$$

$$\Theta_{1i_x}^x(\kappa) = \text{Integer} \quad (26)$$

OPTIMIZATION ALGORITHM

One intuitive way of attacking this optimization problem is to try all possible strategies and choose the most economic. This exhaustive algorithm, however, grows very fast and can very easily become unmanageable even with moderate number of variables. Fortunately there exist modern mathematical techniques which drastically reduce the computational effort involved in determining the optimal strategy. One of the most widely used for these types of problems is the Dynamic Programming [1,2]. The main features fo this procedure is that it starts with a small portion of the problem and finds the optimal solution for this smaller problem. It then gradually and in an organized fashion enlarges the problem, finding the current optimal solution from the previous one until the original problem is solved in its entirety. Applying this technique to the problem at hand, we obtain the following.

Let us make the definitions

$$D_0 \equiv \sum_{i=1}^{J} x_i(0) \qquad D_1 \equiv \sum_{i=1}^{5} x_i(1)$$

$$\vdots$$

$$D_T \equiv \sum_{i=1}^{5} x_i(T)$$

then (25) becomes

$$\sum_{i_x=1}^{N_i^x} \theta^x_{1i_x}(0) S_{1i_x} \geq D_0 \qquad \sum_{i_x=1}^{N_i^x} \theta^x_{1i_x}(1) S_{1i_x} \geq D_1 \qquad \sum_{i_x=1}^{N_i^x} \theta^x_{1i_x}(T) S_{1i_x} \geq D_T \tag{27}$$

If we denote by $J(j,\kappa,D_o,D_1,\ldots,D_T)$ the cost for satisfying the demand in the time interval between j and κ $(j < \kappa)$, then

$$J^*(\kappa) = \min_{j < \kappa} \min_{\left\{\theta^x_{1i_x}\right\}} \left(J^*(j) + J(j,\kappa,D_o,D_1,\ldots,D_T) \right) \tag{28}$$

where

$J^*(\kappa)$ is the optimal cost for satisfying the demand from $t = 0$ to $t = \kappa$

and $\left\{\theta^x_{1i_x}\right\}$ is the set of integers satisfying the first $(\kappa+1)$ conditions out of the set of $(T+1)$ conditions given by (27).

Equation (28) which is nothing else but a functional expression of the principle of optimality [1,2] constitutes a necessary and sufficient condition for the existence of an optimal policy. It represents a recursive algorithm for generating successively the values of $J^*(\kappa)$. Since this recursive algorithm is rather an abstract formulation aid in conceptually understanding this problem may be obtained by an illustration of a simple example.

Let $S_{11} = 7 \quad S_{12} = 9, \quad S_{13} = 15$ (29)

$$C_{11} = 10 + 1.5xS_{11} \quad C_{12} = 10 + 1.3xS_{12} \quad C_{13} = 10 + 1.1xS_{13}$$

The cost of subsequent installations of subsystems S_{11}, S_{12} and S_{13} is given by

$$C_{11} = 1.5xS_{11} \quad C_{12} = 1.3xS_{12} \quad C_{13} = 1.1xS_{13} \tag{30}$$

Let's also arbitrarily set

$$\alpha \cdot PWC(0) = 1, \ \alpha \cdot PWC(1) = 0.9, \ \alpha \cdot PWC(2) = 0.8$$

$$\alpha \cdot PWC(3) = 0.7 \ \alpha \cdot PWC(4) = 0.6 \quad T = 5$$

A feasible strategy of using these three systems, namely S_{11}, S_{12}, S_{13} to satisfy the demand at each instant of time is given in Table I with their associated costs for each system. This strategy is conditioned by not allowing the subsystems to be used in variety of combinations. Hence it is not expected that either of those feasible realizations will be optimal. To find the optimal policy, we use the algorithm of the equation 28. Hence

$$J^*(1) = \min_{j < 1} \min_{\theta^x_{11_x}(0)} \left(J^*(0) + J(0,1,0_0) \right)$$

If we let $J^*(0) \equiv 0$ then

$$J^*(1) = 20.5$$

We can continue using this algorithm until we obtain $J^*(5)$. The results are given in the form of an organized structure customarily called Decision Tree shown in Figure 1. It is important to note the number of paths which are eliminated by this algorithm! The alternative would have been to check every possible path which amounts to having to make 363 calculations. It is seen that the optimal policy is given by the following:

Install at $t = 0$ subsystem S_{12}, $\theta^x_{11_x}(0) = \{0,1,0\}$

Install at $t = 1$ subsystem S_{12}, $\theta^x_{11_x}(1) = \{0,1,0\}$

Install at $t = 3$ subsystem S_{13}, $\theta^x_{11_x}(3) = \{0,0,1\}$

Thus the optimal strategy gives an optimal cost equal to 43.78 which is about 9% lower than the lowest cost of the realizations described in Table 1. It should also be observed via the decision tree that if our study period were less than 5 years, say 4 years, an entirely different path would have given the optimal strategy. This algorithm described here is quite general and can be easily applied to any suitable upgrading scenario.

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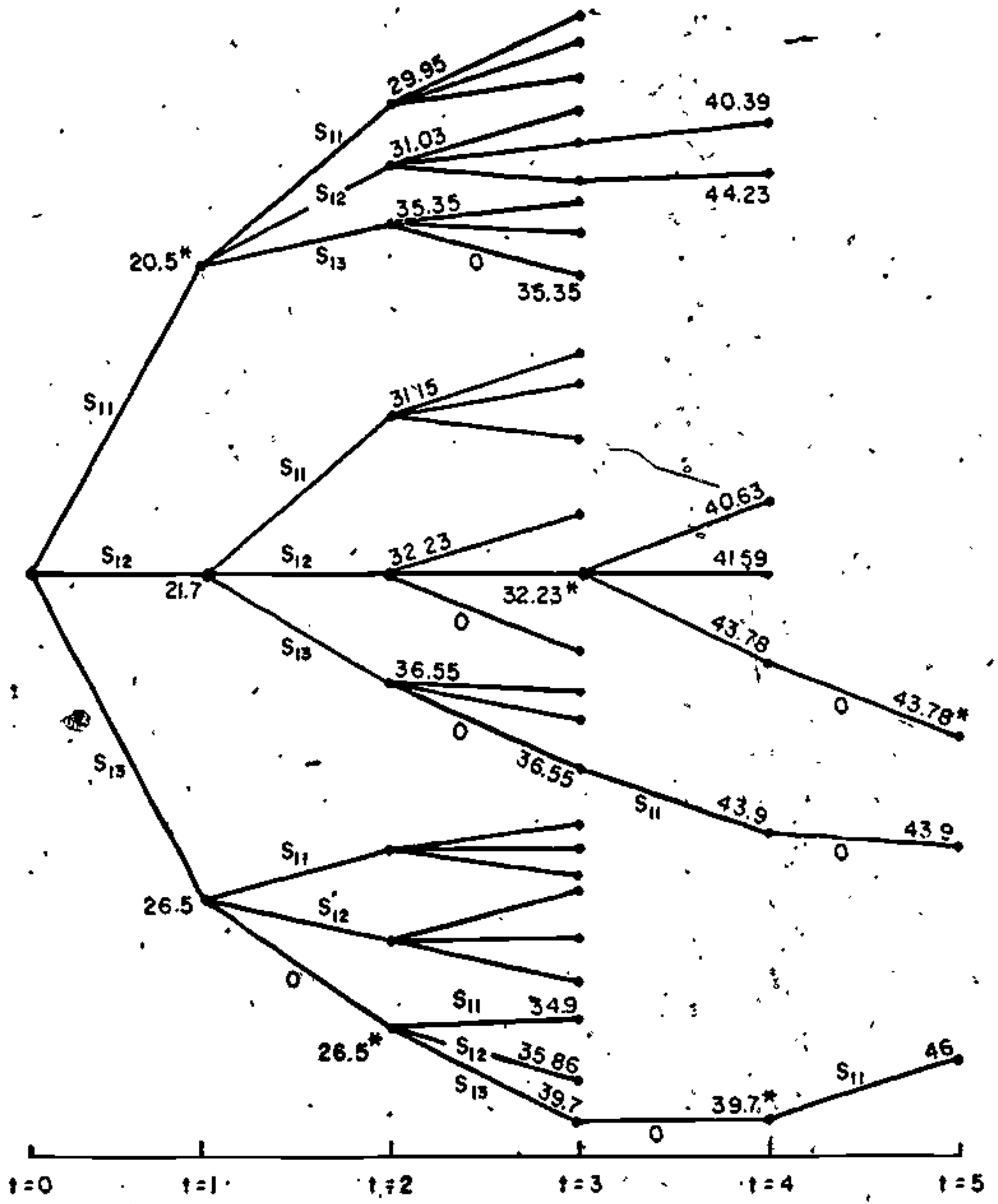
29.95
S11
31.03
40.39
S12
44.23
35.35
20.5*
S13
0
35.35
S11
31.15
S11
40.63
S12
32.23
41.59
21.7
S12
32.23*
0
43.78
S13
36.55
0
43.78*
S13
0
36.55
S11
43.9
0
43.9
S11
26.5
S12
0
S11
34.9
26.5*
S12
35.86
S13
39.7
0
39.7*
S11
46
t=0
t=1
t=2
t=3
t=4
t=5

* REPRESENTS $J^*(K)$

$J^*(5) = 43.78$

FIGURE I DECISION TREE

TABLE 1

FEASIBLE STRATEGIES

COST SUBSYSTEM	$d_0 = 5$	$d_1 = 11$	$d_2 = 18$	$d_3 = 25$	$d_4 = 31$
S_{11}	20.5	10.5	10.5	10.5	10.5
S_{12}	21.7	11.7	-	11.7	11.7
S_{13}	26.5	-	16.5	-	16.5

TOTAL COST OF SUBSYSTEM $S_{11} = 20.5+0.9\times10.5+0.8\times10.5+0.7\times10.5+0.6\times10.5 = 52$

TOTAL COST OF SUBSYSTEM $S_{12} = 21.7+0.9\times11.7+0.7\times11.7+0.6\times11.7 = 47.44$

TOTAL COST OF SUBSYSTEM $S_{13} = 26.5+0.8\times16.5+0.6\times16.5 = 49.6$

SUPPLEMENTAL TELEPHONE SERVICES
PRESENT STATUS AND FUTURE POLICIES

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Abstract

The two long-cherished goals of the Nippon Telegraph & Telephone Public Corporation --- elimination of unfilled applications and nation-wide direct distance dialing --- were attained in March 1979. Now NTT is committed to develop and introduce various new telephone servicas to its 36 million-plus subscribers in parallel with such non-voice services as visual communications, new data network and public switched facsimile services. This paper analyzes the present status of the new services provided on the telephone network, identifies problem areas and suggests future courses and policies.

1. Introduction

In March 1979, the last manual telephone exchange in Japan was converted to automatic operation to mark the final attainment of NTT's long-cherished goals of waiting list elimination and nation-wide direct distance dialing.

However, the large increase in the number of residential telephones has resulted in financial pressure by decreasing average per-line income. Faced with this situation, NTT has to strengthen its financial basis by improving service to its 36 million-plus subscribers so as to meet customer needs and stimulate traffic as well as by introducing such non-voice services as visual communications, new data network and public switched facsimile services.

This paper analyzes the present status of the new services provided on the telephone network, identifies problem areas and suggests future courses and policies concerning:

(1) New services to be provided through the addition of new functions to the existing network (to be referred to in this paper as "network provided supplemental services").

(2) Terminal equipment.

2. Present Status and Problem Areas

2.1 Telephone network

Japan's telephone network has grown to a giant system of more than 36 million subscribers. The network itself was completely automatized in March 1979. Reflecting the long history of development, step-by-step, crossbar and electronic switching systems are used side by side in the network. In addition, depending on the exchange size and hierarchy, differnt types of switches are used.

Table 1 shows switching sytems to be used in different exchanges and Table 2 shows switching equipment actually installed according to type.

Table 1 Types of Switching Equipment Used by Different Exchanges

Type of Switching System		Step-by- Step	Crossbar	Electronic
Introduced in		1926 (No new installation since 1973)	1957	19[illegible]
Local Switches	Small exchanges	A Type or H Type	C-1 C-2	D-30
	Medium size exchanges		C-460	D-20
	Large exchanges		C-400	D-10
Toll switches		–	C-6 (2w) C-8 (4w)	D-10 (TS)

Table 2 Types of Switching Equipment in Use

Type of Switching System	Local	Toll
Step-by-step systems	14%	–
Crossbar systems	81%	81%
Electronic systems	5%	19%

In order to introduce new services in response to the need of the user public, the existence of different types of switches having different functional limitations must be clearly recognized. Necessary modification or improvement of the switches must be properly planned.

The present telephone network has following shortcomings:

(1) In order to introduce new services envisioned through market studies and research activities, substantial modifications to the present telephone network are required. Improvement of the signaling system, sophistication of the message accounting equipment and addition of information storing capabilities may be required.

(2) Because of their design principles, step-by-step systems are hard to modify to accommodate new services. Substantial expenditures will be needed to modify them. For this reason, some of the new services are not available to subscribers served by step-by-step exchanges. Although new installation of step-by-step switches has been already discontinued, 14% of the existing switches are of this type.

(3) Some 80% of Japan's switching equipment is crossbar. Crossbar switches are still being installed along with electronic switches. Although existing new services are mostly available to both crossbar and electronic exchange subscribers, some services to be introduced in the future are not easily accommodated by crossbar switches.

(4) In spite of the fact that most of the new services presently under development are only possible with the use of electronic switches, their installation has been slowed down because large waiting list for telephone installation have been eliminated.

2.2 Network Provided Supplemental Services

Through the end of NTT's fifth Five-Year Telephone Expansion Program, emphasis was placed on the expansion of physical plant to eliminate unfilled applications and provide nation-wide direct distance dialing. During this period, newly introduced items were mainly limited to terminal equipment. Introduction of new network provided services had to wait until the late 1960's when crossbar switches became fairly common.

Table 3 lists the network provided supplemental services presently provided by NTT.

Table 3 NTT's Supplemental Telephone Services
(Services provided by addition of new functions to the switching system)

As of March 1979

Service	Introduced in	Number of users (Thousand)	Switching System			Remarks
			SXS	CB	ESS	
Pushbutton telephone	1969	2,444	-	X	X	Abbreviated dialing of 20 numbers is possible.
Call waiting	1970	199	-	X	X	An incoming call during conversation is notified by audible tone. The subscriber can pick up the call by hook switch operation.
International direct dialing	1973	21	-	X*	X	NTT provide this service as KDD's agent.
Absent subscriber service	1977	20	-	X#	X#	Announcement of absence, shop closure etc. in predetermined message is given. Subscribers' dial operation can choose proper message, start or stop announcement

* Service in crossbar exchanges will start in 1979. Since no number identification function is equipped with crossbar systems, subscribers served by them must dial their own telephone numbers in addition to called party telephone numbers.

# For rotary dial subscribers who cannot input alternate numbers to be called during absence by pushbutton operation, central office personnel will input the numbers.

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Problem areas identified by the experience of these network provided supplemental services are:

(1) With the increase in variety of services, difference in service capabilities of different switching systems has become more pronounced: Most of the new services are not available in step-by-step exchanges.

(2) Difference in costs of providing new services by the type of switching systems renders nation-wide uniform pricing difficult and calls for reconsideration of ratemaking principles.

(3) In spite of the vital need of market tests to assess customer acceptance and willingness to pay, exchange conditions and high costs involved tend to prevent such tests.

(4) Accurate forecast of demand is very difficult because of the factors stated in (3) above. The initial stage of service offering sometimes results either in idle capacity by shortage of demand or unfilled demand because of capacity shortage.

2.3 Terminal Equipment

NTT has been developing and introducing various types of terminal equipment to both residential and business markets. While a full range of equipment is not provided, a fair variety of items is available to customers. Problem areas of terminal equipment service are as follows:

(1) Because of a sharp increase in the number of main lines, the ratio of extension telephones to main telephones is decreasing year by year. As more extensions means more traffic and revenues, the decline is of great concern to us.

Table 4 Extension/Main Line Ratios

Fiscal Year	1962	1967	1972	1978
Extension/ Main Line Ratios	0.57	0.47	0.37	0.26

$$\text{Ratio} = \frac{\text{Total telephones} - \text{Main telephones}}{\text{Main telephones}}$$

(2) Since 1953, customers have been allowed to provide their own PBXs and extensions which meet a set of technical standards approved by the Ministry of Posts and Telecommunications. In this context, NTT must step up its development efforts and introduce equipment well suited to customer needs and requirements.

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(3) Pricing of terminal equipment, which is totally based on flat-rate rentals at present, must be reexamined to enhance the variety of payment methods available to customers.

3. Future Courses

3.1 Network Upgrading

In order to introduce various new services, additional functions such as common control signaling, originating number identification and information storage must be added to the network. These functions can be realized only by stored program control systems. However, crossbar and step-by-step systems will continue to be used for a fairly extended period of time and will need substantial modifications to accommodate new services.

NTT policies toward these problems are as follows:

(1) Processing of these new services at the local exchange must be avoided as long as possible. The call processing functions must be centralized at higher hierarchy exchanges. The addition of necessary functions can be made at these higher rank exchanges.

(2) In order to provide for new services, NTT designated the electronic systems as its standard switching system in 1978 in lieu of the crossbar systems. On this occasion, the following guidelines were established for the introduction of electronic switches.

a. Priority will be given to larger exchanges with large demand for new services.

b. Priority will be given to higher rank exchanges centralizing new service processing functions of local exchanges.

(3) New installation of step-by-step systems was discontinued in 1973. Existing ones will be replaced by electronic switches because step-by-step switches prevent the smooth introduction of new services. Replacement must be carefully planned taking into account their reuse programs and be executed on a phased basis.

3.2 Introduction of Network Provided Supplemental Services

Highly varied lists of supplemental services are envisioned through customer needs surveys and research activities. The services listed in Table 5 are under actual development by NTT. The following must be considered before their introduction.

Table 5 Some Examples of Network Provided Supplemental Services

Service	Description	Sig.	Char.	I.D.	Inf.	Vo.
Dual number	Two numbers are assigned to a single exchange line one of which is unlisted. Calls to the unlisted number can be answered personally while transferring the call to the listed number to the absent subscriber service.				X	X
Automatic call transfer	By inputting, before vacating the home, the number to which calls are to be transferred, the calls arriving thereafter are transferred thereto.	X	X		X	
Conference call	A conference initiator can set up connection with two or more parties by dialing a code number plus parties' numbers	X	X	X		
Hold on enquiry	A subscriber engaged on an established call can set up another call to a third party and switch from one call to another as required .	X	X			
Authomatic booked call	By dialing a code number and designating the message contents, a call is made automatically to the designated number at a specific date and time to deliver the specified message.		X	X	X	X
Wide area telephone service (inward)	Charges of incoming calls to the telephone subscribing to this service are levied to the called party on a flat-rate basis.	X		X	X	
	The same as above with restriction of calling parties' location.					

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Detailed billing	Details of originated calls (dates, called numbers, message units, charges etc.) are given as an attachment to the bill.		X		X	
Recall on busy	By dialing a code number plus the number of a party whose line is busy, a return call will be automatically set up when the party is free.	X	X	X	X	
Calling party identification	The number of the calling party will be automatically sent for the benefit of information providers operated on a membership basis.			X		
Automatic reverse charging	An automatic reverse charging is possible by dialing a code plus the party's number. Reverse charging is authorized by the called party's authorization signal.	X	X	X		

Sig. = Signaling function
I.D. = Identification function
Vo. = Voice response function

Char. = Charging function
Inf. = Information storage function

(1) Differing from terminal equipment services, market data for network provided services needed to assess demand, define required functions, and specify utilization conditions are hard to acquire. Various market tests, including free trial use by selected customers and locally limited test offering, must be actively conducted before introduction of the service.

(2) Substantial investment which is common to various new services will be required to upgrade the network. How to allocate these common costs to different services is an important problem. Establishment of ratemaking principles reflecting this factor is urgently needed.

(3) Various services have been provided on a flat-rate basis until now. Frat-rate pricing has its own advantages in its easiness to understand and stableness of income. However, new services, which are radically different from existing services in their system configuration and service provision process, need new pricing principles. A reconsideration of ratemaking principles is necessary by taking into account customer convenience, usage promotion effects, revenue/cost repercussions etc.

3.3 Terminal Equipment

Varios types of terminal equipment are widely used by residential and business customers. With the acceleration of people's economic and social activities, customers' needs for terminal equipment will be ever more sophisticated and varied.

The recent development of revolutionary new technologies, such as integrated circuits and intelligent terminals has made possible the further development of new terminals.

The following factors are taken into account in the development of NTT provided terminal equipment.

(1) As rapid innovation, stimulated by factors such as new technology, customer needs and competition, is expected in this field, a wide variety of new equipment must be researched and developed.

(2) In developing NTT provided new terminal equipment, emphasis will be placed on:

a. Equipment fundamental in using telecommunications services.

b. Equipment contributing to pioneering new technologies or services.

c. Equipment for the aged or handicapped or equipment promoting social welfare.

(3) Considering the shorter life cycle of the new equipment and responding to customers' desire, two-tier pricing, lump-sum payment and other payment plans must be considered.

(4) In the future, a large variety of terminal equipment will be demanded in small quantities each. NTT may not be able to offer every type of equipment needed by customers. For the private suppliers' equipment which is convenient, NTT will consider such measures as selling them at NTT commercial offices or advising customers of the existence of such equipment.

ALTERNATIVES FOR OPTIMAL TELEPHONE SWITCHING GROWTH

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ABSTRACT

There is a need in most countries to enhance existing telecommunications facilities to accomodate future voice, data, fax, etc. applications. In addition, there is a need to keep existing plant operational for extended periods while offering the same services as electronic switching systems. Upgrading existing step-by-step and crossbar exchanges with attached mini-computers can be a vehicle to achieve this goal. This paper deals with the need for such enhanced systems and how they can be implemented to offer such functions as Custom Calling Features, metering, Usage Sensitive Pricing, computerized maintenence, data communications and information/directory assistance.

INTRODUCTION

With rapid rates of technological progress, and the important expansion of international trade, most nations have identified telecommunications improvement as a significant national priority item. Telecommunications facilities are not only important to streamlining the operations of Government and Commerce, they are becoming critical to individual access to information for education, medical services, and entertainment, as well as business performance measurement, government accounting, and so forth. They are even important for the deployment and operation of high technology manufacturing capability, data collection of all kinds, and the unification of nations with geographically isolated communities.

Toward the goal of improving telecommunications, substantial budgets are being allocated for projects ranging from satellite communications and fiber optics, to installation of local loops for basic telephone service. Central office switching capacity is being expanded by the addition of electromechanical equipment, as well as by installation of newer, stored program controlled central exchanges. Newer equipment allows not only expanded capacity, but many sophisticated new services as well.

New services include such features as; automatic call forward, abbreviated dialing, message recording, call waiting indication. Benefits of new equipment are; improved reliability, lower maintenance requirements, less space required, better cost performance.

As in every other business, common carriers are faced with the dilemma of determining how to achieve the greatest degree of service expansion for the budget available.

In many instances, the function and productive life of installed electromechanical equipment can be extended by the addition of mini-computers to the central office or operator switchboards. Addition of function to installed plant using minicomputers costs significantly less than traditional telephone equipment in many cases. In addition, it is more reliable, accurate, and consumes less power and space.

APPLICATIONS

Examples of some of the mini-computer applications are; Toll Ticketing, Mechanized Cord Board, Centralized Automatic Message Accounting, Directory Assistance, Paper Tape Replacement, Centralized Toll Data Collection, Custom Calling Features, Optional Measured Service, Computerized Electronic Billing Systems, Traffic Data Collection, Magnetic Tape Replacement, Toll Recording, Common Channel Interoffice Signalling and Computerized Director.

Typically, these systems are connected to existing switches and related equipment through digital input and digital output circuits on the mini-computers. Since most switch circuits are "open or closed" or "on or off", they are basically quite compatible with computer interfaces.

At this point, I would like to describe some of the specific computer applications to which I refer. Working in reverse order, I will first describe the Computerized Director. This particular application is designed to replace multiple electromechanical systems at a lower functional cost with a corresponding reduction in maintenance. The system accepts both dial pulse and multifrequency tone signalling, reads automatic number identification for the calling number, and translates and routes all calls. It provides out-pulsing with the appropriate called number in either dial pulse or multi-frequency signalling, as necessary. For increased efficiency, the system provides an added "look ahead" function on out-going trunks to minimize busy conditions and to increase call handling. It also allows updating of the translate tables via teletypewriter, reduces floor space for equipment required, and provides real-time traffic and trouble statistics for the switch to which the equipment is attached.

In realistic business terms, this particular application for one telephone company turned out to provide function at half the price of traditional electromechanical equipment. It consumed one-fourth of the space, required one-tenth of the maintenance, and reduced the hold time to two-thirds of that for electromechanical equipment. This application took nine months from inception to the establishment of an operational system.

Another application is called Mechanized Cord Board. In this instance, mini-computers were attached to operator panels to improve operator call handling efficiency by reducing the average wait time, or the operator work time per call. It further reduced the toll investigation requirements because it increased accuracy of toll recording, eliminated manual recording of specific call information, provided more precise call timing, improved the traffic and work time statistics and established a useful record. It further provided a magnetic media output of the precise record of each call placed. This application was developed for telephone companies who had a relatively small number of operator positions in one location where total replacement of the operator positions could not be economically justified. In this case, the mini-computer was used to enhance the function of older operator positions, provided added function, increased efficiency, and reduction in manual recording of calls. The net benefits were in improved customer service, improved operator efficiencies, reduction of data processing costs, and increased revenue to the telephone company.

Common Channel Interoffice Signalling (CCIS) can be supported by application of mini-computers to off-load signals from voice trunks and to provide additional advanced services such as, automatic call-back, priority call ringing, and preselected collect. In this instance mini-computers can be used to link cross bar and step-by-step end offices to a CCIS network. The function provided, in addition to interfacing central office and CCIS links, would be to generate, receive and interpret CCIS messages, provide buffering, error control, and retransmission. It would further allow utilization of diverse routing, selection of alternate routes on outage, monitoring of line quality and facilitation of maintenance by use of diagnostics.

Advantages acquired in this application are; improved signalling speed, shorter call set-up time, reduced trunk and switch holding times and improved network efficiency. Duplex signalling is accomodated allowing transmission of more information in both directions without interfering with ongoing conversations. It can also minimize bandwidth restrictions and provide a vehicle for controlling fraud which occasionally takes place with inband signalling. The use of mini-computers for CCIS allows common carriers to upgrade their communication facilities to be compatible with CCITT standard #6 and at the same time achieving improved reliability of their interface signalling facilities.

On older step-by-step equipment, two applications, Usage Sensitive Pricing and provision of Custom Calling Features, have been developed using mini-computers. Usage Sensitive Pricing is becoming increasingly popular among telephone companies, so that users of telephone service can be charged based upon their actual use, rather than some arbitrary basis for spreading the cost of service to all users. This system collects the details for all calls-the calling number, the called number, and connect and disconnect times-so that pricing of all calls can be performed on the basis of actual use. These funations are provided at a cost to the telephone companies which is substantially less than that required for traditional electromechanical equipment.

Custom Calling Features allow provision of abbreviated dialing, call forwarding, thre-way calling, call waiting indications, and tone signalling through the older step-by-step equipment. For one case study, the estimated rate of return or return on investment was twenty-four percent with a pay-back of an investment of $385,000 in fifty months to that telephone company. Similar benefits may be available to other telephone operations which wish to add these advanced functions without having to make major changes in or replacement of their electromechanical equipment.

A similar application has been developed for number five cross-bar switches which is called Computerized Electronic Billing System. This application is intended to eliminate paper tape which has been the previous medium for recording of billing information.

A toll Ticketing System is another application of mini-computers in telephone companies' central offices. This is an application developed and sold beginning in 1972. Approximately one hundred systems were sold and installed for independent telephone companies in the United States. In this application, each system replaces or serves an an additional sixty-four ticketers. The cost of the system is lower than the cost of equivalent electromechanical ticketera, and the equipment, with its advantages, pays for itself in approximately thirty months. This system detects the off-hook condition for toll access lines, it records the called and calling numbers, performs route translation, seizes the appropriate out-going trunk, does the onward dialing of the called number, detects called party answer and time, detects the disconnect and time, and creates a complete record of each call placed through that system.

The advantages of a computerized Toll Ticketing System are in improved accuracy and reliability, reduced processing time for call billing, accumulation of traffic and trouble statistics, reduced maintenance, reduced floor space required, and increased revenue.

CONCLUSION

Each of the applications described in this presentation have similar attributes, and offer potential benefits for common carriers who desire to extend the productive life of installed electromechanical equipment while adding function-all at a minimal or most attractive cost. In many cases, this allows telephone companies to offer their subscribers the advantages of new electronic central exchanges without having to experience the very large incremental cost for total new systems.

Application of mini-computers for enhancement of existing electromechanical telephone equipment may also be attractive because of the inherent flexibility of mini-computers and the fact that they can be used both for permanent communications enhancement as well as transitional requirements which carriers encounter while planning future large scale updgades. Mini-computers can be re-programmed and re-attached to switching equipment to support different applications which are dictated by the specific needs of a common carrier at any given time. They may also be applied to monitoring of carrier systems, maintenance, testing, diagnostics, trouble analysis, building security, environmental monitoring and so forth, if a time arises when the mini-computer has no further application for the initial telephone applications.

WHO SHOULD PAY FOR TELEVISION? THE DILEMMA IN DEVELOPING COUNTRIES

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IN the early 1920s when television technology was still in its initial stages of development, a science writer predicted "...when it (television) arrives, we shall find so many conveniences in it that we shall wonder how we ever got on without it in the past."[1]

Fifty years later, in 1975, television had virtually become an integral part of the sprawling global communication system built around sophisticated computers and space satellites criss-crossing the skies. Television now speaks, what Wilson Dizard forecast, on international language of technology, and it has become the "sight and sound interpreter of the dialogue, making it understandable to everyone...television has become the forum of a new age of interdependence, the only mass medium fully capable of crossing geographical, cultural and political barriers to link men and nations in an evolving world community."[2] Indeed, "television has materialized so quickly from a fast moving technological revolution that we have not had a reflective chance to define its purpose and set its goals."[3]

However, the introduction of television in developing countries is a phenomenon originating in the early 1950s. Though television is now being adopted by most developing countries, the medium essentially is at a nascent stage there. In its present format, television in developing nations has usually a restricted coverage generally serving main urban centres, and only rarely it functions in rural areas or in the suburbs. Providing extensive television service is not only a tough problem of technology, it is a colossal financial dilemma of enourmous proportions beyond the economic capacity of most developing countries. Rightly has Wilbur Schramm underlined: "Television is the most costly of the media to capitalize, and it requires perhaps a wider diversity of skills than any other medium. Its receiving sets are expensive, compared with radio, and repairs are most difficult and costly."[4]

Television having established itself as a conspicuous synonym of national modernization, most developing countries have gone in for the medium at varying levels of quality and quantity of coverage of their territories. The medium which is so ubiquitous in the West is only at the elementry stage in developing countries. The reasons for this tardy or hesitant development are many. Generally, lack of finances, dearth of sophisticated equipment and technical difficulties are responsible for the limited expansion of television in developing countries. But if we dig deeper, we shall discover scarcity of financial resources to be the primary cause of the slow development of television systems.

Because of acute financial problems, television has not made concrete progress in developing countries. Again, due to paucity of funds, it is rarely the case that a broadcasting system (especially television) in the developing countries is financed from only one source. While there is an irrepressible desire on the part of the governments of developing countries to instal and develop a television system, the dilemma that stalks this progress is: From which sources should television be financed: Government, private enterprise, licensing system, commercial advertising, foreign investors, international agencies, or...? In one sentence: Who should pay for television in developing countries? This paper will endeavor to offer some answers to this dilemma.

Television is a most powerful medium that reflects, shapes, informs and alters, in that order, the national consciousness in a country. In most developing countries, the television system is owned and financed by the national government. According to a study of broadcasting in the Third World, Elihu Katz and George Wedell found that "in Africa, where most systems are mainly government-financed, broadcasting (including television) relies to varying degrees on advertising revenue; government support is also involved in most countries, although usually on a very small scale."[5]

Here it is essential to state, in general, some of the striking features of broadcasting in developing countries. According to Helmut Drueck, head of the office of the director-general of Westdeutscher Rundfunk, Cologne, broadcasting in developing countries is young, and secondly, "broadcasting is over-burdened with expectations and fears."[6]

Drueck has spelled these "expectations" as follows: "By law or government charter, most broadcasting corporation in developing countries, have the following goals: integration of the nation; mobilization of society, acceleration of economic development, contribution to education, and fostering cultural activity."[7]

The 'fears' with which the broadcast media have to live, according to Drueck, are of two types: First, "the suspicion of government, of the ruling party, of tribe X or tribe Y that the news broadcasts do not correctly and comprehensively report their views while overstating the position of the competitor; and secondly, the accusation that broadcasting does not fulfill the task of educating the people but drowns the nation in irrelevant foreign programs, thereby alienating the people from the 'good roots' of national tradition."[8]

Since the television medium involves large investment of financial resources, it is only the national governments who can foot the bill. "The degree of government financial involvement in broadcasting depends primarily on the structure of the systems. Where the system is directly owned and controlled by government, as for example, in Libya, all expenditure is met from government sources...broadcasting is usually operated by a government department and the service is financed by normal budgetary provision."[9] In such a situation as of Libya, television is organically incapable of forming or altering the public opinion. It is a government mouthpiece and a propaganda tool.

But the irony is that even the independent and reputed networks such as the BBC face the dilemma of financing television system. In a circular to all its members in January 1979, BBC director-general Ian Trethowan pointed out "...how can we get sufficient money to finance, to maintain our services properly, while at the same time keeping our programs independent of government control? And how can we keep faith with the public by continuing to use their money efficiently to give them good program ?"[10]

If the television system has to perform its meaningful role in developing countries, government financing may be a partial answer, but it is not the full answer.

Another method of financing television, probably the commonest, is through subscription. Under this arrangement, all those owning television receiving sets contribute to the cost of operating the entire network. All receiving sets are licensed, and a fixed annual fee is prescribed to be paid. According to Katz and Wedell, "in the U.K., this method is thought to provide the BBC the best guarantee of independence from government."[11]

After studying the various devices of financing broadcasting, including television, Katz and Wedell say as follows: "Other ways of financing include a tax on the sale of retail price of television sets, but in other countries it more commonly is about 50 per cent. In some countries (Malawi, for example), dealers who wish to sell receivers have to buy a license from the government."[12]

Another method resorted to by some governments is to seek finance from general tax collected from every tax payer, whether he owns a set or not.[13]

Yet another method of financing of television network resorted to by some developing countries is through the sale of broadcasting time. Next to licensing, this is probably the commonest way of funding television system.

In this regard, the following table throws most significant light on financing television system in developing countries:

Sources of Financial Support to Television System in Developing Countries

Country	Sources of Revenue	Annual Television Licence Fee in US	No. of Licences Issued
1	2	3	4
1. Algeria	Government 55% Licence fee 42% Commercials 3%	$ 19	300,000
2. Egypt	Government Commercials 10% TV licence fee Tax on Electricity	$ 16	610,000
3. Ethiopia	Government Commercials Licence fee	$ 20	2,500
4. Kenya	Government Commercials Permits	$ 8	37,000
5. Mauritius	Government Commercials Licence fee	$ 7,50	24,000
6. Nigeria	Government Commercials Licence fee	$ 6	Not available
7. Sierra Leone	Government Commercials Licence fee	$ 20	Not available
8. Zambia	Government Commercials Licence fee Grants; foreign resources	$ 10	-do-
9. Cyprus	Government 5% Commercials 45% Licence fee 50%	$ 10	66,200
10. India	Government Commercials Licence fee	$ 6	600,000

1	2	3	4
11. Indonesia	Government 84% Commercials 11% Licence fee 4%	$ 20	300,000
12. Pakistan	Government Commercials Licence fee	$ 5	100,000
13. Singapore	Government Commercials Licence fee	$ 14.5	243,000
14. Syria	Government Licence fee	$ 10	137,000
15. Turkey	Government	$ 6(for rural areas) $ 15(for urban areas)	262,000
16. Barbados	Government	$ 6	Not available

Source: Katz and Wedell op. cit. Appendix A, Table A-2

Thus television in most developing countries is financed by and large by government, licence fees and commercial advertising. There are only two countries in Asia and one in Africa where television is sponsored by government only. Licence fees, commercial revenues and government money jointly fund the television networks in 19 African 10 Asian, one South American and one Caribbean developing countries, whereas commercial revenue and government finance the television system in 11 African, 10 South American, 9 Central American and the Caribbean and one Oceania nations. On the other hand, licence fee and the government sources finance television system in three African and two Asian Countries."[14]

It is worthwhile pointing out here that in most developing countries, governments have a firm or rather severe stranglehold on the television network. The reason for this strict control on television network is: "If the media are owned and controlled (licence funded) by the state, basic supposition is that it represents the will and interests of the nation, and that media too are working in the interest of the nation."[15]

But is this supposition always right? The experience of media control in developing countries has shown that the state's hold on television and other media is an integral part of the overall strategy of the ruling clique or the group.[16] In such a situation when a television network is functioning under strict government hegemony, and it is perpetrating a government's selfish rule and serving an individual party's ends, should television be financed by way of a general licence fee? Or more specifically: When the television system is functioning under the iron hands of a government in a developing country, should the licence fee be charged from every user of television?

There is another dimension of the use of television in a developing country. It is well known that a large majority of people in developing countries is poor, the battle for life and existence is extremely difficult and challenging, the literacy rate is limited. Should all such users in poor countries be made to pay licence fees for watching television? In other words, the television licence fees in developing countries should be done away with, and only the government or advertising should finance the television system.

For, "the performance, utility and relevance of broadcasting should be measured in providing impetus for educational, cultural, economic, social, political and developmental projects in ongoing stage in the country."[17] Profit-making should not be the aim of this mass medium. As Sydney Head has noted: to increase advertising income, billings have gone up severalfold.[18] Television networks in several countries all over the world such as the United States, Canada, Brazil, Egypt, Thailand, France, Australia, the Soviet Union, China and some West Asian nations do not have any system of levying licence fee on television viewing.

Yet another factor is involved in television system being funded by a government. When a government foots the bill of a network, and financial independence is subjected to the discretion of bureaucrats, a plethora of rules and regulations automatically control the functioning of the system. Instead of professionals asserting as to when should the screen be [illegible]glow and what should go or should not go on the air, it would b[illegible]ministers, secretaries or petty officials who will decide.

Television then will become the handmaiden and a slavetool of the powers that be, and would hence be reduced to the position of a faithful mouthpiece and a publicity forum. It should not be forgotten that "mass media which have been funded by public law...are sometimes said to be in the hands of the state."[19] Since television is a public utility, an influential medium of education, enlightenment and information, it will serve the interests of public better if its functioning is not restrained by a jungle of controls and enmeshed procedures. After all the print media which are generally in private sector in some developing countries do not suffer from the fetters which are applied on television system. Let us not forget what former British Home Secretary Roy Jenkins said about the repercussions of the government grants to the BBC. The situation is that "in most countries where television is based on some form of licence, the money is seen, overall, as belonging to the government which doles out as much of it as it sees fit."[20] He also said that "direct grant-in-aid by government interferes with the independence of broadcasting."[21]

The system of licensing television sets is enwined with too many complicated issues. First, there is problem of collection of licence fees. It is estimated that at least one-third of the fees are spent on the collection procedure. Secondly, there is widespread evasion, and there are no fool-proof devices to check it. For television is a "public medium whose signals are available to anyone with right receivers. They reach every home, not merely of those holding licence or permit."[22]

Thirdly, limiting television program only to those who can pay a particular amount of fee would be restricting its free access although airwaves, a natural bounty, are free for everyone. Since ~~access to air~~ signal is universal, it is difficult to justify the imposition of a television licence fee where the audience is economically weak and cannot bear the financial burden, and is at some disadvantaged position, but needs education and information for its progress, and well-being. Finally, the principle of levying licence fee is "incompatible if broadcasting is to remain free from any influences exerted by the government and parliaments. It is somewhat paradoxical...if society is called upon to determine what programmes be broadcast, while at the same time the same authorities are not in a position to provide the money required for this purpose."[23]

A system which cannot support itself cannot be free. In fact, as Albert Scharf, Legal Director of the German Bayerischer Rundfunk, says: "The autonomy of a free broadcasting system should actually also include the competence of that system to provide its own finances."[24]

Thus if a television system has to prove useful to a people in providing them information, enlightenment, entertainment, and above all motivate them to progress, the medium should not be under shackles of any hue. General guidelines should be provided to the professionals who regard national interest above anything else. It is, therefore, imperative that the television system in a developing country is financially independent and its service should be available to the people free without any licence fee.

But how is this possible? One of the answers is: resort to advertising. Lord Thomson once said: "Television advertising is a licence to print money."[25] There are several subsidiary advantages of advertising support to television. In the first instance, with a view to attracting audience, programmes will improve and there will be a stiff competition to broadcast better shows - educational and informational. Secondly, the networks will frame their own independent policies just as the newspapers and periodicals do, and hence it will not become a propaganda instrument in the hands of the ruling group.

In a number of socialist countries such as Yugoslavia, Cuba, Poland, Romania, Czechoslovakia, Hungary and Vietnam, commercials are broadcast on television. In India too, during 1977-78 television advertising revenue totalled around Rs. 1.3 million (or $165,000).26

More and more developing countries are taking to television advertising. Obviously, it has more virtues than vices, especially in a democratic set-up and free economy. This is not to give a blank approval of all television advertising. But as the Verghese Committee (in India) pointed out recently: "The advertising content must be closely monitored and the drive for commercials must not be allowed to intrude ~~on or di~~stort program values."29 Television systems in Brazil and Tanzania derive their revenues only from advertising, and it (advertising) is justified "as a means of accustoming the population to the growing range of indigenous consumer goods that the country's processing and manufacturing industries produce."28

Extensive research has revealed that television has played a significant, indeed predominant, role in the overall development and modernization of developing countries.30 In order to make television function freely and countribute its mite to the overall progress of developing countries which are still struggling hard, and will continue to do so for some time to come, it is necessary that television service should be freely available to everyone without discrimination, cess or licence.

In the U.S.A., vast majority of television ownership rests in private hands, without any licence system for the people or without any licence-system for the people or without government controls; only the Federal Communication Commission lays down some general guidelines. A one-minute advertisement spot during prime time show on ABC, NBC, or CBS, the three most influential networks in the U.S.A., may cost anything between $ 80,000 to $ 1 million. In such a situation, the networks strive to attract maximum audience. Advertisement rates depend on the quality of program and their potential to hold continued interest. ABC recorded top ratings during early 1977 when "Roots" was relayed as did the NBC during the 1976 Olympics. The advertisement revenues so collected have emboldened the networks to present a whole variety of these programs without any fear or favor.

The successful working of American television system based primarily on advertising, has a great lesson for financing television in developing countries. Since, "the disproportionately greater cost of obtaining television coverage has limited both extension of television signals and the multiplication of receivers in most developing countries,"[31] extensive use of the medium for advertising would certainly strengthen the networks and enable them to enlarge their area of operation. Variety of program, balance in presentation of news and views and extensive coverage of events would also then be within the resources of television system. Dependence on foreign program would diminish.

The dilemma of the developing countries is hence twofold: They do not have funds, but they want television to cover the entire territories without any further loss of time. The most rational answer to this two-pronged dilemma seems to be an FCC-type of set-up with a fully commercial television system on the rough pattern of major American networks. In the present situation, it is only in this manner that television can expand rapidly and fend for itself in developing countries.

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DEVELOPMENT AND IMPACT OF TELECOMMUNICATIONS IN THAILAND

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Abstract

Telecommunications development in Thailand is presented to give an overall view of the development process which greatly correlates with demand and government's attitudes. Although the value measurement of telecommunication services is difficult, demand for telecommunication services in both urban and rural life strongly indicates the needs of expansion of telecommunication infrastructure for national development. Impact of telecommunications from some points of political, socio-economic views are given.

Introduction

Telecommunication in Thailand began as early as nearly 100 years ago when the first telephone pair of local battery type linking between Bangkok and Samut Prakarn was set up in 1881 by the Department of Defense. The purpose of this set-up was to report the incoming and outgoing ship to Bangkok. Since then the work of telephone service has been transferred twice; first to the Department of Post and Telegram in 1886 and then to the Telephone Organization of Thailand (TOT) in 1954. During this period, the development of telephone service was almost stagnant because of low demand for telephone service and shortage of financial support.

Not until the early 1960's, the beginning of the period when Thailand enjoyed the economic boom of an average annual growth rate of 8 %, that telephone demand increased rapidly. In order to meet this excessive demand, TOT expanded the main northern and southern microwave routes in the initial period of the First National Economic and Social Plan (1964-1968) and duly completed the work in the period of the Second Plan (1968-1972)(1). Manual exchange long-distance telephone service has then been made possible by interconnecting the Provinces and Districts with the main microwave routes. Operation of the earth stations for international communication via INTELSAT IV satellites was also begun in this period.

In addition, government's and private companies' special purpose telecommunication services such as radio services for maritime navigation, Electricity Authorities, Metropolitan Water, administration of the Interior Ministry, health care programs of the Ministry of Health, agriculture projects of the Ministry of Agriculture and Co-operatives, banking on-line systems etc., have increased in terms of investments since the period of the Second Plan, making a total of more than 65 investment projects at present.

Domestic Communications

The Status of Telephone Service

Since 1971, TOT has increased the telephone numbers in the Bangkok Metropolitan area at an average annual rate of approximately 8 %. Currently, there are in all 32 exchange centres with 272,684 telephone numbers. By the end of 1979, the number of exchange centres will increase from 32 to 41 and telephone numbers will increase from 272,684 to 313,684. The status of local telephone service is shown in Table I (2). In this table, indices showing the status of local telephone service can be divided into 2 groups. The first group measures quantitatively the shortage of local telephone service and the second group measures the popularity of telephone service. It is apparent from the table that telephone service both in Metropolis and provincial areas is desperately inadequate and that nationwide demand for telephone service is almost all double the capacity of present installation.

TABLE I

Indices showing the status of local telephone service as of May 1979

Indices showing the status of telephone services	Metropolis	Provincial areas	Nationwide
1. Quantitative indices			
1.1 Number of telephones (NT)	311,000	105,700	416,700
1.2 NT per 100 population	4.87	0.25	0.86
1.3 NT per demand	64.04 %	41.62 %	56.28 %
1.4 NT shortage	174,416	149,700	324,116
1.5 Waiting months	55	166	80
2. Popularity indices			
2.1 Number of Districts (ND) receiving basic telephone service categorized by population level	Telephone Service Available	Telephone Service Unavailable	Total
ND with more than 100,000 population	75	53	128
ND with between 50,000 - 100,000 population	42	169	211
ND with between 10,000 - 50,000 population	19	285	304
ND with less than 10,000 population	-	17	17
TOTAL	136	524	660
2.2 The longest distance of travel for public telephone service	250 Km.		

In implementing the TOT economic development plan for the period 1972-1980, TOT has introduced the automatic exchange system for application with the long-distance service system for installation throughout the Kingdom. This new automatic exchange system is incorporated with the latest electronic and computer technology and is called Stored Program Controlled Switching System (SPC) with Centralised Automatic Message Accounting (CAMA) for the telephone exchange and message switching system for telex and high speed data communication exchanges.

Radio Communication Services

There have so far been more than 65 investments, both in large and small scale, in radio communication systems mainly HF/SSB, VHF/FM, and UHF/FM by government agencies and private companies. This proliferation of radio frequency has created many technical problems on spectral pollution and bandwidth limitation, preventing any possible future expansion of radio communication service in VHF range.

VHF and UHF mobile radio services operated by the Communication Authority and TELCOM in the Metropolis have been widely used for business purposes connecting mainly the car with the Main Office and in some cases plants or warehouses in the suburban areas with the Main Office. There are plans to change from the present open-channel and semi-automatic mobile radio systems to automatic systems in the near future. Expansion of mobile radio capacity to meet the comparatively high demand is now being carried out.

The scope of HF/SSB and VHF/FM usage ranges from security, public health, public welfare, public administration, internal radio service, etc., to remote control and telemetry. Two-way radio communication portable sets are used by the Land Development Department, Accelerated Rural Development Department, and the Office of Narcotics Control Board, in an integrated development of the Northern watersheds where 300,000 hilly tribespeople are living.

Data Communication

TOT not only provides channel facilities for long-distance telegram and telex to the Department of Post and Telegram but also provides data communication. During the period of June-August 1972 and July-August 1973, testing of data transmission through telephone switched lines was reported at various speeds and the optimum speed of 900 bits per second (bps) for single voice channel was recommended, although the maximum speed may be attained at 2400 bps (3). Today, with more than 100 computers setups in Bangkok, Thailand has a great potential in data communication. Data communication in Thailand is now being used in banking with Bangkok Bank's computer on-line system linking the main office and other 70 branches in Bangkok, in seat reservation by Thai International Airways linking local and foreign ticket offices' display terminals with the main computer at the head office through TOT's telephone networks as well as SITA network via INTELSAT IV satellite, and in management information system by ESSO and Siam Cement. In addition, computer was used with 14 terminals set up at the various stadiums to report the results of the competition in 1979 Eighth Asian Games (with 20 sports events and participants from 25 countries.)

International Communications

With the establishments of the first and second standard earth stations at the District of Siracha, Cholburi, in 1968 and 1970 respectively, international communications have been considerably facilitated and the traffic capacity has been increased manifold within a period of ten years, as shown by Figure 1 (4). International telecommunication traffic with Asian countries has much more capacity than that with European countries. Since demand is the effective expression of wants and needs, moulded by social and cultural pressure (5), it can be concluded from Figure 1 that Thailand has closer social, cultural, and economic ties with Asian countries especially Japan, Hong Kong, Taiwan, and other ASEAN countries, than with the European countries.

Recently, discussions have begun on the possible use of an Indonesian satellite, Palapa I, to provide the twenty first century domestic communication as well as communication link for the five members of ASEAN. All ASEAN members have agreed in principle on the use of Palapa. However, technical problems, including financing of the construction of earth stations in the member countries, are still to be resolved. Initially, the use of Indonesian satellite will be mainly for telephone, telex, telegram, fascimile, and television purposes with the possible opportunities also for education, aeronautical and maritime and security uses. This vast resource is waiting for utilization.

Television Service

At present, there are eight TV channels in Bangkok: four black and white of 625 lines 25 pictures/sec and four color of PAL system. The broadcasting programs in Bangkok are transmitted to upcountry through the Switching Center of the Public Relations Department and through series of TV translators. Local TV broadcasting stations are also available in upcountry. It is estimated that the population living in the broadcasting area is not less than 20 million. This figure indicates that more than half of Thailand's population does not have the access to the effective means of communication with the central and local government. Expansion of TV coverage area is now being carried out by the Public Relations Department.

TV Education

TV education in Thailand is inadequate. So far there are only two universities - Ramkhamhaeng and Sukothai Thammatiraj University which have their selected regular lectures broadcast allowing students to study by themselves at home. This saves travel time and reduces traffic congestion. However, it is also a fact that it deprives the students of a campus-based university and all its implications of social activities, etc. As a result it is only natural that the students prefer attending lectures at the university and enjoying the social gathering as well as the sense of university elite to being just merely a self-studied guy.

Recently, TV programs have been shaped up slightly to provide more education to the public, especially on current issues of interest such as energy conservation, agriculture development in the farmers' year - 1979, etc. Survey conducted in this connection has indicated a very favourable public response, thereby providing encouragement to TV broadcasting stations to expand their education programs.

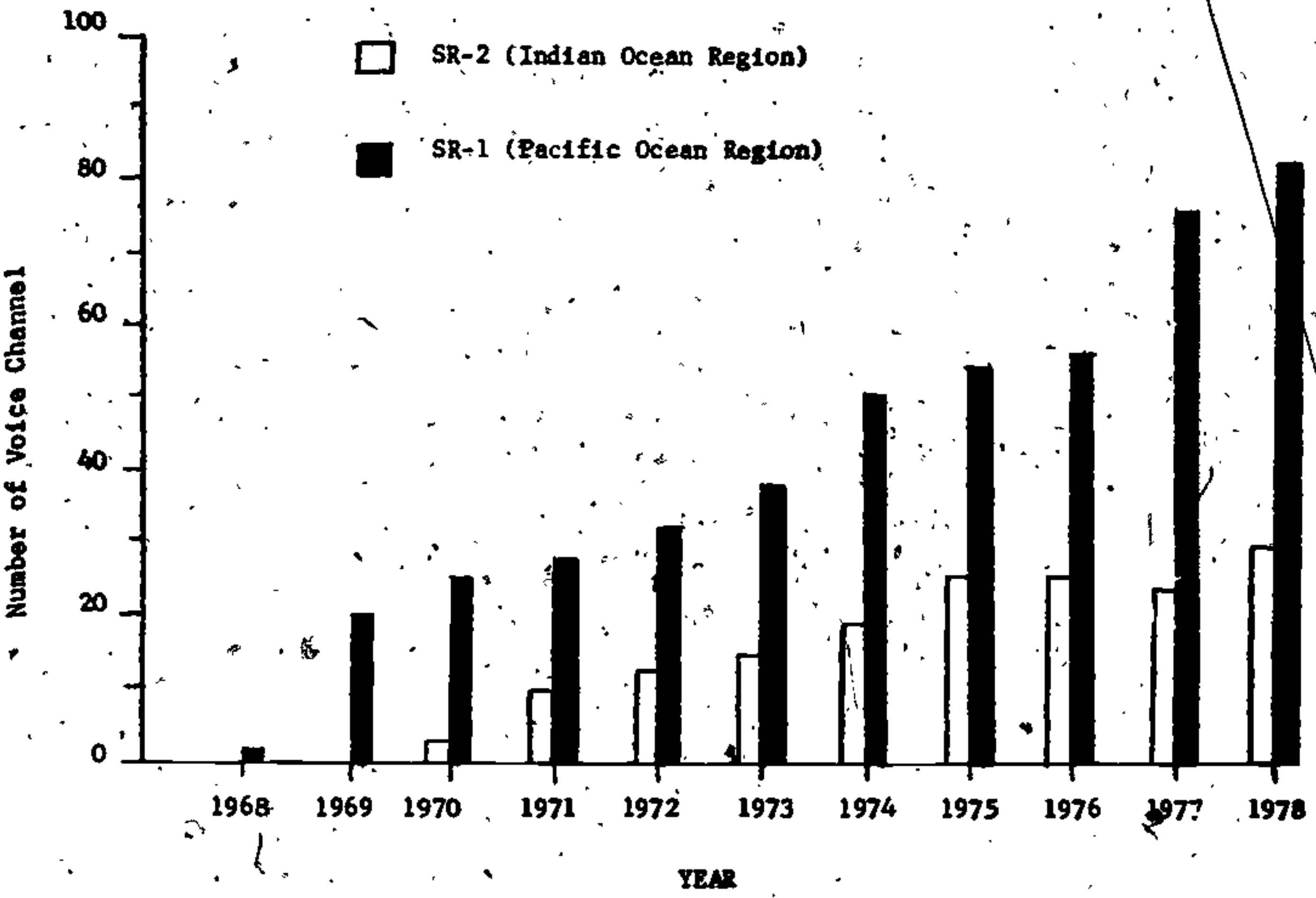

Fig. 1. Statistics of Siracha Earth Station Traffic

Telecommunication Industry

The electronics industry in Thailand has made great progress and since its start has saved the country more than 200 million U.S. dollars in foreign exchange. The import value of radio and television sets has decreased from about 25 million U.S. dollars to only 7.5 million dollars in 1977. Local production of TV sets since the beginning has been estimated at 540,000 and out of this about 5,500 have been exported. Production capacity for TV sets is around 150,000 per year and for radio sets some 1.1 million could be produced. The assembly plants for many reasons are not producing at full capacity (6).

Thailand also produces communications equipment such as telephone units and transceivers. There are now three companies - ELCOM Research, International Telephone and Telegraph Thailand and Thep Electronics with actual production estimated at around 30,000 telephone units and 60,000 transceivers, although production capacity is several times higher. Production of transmitters up to 10 kilo watts at Philips Thailand and the Technical Division of the Public Relations Department is estimated at a total annual rate of 20. Expansion of the industry is not possible unless the government steps in to help or with a commitment to purchase the equipment and strong attempts made to expand foreign markets for the industry. On this point the Government should share in the research snd development cost of local companies in improving their telecommunication products and put in stronger efforts in export promotion through Export Service Centre.

Training

Telecommunication training in Thailand is inadequate and is mostly short of training equipments. At present, only TOT has possessed a telecommunication training center which by its nature is wire-communication oriented. There are 5 universities and 1 institute of technology producing about 400 electrical and communication engineers annually. However, they are mostly academic-oriented but no so well-versed in technical training or application.

The problems of trained manpower shortage are common in all the developing countries and the consequences are so great that ASIA-PACIFIC TELECOMMUNITY has been established by 15 member countries with the objectives to provide the various aspects of facilities including planning, technical standardization, telecommunications, and means of reducing the expenses in management and operation of telecommunication to member countries. It is hoped that with the establishment of ASIA-PACIFIC TELECOMMUNITY in Bangkok, Thailand and other Asian developing countries, especially ASEAN countries, could raise the standard of their communication technology and find the most effective means of both domestic and regional communications.

Impacts of Telecommunication

Value of communication services to the users is difficult to measure. However, since communication services arise in response to human demand (5), a large number of people applying for the telephone installation at a cost of more than the official rate of U.S. $ 1,500 per telephone obviously indicates the high value placed by the users on communication services. Since telephones per capita (7) is an indicator which usually correlate with urban development, supply of telephones which lags greatly behind the demand will be detrimental to urban development and dynamics and in the meantime it will also be detrimental to national development as a whole. Telecommunications development will also improve the quality of both urban and rural life. Cases have shown that the improvement in communications and telecommunications for villages in the communist infiltrated area or remote area has resulted in improving the standard of living and the morality of the villagers.

Health Care

Doctors and nurses are desperately inadequate in the rural areas of Thailand, even though more than ten years ago the Government had instituted the obligatory terms on newly graduated doctors, who received free medical education at the university, to serve the people in the rural areas for 3 years. Villagers in some rural areas have had to walk more than 10 kilometers to get access to health service, if they are lucky enough to have the health facilities. Hence, in recent years, voluntary doctors teams have been despatched to rural areas by the Royal family, universities, and Ministry of Health. Telecommunication links between the District Administration, villages and the teams can facilitate the health service and training of the local health workers.

Education

With the expansion of radio and TV coverage areas and the improvements in their education programs, education in rural areas as in areas of health, agriculture, and rural developments can be achieved. In future, only when it will be possible to broadcast radio and television education programs through Palapa satellite as planned that the full potential of improved manpower can be channellized and exploited for developmental purposes.

Employment

It is estimated that about 50,000 people have been directly involved in telecommunication services, industry, education, and administration. The big portion of this figure goes to the government telecommunication service and administration. Government agencies and state enterprises listed in order of number of employment are TOT, Communication Authority, Department of Post and Telegram, Ministry of Interior especially Department of Home Administration and Police Department, TV broadcasting stations, etc. Only about 5,000 people are employed in telecommunication industry. This figure consists of about 4,000 people working in less than 10 small and medium telecommunication industries as well as telecommunication equipment assembly firms and of about 1,000 people working in family industries. If included the telecommunication equipment selling companies, maintenance shops, and the related business, telecommunication provides a total employment of estimated 100,000 jobs, totalling approximately .25 % of Thailand's population.

Conclusion

Telecommunications development in Thailand has made rapid progress in terms of hardware innovations and expansion in recent years. This trend of development if not pursued in a balanced manner, (economically-wise, social-wise, and defense-wise) and integrated with the existing communications systems will only result in the modernization of equipments, duplication of communication systems, and inefficient uses of the newly invested and existing communication systems, as has been the experience of Thailand in the former days of telecommunications development. Efficient central planning committee for planning and determining the national policy on national telecommunication network is needed to correct the Government's traditional inability and indecisiveness in selecting the optimum communication systems for national telecommunications.

Emphasis should be given in telecommunication development for rural developments as a development infrastructure (8) similar to road and other utilities in order to reduce the economic gap between urban and rural areas.

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SOCIAL NEEDS AND TELECOMMUNICATIONS PLANNING IN TELECOM AUSTRALIA

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Abstract

As the common carrier of telecommunications in Australia the Australian Telecommunications Commission (Telecom Australia) has the responsibility to plan future developments in a manner which effectively account for social needs. Using multi-disciplinary planning techniques the National Telecommunications planning group in 1976 produced the publication Telecom 2000. This was followed by the publication Outcomes from the Telecom 2000 Report in 1978. More recent planning activities have involved a seminar on Social Research and Telecommunications Planning. A further seminar on Telecommunications Planning and Public Policy-Making is to be held in 1980. These approaches to planning have enabled social needs to be recognised as an effective input to Telecom Australia's planning processes.

INTRODUCTION

Under the Telecommunications Act 1975, the Australian Telecommunications Commission (Telecom Australia) has the common carrier responsibilities to 'provide, maintain and operate telecommunications services in Australia which best meet the social, industrial and commercial needs of the people of Australia'. Telecom therefore has a major responsibility to manage the balanced and effective development of telecommunications.

An important part of managing a balanced and effective telecommunications development is the recognition of external needs, and in particular the social needs of the Australian community. The term 'social needs' may have many connotations; from the standpoint of telecommunications planning, the notion that people have a need to relate to one another, to communicate, seems to have the greatest relevance. This need to communicate, of course, can be divided into such groupings as emergency requirements, transactional requirements or the more personal propensities to share information and feelings.

Irrespective of the nature of communication needs, it is of prime importance to telecommunications development that Telecom Australia increases its awareness of social needs and internalises them with regard to its present and future operations.

SOCIETY AND CHANGE

It is meaningful to ask: What will be the shape of society in the long-term future? What part will advancements in telecommunications technology play in this future? There are many scenarios of future society which must be accounted for in the process of planning telecommunications development, but even the scenarios are changing: 'The future is not what it used to be'.

New and developing technologies could offer a broader range of telecommunications products which could provide access to new kinds of information that would serve to improve life at work and home. The widespread introduction of advanced telecommunications technologies could also provide scope for significant changes in social organisation to occur. For example, increased residential penetration of telecommunications in a variety of forms, with centralised computer access could serve to strengthen democracy by providing greater opportunities for participation by the community in government decision-making and promote what might be perceived to be the 'good life' and self-realisation. Alternatively, the decentralised, multi-functional, self-contained, independent nature of services which could be provided by the new technologies may lead to a dehumanisation of society. Each of these views on change and its effects on society may be argued, but neither provides a simple solution of comfort generally to telecommunications planners. They do, however, define some boundaries in regard to the debate which has now emerged over technological change at a time of low economic growth, a growing fuel crisis and high unemployment.

TELECOM 2000

In 1973 the National Telecommunications Planning (NTP) Branch was set up to undertake an exploration of the possible directions of long-term development of telecommunications in Australia. The NTP multidisciplinary team set about this examination interacting with users, academics, consultants, industry, Telecom staff and others by way of seminars, discussion, contracted research and correspondence. The recommendations of Telecom 2000 provided the basis for the required broader perspective for planning to meet social needs into the future.

OUTCOMES FROM THE TELECOM 2000 REPORT

Early in 1976, thirty thousand copies of Telecom 2000 were distributed for consideration and discussion both inside and outside Telecom Australia. The aim was to tell people affected by Telecom Australia's services and policies about the issues involved in the long-term telecommunications

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planning and to invite comment on them. Written responses totalled 210 ranging from formal acknowledgement to comments in depth. The writers of the 111 more substantial responses could generally be identified with some professional or business source. Only 12 could be classified as 'individuals'. The single dominant source of responses was tertiary institutions (41). Other major sources were business (19) and government (18).

The major issues raised in responses involved six subjects: open planning, community involvement, social theory, value position, competition and data policy. These responses were mainly of a high calibre and introduced a wide range of complex issues. An analysis of the responses and the recommendations as accepted by management is set out in the publication Outcomes from the Telecom 2000 Report.

OPEN PLANNING

The Telecom 2000 report set out discussion and recommendations about the desirability of involving the people affected by the actions of Telecom in the process of arriving at particular decisions. This was referred to as open planning. The report itself and the exercise involving evaluation of responses was in effect an open planning exercise. In view of the extent to which Telecom 2000 was distributed, the number of written responses was less than had been expected within Telecom. On balance, however, it was considered to be a successful and useful overture into this mode of planning but it was clear that further thought and additional work would be necessary if the implementation of open planning was to effectively fulfil the expectations of all concerned.

The inherent change in attitude as well as the required changes in processes necessary to implement open planning must inevitably take time - one respondent to Telecom 2000 suggested 10-15 years as being realistic. Telecom may not necessarily agree with this time-scale but it does signify a recognition by others of the difficulties involved.

THE CORPORATE PLAN

Since the setting up of Telecom Australia in 1975 a small group of corporate planners has been working with the various elements of line management to develop a Corporate Plan to bring about the top-down orientation seen as necessary to the future viability of the organisation and improvement in service to the customers.

Recognising the Telecom 2000 recommendation concerning 'open planning' it was also considered important as part of the Corporate Planning Process that in particular Staff Associations be given the opportunity to comment. A draft was distributed and responses were received which assisted the preparation of the final document. The resulting Plan has been made available to the public on request and an abridged 'Highlights' version has been distributed to all staff.

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The Corporate Plan as currently developed broadly consists of three parts:

- the basis for corporate planning;
- the broad strategy to be adopted over the next five years;
- the Planning Guidelines for a ten year horizon.

To establish a basis for corporate planning a set of corporate objectives has [illegible] derived from a study of the statutory responsibilities given to Telec[illegible]ralia in the Telecommunications Act and a knowledge of what is require[illegible]mprove the utility, reliability and economy of telecommunication[illegible]rvices as seen by the people of Australia.

To assist in achieving these objectives the Corporate Plan sets a broad strategy for the next five years of adopting Corporate Thrusts and Actions. Four Corporate Thrusts have been identified by management:

- Quality of Service
- Efficiency
- Staff Relations and Development
- Technology Improvement

POLICY RESEARCH

Telecom undertakes policy research work employing interdisciplinary groups and the range of studies includes the internal organisation, impacts on the external environment and general policy concerning the application of technology to the fulfilment of social needs - in particular those of its customers. Policy research, as a prerequisite for policy review and formulation, is now performed on a much broader base with the involvement of the major functional areas and the use of consultants as necessary. Of particular interest is a Social Research seminar recently conducted and a planned seminar on Public Policy-Making and Telecommunications Planning.

SOCIAL RESEARCH SEMINAR

In August 1979 Telecom Australia organised and funded a seminar, 'Social Research and Telecommunications Planning', with the following objectives:

(i) to increase the awareness within Telecom of the social impacts of its policies and services as perceived by external experts;

(ii) to keep Telecom in touch with social and economic trends that will affect the type of service that will need to be provided in the future, and the manner in which the services have to be provided;

(iii) to further Telecom's commitment to open planning as a way of developing policy;

(iv) to identify fields of social research work of particular relevance to telecommunications plannin[illegible]

This seminar will be discussed in some detail as it provides the foundations for future social research activities within Telecom Australia.

SEMINAR CONCEPT AND STRUCTURE

The concept of the seminar was initiated when the National Telecommunications Planning (NTP) group set about reappraising its organisational role and began questioning the fundamental nature of the social sciences and the contribution they could be expected to make to telecommunications planning. The outcome of this process was a seminar covering a broad range of topics, and involving social scientists, both academic and practising, and Telecom managers - a total of 60 attended with a ratio of about 2:1 non-Telecom to Telecom being the design objective. Two days were set aside for the seminar with opening and concluding half-day sessions spanning two half-day workshop sessions. In sum, we were particularly keen to progress from Telecom 2000 and the Outcomes, and this seemed like a good way to take that step.

The following six workshop topics were very simply derived from NTP's understanding of definitive areas where some social research seemed to be necessary. A degree of overlap was recognised, but it was considered that this type of generous model would enable flexibility of coverage to be achieved in the seminar.

Workshop Topic 1 : Social Trends and Communication Patterns
" " 2 : Distributional Consequences of the Provision of Specific Services
" " 3 : Social and Technical Implications
" " 4 : International Developments as they Affect Australia's Telecommunications Planning
" " 5 : The Information Economy
" " 6 : Planning - Theory and Practice

To cover the topics and derive maximum benefit from the resources which would be necessary to achieve such coverage, an interactive design process was arrived at. We started with the idea of a Delphi process, but decided that we should give the participants more scope to tell us what the topics were really about. In the first instance the six workshop topics were defined briefly (in about a page) and no attempt was made in this exercise for completeness or to otherwise polish the definitions. To some extent they were designed to be almost provocative. These definitions, for want of a better description, were sent to each invitee as part of the invitation process, and a contribution of not more than two pages was requested on one or all of the topics. Three-quarters of the invitees responded to this request. In all, counting general and specific comments, 100 commentaries were received. These commentaries were then synthesised by Departments within Telecom into opening papers for each topic, and copies of these were distributed before the seminar. These synthesis papers avoided identifying the sources of opinions, other than to contrast the Telecom and non-Telecom contributors, to avoid putting people at the seminar in fixed positions prior to entering the workshop activities.

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The synthesis papers then constituted the opening papers for the seminar, and the basis from which workshop discussion stemmed. They were presented by Telecom Presenters from the responsible Departments, and the workshop Chairmen, who were non-Telecom invitees, spoke briefly to each paper and set the basis for discussions during the workshops. In the workshops it was intended that discussion be directed towards identification of:

1. major issues for telecommunications planning, within the scope of the workshop topics;
2. possible implications of these issues within the immediate and the long-term future;
3. studies and social research relevant to these issues;
4. priority for study and research;

and guidelines along these lines were given to the Chairmen in their briefing.

Non-Telecom invitees were selected on the basis of the advice of the Academy of Social Sciences in Canberra, and on advice from Departments within Telecom concerning practising and academic social scientists who have had dealings with Telecom in recent years. In effect, we were looking for people from a broad range of disciplines from various parts of Australia and from various institutions, who had previously demonstrated interest in telecommunications. Telecom invitees were selected with a view to achieving a balance of corporate management and social science representation as well as achieving a broad involvement from the various Telecom Departments.

SEMINAR ANALYSIS

The 'increased awareness', 'keep in touch' and 'open planning' implications of the first three objectives of the seminar are somewhat less tangible than those of the fourth but generally all three were felt to be successful. This success may in part be measured by the spirit of mutual goodwill which has been cemented between Telecom planners and the social science 'world' in Australia and the formal and informal contact chains which have resulted.

The six workshop reports contain a fund of interesting and useful ideas, information and proposals and it would not be possible to give full coverage in this paper. These proposals will be considered by Telecom Australia management and definitive action will be taken to ensure that advantage is taken of what is considered as a most meaningful planning activity.

To assess the full value it is necessary to read the proceedings and in particular the workshop reports. To give some appreciation of the output of the seminar each of the workshops will be discussed briefly in turn.

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SOCIAL TRENDS AND COMMUNICATION PATTERNS

This workshop focused on employment issues as the most important area, being basic to the social sciences and with direct implications for Telecom as a large employer. Some particular researchable areas identified included: attitudes to work, changes in nature and content, decentralisation, growth of leisure, reducing opportunities, stress and accidents.

In addition there was a great deal of discussion on telecommunications/energy use/transport issues. Research in this area does not support the idea of substituting telecommunications for physical movement, travel, and meetings, but does suggest supplementation which could reduce expensive forms of physical movement and make a contribution to energy saving. It was considered that Telecom should develop marketing strategies for increasing public use of services designed to cut down the need for movement and therefore it should sponsor research into these relationships.

DISTRIBUTIONAL CONSEQUENCES OF THE PROVISION OF SPECIFIC SERVICES

This workshop recognised the topic as being about equity and posed the fundamental question of the extent to which new service developments would exacerbate the gap between the 'information rich' and the 'information poor'. Specifically it was considered that there were three distinct ways to deal with equity considerations: pricing, technical standards and management practices and beliefs.

The conflict between equity and efficiency criteria and the question of where Telecom Australia's responsibility lay in this matter, was debated extensively. Telecom was seen to be in a stage of transition in its development where it may now be possible to calmly and properly challenge some of the sacred cows of yesterday including, but not limited to, for instance, the uniform national tariff policy, uniform national standards, a whole range of cross-subsidy questions, and even to look afresh at the potential development by Telecom of an efficient, high-technology Australian industry.

The need for more data to answer the questions raised by these propositions was recognised and consequently a high priority was placed on more research being conducted on demand issues, both in terms of identifying market segments and price responsiveness; cross-subsidisation issues, both current and future; and network utilisation, in terms of who's calling who, why, when and how often?

SOCIAL AND TECHNICAL IMPLICATIONS

This workshop considered that Telecom Australia should become more initiative-taking, progressive and proactive as a leader in social as well as technical matters. In particular it proposed that Telecom should take the initiative in establishing a joint parliamentary committee on the social assessment of technological change affecting services within its responsibilities.

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It further proposed a series of possible areas for research under the general headings of employment and work, including manpower planning and quality of worklife issues; Australian industry structure, covering such issues as supply, decentralisation and union participation; Telecom Australia's structure and processes, including matters of organisational climate, managerial philosophies and internal communication patterns and, finally, the introduction of new technologies, including research into Australian and overseas experiences and staff mobility.

INTERNATIONAL DEVELOPMENTS AS THEY AFFECT AUSTRALIA'S TELECOMMUNICATIONS PLANNING

On more than one occasion this workshop came face-to-face with the fact that technological issues constantly and inevitably now raise political questions. It considered that Telecom must be continually conscious of the political nature of these technical issues and act with this in mind. Moreover, it considered that the way in which technology is seen by the public and by interest groups has changed; it is increasingly perceived as having both an inevitable ideological component and (often unplanned) political consequences.

The workshop presented a large number of recommendations with some concerning Telecom Australia's organisational structure and mode of operations and others being more specifically related to research subjects. Examples of the former included the recommendation that a public policy unit be quickly established by Telecom. Initially the work of the unit would be to give timely advice to top management. Once established it would:

(a) put a persistent input into long range planning; and
(b) raise the general political consciousness within Telecom.

In addition it was recommended that Telecom speed up its response time to specific types of service needs, in particular business communications and that Telecom should form a view on the matter of encouragement of local industries to make telecommunications components, promoting that view strongly. Also it was considered that Telecom should identify innovative local firms and consider how it could use their products.

Recommended research areas included issues of technology transfer, the socio-economic effects of overseas and local data base utilisation and an independent assessment of Telecom Australia's monopoly position.

THE INFORMATION ECONOMY

As a first priority the workshop emphasised the need to research recent developments in the economics of information and, more specifically, the present and future role of information goods and services in the Australian economy. It was noted that the forthcoming seminar on Information Economics sponsored by the East/West Communications Institute (mid-1980) would significantly contribute to the former requirement. Within this overall context the workshop recommended a range of research projects directly related to telecommunications planning including such issues as the impact of information technologies on firms and industries, property rights in information and international data flow.

PLANNING - THEORY AND PRACTICE

The workshop decided to explore 'open planning and corporate planning processes' to see who are the key decision-makers, what are the information points and what are the processes of community consultation and strategic planning.

Since Telecom is in competition with private enterprise, there would be certain proposals and possibilities for the future that Telecom should not disclose in the public interest. However, it was thought that if a decision related to a service essentially far ahead in the future, then open planning could be appropriate.

As a result of a brief case study exercise, the group put forward an overall research proposal that Telecom should concentrate on two aspects in its social research on this topic. The first of these concerned open planning practice as indicated in its experience with Telecom 2000 and the Corporate Plan, and its innovations in science and technology including, for example, wired teletext. The second concerned open planning operations, looking at public and corporate participation procedures in exploring preferred futures and the means of maximising the scenarios that reinforce options for open planning.

It was felt that this research should seek to explore three particular issues: these being how one increased community consultation to achieve maximum participation, how one managed the information generated throughout the open planning process and the means of monitoring changes occurring as a consequence of the planning process and how one specified the values and time constraints that limit the opportunities for obtaining desired or preferred futures, in terms of both efficiency and effectiveness.

PUBLIC POLICY-MAKING AND TELECOMMUNICATIONS PLANNING SEMINAR

It is recognised that telecommunications is an integral part of the fabric of society in Australia. The extent and nature of the role telecommunications plays in shaping society and complementing its development is a complex and dynamic question and therefore requires continuous study in order to develop the necessary understanding to enable effective planning of telecommunications in Australia to take place. There are many institutions, government departments and organisations who in fulfilling their functions, make decisions which affect public policy and as a consequence influence the nature of Australian society. It is of value to telecommunications planning to develop an understanding of the interactive nature of these various bodies and Telecom Australia to facilitate the mutual development of public policy.

It is therefore planned to conduct a seminar on Public Policy-Making and Telecommunications Planning during May 1980. This seminar will take a similar form, both in objectives and format, to the one held recently on Social Research and Telecommunications Planning, in that internal and external participants will be invited to discuss issues of mutual interest and concern. However, the nature of the subject area could mean that preparatory activities would take a slightly different course this time or that a different emphasis might be given to the seminar structuring (e.g. more time devoted to workshop interaction). It is proposed to bring together about 60 people, with a balanced representation of Telecom and non-Telecom participants.

SUMMARY AND CONCLUSION

Telecom Australia as the common carrier of telecommunications has the responsibility for the balanced development of services provided by this technology throughout Australia. In carrying out this task it must take into account the social needs of the people of Australia and manifest these needs in the form of satisfied demand in its development plans and programmes. To achieve this it must establish policy research and planning processes which are able to address, for example, the vexed question of 'distributional consequences' or 'equity' and effectively heed it in the decision-making process. Such questions are fundamental to all sectors of public activity and the issue of institutional responsibilities ultimately remains unresolved.

Telecom 2000 and its sequel Outcomes were socio-technical research and planning activities that provided new dimensions to telecommunications planning in Australia. Telecom's Corporate Plan and consequent operational planning and programming processes have been influenced by the people-oriented approach necessary to the recognition of social needs as established by these reports.

The more recent seminar on Social Research and Telecommunications Planning further extended this work and with its success comes a host of useful concepts, attitudes and recommendations - a veritable window into understanding social needs. The planned seminar on Public Policy-Making and Telecommunications Planning will extend even further these ideas and the research and planning networks established should assist in the formulation and implementation of Telecom Australia's future development plans.

"WE ARE SILENT"

EFFECTS OF WITHDRAWAL OF TELEVISION FROM SATELLITE INSTRUCTIONAL TELEVISION EXPERIMENT (SITE) VILLAGES IN INDIA

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What if your ways of communicating with the outside world were temporarily disrupted or lost altogether? How would you feel?...What would you do?...The questions seem odd because in this day and age we tend to take modern communication media for granted. Nevertheless, events such as the New York Times strike do occur, and people miss their daily newspapers. What alternatives do they have?...How can they know what is happening in the world?

When the United States repositioned their communication satellite and effectively cut off Brazillian villages from educational television, what happened in the villages? And what is the real significance of the regret expressed by then Prime Minister Indira Gandhi when the United States ATS-6 satellite was withdrawn and 1700 Indian villages were suddenly without television?

Do those people feel the need for television now? Is the need for television comparable to that for food and other supplies? What are the sociological and psychological implications of cutting off the communications flow to the villages?

We know very little about such situations. But studies such as "The day they took away TV," conducted by the Knight-Ridder newspaper chain, would seem to indicate a growing interest in this untapped area of communication research. There are three other studies in this area, but they are of limited use because they were either of short duration or were undertaken in artificial environments. These studies are:

a. "Missing Newspapers" Bernard Berelson, 1946.
b. "Missing Extension" Alan H. Wurtzul and Colin Turner, 1975, and
c. "Why TV is Missed", Alexis S. Tan, 1976.

Probably the most important reason that there are so few studies in this area is because one must either (a) create an artificial situation of a missing communication medium, or (b) wait for a natural disturbance in communication to occur. The first alternative is difficult to arrange, and the second difficult to anticipate.

In India, however, a natural situation of this kind occurred when the Satellite Instructional Television Experiment, commonly known as SITE, ended. During this year long experiment, villagers, who had had very little exposure to modern communication media, viewed programs on health, agriculture, education and the like.

SITE was conducted from August 1975 to July 1976 and covered 2300 villages spanning six states of India. These states, referred to as "clusters," were Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh, Orissa and Rajasthan.

The television signals were beamed from the Ahmedabad earth station to an ATS-6 satellite and were received directly in the villages. Since the direct reception system had been designed for two audio channels for language and one video channel for picture transmission, the Andhra Pradesh and Karnataka viewers saw the same picture while hearing the program in their respective languages. This procedure was discontinued after three months, however, because of difficulty of establishing a rapport between the audience and the medium.

The total programming for SITE consisted of over 1300 hours which can be classified into three categories: (a) News, (b) Instructional Programs, and (c) Recreational Programs. The half-hour news for all clusters was given in Hindi and the instructional and recreational programs were in the villagers respective languages. Two and a half hours in the evening were devoted to news, information, and entertainment programs for all of the villagers, and one and a half hours in the morning for schools and teacher training. The time distribution of programs transmitted to the villagers consisted of 28% cultural entertainment, 15% health, nutrition and family planning, 14% current affairs, 12% agriculture, 9% social problems, 6% visits to different places in India and 16% miscellaneous programs.

The experiment, considered as a learning experience to design a system that could produce and telecast relevant educational and developmental programs to widely spread areas, was a singular success.

But let us put aside technical evaluation of the system and examine it from a social perspective. The average attendence per community TV was about 100 after the initial novelty had worn off. Many (30.6%) of the viewers were first-generation mass media participants, and more women watched than men. It was also established that the audience favored instructional programs rather than socio-cultural programs.

Baseline studies conducted by the Indian Space Research Organization before, during, and after, yielded valuable data. The organization found the significant and unexpectedly large gains in information, awareness and knowledge in areas such as health and hygiene, political consciousness, overall modernity and family planning. They also documented that the gains were greater for under privileged sections of the rural society such as females and illiterates, and the gains were increased with amount of television viewing.

A summary of their results appears here, because like all longitudinal studies, pre-, during, and post-study information are all necessary to form a composite picture. In terms of specific SITE objectives these were the findings:

A. INNOVATIONS IN HEALTH AND NUTRITION

On the whole, more females than males changed or gained in the knowledge and use of health and nutrition innovations. (Changes were pronounced in the areas of health than nutrition.) It was also noted that the change exhibited a "ceiling effect" rather than varying directly with exposure to television. The young, the unmarried and the married respondents with two or less children gained more knowledge about health innovations than others. The magnitude of gain was more in illiterates than literates. It seems that the community TV played an important role in narrowing the knowledge gap among various sections of rural populations that had no access to information about modern health practices.

B. FAMILY PLANNING

The proportion of respondents among both sexes who desired a small family of three or fewer children increased due to television viewing. Even though more females than males changed their opinions or gained more knowledge in the family planning area, the adoption rate of family planning practices did not increase significantly. It seems that a one year period was not enough to effect the changes.

C. INNOVATIONS IN AGRICULTURE

No appreciable gain in agricultural awareness was recorded due to an existing high level of knowledge of agricultural practices in the villages. The interactions between Village Level Workers (VLWs) and the villagers, however, did increase due to television viewing. The young and illiterate cultivators with no prior mass media exposure formed an audience of frequent viewers. Regardless of their land holdings, they seemed to have gained most in awareness, knowledge, adoption and use of agricultural and animal husbandry innovations.

D. POLITICAL SOCIALIZATION

Four aspects of political socialization were recorded: (a) Political Information, (b) Empathy, (c) National Integration, and (d) Efficacy of Administrative Units. With regard to political information, people knew most about the Prime Minister's 20 Point program initiated during SITE period. Females made greater gains in the area of Empathy than males. Male frequent viewers felt an increased sense of national integration due to their exposure to the variety of life styles in India. The total administrative efficacy gain score was higher among male frequent and occasional viewers. It was also found that lack of formal education was not a hindrance to learning through television.

E. OVERALL MODERNITY

In both attitudinal and behavioral information the overall modernity (adoption of modern ways) increased as a result of television viewing. The aspiration level for a profession like medicine, engineering or teaching changed in a positive direction, both in male and female frequent viewers, but more so among the females.

F. CHILDREN

For children, exposure to morning programs resulted in very significant gains in the areas of language development and in the attitude of seeking knowledge and information from sources other than conventional classroom teaching. The classroom attendance also rose during the program. Children learned new stories and songs, and activities such as model and toy making became popular in most of the schools.

G. TEACHER TRAINING

About 50,000 teachers were exposed to a multi-media package that explored different methods of teaching Science and Mathematics. Teachers gained substantially from this experiment.

With this background information on SITE and its impact, the present study was designed to explore whether the withdrawal of television in some of the SITE villages would alter or redistribute the media use pattern. An in-depth interview technique was found to be most effective for communicating with mostly rural uneducated people. With this method, we could explore the effects of withdrawal of television programming over time and study the "sleeper effects" if any. Two years after the termination of SITE a three months' field-study during Aug.-Nov. 1978 was undertaken with the help of Social Effects Project Group of East-West Communication Institute. The Director-General of TV in India, Station Manager of the Hyderabad Station and staff provided the necessary help in selecting the villages for study. Most of them still remember the "OLD SITE" and having worked during that period have a kind of emotional attachment to the program. They have still not removed the three meter chicken-mesh antenna from the top of the Hyderabad Television Station.

The Andhra Cluster was selected for the following reasons:

a) The existence there of villages that were included in the SITE program.

b) The inclusion of some of these villages in the SITE continuity Project which used low power terrestrial television transmission in place of satellite. This combination of villages, some of which were able to continue programming and some of which are not, provided the control and experimental villages for our study.

c) Logistics and convenience of the location prompted us to undertake the study at this cluster.

Selection of the villages was a more difficult task, because all the SITE villages were initially selected according to the following criteria:

a) All villages were within 40 Km. of a town that housed a maintenance center.
b) Almost all villages had domestic electric supply.
c) All villages were approachable by Jeep throughout the year.
d) All villages had a suitable public building, such as a school or Panchayat Ghar for location of the television.

These facilities being shared, the villages for the present study were selected on the basis of comparability of population, development and proximity to a town. In addition, transportation and convenience concerns were important considerations in selecting Alipur and Mallepally villages, for both of these villages are near the Hyderabad-Bombay Highway, less than 10 Km. from a neighbouring town. Mallepally village was selected as the control for the study because it was able to replace satellite programs with terrestrial programming. It lies approximately 10 Km. away from its neighbouring town of Sangareddi.. Alipur village was considered as an experimental village for it has not received any television programming since the cessation of the SITE programs.

For clarity during the rest of the presentation, the control village of Mallepally will be called the TV-Village, and the experimental village of Alipur will be called the Non-TV Village. Some of the pertinent demographic characteristics of these villages are given here:

Table-1 shows the population, number of households, area in Sq. Km. and caste composition of the two villages under study. Caste is still an important consideration in the village life of India.

Table-1
COMPOSITION OF VILLAGES

	Control village Mallepally TV Village	Experimental Village Alipur Non-TV Village
A. Population	1265	1336
B. Number of households	155	200
C. Caste Composition		
i. Hindus	75%	60%
ii. Muslim	5%	10%
iii. Christian	10%	25%
iv. Harijans	10%	5%

Source: Census Data

Fortunately for our study, no significant difference in demographics was found between TV and Non-TV villages.

The occupational pattern in the TV and Non-TV villages is divided basically into two categories (Table 2)

a) Workers and
b) Non-Workers or unemployed persons.

The TV-Village had about 58% non-workers, while the Non-TV Village had a higher proportion of non-workers (66%) according to the Census information. In fact, these percentages vary depending upon the time of the year. During crop time more people find jobs and unemployment figures are considerably lower. One major difference between Mallepally (TV-Village) and Alipur (Non-TV Village) is that near Alipur village there is a very large Christian Missionary School, and 20% of the population comprised of school teachers who live on campus. Naturally the literacy level and consumption of mass media is higher in Alipur (Non-TV Village).

Table-2
OCCUPATIONAL DISTRIBUTION

	TV-Village	Non-TV Village
I. Total Workers	626 (49.5%)	462 (34.6%)
a. Cultivators	237	94
b. Agricultural labors	305	215
c. Livestock fishing & allied	27	31
d. Household Industry	14	15
e. Other than Household	2	6
f. Trade and Commerce	15	3
g. Construction	6	25
h. Other Services	20	73
II. Non-Workers *	639 (51.5%)	874 (65.4%)

Alipur, the Non-TV Village, existing so close to the city of Zaheerabad does not have a bus service and depends solely upon pedi-cabs and bullock-carts for its transportation needs. Mallepally, the TV Village, has a regular bus service twice a day from the neighboring town of Sangareddi.

In the Non-TV Village, there is only a primary school up to 5th grade, but the adjoining Mission School more than provides for the needs of the village. The TV-Village has a middle school up to 8th grade, and most people limit their education to that. Medical facilities are not available to either village. A doctor used to come to TV-Village for a few hours a day, but for any serious illness, people from both villages had to go to neighboring towns. Both villages lacked telecommunication facilities and relied solely upon postal service for outside communication. Clean drinking water is a problem for both villages, because some wells are owned privately resulting in fewer wells for the general populace.

Table-3
FACILITIES

	TV-Village	Non-TV Village
1. Educational	middle class school	primary school well equipped high standards Mission School
2. Permanent Medical	none (doctor visits week-day morning)	none (all people go to neighboring town)
3. Communication	small post office. no telephone	small post office no telephone.
4. Drinking Water	5 wells (3 individually owned)	6 wells (4 individually owned)

Inter-personal communication in Indian villages is well developed, and a strong sense of cohesiveness exists among the villagers. For example, despite the lack of communication facilities, the details of the researcher's visit were known to everyone within a matter of one to two days. If such a strong structure of interpersonal communication exists in an Indian village, one cannot help but wonder, whether introduction of modern tele-communication will alter the existing cohesiveness of the community.

A closer look at the village reveals the following communication nodes:

A. Long Platforms, which one might very well call the "communication platforms," exist at many locations inside a village. The people sit around, gossip, talk of mutual concerns, approve social mores, and criticize those who violate customary rules and behavior.

B. Tea Vendor shops provide a place for people to sit, drink tea, smoke cigarettes or bidis, eat paan and generally relax. Many shops have radios and occassionally newspapers. Many informal discussions take place here:

C. Religious Places like Hindu Temple, Christian Churches and Muslim Mosques represent another communication setting. Many people in the villages meet there and talk over their concerns.

D. Bus Stops/Pedicab Places - Many people wait for hours to ride a bus or a pedicab that takes additional hours to go to a neighboring city or town. Their gossip sessions include a wide variety of subjects, both productive and unproductive.

E. Beer Vendor Shops where people come to buy and relax. Many times people spend their whole day's earning with absolutely no money left for their families. A different kind of dialog takes place at these places.

F. Religious Song Groups and Festivals which not only show the colorful life but also take part in shaping the group norms in the village.

Table-4
COMMUNICATION AND TRANSPORTATION

	TV-Village	Non-TV Village
1. Literacy Level	15-20% overall	17% overall 60% with adjoining Mission School 15% without Mission School
2. Number of Radios	20	350 One Community Radio Tea Vendor shop radio
3. Number of newspaper subscribers	None	26 5 in the village 20 in the Mission School Tea shop Vendor
4. Transportation Means	Bullock carts (30%) Bus service to neiboring town (twice daily)	Bullock carts (20%) Cycles with 15% household

After examining some aspects of interpersonal communication environment in the Indian villlages, the researcher drew a stratified random sample of 28 respondents from each village. The sample size was based on the assumption that each interview would last one full day to allow for in-depth study and cross-examination. Because most people did not understand English and Hindi, interpreters were used. An open-ended question was asked and villagers responses were recorded. A few more questions were added to the prepared questionnaire in the field, to increase the scope of discussions. Separating the responses into different classes was done after the completion of the field study.

And lastly, personal details were taken about the respondents themselves. After the field study, an appropriate classification schedule for each question was made and data compiled for each village.

Some of the demographic characteristics of the random sample cnosen are given here in Table-5:

Table-5
INFORMATION ABOUT RESPONDENTS

	TV Village	Non-TV Village
Median Age	35-44 years (10)	35-44 years (11)
Sex	Males (22)	Males (21)
Caste	Hindus (18) Christians (4)	Hindus (13) Christians (9)
Religion	Hindus (20)	Hindus (15)
Median Education	Standard 9 and above (11) Illiterate (9)	Standard 9 and above (20) Up to standard 5 (6)
No. of years in the village	Since birth (23)	Less than 5 years (11)
Marital Status	Married (24)	Married (22)
Average size of family	3.61	3.16
Child Spacing	2.59	2.69
Family Planning adopted	60%	50%
Type of House	Cemented (12)	Mixed (12)

(CONTINUED)

ERIC Full Text Provided by ERIC

Table-5 (CONTINUED)

	TV Village	Non-TV Village
Owns Radio	(16)	(19)
Owns Cycle	(14)	(20)
Owns Bullock Cart	(14)	(5)
Median Occupation	Cultivators (12)	Others and teachers (15)
Second Highest Occupation	Agricultural labor (7)	Non-workers (7)

Table-6 gives the general mobility pattern and lastly Table-7 gives the media consumption habits of the respondents.

As we mentioned earlier, the SITE longitudinal studies had three phases: (a) Pre, (b) during, (c) post and (d) after two years period. We had reviewed some of the conclusions of first three phases and would like to add our findings on the "After 2 Years Phase" to them.

Table-6
MOBILITY PATTERN

	TV Village	Non-TV Village
Inter-personal contacts inside village	Meets all people (22)	Meets all people (25)
Visits to other cities/ relatives per year	4 times (16)	4 times (13)
Visited other States	(12)	(20)
Toured India	(3)	(9)

Table-7
MEDIA CONSUMPTION PATTERN

	TV-Village	Non-TV Village
a. NEWSPAPERS	Does not read at all (17)	Reads regularly (11)
b. RADIO	More than 3 hours/ day (11)	1-2 hours/day (10)
c. TELEVISION	1/2 to 1 hour/day (11)	1-2 hours/day (10)
d. MOVIES (IN NEIGHBORING TOWN)	(Widely distributed pattern)	(Widely distributed pattern)

The awareness level of the participants regarding the SITE in general was almost the same in both the villages, because a comparable number of people could remember the pertinent facts about SITE. However a greater number of respondents in the Non-TV Village remember the date of withdrawal of TV from their village.

Table-8
AWARENESS LEVEL OF INTRODUCTION AND WITHDRAWAL OF SITE

	Introduction		Withdrawal	
	TV-Village	Non-TV Village	TV-Village	Non-TV Village
A. Completely OK	3	2	1	3
B. Partially OK	16	15	14	13
C. Not OK	7	5	2	1
D. Not Known	2	6	11	11
N=	28	28	28	28

Similarly, fewer respondents in Non-TV Village said that they do not know who was responsible for withdrawal. While most respondents in both villages held the government of India responsible for the introduction and

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withdrawal of television, an equal number of respondents (5) in Non-TV Village blamed ISRO/TV deparment and Village and Local Administration for withdrawal.

Table-9
RESPONSIBILITY OF INTRODUCTION AND WITHDRAWAL OF SITE

	TV-Village		Non-TV Village	
	Introduction	Withdrawal	Introduction	Withdrawal
1. ISRO/Television Department	7	3	2	5
2. Government of India	9	3	11	9
3. Government of India and USA	4	9	7	2
4. Sarpanch/Local govt./State Authorities	2	3	6	5
5. Do not know/ Not known	6	10	1	7
N=	28	28	28	28

In examining why TV was introduced, a majority of respondents in Non-TV Village thought it was for agriculture and educational improvement. The Non-TV Village however thought it was introduced for basic development.

Table-10
REASONS OF INTRODUCING SITE*

	TV-Village	Non-TV Village
1. Agricultural improvement	18	22
2. Educational purposes	18	12
3. Entertainment	2	2
4. Basic Development (including knowledge about health, industrial development, sanitation and cleanliness)	12	17
5. Government Propaganda	1	1
6. Do not know/Not known	1	3

The majority in both villages felt that content and quality of programs in no way justified the withdrawal of television from their village.

Table-11
PROGRAM CONTENT FACTORS JUSTIFY THE WITHDRAWAL OF SITE

	TV Village	Non-TV Village
A. None	14	18
B. Language	4	-
C. Difficult programs not understood	1	-
D. Do not know	7	7
E. Language and difficult programs	1	-
F. Other Reasons	1	3
N=	28	28

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It is interesting to note that most respondents in Non-TV Village thought they watched television longer than they actually did. Analyzing this in the light of media use and village infra-structure it appears that such reporting by the Non-TV Village of higher use of television is nothing more than a natural manifestation of the loss of television in their daily life. In fact their claims were exaggerated.

Table-12
PERSONS WITH WHOM TELEVISION WAS WATCHED DURING SITE

	TV Village	Non-TV Village
A. With family	24.28%	43.92%
B. With neighbors	3.90%	10.71%
C. With friends	41.78%	38.92%
D. With relatives	8.57%	0.7%
E. With others	14.28%	10.71%
F. TV not watched	7.14%	-

About 43% of the respondents watched television with their family, 39% with friends and 11% with other in Non-TV Village. In TV-Village, 25% watched with families and 42% with friends. Even though the majority of respondents watched television programs for educational reasons such as information about agricultural practices, education, health and news, there were significant differences between villages. People in Non-TV Village watched television primarily for education, while those in TV-Village watched primarily for agriculture and entertainment. Only a few respondents thought television should be governed by age old customs and laws. The majority found a new freedom in this medium, and were hopeful because of it. Only one respondent mentioned television as a propaganda arm of the government. Another significant difference between the TV and Non-TV Villages was found when a question was asked about major reasons for disliking SITE programs. The Non-TV Village people, having lost their television, found no reasons to dislike SITE programs, while a number of reasons for disliking SITE were listed by almost 2/3 of the respondents of TV-Village.

Table-13
MAJOR REASONS FOR DISLIKING SITE PROGRAMS

	TV-Village	Non-TV Village
A. None	9	25
B. Language	3	1
C. Less news and movies	1	1
D. Personal prestige	1	-
E. High expectations/Less possible control	2	-
F. Language, less news	6	-
G. Do not know	6	-
N=	28	28

Table-14
ATTITUDE TOWARDS TELEVISION*

What basic needs would not be fulfilled?†

	TV-Village**	Non-TV Village
A. Educational needs (including agriculture, education, irrigation methods, farming and health, etc.)	(11)	17
B. Entertainment needs	(3)	5
C. Informational needs (News, world events)	(15)	15
D. Others	(-)	1
E. Do not know/No difference	(10)	3

* After its withdrawal

** In case TV is withdrawn

† Multiple answers

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What are some of the long term effects? A number of people felt that their knowledge about agriculture, health and education had improved significantly. People also felt that the distinctions among castes, which had been very sharp up to this point had begun to soften, allowing them a little more freedom.

Table-15
LONG TERM EFFECTS OF SITE*

	TV-Village	Non-TV Village
1. No changes/Do not know	6	5
2. Reduced caste barrier	8	12
3. Reduced monotony, (entertainment)	3	4
4. Improved knowledge about agriculture, health and education	10	20
5. Increased expectations	1	3
6. General improvement, e.g. cleanliness, cooking, etc.	3	10

* Multiple choice answers

It is also interesting to note that on this open-ended question, the Non-TV Villagers marked more responses than their TV counterparts.

Majority (85%) of respondents in the Non-TV Village compared to 68% of respondents in the TV-Village felt that television is needed for educational and informational purposes. Entertainment needs were mentioned by only 3 respondents in the TV-Village and 5 in the Non-TV Village.

Television, after its withdrawal, became a topic of discussion and concern for most people in the Non-TV Village. These people did not revolt against the administration. They only partially understood the final television broadcast concerning the withdrawal of television from their villages. Some of them (3%) showed concern by asking elders and ISRO people, while others asked family members or professionals (20%). Because of the mistrust of district authorities and Block Development Administration, most refrained from going to them.

About half the respondents in the Non-TV Village were either confused or did not know whom to blame for withdrawal of television. Only about 40% blamed the Indian and US governments. The USA culpability dropped after two years, because of geographical separation between India and USA and implied social customs of the region. However the distrust for local village management and state government (20%) continued even after two years period of television withdrawal. In the TV-Village an interesting side light occurred. If the present TV system were to be withdrawn for any reason, half of the respondents thought USA would probably be blamed.

Table-16
REACTION OF VILLAGERS TOWARDS WITHDRAWAL OF TELEVISION

Concern Expressed	TV-Village*	Non-TV Village
1. Asked village elders and friends	(8)	5
2. Asked family members/professionals of the same discipline	(2)	4
3. Asked ISRO people	(13)	1
4. Concerned but spoke only with peers in the village	(2)	18
5. Did not show concern at all	(3)	-
N=	(28)	28

* In case TV is withdrawn

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Table-17

REACTION OF VILLAGERS TOWARDS WITHDRAWAL OF TELEVISION FROM THEIR VILLAGE

Responsibility of Withdrawal	TV-Village*	Non-TV Village
A. ISRO/TV Department	(1)	--
B. Government of India	(-)	3
C. Government of India and USA	(13)	8
D. Sarpanch/Panchyat/A.P. Government	(1)	4
E. Do not know	(13)	13
N=	28	28

* In case TV is withdrawn.

A strong feeling that television is for backward classes exists in the Non-TV Village of Alipur. These same people expressed maximum concern about its withdrawal. Some upper class people disliked SITE because it spread the 20 Points program, which included the message of non-payment of loans, and abolition of bonded labor, and thereby reducing their apparent control in the village.

Most respondents in the Non-TV Village switched to newspapers, because of high literacy rate. This tends to indicate that people switch over to the most convenient medium, as soon as one medium of use is disrupted. The switch-over seems to follow the exponential path. The frequency of seeing movies also increased by the respondents, especially among young males.

As a last assessment of the interactive (voice) communication needs of the TV and Non-TV Villages, a proposal for installing a telephone was put forward. It was explained that if a telephone service was installed in their village, it could be used for a) medical emergencies, b) fire and c) theft, all of which are beyond the control of villagers. Majority of respondents in both villages were willing to pay a monthly tax for that service. There were no respondents in the Non-TV Village who opposed this idea, 50% were willing to pay between Rupees 1-2 per month per family. The other 50% had even agreed to pay as high as Rupees 2-3 per month per family. In contrast in the TV-Village one respondent was not willing to pay, 3 could not afford though they liked the idea, 30% said they would be willing to pay Rupees 1-2 per family per month. About 40% were willing to pay Rupees 2-3 and another 20% were willing to pay Rupees 3-4 per family per month.

Table-18
PERCEIVED NEED FOR TWO-WAY COMMUNICATION (TELEPHONE) FOR SPECIAL SERVICES

	TV-Village	Non-TV Village
A. Ready to pay 1-00 to 2-00 Rupees/ month	6	13
B. Ready to pay 2-00 to 3-00 Rupees/month	12	13
C. Ready to pay more than Rupees 3-00/month	6	2
D. Not prepared to pay, but feel the necessity of telephone in the village	3	-
E. Not prepared to pay/Do not want telephone in the village	1	-
N=	28	28

So, in summary, just what did people gain from their exposure to television?

A large number of respondents in both villages feel that a process of change has begun, and essentially it is for a better life. One old man summed up his views of the changes in just two words: "Jehaniyat and Tamiz," meaning world wide knowledge and manners. When asked how he came to that conclusion, he said that it was written in the behavior of the people, who do not run away from investigators who visit their village now. Instead they can communicate with and even begin to trust these strangers. The Non-Television respondents are even more dramatic in their assessment of television, its impact and its withdrawal: "We lost the light, and out hearts do not beat faster." They said, "We are silent."

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A DOMESTIC COMMUNICATION SATELLITE FOR AUSTRALIA: COMMUNICATION PLANNING UNDER STRAIN

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Abstract

The events leading up to the announcements of a domestic communication satellite for Australia are outlined. The implications of the satellite decision are discussed in relation to planning for the communications infrastructure as a whole. It is suggested that the communication satellite debate has revealed weaknesses in the existing policy planning process and that these will be exacerbated by the satellite decision unless appropriate strategies are developed.

INTRODUCTION

On October 18, 1979 the Minister for Post and Telecommunications, Mr. Staley announced that the Australian government had decided to establish a domestic communication satellite system. (1) While questions of management, control and funding of the system have not yet been finalised, the decision to establish a domestic communication system will have profound implications for the management and control of the Australian communications infrastructure. In fact the two years of public debate and government inquiry which preceded the Minister's announcement suggests that the process of communications policy development itself will need to be reconceived afresh. Government inquiry and public debate have revealed some major problems with national communications policy development and planning which will need to be rectified.

The communication satellite debate has shown that there needs to be greater attention to forward system planning and policy formulation, greater attention to the interface between various communication sectors, a more systematic analysis of the relationship between the national and commercial broadcasting services, coordination of statutory authorities such as the Australian Telecommunications Commission (Telecom) and any satellite authority, and careful examination of frequency management and long term planning processes.

In order to fully appreciate the implications of the communication satellite decision for the communication policy planning process in Australia it is necessary to trace the history of the communication satellite initiative. This, in turn, requires some background information on the existing communications infrastructure.

Responsibility for the communications infrastructure lies ultimately with the Minister for Post and Telecommunications. His Department, the Postal and Telecommunications Department (P+T) provides policy advice on postal, telegraphic, telephonic, broadcasting and other services which are subject to legislation for which the Minister is responsible. (2) It also has a licensing and regulatory function in the administration of the radio frequency spectrum. In order to do this the Department is divided into five functional divisions. They are the Broadcasting Division which focuses on radio and television broadcasting and related areas, the Broadcasting Engineering Division which establishes technical policies and plans for the radio and television broadcasting systems and provides the national broadcasting services transmission system, the Policy Division which is concerned with the Overseas Telecommunications Act 1946, the Postal Services Act 1975, and the Telecommunications Act 1975, the Radio Frequency Management Division, which administers the use of the radio spectrum and the Management Services Branch. (3)

This means that the Postal and Telecommunications Department provides policy advice and technical services to the Minister in relation to a series of communication related organisations. They are the Australian Postal Commission (Australia Post), the Australian Telecommunications Commission (Telecom) which provides national telecommunications services, the Overseas Telecommunications Commission (Australia) (OTC) which is responsible for telecommunication services between Australia and other countries, external territories and ships at sea, the Australian Broadcasting Commission (ABC) which operates the national radio and television services as well as the overseas shortwave radio service, the Australian Broadcasting Tribunal (ABT) which is responsible for the licensing and supervision of public (but not national) and commercial radio and television stations, and the Special Broadcasting Service (SBS) which provides multilingual and other special radio and television services.

In principle, the concentration of control over the communications infrastructure in the Postal and Telecommunications Department makes coordinated cross-sectoral planning possible. But the events of the last two years suggest that coordinated communication planning is not the normal course of events and that this kind of planning can only take place when new organisational structures are either temporarily or permanently created. It will be argued that the National Commonwealth Government Task Force on the National Communication Satellite System was an administrative response to a previous inability to coordinate communication planning. It will be suggested that the communication satellite debate revealed weaknesses in the ongoing communication policy planning process and that the decision to proceed with a domestic communication satellite system will exacerbate those strains. An historical account of the communication satellite decision-making process will provide the context for the argument to be presented.

THE BACKGROUND OF THE SATELLITE DEBATE

The initiation of public debate about a communication satellite for Australia can be dated quite accurately. On August 15, 1977 Mr. Kerry

Packer, of Television Corporation Limited (now Publishing and Broadcasting Ltd.) sent an unsolicited report to the Commonwealth Government. The report, written by Donald S. Bond, was entitled "The Opportunity for Television Program Distribution in Australia Using Earth Satellites". In a covering letter Mr. Packer suggested that following the Green Report, there was general acceptance of the proposition that all Australians were entitled to equality of services such as radio and television broadcasting, telephony education and medical care whether they live in the cities, the country or the outback. (4) He went on to argue that

> "In particular I believe that television services should be provided to areas not at present served and that all four Australian networks should reach all the nation's citizens. I am of the opinion that our existing communication network is not satisfactory nor capable of providing such a service to the Australian people. The present Broadcasting and Television Act does not permit networking from major capital city stations, which is a restriction which must be looked at in the light of present day communication possibilities and in view of the stated objectives of the Green Report to develop 'an Australian identity'". (5)

According to the Bond Report a domestic communication satellite system would overcome the limitations of Telecom's existing terrestrial system, and lead to the attainment of the policy objectives outlined in the Green Report.

In his letter Mr. Packer articulated many of the issues which were to play a major part in the subsequent debate. The issue of equal access to services, criticisms of the existing terrestrial system operated by Telecom, the question of networking and local versus national identity have all been recurring themes in the debate.

The Bond Report did not only provide the agenda for the public debate. On August 15, 1977 the then Minister for Post and Telecommunications Mr. Eric Robinson announced that the Australian Government would establish a Task Force to inquire into all aspects related to a national communications system for Australia. The Terms of Reference were notified on November 3, 1977 and apart from referring to the issues outlined in Mr. Packer's covering letter and the Report itself they requested that the Task Force study and assess the Bond Report itself.

Reaction to the Government announcement of a Task Force inquiry was immediate. Negative reactions came from the Australian Labor Party, unions representing postal and telecommunications unions employed on the terrestrial telecommunications network and from regional television operators. There was a general feeling that the Publishing and Broadcasting organisation was advocating the development of a television distribution system which would lead to a greater monopoly control of the media. (6) It was feared that networking together with an increase in the number of commercial television outlets in small markets would lead to the disappearance of the then viable regional broadcasters.

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Mr. Harold White CBE, the General Manager of the Overseas Telecommunications Commission was appointed Chairman of the Task Force. Other members of the Task Force came from the Postal and Telecommunications Department [2], the Department of Defence [2], the Department of Transport [2], the Department of Health, the Department of Finance, Telecom and the Overseas Telecommunications Commission.

TELECOM'S ROLE IN TELECOMMUNICATION PLANNING

One one level it is possible to interpret the Government's response to the Publishing and Broadcasting document as a reasonable response to the suggestions of an important constituent. But it is important to note that the decision to establish a Task Force where Telecom was only one of a number of participants cut across the traditional areas of Telecom's responsibility. As was noted above Telecom has the legislative responsibility for the provision of the national telecommunications system. But Telecom had been studying the feasibility of a domestic communication satellite system since 1972. The results of Telecom's continuing investigations and the conclusion of the National Satellite System Studies which were published in November 1977, was that

> "A national satellite system cannot at present be justified on purely economic grounds for the provision of services which are the responsibility of Telecom Australia, although the market for greatly improved national TV program distribution at rates which reflect costs is an important factor ... There are national advantages arising from such matters as wider TV distribution, improved medical and educational services in the more remote areas, and improved defence and Foreign Affairs communication which need to be considered. These are not within Telecom Australia's capacity to evaluate, although it has consulted closely with the responsible Government departments ... The method of funding of the high capital and annual costs involved is a key issue if a satellite system is considered justified on national grounds". (7)

From an institutional view it is understandable that Telecom came to that conclusion. With its large investment in a terrestrial communication system, the requirement to generate at least 50% of its working capital from trading revenues and its committment to a principle of the user paying for costs, it was clear that where marginal expansion of the terrestrial network was not possible it would be uneconomic to invest in a satellite system for small numbers of users remote from the terrestrial network. The notion of an institutional view should be stressed. For while there might be public benefits to be gained from a satellite system, the costs to Telecom and hence cross subsidisation by existing users would have been, in Telecom's view, unacceptable.

At the crux of this argument is the conflict between institutional needs and the needs of a more generalised public. Telecom had decided that the costs of expanding services would be unacceptable and could not reasonably be passed on to existing users of its telecommunication system. It was Telecom's judgement that there was a price beyond which it would be imprudent to move in a financial as well as a political sense. But it should be noted that the users of the Telecom system located in the major urban areas already subsidise the rural and outback services. So the political and financial judgement made by Telecom really concerned the level of cross-subsidisation rather than the existence of cross-subsidisation per se.

In retrospect there is a lesson which can be learned from Telecom's conclusions. Telecom should have either created or had access to a governmental organisation or process which could attempt to assess the "national advantages" which might be derived from a satellite augmented telecommunication system. Obviously these national advantages would go beyond the economic costs and benefits which might be felt by Telecom and its customers. This organisation could be within Telecom, the Postal and Telecommunications Department, or elsewhere. But the point remains, Telecom did not appear to have the ability or desire to become involved in the problem of national advantages which might be gained from a communication satellite system and there did not appear to be any mechanism for those issues to be raised within the Postal and Telecommunications Department or the Government. The establishment of the Satellite Task Force can be seen as an organisational response to that shortcoming.

THE COMMONWEALTH GOVERNMENT TASK FORCE REPORT

In July 1978, nine months after its creation, the Task Force reported to the Government. (8) In the meantime the Task Force had invited and received submissions from government departments and instrumentalities, professional organisations, the broadcasting and media industry, trade unions, academics, computer users and industry, equipment suppliers, cultural and community groups, groups representing isolated people and members of the public. The Task Force also conducted public hearings and members conducted a series of overseas study tours.

The Task Force recommended that a national communications satellite system should be introduced as early as practicable and this recommendation was based on its belief that such a system would improve Australia's public telecommunications and broadcasting services, particularly for people in remote areas (remote telephony and limited direct radio and television broadcast), and it would also improve communications associated with defence, transport, health, welfare and education. It should be noted that the recommendations of the Task Force were not unanimous because the representative of the Department of Finance dissented from the primary recommendation because he believed that the marginal improvements which a satellite system would make to the existing terrestrial system might be obtained more cost effectively through conventional means. (9)

The Task Force also recommended that a national satellite commission should be established with the responsibility for assembling user requirements, specifying, planning, providing, developing, marketing and operating the space segment of the national communications satellite system. The commission would operate under an Act of Parliament and it would report to Parliament through the Minister for Post and Telecommunications. The commission would be permitted considerable freedom in the provision and marketing of a full range of satellite communications services with the exception of domestic and international telephone, telex, and telegram services directly to the public. The representatives of the Department of Finance and Telecom dissented from this recommendation. (10)

Embedded in these recommendations on ownership and control and the legislative charter of the satellite commission are the twin themes which have been discussed in this paper. One concerns the centrality of the Postal and Telecommunications Department, through the Minister, in the formulation of communications policy and in the subsequent development of the communications infrastructure. The other relates to the relationship between Telecom and any satellite activities. For the limitations on the kinds of services which the satellite commission might offer relate in a somewhat ambiguous way to the existing operations of Telecom and the Overseas Telecommunications Commission. The ambiguity hinges on an interpretation of the phrase "direct to the public".

The other major recommendation made by the Task Force relates to broadcasting. It was suggested that a domestic communication satellite system would "influence the prospects for the establishment of new television stations". (11) At an appropriate time it was suggested that the Minister invite applications for additional television broadcast licences. But the Broadcasting and Television Act limits the number of broadcasting outlets which one organisation can control. It was noted that in order to provide additional outlets in less populated areas these ownership limitation provisions might need to be relaxed.

Here we see consequences for the communications infrastructure arising from a discrete technological innovation. The point to be made is that the consequences of new communication technologies usually cross the boundaries of legislative responsibility and this places strain on organisations with a particular legislative charter. Returning to an earlier theme, system-wide coordination becomes increasingly necessary when new technologies are introduced.

THE WORKING GROUP

The Government published the Task Force Report and invited public response for a period of three months, subsequently extended to three months, and created a National Communications Satellite System Working Group in October 1978. The Working Group members came from the Postal and Telecommunications Department, the Department of the Prime Minister and Cabinet [2], Department of Defence [2], Department of Finance [2], Department of Science [2], Departments of Science, Transport and Health. It should be noted that the only organisation represented on the original Task Force and not represented on the Working Group was Telecom.

The Satellite Working Group reviewed approximately 150 submissions, most of which came from organisations or individuals who had not made a submission to the original Task Force. The Satellite Working Group attempted to avoid duplication of the Task Force but some matters needed to be considered further. These included the impact of satellites communications on commercial television, the possibilities of direct broadcasting by low powered satellites, financial issues and matters of ownership and control. (12)

Because the Task Force Report and the Bond Report which preceded it covered many similar areas, although the Task Force Report was obviously more detailed and rigorous, the Report of the Task Force tended to receive the same kinds of responses which were elicited by the Bond Report. For this reason an analysis of responses to the Task Force Report does not add a great deal to the issues under discussion. (13) But the response from Telecom is worth detailed discussion because it raises many of the issues which have been tentatively raised already. (14)

Telecom restated its denial of the need for a domestic communication satellite on the grounds that

> "... when considered as part of the total telecommunications complex in Australia there would be insufficient return from a comprehensive national satellite system to service the capital involved in space and ground facilities and cover the annual operating costs". (15)

Telecom argued that a significant part of the total costs of the system can be attributed to the provision of remote telephony, television and radio services to homesteads and isolated aboriginal communities the revenues would be inadequate to cover costs. If one removes the remote telephony, television and radio service from the system Telecom suggested that there was no significant route or segment of a main route where satellite circuits would be more economical than terrestrial ones.

But more germane to the issues under discussion are Telecom's comments on what it terms "basic issues requiring government decision". They are

> ". What priority should be given to the provision of some 2,000 remote area telephone services at perhaps $40,000 per service to cover both ground and space costs bearing in mind the heavy expenditure on more than 100,000 services in other low return rural areas over the next 8 years. (16)
> . Is greatly increased relaying of commercial television programs required?
> . Just what market is there for Commonwealth Government services, including the ABC, Transport, Health, Education and Defence?
> . Are the broad benefits sufficient to outweigh the shortfall in returns compared with costs? (17)"

These "basic issues requiring government decision" are in fact variations on the points made in its 1977 National Satellite System Studies. In that

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document they were described as issues which "are not within Telecom Australia's capacity to evaluate". They are, in fact, system wide decisions which would need to be derived from a policy embracing the entire communications infrastructure.

Telecom also argued that a low cost entry into the satellite delivery might be best if it was done through the use of leased INTELSAT circuits and if such a decision was made, Telecom, as the national telecommunications entity, should be the operator.

Telecom's opposition to the development of a communication system can be seen as a result of an inherent conflict in the communications policy process. On the one hand Telecom is required to provide the most cost efficient service as is practicable and where inherently costly services are required as a result of Government policy there is a tradition for Government subsidisation of that particular service. (18) On the other hand the drift of Government communication policy which can be inferred from the Task Force Report and the subsequent Report of the Working Group is that Telecom is not adequate to the task of providing a comprehensive service. Telecom is caught in a classical conflict situation.

In October 1979, the Working Group Report was released by the Government. The Report contained the conclusions that because of significant limitations in the current telecommunications system, telecommunications in Australia would be enhanced by the development of a complementary communications satellite system. It should be noted that the representatives of the Department of the Prime Minister and Cabinet dissented from this recommendation and suggested that a decision be deferred while further planning was undertaken over the next year. The representative of the Department of Finance also dissented but thought that the issue should be examined after a lapse of three years. (19)

Based on Canadian experience the Working Group considerably reduced the Task Force's estimate of costs for providing a limited direct broadcast television service to the remote outback. It was estimated that by using low powered transponders for the direct broadcast service a multipurpose system would involve outlays of AUS$200-260m over the period 1982-1992.

The Working Group endorsed the Task Force's recommendation on ownership and control of the system although the Department of Finance representative dissented and argued that if a system was to be created it would be best as a largely autonomous subsidiary of Telecom. (20)

GENERAL ISSUES

Certain aspects of the Working Group Report bear directly on the theme of this paper. These relate to the coordinated planning of the entire communications infrastructure. Some are directed to Telecom's current plans while others are directed to the formulation of broadcasting policy and technical planning which is carried out by the Postal and Telecommunications Department. They are as follows:

1. The Working Group cast some doubt on the economic arguments presented by Telecom. The Working Group was not certain that the point where terrestrial links were less economic than satellite links was where Telecom had suggested. While acknowledging that the "break even" concept is very complex they argued that overseas experiences were difficult to reconcile with Telecom's proposition. As a consequence the Working Group recommended that Telecom should review its trunk route capital program in the northern areas of Australia. (21)

2. Telecom's rural telephony program was also considered. The rural telephony program, previously approved by the Government, and to be achieved using terrestrial means involves the conversion of some 100,000 subscribers from manual to automatic service. The program is to run until 1989 and cost AUS$530 million. The Working Group considered that a significant number of services due for conversion 1985-1989 could be interconnected using a satellite system at a cost which would be comparable with terrestrial techniques. As a consequence the Working Group recommended that relevent areas of Telecom's rural areas program be reviewed. (22)

3. The Working Group also commented on the need for information about the needs of people in remote areas, such as graziers, miners and Aboriginals. Because there is no clear data on numbers of people in remote areas, as opposed to rural areas, the Working Group recommended that Telecom carry out, as soon as possible, a detailed survey to determine the number of potential subscribers in remote areas. It can be seen that Telecom is being encouraged to consider the extension of its service into areas which it would have originally considered to be uneconomic.

4. Frequency allocation in the 4/6 GHz, 11/14 GHz and 12 GHz bands was considered by the Working Group. It recommended that the Postal and Telecommunications Department review the use of those frequencies so that any particular features seen to be necessary in any satellite system should not be compromised. But while not the subject of a recommendation there was some discussion of the costs associated with the rearrangement of the VHF band and the provision of transmission frequencies for broadcasting. (23) Costs associated with making use of the VHF band by providing new transmission facilities was AUS$68m - $100m, while a UHF option was estimated to cost AUS$183m. Given the history of ad hoc and changed decisions in past frequency allocation in Australia the recommendations of the Working Group point to the need to overcome shortcomings in the frequency allocation and planning process.

5. A review of broadcasting policy was also recommended by the Working Group. It was suggested that the Government ask the Minister to submit a proposal for future broadcasting policy taking into account the interests of viewers and listeners, the broadcasting industry and the capabilities of satellite communications. (24) Again there was a recognition of the need for overall planning and coordination.

6. The final recommendation which relates to the issues being considered in this paper concerns a mechanism for the review of investments in communications facilities. The Working Group argued that

> "... because of reliance on a wide range of potential users for sufficient satellite demand and to minimise duplication of facilities, the mechanism should be established to ensure a coordinated approach to investments in communication facilities - this is to ensure that investment actions by any one body do not jeopardise the financial prospects of a national communications satellite system". (25)

What this implies is that there will need to be some coordination across Government departments. For while the Minister for Post and Telecommunications has control over activities within his Department, there is no adequate mechanism for coordination across departments. For this to happen in any sensible manner it will be necessary to clearly articulate the future direction of the entire communication infrastructure.

CONCLUSIONS

In two years since August 1977 plans which will radically alter the Australian communications infrastructure have been formulated. On the surface the most visible indicator of these changes will be a domestic communication satellite system which could be operational by 1984. But while the creation of a domestic communication satellite system is of obvious importance these two years will be remembered because of other less obvious happenings.

The most significant occurrences have been at the level of debate about the nature and direction of the communications infrastructure. For the first time there has been a need to consider questions of broadcasting and telecommunications policy at the same time. And, for the first time since the Post-Master General's Department was reorganised as the Postal and Telecommunications Department in 1975, there have been two inquiries which have revealed strains in the communications policy planning process.

These strains have come about because of the inherent conflict between Telecom and the overall communications development. They have come about because the Postal and Telecommunications Department as it is presently structured does not seem to be able to consider and plan for the development of the communications system as a whole. One aspect of this problem can be seen in the structure of the Postal and Telecommunications Department which was outlined above. While the Policy Division has formal oversight of the Telecom, OTC and Australia Post and questions of broadcast policy are overseen by the Broadcasting Division, coordination and planning of the two sectors must remain cumbersome. And if a domestic satellite commission is added to the system, the strains could become worse.

As soon as the ownership and management structure of the domestic communication satellite organisation is decided it will be necessary to rethink aspects of the management and planning structure of the Postal and Telecommunications Department. The possible addition of another authority intent on growth and market development will make it essential that there is an overall coordinated plan for the development of the communications system as a whole. With such a plan it will be possible to provide orderly development of frequency planning, investment priorities and communication system goals. When this has been done it will be possible to apportion appropriate areas of responsibility to the various communication authorities under Ministerial control.

NOTES

(1) Australia, Parliamentary Debates (House of Representatives) Daily Hansard, Thursday, 18 October 1979, pp.2224-2229.

(2) Department of Administrative Services, Commonwealth Government Directory, 1979, Canberra: Australian Government Publishing Service, 1979, pp.207-214.

(3) It should be noted that the structure of the Postal and Telecommunications Department has been influenced by a series of separate political decisions. The Radio Frequency Management Division was originally located in the now defunct Post-Master General's Department and the Broadcasting Engineering Division was with the predecessor of the Australian Broadcasting Tribunal, the Australian Broadcasting Control Board.

(4) Postal and Telecommunications Department, Australian Broadcasting: A report on the structure of the Australian broadcasting system and associated matters, Canberra: Australian Government Publishing Service, 1976.

(5) Packer, Kerry. Covering letter to Bond, Donald S., The Opportunity for Television Program Distribution in Australia Using Earth Satellites, Sydney: Television Corporation Ltd., 1977. Known hereafter as the Bond Report.

(6) The Publishing and Broadcasting Ltd., Consolidated Press Holdings and Australian Consolidated Press Ltd., group controlled by the Packer family have extensive publishing, broadcasting and other commercial interests. They publish 7 magazines including The Australian Women's Weekly, The Bulletin and Cleo, 8 country newspapers, Little Golden Books. They have significant interests in television stations TCN9 Sydney, GTV9 Melbourne, radio stations 3AK Melbourne, 6PM Perth, and three others. The organisation initiated commercial cricket and now holds the Australian television rights for Test Cricket.

(7) Australian Telecommunications Commission, National Satellite Communications System Studies, Melbourne, November 1977, p.10.

(8) Commonwealth Government Task Force on a National Communications Satellite System, Report, Canberra: Australian Government Publishing Service, 1978.

(9) Ibid. Annex A.

(10) Ibid. pp.126-7.

(11) Ibid. p.XIV.

(12) National Communications Satellite System Working Group, Report, Canberra: Postal and Telecommunications Department, 1979. (mimeo), p.1.

(13) At the time of writing most submissions to the Working Group have not been made public.

(14) As far as the author is aware the Telecom response Australian Telecommunications Commission, A National Communication Satellite System:

A Submission to the Commonwealth Government Interdepartmental Working Group by the Australian Telecommunications Commission, Melbourne, March 1979, has not been made public at the time of writing.

(15) *Ibid*. p.1.

(16) Telecom had announced Government approval for a AUS$500m rural telecommunications expansion. See "$500m upgrade for rural phones", *The Financial Review*, October 17, 1979, pp.1-2.

(17) Australian Telecommunications Commission, *A National Communication Satellite System* ,.. *loc.cit*.

(18) *op.cit*. p.12.

(19) National Communications Satellite System Working Group, *Report*, Canberra: Postal and Telecommunications Department, 1979, p.IV.

(20) *Ibid*. p.VI.

(21) *Ibid*. p.20.

(22) *Ibid*. p.19.

(23) *Ibid*. p.83.

(24) *Ibid*. p.41.

(25) *Ibid*. p.137.

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THE PLANNING DEVELOPMENT AND EXTENSION OF MULTI-CULTURAL BROADCASTS IN NEW ZEALAND RADIO

1975 - 1979

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A review of the activities undertaken by the Broadcasting Corporation of New Zealand - Radio New Zealand Service, from 1975 to the present day, arising from the broadcasting restructuring recommendations of the New Zealand Government appointed 'Adam Committee' of 1973.

Decisions affecting programme content and output examined and explained, and the extension of services to cater for rapidly expanding Polynesian audiences detailed, with indications of the success of schemes completed and further development planned for the next decade.

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The Greater Auckland Region, New Zealand, has the largest urban Polynesian population in the world. At last census - 1976 (i) - 105,250 were identified as being Polynesian, or of Polynesian descent. The largest group is the New Zealand Maori, comprising 65,000 - the remaining 40,000 - the people of the South Pacific Islands - the majority - Fijians, Tongans, Nuieans, Cook Islanders, Samoans and Tokelau Islanders. The total Polynesian population of the country is approaching 320,000 or just over 10%.

By New Zealand standards, a huge audience, and yet, in 1975, except for some Maori news, a weekly magazine programme, and occasional items of Island news there were no other radio programmes to cater for or reflect their interests, cultures, idealogies and customs.

It was a situation that had to change, and moves were already underway to do so. In 1973, the then New Zealand Minister of Broadcasting had announced that a committee of four persons would be set up to advise upon the creation of a new system of broadcasting in New Zealand.

The Chairman of that Committee was Professor Kenneth Adam, CBE, of London, and the 'Adam Report' (ii) was presented to the House of Representatives on 31 July 1973, to become the basis for the Broadcasting Act of 1975.
In the Report, the direction for the development of multi-cultural Polynesian Broadcasting in New Zealand was stated as follows: "In several submissions and interviews, it was represented to the Committee that a Polynesian station should be established in Auckland, that its programmes should focus on music, culture, language and the current concerns of Maoris and Islanders; and that it should be staffed by Maoris and Polynesians whenever current availability or training programmes made that possible."

"The difficulties of providing a real vehicle for the expression of any culture and its language were patently not to be surmounted by devoting to it some half and quarter hour slots out of a programme otherwise designed wholly for the cultural majority."

"The Committee would therefore recommend that a Polynesian Commercial Station be set up in Auckland for the expression, enjoyment, and understanding of New Zealanders of all cultures."

The Committee than added a further dimension -

"Programmes prepared for the Polynesian station would be of invaluable assistance to the External Services of Radio New Zealand. A programme on how Cook Islanders were faring with employment in Auckland, discussed in their own tongue, could be taped and airmailed for re-broadcast in the Cooks with the sure knowledge that it would interest almost every family in those Islands."

(i) N.Z. Department of Statistics "1976 Census of Population and Dwellings"
(ii) "The Broadcasting Future for New Zealand". Adam Committee on Broadcasting.

For the most part, Pacific Island people do not have shortwave receivers, therefore the shortwave overseas service needed to provide specific programmes which could be relayed through local medium wave transmitters. A dependable and regular news service, particularly in the language of the listener was essential for the South Pacific - an area where an adequate newspaper service had not been developed, and where broadcasting had been able to identify itself closely with the heart and soul of Pacific life.

It would also help publicly to ensure that neighbouring countries were kept widely informed of day to day policy developments within New Zealand.

The direction had been given, the Broadcasting Act 1975 was passed into law - the planning could begin in earnest.

It was generally agreed that New Zealanders stood to be enriched, by programming of ethnic material for our two cultural streams (European and Polynesian) - as such programmes can enhance the way people perceive themselves and their culture and languages.

The questions to be answered were many - (1) Who should co-ordinate and plan the new station? (2) What should be the location of the station? (3) How many staff would be required, or desirable? (4) How many cultures/languages should be reflected in the programmes? (5) What was the biggest need? (6) What type of programmes would be most effective? These questions and many others were put to many groups and individuals including the Department of Maori and Island Affairs, the New Zealand Maori Council, the Maori Womens Welfare League, the Maori Artists and Writers Association, and the Auckland Polynesian Council.

By mid 1975, full support for the concept had been given by all interested parties, and a significant request was received from the National Maori Continuing Education Committee that full consideration be given to the appointment of a Maori or other Polynesian to be Manager of the new station. This was agreed, if a suitable person could be found.

Concurrently, and to assist with the foundation of an archive for the new station, a research project was requested from the Maori Research Institute at Waikato University, to catalogue the Maori Archive material held by Radio New Zealand.

Further, the Broadcasting Corporation commissioned a survey among the Islands of the Pacific to determine audience needs - the funding being provided by the Foreign Affairs Department of the New Zealand Government, and - made a recommendation that a Maori and Pacific Island Programme Consultative Committee be set up.

This last Committee when finally established, was to become a catalyst for the later development of programme concepts.

Maori News and Cultural programmes had meantime continued at their old level, on the National Radio Network, and in mid 1976 a weekly news bulletin in Samoan and Cook Islands Maori (or Rarotongan) and a musical programme of the Pacific Islands were introduced.

Then in November 1976, authorisation was given by the Board of the Corporation of Radio New Zealand for detailed costings and surveys for the establishment of a station such as that envisaged in the Adam Report, to be prepared.

Preliminary investigations, and discussion had decided that the site should be in close proximity to the major concentration of the Maori and Polynesian population living in the greater Auckland area. It was believed that as the station was to reflect the cultures, social and economic values and happenings, then it should be close to, and available for access by interested parties.

However, when the detailed surveys were completed, it was agreed that in the four year period since the presentation of the Adam Report to Parliament, financial considerations, particularly the economic downturn being experienced in New Zealand, and the policy of the Government, had dictated that the blueprint for the separate Polynesian station be shelved in the meantime, but that some action could be taken within the existing framework of Radio New Zealand's three Networks, and Shortwave Service.

To quote from the report of the then Radio New Zealand Programme Supply Manager, Bruce G. Broadhead -
"Maori and Pacific Island Programmes are behind the times in their content and presentation, and lack clear objectives. The total Radio New Zealand output shows little evidence of the quarter of a million Maoris in the country. This is probably of greater importance than the adequacy or otherwise of the special programmes, since it affects the Community Stations to which most people listen."

(In 1977, the staff working specifically in the compilation of Maori and Pacific Island programmes numbered 5 - 3 in Wellington, the Radio Network Centre, and only 2 in Auckland, the population centre.)

So the time had come to act - lack of money notwithstanding, and Radio New Zealand called a meeting of a planning group in Auckland at which the following points were to be discussed.

(1) The requirements of Polynesian audiences in New Zealand and the Pacific.

(2) The requirements of the general New Zealand audience for Maori and Pacific Island programmes.

(3) A system for gathering and disseminating news and information covering
    (a) The Maori and Polynesian populations in New Zealand, and
    (b) The Pacific Islands.

(4) The organisational structure and arrangements needed to satisfy these requirements efficiently. (This last to be concluded after the resolution of the first three.)

In June 1977, the planning group - comprising Broadcasting Executives, Maori and Pacific Island programmers and News and Current Affairs staff, met and produced recommendations based on the Polynesian station concept, but utilising existing outlets.
Broadly, they providedfor:

(1) The establishment of a Maori and Polynesian Broadcast Unit with a Manager and a staff of seven - including two journalists, preferably Polynesian, three Maori programmers, and two Pacific Islands programmers.

(2) For the Maori listener -
    (a) a daily bulletin of news in Maori on the National Network
    (b) A weekly (Saturday) programme in English of and about Maori affairs
    (c) A weekly (Sunday) programme in Maori covering current events
    (d) Encouragement of local Community radio stations to broadcast a daily news bulletin in Maori.

(3) For the Polynesian/Pacific Island listener -
    (a) A daily news bulletin to be broadcast by the Mediumwave and Shortwave stations in the vernacular languages - Cook Islands Maori, Samoan, Tongan, Nuieah, and Tokelau - the news to be gathered and translated by people of these nations, working from Auckland.
    (b) A daily programme of music, shipping news, weather etc on the shortwave service.
    (c) A weekly digest of South Pacific happenings broadcast on shortwave.

(4) The continuation and extension of a topical tape service of magazine material to be airmailed to the Pacific Island Communities, for playing by their own mediumwave stations.

The planners also recommended that, in general English language broadcasts, to assist in reflecting the multi-cultural South Pacific society existing in New Zealand
(a) emphasis on Maori language and pronunciation to be continued,
(b) efforts to recruit Polynesian "on-air" staff be revived,
(c) announcing staff with sufficient knowledge be encouraged to reflect on Maori and Polynesian matters of moment in their broadcasts.

Finally, they stated that the Unit should be sited close to its Polynesian audience, at Papatoetoe, a suburb ten miles south of the centre of Auckland.

These proposals were substantially accepted and were actioned.

On Monday, 24 October 1977 vernacular broadcasts started.

There were problems in hiring and training suitable staff, particularly from the Pacific Islands. There were some small tribal jealousies, but these paled into insignificance before the acceptance with enthusiasm of the programmes by the people they are designed for.

Earlier I mentioned the recommendation, that a Programme Advisory Committee be formed. The Advisory Committee was to consist of fifteen persons, not less that eight Maoris and not less than four covering the ethnic groups described by the term 'Pacific Islanders' - Samoan, Cook Islanders (Raratongan) Tongan, Fijian, Nuie and Tokelau. In early 1978, the Committee was formally constituted. (In its present composition it actually has nine Maoris, including the Chairman, two Samoans, one Tongan, one Tokelaun and one Cook Islander. Radio New Zealand staff are ex-officio members of the Committee.)

The specific functions of the Committee are:

(a) to advise Radio New Zealand on matters relating to Maori and Pacific Islands programme needs in its general services, including Commercial (Community) stations, local and network stations

(b) to advise and comment on Maori and Pacific Islands programmes

Using the above as a yardstick, in June 1978, the Committee nominated priorities for development in the next five years. They considered the specific areas of: time placement, stations used, content, interest felt among the audience (grassroots, grapevine comment) and the ease of understanding.

The priority areas nominated were:

(1) The educational needs of the Maori and Polynesian population. Programmes had already been included in the National Broadcasts to Schools sessions, and these were continued. (See below)

(2) Informative programmes designed for Pacific Islanders living with Europeans. The opinion was that they wished to hear programmes spoken in their own language rather than English, however, if they were also broadcast in English, those who could not understand the Polynesian languages could benefit as well, therefore developing an appreciation of the problems facing the Polynesian New Zealander. Specifically, the programmes required were News, Current Affairs and educationally orientated material.

(3) As a Programme Supply Section, the Maori and Pacific Islands Unit should be directed to advise Community Stations on matters concerning or reflecting the language and cultures of the Polynesian people.

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(4) Positive discrimination should occur within the employment policies of Radio New Zealand to ensure the employment of suitably qualified Maoris and Pacific Islanders to reflect the population basis.

(5) Talk back programmes should be introduced, discussing things Maori in the English and Maori languages, and things Polynesian in the English and Polynesian languages.

This was a tremendous demand for Radio New Zealand's programmers to meet and while it could not be done overnight, a programme schedule was developed for the seventeen non-commercial stations:

Daily 7.00 pm - Maori and Pacific Island News in the vernacular
7.18 pm (following the News), a magazine programme featuring one of the cultures. The schedule is: Monday - Samoan, Tuesday - Maori, Wednesday - Tongan or Tokelau, Thursday - Nuiean, Friday - Cook Islands Maori.
Saturdays at 5.30 pm for half an hour, there is a programme called Tangata atu Motu - a Pacific Newsletter in English.
Sundays from 9.30 pm for half an hour, a two-way Pacific Music Requests, programme.
During the week there are also four programmes dealing with Maori culture and language..

By 1978 the staff of the Unit had increased, and now included the Manager, Haare Williams, a Maori with a teaching degree in Maori Studies and Education from the University of Waikato; Wiremu Kere Kere, a broadcaster of many years experience, an elder with much 'mana' (or standing) among the Maori people; Maori and Pakeha (European) journalists; two Maori programme presenters and programme presenter/translators from Nuie, Tonga, Samoa and the Cook Islands.

Within the programme framework, the staff have reached out into the New Zealand Polynesian Community, and produced programmes which have reflected the priorities laid down. For example - under (1) above - Maori language lessons for the beginner, an important part of the broadcasts, were scheduled for playing on thirty stations both Commercial (Community) and non-Commercial. This need for Maori language information had been developed in the early 1970's when a session called 'Maori For Beginners' comprising twenty-six lessons written by Professor Bruce Biggs, had been broadcast.

In our Broadcasts to Schools:

(a) A programme called 'Mo Te Ranga Tahi' has been included. This has been aimed at introducing children to the world of the Maori. While the main emphasis is on life in pre-European times, some of the material has dealt with the problems and experiences of Maori people in the present day, thus enabling the children to relate what they learn to their own experience. School teachers have taped the programmes so that children can learn the songs and recite the poems in Maori that have been included.

(b) A series of plays called Springboard was written within a range of language suitable for children learning English as a second language, and was directed primarily to those youngsters from the Pacific area and now living in New Zealand. Each story has folk origins in parts of the South Pacific area, and supplies some experience of imagination and fantasy often absent from pure language teaching.

(c) For many years the policy of including Maori songs wherever possible in the various singing lessons has been followed. These have been of both traditional and modern origin, and have been featured at Standard 1 - 4 (ages 7 - 11) and Form 1 - 2 (ages 11 - 13) levels.

(d) Family of Man social studies programmes directed to Forms 1 - 4 have included the MAORI WARS, THE MARAE, and THE FOREST OF TANE MAHUTA. These broadcasts based on Maori topics have been designed to demonstrate cultural differences, interaction, and social controls and change, as required by the school syllabus.

Under (2), leaders of the Pacific Islands Community in Auckland and Wellington, (the main areas of population concentration) have taken part in interviews, discussions and talks, on topics considered to be of major importance. These broadcasts have mainly been in the vernacular.

In addition, and following considerable discussion with Maori and Pacific Island church leaders, a meeting was held in Auckland to review and revise practices in the broadcast of church services, and to canvass ideas for further development of programmes reflecting Maori and Pacific Island concerns, as part of the regular output of religious programmes on Radio New Zealand. As a result of this discussion, new arrangements have been made for regular broadcasts of Maori and Pacific Island church services with the emphasis, at those groups' request, on special services designed for broadcast.

Two major steps were taken in 1978. In the first, a 'Maori Language Week' was declared throughout New Zealand, and special programmes were broadcast relating to all things Maori. It was a tremendous success, and in 1979 on the basis of the success achieved the previous year, a formal programme of broadcasts was drawn up. A schedule of broadcasts is attached as Appendix I. The Programme included Maori customs and language lessons, music, greetings and proverbs. These last three were also included in English language broadcasts. All new material was recorded for future replay.

Secondly, a full coverage of the New Zealand Polynesian Festival of Music and Culture in Lower Hutt was undertaken, by adopting for three days the earliest recommendation of the Adam Committee, for a 'Radio Polynesia'. Radio New Zealand obtained a temporary licence for a low power repeater station in Auckland with a transmitting strength of 1 kw, and linked it with Wellington's 20 kw auxiliary station 2YB.

Programmes interspersed with news broadcasts and live inserts from the Festival were broadcast over three days - Friday, from 12.00 noon -10.00 pm,

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Saturday, 6.00 am - 11.00 pm, and Sunday 6.00 am - 2.00 pm.

Staff from the Unit were supplemented by Production and Administrative staff from other sections, and the whole exercise (for just three days broadcasting, temporary stations etc) was budgeted at just under NZ $7,000.

The programme reflected all components of the five priorities laid down by the Advisory Committee - talk back, open and access radio language teaching, educational programmes, a church service, aspects of lifestyles and cultures. A schedule is set out in Appendix II.

To say the least, it was a resounding success, and has set an excellent precedent for future occasions. That it was so, was due in no small measure to the professionalism and enthusiasm of staff involved.

The shortwave stations of Radio New Zealand also relayed the programmes on the Saturday and Sunday.

I must mention here the development of the 'Pacific Service Hour', a programme beamed to the Pacific Islands by our shortwave transmitters, at 2,300 GMT, Monday to Friday. You will recall a recommendation from the Planning Group of 1977, for a daily news bulletin in the vernacular of the Pacific Islands peoples. In this broadcast, the news in English is followed by news in the vernacular - Tongan, Samoan, Nuie, Cook Islands Maori, and finally a programme of musical requests. It is the first step, in sending to the Islands people, news about New Zealand, and its Polynesian peoples. Consideration is currently being given to including this broadcast hour on internal mediumwave stations to better serve the need for news and information of the indigenous Polynesian population.

The development continues. In November and December, a series of six ninety minute open-line talkback sessions was scheduled for the Concert Network as planned by the Advisory Committee, in their fifth recommendation.

In summary -'Te Reo O Aotearoa' - the Voice of New Zealand - is now heard throughout the South Pacific Basin, through Radio New Zealand's mediumwave and shortwave transmitters.

The logohead of the Unit symbolises the coming together of the two cultural streams in NewZealand - Polynesian and European. (See Appendix III)

It is a strong and vital infant, and with planned expansion in telecommunications in the years to come, has a rôle to play in the cultural and economic development of the peoples and countries its programmes reach, that will far exceed its humble beginnings.

To quote Haare Williams, Manager of the Unit - "Our objective is the expansion of Maori and Pacific Island programmes. It is that, and no less...."

Tena Koutou Katoa

The author acknowledges the assistance of Haare Williams and Wiremu Kerekere of Te Reo O Aotearoa in providing background information, and Beverley Wakem of Radio New Zealand for her support and encouragement.

GLOSSARY

Maori:

Marae - Courtyard for gatherings
Mo Te Rangitahi - for the young generation
Tane Mahuta - The forest of Tane (God of the Trees)

Samoan:

Tangata Atu Motu - People of the Islands

APPENDIX I

MAORI CULTURAL WEEK - TE REO O AOTEAROA

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY		SATURDAY
10.30	News in Maori and News in English Music Mini documentary		News in Maori and English Music Mini documentary	Music Mini documentary		6.00	News in Maori & English Breakfast stations with guest
11.00	Opening & Centres	Access Radio Rotorua	Access Radio Hastings	Access Radio Dunedin		6.30	Mini documentary Music & chat with guest
11.30	Akona te Reo - Maori Language lessons Music of the Maori Korero Maori - thoughts of people in the Maori language					7.00	News in Maori & English Sport
						7.30	Comment Music of the Maori Summary
12.00	News in Maori and the News in English						
	Music	Music	Music	Music			
12.30	Telephone talkback Harry Dansey	Telephone talkback Nick Brown	Telephone talkback Group of Youth	Telephone talkback Ann Tie		12.30	News in Maori & English Sports Music News Summary
1.00	News in Maori & English Music	News in Maori & English Music (live)	News in Maori & English Music (live)	News in Maori & English Music (live)	News in Maori & English Music		Music NZSO Ngaruawahia Sport Access radio-Ruatoki School
	1.20 pm to 2.00 pm - Broadcast to Schools 150 word insert						
2.00	News in Maori & English	News in Maori & English	News in Maori & English	News in Maori & English	News in Maori & English		News in Maori & English
2.30	Sth Auckland Sec. Schools Competition Myths & legends	Story. Bruce Stewart	Story: Wiremu Parker	Story: Katerina Mataira	Akona te Reo - Language lessons OPEN RADIO Papatoetoe		Activities around the country
3.00	Comment News in Maori & English Activities around the country				News in Maori and News in English Comment OPEN RADIO Public invited		Comment Talkback- Alby Prior
3.30	1979 Polynesian Festival Kingi Ihaka						
4.00	News in Maori & English				News in Maori & English Music & Mini documentaries Korero Maori		News in Maori & English Music & Mini documentaries In Maori.
4.30	Whaikorero (Oratory)				Whaikorero (Oratory)		Whaikorero (Oratory)
5.00	Closedown				Closedown		Closedown

Mini documentaries: Endorsements of Maori language, personalities in the Maori world, what's going on, place names, proverbial sayings, local activities to promote language (2 mins long).
Programmes will attempt to give a sense of national involvement - e.g. Access Radio. Activities around the country etc.

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APPENDIX II

TE REO O AOTEAROA FESTIVAL 79

FRIDAY 16 FEBRUARY

12.00	Birdcall, hymn & prayer. News in Maori & English
12.30	Midday Music & Comments with Henare Te Ua (announcements)
1.00	Samoan news & English news
1.30	TANGATAWHENUA - the people of the Te Whanganui-a-Tara Welcome by Tangata-kainga
2.00	Cook Island News & English News POLYNESIA - a background
2.30	Taped music. mini documentary Taped music and announcement
3.00	Niuean News & English News Music
3.30	The musical & literary forms of Polynesia.
4.00	Tongan News & English News
4.30	Music & announcements
4.45	Muru - Scripted - Poetry from the Pacific (English)
5.00	Tokelauan News & English News Music & announcements
5.55	Mini documentary - (personalities)
6.00	News roundup - English, Maori, Tongan, Cook Island, Niuean, Tokelauan.
6.30	Music & background to Festival A background to Life in Samoa A background to life in Niue.
7.00	News in Maori & News in English
7,05	TELEPHONE TALK BACK Hosts: Kingi Ihaka & Ralph Love & a Pacific Island Leader.
8.00	News Questions about the Festival, background, previous occasions
9.00	PLAY MUNGU by Bruce Stewart
9.45	News roundup & highlights
10.00	Birdcall, hymn & prayers

SATURDAY 17 FEBRUARY

6.00	Birdcall - prayer - hymn News highlights and announcements
6.30	News in Maori & English
7.00	Music for breakfast & announcements with host
7.30	Mini Documentary Music & Telephone enquiries
8.00	News: Samoan, Cook Is, Tongan, Niuean & Tokelauan & English
8.30	Ceremonial welcome by tangatawhenua and Tangata-kainga to Van Ihaka, Festival Committee, Te Atairangi Kaahu & visiting tribes
9.30	Combined welcome to His Excellency The Governor-General, Vice Regal Party, Prime Minister, Diplomats,
10.00	Dedication service Interviews with Dignitaries at the Festival FESTIVAL PERFORMANCES 10.15 - 1.00
1.00	Music
2.00	Cook Is News & News in English
2.30	Festival Performances With description & comments
5.30	News in Maori & English
5.55	Music (snippets from Festival) Mini documentary (personalities)
6.00	News - English, Maori, Cook Is, Tongan, Niuean, Tokelauan. Samoan, Music (snippets from Festival)
6.30	Background to some of the Pacific Island groups participating
7.00	News: Samoan, Cook Is, Tongan, Niuean, Tokelauan.
7.05	Legends of Polynesia
7:30	Festival performances to continue with relevant comment
10.30	News roundup and highlights Hymn, prayers, and birdcall

SUNDAY 18 FEBRUARY

6.00	Birdcall - Prayer - Hymn News highlights & roundup
6.30	News in Maori & English Music for breakfast and announcements with host
7.00	Mini documentary
7.30	News in Maori & News in English Music for Breakfast
8.00	Church Service
8.30	News in Maori & English
8.45	Polynesian Festival News
9.00	Final performances at Festival with comments and background.
1.00	News in Samoan, Cook Is, Tongan, Niuean. Tokelauan & English
1.30	Music from the Festival Poroporoaki (Tangata-kainga) Valedictions & farewell News roundup & highlights Prayers, hymn, birdcall

ENDS.

ADDITIONAL INFORMATION

29 groups participating
19 Maori tribal groups, 10 Pacific Island groups

Ceremonial - on grounds
Festival - on stage

1000 performers expected

Expected crowd: 6,000 +

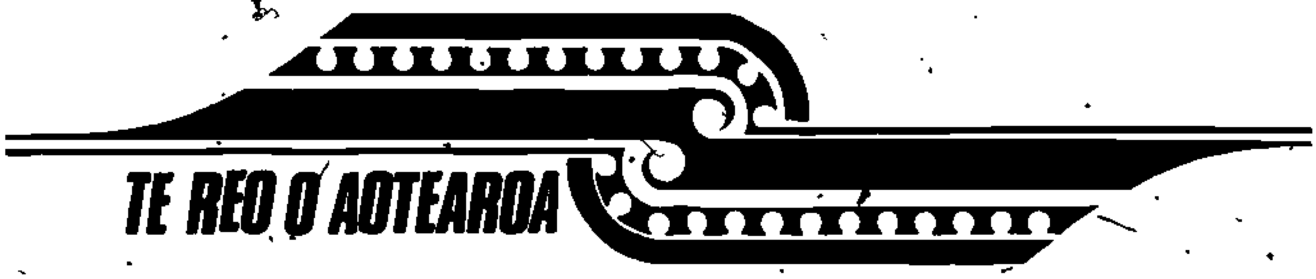
Ceremonial welcome
Performed by host group Te Upoko o Te Ika Party, about 400 strong.

8 - 10 speakers in both ceremonies

Alternative venue
In case of wet weather - Lower Hutt, Town Hall.

Vehicles:
Te Reo O Aotearoa vehicle
Radio New Zealand car

APPENDIX III



(1) TE REO O AOTEAROA is a phrase which symbolises the "VOICE OF NEW ZEALAND" and also symbolises the principles of communication.

(2) THE LOGO represents the coming together of our two cultural streams and meeting at a central point on equal terms.

(3) THE CENTRE of the design stands for the "HOOK" which fished up the Islands of the Pacific. In New Zealand, it was the culture hero MAUI who performed this feat.

(4) THE OCTOPUS is also represented in the design - a common feature of myths, legends and stories in the Pacific.

(5) THE HORIZONTAL lines stand for the far horizons reached by migrant peoples to come to Aotearoa - including Maori people.

(6) COLOURS - blue for the Pacific - Te Moananui-a-Kiwa.

RECEPTIVITY TO THE IMAGE MEDIA

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Abstract

This report describes three analysis related to such emarging media that utilize both existing telephone links and TV screen at home such as CAPTAIN system[1] or VRS[2].

1. Classification of Informational Content and Media
2. Measurement and Analysis of the Effect on the Recipient and Differences in the means of Transmission
3. Verification of the Process by which Information Terminals Proliferate

All these analysis were carried out from the recipient's point of view. We fear that preoccupation with technological function may shade social choices of a medium. In Japan, the phrase 'excuse my just using the phone' is already 10 or 20 years out of date. This implies the importance of social choices, rather than technological functions.

INFORMATION HAS TWO ASPECTS - HARD NEWS AND ENJOYMENT.

The fact is that there are no clear conceptual standards for information. In considering information, the general course is to divide it into information in the narrow sense, and other information, i.e., that portion of information in the broad sense not included in the narrower term. However things that are designated as information in the broad sense by one theorist are often included in the narrower sense by another. With the rise of teletext and CATV systems, a different breadth attaches to the term 'information' when applied to TV's role not only as an entertainment medium but also as a medium of information and education, compared to when it refers to TV as a today's typical informational medium, carrying entertainment, news and educational programs.

FOOTNOTE

(1) Japan's wired teletext system which can display 8 lines of 15 characters on TV screen, when requested through telephone links, but now at experimental stage.

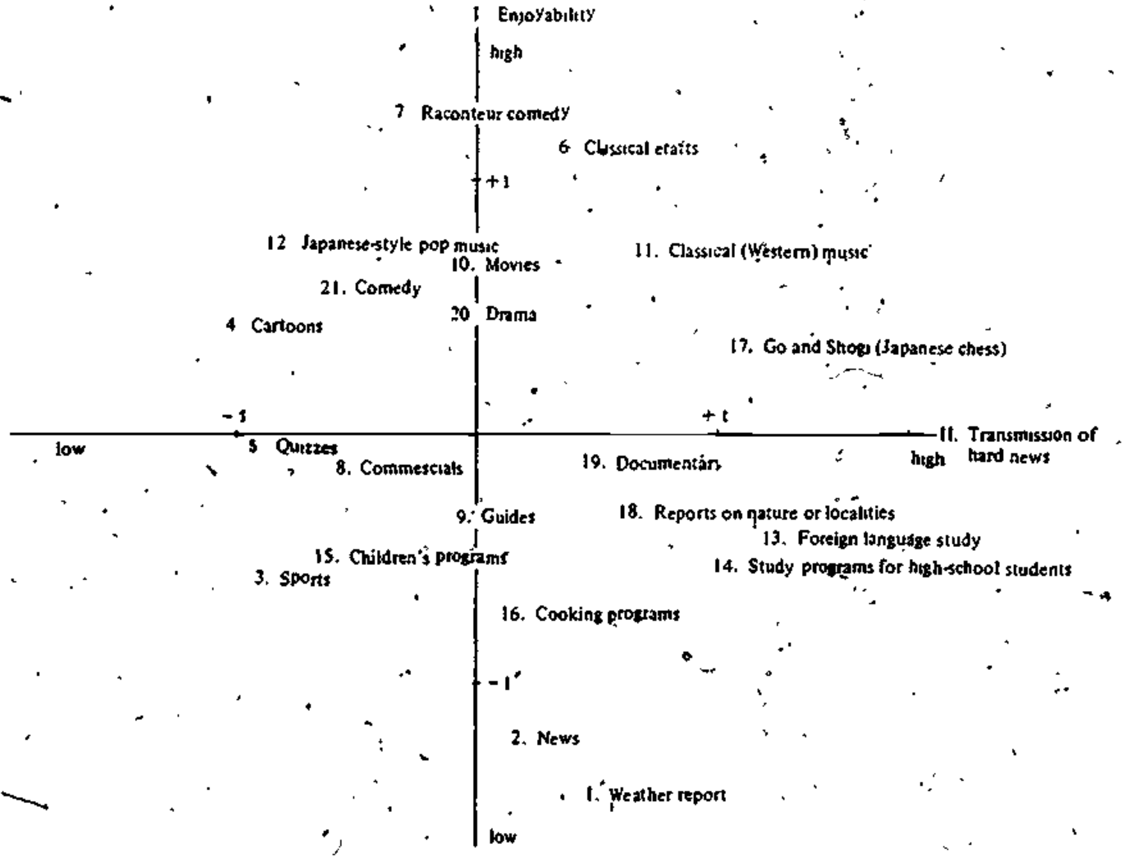
(2) Video response system, an image medium which can display both written text and motion pictures on TV screen, when requested through telephone links, developed by Nippon Telegraph and Telephone.

Any attempt to classify information according to a simple standard will be a ponderous exercise. One might consider that Euro-american movies are entertainment information, but there was a time when they were the ultimate source of fashion news for Japan's tailors. In those days, watching foreign movies was part of a tailor's job, so that a single-dimensional classification based on work and play will not clarify the position of foreign movies.

There are various aspects to information. In the example of foreign movies, most people focused on the entertainment aspect but tailors were primarily aware of the fashion news content. To take the example of TV commercials, some people may view them as entertainment, while others see them as product information. The important aspect is that which is focused upon by the recipient.

The nature of information is more easily understood if considered in two dimensions. Taking information via TV as a model, the question of what aspect of programs held people's attention was investigated. For this purpose, recipients' evaluations of similarities among programs were converted into distances separating the programs, and plotted two-dimensionally in Diagram A. Children's programs and commercials, and drama and movies formed similarity pairs, while Japanese-style pops and Western classical music, though both come under 'music', were very different; indeed it can be seen that Japanese pop music is closer to comedy.

EXHIBIT A. SIMILARITIES AMONG TV PROGRAMS



There are two factors to consider in information—hard news value and entertainment value. The horizontal axis in Exhibit A is an index of usefulness or informativeness. Since it can be considered as showing information in the narrow sense, it was called the hard news axis. The vertical axis is an index of emotional stimulus, and since it can be considered as showing information other than that included in the narrow sense, it was called the enjoyability axis. Thus the nature of information can be clarified by the way it applies stimuli of two kinds—hard news and enjoyability, bringing into relief the two aspects of information.

INFORMATION SERVICES ARE IDENTICAL WITH THE MASS MEDIA

There are those who consider the new media that are now making their appearance as occupying a middle ground between the mass media and the personal media. For reception of information via the new media is recognized as differing on the one hand from personal communication, in which sender and recipient interact upon each other in a paired relationship, and on the other from mass communication, in which transmission is unilateral, from sender to a multitude of recipients. There is also a recognition that the number of recipients differs vastly from that of the mass media.

In terms of the number of recipients, the difference from the mass media is unclear. Exhibit B compares existing media with the new media, showing the boundaries for representative media according to the number of recipients, and to the types of information source (the number of channels) as perceived by the recipient. Exhibit C tabulates these coordinates.

EXHIBIT B. POSITIONING OF NEW AND EXISTING INFORMATION MEDIA

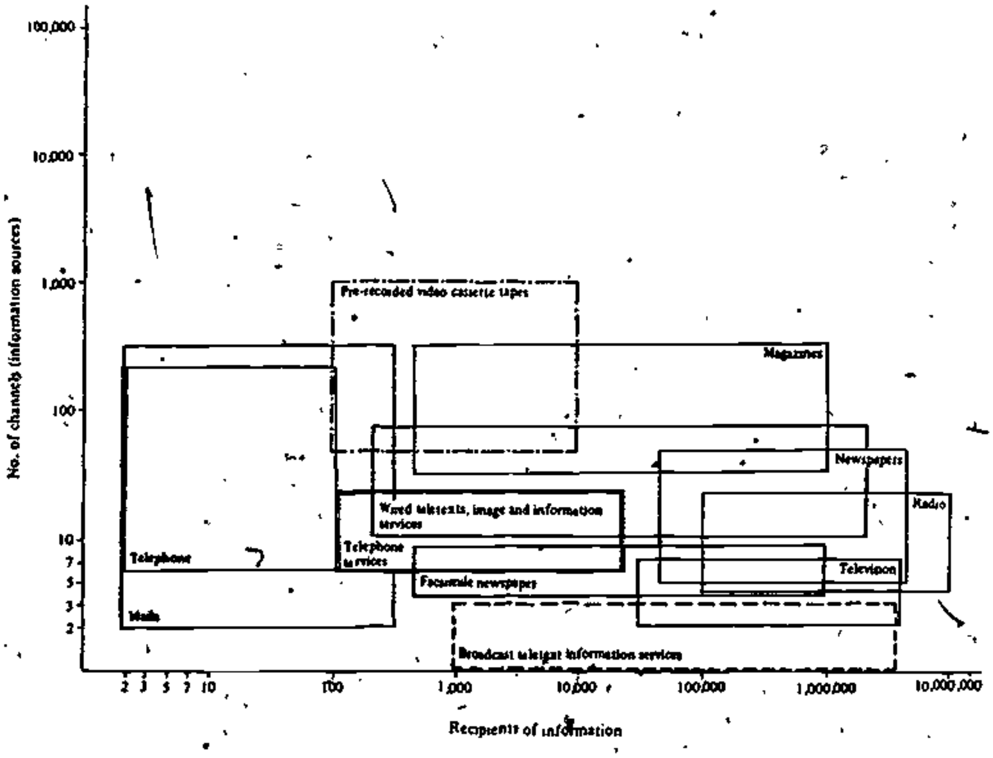


EXHIBIT C. CHANNELS AND NUMBER OF RECIPIENTS OF INFORMATION MEDIA

Medium *indicates newly appeared information service media	Channel	Estimated No. of channels	Recipients	Estimated number of recipients
Telephone	No. of reachable subscribers	6 ~ 200	Called parties and those receiving transmitted content	2 ~ 100
Telephone service*	Kinds of service	6 ~ 20	Subscribers per service	100 ~ 20,000
Radio	Stations receivable	4 ~ 30	No. of listeners	100,000 ~ 10,000,000
Broadcast teletext (written transmission)*	Kinds of service	1 ~ 3	No. of viewers	1,000 ~ 3,000,000
CATV teletext (Prestel, Captain)*	Kinds of service	10 [illegible]	Subscribers per service	200 ~ 2,000,000
CATV information service (VRS)	Kinds of service	10 ~ 70	Subscribers per service	200 ~ 2,000,000
Facsimile information service	Kinds of service	10 ~ 70	Subscribers per service	200 ~ 70,000
Telex	No. of reachable subscribers	2 ~ 200	Called parties and those receiving	6 ~ 30
Facsimile	No. of reachable subscribers	1 ~ 70	Called parties and those receiving	4 ~ 30
Facsimile newspaper (facsimile broadcasting)*	Kinds of newspaper receivable	3 ~ 8	No. of receivers	500 ~ 1,000,000
Newspaper	Kind of newspapers available	5 ~ 50	Circulation	5,000 ~ 5,000,000
Magazines	Kind of magazine available	30 ~ 300	Circulation	500 ~ 1,000,000
Books	No. available for reference	100 ~ 100,000	Size of press run	500 ~ 100,000
Mail	No. of potential correspondents	2 ~ 300	Correspondents and those receiving transmitted content	2 ~ 300
Pre-recorded video cassette tapes	No. of programmes for sale	50 ~ 1000	No. of each program sold	100 ~ 10,000
Movies	No. that can be seen	10 ~ 70	Size of audience for each movie	1,000 ~ 700,000
Television	No. of channels	2 ~ 7	Size of audience	30,000 ~ 5,000,000

Note: as for figures scale in powers of 10 is important.

The new media occupy a position intermediate between the mass media and the personal media, but in terms of the number of recipients, there are many areas in which they overlap mass media. This is the result of the fractionalization of the market by the existing mass media, which has meant fewer recipients, i.e., a movement to the left in the diagram.

The quality of communication too is no different from that of the mass media. Since in the new media a selection signal moves along the information-transmission path from recipient to sender, these media are referred to as 'bi-directional', but this bi-directionality of signals in no way implies the establishment of two-way personal communication. Except when a flesh-and-blood human being responds to the individual recipient, there is no basic difference in the reception of information provided by new media information services and of that from the mass media.

The new media are a diversification and individualization of the mass media. Differing not at all from the mass media either in the quality of communication or in the number of recipients, the new media cannot help but be considered by the recipient to be identical with them. New media do not package their information in order to meet the preference for diversification. New media are merely edited individually, and do not respond individually to each recipient. Thus for the recipient, the positioning of the new media is no different from a response to the market fractionalization of the mass media, or a response to diversification and individualization. The only difference to be seen in comparison with before is in the means of access to the information source, and the mode by which transmission takes place.

The transmission mode should be selected in accordance with the content of the information. There is a tendency to consider that images are the most effective transmission mode. It is true enough that image information comes closest to face-to-face transmission, and that teleshopping*, which is heralded as the next revolution in retail trade, is thought to depend on the development of CATV. However it is also pointed out that if the viewers are naive, there is a danger of frequent misunderstandings. Thus the fact is that images are not a panacea; what is essential is to select a mode of transmission that is suitable for the content of the information.

EMOTIONAL IMPACT WAS THE HIGHEST IN MOTION PICTURES PLUS SOUND MODE.

EXHIBIT D. EVALUATION OF IMPRESSIONS- EMOTIONAL IMPACT FACTOR

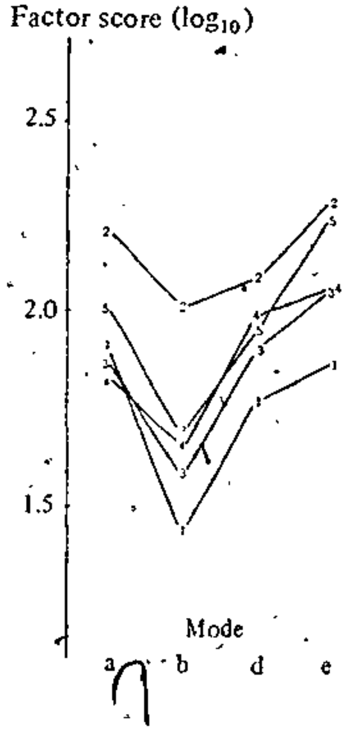
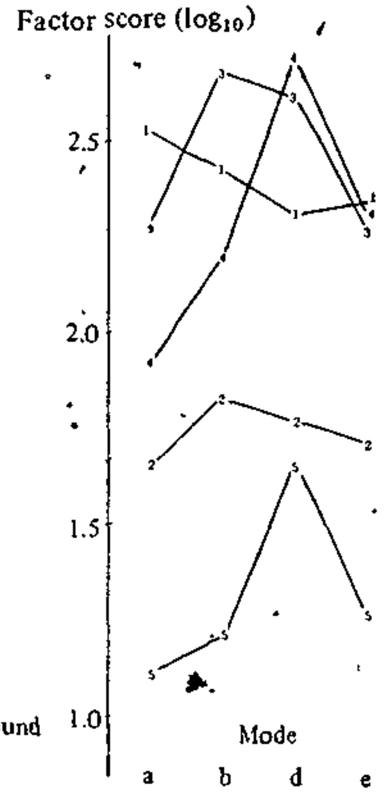


EXHIBIT E. EVALUATION OF IMPRESSIONS- EASE OF TRANSMISSION OF MEANING/CONTENT



a – e indicate modes
a = sound
b = writing
d = writing + sound
e = motion picture + sound
1 – 5 indicate contents

Subjecting the Evaluation of Impressions to factor analysis suceeded in bringing out two factors—emotional impact and ease of transmission of meaning/content. The scores of each respondent were then obtained for each factor, and the averages are shown in Exhibit D and E.

(1) Regular mode differences were observed in emotional impact, no matter what the informational content.

The pattern of the emotional impact factor showed great similarity for all contents. Since the aggregate of emotional impact is inherently different for each content, the fact that the patterns are the same signifies that there is a regular mode difference, irrespective of content. Thus in this area it is possible to make a definitive statement on mode differences. If the emotional impact of the writing mode is taken as 1, that of sound is 2.0, writing + sound is 1.8, and motion pictures + sound, at 2.7, is the highest.

(2) It was impossible to observe any mode differences in the ease of transmission of meaning that transcended content.

The factor 'ease of transmission of meaning content' measured reactions in the psyche. The fact that consistent results were not obtained is due, we feel, to the attitude of the respondents to the experiments, and the fact that the questions on the memory tests were too easy.

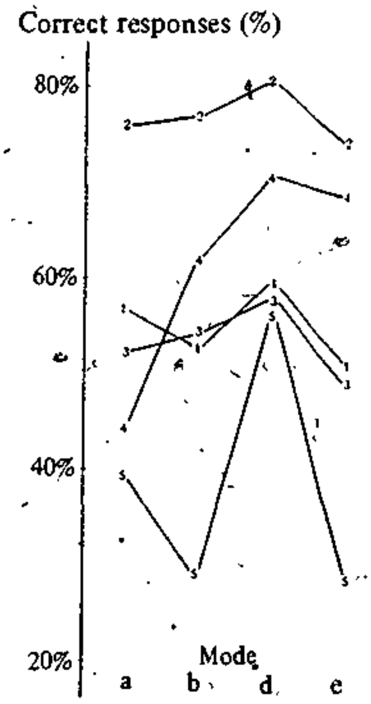
Since there was no regularity in the pattern of ease of transmission of meaning/content for the various contents, we can only discuss mode differences in terms of the nature of the content. This said, the results show that the motion pictures + sound mode shows no superiority over the other modes, and indeed those modes that involve writing are better.

All in all we may say that when one comes in contact with information for the purpose of learning something, there may be differences in the ease of transmission, but in the end meaning/content will be accurately transmitted, irrespective of the mode in which it is presented. The existence of mode differences shows the ease with which emotion can be transmitted. Transmission was easiest in the motion pictures + sound mode, followed by sound, writing + sound, and lastly by the writing mode. This can be shown numerically, giving the writing mode a value of 1, in which case the score for the writing + sound mode is 1.8, the sound mode is 2.0, and motion pictures + sound mode is 2.7.

(3) No mode differences were observed in the accuracy of meaning/content transmission for information in which meaning/content transmission was emphasized.

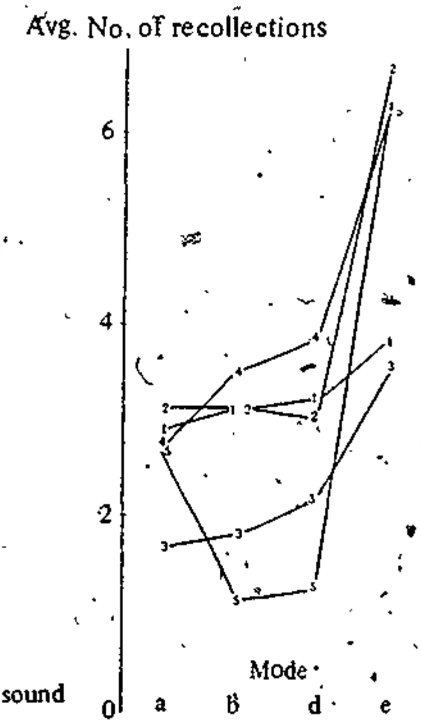
The percentage of correct responses to Memory Test I were calculated and are shown in Exhibit E. Although there were differences in the level of correct responses according to content, there was no mode difference for Contents 1, 2 and 3. The fact that Content 4 scored lower for the sound presentation than for the other modes can be explained as follows: Presentations in the sound mode were, for all the contents, by means of the original voice of th program narrator, and the narrator of Content 4, perhaps because he was, unlike the narrators of the other contents, an amature-spoke rapidly and with indistinct pronunciation. It is thought that the cause lies in this peculiarity of this narrator. Since Content 5 was a commercial, it was not in any case the aim to transmit meaning or content; it was considered essentially different from the other contents. Thus in the information with which we are concerned, we may say the accuracy with which meaning/content was transmitted did not exhibit any mode differences.

EXHIBIT F. MEMORY TEST I



a — e indicate modes
a = sound
b = writing
d = writing + sound
e = motion picture + sound
1 — 5 indicate contents

EXHIBIT G. MEMORY TEST II



(4) In the ease of recall of peripheral information, the motion pictures + sound mode scored highest, but there was no difference in the other modes.

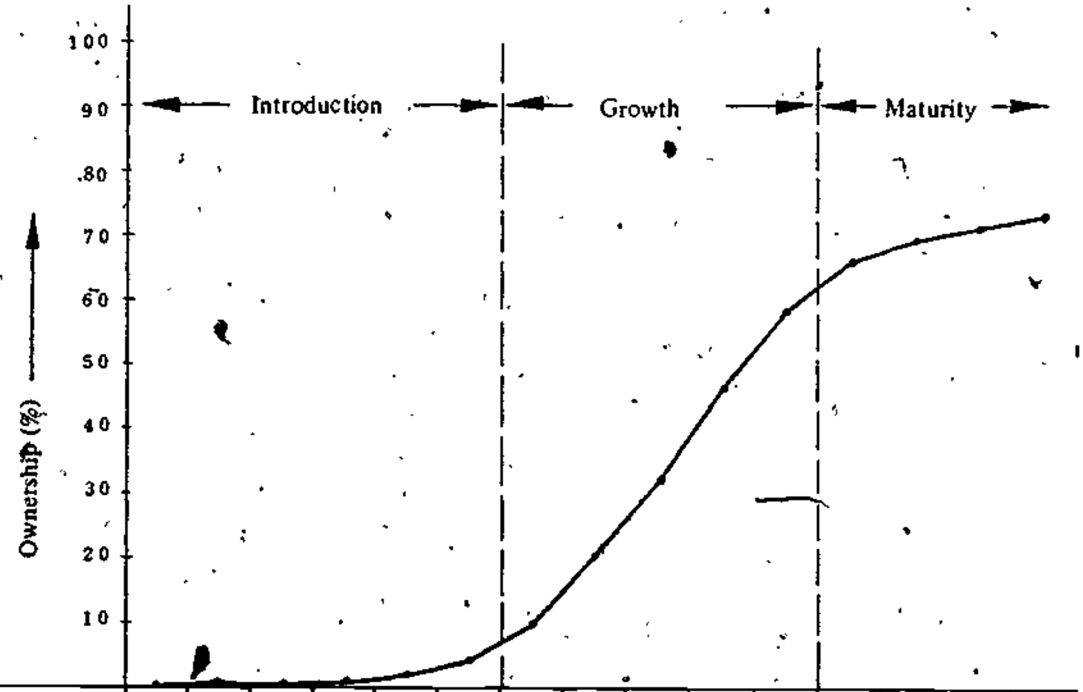
Exhibit F shows the results of Memory Test II. Bearing in mind what was said about Content 4 in the sound mode, we may say that contents 1 - 4 show an identical pattern. That being the case, Exhibit F shows no differences in the transmission of peripheral information in the sound, writing, and writing + sound modes. The fact that the motion pictures + sound mode scored significantly higher may be attributed to the fact that motion pictures are inherently richer in peripheral information for the recipient to perceive.

In the ease of recall of peripheral information, the motion picture plus sound mode scored highest, but there was no difference in the other modes. When a person comes into intense contact with information for the purpose of learning something, it will be transmitted without difference, in any mode whatever. And thinking of the fact that a certain peripheral information often guides us to recall the whole things, we can endorse the advantage of motion pictures plus sound mode in audio—visual methods of education.

PRICES DROPPED TO DOUBLE THE MONTHLY INCOME, USHERING IN THE PERIOD OF GROWTH.

Statistically studying the diffusion process of monochrome TV sets in Japan, we found that the prices dropped to double the monthly income and ushered in the period of the rapid growth. The boom continued for 5 years until the ownership reached 66.0%, when for the first time the price appeared statistically significant variable to the ownership. This means that TV was an extremely strong terminal for entertainment information no matter how expensive it was. Nontheless the TV stations adopted a policy to set up street-corner TV sets in order that those who did not own a set would experience TV viewing. This resulted in a favourable circumstance accelerating the boom.

EXHIBIT H. CHANGES IN THE OWNERSHIP OF MONOCHROME TV SETS



Year	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
Ownership (%)	0	0.1	0.3	0.9	2.2	4.6	9.9	20.1	32.2	46.3	58.5	66.0	69.2	71.4	72.9

Note: Ownership = $\frac{\text{No. of monochrome TV reception licenses}}{\text{National total of households}} \times 100$

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TWO-WAY COMMUNICATION SYSTEM
BY USE OF A VIBRATION PICK-UP TYPE EAR MICROPHONE

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ABSTRACT

A vibration pick-up type ear microphone has been designed in order to get communicate in high ambient noise, with hands free and with several types of masks. Simultaneous talking and listening communication without obstruction of external ear canals through one ear can be obtained with a sound pressure type esrphone. In this paper, a newly developed VOX and behined-ear wireless communication systems will be reported.

1) VIBRATION PICK-UP-TYPE EAR MICROPHONE

In trying to improve the conventionsl sound-pressure-type ear microphone (SPE-Mic) a vibration pick-up-type ear microphone(VPE-Mic) was conceived. The SPE-Mic incorporated a super-mini-sized microphone in an ear plug, while the VPE-Mic utilized instead a piezoelectric element, which runs parallel with the temporal bone in the external auditory canal, and picks up the bone conducted speech signals by utilizing the principle of an acceleramater(Fig.1) The external auditory canal wall was chosen instead of other places on the skull since the collection of vibrations conducted to bones deeper than the ear canal cartilage may involve phonetically higher range elements and may be less influenced by the lower jaw. And the typical frequency response of the VPE-Mic is measured by a vibration shaker(Fig.2)

11) SPECIFICATION OF VIBRATION PICK-UP-TYPE EAR MICROPHONE

The speech intelligibility scores for the various high-pass filter conditions shown in Fig.3. Note thst the scores exceed 96% at cutoff frequencies of 200, 500 and 1000 Hz and are 94% at 1500 Hz. When the ear microphone is used in a mask with an HPF of 500 or 1000 Hz, the sound articulation is decreased by only 0.5% and no significant difference is observed. As a result, the VPE-Mic csn suitably be used as a mask microphone.

The sound articulation obtained with each type of microphone in an ambient noise field shown in Fig. 4. The intelligibility of the noise-canceling microphone linearly decreases with increasing ambient noise. For both ear microphones, the rate of decrease is not significant under 110dB. In ambient noise over 110dB, however, the sound articulation grsdually decreases. The vibration pick-up-type ear microphone gives 10% better intelligibility thsn the sound-pressure type with earmuff. Furthermore, the former gives better sound articulation scores than the noise-canceling microphone at any measured ambient noise level.

111) TWO-WAY COMMUNICATION DEVICE WITH VIBRATION PICK-UP-TYPE EAR MICROPHONE

A two-way communicating device wss newly designed in order to talk and listen simultaneously or VOX without obstruction of the ear canal. As shown in Fig.5, reception is accomplished by introducing sound pressure from the small earphone by use of the acoustic tube. Two types of two-way devices are shown in Fig.6. The sound pressure from the earphone is easily eliminated because sensibility of the VPE-Mic to sound pressure is low renged.

The two-way communicating device is, therefore, used for talking and listening through one ear. This device is expecially suitable for a hand-free wireless communication system.

IV) VOICE CONTROLLED TRANSMITTING SYSTEM WITH BAND PASS FILTER

Two way communication through one ear can be obtained by a VPE-Mic combined with a sound pressure type earphone. It is one of advantages of this microphone that voices except for the speaker himself are seldom picked up because this microphone is fundamentally bone conduction type. However, it is revealed that the VOX for this communication device did not work well in the following instances. ① Howling occured due to closs talk which was produced by too high level of the sound signal through an acoustic tube. ② The VOX did not work well when noise entered into the microphone especially under ambient noise of more than 95dB(c). ③ The VOX did not work well when wide band noise produced by microphone or cord touching entered into the microphone. Fig.7 is a spectrum of vowels and tach noise of microphone.

It was found that the VOX worked more steadily when the driving signal obtained through BPF was used. As a frequency response of the BPF, low cut off with 100Hz and high cut off with 500Hz were reasonable.(Fig.8)

Fig.9 showes a black diagram of VOX with BPF.

Followings are advantages. ① Sound volume of the earphone was increased because of reduction of cross talk. ② The VOX worked well even under 110dB (c) noise tanks to excellent avoidance of ambient noise. ③ The VOX worked well thanks to reduction of noise produced by microphone or cord touching.

V) APPLICATION OF VIBRATION PICK-UP-TYPE EAR MICROPHONE

Possible fields of application for the vibration pick-up-type ear microphone are that it can be (a) used as a howlingless microphone, (b) used as a mask microphone, (c) used as a hands-free microphone, (d) used as a microphone for voice communication under high ambient noise condition.

V-1) SIMULTANEOUS TWO-WAY COMMUNICATION SYSTEM

We designed a wireless simultaneous send-and-receive system built in a helmet to be used with free hand for short distance (with 100mW).

In Fig.10a, the two-way system is demonstrated, by which simultaneous talking and listening are obtained through one ear. In high ambient noise, an earmuff can be additionally used. In Fig.10b, the two-way commuhication system built in an earmuff for high ambient noise is shown.

A speaker is built in one earmuff and a VPR-Mic in the other earmuff.

V-11) TWO-WAY RADIO WITH VOX

Nobody can deny voice controlled transmitting system should be used when the VPE-Mic is employed for conventional radio communication.

It is a must that voice control never works wrongly by sound signal from the earphone, ambient noise and noise produced by microphone or cord touching. We, hence, designed the two-way radio with BPF installed VOX mentioned above.

This two-way radio is very usefull especially when both hands are occupied. We are now attempting to make one-side-ear communication device. For this device, VOX is installed in a behind-ear-case in order to guide voices of another person through an acoustic tube of the case.(Fig.11)

V-111) THREE TYPES OF BEHIND-EAR WIRELESS COMMUNICATION SYSTEMS

V-111-1) BEHIND-EAR WIRELESS MICROPHONE WITH EAR MICROPHONE(Fig.12a,b)

A wireless microphone was designed with transmitter built in a behind-ear case. Using this equipment, communication under ambient noise can be obtained without closing an ear canal.

A wireless communication can be practical as voice from an ear microphone is put in a CB-radio set in a motor car through a FM receiver.

V-111-2) A COMBINATION OF A BEHIND-EAR TYPE WIRELESS TRANSMITTER RECEIVER AND A FM RECEIVER(Fig.13).

It is difficult to put conventional FM two-way radio in a case of behind-ear type hearing aid case, because of its small room. This fact let us to put a newly designed induction receiver with a transmitter in that case.

The voice sound of co-worker is received by a FM radio in a pocket, and then, is finally received by an induction receiver through a loop antenna.

It is one of benefit that simultaneous talking and listening through one ear can be obtained without obstruction of an ear canal with both hands free.

A local communication less than 30m can be well parformed with this device. Moreover this device is very useful for workers who need communications for each other especially under high ambient noise or poor condition of weather.

V-111-3) A COMBINATION OF A BEHIND-EAR TYPE WIRELESS TRANSMITTER-RECEIVER AND A TWO-WAY RADIO.(Fig.14)

A new wireless communication system with a repeater station was designed with combination of a behind ear wireless communication equipment and a two-way radio. Bone conducted voice sounds are transmitted through a transmitter build in a case of behind-ear type hearing aid. The voice signal is received by a FM receiver, and the signal is finally put into a two-way radio. The signal is transmitted by a two-way radio and received by another two way radio. The signal is transmitted to a receiver in a case of behind-ear type hearing aid, in order to obtain sound pressure which stimulates the external ear canal.

With a VOX, a communication with hands free is well performed. In this system, a cord or touching noise is remarkably reduced, which is common in a VPE-Mic.

Therefore the communication with this system could be comfortable and easy.

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(3) H. Ono and S. Saito, "Improvement and Evaluation of the Vibration Pick-Up-Type Ear Microphone", J. Acoust. Soc. Am. 60, S106(A) (1976).

(4) H. Ono, "Improvement and Evaluation of the Vibration Pick-Up-Type Ear Microphone and Two-Way Communication Device", J. Acoust. Soc. Am. 62, 760-766(1977).

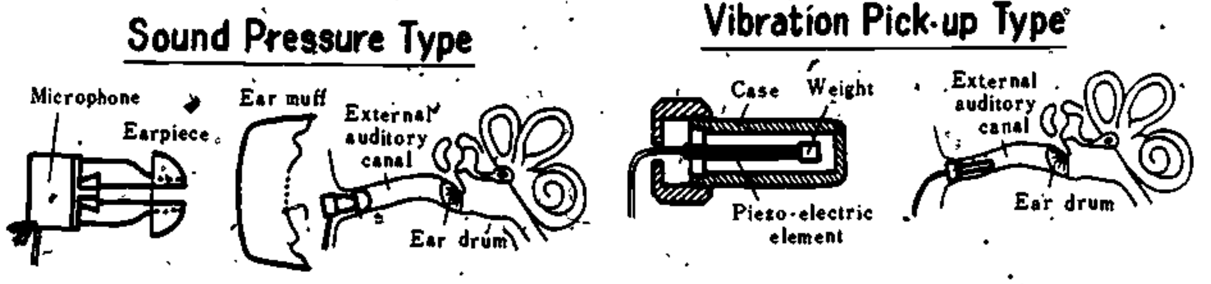
Sound Pressure Type
Microphone
Earpiece
Ear muff
External auditory canal
Ear drum
Vibration Pick-up Type
Case
Weight
Piezo-electric element
External auditory canal
Ear drum

Fig. 1 TWO TYPES OF EAR MICROPHONES.

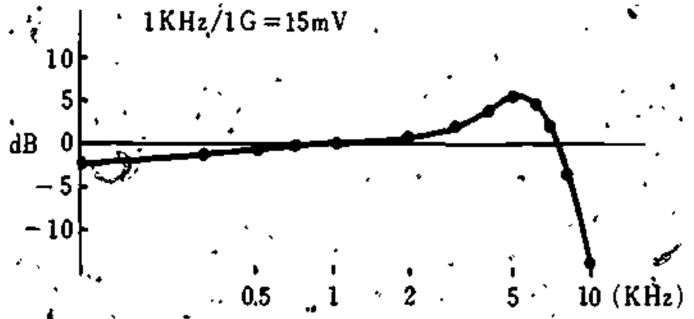

Fig. 2 FREQUENCY RESPONSE OF VIBRATION PICK-UP TYPE EAR MICROPHONE.

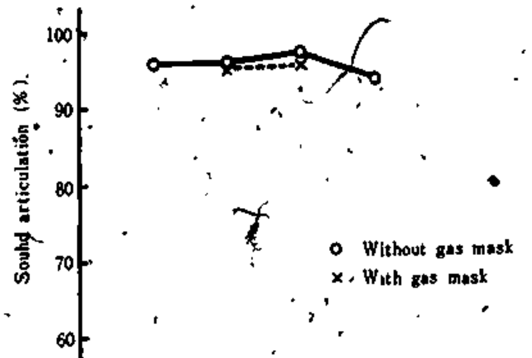

Fig. 3 SOUND ARTICULATION THROUGH SEVERAL HIGH-PASS FILTERS. WITHOUT MASK (○) AND WITH GAS MASK (×).

(5) H. Ono and S. Saito, "Development of a Vibration Pick-Up-Type Ear Microphone and Communication Devices for Daily Use", INTERNOISE 79 Proc., 797-800(1979).

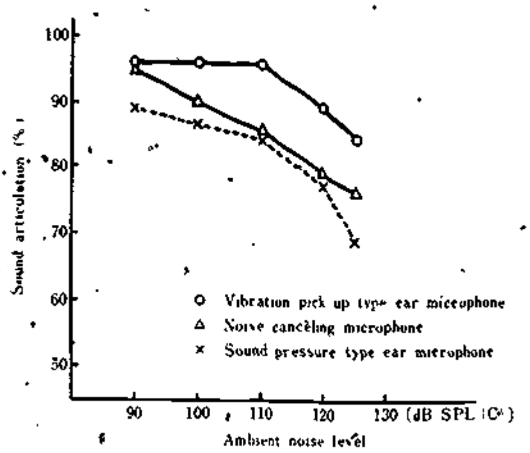

Fig. 4 SOUND ARTICULATION IN AMBIENT NOISE BY USE OF THREE TYPES OF MICROPHONES.

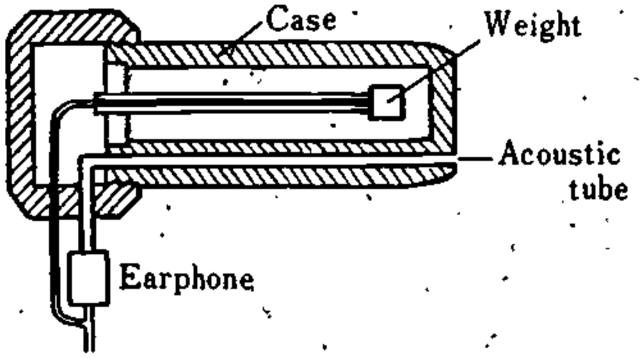
Case
Weight
Acoustic tube
Earphone

Fig. 5 TWO-WAY COMMUNICATION DEVICE WITH VIBTATION PICH-UP TYPE EAR MICROPHONES.

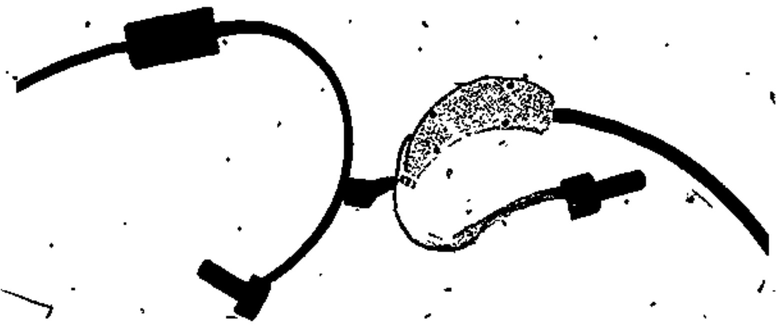

Fig. 6 TWO TYPES OF TWO WAY DEVICES.

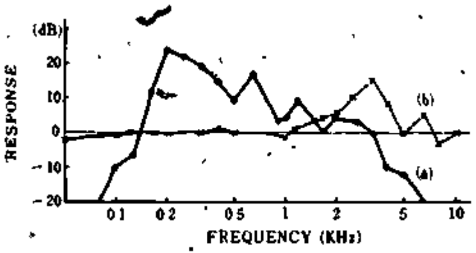

Fig. 7 SPECTRUM OF 5 VOWELS (a) AND TACHING NOISE OF MICROPHONE (b).

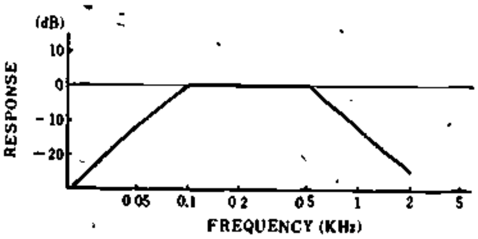

Fig. 8 FREQENCY RESPONSE OF BPF.

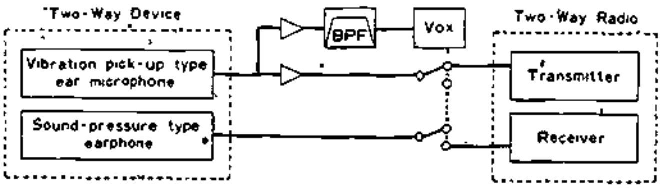
Two-Way Device
Vibration pick-up type ear microphone
Sound-pressure type earphone
BPF
Vox
Two-Way Radio
Transmitter
Receiver

Fig. 9 BLOCK DIAGRAM OF VOX WITH BPF,

Fig. 10 a HELMET TYPE SIMULTANEOUS TWO-WAY COMMUNICATION.

Fig. 10 b . EARMUFF TYPE SIMULTANEOUS TWO-WAY COMMUNICATION SYSTEM.

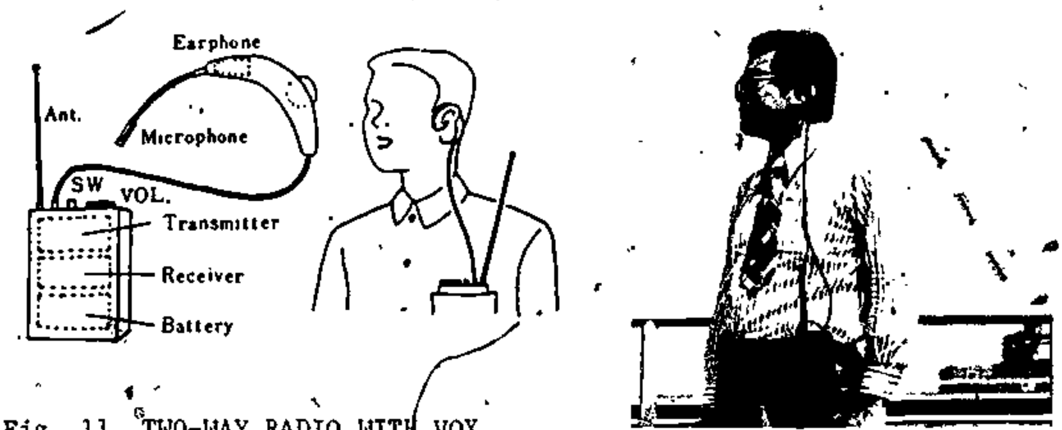
Earphone
Ant.
Microphone
SW
VOL.
Transmitter
Receiver
Battery

Fig. 11 TWO-WAY RADIO WITH VOX.

Fig. 12 a BEHIND-EAR TYPE WIRELESS MICROPHONE.

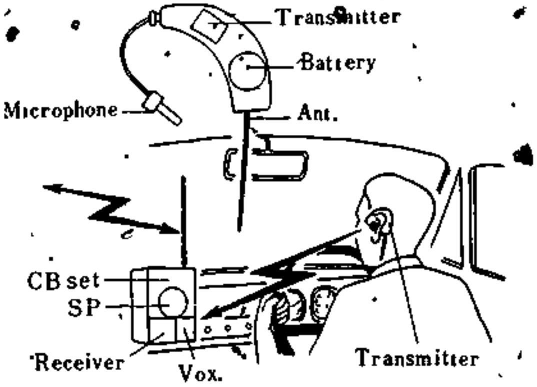
Transmitter
Battery
Microphone
Ant.
CB set
SP
Receiver
Vox.
Transmitter

Fig. 12 b WIRELESS MICROPHONE WITH A CB RADIO SET.

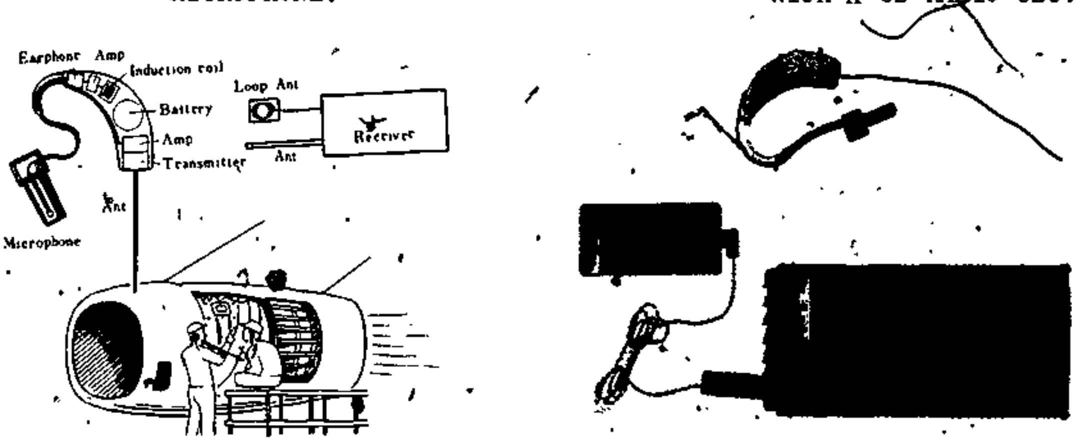
Earphone
Amp
Induction coil
Loop Ant
Battery
Amp
Transmitter
Ant
Receiver
Ant
Microphone

Fig. 13 BEHIND-EAR-WIRELESS TRANSMITTER-RECEIVER WITH A FM RECEIVER.

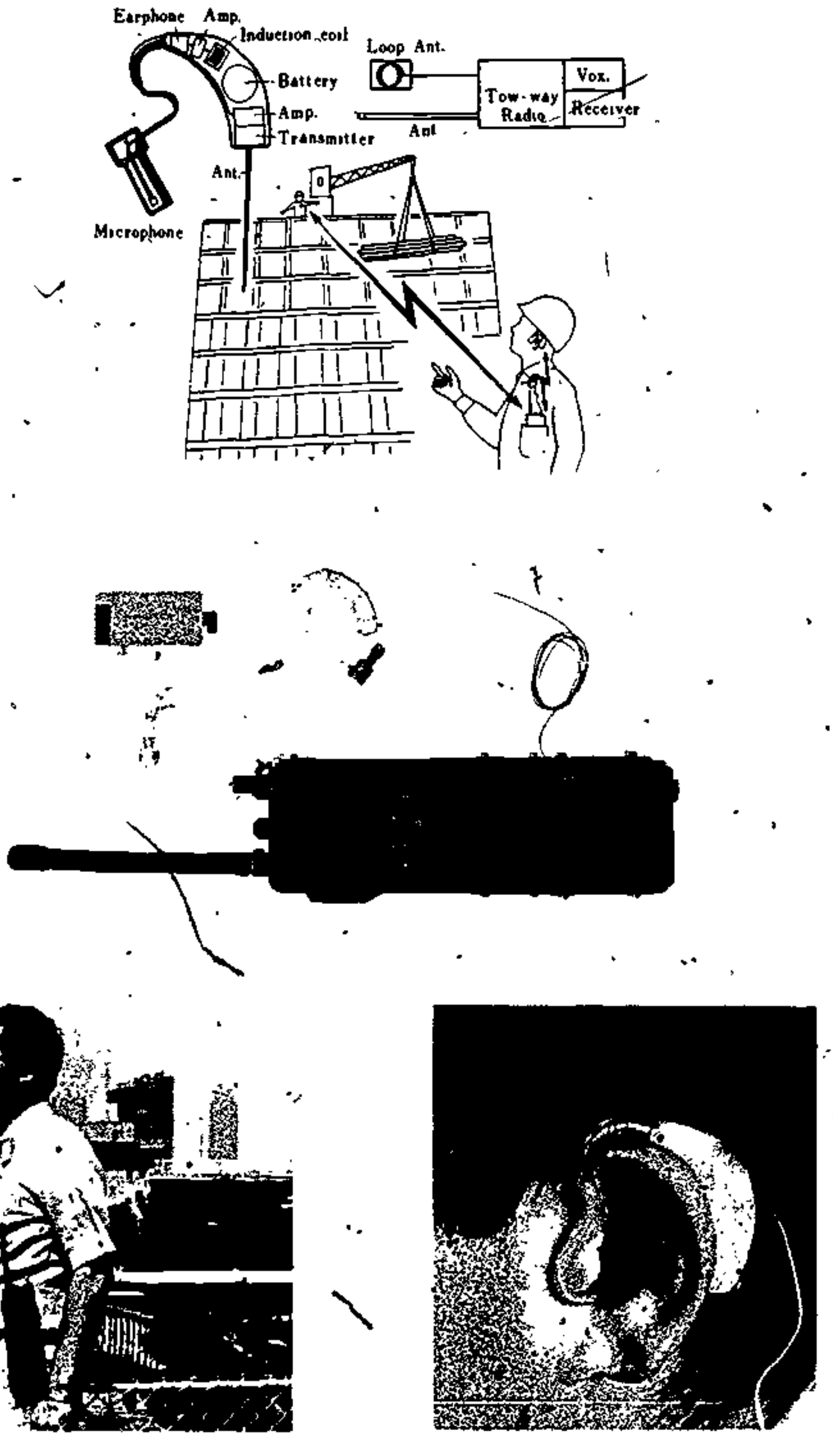
Earphone
Amp.
Induction coil
Loop Ant.
Vox.
Battery
Tow-way Radio
Receiver
Amp.
Transmitter
Ant
Ant.
Microphone

Fig. 14 BEHIND-EAR-WIRELESS TRANSMITTER-RECEIVER WITH A TWO-WAY RADIO.

THE GEO-STATIONARY PLATFORM: IMPLICATIONS FOR THE PACIFIC

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ABSTRACT

A number of major themes and issues must arise in any discussion of the use of a geo-stationary communications platform for use in the Pacific. These include technical/design, economic, legal, regulatory, management, and environmental. The author discusses these and others as regards a late 1980's use of such a vehicle. In all instances user considerations are deemed primary.

OVERVIEW

New ideas, applications, or approaches to contemporary requirements are always questioned because they are a departure from past principles or practices. A notion such as a geo-stationary platform is no exception. This brief report, outlines ways in which it might be considered as an alternative or complementary approach to current space-linked services in the Pacific area(1), and is the continuation of the author's involvement in the project that originated with a pre-proposal study of user needs and requirements, assistance with proposal development and review, and consultation on project activities.

The report attempts to identify and suggest areas where a geo-stationary platform may have very attractive and saleable features for use throughout the Pacific, and others which might require further definition; as well as to outline possible strategies and tactics that might be employed to further the acceptance of a geo-stationary platform.

A principal objective of this document was for it to serve as an introduction and a catalyst for a face-to-face discussion with principal users of such a capability. Consequently, certain items require greater elaboration and detail and some observations are "time-specific" and are linked to the recently "sampled" events. Policies and practices change and the suggestions made here will obviously require reassessment in light of any new developments.

THE "CHOICE" FEATURES

What characteristics of the geo-stationary platform are most attractive and saleable? A number of features have been advanced including economy of scale, centralized operations, connectivity, reduction of congestion of the geo-stationary arc, frequency reuse via multibeams, and the potential for small and less expensive ground terminals. In discussions during the past few weeks certain briefs seem to be more readily accepted than others. The majority of the discussions have centered on communications payloads and consequently the unstated (an occasionally stated) assumptions that the platform has to be better than current or planned communication satellites.

Built-Out Obsolesence/Amortization Over Many Years.

The current projected life of most communication satellites is seven years. The design study is committed to evolving a platform that will have a life of at least sixteen years.

INTELSAT, for instance, estimates that each of the INTELSAT V satellites will cost 72.5 million dollars to put in orbit, with a design life of seven years(2). Both C and KU frequency bands will be available and frequency reuse is planned. To replace the satellite at the end of seven years, will require much more than $72 million dollars; estimating inflation, increased labor costs, etc. A fact that the initial investors in a space platform need not confront.

Data must be developed to identify how long the platform can operate without any replacement of components. This information would be vital to anyone promoting or examining the use of a platform, as contrasted to a contemporary satellite. The next increment of costing would relate to replacement costs for new components, including transport. Taking advantage of new, more reliable (lower cost) components, which would extend and increase the life of the platform, should be factored into any equation. To refurbish and modernize the platform and amortize the initial capital investment over additional years is indeed an attractive feature. One of the primary drivers in the definition of platform concepts is the potential economic savings of a geo-synchronous platform program, as compared to a customized expandable satellite program.

Beat the Demand Curve.

Most curves for current satellite use demonstrate great capacity at launch and limited use in the early years. As the satellite traffic capacity begins to increase the years of the satellite's life decreases.

The platform, on the other hand, can be designed with initial capacity to handle a lower level of traffic, with back-up communications capacity. The additional transformers can be brought on-line as the traffic demand increases, and consequently the platform is designed at the outset to handle planned growth.

Meet Multi-User Requirements.

The platform's ability to adapt to the needs of the moment will give it a unique advantage. It will be possible to program or automatically direct more or less energy to a given area depending on traffic and atmospheric absorption, and S, C, KU, and Ka frequency band capacity can all be provided.

Reduction of Earth Station Size and Cost.

The ability to increase satellite antennae size and power on the space platform should lead to a reduction in the power and antennae size required in the ground terminals. This in turn could lead to reduced operations and maintenance. For an individual user, a large part of the outlay to participate in communications systems is the terminal cost and maintenance. Consequently, less expensive terminals which can handle voice, data, and video might enhance the attractiveness of utilizing the platform for a greater number of users, increase revenue, and help amortize the initial investment cost more rapidly.

Amortizing the Arc.

The continued demonstration of economic advantages of using geo-synchronous operations and the projected increases in demands for long-range communications are expected to produce continued growth in both the numbers and capabilities of geo-synchronous systems.

The geo-stationary platform continues to provide the potential for reducing crowding in the spectrum-orbit area. Its greater capacity for carrying transponders at numerous frequency ranges will still have to observe the spacing requirements for all bands but should diminish the requirement for greater numbers of communications vehicles to be spaced. It is anticipated that a significant reduction in the on-orbit inventory of space elements can be achieved with the platform approach.

The current WARC in Geneva could provide additional rationale for space platforms, if indeed there is a requirement imposed world-wide for the reservation of specific frequency bands within regions, for individual nations. Such an action, or related reservation of orbit-arc options would highlight the potential value of geo-stationary communication platforms.

Connectivity Within and Without.

The central computer systems and distributed processors in the space platform could control mechanical devices, the handling, storage and

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processing of a variety of communications, command, and telemetry signals. Processing instead of relaying would be its role. Intra-connectivity within the platform, to handle a range of frequency requirements, would enable the elimination of current ground to satellite to ground interconnections, speed-up transmission and minimize the potential for interference.

If a number of platforms were put into operation to provide coverage for the entire earth, the limitation of current satellites to provide transmission only between points with a single satellite coverage area would be overcome. Inter-platform links could provide coverage for different zones and speed up transmission. Improved service quality and economy would be experienced.

A 1973 Rockwell report outlined how four platforms could provide coverage for the earth(3). A recent INTELSAT contract is directed toward evolving a TWT that would provide the technical capability for inter-satellite links. This TWT activity has relevance for the platform endeavor.

Retrieval of Experimental/Test Components.

Once the servicer units are operational and can replace and retrieve components from the platform this will enhance operational longevity and servicing of the platform, and also enable communications and other experimental units to be retrieved. Heretofore, once a communications component failed or test equipment stopped functioning it was impossible to examine the components. The platform with its servicer approach now provides the potential for the analysis of equipment functioning and failures to take place on earth.

SECOND ORDER ARGUMENTS

There are another group of saleable features or conditions that are related to the preceding but stand alone as suitable for advancement with particular audiences or as intriguing possibilities to explore.

Multiplicity of Service Approaches

The history of communications technology has demonstrated that users are served in many different ways by variations of related technology. The geo-stationary platform is no exception. In the 1980's there may be integrated communications services via space vehicles that combine multi-purpose geo-stationary platforms and customized communications satellites.

Personal Communications

Personal communications wrist radio-telephones linked by geo-stationary platforms would serve many personal needs. The potential low-cost and the opportunity for many users in such a system is intriguing and a compelling reason for some to advance the entire platform concept. Although the design team recognizes the many problems with this approach it should not be discounted as a possible mission, even if primarily for international, as contrasted to comestic use.

The growth of the transistor radio, the hand-held calculator will serve as precedents for wide-scale, individual use of personal wrist radio telephones..

Ideal for Developing Nations

In instances where a country, such as China, has no sizeable capital investment in terrestrial telecommunications and would like to quickly establish video, voice, and data communications, a geo-stationary platform might be very attractive. Low cost earth terminals could be combined witb a platform providing multiple frequencies for a full service capability.

Selection of Missions That Have High Telecommunications/Transportation Payoffs

The social and political climate in which the platform must be "sold" will be one of energy conservation, high energy costs, and conversion to alternate energy sources. Selections which can readily be recognized as saving paper, reducing energy consumption, while simultaneously reducing pollution created by short and long-distance hauling of mail, will make platform use very attractive. The sizeable growth of teleconferencing provided by the 18/30 GHz studies is very encouraging for geo-stationary platform considerations. The sizeable wide-band requirements are ideal for the multi-transponder platform and allows any brief for the platform to underscore the savings in energy (fuel savings in air and ground transportation), saving of people's time and reducing pollution.

SUMMARY

A number of issues need to be addressed and these include:

Technical/Design

- Attention has to be given to all the technical issues ranging from an unmanned vehicle to massive vehicle, which would combine such applications as energy generation and permanent stations for scientific and possibly manufacturing operations.(4)

- Earth terminals in any proposed space platform network will require improvement on transmission, lower noise receivers and improved efficiency, particularly at K-Band.

- Large aperature multiple-beam antennas operating at UHF and at X and K-band frequencies need to be developed.

- Phasing in and integration of the platform with plans and technical advances through 1990 in communication satellites is mandatory.

- Antennae size and pointing, flexibility and capacity of beams, connectivity, size of footprints, and integration of current and planned earth stations are critical issues and will require creative solutions.(5)

- The platform must provide acceptable transmission performance, optimum utilization in the network, reliability equal to terrestrial systems, and high capacity near end of life.

- No carrier will accept planned outage; and cross-switching may pose problems among carriers.

Economic

- Cost-benefit models must include the possibility of international cost-sharing and INTELSAT might own and operate the platform and least other components.

- Video growth market, as well as electronic mail, secure voice service, increase demand for other broad-band areas indicates that the market will grow and the market should be ready for a platform by 1990.

- Economic scenarios must incorporate amortization of present investments and ground equipment in order to be attractive to present operators.(5)

- Cost of service when contrasted to total capability will be an important relationship in selling the concept to investors, users, and the F.C.C.

- The platform, even in the 1990's, will be in direct competition with terrestrial and aquatic means of communications.

Legal/Political/Regulatory

- A number of FCC Dockets are relevant to any space platform design including those on communication changes, practices, classifications, rates and regulations of COMSAT, resale and shared use rulings. These need to be investigated, in-depth, during the design activity.

- Regulatory climate currently encourages a competitive market place whenever possible. Any policies and rules that tend to restrict competition and delay technological change may be eliminated... A mixed operational mode (monopoly and competitive) may make sense.

Management/Governance

- Issues of how platforms should be developed and implemented ie. on a national, regional or international basis must all be considered as well as, what interest U.S. industry, other nations, and regional bodies have in such platforms. A multi-national project at the outset might provide sizeable savings but compound the institutional problems.(6)

- The management structure of the undersea cable is not the best model for the space platform. Too cumbersome and complex.

General

- How the platform will fit, enhance, and improve upon current communications costs must be defined. Maritime interests need to be considered.

- Current NASA budget cuts and the requirement to fund a platform from phase-out of shuttle spending will have considerable bearing on the construction and operation of a platform.

- A clear definition of how the platform will aid the parking and frequency arc problem is a recurring theme.

- Potential users must identify and be prepared to support the services provided via the platform.(7)

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OPPORTUNITIES IN THE 1980'S - THROUGH TELECOMMUNICATIONS

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Abstract

The application of new communications technology will represent the means of very significantly benefitting Pacific Regions in the 1980's. This paper explores a range of the opportunities which could be available. It considers the moves to "information societies" and outlines an important opportunity which telecommunications/computers/information handling could provide for assisting the development of regions. The paper then reviews some of the special considerations needed to ensure that the results achieved go beyond planning to the realisation of significant practical benefits.

1. INTRODUCTION - AND THE IDENTIFICATION OF REAL OPPORTUNITIES

We live in a world when the impossible has come to seem the expected. So great has been our progress in so many technological directions that we have been left feeling that yesterday's science fiction is today's normal practice (or tomorrow's at the very latest). It has almost become hard to think about what might happen in the future because it all seems to be happening now.

This impression is perhaps strongest in the communications world. There, through technical reading, the media and other professional exchanges we have become almost like the child in the toyshop. We seem to be surrounded by so many appealing, wonderful things in the communications environment that it is hard to choose between them. We run the risk of becoming attached to something we cannot fully apply, enjoy or perhaps even afford.

In this context it seems important to consider:

(a) What is happening in communications now and in the near future that seems particularly relevant?

(b) What is happening in our society that could affect the usefulness and acceptability of such developments?

(c) What special opportunities exist that should be pursued?

(d) How can it all be made to happen?

There is a danger in all of this of generalisations because each person has his or her own special interests and needs. In addition we are in a period when almost anything is possible technologically; so it is not easy to be definite about what will and will not be successful.

Nevertheless, recent experience indicates that there are steps which can be taken to gain early from these dramatic developments.

2. TECHNOLOGICAL OPPORTUNITIES FOR TODAY

One of the most significant developments for the Pacific is the satellite. By means of this remarkable invention (which has now operated so long and so stably that we take it for granted) we are able to have instant access to visual images and data from enormously widespread parts of the world. Through INTELSAT and the surveillance satellites like LANDSAT we are able either to communicate between nationals or gather vital information on weather and other world conditions.

In addition, countries like Canada and Indonesia have established their own satellites - and Australia has just decided that this is a step they should take also. So opportunities are emerging for countries to contemplate developments for themselves and perhaps their neighbours of a dramatically new kind.

When considered in conjunction with efficient modern communication links, combined with the increased advent of very cost effective mini-computers and micro-processors the possibilities of satellites seem limitless. How far one can go obviously depends on the investment made. However, the scope was indicated in a recent reference to a proposed geostationary platform comprising a multi-purpose satellite in geosynchronous orbit which could provide to the Continent of United States:

- Broadcast education over five simultaneous video channels for 16 hours a day.
- Personal voice communications to 45,000 simultaneous users equipped with hand-held communicators.
- National information services, giving instant access to Government, University and commercial data banks.
- Tele-conferencing on up to 150 simultaneous two-wave video-channels.
- Electronic mail transmission at the rate of 40 million pages per day, with overnight delivery from 800 sorting centres.

That might be on much too grand a scale for most of us to contemplate. But even in a more modest way one can foresee the possible opportunities which can flow for public-service requirements and private needs. These will include particularly policy and disaster relief communications, and medical services - especially in difficult terrain or remote areas such as we have in Australia, and abound in the Pacific area.

Another significant advance that has been made is in the area of compressing and treating information in small and low-cost facilities. As has been pointed out the impact of video discs and video tape cassette recordings has yet to be felt. But they could well revolutionize the whole area of libraries and information storage by making it possible to organise and access material which might originally have been developed in a variety of different formats.

People will be able to catch information and digest it in their own home, visually and aurally, greatly influencing their approaches to entertainment, education and communications at large. The ability to have animination, colour and other stimuli to reinforce the message is likely to have profound effects on the success of the "people development" systems.

As well as these advances, low-cost compact computer facilities are already replacing much of the more conventional approach to accessing information - making it easier for people to locate items, review material at a distance and/or selectively, and even make changes to that information if it seems appropriate. When coupled with effective new transmission systems this development is likely to revolutionise the treatment of a spectrum of work and domestic activities.

There is an increased move towards the transmission of data in digital form instead of analogue form. This will enable information to be transferred much more readily between terminals, computers, facsimile machines, etc. Moreover, new materials like optical fibres represent opportunities for lower cost information handling that today's planner just has to take into account.

There is then a whole range of technological developments which are already available in some form and which our studies have indicated will be in widespread use within the next 10 years or soon thereafter. Our survey of international developments in this field indicated that a comprehensive list of these would certainly include such prominent areas not already mentioned as intelligent terminals, data-[illegible] systems and networks, audio input and output systems (with computers [illegible] to recognise and understand the spoken word), computer augmented message systems, wide-scale electronic monitoring, mobile services, and special developments in picture transmission like facsimile.

All of these are at such a stage of acceptance that they will definitely form a part of the communications system of countries throughout the Pacific.

3. SOCIAL INFLUENCES ON PACIFIC COMMUNICATIONS

History has shown that the strong controlling factors on introduction of technology are the size of the investments on the one hand and the preparedness of society to accept them. And experience further shows that social acceptance of some new approach or behaviour is very slow. All of which means that it is important to gain an understanding of the societal attitudes as part of the planning process.

It is not that long ago that people were promoting the concept of the "office in the home". With the aid of computers and communications technology it was proposed that people could have work centres established at home whereby they could save the time, stress, cost and energy implications of travelling to work. Instead from their home console they could call up the data banks, etc. as well as their colleagues and complete their normal day's activities.

It was found, however, that, people do not operate that way. They need to be with others outside of the family. Studies confirmed that the more appropriate direction would be the establishment of work centres, closer to home than the office to which people might move. But again it was found that this would need to be regarded as more of a long term solution since people are simply not conditioned to operating in that mode.

It has become increasingly apparent in communications planning that one must take greater account of those who will use the system instead of relying on the ideas of the planner or operator. In this connection we have found in Australia recognition of the need to identify the communications behaviour and attitudes of ethnic groups. Work we have recently completed has identified some very interesting needs and actions of people who come from different cultural and language backgrounds.

It seems likely that studies of this nature will form fundamental conponents of communications planning within and between countries in the Pacific. It also seems probable that some of the findings (e.g. in relation to those who are most disadvantaged, their attitudes to governmental agencies and administration, the usage of media and literature, etc.) will find close parallels in other regions.

In summary then the acceptance of new technologies will depend upon an understanding of the requirements of the cultures involved and the communications networks which are already in existence. I believe we will increasingly emphasise communications improvement rather than communications development. And if we can get a clear understanding of current practice and needs we can be well on the way towards that improvement.

4. THE SPECIAL OPPORTUNITY PROVIDED BY INTEGRATED TECHNOLOGY

In many countries and organisations a major impediment to development is the lack of trained people to meet the particular needs. This is a difficult situation to overcome quickly since the training of new skills can take a generation or more, even with modified curricula which focus training on the development of specialists rather than generalists in the interim.

The possibility now exists, however, for this situation to be radically changed through the combined capabilities of modern telecommunications and new developments in information handling plus computer modelling. The approach is to provide to people with limited training the ability to interrogate data banks, decisions models and/or skilled persons using intelligent terminals and the appropriate telecommunications links (including satellite access for remote areas). As with the MEDICHECK type of system, where one can carry on a "conversation" with a programmed terminal, it is possible for a person to reach much clearer decisions about a complex situation than would be possible without their extensive further training. In the case of MEDICHECK of course it is to do with one's own health. But this concept could be translated into advice on how to operate or maintain complex equipment (the absence of which advice can preclude such valuable aids), how to decide on make/buy/store aspects, how to optimise the running or scheduling of manpower and equipment and so on.

The technology exists to do this now. The analytical approaches also exist to meet many of the needs. Most importantly the concept is one which could enable regions to greatly accelerate their social and general development by leap-frogging their training problems with the leverage of technology.

5. STEPS TO EFFECTIVE IMPLEMENTATION

In general, we are being involved in a world with new technologies available for application, a move towards the new information order, and with scope for new and far-reaching communications services. So how do we achieve what, with a minimum of difficulty?

The key ingredient in this process can be to establish the most effective organisation. This can require the separation of the owners/operators/users rather than trying to include all within the one group. Most importantly it can involve the establishment of an organisation structure which permits communication and participation with those involved at all levels.

Next, the key step is obviously to establish just what are the needs and attitudes of those involved in the process under review. It is constantly surprising how different a situation can seem if one talks with those directly involved. Not only can this lead to much greater acceptance and use of the communications or related area, but it can often result in a simpler system satisfying everyone's requirements.

In parallel with these activities an important step is clearly to keep in touch with technology and to relate it to the future of the region under review. In recent times "futurology" has been well publicised and sometimes quite justly criticised. Nevertheless, there are approaches for looking at scenarios of the future and current states of technological development to enable a much more certain determination to be made as to technologies and activities likely to be of real value and relevance to in the area or section of people. It would now seem a pre-requisite for this to be incorporated in any telecommunications planning at the top levels.

In parallel with developments of a technological nature it seems important to keep in touch with those areas of management where the application of data bases and computer modelling could be used in conjunction with the telecommunications systems to provide integrated means of meeting community requirements.

In combination these ingredients of good organisation, sound information, relevant participation at all levels and careful and analytical thinking can enable the Pacific to capitalise on telecommunications developments of potentially very great significance. Moreover by applying some of the concepts discussed it seems likely that countries within the Pacific zone could substantially advance their positions - using information and technology as leverage instead of the harder to obtain (and sometimes socially less desirable) large-scale capital investments.

NTIA'S ROLE IN INTERNATIONAL TELECOMMUNICATIONS

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NTIA's immediate goals in international telecommunications policy are threefold. The first is to develop, propose, and apply consistent U.S. telecommunications policies and positions that promote fair competition and greater reliance on marketplace forces. The second is to examine the merits of and make recommendations for change in the existing U.S. international telecommunications industry in order to increase the availability of both basic and enhanced services. The third is to assess the opportunities for introduction of new technologies and services into international telecommunications.

To accomplish these goals, the NTIA Office of International Affairs has established six major project areas:

1. Facilities Planning Process
2. Response to Rewrite
3. FCC Proceedings
4. Oversight/Instructions
5. New Technologies/Services
6. Representation and Liaison.

Many of these are of a self-explanatory nature. However, I would like to take a few minutes to highlight some of the crucial aspects of key efforts.

The Facilities Planning Process is a major international project. As you may be aware, the institutional and regulatory problems which have emerged in the area of international facilities planning during recent years have at times reached the crisis level. Difficulties in reaching agreement between the U.S. and foreign carriers and the FCC concerning the implementation of needed facilities have threatened to imperil the quality of service in the North Atlantic. It was as a result of these difficulties that the North Atlantic Consultative Process on Facilities Planning emerged. This international forum has served to provide an opportunity for the U.S. Government, service carriers, and other North Atlantic countries (Europe and Canada) to exchange different views on expected facilities requirements and, to some extent, defuse some of the difficulties which have developed.

NTIA, through the Facilities Planning project, has played a major role in the Consultative Process. It has been a key participant in the technical working groups which support the Consultative Process and has represented the United States during the formal meetings. In this regard, NTIA provides the only independent traffic forecasting capability available to the U.S. Government. As expected, demand is a driving force behind facilities planning; therefore, it is essential that the U.S. Government take an active role in estimating future trends.

NTIA has also participated, and will continue to have a role, in working groups considering service reliability and quality of service requirements and, most importantly, the development of a standardized cost methodology to compare alternative cable and satellite facility configurations. We feel that it is unlikely that either COMSAT or AT&T would unilaterally develop a methodology which the other would accept, but we also feel that the U.S. Government cannot develop a methodology and impose it upon industry. On the other hand, we believe that a joint effort to develop such a methodology, including industry and government, could be successful. I do not suggest that development of a standardized cost methodology will be an easy task; however, I would like to point out that this problem and others like it (e.g., achieving coordinated cable/satellite planning) will continue to plague international facilities planning and the foreign relations flowing from it until workable solutions are developed.

Thus, the Consultative Process to date has been a major NTIA international activity, and is likely to continue to grow in the future. While the Consultative Process in the North Atlantic has not provided a total solution to problems in facilities planning, it clearly has proven a step in the right direction. In fact, we are sufficiently encouraged by the experience of the North Atlantic Consultative Process to seek advice on whether it could also be helpful in the Pacific region. Facilities planning in the Pacific has thus far not been characterized by the same tension as in the Atlantic. As traffic demand increases, however, and facilities choices expand and become more sophisticated, the potential for disagreement and conflict is augmented. We hope that a joint effort may be able to derail any problems before they mushroom.

Our efforts in the area of New Technologies and Services would be important in our rapidly changing society, even if the requirements of the Consultative Process were not present. However, it must be realized that the results of this project serve both the immediate needs of the Consultative Process and the long term need of developing functional policy which will be relevant to future international telecommunications requirements and expectations. For example, NTIA has done a considerable amount of work in the area of satellite technology and the functions and relationships of those institutions directly related to the development and implementation of satellite technology. In the past, we explored the implications of regional/domestic satellite competition with INTELSAT. Currently, we have a major study of satellite service and institutional structures underway. This study will examine possible shifts in the COMSAT/INTELSAT roles with regard to increasing competition between cable and satellite. NTIA also plans a study of COMSAT's structure and its implications with regard to potential COMSAT roles in a variety of existing and new satellite services and related activities. In the case of submarine cable technology, NTIA recently contracted to update its World Submarine Cable Compendium and to provide within it a full review of fiber optic cable potential. This compendium, by the way, is recognized as the basic world reference on the subject and is used by telecommunications experts all over the globe. When the compendium is finished, we will, of course, make it generally available.

In the case of new services, NTIA has been involved in a number of efforts to facilitate and/or expand the introduction of beneficial innovation in international markets. This, as you know, is a particularly difficult undertaking internationally because of the many economic and technical obstacles. On the other hand, we see forces at work which will overcome these obstacles by recognizing that introduction of new services and new competitors will yield expanded business opportunities. One of our efforts in this area, which is only in the embryonic stage, is the identification of the existing size of the international data service market, its components and its prospects. At the present time, there is little hard data upon which to reasonably predict the future, and this void has contributed to misunderstandings about beneficial innovation. We will, however, continue our dialogue with the FCC, Congress, and our foreign partners in order to improve the environment for acceptance of new services and competitors. We firmly believe that creation of this environment is the key to a robust telecommunications service for the international user.

NTIA's efforts in oversight activities related to INTELSAT are growing. COMSAT, which is the designated U.S. entity in INTELSAT, has grown from infant industry status to that of a dominant organization. NTIA's role is essentially to exercise, along with the Department of State, supervision over COMSAT in its dealings with foreign entities and governments in order to insure that COMSAT does not act in a manner inconsistent with U.S. foreign policy or the national interest. We accomplish this role through a series of consultations prior to INTELSAT Board of Governor meetings. Generally, before these meetings, we are provided with a series of contributions offered by the various signatories. At a pre-briefing, the Government parties and COMSAT discuss the position that the latter intends to take with regard to these contributions and other items on the Board of Governors agenda. If we all agree with COMSAT's approach, no further action is usually taken. If there is disagreement, however, we instruct COMSAT as to the position it will take. The U.S. Government representatives discuss the appropriate language of the instruction and send a letter to COMSAT before the Board of Governors meeting.

The oversight of the future will be substantially expanded from the above. First of all, a similar process will have to be created for INMARSAT, which was first constituted in November of 1978. Beyond this, however, we will have to consider the implications of COMSAT's expansion into many other activities, some possibly unregulated but most interrelated to a significant extent. I might mention that the existing and potential activities of COMSAT include those of supplier of monopoly services via INTELSAT/INMARSAT, technical advisory and research services for a worldwide clientele of government and non-government customers, manufacturer and supplier of satellite earth station hardware, domestic direct broadcasting satellite services, land resource satellite services, SBS (COMSAT/IBM/AETNA partnership) business services, and others. The NTIA contractual efforts referred to previously will provide some of the needed answers for NTIA's performance of its oversight activities. Other NTIA efforts in this area include a study of potential alternatives to the Authorized User Decision. This is under development in anticipation of a formal revisiting of this decision by the FCC in the near future.

NITA's Office of International Affairs has devoted a major effort in the past to advising Congress on the international aspects of its rewrite activities, and we are continuing to explore options for legislation. We have recommended that Section 222 be repealed and that the

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Congress make more explicit the President's authority to instruct COMSAT in its INTELSAT activities. We believe that these two actions are the absolute bare minimum that Congress must take in the international telecommunications field. In the long run, however, we will continue to exhort Congress, as well as the Commission, to push forward on a comprehensive basis in developing legislation and policies that promote the entry of new carriers, the institution of diverse services, and the creation of a freer marketplace. We firmly believe that these goals are in the best interest of the using public.

Thank you and, of course, I would be pleased to answer any questions.

EDUCATIONAL BROADCASTING:
TWO LESSONS FROM THE
OPEN UNIVERSITY EXPERIENCE

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Abstract

The Open University of the United Kindgdom has developed a distance learning system which allows adults to study undergraduate level courses at home. Television and radio programmes form an important part of these courses. This successful use of educational broadcasting contrasts sharply with many other projects where the results have frequently not matched the expectations. After a description of the University's teaching system - and the role of broadcasting - this paper uses examples taken from the Open University's experience to suggest two reasons why educational broadcasting has not always been as successful.

The Open University was set up to provide an opportunity of higher education for adults who were unable to go to university when they left school. Although students must normally be at least 21 years old, and resident in the United Kingdom, the University demands no other entry qualifications. In 1979, its tenth anniversary year, the University has over 75,000 students and has already awarded over 30,000 degrees.

THE OPEN UNIVERSITY'S TEACHING SYSTEM

Students, who are mostly in full-time employment, study at home and select courses from the list of over 100 currently offered by the six faculties - Arts, Mathematics, Science, Social Sciences, Technology, and Educational Studies. For an ordinary BA degree students must obtain 6 credits but for a BA (Honours) they need 8 credits. A credit is awarded for the successful completion of a full credit course lasting 32 weeks from January to November. During this time - although there are obviously wide variations - students can expect to have to devote 12 - 15 hours each week to Open University study.

Students study using a combination of specially written correspondence texts, set books, and specially produced radio and television programmes. Throughout the course optional face to face tuition is available at one of the 260 local study centres spread around the country, but a student's main source of personal tuition is by correspondence.

To overcome the problem of teaching science and technology with students working at home many of the courses in these disciplines also send students a home experiment kit. These kits can contain quite sophisticated equipment but there are obviously limits to what can be sent to students. This is one of the reasons why some courses have a compulsory, residential summer school lasting one week. Summer schools are held on the campuses of conventional universities when the students of those host institutions have left for their summer vacations. Each of the five introductory courses and some higher level courses (particularly those in science and technology) include a summer school. All Open University students will therefore experience at least one week of full-time study.

At the end of each course every student must take a three hour written examination at a specially designated examination centre. As with other British universities these examinations are scrutinized by independent external examiners to ensure that academic standards are maintained. Finally the student's grades for assignments submitted throughout the year are combined with the exam result to determine whether the student will be given a credit.

The Open University's headquarters are at Walton Hall, 50 miles north of London in the new city of Milton Keynes. Here new courses are designed by course teams which include central academic staff, BBC producers, educational technologists, full-time academic staff from the regions and a back-up team of graphic artists, editors, photographers, librarians, etc.

The full-time regional academic staff mentioned as forming part of the course teams are also the core of a regional network which covers the whole of the United Kingdom. Thirteen regional offices are responsible for the 260 study centres where students come into contact with the part-time tutoring and counselling staff. The University employs over 5,500 part-time staff who are drawn mainly from other higher education institutions throughout the country.

Another centre at present away from the headquarters at Walton Hall is the BBC-Open University Production Department at Alexandra Palace in North London. Although a new production centre is currently under construction at Walton Hall the Open University's television and radio programmes have been produced - perhaps rather appropriately - at Alexandra Palace, the building from which the world's first public television programmes were transmitted in the 1930's.

BROADCASTING AT THE OPEN UNIVERSITY

A formal agreement between the Open University and the British Broadcasting Corporation (BBC) provides for the production of up to 300 new television, and 300 new radio programmes each year. This agreement also includes transmission time for the growing number of Open University programmes. In 1979 the BBC transmitted just over 35 hours of television on its two national networks and approximately 26 hours of radio on two of the BBC's national FM radio networks.

The Open University's commitment to broadcasting is therefore considerable. Of the total Open University budget in 1979 - approximately 64 million dollars - almost 12½ million dollars were paid to the BBC for producing and transmitting the television and radio programmes.

This level of production means that just over 300 BBC personnel work in the Open University Productions Department of whom 60 are specially trained producers. As these producers are involved in all stages of the course production process there is clearly a need for them to combine both academic and media expertise. Many were therefore recruited from the academic world and given training in production techniques by the BBC.

As well as the colour television studio, and a radio studio at Alexandra Palace the Department also has its own colour outside broadcast unit which includes videotape facilities. By adding many of the support services, such as film cutting rooms, a video rostrum area, graphic design facilities, etc. the department has become a self-contained production centre - though it still has the advantage of being able to call on central BBC departments for film crews, source material, and technical expertise.

Despite this major commitment it must be remembered that broadcasting only plays a part - though sometimes a very important one - in a complex multi-media distance learning system. Even on the introductory courses, which are given the maximum allocation of radio and television programmes, students receive only one 25 minute television programme and one 20 minute radio programme per week. On more advanced courses students may only receive one radio and one television programme a month. But despite the comparatively small proportion of a student's time devoted to broadcasting it is an important and successful element of the Open University's teaching system.

THE HARDWARE IS NOT ENOUGH

In contrast to the Open University's experience of using broadcasting as part of an educational system a review of the available literature soon shows that when broadcasting has been used elsewhere the results have frequently not matched the expectations. In the third world, broadcasting was often held up as a panacea for their development problems. In Europe and North America disappointment followed many of the attempts to use broadcasting either as part of compensatory education programmes in the schools, or as a way of handling the explosion in student numbers in higher education.

Since the technical standard of the hardware available to many of these less successful projects was comparable with that used by BBC-Open University Productions; and since many of these projects also used experienced professional broadcasters as programme producers it might be useful to analyse the context in which Open University broadcasting has proved successful. Perhaps in this area some clue can be found to explain why similar hardware can be less successful in one setting than another.

To analyse the ways in which broadcasting is used at the Open University the work of Katz and Wedell seems helpful (1). They have suggested that before the use of educational broadcasting in the third world can be analysed it is first necessary to make a distinction between two types of educational broadcasting. Although the Open University uses broadcasting in a more developed country than those which Katz and Wedell studied the distinction still seems relevant.

Katz and Wedell called these two types "Intensive" and "Extensive" and suggest that they should be seen as the two extremes of a continuum. The extensive form of educational broadcasting includes "... all types of programming that are intended in one way or another to encourage greater understanding among sections of the general audience"(2). These programmes aim at informal education, usually of adults at home, and have no multi-media support, demanding little or no preparation by the viewer. In contrast the intensive use of educational broadcasting is aimed at the formal part of the education system. Specialised programmes are produced for particular target groups of students and multi-media support is usually provided.

If these two types are viewed as the extremes of a continuum along which all educational broadcasting projects could be placed it is obvious that the Open University would come very close to the intensive end of the continuum. Programmes are very specialised and carefully designed as part of a multi-media learning package which can result in a formal qualification for the students.

The First Lesson

From this recognition of the type of educational broadcasting used by the Open University an important lesson can be drawn. Katz and Wedell argue that these intensive uses are less likely to succeed as they can only function with a "... highly developed co-ordinating structure working with considerable resources"(3). They quote Richmond Postgate who gives a clear example of the difficulties in running an intensive educational broadcasting system in a developing country.

> "Failures are very common at interfaces. Most new schemes have many interfaces. For instance, a successful school broadcasting radio service involves a producer, teacher, inspector, headmaster, a maintenance system, a local supplier of batteries, a reasonable engineering system to produce a signal, a producer of acceptable support material, a distribution system, an effective feedback system, a personnel training system, and an organisation that sustains, harmonises and finances all these items."(4)

At the beginning of this paper, within the constraints of time, some idea was given of the complexity of the Open University system which surrounds this successful use of broadcasting. Had space allowed, a more complete description of the University would have emphasised even more clearly the tremendous number of interrelated support systems. And yet even this complex structure can only function because within the United Kingdom there are other functioning systems which the Open University can use.

To give just two examples. The University uses the national postal service which - although everyone complains about it - is rapid and reliable enough to allow the University to mail about 20,000 course packages to students every week. This adds up to an average weekly weight of 35 tons. The postal system is also reliable enough for students to mail their assignments to their correspondence tutors and in return receive comments and advice.

The University also draws on the large pool of qualified staff in other higher education institutions to act as part-time tutors and counsellors. If Britain did not have this large higher education system the Open University, as presently constituted, could not function.

Although many other examples could be given the lesson is clear. Even if the BBC-Open University Production Department, together with a national transmission network, were given to another country this would not be a guarantee that this new country would be able to use intensive educational broadcasting successfully as part of a distance learning system. Unless the support systems either existed within that country - or could be rapidly established - the expectations would probably not be matched by the results.

THE NEED FOR A NEW EMPHASIS ON THE USER

Up to this point the user has received relatively little attention in this paper. But sadly this is often the situation when attempts are made to introduce educational broadcasting. Too often the emphasis is on the hardware with little thought for the demands the new broadcasting will make on the individuals for whom it is intended.

Recently there has been an increasing awareness that perhaps people are not as easy to change as we once thought. They find it difficult to 'unlearn' deep-seated roles and behaviours and to adopt the new ones required by an innovation. The implication of viewing innovation in this way is that instead of seeing it as a series of events, and concentrating on the stages by which the hardware is installed, the emphasis should really be on the user. The questions which should be asked are those which attempt to discover what changes the innovation will demand of the users and how they can be helped to make those required changes(5).

But the emphasis on the hardware still goes on. To take only one example. In the Indian Satellite Instructional Television Experiment (SITE), conducted during 1975-76, 82 percent of costs were for hardware - earth stations, studios, television sets, etc. Only 9 percent of total costs were spent on software production - the programmes. The management and co-ordination of the project by the Space Agency accounted for a further 6 percent which means that only 3 percent was spent on social research and evaluation (6).

It would, however, be wrong to give the impression that this lack of forethought in the introduction of new technologies for education is restricted to the developing world. An almost 'classic' example of the problems which can result has been given by John Lee in his book, Test Pattern (7). This analyses the attempts at Scarborough College - part of the University of Toronto, in Canada - to use televised lectures as a replacement for large, year lectures with undergraduate students. This was a response to the projected explosion in student numbers in the second half of the 1960's with the resulting shortage of qualified and experienced teachers.

In the introduction to his study Lee summarises very well the way in which the problems individuals might face were given little emphasis.

> "The decision to go all-out for television at Scarborough reflected a general tendancy among North American governments to believe that 'crash programmes' could solve urgent social problems. Much less attention was paid to the slower process by which human values and attitudes are changed. Generous budgets and emergency plans might raise new buildings almost overnight and equip them with new technologies, but the attitudes of students and professors could not be altered so fast or so arbitrarily."(8)

As in many other instances of educational innovation the demands made on the users were not given sufficient thought. At Scarborough College, although university teachers were going to have to use television as a replacement for the conventional year lectures it was found that in some cases, when new staff had been appointed the question of using television had not been raised: in fact some appointees were apparently not even told that the television facilities existed(9). The students fared no better. Because the existing lecture timetable was built around fifty minute lectures separated by ten minute periods for class changes the use of televison was structured to fit this format (10). No one appears to have questioned the assumption that because students seemed reasonably happy with two or three, fifty minute face-to-face lectures a day they would find two or three, fifty minute televised lectures equally acceptable.

In Scarborough College the lecturers and students had to develop new skills. The former to teach through television, the latter to use television as a learning resource. The roles for both lecturer and student had been radically altered but there is little evidence of opportunities being given for either group to develop the new skills, or practice these new roles.

The Second Lesson

At this point I want to take a second example from the Open University's experience of using broadcasting. It illustrates very clearly that even with sophisticated hardware, skilled producers, and a massive support system it is still possible that the intended outcome of the programmes may not be achieved if the users do not possess the skills required to make use of the learning resource being offered to them.

As part of the Open University's commitment to progressively developing its system of distance education the University has established an Institute of Educational Technology. This Institute was set up to conduct research into the Open University's teaching system and to feed back the results of that research into the production of new courses. There is a staff of about 70 and in 1979 its budget was approximately 1,400,000 dollars - though this was supplemented by funds from external sources.

I am a member of a research group which forms part of that Institute and has been given the task of researching into the audio-visual component of Open University courses. One element of the work of this research group since 1974 has been a number of studies which looked at individual television programmes in great detail. Two of my colleagues, Tony Bates and Margaret Gallagher had conducted a number of these studies when it became clear that one type of programming was resulting in a recurring pattern of problems among students (11).

By 1976 an increasing number of courses were planning to use television to present 'case-studies' to their students. These programmes use what could probably best be described as a documentary format to present student with 'real-world' examples which they can then analyse using the theories, concepts, and criteria they have met elsewhere in their courses. Although this type of programming covers a wide spectrum, and some would question the validity of of the terminology, 'case-study' and 'documentary' it is clearly a particularly valuable use of the television resource which the Open University is most fortunate to possess. Its value lies in the fact that it presents students with the opportunity to discover whether they can use the theories and concepts they have learned to gain a better undertanding of the world about them.. In other words these programmes provide an opportunity for students to develop the higher order learning skills such as analysis, synthesis, and evaluation.

The evaluations of these programmes showed that a significant proportion of the students were unable to use these case-study programmes in the ways in which the producers had intended. One example will serve to illustrate these problems.

An advanced level course in the Social Sciences looks at the structural basis of inequalities and their social and political implications. In the first part of this course a television programme uses the role of women in the home and at work to examine conventional assumptions about inequality; to distinguish between inequality and differences; to establish the significance of class in social relationships; and to identify the role of ideology in perpetuating these relationships.

The programme was supported by many pages of printed materials which related to the concepts with which the material in the programme was linked. In addition the objectives of the programme were clearly stated. And yet, despite the care with which this programme had been integrated with the other components of the course, a majority of the students were unable to analyse the material as had been intended.

Here it must be emphasised that this problem was most certainly not the result of shortcomings in either the technical quality of the programme, or of the production skills which had gone into it. Indeed the Open University is fortunate that its link with the BBC ensures both a high technical and professional standard. And yet the problem was there. Many of the students could not make full use of this learning resource.

Here the new use of the technology - broadcast television as part of a distance learning, university level course - was demanding from students a set of skills which many did not possess. In addition the familiarity of the medium, and the documentary style of presentation led students to misinterpret the response which was required from them.

With the programme on inequality the students identified very strongly with different individuals who appeared in the programme. In normal network television a producer would be extremely pleased with this result, however, in this case the objective of the programme had been to give students an example which allowed them to apply the concepts of ideology, class, and social change.

Partly as a result of findings such as these several approaches are being tried to help students develop the skills needed to make full use of case-study type programmes. A package of materials is being developed to help new students identify the different types of television programme produced by the Open University, and to realise that each type requires a different response. Some individual case study programmes have already been produced with much clearer "signposting" built into the programme to help students identify the most important aspects. But a more long term solution is also being planned. The new version of the introductory course in Social Sciences will structure its use of television to help students develop these skills. Early programmes will include documentary material, but students will be given considerable help with the analysis of that material. As the course progresses the programmes will give students less and less help until, by the end of the course, most students should be able to cope with case study programmes on their own.

CONCLUSION

Although this paper has concentrated on two problems in the use of educational broadcasting these should only be taken as cautionary notes. The danger is that if educational broadcasting continues to be oversold there will be a backlash. Educational broadcasting is a valuable resource but a continued emphasis on the hardware, together with a failure to recognise the problems which users may face will mean that in many more cases the results will not match the expectations.

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HUMANIZING TELECOMMUNICATIONS:

Enhancing the Learning Climate in Group Teleconferencing

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Abstract

This paper focuses on the use of interpersonal communication training to facilitate the achievement of learning objectives in group teleconferencing by two-way audio systems and by computer.

Communicating
In-tune-ness or what-a-mess
Still depends on Man.

It has been said that futures are invented rather than predicted.(3). Futures encouraging the growth of a learning society where there is an increasing interchange of information on innovations in health, science, education and technology include the intervention of telecommunications, particularly in the form of group teleconferencing. This paper will explore ways of enhancing learning contexts for group teleconferencing by two-way audio systems and by computer.

"Humanizing" is defined as optimizing the climate for group communication so that learning outcomes can be maximized. Learning outcomes are categorized as cognitive (information gain), affective (attitude change or reinforcement),and psychomotor (skill acquisition or behavioral change).

Group teleconferencing can be likened to an intercultural interchange. I would like to begin by defining "culture" and "interchange." Singer (12), in his perceptual model of cultures, describes a culture as a pattern of perceptions and behavior which is accepted and expected by an identity group. Since by definition each identity group has its own pattern of behavioral norms, each group may be said to have its own culture.

A dyad is the fundamental unit of an organization (2) or culture. An interchange dyad operates to achieve a mutual purpose. Intercultural interchange is centered in interaction, and the communicators have an opportunity to change each other in fundamental ways (6).

Whether the interchange is face-to-face or interface, a learning climate that is indicative of a high level of trust, spontaneity, and openness seems to facilitate group interaction, interchange of [illegible]ormation, and the solving of complex problems.

I would like to cite two examples of face-to-face groups that were able to achieve their learning objectives by changing the climate. The first group consisted of adolescents at Tripler Army Medical Center who were referred by the courts and by their schools for group psychotherapy.

Ideally, in group counseling members may be considered to be experts in their own problem area and may function as peer counselors by sharing information, behaving in a supportive manner that would encourage interaction. This would happen if the group is perceived as warm, empathetic, and sincere by the membership.

After two sessions the counselor considered this particular group to be "cold," "closed," and "hostile." How could you generate warmth, openness, and spontaneity in such a group? I offered an intervention in the form of communication training, based on the success of a peer-counseling project at Kahuku High School.

The Kahuku Project (4) selected trouble-makers in school for training as peer counselors. In measuring the success rate, there was no significant difference between the professional counselors and peer counselors. Furthermore, the peer counselors went on to take active roles in the mainstream of school life in both scholarly endeavors and in extracurricular activities. Interpersonal communication training, which was the heart of the training content for the peer counselors, was cited as the variable that made the difference in their new relationships with their teachers, administrators, and fellow students. Through communication training the peer counselors were able to change their environment so that learning could take place.

Using a pre-test, post-test quasi-experimental design (9), I worked with the Tripler group, using various activities in communication training as the independent variable. Many of the activities had been tested previously in workshops with the University of Hawaii's communication classes (8), with the University's residence managers, organizations from the business and political sectors, and a group of trainees which included a large number of the district-court judges on Oahu.

The dependent variables were measures of trust, closeness, and spontaneity. After two sessions of communication training, when the post-test measures showed significant gain scores in these elements, the group continued with their counseling activities. Professional counselors who continued to work with the group indicated that in the subsequent sessions there was evidence of supportive behavior that encouraged a high level of participation and problem-solving.

Can communication training build learning contexts when the participants are not face-to-face but separated geographically? Can persons of different cultural backgrounds who are widely separated by space create a viable learning context which would enable an effective interchange of cognitive and affective messages? In the summer of 1971 my communication class at the University of Hawaii-Manoa was involved in the first PEACESAT learning experiment, when it was interconnected by satellite with the communication class on Hilo campus.

The 24 students on the Hilo campus were primarily local residents, mostly Orientals and a few Caucasians. The 30 students on the Honolulu campus were a cosmopolitan group from Cambodia, Malaysia, Vietnam, the Philippines, California, Texas, Alaska, and Hawaii.

The experimental design called for a series of 12 interchanges between the two groups dealing with six kinds of interpersonal communication: basic intelligibility, giving directions, problem solving, and attitude prediction.

In communicating affects (friendliness, sincerity, relationships), the intended and perceived messages of the satellite groups were positively correlated at the .05 level of significance. In information gain the mean gain scores of the satellite group (Manoa) were significantly higher than those of a comparison peer group who participated in a similar activity face-to-face.

In the information-gain activity the satellite groups decided to have interchanges rather than lectures, because in a prior session one of the teammates had spoken for seven minutes before realizing that she was not transmitting because of a technical failure. Intermittent checks requesting feedback would have caught this error earlier. An interchange model would permit this more readily than a lecture format.

The information-gain exercise was the activity that maximally utilized the outcomes of communication training, such as the units on communicating affects and basic intelligibility. An inference can be made that the significantly higher achievement of the satellite group over the face-to-face group was the result of communication training in which the design was appropriate for the group that communicated by means of two-way audio systems.

An interchange model over the tele-lecture format was utilized in a group teleconference in a recent project I participated in this past summer, "The Use of Telecommunications Technology in the Training of Rehabilitation Personnel" (2). The project included three four-hour sessions at which rehabilitation personnel as well as communication specialists were present. The teleconference dealt with the topic of learning through teleconferencing. Participants from Hawaii, Alaska, and continental United States were interconnected by a two-way audio system called the "Meet-me" bridge. The first session, a lecture on telecommunications, generated feedback concerning the participants' preference for an interchange system. The last two sessions utilized small groups by regions, which produced a higher level of interaction than the first session. Although the opportunity to give feedback changed the format from lecture to interchange, there appeared to be a few members dominating the interaction.

The participants attributed their reluctance to speak out publicly over the two-way audio system as "stage fright," the feeling of vulnerability because "the whole world is out there listening to you." In their face-to-face groups at the conference site, however, they were open and spontaneous.

The opposite of "stage fright" is a class of activities identified as composure practices. Composure is used in the sense intended by Goffman (5) as self-control, self-possession, or poise. These three forms are illustrated in the following way:

1. "Composure has a behavioral side, a capacity to execute physical tasks (typically, involving small-muscle control) in a concerted, smooth, self-controlled fashion under fateful circumstances.

2. "Along with the value of smooth movements and unruffled emotions, we can consider that of mental calmness and alertness, that is presence of mind.

3. "Stage-confidence - the capacity to withstand the dangers and opportunities before large audiences without becoming abashed, embarrassed, self-conscious, or panicky."

Concommitant with composure is the affect of "feeling more at home in the world" (14). Composure and "feeling at home with the world" appeared to be a by-product of the communication training of the Tripler and Kahuku groups. It was also demonstrated by the satellite groups between the Manoa and Hilo campuses. Is this an outcome that can be incorporated into communication training for group teleconferencing?

In the two-way audio systems, communicators were able to utilize two kinds of auditory cues, verbal and nonverbal. The nonverbal cues were paralanguage cues such as intonation, rate, volume, and quality. Training in these components were included in the communicating of affects. However, in the group teleconference by computer, the output is visual - print. The basic dyad comprises a writer-reader relationship.

Can a viable learning atmosphere be created in group teleconferencing by computer? In the first large-scale investigation of its kind the National Science Foundation conducted extended observations of approximately 500 members of more than 18 organizations that used computer conferencing (13). Among these organizations were NASA, the U.S. Geological Survey, ERDA, and the Kettering Foundation. A total of 5,400 hours were analyzed in depth.

Some of the variables affecting the atmosphere were (1) group leadership, (2) interpersonal feedback, (3) volume of information, and (4) skill in typing. Two other variables were experiencing of synchronous communication (where two or more people were present simultaneously) and the "receiving ratio" (the ratio of private messages received to all private messages sent).

Differences in group leadership did much to enhance the atmosphere or to create ambiguity about personal contact. Immediate interpersonal feedback was sometimes lacking, since it may have been several days until others see one's messages; even there, there was no certainty that they would respond. Also, the volume of information in a computer conference can become overwhelming and further discourage a sense of interpersonal interaction. A lack of typing skill may mean that some have assigned subordinates to sign in for

The concept of "twigging" to handle information overload among members in the scientific community was introduced by Weick (15). "Twigging" entails the balancing of relevance and quantity of information by means of adjustments in the perceived environment and the practices applied to it. To maintain this balance, the reader changes either relevance (desires) or quantity. Some cognitive objectives on ways in which to handle overload and their advantages and disadvantages may be useful.

As far as motivational variables are concerned, if one looks at motivation as a function of achievement rather than the reverse, a satisfying interchange would generate greater motivation toward the seeking of similar rewarding experiences.

Communication training may have been minimized as an integral part of group teleconferencing because of the notion that communicating involves "common sense." However, as Szaly (11) emphasizes, the greatest illusion is the "universality of common sense."

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THE INTERDISCIPLINARY M.S. PROGRAM IN TELECOMMUNICATIONS AT BOULDER, AND ITS POSSIBLE USE FOR TRAINING STUDENTS FROM OVERSEAS

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Abstract

A description is given of the inception and operation of the Master's Program in Telecommunications at Boulder, and covers the program structure, use of media, the telecommunication seminar, the thesis, the student body, program administration, and overseas students at Boulder. The needs of developing countries are outlined and a discussion is given of a proposed new International Center for Telecommunications Education to operate alongside the existing program, for the special training requirements of Third World senior executives and administrators.

PROGRAM INCEPTION

The Telecommunications master's degree at the University of Colorado is a graduate degree from an interdisciplinary program, started in 1971 after more than a year of preparation. The initial idea of developing a master's program that was neither an engineering program nor a social science program but one that helped to bridge the gap between the technology and the social structure in which it is governed and operated, resulted from conversations between some members of the U.S. Department of Commerce and representatives from the University's Departments of Political Science and Electrical Engineering.

The original objectives of the program included providing a curriculum in which students without necessarily any formal technical background but with an interest in communications could learn some of the vocabulary and concepts which underlie the technology of telecommunications systems while also providing detailed information on the economics and political structures which govern the industry. At the same time, we wanted to develop a program in which engineers could learn about the social and economic structures while improving their knowledge of the technology. We also hoped that by placing these two groups of students in many of the same classes and by having them work together in teams of twos and threes on projects, that both groups would obtain a better understanding of the complex social, political, economic and technical problems which govern the field.

PROGRAM STRUCTURE

The program was initially designed around a twelve-month enrollment and the earning of a minimum of 30 credit hours. It commenced with a core structure consisting of two courses from Electrical Engineering, one from Political Science, one from Business and one from Sociology. Although not obligatory, most students were expected to take the core courses, together with a number of electives. In addition, there was the telecommunications seminar, a weekly event, and a summer project or thesis.

In the subsequent evolution of the program, a course "The Introduction to Communication System Theory" was added to provide an exposition, in an engineering context, of necessary basic mathematical and electrical concepts. Further courses added were in the areas of telecommunication law, computers and telecommunications, data transmission, the telephone network, electromagnetic transmission, engineering management, engineering economy, and mass media and society. In addition, a telecommunications laboratory was set up with NSF funding, for the roughly 50% of students lacking an adequate contact with the electrical side of the subject. In the summer, courses on cable TV and current issues in telecommunications policy were added.

With the further development of the curriculum as outlined above, an additional feature became apparent: the number of relevant courses, both core and elective, has grown such that the students are confronted with an almost embarrassing choice. With a 12-hour requirement per semester there are just not enough hours to go around. Very few students voluntarily exceed the minimum, and those who have tried 15 hours per semester, which is the maximum that the Graduate School recognizes, find that the load is excessive. Quite a few students extend their enrollment to 18 months, and where possible, they are now encouraged to do this. The further period thus made available enables quite a few additional courses to be taken, and has the further advantage of helping to prevent the curriculum from being overweighted with engineering-type courses.

USE OF MEDIA

About five years ago, when a number of students were registered on the Colorado Springs campus (some 100 miles from Boulder), an attempt was made to use video-taped material to save unnecessary travel. The professor concerned had previously taped some of his other classes successfully and was willing to try the method out here. Dr. James Gibbons of Stanford had earlier shown that superior understanding of lecture material was possible in small groups using video-taped material and selected tutors. In the present instance the experiment was not judged a success. The class presentation involved much interaction with the students and although this came over well on the tape, the viewing students were unable to participate directly. Presumably with a live broadcast and telephone contact the process could have been improved, but the facilities for this were not available.

Mainly because most of the classes in the telecommunications program are of this interactive form rather than straight lectures, no further attempts have been made to use the media to extend the presentations off campus, though the matter has been looked at again from time to time.

TELECOMMUNICATIONS SEMINAR

The seminar is a weekly event, and although not originally for credit, it now earns, at the students' request, 1 credit-hour per semester, with the number of hours for graduation increased to 32. It is the only part of the program that is strictly mandatory. Lasting about two hours, it usually consists of a lecture-type exposition followed by, or interspersed with, questions, comments and discussion. The purpose is to expose the students to a broad spectrum of points of view on a wide range of topics so as to supplement and also exemplify the in-depth course material.

The program has been extremely fortunate to have a number of experts in the field who are available locally. In particular, at the adjacent Department of Commerce facilities (including those of the National Telecommunications and Information Administration and the National Bureau of Standards) there are a number of highly-qualified individuals with first-hand knowledge of aspects of the ITU and its various subordinate agencies. This has created a unique opportunity to present the student with inside information on the working of these bodies. Other local experts in various fields cover such topics as TV and radio programming, frequency spectrum management, local regulatory agencies, the operation of the telephone system, rate determination, cable-TV operation, satellites, educational communication networks; and many other diverse subjects.

We feel that this seminar is an essential and valuable part of the total program, as it helps to maintain a variety and balance that might be lost from a mere personal selection of elective courses. It provides "real world" exposure of a kind not readily available in a more academically oriented course.

THE THESIS

The project or thesis is a substantial part of the student's contribution to the program. The main difference between the two forms is that a thesis must be done by a single student, whereas the project could be a team effort by two, or maybe three, students. Otherwise, the same standard is required for each: but as of now only the thesis is accepted by the Graduate School for record and placement in the college library.

Normally the project/thesis is done during the summer months, though most students are preparing for it one way or another from about the beginning of the calendar year. The choice of subject is left to the students, and almost without exception, they turn out to have a prior interest or knowledge that leads them to a suitable choice that is then confirmed by the student's thesis committee. The range of subjects has been extraordinarily wide: from a consideration of the University's telephone exchange to European cable TV; from emergency communications in Colorado to an analysis of telecommunications in developing countries; from the production of TV programs on Public Access to the use of telecommunications by the Boulder medical community; from domestic satellites to pay-cable economics. It is a pleasure to note that well-placed individuals in industry and government have volunteered to help in overseeing certain of these projects, to everyone's benefit.

THE BOULDER STUDENT BODY

The age spread of enrolled students has been from the early twenties to over 50, with an average age of about 30. The military showed a substantial interest in the telecommunications program from its inception. In the first few years it provided about 50% of the enrollment, though this percentage has declined in the last few years. At the same time, we have noticed an increase both in applications from overseas, and also in the number of in-state students, who, by and large, have made up only a small part of the class.

Many of the students are "mature" students, with a considerable background in the real world. The military students in particular have a wide range of experience in dealing with large and complex communication systems, and they bring to the class a discipline and a camaraderie which influences the class atmosphere in an unmistakable and beneficial way.

Many students leave their jobs to come to the program and support themselves on savings. Some work part-time, taking two to three years to complete the program.

PROGRAM ADMINISTRATION AT BOULDER

Most of the staff for the program were already teaching in various departments, and a re-arrangement of schedules and, in some cases, an increased teaching load, provided the necessary faculty involvement to permit the program to get under way with an initial grant of some $80,000 from the National Science Foundation. Both initial costs of organizing the material and professors' salaries were covered by this. Subsequent grants by the International Communications Association of $6,000 per year for several years enabled some assistance to student fellowships to be made. Currently the program is receiving about $2,500 in donations, most of which is earmarked for student grants-in-aid, but this sum does not go very far, and is quite inadequate to provide even one full-time scholarship.

It appears that this program is well-known, both nationally and overseas, with interest having been shown from as far away as Australia. An initial mailing of brochures to departments of electrical engineering and political science brought in a very large early response. The program is also well-known to the U.S. military and to government agencies. One of the sources of publicity is the students themselves, both in talking to other potential students and also, indirectly, via their projects. The latter often involves them in correspondence with industry, state, and national government agencies, and consultancy firms, with a consequent valuable, if unwitting, publicity for the program.

Many students, including those from the military, return to their previous jobs after completing the program. About a third of the class seek a new job, either with industry, government, or privately. It appears that most students have found the job they wanted fairly quickly, and indications are that previous experience, and in particular, a good technical background, is a very definite asset.

STUDENTS FROM OVERSEAS

A substantial number of overseas students, mostly from Africa and the Middle East, have graduated from this program. The majority were sent by their respective governments, but some of the few that were self-supported tended to encounter funding problems. Since all classes are conducted in the English language, fluency in English is essential. The University requires an adequate score on the TOEFL test, or other demonstration of an ability in English, but there is a difference between an ability to "get by" in a language, and to be really proficient in it. Some of the classes require a substantial amount of reading and writing of papers, and a bare sufficiency in English is not really enough to enable the student to do well at this.

There is a similar insufficiency in elementary mathematics. Most students have at one time or another been exposed to the necessary algebra and trigonometry, but an absence of fluency in handling these concepts, both readily and correctly, is apparent. The introductory course mentioned earlier offers needed revision, but a certain minimum basis is needed for this to be able to take root.

Not all overseas students return to their mother country on graduation. Motives vary, of course, but in the past year, for instance, students from Iran and Lebanon have been reluctant to return, and have sought ways of remaining in the U.S., at least temporarily.

To accommodate the specific needs of these overseas students, it may be necessary to expand somewhat the Political Science course on international regulation in order to cover still more background on the workings of the agencies of the ITU. The treatment of aspects of operating a national network, particularly as part of an international network linked by satellites and cable, would also merit some expansion. The local Bell telephone management has expressed an interest in such educational and training possibilities. There is, further, the likelihood that the University may shortly become involved in special training seminars in telecommunications for high-level U.S. executives, with the possibility of fruitful interaction with the Boulder telecommunications program and senior overseas students.

Technician training is another matter. Most universities have a department of electrical engineering dealing with such matters, but Texas A&M University has a special 4-year program for undergraduate trainees, culminating in a B.S. in Engineering Technology with a speciality in Telecommunications. It would probably be difficult to better this ad hoc curriculum.

NEEDS OF DEVELOPING COUNTRIES

Those developing countries with universities offering engineering programs, even those without an emphasis on telecommunications, are generally able to train electrical engineers who can install, operate, and maintain the telecommunication services. Although many administrators from developing countries, especially the newer and smaller ones, would appreciate additional help in training both engineers and technicians (especially help in financing to send their students to schools), the problem seems to be seen as one that is being solved to the general satisfaction of most. Certainly programs like that at Boulder could be of benefit here. However, there is one major deficiency in training which has been repeatedly mentioned by administrators of telecommunication agencies from developing countries. They expressed concern about the relative lack of proper training of managers of telecommunication systems to enable them to see and overcome the larger problems of regulation, of finance, of the need for total system integration, and to determine what level and type of technology is appropriate for their countries' particular needs. "Appropriate" in this sense applies to the level and kind of services offered to the technological level of engineering and maintenance staffs, to the availability of capital for equipment investment, to the equipment's revenue production capabilities and to long-range goals and priorities. The most modern and most sophisticated equipment may not be appropriate for a particular developing country. There is the question of whether the maintenance staff can properly handle new equipment and whether retraining is worth the expense. Questions of modernity, national prestige, politics, public relations, requirements, etc., clash with sound engineering and financial judgment. Many of the existing telecommunications training programs in the developing countries do not address themselves to these latter questions. For instance, the CETUC program in Brazil consists virtually entirely of technical courses. Even where good technical programs exist there appears to be relatively little emphasis on such features as switching systems.

The I.T.U. with funds from U.N.D.P. has launched an extensive technical assistance program which includes some emphasis on regulation, although this appears to be in isolated individual areas. The technical assistance program of the I.T.U. is indeed essentially technical. As reported in some detail in the Union's annual reports, such assistance is frequently provided to governments in the preparation of specifications and tender analysis for transmission networks. It also includes assistance for the integration and coordination on several subregional programs for the development of telecommunication systems. The assistance is not designed to offer training to produce managers with a balanced and integrated background in both the requisite technical and nontechnical areas.

A CENTER FOR THE TRAINING OF THIRD WORLD TELECOMMUNICATIONS EXECUTIVES AND MANAGERS

Different segments of the telecommunications management community need different types of programs to expand their horizons and to fill in gaps in their backgrounds. If they are to make executive decisions that lead to the development of well-integrated telecommunications systems which are compatible both with current equipment and with the future developments resulting from rapidly changing technology and the international political scence, they need a broad background and knowledge of trends. Executives of the level of director general for telecommunications or postal telegraph require training that can be compressed into relatively short blocks of times on the order of a few days to a month. Programs for this group of executives require emphasis on policy, planning, future developments and the long-range implications of various political and technical decisions. Programs for this group of individuals are quite different than that of directors responsible for the day-to-day operations of the telecommunications system or the construction and installation of a particular system. This latter group of managers can afford longer periods of training that is considerably more concerned with the details of current technology, compatibility with past systems, and future developments. They are less concerned with the problems of the impact of system design on long-range social structures and community development. They have all the problems they can handle in seeing that the system gets properly installed and can be maintained in a workable fashion, and the time scale on the effect of future developments is much shorter than that of the chief executives.

The Bell System has developed a diversity of programs at their training center in Illinois to deal with a substantial fraction of these problems. Many features of their program would be appropriate for the training of personnel from developing countries, although the program we envision covers a broader range of problems and technologies. For example, problems associated with policy matters on broadcast material and the distribution of information through a network such as educational TV may very well be of interest to a large part of our intended student body. Additionally, it is appropriate that the training consider a much wider diversity of equipment and techniques, as there is a much greater multiplicity of sources and approaches to telecommunications problems on a world-wide basis than that utilized by AT&T.

In addition to the course content, the acquisition of appropriate living classroom and laboratory facilities is necessary in order to provide an environment where this class of students can function effectively. Previous experiences show that the students have a great deal to learn from each other, as well as from formal courses. The appropriate planning of facilities and time schedules can greatly enhance the exchange of information between participants. With appropriate planning this can well become one of the most significant and effective parts of the program. In the current program at the University of Colorado with master's degree students, there is a great deal of interaction among the participants and a high degree of continuing exchange of information after graduation from the program.

In order to accomodate the special training and educational needs of senior executives, it is recommended that an International Center for Telecommunications Education be established at the Boulder Campus of the University of Colorado to permit the United States to assist in telecommunications training for high-level personnel from developing countries. Indications are that a "neutral" academic environment would enhance the efficiency of a training program for foreign personnel by removing the effects of possible extraneous political influences. Initial studies will need to be undertaken in order to:

(1) further detail a program specifically for senior level participants from developing countries. Questions to be addressed would include appropriate level and kind of training to be offered including the desirability of summer internships and certain other specialized training in connection with U.S. government agencies (FCC, NTIA), and industrial companies (Bell, Western Electric, IBM, for example) in the private sector. Considerable interest in such cooperative training has already been expressed by representatives of both governmental and private industry.

(2) determine the potential demand and the optimum number of senior-level participants who could be accommodated at any one time together with the resultant impact on the University of Colorado's faculty, staff, and facilities.

(3) determine the form of organization which would be responsible for the training of senior level participants from developing countries.

A Board of Governors would be responsible for over-all policy determination, particularly as regard long-term guidance of the program. This Board will have the responsibility of ensuring the effective functioning of the Training Center as a National and International resource. It will have seven members to provide input from various segments of the National and International interests at a high level of telecommunications management. It is proposed the Board be formed from the following agencies and industries:

FCC
NTIA
ITU
Major Telecommunications Industry
Major Computer Industry
U.S. State Department
University of Colorado

An Academic Operations Council will be responsible for program development including the curriculum, for the hiring of a Director, for reviewing operations, and for determining general priorities. The Council will be responsible for annually attending one or more international telecommunications conferences to assist in recruiting and orienting prospective participants to the program. In addition, it will be responsible for selected follow-up with the sponsoring foreign government agencies. It will have three members consistent with the interdisciplinary nature of the program, with one member from the Social Sciences, another from Electrical Engineering, and the Third from Technical Management/Economics.

The Academic Operations Council, with the advice and consent of the Board of Governors, will select a Director with responsibility for performance and for the commitment of resources, subject to policy established by the Council.

The Director will be responsible for the employment, consistent with policies of the University of Colorado and the Council, of permanent and visiting professional staff. He or she will be responsible for establishing technical and administrative support functions and for employing staff to support these functions.

It is tentatively proposed to supplement existing University of Colorado faculty with six permanent and nine part-time visiting fellows in areas to include the following:

Computers and data transmission
Economics
Frequency management
History of communications systems
Legal and regulatory
Systems management
Social impact
Telephone switching

It is anticipated that a number of the part-time faculty will be selected from the agencies represented on the Board of Governors. This will permit the Center to combine the expertise of the agencies with that of the regular academic faculty.

Participants will be recommended by their respective governments directly to the Center or through the ITU. Applications will be screened and final selections made by an Admissions Committee responsible to the Director.

It is anticipated that for some period of time the roster of participants will be drawn from those who are in the higher levels of management, planning, and operations positions. Each participant's own agency will be expected to continue his/her salary while in attendance.

Further investigation will establish some estimate of level of demand. One estimate of the Center's ability to handle on-going groups would be 15-25 top executives for the shorter courses, and 50-200 at the engineer level at any one time for longer programs.

CONCLUSIONS

The on-going master's program at Boulder is able, with very little change, to accommodate the needs of middle-level overseas telecommunications students. The latter must, however, be reasonably fluent in the English language, and a minimum mathematical ability is necessary in order to make headway with the technical courses. It is assumed that the student's agency is responsible for funding his educational and other costs for an involvement in the program for a period of about 18 months. For senior administrators and executives of developing countries, a new format is required, and the setting of a new International Center for Telecommunications

Education is recommended and is currently under study. Such a center should have input from both national and international agencies and should operste in parallel with the current Boulder program.

Boulder has a very tolerant social outlook, with many overseas students at the University, and would welcome the opportunity to participate in the education and training of the future operators, administrators, and managers of overseas telecommunications facilities of developing countries.

IMPLEMENTATION OF THE ADVANCED TECHNOLOGY IN OPERATIONAL ACTIVITIES AND ITS EDUCATIONAL ASPECT IN THE DEVELOPING COUNTRY.

Djauhari (*)
Djoko Hartanto (**)

1. ABSTRACT

As a developing country, Indonesia has always been faced with the problem of choosing the proper technology to meet the objectives stated in the main line of The National Strategy in all of its development programs.

In the case of telecommunications, Indonesia has adopted an advanced technology, a Domestic Satellite Communication System which, in the Indonesian language, is known as SKSD. This choice has certain implications in its operational activities with respect to hardware, software, and maintenance.

This paper discusses the problem of education in relation with the operational activities, especially as related to data communications.

2. BACKGROUND

Developing countries face many problems in their development activities. Indonesia is no exception, especially in the area of education. Providing education for 135 million people is not an easy task. The Government of Indonesia has therefore recently established a commission consisting of experts in education problems to develop a New National Education Pattern.

Universities, as institutes for higher learning, cannot be separated from this problem. Lack of facilities experienced by State Universities as well as Private Universities is the main reason why many high school graduates cannot continue their studies in the Universities and why most of the Universities have very low output. This fact characterizes the execution of development. One example is that the results of many development projects are dependent on the capability of contractors and suppliers' personnel in executing the projects. This is especially true for a specialized field like data communications. On one hand there is an increasing demand for this technology but, on the other hand, the number of people with adequate expertise in this technology is very limited among both the users and the suppliers.

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This paper presents results of observations and opinions in the field of education with emphasis on data communications, based on experience gained in the education of electronics in the Faculty Engineering, University of Indonesia, and from the preparation for the implementation of data communication applications in the Ministry of Finance.

3. DOMESTIC SATELLITE COMMUNICATION SYSTEM (SKSD)

Due to the increasing demand for telecommunication facilities for telephone, telex, telegram, data, and event broadcasting, and also due to the geographical condition of Indonesia (1), the Indonesian Government decided to implement a Domestic Satellite Communication System (SKSD) with two PALAPA satellites.

The SKSD consists of two segments: space segment and ground segment. The space segment consists of ~~two~~ PALAPA geosynchronous communication satellites, one of which will function as a full backup and will provide system growth. Each satellite is equipped with 12 transponders. The first of these PALAPA satellites was launched on 8 July 1976 from Cape Kennedy in Florida, and the second one was launched on 11 March 1977 from the same place.

When the SKSD was inaugurated on 16 August 1976, the ground segment consisted of 40 earth stations scattered throughout the Indonesian archipelago. From the 40 earth stations one station, which is located in Cibinong (Jakarta), also serves as a Master Control Station (MCS); 18 Main Traffic Stations (MTS) are located in 18 Provincial Capitals; and 21 Light Traffic Stations are distributed in the remaining 7 Provincial Capitals, 10 District Capitals and 4 Industrial Areas.

Hundreds of engineers and technicians are required to operate the system. Training facilities which has been used in meeting the requirement for trained personnel are Telecommunication Training Centre, Universities, Technological Institute, and Regional Training Units.

At present the PALAPA system is also used in the ASEAN community for domestic and border communications. This first generation of PALAPA satellites will be phasing out in 1982 and 1983, respectively, and the second generation, with capacity twice of the predecessor, will replace it.

4. DEMAND ON DATA COMMUNICATION

The telecommunication infrastructure of Indonesia has been expanded significantly, quantitatively as well as qualitatively. In the last few years, the demand for data processing capability has increased substantially, in the government sector as well as the private sector (see Table 1).

The activities in the data processing initially started with batch processing, which was then upgraded by transfering the data from the regions via magnetic tape to the centre for off-line processing. There is currently a demand for on-line systems between the data processing centres located in the capital cities of the provinces with that of Jakarta using a remote job entry mode.

In some applications, e.g., Government Financial System, Government Inventory Control System, and Defence System, there is a need for an on-line network which implies the development of a Distributed Data Processing Network.

As an example, in the Government Financial System, there is a requirement for Distributed Data Bases for Routine and Development Expenditures, as well as for Custon and Tax Revenue among several provinces.

As in the case of other new technologies, it can be expected that the demand for data communications will increase as soon as the data communications network for one application has been successfully implemented.

As far as data communications technology is concerned, the Government of Indonesia is undertaking studies to determine the most suitable technology for Indonesia from the point of view of economy, reliability, operations, and maintenance.

With the bird in the sky (SKSD), one possibility is the use of a small earth station with a small diameter antenna (3-5 meters) on the tops of the roofs of buildings. However, due to the danger of interference with the existing terrestrial microwave links, such a possibility has to be studied very carefully. Despite its reliability, intracity roof-top to roof-top communication might sound ridiculous.

5. THE NEED FOR SPECIFIC EDUCATION

Every application of new technology, in developing countries will usually bring forward the problems of providing capabilities to operate and maintain the system. One way to provide the require capability is by having in-house training or education. This has been implemented by PERUMTEL (The Indonesian Telecommunication Public Corporation) in recruiting personnel for the maintenance and operation for its SKSD. This is partly done through its own Telecommunication Training Centre and partly by working with Universities or Technological Institute.

The problem now is to train and educate personnel to operate and maintain system having new technology. This is, in fact, the main tas, of the education institutions, which in this case are the High Schools and the Universities. To support the development activities in Indonesia, there is a tendency for the Universities to leap forward technologically by importing the latest technology. An example is data communications. Despite the lack of some teaching elements, the Universities recognize that their graduates are expected to be able to cope with today's as well as tomorrow's technology. Therefore, the Universities are determined to develop a suitable and flexible curriculum. Some serious efforts are now being taken to provide the three most essential teaching elements, namely:

a. The availability of comprehensive and up-to-date reference library;

b. The availability of up-to-date laboratory facilities; and

c. The availability of up-to-date teaching staff.

Indonesia has 40 State Universities, 5 of which have been chosen by the Government to be the 'Centre of Excellence'. Basically, this implies that those 5 Universities are made responsible for guiding the others in some specified areas of science. Of those 5 Centres, Electrical Engineering Degree Program is offered by three Centres: The University of Indonesia, The University of Gadjah Mada, and The Bandung Institute of Technology. The total number of graduates in Electronics will be an average of 60 persons annually. Statistics available in the Department of Electrical Engineering of The University of Indonesia show that the graduates are distributed equally among the following fields: telecommunications, electronics, computer science, and aviation. Regarding the fact that the University graduates are not intensively trained in a specific theory or practice of technology, the companies that hire them always offer 6-12 months of training in managing the new technology.

From the above discusaion, it can be concluded that there are not enough University graduates to participate in the Development Activities, let alone to support the implementation of a specialized technology. That is the reason why most of the results of the Development Activities especially in the application of new technology, are much more dependent on the capabilities of the personnel of the company applying or executing the technology.

It is, therefore, the opinion of the authors that:

1) Univeraities should exert a conscious effort to increase the production of graduates to support the National Development Activitiea;

2) Industries should acquire their capabilities to guarantee that the operation of any system installed will function properly;

3) Foreign experts should transfer the technology or know-how to the local counterpart in every installation of new technology; and

4) Last, but most important, Universities in the Developed Countries should play an active role in helping Universities in the Developing Countries to overcome their basic problems.

If the above opinion can be implemented, the National Development goal can be sped up and the uncalculated waste can be minimized.

TABLE 1

COMPUTER INSTALLATIONS IN INDONESIA

	1977	1978
Central Government	8	14
Regional Government	4	6
Universities	3	6
Utilities	10	15
Oil, Mining	16	20
Manufacturing	8	10
Retailing	3	5
Banking	6	10
Insurance	3	5
Air Transport	3	5
Data Centers	5	10
Others	4	41
	74	147

NOTES

(1) Indonesia consists of 13,677 islands, of which 992 are inhabited. Indonesian archipelago sprawls along the equator for more than 5,110 kilometers, with a total land area of 1,904,345 square kilometers. The inhabitants are spread throughout 50 thousand cities and villages.

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EFFECTIVENESS OF SATELLITE TUTORIALS

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Abstract

This paper describes results from a recent study which explored the effectiveness of tutorials conducted via communications satellite ATS-1. These tutorials constitute one experiment in distance teaching conducted by the University of the South Pacific. The University and its Extension Services organization are briefly described, and the framework for the satellite tutorial is developed in this context. Following this, results are elaborated from a study which explored both student and tutor assessments of effectiveness. The paper concludes with a discussion of USP's communications systems capability for future programming both in tertiary education and outreach in the southwest Pacific.

THE UNIVERSITY

The University of the South Pacific (USP) was established in 1967. From the outset it was an unusual university in that it was set up to serve a wide range of needs in higher education in no less than ten Pacific Island countries. Today, USP is one of the world's two regional universities. It serves a geographic area as large as that of the United States, with a population of 1.5 million people situated on a land area approximately the size of Denmark.

Even though the land area is small, the cultural diversity of the university region is huge. The three socio-geographic areas of the Pacific are covered: Melanesia in the west, part of Micronesia in the north, and the major portion of the Polynésian triangle in the east. The specific countries served are the Cook Islands, Fiji, Kiribati, Nauru, the New Hebrides, Niue, Solomon Islands, the Tokelau Islands, Tonga, Tuvalu and Western Samoa. But with the commonality of the Pacific which they share, the countries comprising the USP region possess huge differences in economic development and political form. Fiji, with nearly half the population of the region, has an economy based upon various sectors; some of the smaller countries have monocultural economies and tiny populations. Politically, the university region includes the world's only condominium, a kingdom, and several states having been independent less than ten years.

EXTENSION SERVICES

It was recognized in the early planning for the university that a capability for offering courses remote from central campuses would be required.

An administrative unit, Extension Services, was set up to coordinate the external studies programs, and a network of University Centres was established throughout the region. With the development of the institution, the extension centres have become involved in continuing education and outreach programs, as well as in the coordination and administration of degree and diploma level courses.

Since 1972, the USP Centres have participated in experimental projects utilizing NASA's ATS-1 satellite. In 1974 the University established its own communications network, and this has resulted in experimental programs in the areas of health, agriculture and social development, as well as those having to do with tertiary education.

SATELLITE TUTORIALS

One of the most interesting and promising of recent experiments is the tutorial conducted via satellite. In this, the course tutor (based at the Laucala Bay Campus, Suva, Fiji) communicates directly with students and "local tutors" at USP Centres from one corner of the Pacific region to the other. Basically, this satellite communication is in support of correspondence courses which are written by faculty (course tutors based in Fiji) and distributed throughout the USP region by Extension Services. But with the satellite and other supportive mechanisms, the extramural courses are distinctly different from and superior to more traditional mail correspondence packages.

The satellite support is particularly valuable in the context of the Pacific region where mail connections are not only infrequent but also plagued with problems of immense distances and underdeveloped infrastructures. Indeed, any interactive communication by correspondence between tutor and student literally may consume months. The satellite helps to bridge this gap, and even for students who live on islands remote from the USP Centre terminal, there is at least a mechanism for indirect contact facilitated by satellite communications. This occurs between the course tutor (in Fiji) and the local tutor at the Centre, who then can contact and interact with students as particular conditions best allow.

Most USP extramural courses are structured with a single Suva-based course tutor and one local tutor based at each Centre where a given course is offered. And while the course tutor is typically an academic specialist, the backgrounds of local tutors vary widely. In some cases, the Centre Director serves also as a local tutor for one or more courses. In other cases, a qualified professional with expertise in a particular discipline may be employed as a local tutor. In still other cases, a volunteer from a metropolitan country might serve as a local tutor for several courses at an introductory level.

TUTORIAL EFFECTIVENESS

During the period August 1978 through June 1979, the author studied the characteristics and effectiveness of satellite tutorials at USP. Questionnaires were developed and administered to student and (both course and local) tutor groups. In addition, detailed interviews and on site observations were conducted in a total of six countries served by USP. Detailed elaboration of evaluative instruments, administrative techniques and primary findings may be found in Reference (1), while important overall results are summarized under the following seven headings.

1. Attendance. The question of attendance is important in at least two respects: (a) what proportion of students is able to attend satellite tutorials due to physical proximity to USP Centre terminals, and (b) of those able to attend, what fraction choose to do so? The combined estimate of local and course tutors is that 70% of enrolled students are physically able to attend, with approximately 60% of this group (42% overall) actually attending, on average, throughout the course of a semester.

2. Prior Preparation. To what extent do extramural students prepare for the tutorial sessions? The general tutor response is an almost typical teachers' lament: it appears that external students are as conscientious as their peers on campus, but not nearly as well prepared as their tutors would wish.

As to the mechanics of preparation, the most common mode is group discussion, followed by reading assignments, occasionally by written assignments, and in some cases by activity with audio/visual materials having been sent terrestrially to the USP Centre. The local tutor is often instrumental in orchestrating group discussion and a/v sessions.

3. Instructional Objectives. Tutors note the following to be important: (a) motivating the student, (b) communication (or instruction) between course and local tutors, and (c) discussion of questions relating to subject matter or administrative aspects of the course. When students are polled concerning purposes for satellite tutorials, only 50% feel these to be well defined. Student interpretation of purpose typically is "question answering" or "discussion of problems". Often this devolves to administrative matters (when will assignment 3 be returned?), or with gentle elicitation from the tutor of information (what themes will be stressed on the examination?). Other student views on rationales for tutorial sessions can be summarized as (a) maintaining a personal link with the Suva-based course tutor, (b) exchanging ideas with other students in the Pacific, and (c) enabling the tutor to deliver pre-planned lectures.

4. Communications System. On the negative side, the most frequently cited problem is that of poor reception. With ATS-1, this is due primarily to perturbations on the geostationary satellite orbit. And given the relatively short timeframes in which these fluctuations occur, a given USP terminal may be receiving and transmitting quite well during the beginning of a one hour tutorial, but then fade dramatically some 30 minutes into a session. A second problem is that the tutor is unable to interrupt students (the reverse is also true)! This can be distinctly troublesome with long-winded questions or answers. Thirdly, microphone placement is typically less than optimum: units are often placed precisely where students and tutors would most advantageously place references or notebooks. Fourth, the system is non-visual,

yet most USP students use English as a second language while course tutors are often highly verbal in English. Beyond the language problem, there are additional cultural and individual characteristics which tutors occasionally note (e.g., shyness; lack of familiarity with equipment).

On the positive side, the students genuinely enjoy using the system once they become accustomed to its operational features. Moreover, there is the degree of personal contact with their course tutor and their peers who are physically scattered over thousands of kilometers of ocean.

5. Local Tutor Role. Students indicate the primary function of the local tutor to be one of interpreting what the course tutor said or wanted. Secondary roles include preparing the local discussion group for participation in the tutorial, pacing student progress within the overall course timeframe, and motivating the individual student. Course tutors tend to identify the same functions for local tutors as do their students, and also emphasize strongly the overall importance of these individuals to student success with extension courses.

6. Effectiveness of Tutorials. Both student and tutor groups were asked a variety of questions which explore the effectiveness of satellite tutorials. In addition, the projective indicator technique (2) was employed to obtain an assessment of affective response for both groups on the effectiveness issue. Very briefly, this technique utilizes single word responses given by studentand tutor groups to establish a numerical index indicative of overall affective reaction. In the present cases, the index could range from +5 to -5. The more positive the index, the more positive value ascribed by the rating group to satellite tutorials. The indices obtained were [illegible].4 for the student group and 1.0 for tutors. Clearly; both groups have a positive disposition toward satellite tutorials, but compared to other work done by the author (3), the indications are not so strong as to be overly reassuring. In brief, more can be done to improve the effectiveness of the tutorial sessions and/or process.

7. Author's Assessment. Satellite tutorials are important elements in the delivery of extension courses at USP. The sessions are particularly valuable as vehicles through which positive feedback and encouragement can be provided to students. Since most students use English as a second language, and moreover work and study under comparatively difficult conditions, such motivational elements are highly significant. A secondary use of the tutorial is as an administrative device. Considerable time is devoted to stock-taking on the receipt of materials both to and from students. Since logistical problems do exist and are formidable, such discussion is necessary and appropriate. In continuing (declining) order of importance, the third use of the satellite tutorial is as a pedagogical agent in teaching. While such tutorials probably can contribute to cognitive domain learning, their use for presentation or explication of new material is of doubtful value. On an overall basis, however, there is no doubt that satellite tutorials represent an effective and useful link between the course tutor and his or her remotely based students.

FUTURE SYSTEM

Presently, Extension Services is in the midst of commissioning an upgraded and extended communications system. In addition to enhanced capability for broadcast mode communication over narrow band transponders (as with ATS-1), the new system includes a selective tone calling capability, plus facsimile and slowscan television facilities. Moreover, the audio production studio is being modernized, and a new video production studio is being established. All of these facilities will enable a broadened programmatic output, both in teaching and in various developmental outreach activities. In the latter, joint programs are planned with various organizations serving the South Pacific region. Topical areas in which the communications system will play an important role include health, agriculture, environmental resources, and social and economic development.

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THE DISTRIBUTIONAL IMPACT OF AN ALTERNATIVE TELEPHONE RATE STRUCTURE

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Telephone rate structures have characteristics which reflect society's attempt to achieve several different objectives (1):

1. universal service
2. static efficiency in resource allocation
3. equity for different users
4. financial self-sufficiency
5. preemption of uneconomic entry
6. consistency with expected technological change
7. administrative simplicity
8. historical continuity

The purpose of this study is to evaluate the impact of a radically changed telephone rate structure on the welfare of the average family in each of twelve income classes. This alternative rate structure has characteristics which achieve objectives 1-2 and 4-7 more nearly than does the existing rate structure. The incidence of the welfare effects of changing to a new rate structure is an important aspect of the degree to which that rate structure is equitable, i.e., meets objective 3.

The alternative rate structure, whose distributional properties are to be analyzed in this paper, possesses characteristics very different from existing structures; specifically as compared with present telephone tariffs, this alternative structure:

1. cuts monthly access charges drastically (by at least 50 percent);
2. imposes a time of day call charge for local calling;
3. reduces all long distance charges especially on nights and weekends; and
4. bases long distance charges on duration of call rather than distance.

These very extreme changes mean that a welfare analysis of these changes would *not* be an evaluation of the more moderate and gradual types of rate structure adjustments likely to be made by regulators. Yet this examination of incidence effects should help policy makers understand the benefits and dangers to fair treatment of consumers as they move in this direction (i.e., essentially toward a more usage sensitive and less distance sensitive rate structure).

To better understand the incidence complications of adopting such a rate structure, or structures of similar character, this paper explores the changes in annual telephone expenditures that might be made by families in each of 12 income classes if the particular rate structure shown in Table 1 were adopted (2).

In addition to the direct "household effects" caused by changes in household spending on telephone service, businesses will also pay slightly more for the telephone services they utilize under the alternative rate structure than under the existing rate structure. This slight increase in expenditure will reflect itself in changed prices for the goods and services which the businesses sell or in changed payments to the inputs utilized in producing those goods and services. As a result, the consumer, either through his income or through his general consumption expenditures, will be affected by changes in business telephone expenditures.

For a variety of reasons, it is not possible to interpret either an increase or a decrease in per-family telephone expenditures as a straightforward decrease or increase in the well-being, or welfare, of a family. To make welfare determinations in such circumstances, various price indices must be compared (3). One commonly used index of price change (the Laspeyre Index, *L*) weights prices in any two periods under examination (say, before and after the adoption of a new telephone rate structure) by the quantities consumed in the initial period. Another alternative (the Paasche Index, *P*) would be to weight prices by quantities consumed in the final period. Still another possibility (the Index of Income Change, *E*) would be to weight prices in each period by the quantities consumed in each period, respectively; this, of course would simply be the ratio of final expenditure to initial expenditure.

For a family of a given income class, if the ordering of the various indices is such that the index of expenditure change, *E*, is greater than both the Paasche Index, *P*, or the Laspeyre Index, *L*, then it may be concluded that the family is better off after the change in prices. Conversely, when *E* is less than both *P* or *L*, the individual family's welfare can be said to have fallen under the new price regime. Other orderings of these three price indices are either logically contradictory or indicate that no conclusion can be drawn as to the change in a family's level of welfare (4).

Background Data and Information

In order to compute price indices before and after a change such as that to an alternative rate structure, it is first necessary to estimate the various prices and quantities being consumed (before and after) in various sectors of family telephone expenditure: residential local, residential toll, and distributed business expenditures. Estimated 1975 telephone rates and revenues under the existing and alternative rate structure are presented in Table 1 (5). All telephone service rates and revenues shown in Table 1 have been deflated to 1972-1973 values in Table 2. Expenditures on telephone service by income class (shown in Table 3) were taken from the 1972-1973 Consumer Expenditure Survey (CES) (6).

Table 1

TELEPHONE SERVICE RATES AND REVENUES IN 1975 AND UNDER AN ALTERNATIVE RATE STRUCTURE

	Initial - 1975			
	Business		**Residential**	
Type of Service	**Rates (dollars)**	**Revenues (billions of dollars)**	**Rates (dollars)**	**Revenues (billions of dollars)**
Local:				
Station[1]	$21.00/mo.	$2.86	$7.43/mo.	$5.95
Extension[3]	3.00/mo	.30		
Call[5]	.0187/call	1.78	.0041/call	.40
TOTAL		4.94		6.35
Toll[7]:	.21/min.	5.52	.21/min.	7.88
TOTAL		10.46		14.23

	Alternative - 1975			
	Business		**Residential.**	
Type of Service	**Rates (dollars)**	**Revenues (billions of dollars)**	**Rates (dollars)**	**Revenues (billions of dollars)**
Local:				
Access[2]	$10.00/mo.	$1.28	$3.00/mo.	$2.55
Equipment[4]	1.00/mo.	.21	1.00/mo.	.85
Call[6]	.054/call	4.67	.042/call	3.31
TOTAL		6.16		6.71
Toll[8]:	.109/min.	4.53	.109/min.	8.98
TOTAL		10.69		15.69

[1] Initial station rates represent estimated average charges. Residential initial local station revenues were derived by multiplying the number of present main stations (66.7 million) by the initial monthly charge and then by 12 to give annual revenue. Business revenues represent the total of 9.4 million business mains at $21 per month and 1.3 PBX trunks priced at $31.50 per month. See Charles River Associates, *The Economics of Competition in the Telecommunications Industry* (Boston, Mass: CRA, 1979) Appendix C, Table C-12, for more complete explanation.

[2] The alternative rate structure access charges and revenue are taken from Local Rate Structure A, as seen in CRA, *Op. Cit.*, Appendix C, Table C-8.

[3] The business extension charge is assumed to be roughly twice the residential extension estimate of $1.50. Business extension revenue was estimated by estimates of 8.4 million business and Centrex extensions which is the total after deducting 39.9 million residential extensions from 48.3 million total industry extensions (excluding PBX and KTS). Residential extension revenues are not included in this analysis.

[4] Business and residential equipment charges are taken from the alternative rate structure as seen in CRA, *Op. Cit.*, Appendix C, Table C-8. Business equipment revenues under the alternative rate structure were derived by estimates of 9.4 million business mains and 8.4 million business extensions (CRA, *Op. Cit.*, Appendix C, Table C-7). Annual residential equipment was estimated using 70.7 million main stations.

Footnotes continued on following page.

Table. I (Continued)

TELEPHONE SERVICE RATES AND REVENUES IN 1975 AND UNDER AN ALTERNATIVE RATE STRUCTURE

[5] Initial average per-call charges were derived by assuming 120 calls per household per month. This implies 97.1 billion residential local calls (67,447,000 households); from a total of 192.3 billion calls (see CRA, *Op. Cit.*, Appendix C, Table C-8, footnote 4, p. C-27) 95.2 billion vusiness local calls are left. Since 10 percent of residential and 46 percent of business phones have metered local service, 95.2 billion business calls x .46 = 43.79 billion measured business local calls and 97.1 billion residential calls x .10 = 9.71 billion measured residential local calls. Since a total of 53.5 billion metered local calls results in an average per-call charge of \$.0406 (\$2.17 ÷ 53.5), this implies an average residential charge of \$.0041 per call (\$.0406 x .10), and \$.0187 per call (\$.0406 x .46) for business calls. Initial local call revenues for both business and residential are then derived by multiplying the total number of local calls by the respective price per call.

[6] Assuming the peak, shoulder and off-peak local call distribution as explained in CRA, *Op. Cit.*, Appendix C. Table C-8, footnote 4, p. C-27, the alternative rate structure average per-call charge is derived as follows:

.80(\$.06) + .10(\$.04) + .10(\$.02) = \$.054 for business calls, and
.35(\$.06) + .40(\$.04) + .25(\$.02) = \$.042 for residential calls.

Under a local alternative rate structure (CRA, *Op. Cit.*, Appendix C, Table C-8), residences are assumed to make 93 calls per month at \$.04 shoulder call charge. This implies 78.9 billion residential calls per year (70.7 million main stations), and \$3.31 billion call revenues per year, given average per-call charge as derived above. Assuming businesses make 12 local calls per day at \$.06 peak charge, 250 business days per year yields 86.4 billion local calls per year, and local calling revenues of \$4.67 billion.

[7] \$.21 per minute is derived by dividing \$13.4 billion of initial total toll revenue by total interstate and intrastate toll minutes of calling volume of 62.8 billion at the old rates. Total initial toll revenue and toll calling volume are taken from CRA, *Op. Cit.*, Appendix C, Tables C-9 and C-12.

Business and residential initial toll revenues were calculated from total toll revenues using a 40-60 business-residential split which is explained below. In 1972, business long distance interstate messages were 46.7 percent of total; residential was 50.1 percent. For 1973, the figures were 47.4 percent and 49.6 percent respectively. Thus, the split for business for 1972-1973 is 47/97 = 48 percent and that for residential is 50/97 = 52 percent. (Source: Long Line Statistics 1950-1975.) Bell Statistical Manual shows an average for the years 1972-1973 of 3,394,599 long distance interstate messages. Forty-eight percent of this is 1,629,408 total business long distance interstate messages and thus 1,765,192 residential messages. According to Long Line Statistics, for 1972-3 the average residential long distance interstate message length by paid minute was 9.67, and businesses averaged 6.09 minutes in length (see page 118 of Long Lines Statistics 1950-1975). Therefore, 6.09 minutes x 1,629,408 messages = 9,923,095 total business minutes which equals 37 percent of total, and 9.7 minutes x 1,765,192 = 17,122,362 total residential minutes or 63 percent of total. The distribution of messages by time of day, assuming the length of call is the same in each category, is:

Footnotes continued on the following page.

Table 1 (Continued)

TELEPHONE SERVICE RATES AND REVENUES IN 1975 AND UNDER AN ALTERNATIVE RATE STRUCTURE

	Day (Percent)	Evening (Percent)	Night/Weekend (Percent)
Business	74.2 (1)	22.3 (.65)	3.5 (.40)
Residential	36.0 (1)	55.5 (.65)	8.6 (.40)

The numbers in parentheses indicate the proportion of the 1978 full rate taken from the 1978 Boston area phone book (New England Telephone and Telegraph). Thus, the percent of business calls paying full rate is 90.1, and that for residential is 75.5 percent. Then the share of total long distance minutes times the percent of calls paying full rate serves as an approximate measure of the share of total toll revenue that each service category earns. This implies 41.2 percent for business and 58.8 percent for residential. Estimate of total toll service revene was taken from CRA, *Op. Cit.*, Appendix C.

Business and residential toll per-call charge under the alternative rate structure was taken from CRA, *Op. Cit.*, Appendix C, Table C-11e.

Assume residential price elasticity for toll calling of -1.2, and business price elasticity of toll calling of -0.7. Given initial quantity demanded for business of 26.29 billion minutes ($5.52 billion ÷ $.21/min), then new quantity demanded under the alternative rate structure is $4.53 billion. Similarly, initial residential toll minutes of 34.52 billion (7.88 billion ÷ $.21/min) result in the alternative rate structure toll revenues of $8.98 billion.

SOURCE: Calculations by Charles River Associates Incorporated, based on sources cited above.

Table 2

TELEPHONE RATES AND REVENUES IN 1975 AND UNDER AN ALTERNATIVE RATE STRUCTURE DEFLATED TO 1972-1973

	Initial - 1975					Alternative			
	Business		Residential			Business		Residential	
Type of Service	Rates (dollars)	Revenues (billions of dollars)	Rates (dollars)	Revenues (billions of dollars	Type of Service	Rates (dollars)	Revenues (billions of dollars)	Rates (dollars)	Revenues (billions of dollars)
Local:[1]					Local:[1]				
Station	$18.14/mo.	$2.47	$6.42/mo.	$5.14	Access	$8.64/mo.	$1.11	$2.59/mo.	$2.20
Extension	2.59/mo.	.26			Equipment/ Phone	.86/mo.	.18	.86/mo.	.73
Call	.0162/call	1.54	.0035/call	.35	Call	.047/call	4.06	.036/call	2.84
TOTAL		4.27		5.49	TOTAL		5.35		5.77
Toll:[2]	.20/min.	5.26	.20/min.	7.50	Toll:[2]	.104/min.	4.31	.104/min.	8.55
TOTAL		9.53		12.99	TOTAL		9.66		14.32

[1] Average 1972-1973 local rates are 86.4 percent of those in 1975:

$$\frac{117.0 + 124.4}{2(139.7)} = .864$$

where 117.0 = 1972 local rate index
124.4 = 1973 local rate index
139.7 = 1975 local rate index
(Based on 1960=100)

[2] Average 1972-1973 toll rates are 95.2 percent of those in 1975:

$$\frac{100.9 + 102.6}{2(106.9)} = .952$$

where 100.9 = 1972 toll rate index
102.6 = 1973 toll rate index
106.9 = 1975 toll rate index
(Based on 1960=100)

SOURCE: Calculations by Charles River Associates Incorporated. 1972-1973 local index computed from local rate indices reported in American Telephone and Telegraph, *Statistical Report, 1976*. 1972-1973 toll index computed from message toll rate indices reported in National Association of Regulatory Commissioners, *Toll Rates in Effect July 12, 1976*.

Table 3

TELEPHONE AND CONSUMPTION EXPENDITURES BY INCOME CLASS, 1972-1973

(1) Family Income Before Taxes	(2) Assumed Midpoint Income	(3) Average Annual Telephone Expenditure Per Family (Dollars)[1]	(4) Number of Families (Thousands)	(5) Average Annual Consumption Expenditure Per Family (Dollars)	(6) Total Consumption (billions of dollars)	(7) Proportion of Total Consumption by Income Class[3]
Total Reporting		$170.90.	67,447	$7,883.95	531.75	1.0000
Under $3,000	$1,500	86.21	9,065	3,039.34	27.55	.0518
$3-3,999	3,500	112.68	3,991	3,999.69	15.96	.0300
$4-4.999	4,500	124.88	3.624	4.531.32	16.42	.0309
$5-5.999	5,500	128.03	3,282	5,099.71	16.74	.0315
$6-6.999	6,500	148.81	3,401	5.724.97	19.47	.0366
$7-7.999	7,500	156.85	3.251	6.147.90	19.99	.0376
$8-9,999	9.000	166.78	6,594	6,921.21	45.64	.0858
$10-11,999	11,000	178.38	6.278	7,888.79	49.53	.0931
$12-14.999	13,500	188.93	8,375	8.889.67	74.45	.1400
$15-19.999	17.500	213.42	9.996	10,639.26	1[illegible]5.35	.2000
$20-24.999	22.500	229.19	5,028	12,591.46	63.31	.1191
$25 and over[2]	37.500	289.25	4.560	16.737.95	76.33	.1435

[1] Column (6) = Column (4) × Column (5).

[2] Assume $50,000 as upper limit.

[3] Column (5) × Column (4) divided by $531.75 billion of total family consumption expenditures.

SOURCES: Columns 1, 3, 4 and 5 were taken from U.S. Department of Labor, Bureau of Labor Statistics. *Consumer Expenditure Survey Series: Interview Survey, 1972-1973*, Report 455-4, 1977, pp. 4-9. Calculations resulting in columns 2, 6, and 7 by Charles River Associates Incorporated are based on columns 1, 3, 4, and 5.

Residential Local Expenditure

Under the alternative rate structure, residential consumer savings from lower station connect and equipment charges amount to $2.97 per month or $35.64 per year (Table 2) per main station (7). The result of this decline in price is an estimated increase in the number of residential main stations, or subscribers, of approximately 4 million (8).

The 4 million families who newly subscribe to the telephone network represent a group for whom the move to the alternative rate structure is clearly an improvement over the existing rate structure; presumably, these new connections will be made only if the individuals felt that their level of well-being would thereby be increased. Given the configuration of residential connect and calling charges, this group probably desires, in the main, connection to the system and does not represent a large demand for calls, either toll or local; this new group of 4 million main stations should therefore have significantly different calling and welfare patterns from existing subscribers to the telephone system. Specifically, existing subscribers are more likely to make large numbers of calls, at least local calls, under the present rate regime which features very low or zero charges for local calling. The essential or difficult welfare question, in fact, is whether the gain from reduction in connect and equipment charges for existing subscribers is or is not offset by welfare losses from increased expenditures for local calling as the price on those local calls rises significantly under the alternative rate structure. Because existing and new subscribers are very likely to have different calling characteristics and because information on new subscribers is necessarily speculative (e.g., as to quantity of local and toll calling), this analysis will separate new subscribers from the determination of welfare changes created by the change in price structure. The families for whom welfare changes are computed therefore will represent existing subscribers to the telephone network. This procedure means that the analysis is biased toward concluding that families in particular income classes, specifically the lowest two or three income classes, will show a diminished level of well-being under the alternative rate structure. Were new connections to the telephone network also included, many of these connections would be made by families in the lowest two or three income classes (9) and these new connections would provide an undeniable welfare gain for these lowest income groups. In short, the deletion of new subscribers from the welfare analysis means that much of the beneficial welfare impact of moving toward even greater extensions of service to the U.S. public will be missed by this analysis.

Table 3 indicates that the average annual telephone expenditure of the average (reporting) U.S. family in 1972-1973 was $170.90. Under the existing rate structure, as shown in Table 2, residences are charged $6.42 per month on average for connecting one main station to the telephone network. Converting this charge to an annual figure of $77.04 (12 x $6.42) and subtracting that from total family expenditure on telephone service results in a sum of $93.86 ($170.90 - $77.04) which should represent the average family's annual expenditure for local and toll calls. Such calculations were made (see Table 3) for each of the 12 income classes under examination.

To further break down total annual expenditure for local and toll calling into its constituent parts, the average number of annual local calls per family for each income class must be estimated (10). Data from the Consumer Expenditure Survey (11) indicate that the average age of the head of the family in the lowest income class is 57 years as compared to an average age in the low- to mid-40s for the $8,000 to $25,000 income class. The lowest income class also has a disproportionate number of persons aged 65 or over as compared with other income classes. Conversely, the distribution of children under 18 is such that the lowest income class has disproportionately few children. The size of the family generally increases as the level of income increases. In short, the lowest income class is heavily weighted toward single-person families who are older and retired.

If it is reasonable to suppose that calls per family increase as the size of the family increases, as the number of children (teenagers in particular) in a family increases, and as work contacts increase, per-family calling should then rise as income increases. Given the paucity of information, the safest assumption would seem to be that local calling is distributed across income classes simply in proportion to population in that class (12). Column 1 of Table 4 shows the initial number of calls per household per year as derived from the distribution of population across income classes in the Consumer Expenditure Survey data.

In order to compute the estimated residential local calling expenditures under the alternative rate structure, the elasticity of calls to a change in calling charge in different income classes must be estimated. Data limitations preclude rigorously estimating "actual" demand elasticities. The elasticities used, as shown in Column 4 of Table 4, do possess, however, various desirable characteristics: they become more inelastic with higher income (13); they are consistent with an aggregate elasticity of approximately -.1 (14); and there are no large jumps in elasticity between income classes.

Table 4 illustrates some of the problems in identifying changes in levels of well-being with changes in expenditures. As a result of moving from the initial rate structure to the alternative rate structure, for example, the lowest income class reduces its expenditures on connect and local calling by approximately $25 per year. However, this reduction in expenditure is accomplished at the price of cutting the annual number of local calls per family in half; rather than making two phone calls per day under the initial rate structure, the typical family (previously connected to the system) in the lowest income class will be making approximately one phone call per day under the alternative rate structure (a similar comment can be made about the next to the lowest income class as well). However, the per-call price of local calling under the alternative rate structure employed in Table 4 is derived by aggregating calling patterns across various times of day, each time of day having its own cost-based price. Implicit in the application of the same aggregated per-call charge for local calls across all income classes is the assumption that each income class will distribute its calling pattern by time of day in exactly the same fashion (15). Lower income classes may be more sensitive to higher peak charges and could shift their calling to times of day in which the charges are lower. As a result, the effective

Table 4

AVERAGE RESIDENTIAL EXPENDITURES FOR LOCAL TELEPHONE SERVICE BY INCOME CLASS: INITIALLY AND UNDER AN ALTERNATIVE RATE STRUCTURE

Income Class	(1) Initial Number of Calls Per Family Per Year[1]	(2) Initial Local Calling Expenditure Per Family[2]	(3) Initial Total Residential Expenditure Per Family[3]	(4) Elasticity of Calls to Per-Call Charge	(5) Alternative Estimated Number of Calls Per Family[4]	(6) Alternative Local Calling Expenditure Per Family[5]	(7) Alternative Local Residential Expenditure Per Family[6]	(8) Change in Total Local Expenditure Per Family[7]
Under $3,000	706	$ 2.47	$ 79.51	-.3	351	$ 12.64	$ 54.04	-$25.47
$ 3-3,999	960	3.36	80.40	-.3	477	17.17	58.57	- 21.83
$ 4-4,999	1,060	3.71	80.75	-.25	592	21.31	62.71	- 18.04
$ 5-5,999	1,210	4.24	81.28	-.20	759	27.32	68.72	- 12.56
$ 6-6,999	1,261	4.41	81.45	-.20	791	28.48	69.88	- 11.57
$ 7-7,999	1,363	4.77	81.81	-.15	961	34.60	76.00	- 5.81
$ 8-9,999	1,412	4.94	81.98	-.10	1,118	40.25	81.65	- .33
$ 10-11,999	1,615	5.65	82.69	-.10	1,279	46.04	87.44	+ 4.75
$ 12-14,999	1,715	6.00	83.04	-.10	1,358	48.89	90.29	+ 7.25
$ 15-19,999	1,816	6.36	83.40	-.05	1,616	58.18	99.58	+ 16.18
$ 20-24,999	1,917	6.71	83.75	-.04	1,746	62.86	104.26	+ 20.51
$25,000 and over	1,917	6.71	83.75	0	1,917	69.01	110.41	+ 26.66

[1] Derived by assuming local calling was distributed by the proportion of population in each income class and dividing the income classes' calling volume by the number of families in that income class.

[2] Column (1) x $.0035 (estimated per-call charge for local residential calls; see Table 2).

[3] Column (2) plus initial station connect charge of $77.04 (derived from Table 2: $6.42 x 12 months).

[4] Estimated volume of calls under the alternative rate structure at $.036 per call.

[5] Column (5) x $.036 (estimated per-call charge for local calls under the alternative rate structure. See Table 2).

[6] Colum (6) plus the alternative rate structure annual access and equipment station charges of $41.40 ($3.45 x 12 months).

[7] Column (7) less Column (3). A plus sign indicates an increase in expenditure under the alternative rate structure and a negative sign a decrease.

SOURCE: Calculations by Charles River Associates.

local per-call charge for the lower income classes when averaged across all times of day might well be lower than that for higher income classes; the reduction in local calling by 50 percent derived for the lowest income class is thus probably an overstatement. Without knowing the nature of the shift in calling patterns for the families in the various income classes, however, it is impossible to know exactly how many additional phone calls above those shown in Table 4 under the alternative rate structure would be generated by shifts in time-of-day calling patterns.

Table 4 suggests that the change in local expenditures per household moves from negative to positive under the alternative rate structure as income level rises. For higher income classes with (by assumption) virtually inelastic demands, there is a significant increase in annual expenditure, presumably tapping the willingness to pay as revealed by the inelastic demands of those income classes.

Residential Toll Expenditures

Column 1 of Table 5 displays the average family's annual expenditure on toll calls under the existing rate structure for each income class. These estimates are derived by subtracting local calling expenditure under the existing rate structure, shown in Table 4, as well as the annual connect charge of $77.04 from the total annual family expenditure for telephone services.

By dividing average family expenditure on toll calling by the estimated existing average toll charge of $.2 per minute (see Table 2), it is possible to derive, as shown in Column 2 of Table 5, estimates of the number of toll calls made by families in various income classes under the existing rate structure. To derive toll charges under the alternative rate structure, an overall aggregate toll elasticity of -1.2 is assumed (16). Applying that elasticity across all income classes -- since there is no available evidence, pro or con, as to whether or not toll elasticities change across income classes -- the number of toll calls under the new alternative rate structure can be estimated, as well as the level of toll expenditures under the new rate structure as shown in Column 5 of Table 5.

As a result of the assumed toll elasticity being greater than one, all families spend more money on toll calling under the new rate structure than under the old. The amount of increase is minimal for the lowest income class, $1 per year, but is as much as $28-29 dollars per year for the highest income class. Once again, though, these changes in expenditure mask significant changes in price and quantities.

Distributed Business Telephone Service Expenditures

The telephone companies often argue that a major cut in toll charges, such as that embodied in the alternative rate structure, would necessitate a sizeable increase in local residential rates. Under the alternative rate structure, however, toll calling charges for both businesses and residences are reduced, yet total business expenditures for telephone services are increased, thereby negating the need for dramatic price rises in residential local-access charges. Under the alternative rate structure, business toll revenues fall by approximately

Table 5

RESIDENTIAL EXPENDITURES FOR TOLL TELEPHONE SERVICE BY INCOME CLASS: INITIALLY AND UNDER AN ALTERNATIVE RATE STRUCTURE

Income Class	(1) Initial Residential Toll Expenditures per Family [1]	(2) Initial No. of Minutes per Family [2]	(3) Call Elasticity	(4) Alternative Minutes per Family [3]	(5) Alternative Residential Toll Expenditures per Family [4]	(6) Change in Residential Toll Expenditures per Family [5]
1) under $3,000	$ 6.70	34	-1.2	75	$ 7.80	$ + 1.10
2) $3 - 3,999	32.28	161	-1.2	353	36.71	+ 4.43
3) $4 - 4,999	44.13	221	-1.2	484	50.34	+ 6.21
4) $5 - 5,999	46.75	234	-1.2	513	53.35	+ 6.60
5) $6 - 6,999	67.36	337	-1.2	739	76.86	+ 9.39
6) $7 - 7,999	75.04	375	-1.2	822	85.49	+10.45
7) $8 - 9,999	84.80	424	-1.2	929	96.62	+11.82
8) $10-11,999	95.69	478	-1.2	1048	108.99	+13.30
9) $12-14,999	105.89	529	-1.2	1159	120.54	+14.65
10) $15-19,999	130.02	650	-1.2	1425	148.20	+18.18
11) $20-24,999	145.44	727	-1.2	1593	165.67	+20.23
12) $25,000 + over	205.50	1028	-1.2	2253	234.31	+28.81

[1] Derived by subtracting Column (3) of Table 4 from Column (3) of Table 3.

[2] Estimated volume of calls at $.20/minute per-call charge (see Table 2); Column (1) ÷ $.20/minute.

[3] Estimated volume of calls under the alternative rate structure using $q_1 = q_0 (P_0/0_1)^E$ and call elasticity (E) in Column (5).

[4] Column (4) X $.104/minute (see Table 2).

[5] Column (5) - Column (1). A plus sign indicates an increase in expenditure under the alternative rate structure; a minus sign indicates a decrease.

SOURCE: Calculations by Charles River Associates Incorporated.

$1 billion (as shown in Table 2), but this $1 billion is offset by a $1 billion increase in business expenditures on local telephone service (17).

Businesses, of course, represent contractual arrangements linking dollars of revenues to payments to the factor inputs which generate those revenues. What businesses pay for telephone services will ultimately be reflected in changed prices to consumers for the goods or services produced by the business or in changed payments to the factors of production (land, labor, capital, management) utilized in the production process. One way of distributing telephone service expenditures as a type of sales tax; i.e., telephone expenditures are passed on to consumers as a constant percent of sales. In essence this implies that the U.S. economy is generally competitive so that changes in telephone expenditures by businesses are paid by consumers in the long run, rather than "absorbed" by reduced payments to the factors of production. Thus, under these assumptions, consumers in a given income class would pay business telephone service expenditures in proportion to that income class's share of total consumption expenditures.

To measure the effect of changes in business telephone expenditures as they flow through to families in the various income classes, business telephone service expenditures for 1972-1973 (approximately $9.53 billion) were distributed by each class's share of total annual consumption, as shown in Column 1 of Table 6. Total business telephone expenditures are estimated to rise to $9.66 billion under the alternative rate structure and this is distributed in Column 2 of Table 6. Assuming that the changes in telephone expenditure and shift consumption patterns among classes perceptibly, business expenditures under the initial and alternative rate structures were distributed by each income class's proportion of total consumption expenditures (from Table 3, Column 7). Since the size of the total increase in business expenditure was small, approximately $130 million, each family was faced with a very small increase in distributed business expenditures. The lowest income class faced an annual increase of less than $1 per household while the highest income class faced an increase of approximately $4.

Overall Change in Family Expenditures for Telephone Service

The estimated changes in residential local, residential toll, and distributed business expenditures created by moving to the alternative rate structure are summarized in Table 7. It is clear that the upper income families will pay significantly more for their telephone services under the alternative rate structure than under the existing rate structure. A family in the lowest income class, however, will pay approximately $2 per month less for it's telephone service. (Recall, though, that the lowest income class also reduces its local calling by approximately one-half under the alternative rate structure.) While the alternative rate structure does result in significant expenditure increases for several higher income classes, these increases occur because those families are assumed to make large numbers of local calls at peak hours and to more than double their toll calling under new lower toll rates, thus offsetting lower connect and equipment charges.

Table 6

THE CHANGE IN DISTRIBUTED BUSINESS TELEPHONE SERVICE EXPENDITURES FROM THE EXISTING RATE STRUCTURE TO AN ALTERNATIVE RATE STRUCTURE

Income Class	(1) Initial Distribution of Total Consumption by Income Class[1]	(2) Column (1) x $130 Million[2] (millions of dollars)	(3) Number of Families[3] (thousands)	(4) Change in Expenditures Per Family[4]
Total	1.0000	$130.00	67,447	$+1.93
Under $3,000	.0518	6.73	9,065	+ .74
$3-3,999	.0300	3.90	3,991	+ .98
$4-4,999	.0309	4.02	3,624	+1.11
$5-5,999	.0315	4.10	3,282	+1.25
$6-6,999	.0366	4.76	3,401	+1.40
$7-7,999	.0376	4.89	3,251	+1.50
$8-9,999	.0858	11.15	6,594	+1.69
$10-11,999	.0931	12.10	6,278	+1.93
$12-14,999	.1400	18.20	8,375	+2.17
$15-19,999	.2000	26.00	9,996	+2.60
$20-24,999	.1191	15.48	5,028	+3.08
$25 and over	.1435	18.66	4,560	+4.09

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[1] From Column (7), Table 3 of this appendix.

[2] $130 million is the increase in business telephone expenditures as rate structures move from the initial one generating $9.53 billion in business expenditures to the alternative rate structure generating $9.66 billion in business expenditures. See Table 2 of this paper.

[3] Column (4) of Table 3.

Footnotes continued on following page.

Table 6 (Continued)

THE CHANGE IN DISTRIBUTED BUSINESS TELEPHONE SERVICE EXPENDITURES FROM THE EXISTING RATE STRUCTURE TO AN ALTERNATIVE RATE STRUCTURE

Column (4) ÷ Column (3). The positive sign indicates an increase in expenditures under the alternative rate structure.

SOURCE: Calculations by Charles River Associates Incorporated based on sources cited above.

Table 7

ESTIMATED INCREASE (+) OR DECREASE (-) IN TOTAL ANNUAL EXPENDITURES BY A FAMILY FOR TELEPHONE SERVICES UNDER AN ALTERNATIVE RATE STRUCTURE, BY INCOME CLASS

Family Income Before Taxes	Change in Residential Expenditures			Change in Business Expenditures	Change in Total Annual Telephone Expenditures
	Local	Toll	Total		
Under $3,000	$-25.47	+ 1.10	-24.37	$+0.74	$-23.63
$3-3,999	-21.83	+ 4.43	-17.40	+ .98	-16.42
$4-4,999	-18.04	+ 6.21	-11.83	+1.11	-10.72
$5-5,999	-12.56	+ 6.60	- 5.96	+1.25	- 4.71
$6-6,999	-11.57	+ 9.39	- 2.18	+1.40	-0.78
$7-7,999	- 5.81	+10.45	+ 4.64	+1.50	+ 6.14
$8-9,999	- .33	+11.82	+11.49	+1.69	+13.18
$10-11,999	+ 4.75	+13.30	+18.05	+1.93	+19.98
$12-14,999	+ 7.25	+14.65	+21.90	+2.17	+24.07
$15-19,999	+16.18	+18.18	+34.36	+2.60	+36.96
$20-24,999	+20.51	+20.23	+40.74	+3.08	+43.82
$25,000 and over	+26.66	+28.81	+55.47	+4.09	+59.56

SOURCE: Calculations by Charles River Associates Incorporated.

Welfare Change As Measured by Price Indices

If the existing rate structure is changed to the alternative rate structure, the overall impact of various price and quantity changes can be compared by computing price indices for each of the 12 income classes under examination. Table 8 displays the results of these price index computations (18).

As the ordering of indices displayed in Table 8 exhibits, the movement to the alternative rate structure makes families in none of the income classes unmistakably worse off. Indeed, all income classes but the very lowest are made better off by the move to the alternative rate structure (19). For the lowest income class, the fact that *E* is greater than *P* means that the individual family in the lowest income class does not suffer a fall in standard of living by a move to the alternative rate structure; however, the fact that *E* is not greater than *L* means that the new rate regime cannot be described as one in which the family's standard of living has been increased.

Two important considerations, moreover, bias this analysis toward concluding that families in the lowest income class will be harmed by moving to the new rate structure. First, the lowest income class should contain a significant portion of the 4 million new subscribers gained under the alternative rate structure, the gains from which are ignored in this analysis. Second, the assumption that families in all income classes adjust their local calling patterns in exactly the same way to a new regime of local time of day user charges requires that the lowest income class make the same adjustments in calling patterns as the highest income class. The lowest income class seems more likely than the highest income class to shift local calling to times of day in which calling charges are lower.

Summary and Conclusion

This paper reports on an evaluation of the income incidence of welfare changes due to the adoption of a radically new type of telephone rate structure. This new rate structure was characterized by lowered access charges, positive prices for local calling and lowered and distance insensitive long distance charges. The families in the lowest income class (income under $3000/yr.) who are existing subscribers are the group most likely to be adversely affected by the changed rate environment. Yet this analysis showed that such families were not clearly harmed or helped by these radical changes.

This study is of interest methodologically because it allows the analysis of equity to go beyond superficial discussions of subjective opinions of fairness. The use of index number allows the explicit modelling of welfare changes across income classes and provides useful information for regulators and policy makers.

Table 8

INDEX NUMBERS AS INDICATORS OF WELFARE CHANGE[1]

Index Numbers Excluding Distributed Business Expenditures

Income Class	E	L	P	Index Relationship	Welfare Change Under the Alternative Rate Structure
under $3,000	.72	.82	.66	L>E>P	Inconclusive
$3-3,999	.85	.82	.64	E>L>P	Positive
$4-4,999	.91	.82	.64	E>L>P	Positive
$5-5,999	.95	.85	.67	E>L>P	Positive
$6-6,999	.99	.82	.65	E>L>P	Positive
$7-7,999	1.03	.83	.66	E>L>P	Positive
$8-9,999	1.07	.82	.67	E>L>P	Positive
$10-11,999	1.11	.84	.67	E>L>P	Positive
$12-14,999	1.12	.84	.67	E>L>P	Positive
$15-19,999	1.16	.82	.67	E>L>P	Positive
$20-24,999	1.18	.81	.67	E>L>P	Positive
$25,000 and over	1.19	.75	.65	E>L>P	Positive

[1] Index numbers derived as follows:

Index of income change $E = \frac{\Sigma p^1 x^1}{\Sigma p^0 x^0}$

Laspeyre index $L = \frac{\Sigma p^1 x^0}{\Sigma p^0 x^0}$

Paasche index $P = \frac{\Sigma p^1 x^1}{\Sigma p^0 x^1}$

SOURCE: Calculations by Charles River Associates Incorporated.

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Notes

1. Chapter 3 of CRA's report entitled *The Economics of Competition in the Telecommunications Industry* (Boston, Mass.: CRA, 1979), discusses the rationale underlying these goals and the native rate structures that meet these goals.

2. Numerous simplifying assumptions are required to effectively model changes in family expenditures on telephone service (or any other good or service). Every attempt has been made to clearly identify these assumptions.

3. For a more complete explanation, see C. E. Ferguson, *Microeconomic Theory*, (Homewood, Ill.: Richard D. Irwin, Inc., 1969), pp. 67-72.

4. Strictly speaking, an individual family's welfare change cannot be measured without examining *all* of its expenditures. This analysis will assume that telephone expenditures are sufficiently small and separable from remaining expenditures so that changes in the former can be examined without concern for changes in the latter. In addition, data do not exist to analyze changes in all expenditures.

5. The relevant telephone statistics were mostly taken from CRA, *op. cit.*, Appendix C.

6. The CES data were used for determining the distribution and level of total telephone expenditures. No breakout of actual expenditures by service category within the total of telephone expenditures was available at the time of this analysis. See Bureau of Labor Statistics, *Consumer Expenditure Survey Series: Interview Survey, 1972-73*, Report 455-4, U.S. Department of Labor, 1977, pp. 8-9.

7. Residential extension phones have not been included in this analysis because of the lack of data on the distribution of extension phones across income classes. The exclusion of residential extensions reduces estimates of total initial revenues by $0.7 billion (39.9 million extensions at an estimated monthly charge of $1.50).

8. See CRA, *op. cit.*, Table 3-4, p. 3-40.

9. See Table 7, Page 51, of Bell Exhibit 21 in FCC Docket 20003. This exhibit consists of a report on the proportion of households with telephones in various sociodemographic categories, including income classes. The report was authored by Lewis J. Perl and entitled "Economic and Demographic Determinants of Telephone Availability," prepared by National Economic Research Associates, April 15, 1979.

Notes (Continued)

10. One source of data for such an estimation indicates that the lowest income class (from $0 to $300 per year) makes approximately three times as many phone calls as the average family in the highest income class (from $30,000 up). See Bridger Mitchell, "Optimal Pricing of Local Telephone Service," *American Economic Review* 68 (September 1978): 517-537. Mitchell's source for residential calling by income level was a study by American Telephone & Telegraph entitled *Subscriber Line Usage Study, May 1972-June 1973.* According to Mitchell, this study was based on 10 California exchanges which used No. 1 ESS switching equipment.

11. Bureau of Labor Statistics, *op. cit.*, pp. 4-5.

12. Although not reported, the analysis of this study was also conducted using two alternative distributions of local calls: a California distribution taken from Bridger Mitchell ("Optimal Pricing of Local Telephone Service"); and a uniform distribution by proportion of families in each income class. The conclusions about the well-being of families in the various income classes before and after a change to the alternative rate structure seemed largely insensitive to which distribution was used.

13. For a mathematical derivation of this general result, see Bridger Mitchell, "Optimal Pricing of Local Telephone Service," p. 43.

14. This is the approximate aggregate elasticity which is reflected in the number of calls and calling charges for residential local calling in Table 2. Such an elasticity is at the inelastic end of the range of estimated elasticities. See CRA, *op. cit.*, Appendix C, p. C-2. A doubling of the elasticities across all income classes does not greatly modify the welfare results of the analysis.

15. The alternative rate structure assumes that 35 percent of all residences pay the peak charge, 40 percent of all residences pay the shoulder charge, while the remaining 25 percent of calls pay the off-peak charge.

16. This elasticity is consistent with data showing that the elasticity of toll calling is greater during the evening than the day and greater for residential customers than for businesses. An elasticity of -1.2 is in the midpoint of the range of estimates for the evening/night period and for residential customers. See CRA, *op. cit.*, Appendix C, p. c-2.

17. This $1 billion increase is consistent with lower connect and equipment charges for business coupled with higher local usage charges, representing the demand for capacity imposed by daytime calling of businesses.

18. Table 8 does not include the business expenditures in the welfare analysis because data are not available on the myriad price and quantity changes which would occur as businesses flow through the increased expenditures on telephone services. Given that the change in distributed business expenditures per family is approximately $1 to $4 dollars per year, it is

unlikely that the deletion of business expenditures from this analysis changes the results. If, however, the existing rate structure were adjusted to one in which business expenditures *in toto* were dramatically increased or decreased, then a complete welfare analysis would have to include some measure of the impact of distributed business expenditures on family expenditure patterns.

19. Reworking this welfare analysis based on the distribution of residential local calling as shown in the ten California exchanges cited in Bridger Mitchell, "Optimal Pricing of Local Telephone Service," does result in the existing subscribers in the lowest income class being worse off. The California distribution of local calls is U-shaped across income classes. For reasons argued in the text, this distribution seems unrepresentative.

U.S. REGULATION AND INTERNATIONAL COMMUNICATION: THE CASE OF VERTICAL INTEGRATION OF RATES

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This paper briefly presents the structure of the international communication rates of the United States telecommunication carriers. The rate structure is examined in light of the international communication industry structure; key regulatory decisions of the U.S., and; the economic and performance effects of rapid technological advances which have characterized the development of the two competitive modes of facilities which form the U.S. international communications network: communication satellites and submarine cables. Economic regulation of certain industries such as communications, transportation and energy is highly developed in the U.S. Similar industries in other countries are either government-owned and operated or the government maintains a majority interest. The firms within the U.S. International Communications Industry are subject to regulation by the Federal Communications Commission (FCC) under the Communications Act of 1934(2). This analysis of rapidly changing technology in international communications facilities and concomitant effects on rates offers some new perspectives on objectives and limitations of government regulation.

A. Salient Facts About the U.S. International Communications Industry

The first voice grade submarine cable was installed between the U.S. and Scotland in 1956 and the first commercial communication satellite was launched in the Atlantic region in 1965. During the period 1956-1979, thirty submarine cables belonging to four different vintages of technology have been installed in the Atlantic, Pacific and Caribbean Ocean regions; forming the U.S. international submarine cable network. The second in the latest generation of submarine cables will be installed in the Atlantic ocean region in 1983. During the period 1965-1979, twenty-seven commercial communication satellites belonging to six different vintages of technology have been launched in the Atlantic, Pacific and Indian regions; forming the U.S. international satellite communication network. The first in the latest generation of satellites is expected to be launched in early 1980.

The U.S. international communications industry is unique due to extensive regulation and policy supervision of the U.S. Government for reasons of foreign policy and national security, in addition to the more common reasons for regulation of domestic utilities. Its structure may reasonably be considered a regulated duopoly. The dominant firm in the industry is the American Telephone and Telegraph Company (AT&T). The second firm is the Communication Satellite Corporation (COMSAT), created as a monopoly by a special act of the U.S. Con-[illegible].(3) From an end-user perspective (the U.S. public), the struc-[illegible] essentially a regulated monopoly (AT&T) because COMSAT is not authorized to serve the U.S. public directly. In addition, there are several other firms which are a part of this industry and are identified as the International Record Carriers (IRCs).(4) These IRCs, however, use AT&T's and COMSAT's facilities. AT&T owns and operates submarine cables in coordination with overseas administrations and foreign telecommunications entities. As a consequence of numerous regulatory decisions it provides Indefeasible Rights of Users (IRUs) in these submarine cables to IRCs through long term lease arrangements or part ownership. COMSAT owns, in partnership with other overseas administrations, communications satellites. It also operates the global satellite network on behalf of this partnership.(5) The partnership is known as the International Telecommunication Satellite Consortium (INTELSAT). Thus, COMSAT is a joint owner in the satellite network as well as the U.S. Signatory (representative) in INTELSAT.

B. International Facilities and the Technology Race Between Cables and Satellites

The evolution of the U.S. international communications industry has been characterized by a de facto technology race between submarine cables and satellites which has been reinforced by a series of FCC and other U.S. Government decisions. In the thirty cables since 1956, the voice circuit capacity per cable has increased from 36 voice circuits in the first generation to 4,000 voice circuits in the latest generation of cables. This is indicated below:

Type of Technology	Number of Submarine Cables	Voice Circuit Capacity Per Cable
SB	8	36
SD	10	128
SF	7	845
SG	6	4,000
SH(6)	--	16,000
	31	

Since 1965, twenty-seven communication satellites have been launched by COMSAT, and seven more belonging to the latest vintage of technology will be launched during the period 1980-83. The voice circuit capacity per satellite has increased from 240 voice circuits in the first generation to 12,000 voice circuits in the latest generation, as indicated below:

Type of Technology	Number of Satellites	Voice Circuit Capacity Per Satellite
Intelsat-I	1	240
Intelsat-II	4	240
Intelsat-III	8	1,200
Intelsat-IV	8	4,000
Intelsat-IV-A	6	7,500
Intelsat-V	7	12,000
	34	

Since neither AT&T or COMSAT is in a position to optimize an appropriate mix of both types of facilities, their ownership rights have determined the marketing strategy of both firms. Sub-optimal investment positions have been made by both -- taking the form of a technology race -- resulting in over-investment, considerable excess capacity and inefficient modes of total system operation. Capacity utilization rates in international communications have been determined largely by the nature of cable and satellite technology as well as by growth in demand. These factors have resulted in a need for spare and in-orbit back-up satellite facilities of identical technological vintages and have been a key factor in the separation of satellite operations in the form of primary and major path satellites in each ocean region. Additionally, because of the nature of cable technology, cable failure restorations have generally been accomplished via satellites.

C. Market and Service Segmentations: Key U.S. Regulatory Decisions

The relationship among all of these firms as well as their usage of facilities, e.g., cables and satellites, is controlled by various agencies of the U.S. Government. This control includes rate base regulation by the FCC. Also, the U.S. Department of State exercises oversight functions because both of the U.S. entities (COMSAT and AT&T) are actively engaged with foreign administrations in the construction and operation of their respective facilities.

COMSAT, by law,(7) is not authorized to serve the U.S. public directly and is also not authorized to interfere with or participate in, the planning, construction or operational implementation of submarine cables. Similarly, AT&T and the IRCs are not authorized to participate in the planning or implementation of international commercial communication satellites. By regulatory decisions, COMSAT must sell satellite circuits only to AT&T and the IRCs who, in turn, are authorized to serve the public either through these leased satellite circuits or through their own cable circuits.(8) Additionally, during the period 1965-1973, AT&T together with the IRCs was the biggest stockholder of COMSAT and was, accordingly, represented on COMSAT's Board of Directors.(9) AT&T and the IRCs also own the U.S. satellite earth stations in partnership with COMSAT. Consequently, COMSAT's biggest customer is also its biggest competitor and a significant owner of its physical assets.(10)

The market for international communication services to the U.S. end-users has been segmented as a result of a series of regulatory decisions. Voice services are provided by AT&T and non-voice services by the IRCs.(11) International television services are provided on a weekly rotation basis by AT&T and the IRCs. This artificial segmentation of the market represents a compromise by the FCC among the numerous international carriers (AT&T and the IRCs); it does not reflect any inherent requirement of the technologies or any other criteria which would logically justify this separation.(12) The IRCs lease cable circuits from AT&T and satellite circuits from COMSAT to provide non-voice services to the U.S. public. AT&T leases satellite circuits from COMSAT and uses them together with its own cable circuits to provide voice services to the U.S. public.

In addition to the above, a series of regulatory decisions have been enacted since 1965 which have resulted in the almost simultaneous construction of new submarine cable and satellite facilities. These appear to be as a result of the compromise approach adopted by the FCC when faced with competing applications for construction of facilities by COMSAT, AT&T and the IRCs.(13) In order to mitigate the adverse economic effects associated with the simultaneous construction of new facilities with successively larger capacities, the FCC has enacted a number of regulatory rulings which were intended to ensure that competing international facilities had "circuit activation parity" or "proportional fill" policies. The primary objective of this appears to be to ensure that, in view of the prevailing market structure, AT&T and the IRCs did not attempt to siphon away business from COMSAT by refusing to lease satellite facilities and, thereby, retard the growth of satellite technology.(14) In summary, it is significant to note that an analysis of the above key regulatory decisions seems to suggest that the FCC has consistently adopted a compromise approach both among the carriers and between COMSAT and the carriers, thereby, promoting policies which appear to protect the competitors rather than to encourage competition among them.

D. Technological Changes and Their Effects on Direct Costs

Since the inception of the first voice grade submarine cable in 1956, the technology of cables has advanced at such a rapid rate that a new generation of cable technology was introduced on an average of one every five years during the period 1956-77. Thirty submarine cables belonging to the various generations of technology were installed; forming the U.S. international submarine cable communication network. It is planned that the next cable in the latest generation of technology will be installed in 1983.

Such rapid advances in cable technology were achieved through the applied R&D efforts of AT&T and by incorporating technological changes in the various sub-systems of cable design and operations. In the various generations of technology, major changes incorporated to achieve higher voice circuit capacity included improvements in the: efficiency of bandwidth usage; design and components of repeaters and equalizers; more efficient trade-offs among repeater spacings, cable attenuation, and cable design; physical and communications properties of cable materials; and cable terminal and power feed facilities. As a result of these changes, the voice circuit capacity of cables increased from 36 voice circuits per cable in the first generation of technology (SB-1956) to 4,000 voice circuits per cable in the latest generation of technology (SG-1977) and will further increase to 16,000 voice circuits in the SH cable. An analysis of unit capacity cost effects of these technological changes indicates that capacity cost per circuit, per year, per nautical mile declined from $19.54 in the SB cable to $0.62 in the SG cable and will further decline to $0.24 in the SH cable.

An analysis of direct(15) Operations and Maintenance (O&M) costs, per circuit, per year, per nautical mile, indicates that such costs declined from $20.27 in 1960 (SB cable) to $0.26 in 1976 (SG cable) and are expected to decline further to $0.09 in the SH cable. Additionally, the unit O&M costs in any particular year were lower for the latest generation of cables as compared to earlier generations. The reductions in unit O&M costs were achieved through improvements in: the design and operations of cableships; repair operations (e.g., more efficient cableplows, elimination of divers, higher speed of cableships, more efficient fault location systems, etc.) and; integrated operations of terminal facilities at sea shores.

Similarly, rapid advances in satellite communications technology were achieved. During the period 1964-77, a new satellite technology was introduced on an average of one every three years. Twenty-seven communication satellites belonging to the various generations of technology were launched; forming the U.S. international satellite network. Plans have been made to launch the next satellite in the latest generation of technology in early 1980.

Such rapid advances in satellite technology were achieved through the applied R&D efforts of COMSAT Laboratories and by incorporating technological changes in the various sub-systems of satellite design and operations. In the various generations of satellite technology, major changes incorporated to achieve higher voice circuit capacity included improvements in the: efficiency of bandwidth usage (e.g., dual polarization, beam and spatial isolation); launch vehicle capability; fuel injection system; internal sub-systems of satellites to achieve higher design lives; and multiple access, antenna design and modulation techniques. As a result of these changes, the voice circuit capacity of satellites increased from 240 voice circuits per satellite in the first generation (IS-I - 1965) to 7,500 voice circuits per satellite in the latest generation (IS-IV-A - 1977) and will increase further to 12,000 voice circuits in the IS-V satellite. An analysis of unit capacity cost effects of these technological changes indicates that capacity cost per circuit, per year declined from $45,690 in the IS-I satellite to $990 in the IS-IV-A satellite and will further decline to $740 in the IS-V satellite.

An analysis of direct O&M costs per circuit, per year indicates that such costs declined from $20,254 in the IS-I satellite to $503 in the IS-IV-A satellite and are expected to decline further to $450 in late 1979. Additionally, the unit O&M costs in any particular year were lower for the latest generation of satellites as compared to earlier generations. The reductions in direct unit O&M costs were achieved through improvements in: Tracking, Telemetry and Command (TT&C) Operations; ground control operations; and teleprocessing equipment design (resulting in reduced labor input).

For example, as indicated in Figure-1, a comparative evaluation of the two types of facilities based on fixed investment requirements per circuit, per year, indicates that cables are cost competitive with satellites in the Atlantic region; are superior to satellites in the Caribbean and US-Hawaii regions; and are less than competitive with satellites in the Pacific region. It is significant to note that in a comparative evaluation of the two types of facilities, various technologically determined system characteristics make it difficult to conclusively establish the desirability of one type of facility as compared to the other. It is additionally for this reason that in competing applications before the FCC for permits to construct new facilities, the proponents of each technology tend to emphasize those factors which appear to have the relative advantage in terms of their own technology. These characteristics include: transmission delay, system reliability, channel noise levels, national security, multiple access capability, facility life expectancy and system capacity.

E. Growth in Demand and Variations in Circuit Loading

During the last quarter century, the international communication industry has been characterized by an unprecedented growth in demand primarily due to the availability of new communication facilities. For example, the U.S. international telephone traffic to the "rest of the world" grew from 6.86 million minutes in 1956 to 647.90 million minutes in 1976 (annual growth rate of 25.5%), the telex traffic grew from 12.76 million minutes in 1964 to 149.97 million minutes in 1976 (annual growth rate of 22.8%), and the telegraph traffic declined slightly from 597.71 million words in 1956 to 517.92 million words in 1976, thereby indicating a substitution effect between telephone/telex and telegraph services.

During the period under consideration, a new cable was constructed on an average of one each year, resulting in an increase of cable network capacity from 36 voice circuits in 1956 to 21,607 voice circuits in 1978. This capacity will further increase to 37,607 voice circuits by year-end 1983. Similarly, an average of two satellites per year were launched since 1965, resulting in an increase of satellite network capacity from 240 voice circuits in 1965 to 43,000 voice circuits in 1976. This capacity will further increase to approximately 60,000 voice circuits by year-end 1980.(16)

Figure 2 presents the variations in information loading in international facilities.(17) This figure indicates that the information loading per circuit, per year has remained almost steady for a period of twenty years despite enormous increases in the telephone and telex services. The implication of this is that such increases in capacity have been undertaken that despite growth in demand the information loading per activated circuit has remained almost stable. It is worth recalling that this growth in capacity has been justified on the grounds of "quality of service", redundancy, diversity, reliability and circuit restoration requirements. In view of numerous operational and technological constraints, as reinforced by regulatory requirements resulting from needs for national defense, it is difficult to estimate an optimal maximum sustainable facility loading rate, because of dependence on the subjective nature of judgments associated with "quality of service" and diversity requirements. However, the experience of periodically high utilization rates in the Pacific region seem to suggest that a utilization rate around 30% would not adversely affect the quality of service.(18)

F. Intermediate Entities and Structures of International Carrier Rates

In the provision of international communications services to the U.S. public, use is made of facilities belonging to at least five different entities because of the organizational structure of the international communications industry. In this section, we will exemplify some of the organizational elements in order to clarify the structure of rates. For example, in a telephone call made from Cleveland, Ohio to Munich, Germany, use is made of facilities wholly or partly owned by the following entities which are answerable to different regulatory agencies for purposes of establishment of rates.

Entity	Jurisdiction
1 (1) Ohio Bell - Local Network	Ohio Public Utility Commission
2 (2) AT&T Long Lines Domestic Network	Federal Communications Commission
(3) AT&T Submarine Cable in Joint Ownership with Foreign Administrations	Federal Communications Commission
3 (4) COMSAT earth station - joint ownership with AT&T	Federal Communications Commission
4 (5) INTELSAT satellite -- joint ownership with COMSAT and foreign administration	International Regulations
5 (6) United Kingdom and French domestic network for transit facilities	Foreign Administrations United Kingdom and France
(7) German domestic network for termination of the call	Germany

If, however, a telegram is placed from Cleveland to Munich, a slightly different set of facilities is used. Since AT&T is not allowed to provide services other than telephone, the caller in Cleveland would call the Western Union Telegraph Company offices or any post office. The caller would not generally be aware (as a majority of the U.S. public is not) of the International Record Carriers (IRCs) offices. The Western Union Telegraph Company would accept the customer's telegram, but it is a domestic carrier and is not allowed to offer international services. Western Union would send the telegram to New York IRC offices where it would be assigned to any of the IRCs according to a prearranged quota system and then transmitted through either cables or satellites. Thus, in the case of telegram, telex and data services, use is made of facilities wholly or partly owned by non-AT&T carriers, such as Western Union, for the domestic loop. The use of facilities of different entities in the transmission of international communications results in the establishment of rates which represent a compromise in resolving a variety of conflicts and problems among AT&T, the IRCs, COMSAT, Intelsat and foreign administrations. Some of these conflicts have been resolved, or rather, stabilized, in a status quo manner by a series of FCC and Congressional decisions.

AT&T and the IRCs average satellite lease rental charges of COMSAT with the cost of their own submarine cable facilities (composite pricing). Thus, there are four levels of rates involved in international communications: (a) Intelsat Charges to Carriers: For the use of satellites, Intelsat establishes rates for its member participants for each half-circuit of two way transmission. COMSAT, as the U.S. member in Intelsat, invests in satellites and leases capacity in satellites jointly owned by COMSAT and the other members of Intelsat; (b) COMSAT Charges to Carriers: COMSAT leases the same satellite capacity to AT&T and the IRCs through the U.S. earth stations which are jointly owned by COMSAT, AT&T and the IRCs. COMSAT, thus, establishes rates for the use of satellite circuits by AT&T and the IRCs; (c) Carrier Charges to the United States public: AT&T and the IRCs combine satellite rental charges with the cost of their own submarine cable facilities and establish rates for various services to the U.S. public; (d) Foreign Administration Charges to Their Public: In addition to message services (e.g., telephone, telex, etc.), for services which are leased for a period greater than a month and utilize full circuits, the foreign administrations establish their own half circuit rates. Similarly, the U.S. Carriers establish their own half circuit rates to the U.S. public.

These services generally include the full time lease of voice grade circuits, or full time lease of telex circuits. The U.S. half-circuits rates need not be the same as the foreign half-circuit rates.

Some additional features of international communication rates should be noted: (1) Since all U.S. international carriers are rate base regulated and generally have a monopoly position they have no real incentive to reduce rates unless confronted by potential entry in selected markets. Consequently, the rate reductions have either been made voluntarily by the carriers or the FCC has used its licensing authority for construction of new facilities as a means to force the carriers to reduce rates; (2) The composite pricing structure tends to reinforce a higher cost structure because the current unit costs are markedly lower than embedded costs and composite pricing structure, thus, represents the cost effects of average technology rather than the latest technology; (3) In view of the fact that cables have 24 years of depreciation life (compared to 7 years for satellites) and that AT&T has a virtual market monopoly, the carriers have been able to shift the burden of obsolescence to the consumer in the form of increased future charges, thus, withholding the benefits of new technology; (4) International communication involves joint cooperation between the U.S. and every other foreign country in terms of methods of communication operations, establishment of rates, and the exchange of revenues for outgoing and incoming communication calls. As a result, the three sets of rates, namely: accounting rates (based on facility ownership and usage); settlement rates (based on exchange rates and bulk buying arrangements); and collection rates (charges to the public), tend to differ considerably on a unit basis. This paper addresses only the collection rates.

In this vertical integration of rates, Intelsat establishes essentially "pipe line" rates for its member countries (i.e., rates for communication channel irrespective of the information flow content), and its rate establishment philosophy is based on: (1) the ownership-use concept;(19) (2) cost averaging between services and ocean regions; (3) 14% return on the use of capital assets; and (4) the revenue requirement per unit of capacity which is generally used as a standard for bulk capacity rates (a half-circuit (unit) is used as a standard for other rates such as television (240 units) and restoration/data services). The concept of "ownership-use" almost forces Intelsat to periodically reduce its rates to member countries because the limit of 14% return on assets cannot be exceeded in any year because of the constraints of the operating agreements. This indirect limit on the profit levels of Intelsat generally appears to be the key instrumental factor in reduction of Intelsat rates as engendered by the declining unit cost effects of technological changes in satellites (see figures 3 and 4).

The U.S. carriers are rate base regulated by the FCC but regulatory lags, coupled with the fact that, in reality, rates are not subject to regular periodic reviews, have resulted in reductions in U.S. carrier rates which have generally been *ad hoc* and sporadic. Additionally, as is indicated in Figure 5, carrier rates are many times the Intelsat channel rates due to: the addition of direct and indirect overhead costs of many intermediate entities and composite pricing; variations in profit levels and objectives; additional costs of interconnect facilities; corporate R&D efforts; potential cross-subsidization of services, and; individual service marketing strategies. Figures 3 and 4 present the decline in, as well as the structural relationship between, Intelsat, COMSAT and the U.S. service carrier rates for voice grade circuits between US-Europe and US-Australia for the period 1964-77. The divergence between the rates as well as the differences in the rates of decline are indicative of the distortions caused by the organizational relationships between firms in this industry. Similarly, Figure 6 presents the divergence of rates between carriers and the historical decline in rates for international television transmission. Table 1 presents a similar rate profile for message telephone services between the U.S. and selected overseas countries.

Tables 2 and 3 present the comparative summary of the U.S. and selected foreign administration rates for each half of the same voice grade circuit and for message telephone service, respectively. It is interesting to note that foreign countries' rates for commensurate services are as much as 50%-60% higher than the U.S. rates, reflecting: variations in rate establishment philsophies; differential rates for social and business usage, and; differential internal industry structures.

A number of factors appear to have contributed to the decline in overseas communication rates. First and foremost is the declining unit capacity and O&M costs of the successive generations of submarine cables and satellites. Second, although the FCC has never instituted formal inquiry into AT&T's and the IRCs overseas rate structure it has, nevertheless, requested that rates be reduced whenever it has authorized the construction of new facilities. Third, the initiation of the alternative and competitive mode of communication, e.g., satellites, appears to have provided enough threat as well as incentive to cause AT&T and the IRCs to reduce their overseas rates. Fourth, the rates to the overseas U.S. points, e.g., Hawaii and Puerto Rico, were reduced when the "overseas" carriers were designated "international" carriers, and the rates for the U.S. owned overseas territories were integrated into the domestic longhaul rates for purposes of uniformity.

G. Implication of Basic Findings

Rapidly changing technology in a regulated industry seems to present some dilemmas for regulatory agencies in terms of decision making and the establishment of objectives of economic regulation. In clarifying regulatory objectives, agency officials must consider the conflict between seeking to minimize cost/rates in the short-run by maximizing utilization of existing facilities, as over against encouraging the construction of facilities embodying the latest in technology and promoting technological innovations which might indirectly promote periodic underutilization of new as well as old facilities. Obviously, a fixed regulatory posture with emphasis on cost/rate minimization in the short-run may prove to be disadvantageous in the long-run, especially if it results in restrictions on service innovations, reduced R&D efforts, and foreclosure of entry of new technologies.

In international communications, technological innovations tend to occur rapidly whereas associated evaluative processes, both legal and economic, proceed at a slower pace. Under the judicial system of the U.S., including but not limited to regulatory statutes, carriers are able to appeal to higher judicial authorities (e.g., Court of Appeals) in order to seek relief from a regulatory agency's decision concerning rate structures and/or construction of facilities. Fear of such judicial appeal seems to have resulted in hastily made decisions on the part of the FCC. It would appear, therefore, that some methods/procedures should be instituted which would expedite the evaluative processes without compromising the legal rights of carriers as well as those of the regulatory agencies.

The current structure of this industry has evolved as a result of numerous regulatory as well as congressional decisions. The structure, in brief, being that AT&T and the IRCs have a monopoly on the end-user markets and that COMSAT has been transformed into a virtual vertical affiliate of AT&T. The following issues and alternatives are suggested as the basis for developing policies which would enhance competition and, perhaps, improve performance of this industry.

Inter-modal competition could be enhanced further if COMSAT were to be allowed to serve the end-user market instead of being restricted to selling satellite circuits only to AT&T and the IRCs. This would afford the end-user an opportunity to choose between "...a sufficient variety of price-quality combinations--consistent with efficient production--so that each can register a free and tolerably well informed monetary appraisal of the quality differentials that are offered."(20) The end-user would then be able to select between service offerings made by either AT&T (cables) or COMSAT (satellites).

The implications of the above would be that AT&T would no longer be required by regulatory statutes to lease satellite circuits from COMSAT and, likewise, COMSAT would not be dependent on AT&T for the sale of satellite circuits. AT&T and COMSAT would compete with each other on the basis of existing and potential advantages of their respective facilities.

Another advantage of the above alternative would seem to be that it would allow inter- and intra-modal competition in the domestic component of international services. COMSAT, AT&T and the IRCs, as well as existing and future domestic carriers, would be able to interconnect their domestic networks consisting of either domestic satellites, microwave, or coaxial cable systems, with the international cable or satellite networks. This would enhance inter- and intra-modal competition in the domestic component of international services because the domestic as well as the international carriers would be free to choose among different types of facilities, e.g., satellites, coaxial cables, microwave, etc.(21) Additionally, this alternative would enhance competition with the existing domestic carriers such as AT&T and Western Union.

Competition could be further increased if the separation of markets for voice and non-voice services could be eliminated. This would allow international carriers to integrate transmission technologies and introduce service innovations. In the domestic component of international services, it would allow existing and future carriers to integrate domestic facilities for provision of joint service offerings (voice and non-voice).

A summary analysis of key regulatory decisions as presented in this paper seems to suggest that the effectiveness of economic regulation could be increased by developing more sophisticated capabilities to evaluate technical/economic potentials of newly emerging advances in technology so that such potential could be evaluated in advance of application by the carriers to construct facilities. This would engender a need to continuously monitor technological developments as well as to maintain a current information base on the activities of regulated carriers. One of the advantages of the above would seem to be that it could result in expeditious dispositions of carrier applications for construction permits and other matters.

A continuous surveillance of technical/economic potentials of new advances in technology would allow the agencies to engage in long range regulatory planning; to establish guidelines for future construction of facilities; to institute associated evaluative processes and procedures, and; to establish criteria for judgment of public interest. Any form of regulatory process faced with new technological advances must be able to reassess objectives/procedures because it is not possible to plan and construct facilities in advance to cover all possible technological changes and alternatives. Additionally, this would allow the agencies to institute appropriate cost of service/rate proceedings instead of merely reacting to proposals advanced by the regulated carriers. Furthermore, this would afford an opportunity to more thoroughly investigate, perhaps with the assistance of objective (non-participating) entities, some fundamental issues such as: What level of underutilization of capacity should be considered as undue burden on the end-users? and What are the long-term ramnifications of alternative regulatory postures?

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NOTES:

(1) The ideas and conclusions presented in this paper represent the views of the author and should not be interpreted as representing the views of the XEROX Corporation or any of its affiliated organizations.

(2) 47 United States Code, 1934, as amended.

(3) Communications Satellite Act of 1962, 47 USC 1962.

(4) These include Western Union International, Inc., ITT World Communications, Inc., RCA Global Communications, TRT Telecommunications, Inc., etc.

(5) The Management Services Contract (MSC) between COMSAT and Intelsat was terminated on January 2, 1979 and was replaced by the Technical Services Contract. According to the terms of this contract COMSAT is to provide services to Intelsat for a period of six years.

(6) The SH cable is still in the developmental stages. It is expected to possess a 16,000 voice circuit capacity. See 30 FCC 2d, note on p. 574 and also see AT&T filing with the FCC, Docket 18875, August 31, 1977.

(7) Communications Satellite Act of 1962, 47 USC, 1962.

(8) The Authorized User Decision, 4 FCC 2d, 421, 1966.

(9) See COMSAT Annual Reports to the President and the U.S. Congress, each year, 1965-1973.

(10) The Earth Station Ownership Decision. 5 FCC 2d, 812, 1966.

(11) The TAT-IV Decision, 37 FCC 1151, 1964.

(12) The "Carrier of the Week" Decision, 2 FCC 2d, p. 41, 1966.

(13) See for example, Virgin Island and Puerto Rico Earth Station Decision, 5 FCC 2d, 823, 1966; TAT-V and VI decisions, Cantat II and Transpac II cable decisions, Intelsat V and TAT-VII decisions, FCC Docket 18875.

(14) See 30 FCC 2d 571, 1971. It should be noted that "circuit parity" and "proportional fill" policies are not economically compatible when facilities have different voice circuit capacities.

(15) Direct O&M costs do not include direct and indirect overhead, and as a result are representative of actual costs incurred in the operations of facilities.

(16) Although new technologies were introduced in cables on an average of every five years and in satellites on an average of every three years, individual cables and satellites belonging to the various vintages were installed/launched on an average of one per year in the cable system and two per year in the satellite system.

(17) Information loading per circuit, per year is easily obtained in communication services by aggregating the various services in the form of a homogeneous output such as "minutes of total transmission": Telephone (minutes), telex (minutes), television (minutes), telegraph (words divided by transmission speed in words per minute). The aggregate minutes of transmission is divided by the number of authorized circuits that transmit the information in a given time period, e.g., per year. This procedure yields information loading per circuit, per year and is internally consistent.

(18) It follows that for a given level of traffic, an excess capacity in the same as well as in different types of facilities increases the probability of a circuit being available when requested and it also increases reliability, diversity and circuit restoration in the event of a fault in the system.

(19) The ownership-use concept refers to the operating agreements between the member nations of Intelsat. Under this concept, a member country's percentage investment in Intelsat facilities is based on its percentage usage of the total satellite usage in a given year. The divergence between investment shares and usage percentage is periodically adjusted. Note that the financial burdens associated with unused satellite capacity are shared by member countries in proportion to their usage of satellites. For a detailed description of the applicability of standard economic theories to Intelsat pricing, see Reference 18. Having personally participated in some of the pricing exercises in the Intelsat Board of Governors meetings, it is interesting to note that, oftentimes, diplomatic finesse and political expediencies played major roles in such pricing exercises.

(20) A.E. Kahn, The Economics of Regulation, Volume 2 (New York: John Wiley & Sons, Inc., 1971), p. 216.

(21) Such as SBS and XEROX (XTEN) who have recently petitioned the FCC to operate domestic satellite networks and the American Satellite Corporation which already operates a domestic satellite network. This also includes other specialized common carriers who either already operate or intend to operate domestic microwave/coaxial cable networks.

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FIGURE 1

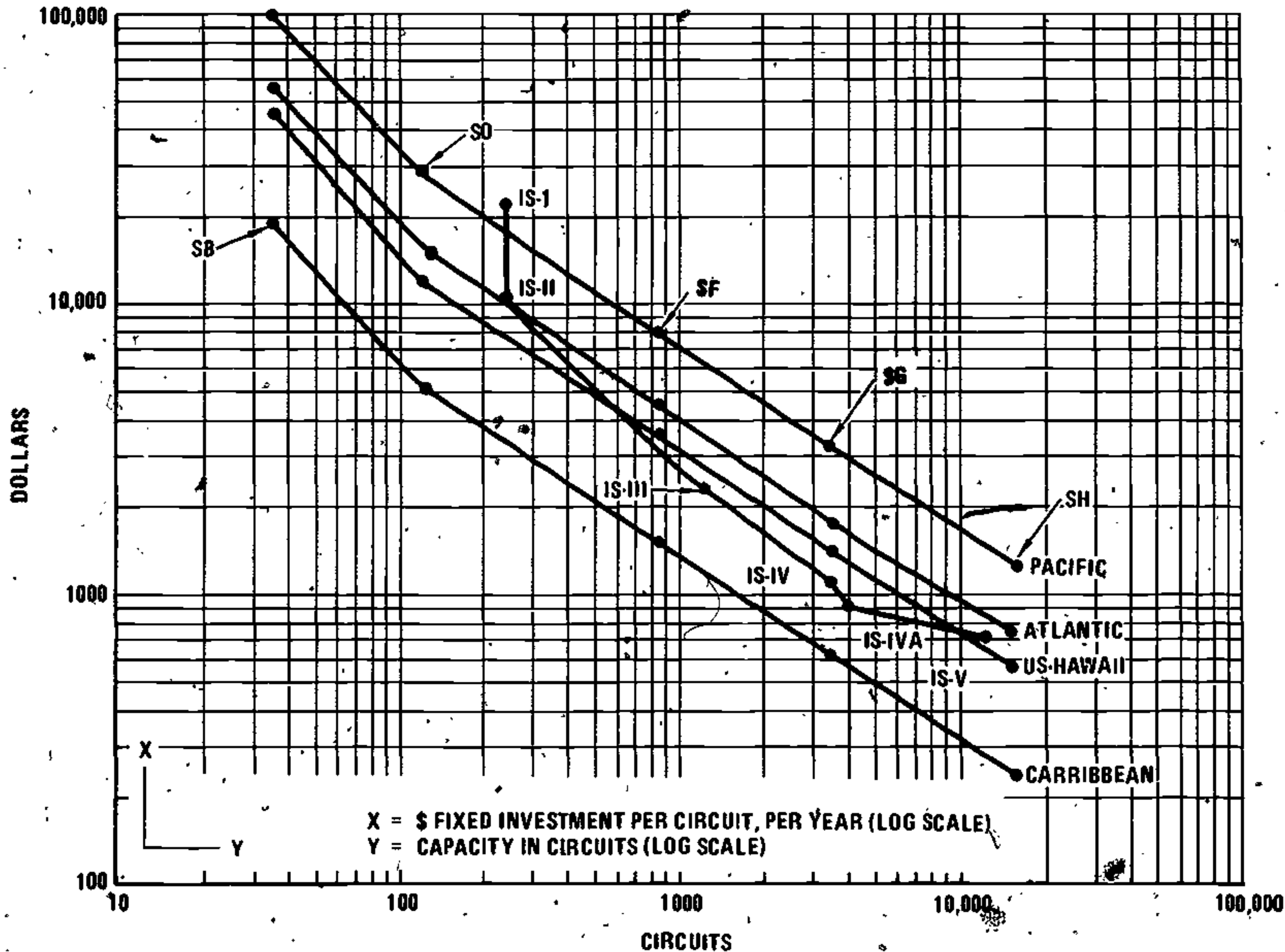
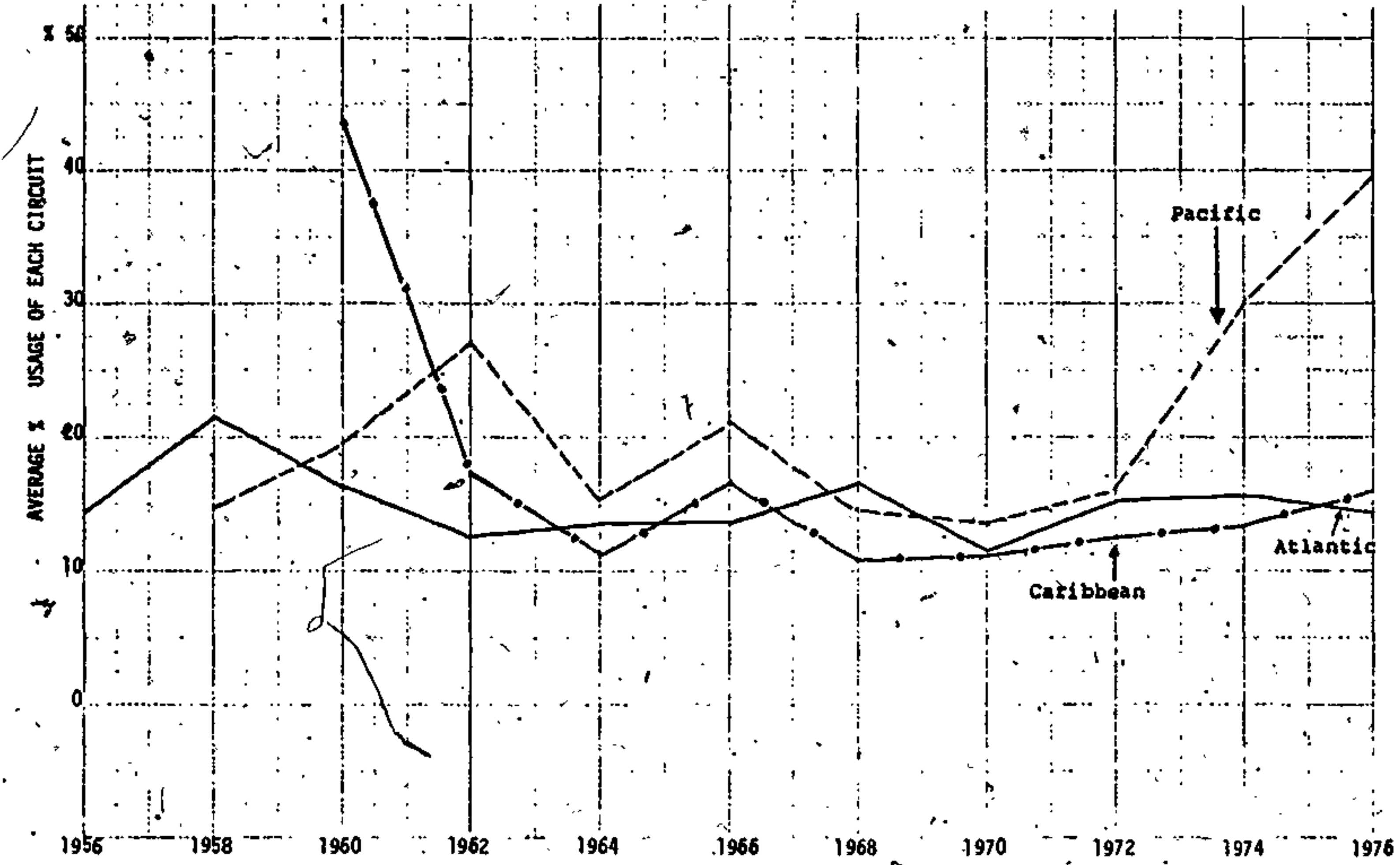

100,000
10,000
1000
100
DOLLARS
10
100
1000
10,000
100,000
CIRCUITS
SO
IS-1
IS-II
SB
SF
SG
IS-III
SH
IS-IV
IS-IVA
IS-V
PACIFIC
ATLANTIC
US-HAWAII
CARRIBBEAN
X
Y
X = $ FIXED INVESTMENT PER CIRCUIT, PER YEAR (LOG SCALE)
Y = CAPACITY IN CIRCUITS (LOG SCALE)

FIGURE 2

VARIATIONS IN CIRCUIT LOADING IN THE ATLANTIC, PACIFIC, AND THE CARIBBEAN OCEANS



31–37

FIGURE 3

CHANGES IN THE STRUCTURE OF MONTHLY RATES FOR LEASED VOICE GRADE CIRCUITS (HALF-CIRCUIT)

($ DOLLARS)

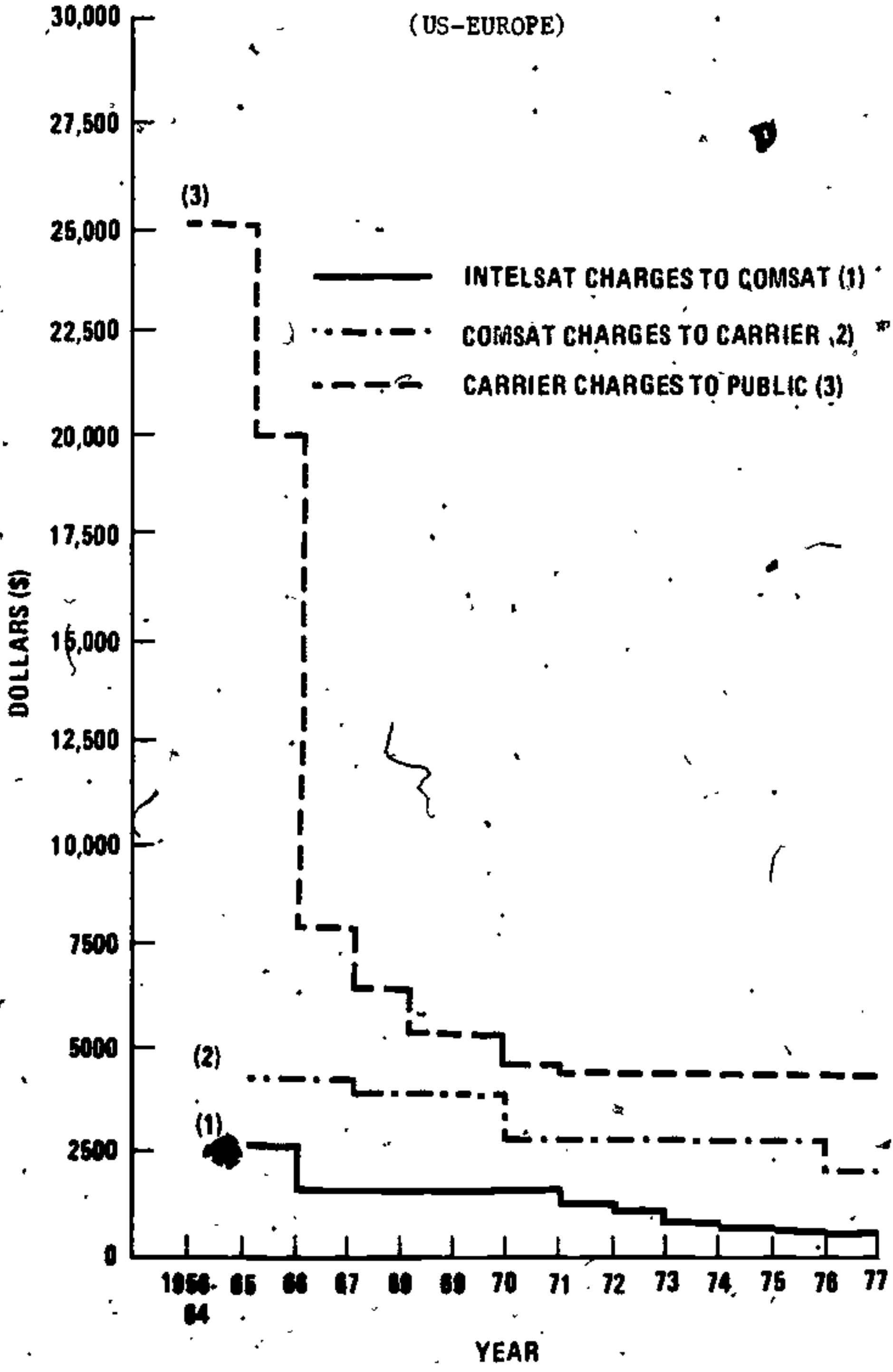


FIGURE 4

CHANGES IN THE STRUCTURE OF MONTHLY RATES FOR LEASED VOICE GRADE CIRCUITS (HALF-CIRCUIT)

($ DOLLARS)

(US–AUSTRALIA)

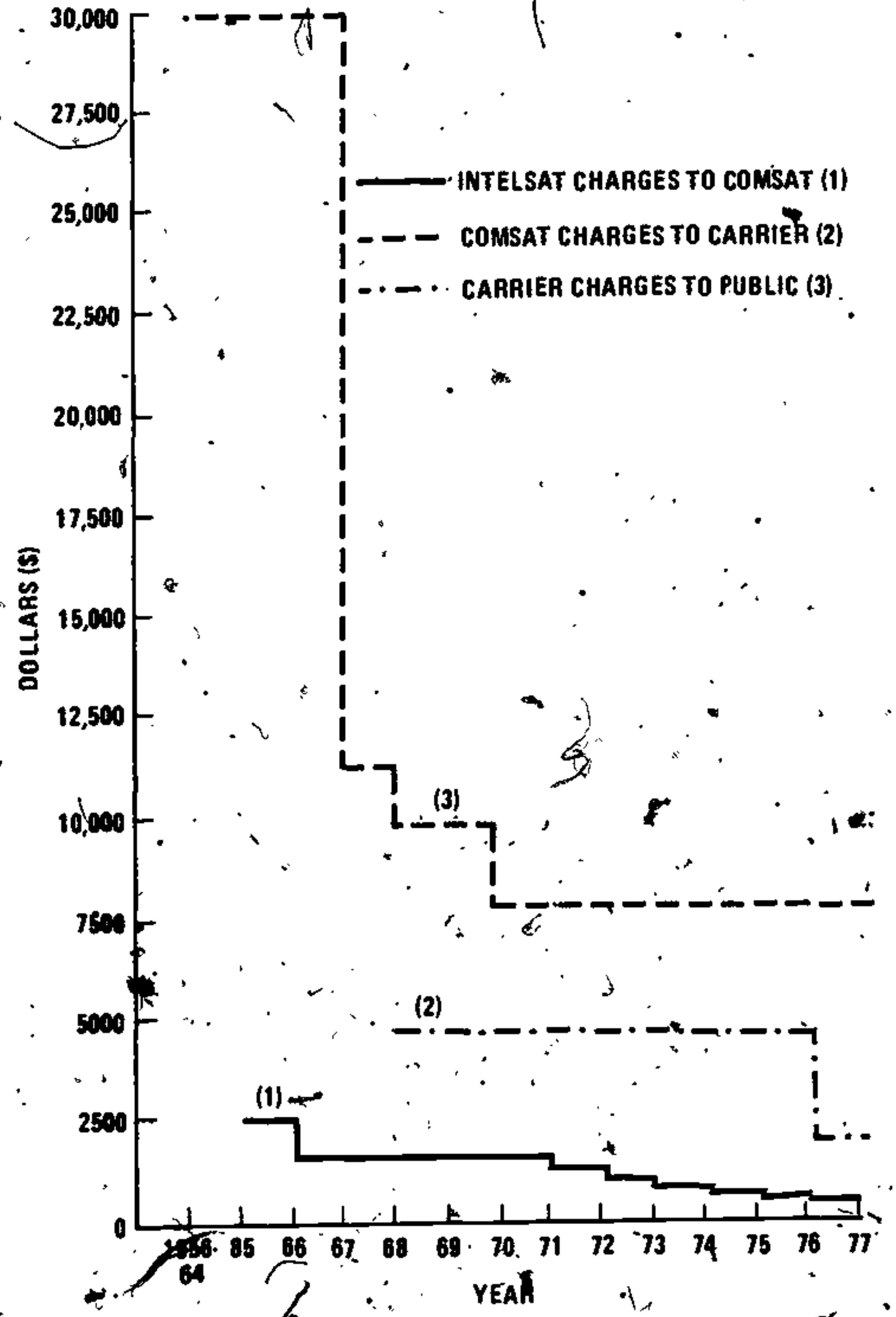
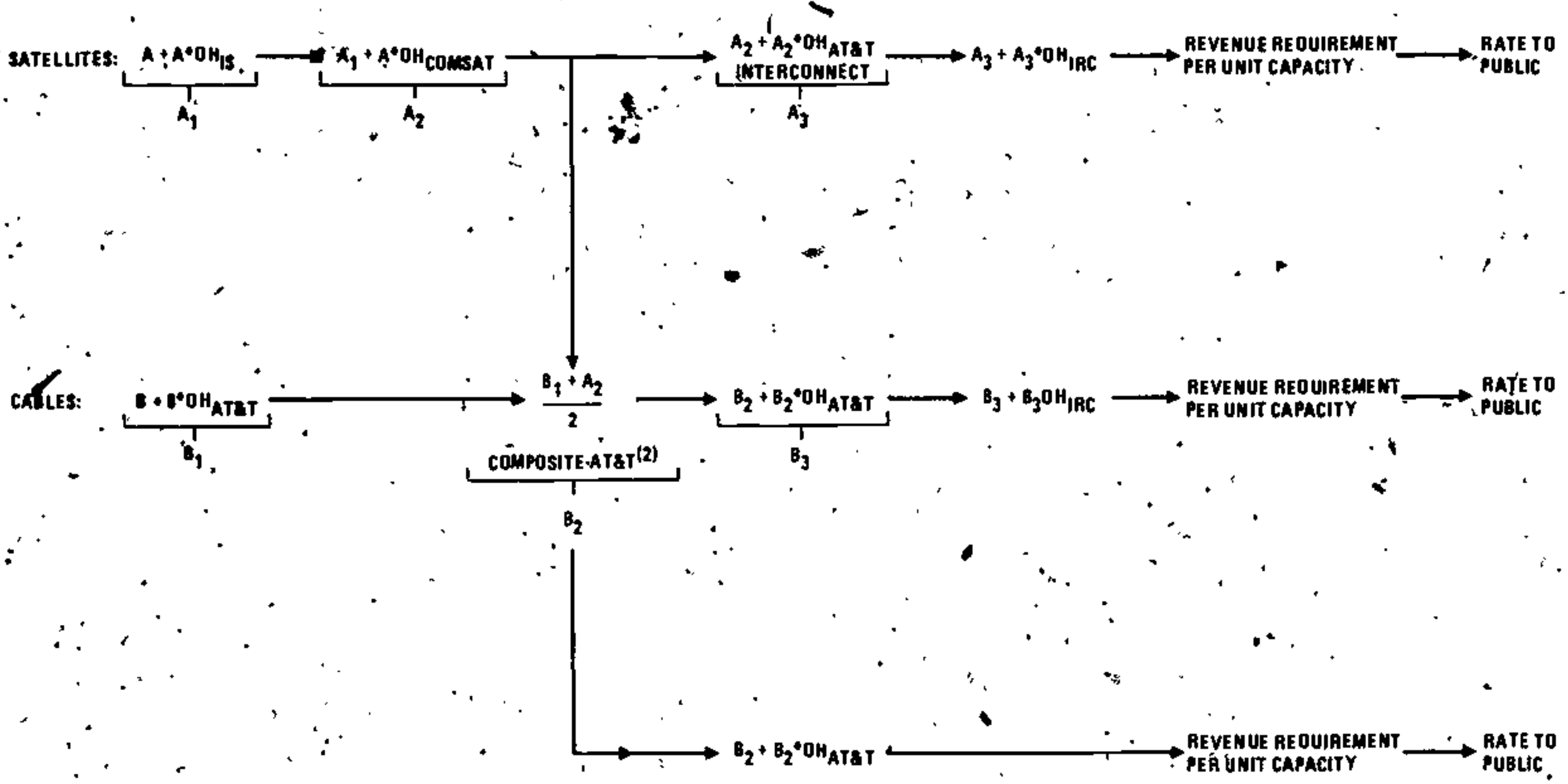


FIGURE 5

CORPORATE OVERHEAD ADDITIONS TO TOTAL ANNUAL DIRECT UNIT COSTS IN INTERNATIONAL FACILITIES


SATELLITES:
A + A*OH_IS
A_1
A_1 + A*OH_COMSAT
A_2
A_2 + A_2*OH_AT&T INTERCONNECT
A_3
A_3 + A_3*OH_IRC
REVENUE REQUIREMENT PER UNIT CAPACITY
RATE TO PUBLIC
CABLES:
B + B*OH_AT&T
B_1
(B_1 + A_2) / 2
COMPOSITE AT&T(2)
B_2
B_2 + B_2*OH_AT&T
B_3
B_3 + B_3OH_IRC
REVENUE REQUIREMENT PER UNIT CAPACITY
RATE TO PUBLIC
B_2 + B_2*OH_AT&T
REVENUE REQUIREMENT PER UNIT CAPACITY
RATE TO PUBLIC

ABBREVIATIONS:
A,B = TOTAL DIRECT UNIT COSTS OF SATELLITE AND CABLE FACILITIES
OH = OVERHEAD RATE %
IRC = INTERNATIONAL RECORD CARRIERS
IS = INTELSAT
AT&T = AMERICAN TELEPHONE AND TELEGRAPH COMPANY

NOTES:
1. NOTE THAT ONLY AT&T AND THE IRCS PROVIDE SERVICES DIRECTLY TO THE PUBLIC.
2. CABLE AND SATELLITE FACILITIES ARE COMPOSITED BY AT&T

FIGURE 6

CHANGES IN THE STRUCTURE OF TELEVISION RATES PER MINUTE OF TRANSMISSION

(US—EUROPE)

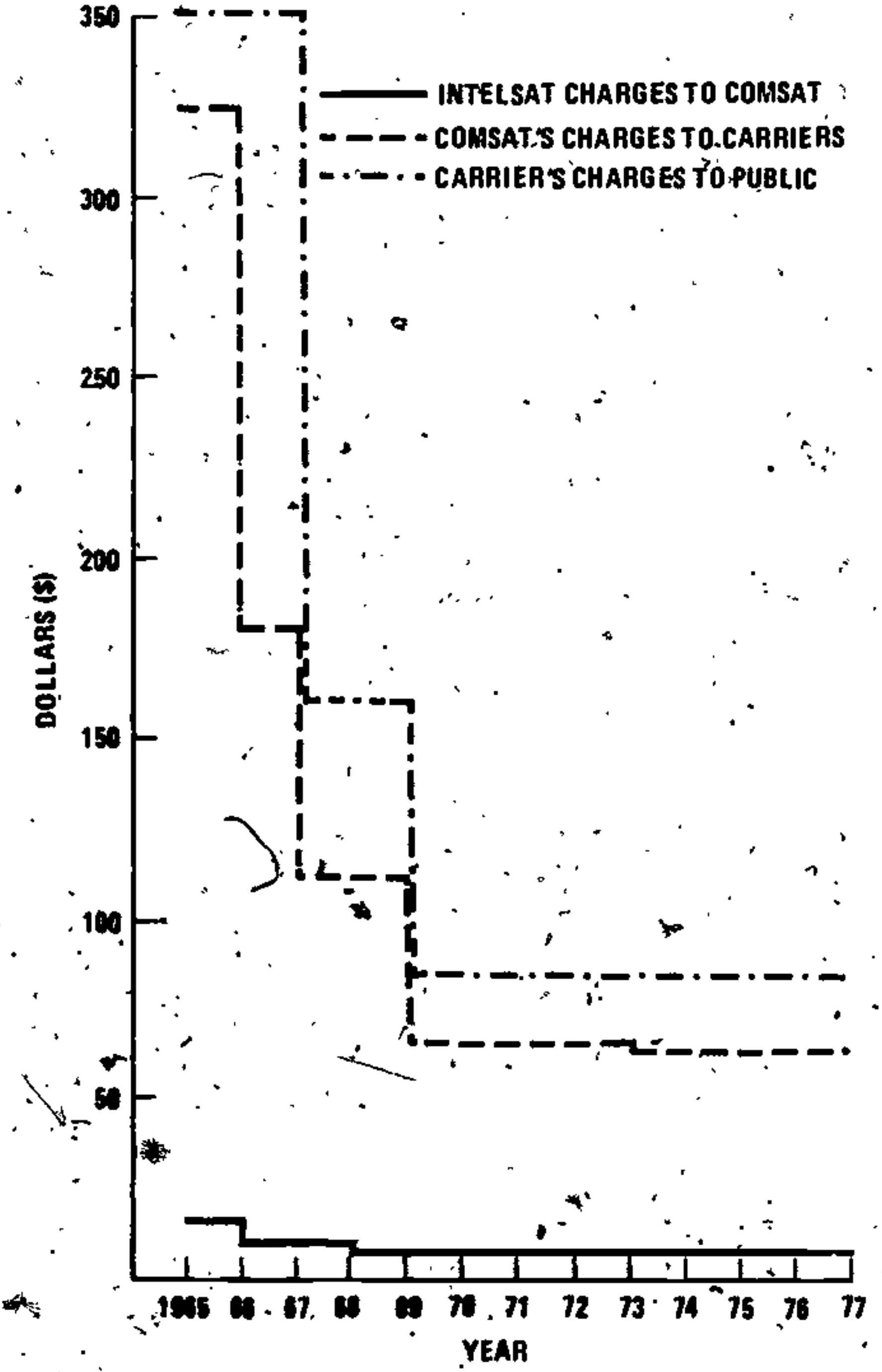


TABLE I

CHANGES IN THE STRUCTURE OF MESSAGE TELEPHONE RATES (WEEKDAYS)

$ FIRST 3 MINUTES

	1927	1928	1929-1944	1945-1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
US-UK	75	45	21	12	12	7.50*	7.50	7.50	5.40	3.60**	3.60	3.60	3.60	3.60	3.60	3.60	3.60
US-PUERTO RICO			15	6	5.50*	5.50	5.50	4.05**	4.05	4.05	4.05	4.05	4.05	4.05	3.90	3.90	3.90
US-AUSTRALIA			21	12	12	12	12	9*	9	9	9	9	9	9	9	9	9
US-HAWAII			21	12	5.50	5.50	5.25	5.25	5.25	4.65	3.90	3*	2.40**	3.15	2.70	2.70	2.70
US-JAPAN			21	12	12	12	9*	9	9	9	9	9	9	9	9	9	9

* STATION TO STATION RATE

** IDDD INTRODUCED

TABLE 2

U.S. AND FOREIGN ADMINISTRATIONS' HALF-CIRCUIT VOICE GRADE MONTHLY LEASE RATES – 1977

	UNITED STATES HALF-CIRCUIT RATE ($)	FOREIGN ADMINISTRATIONS' HALF-CIRCUIT RATE ($)	TOTAL ($)
EUROPE			
AUSTRIA	$4,575	$7,768	$12,343
FRANCE	4,575	4,930	9,505
ITALY	4,575	7,301	11,876
NORWAY	4,575	5,675	10,250
UNITED KINGDOM	4,575	4,888	9,463
WESTERN PACIFIC			
AUSTRALIA	$7,900	$ 9,840	$17,740
JAPAN	6,700	13,403	21,203
SINGAPORE	7,900	10,542	18,442
NEW ZEALAND	7,900	8,300	16,200
TAIWAN	7,900	12,105	20,005

SOURCE: DATA COLLECTED FROM AT&T AND FROM RESPECTIVE FOREIGN EMBASSIES, WASHINGTON, D.C.

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TABLE 3

TELEPHONE RATES

UNITED STATES AND SEVEN FOREIGN COUNTRIES

3 MINUTES – DAY TIME RATE – STATION-TO-STATION

	UNITED STATES TO FOREIGN COUNTRY (DOLLARS)	FOREIGN COUNTRY TO UNITED STATES (DOLLARS) (1)	FOREIGN COUNTRY TO UNITED STATES (NATIONAL CURRENCY OF COUNTRY)
UNITES STATES – FRANCE	$6.75	$ 7.51	36.9 FRANCS
UNITED STATES – UNITED KINGDOM	3.60	5.22	2.7 BRITISH POUND
UNITED STATES – GERMANY	6.75	14.24	30 MARKS
UNITED STATES – AUSTRALIA	9.00	8.19	7.2 AUSTRALIAN DOLLAR
UNITED STATES – ITALY	6.75	6.06	5290 LIRA
UNITED STATES – BRAZIL	9.00	9.48	152 CRUZEIROS
UNITED STATES – ARGENTINA	8.00	13.96	8971 PESOS

(1) BASED ON EXCHANGE RATE ON FEBRUARY 8, 197[illegible]

SOURCE: COLLECTED FROM AT&T AND FROM RESPECTIVE FOREIGN EMBASSIES, WASHINGTON, D.C.

DEMOGRAPHIC EFFECTS OF LOCAL CALLING UNDER MEASURED vs. FLAT RATE SERVICE: ANALYSIS OF DATA FROM THE GTE ILLINOIS EXPERIMENT

Rolla Edward Park, Bridger M. Mitchell and Bruce M. Wetzel.*
The Rand Corporation
Santa Monica, California

Abstract

When the billing of local telephone service is changed from flat rate to measured service the distribution of monthly calling rates is altered. This paper models the distribution of flat-rate telephone usage in terms of demographic variables and stochastic components; the shift to measured service affects both the systematic and stochastic parameters. The model is fitted by maximum likelihood to data for interviewed households participating in General Telephone's Local Measured Service Experiment in Illinois.

I. INTRODUCTION

Most residential telephone service in the United States is provided for a flat monthly fee, with no extra charge for calls to telephones within the local area. An alternative, common in the rest of the world and increasingly discussed in the United States, is to levy a charge for each local call and/or each minute of local calling. This alternative--referred to as "usage sensitive pricing" or "local measured service" could possibly be both more efficient and more equitable than flat rate charges. However, in practice, not much is known about the effects of switching from flat rate to local measured service. Are the efficiency gains sufficient to offset the additional costs of measurement and billing? Who gains and who loses from conversion to measured service? (1).

In this paper we provide some additional information by analyzing the effects of the change from flat rate to measured service on the distribution of residential telephone usage in a particular experimental setting. The analysis reported here is limited to number of calls; accurate data on minutes of local usage are not yet available.

THE GTE LOCAL MEASURED SERVICE EXPERIMENT

General Telephone and Electronics, recognizing the need for better information on subscriber demand for telephone calls and related matters, is conducting a local measured service experiment in three small exchanges in central Illinois--Jacksonville, Clinton, and Tuscola. For over two years, GTE recorded information on individual customers' telephone use under the flat rate tariffs in effect in those exchanges. Then, on September 1, 1977, GTE switched to the measured service tariffs shown on

Table 1, and continued to record usage information (2). In contrast to some measured service plans that are available elsewhere, the experimental tariffs are non-optional and include no free calling allowance. The only way residental subscribers can avoid paying for each outgoing call is by downgrading to multi-party service, which is still on flat rate. Very few have done so--only one half of one percent during the three months following the switchover date. (3).

Table 1

GTE EXPERIMENTAL MEASURED SERVICE TARIFFS
(Residental Single-Party Telephone Service)

	Experimental Measured Service Charges in Urban Areas		
	Per Month[a]	Per Call	Per Minute
Jacksonville	$3.15	2¢	1¢
Clinton and Tuscola	2.50	--	1.5

Note: 20 percent discount evenings (5-11 p.m.) and 8 a.m.-11 p.m. Sunday.
50 percent discount nights (11 p.m.-8 a.m.).
$19 ceiling on usage charges per month.

[a] The experimental monthly charge is approximately 40 percent of the pre-experimental flat-rate monthly charge.

II. DATA AND MODEL

THE DATA

We work with a unique set of [illegible] from the GTE-Illinois experiment. These data combine for the first [illegible]emographic information on several hundred households with information [illegible]ach household's telephone usage under both flat rate and measured rate tariffs.

The demographic information comes from a telephone survey conducted during April 1978. The basic sample was drawn as a systematic sample from a list of households ranked by their local minutes of telephone usage during June, July, and August 1977. This sampling method assured that all usage levels are equally represented in the basic sample. This basic sample was then augmented by drawing additional households from the highest and lowest 10 percent of users. Thus high and low users are overrepresented in the stratified sample. A total of 728 completed interviews resulted.

We linked the interview data to the number of telephone calls for six separate months: the last three months under the flat rate tariff (June, July, and August 1977), and the same three months one year later under the measured service tariff (June, July, and August 1978).

Data were incomplete for a portion of the sample. For 102 households missing interview data values were estimated from regression equations on households with complete data. Sixty households were omitted because of inconsistent or unusable survey data, change in class of service, no service during part of the sample months, or zero usage in one or more months. After these exclusions, a total of 668 households (4,008 monthly observations) remained for analysis.

The demographic variables ultimately used in the model were chosen from those measured in the household survey. The selected variables, based on their statistical significance in preliminary estimates of equation (2), are

SIZE = logarithm of household size
INCOME = logarithm of household income ($000)
AGE, AGESQ = age and age^2 of head of household, measured in scores (20 years)
TEEN = 1 if teenager in household, 0 otherwise
FRIENDS = 1 if household reported many local acquaintances, 0 otherwise
ESTINC = 1 if income value estimated, 0 if reported
ESTAGE = 1 if age value estimated, 0 if reported (4)

Table 2 shows the weighted average number of calls per month for the stratified sample, for the three flat rate months and the three measured rate months. When the sample data are averaged using population weights for each stratum, one finds an eight percent lower calling rate under the measured tariff than under flat rate.

Table 2

WEIGHTED AVERAGE NUMBER OF CALLS
FOR THE STRATIFIED SAMPLE

Stratum	Number	Average Calls per Month Flat Rate	 Measured	Percent Change
Lowest 10 percent	78	17.3	21.6	+23
Middle 80 percent	395	80.4	76.3	-5
Highest 10 percent	195	206.3	162.6	-21
Weighted average	668	86.7	79.4	-8

Figure 1 shows the distribution of calls by our sample households during June 1977. This is a typical skewed distribution with most households making relatively few calls and a smaller number of households making relatively many calls. Analysis of these distributions for the Illinois exchanges by methods introduced by Box and Cox (1964) establishes that a power function of the monthly calling rate $C = (\text{calls})^{0.27}$ is normally distributed. This finding agrees with results reported by Pavarini (1979) for 73 Bell System switching offices.

In order that our regression results represent population characteristics, we must reduce the weight given to the observations drawn from the lowest and highest 10 percent of users to undo the effects of oversampling. For each stratum, the appropriate weight is proportional to the square root of the ratio of the number of households in that stratum of the population to the number in the sample (5). We calculate the weights separately for each exchange.

THE MODEL

To motivate the model that we actually estimate we start with the following simple relationship:

$$C_{it} = \beta_o + \beta Z_i + \alpha_o T_t + \varepsilon_{it} \qquad (1)$$

where

$C_{it} = (\text{calls}_{it})^{.27}$ is the power function of the number of calls by household i during month t;

Z_i is a vector of variables characterizing household i;

T_t is a dummy variable equal to 1 in the three months during which the measured service tariff is in effect, and zero otherwise;

ε_{it} is an independent, identically distributed error term;

and β (a vector) and α_o are coefficients to be estimated. This simple relationship explains household telephone calling as a function of demographic characteristics and a (presumably downward) shift when the measured service tariff is in effect.

The model that we actually estimate is more complicated than that for the following reasons:

1. We do not expect the error term ε_{it} to be independent and identically distributed; rather we expect that there are components of error (μ_i) specific to each household that persist from month to month. Because of unobserved influences, or because of taste differences, or for whatever reason, a household that makes an inexplicably large number of calls this month will probably do so next month and next year as well.

These assumptions imply that the error covariance matrix is block diagonal, $V = \text{diag}\ [\Omega, \Omega, \ldots, \Omega]$ where the six by six (month) blocks Ω for each household have the structure shown in Table 3. Note that there are five different values for elements of Ω, but only four underlying parameters to be estimated--σ_ε^2, σ_μ^2, σ_ν^2, and ρ. We estimate equation (2) by a maximum-likelihood procedure starting from ordinary least squares estimates of the coefficients (6).

Table 3

ASSUMED STRUCTURE OF ERROR COVARIANCE MATRIX, Ω

$$\begin{array}{l|ccc|ccc|}
\text{Month:} & 1 & 2 & 3 & 4 & 5 & 6 \\
1\ \text{Jun 77} & A & B & B & C & C & C \\
2\ \text{Jul 77} & B & A & B & C & C & C \\
3\ \text{Aug 77} & B & B & A & C & C & C \\
\hline
4\ \text{Jun 78} & C & C & C & D & E & E \\
5\ \text{Jul 78} & C & C & C & E & D & E \\
6\ \text{Aug 78} & C & C & C & E & E & D
\end{array}$$

Where:

$A = \sigma_\mu^2 + \sigma_\varepsilon^2$

$B = \sigma_\mu^2$

$C = \sigma_\mu^2 + \rho\sigma_\mu\sigma_\nu$

$D = \sigma_\mu^2 + 2\rho\sigma_\mu\sigma_\nu + \sigma_\nu^2 + \sigma_\varepsilon^2$

$E = \sigma_\mu^2 + 2\rho\sigma_\mu\sigma_\nu + \sigma_\nu^2$

III. RESULTS

The calling rate model (2) may be applied to the three exchanges in several ways. We test four increasingly stringent specifications. In the first (H_1), we assume that a separate model applies in each exchange and estimate three complete sets of coefficients and stochastic parameters. The second specification (H_2) assumes that the effects of the demographic variables are the same across exchanges, but that both the stochastic parameters and the flat-rate intercept (β_0) differ. Specification H_3 allows only the intercepts to differ, and the final specification (H_4) assumes that the exchanges are identical in all respects and estimates a single set of coefficients and parameters.

A statistic for testing these nested hypotheses can be constructed from the value of the likelihood function under each specification. Under

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4\ \text{Jun 78} & C & C & C & D & E & E \\
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\hline
\end{array}$$

Where:

$A = \sigma_\mu^2 + \sigma_\varepsilon^2$

$B = \sigma_\mu^2$

$C = \sigma_\mu^2 + \rho\sigma_\mu\sigma_\nu$

$D = \sigma_\mu^2 + 2\rho\sigma_\mu\sigma_\nu + \sigma_\nu^2 + \sigma_\varepsilon^2$

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A statistic for testing these nested hypotheses can be constructed from the value of the likelihood function under each specification. Under

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the hypothesis H_i, minus twice the logarithm of the likelihood ratio of specification H_i to specification H_{i-1} is distributed approximately as χ^2 with degrees of freedom equal to the difference in the number of independent parameters estimated under H_i and H_{i-1} (7).

At a 99 percent confidence level (P=.01) the test statistic falls just short of significance and we accept the specification H_2 that the three exchanges have a common set of demographic coefficients. In similar fashion we accept H_3 but find that specification H_4 is too stringent. Our final model, therefore, is specification H_3--separate intercepts for the flat-rate calling rates in each exchange and a common set of demographic coefficients β and stochastic parameters Ω.

The maximum likelihood estimates of the systematic part of equation (2) for specification H_3 are shown in Table 5. The first set of coefficients characterize calling under the flat rate tariff. For the same level of demographic variables, households in Jacksonville make more calls than to those in Clinton and Tuscola. The coefficients of the demographic variables measure the partial effect of each variable on monthly calling. They show:

(1) The number of calls that a household makes each month is strongly dependent on its size (number of people in the household);

(2) Households with higher incomes tend to make fewer calls, but the effect is small and insignificant;

Table 4

TESTS OF ALTERNATIVE MODEL SPECIFICATIONS

Test of Specification	Against	Chi-Square Statistic	d.f.	Critical Value at P=.01
H_2: common demographic coefficients for each exchange separate stochastic parameters separate intercepts	H_1[a]	54	(34)	55
H_3: common demographic and stochastic parameters separate intercepts	H_2	20	(8)	22
H_4: all parameters common	H_3	22	(2)	9

---

[a] H_1: separate demographic and stochastic parameters for each exchange.

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---

[a] H_1: separate demographic and stochastic parameters for each exchange.

(3) Calling increases with the age of the household head, reaching a maximum in the retirement years;

(4) If teenagers are present calling rates are slightly, but insignificantly reduced;

(5) Households reporting many acquaintances in the local community make significantly more local calls;

(6) Households with missing values for income and age call at significantly different rates than do those for which these variables are observed.

The second set of coefficients characterizes the systematic reaction to the measured service tariff. They indicate that

(1) Larger households reduce their calling significantly more than do smaller households;

(2) Higher income households reduce calling less than those with lower incomes;

(3) Households with older heads tend to reduce calling somewhat more than younger households;

(4) Households with teenagers make significantly smaller reductions in calling than households with no teenage present;

(5) Acquaintances and the use of estimated income and age variables do not significantly change responses to the measured service tariff.

Table 5

MAXIMUM LIKELIHOOD ESTIMATES--SYSTEMATIC PART

Variable	Flat Rate		Measured Rate	
	Coefficient	t-statistic	Change in Coefficient	t-statistic
Intercept				
Clinton	2.079	8.5	.179	1.3
Jacksonville	2.230	9.1		
Tuscola	1.963	7.9		
SIZE	.746	10.8	-.149	-3.8
INCOME	-.043	-1.0	.037	1.5
AGE, AGE2	.319, -.050	1.6, -1.2	-.167, .023	-1.4, 1.0
TEEN	-.054	-0.7	.121	2.9
FRIENDS	.212	2.6	-.024	-0.5
ESTINC, ESTAGE	.154, -.229	2.2, -1.6	.045, .026	1.1, 0.3

Table 6 shows our estimates of the four underlying stochastic parameters of the covariance matrix Ω. The between-household variance σ_μ^2 is about six times as large as the within-household variance σ_ε^2, confirming our expectation that inexplicably high or low calling rates for particular households tend to persist over time. The variance of the household response error σ_ν^2 is about 45 percent larger than the within-household variance. The household-specific error component μ and the response error ν are negatively correlated ($\rho = -.36$), indicating that households with especially high calling tend to reduce calling more in response to measured service than do households with especially low calling rates.

Table 6

MAXIMUM LIKELIHOOD RESULTS--STOCHASTIC PART

Parameter		Estimate
σ_ε^2	within-household error	.043
σ_μ^2	household-specific error	.262
σ_ν^2	household-specific reaction to measured service	.062
ρ	correlation between μ and ν	-.357

Our regression results--the systematic and stochastic parts taken together--imply a particular distribution of calling rates for households with given demographic characteristics. Figure 2 is plotted for households of 3 people and $20,000 income with a 40 year old head. The solid curve shows the relative frequency with which households with those characteristics would use the telephone under a flat rate tariff. For example, about twice as many households would make between 60 and 70 local calls per month as would make between 170 and 180 calls per month. The dashed line shows what the measured service tariff does to the distribtuion. Measured service shifts the distribution to the left and reduces its variance somewhat. As a result, the relative frequency of high calling rates declines and the proportion of households near the center of the distribution increases; there is only a modest effect on low calling rates.

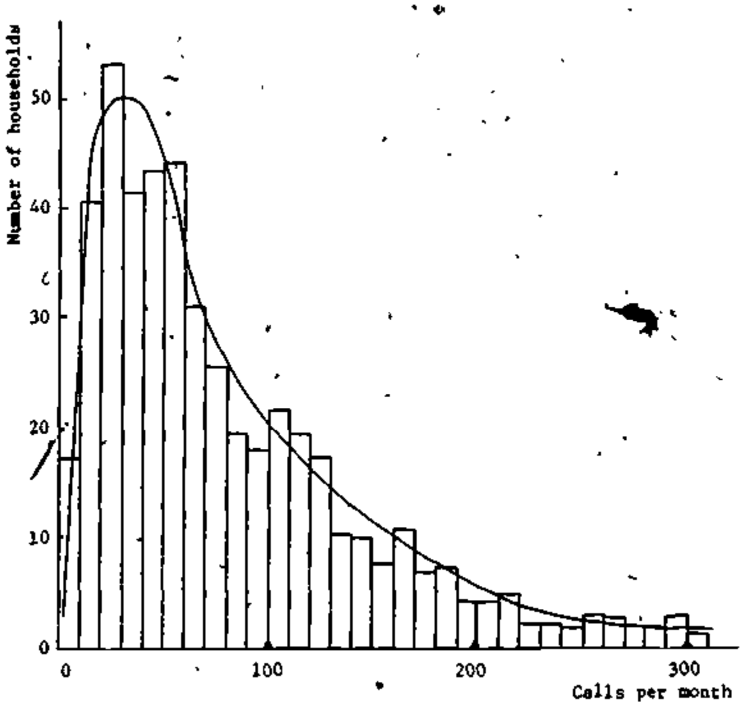

Fig. 1-- Weighted counts of sample households making different numbers of calls during June 1977

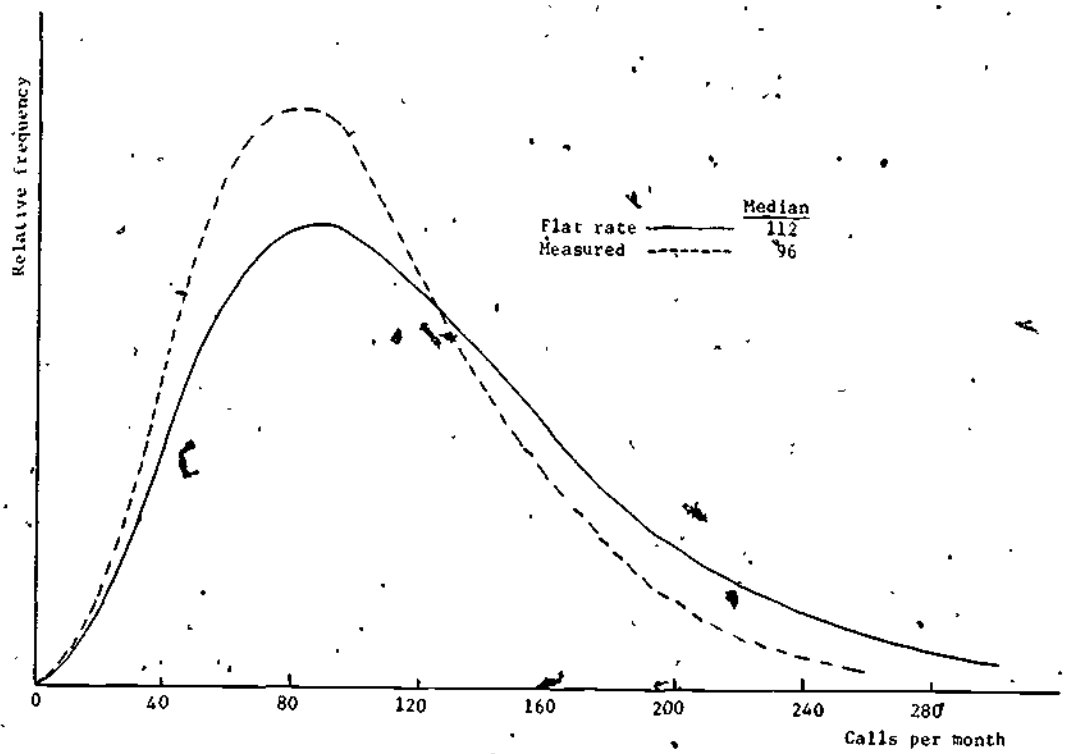

Fig 2--Distribution of Typical Three-Person Households by Their Calling Rates

Footnotes

[*] J. H. Alleman contributed to the early stages of this research and H. Y. Kraepelien suggested refinements to our analysis. G. Cohen and J. Jensik provided us with access to the GTE experiment and assisted us in interpreting the experimental data files. This paper summarizes research reported in greater detail in Park, Mitchell, Alleman and Wetzel (1979) and was supported by National Science Foundation grant No. DAR77-16286 to The Rand Corporation.

[1] For previous attempts to answer questions like these, see Alleman (1977), Kraepelien (1976), Mitchell (1978), and Pavarini (1979).

[2] The experimental tariff is not a cost-based tariff. Information on the appropriate marginal costs of telephone use were not available when the tariff was designed.

[3] For a more extensive description of the GTE experiment and its background, see G. Cohen (1977).

[4] Demographic variables tried and rejected were: education, length of residence, and number of automobiles owned.

[5] These weights (square root of the ratio) are applied to the raw data for each observation. Multiplying to construct the moment matrix results in each observation contributing to the moment matrix in proportion to the ratio itself.

[6] See Jöreskog and Sörbom (1978).

[7] See Jöreskog (1979).

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