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ABSTRACT

The Pacific Educational Computer Network Feasibility Study examined technical and non-technical aspects of the formation of an international Pacific Area computer network for higher education. The technical study covered the assessment of the feasibility of a packet-switched satellite and radio ground distribution network for data transmission between computers and terminals in widely dispersed areas. The theory that a satellite operating on a broadcast mode could reasonably service a variety of institutions in the Pacific led to experimental data transmission and exchanges of working papers on hardware development and protocols between universities in Hawaii, Alaska, Japan, New Zealand and Korea. Non-technical efforts were concentrated in determining the level of interest in undertaking network development, the kinds of equipment existing in Pacific Rim institutions, possible uses of the computer network, and an investigation into the organizational, political, and financial aspects of the formation of such a network. (Author)

PACIFIC EDUCATIONAL COMPUTER NETWORK STUDY

A FINAL REPORT FOR
NATIONAL SCIENCE FOUNDATION GRANT NO. NSF-GJ33220

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1. STUDY OBJECTIVES

The Pacific Educational Computer Network Study originally proposed tc do the following:

1. Investigate how satellite communication technology can be used to support new forms of information processing in the field of education; and
2. Investigate international implications of international educational networking with Japan in a correlative study funded by the Japan Society for the Promotion of Science.

The study progressed along two different paths, one concentrating on technical network alternatives and the other on the non-technical factors of network development. The former included theoretical treatment on the design of a packet-switched network for satellites and associated ground distribution system. The latter included a preliminary investigation of non-technical issues involved in international network development, a study of interest of educational institutions in the Pacific Rim, the informal organization of working and interest groups for international educational network development, and an investigation of alternatives for organizing the participants of such a network.

2. SUMMARY OF ACCOMPLISHMENTS

The accomplishments of the Pacific Educational Computer Network Feasibility study can be divided into two parts: technical progress and non-technical progress.

Early in the investigation, it was apparent that similar network developments in the United States were capable of producing efficient technical networks but were having some difficulty in providing non-hardware services to their clientele. Hence, it was decided that for a development the size of the Pacific Educational Computer Network concept, a non-hardware component concentrating on the political, social, and economic issues with respect to networks was also necessary to determine the feasibility of the total network.

Technical Accomplishments. In conjunction with other grants supporting satellite data transmission research at the University of Hawaii, theoretical work on the organization of the channel and packet transmission modes has been taking place. There are two relevant aspects to the technology component, given the limitation of currently available equipment. These are: (1) the organization and methods of satellite communication and (2) the organization and technology of ground station distribution and communication networks. Advances in research and the use of small ground stations may make the second component unnecessary in the future.

With respect to packet communications, the method used by the ARPANET, we have completed work in a related project on the theoretical optimization of a channel, an aspect which is totally relevant to the Pacific Network situation. With the existence of circumstances that would allow the implementation of these ideas, these research results could be adapted to serve as the

major communications mechanism of the Pacific Network. The primary features of this satellite based system are (1) complete broadcast mode with the possibility of a voice channel operating piggy-back with the data communications channel, (2) the channel organization, termed 'slotted ALOHA', implies a random access entry into the communications channel but the entry will have to be into a specific slot in the stream rather than directly into the stream at any point (this method is described in references [2] and [19]).

With respect to ground communications, the description of the experimental ALOHA System utilizing radio channels on the campus of the University of Hawaii was given wide coverage in EDUCOM [1], the bulletin of the Inter-University Council on Communications. This article was prepared to illustrate the terminal equipment and ground station requirements for a larger scale network such as the Pacific Educational Network. It also emphasizes the declining costs for such terminal equipment. Consideration of constructing cheap ground stations for the satellite links has also been started on an informal basis.

The work on the technical aspects of a satellite network have been based on adaptation of previous research, and among the informal Pacific Network Working Group, there has been considerable technical discussion and modest experimentation on the means by which actual connections are made and by which the data is transmitted. Earliest experimentation took place on the ATS-1 between Ames, Alaska, and Hawaii. From this and from the basic ALOHA packet and transmission unit designs, technical consultation has been provided to Australia, New Zealand, Japan, and Taiwan in the construction of transceiving equipment. Satellite connections are not available for widespread international communications testing so the equipment constructed at these universities

will be used for local network communications with the later possibility of establishing satellite links.

Australia and New Zealand have discussed bilateral agreements which will enable their terminal control units to act as network connectors. The University of Sydney and the University of Victoria at Wellington in conjunction with Wellington Polytechnic are looking forward to participating in satellite link experiments with the University of Hawaii.

New Zealand already has a PEACESAT terminal and has hopes of integrating their PEACESAT and Pacific Network usage. PEACESAT is a voice and facsimile network also based at the University of Hawaii using ATS-1 as the telecommunications device.

Experimentation with Japan has been underway for more than a year now. The connection from the University of Hawaii to Tohoku University in Sendai, Japan, is made through the ATS-1 satellite. The Japanese telecommunications authority, however, requires that the return communication take place on other transmission media and therefore the link from Japan to Hawaii is taking place via TELEX [15]. This experiment, though cumbersome in technique, proves that the basic data communications can take place via satellite over a wide geographic area. The cost of the transmission to Japan is negligible but the cost of the return TELEX-transmission is prohibitive for extensive experimentation.

Even though the actual transmission testing was limited, there was substantial technological interchange. The directors of the NSF-sponsored project and the JSPS-sponsored project visited each other periodically. Japan

sent a graduate student to the University of Hawaii to work with The ALOHA System on minicomputer multiplexor development and he has since returned to Japan to implement their version of the equipment. Other Japanese students under similar agreements are expected.

Japan is possibly more advanced in the development of a national computer network for higher education because of the positive influence of the government in its development. Major regional computer centers already exist and the plans are to connect all these centers in the mid-1970's.

Taiwan had a former University of Hawaii student working at its National Telecommunications Laboratory and the technical administrators there became very interested in the land-based ALOHA technology. Our project director was invited to speak to them and arrangements were then made to adapt The ALOHA System technology to an experimental network with the hopes of expanding it later. The specific problem faced in Taiwan is not a lack of computers but the severe under-utilization of these computers. If the need could be easily consolidated or if the access to the computers could be distributed, the equipment would be more economically utilized. The ALOHA System technology was considered to be an excellent device to do this, but for several reasons the implementation was not without problems. For example, the mountains in the geographic test area prevented line-of-sight connection and deflecting devices had to be constructed. The experience provided more information on ground system performance, since The ALOHA System was concurrently experimenting with repeaters to transmit the signals over the mountain ranges in Hawaii.

For experimental purposes, TELEX connections were provided to the Korean Institute for Science and Technology and the Institut Teknologi Bandung in Indonesia for experimentation in overseas connections and for familiarizing themselves with U.S.-developed time-sharing software. They are linked through The ALOHA System to the University of Hawaii Computing Center where they can access the timesharing facilities.

We have initiated a series of working group notes prepared by an ALOHA System engineer to inform the participants who are seriously planning or constructing hardware interfaces of latest technical developments.

Non-Technical Accomplishments. The tasks in developing the non-technical component of the system began with the attempt to describe the concept and possibilities of the proposed Pacific Educational Computer Network. A paper on preliminary considerations was developed to elicit response from interested parties. There were essentially two types of interest that were attracted: (1) those who saw satellite experimentation as a desirable experience for their research and academic programs; and (2) those who saw the satellite network as a means by which they could tap computational resources that they themselves could not afford.

A planning meeting was held in January 1973, to discuss the concept with input from several international sources, including the United Nations, Australia, Japan, Thailand, and an international computer consultant from UNESCO. The response was enthusiastic but everyone realized that the matters of funding and political maneuvering would be a key to the continuation of the network. At this meeting, preliminary data on an interest survey distributed to 60 institutions in the Pacific Basin was presented and the early results were encouraging.

During the next year, research took place on organizational and functional aspects of a computer network. A study was conducted on existing networks and their experiences in the United States and from this, the major benefits and possible organizational schemes for a Pacific Educational Computer Network were derived.

It was found that, of the various educational networks in existence in the United States, the most successful were those which stressed a user services motive; the technology required to implement a network is generally assumed at this time. In addition to the general use of networks for class computing and research, applications which seem to be complementary in the environment of higher education were computer-aided instruction (CAI), and library search services. Both CAI and library applications have the potential to be extremely cost effective by using networks as a coordinating and distribution device.

Alternative means for the organizational development of the network and for feasibility and start-up funding were discussed. The politics and economics of these alternatives were also recognized but extensive study on these aspects were deferred until the third year.

The Seventh Annual Hawaii International Conference on the Systems Sciences focused on Computer Networks. Supplemental grants from the National Science Foundation supported travel expenses for several prominent and interested network people to Hawaii to discuss the implications of the Pacific Network. Presentations by Dr. Martin Greenberger, who has been active in national educational networking in the United States; Dr. Juro Oizumi and Dr. Hiroshi Inose, who are connected with the development of the Japanese Educational Computer Network; Dr. John Bennett, who reported on computing in the South Pacific; and Dr. Harry Huskey, who has served as a UNESCO

consultant to Southeast Asian countries, were funded under these arrangements. A working group of participants or interested parties was brought together by conference attendees to a series of subconference meetings to discuss possibilities and implications of Pacific Network development. Dr. Robert Kahn of ARPA and Dr. Jai Singh, who recently completed a series of educational satellite studies at Washington University, attended and were valuable resource persons.

At this conference, the desirability of the ARPANET as an accessible set of computing resources for the Pacific Educational Computer Network was discussed but the complication involved in international telecommunication agreements appear to be overwhelming without a better administrative and policy-making mechanism. It was evident that the international environment for non-commercial telecommunications policy is unstructured and there is no indication of a quick solution to the problem.

As a result of this conference, an informal working group of those persons interested in hardware participation was formed. Also, a mechanism for information distribution on a semi-formal basis was established with the University of Hawaii being the central point of dissemination.

Since the conference, we have worked on various aspects of data collection on different international systems as well as beginning some micro- and macro-economic studies on educational network behavior.

3. Summary

The Pacific Educational Computer Network Study has progressed to the point where the basic technical methodology and goals and organizational structures have been described. It remains for more interaction to take place between the interested parties to decide on a specific course of action and to begin a series of economic studies which show whether such a network can be developed and maintained with some degree of financial viability.

There has not been a study addressed to the development of a financially viable network from an economic and non-commercial business viewpoint. There has been work on various micro-economic aspects of educational networks but none which addresses the problem of whether, within the total network, there is sufficient supply to the demand or sufficient demand to keep the network viable. Nothing guarantees that an equilibrium condition of supply and demand can be met.

Nationwide experience in non-commercial networking so far has been limited to a subsidized network which does not yield valid supply and demand data. Neither the artificial economic context of subsidized nets nor the experience of commercial nets is particularly apropos for the development of a self-sustaining national science or higher education network. Even though the benefits are obvious, the cost component will be the deciding factor.

If this study is continued, substantial effort will be dedicated toward preparing the economic feasibility studies, and self-subsistence plans for large scale non-commercial networks. The ultimate objective would be to provide a cost/benefit analysis of large scale non-commercial networks, given

a variety of financial and political constraints. The major mechanism for studying these factors would be a simulation model which would incorporate both the policy and available statistical information. Study on this has already been started as part of the graduate studies of Ph.D. level economics students currently working on this and related projects.

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