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ABSTRACT

Seven papers from the 1987 CAUSE conference's Track V, Communications, are presented. They include: "University of Miami LAN: A Case Study" (Ruben Lopez and M. Lewis Temares); "Designing and Implementing an Integrated Communications Environment in a Small College" (Charles S. Garratt IV, Jack M. Lewis, and John L. Van Hemert); "Commonwealth of Massachusetts Higher Education Communication Network: A Case Study" (Ann von der Lippe and Buddy L. Bruner); "A Software-Defined Integrated T1 Digital Network for Voice, Data, and Video" (James R. Hill); "Campus Connectivity with the Data/Voice PBX" (David P. Redlawsk); "A Simple Strategic Plan for Providing Distributed Computing Resources Together with a Tactical Plan for Implementation" (Daniel V. Goulet and Bruce Staal); "Strategies for Financing the University Communications Utility" (Erv Blythe and Judy Lilly). (LB)

Leveraging Information Technology

Proceedings of the 1987 CAUSE National Conference

TRACK V: Communications

December 1-4, 1987
Innisbrook Resort
Tarpon Springs, Florida

CAUSE, the Professional Association for Computing and Information Technology in Higher Education, helps colleges and universities strengthen and improve their computing, communications, and information services, both academic and administrative. The association also helps individual members develop as professionals in the field of higher education computing and information technology.

Formerly known as the College and University Systems Exchange, CAUSE was organized as a volunteer association in 1962 and incorporated in 1971 with twenty-five charter member institutions. In the same year the CAUSE National Office opened in Boulder, Colorado, with a professional staff to serve the membership. Today the association serves almost 2,000 individuals from 730 campuses representing nearly 500 colleges and universities, and 31 sustaining member companies.

CAUSE provides member institutions with many services to increase the effectiveness of their computing environments, including: the Administrative Systems Query (ASQ) Service, which provides to members information about typical computing practices among peer institutions from a data base of member institution profiles; the CAUSE Exchange Library, a clearinghouse for documents and systems descriptions made available by members through CAUSE; association publications, including a bi-monthly newsletter, *CAUSE Information*, the professional magazine, *CAUSE/EFFECT*, and monographs and professional papers; workshops and seminars; and the CAUSE National Conference.

We encourage you to use CAUSE to support your own efforts to strengthen your institution's management and educational capabilities through the effective use of computing and information technology.

INTRODUCTION

As professionals in an always-exciting field, we are constantly facing challenges to blend new information technologies into our institutions. It is important for higher education to develop environments that promote the use of information technology for strategic advantages, that allow faculty, staff, and students to benefit from existing technology, and that stimulate the discovery of new opportunities.

The 1987 CAUSE National Conference, with its theme "Leveraging Information Technology," offered the opportunity for us to share, exchange, and learn of new developments in information technology to improve and enhance our environments. The CAUSE87 program was designed to allow the fullest possible discussion of issues related to these new developments. Seven concurrent tracks with 49 selected presentations covered important issues in general areas of policy and planning, management, organization, and support services, as well as in the specialized areas of communications, hardware/software strategies, and outstanding applications.

To expand opportunities for informal interaction, some changes were made in the program schedule. CAUSE Constituent Groups met the day before the conference, as they did in 1986, but were given opportunities to meet again during the conference. Current Issues Sessions were moved to Thursday afternoon to provide some flexibility with time, encourage interactive participation, and extend opportunities to continue discussions with colleagues. Vendor workshops were offered for the first time this year, the day before the conference. The Wednesday afternoon schedule accommodated continued vendor workshops, vendor suite exhibits, and concurrent vendor sessions.

David P. Roselle, President of the University of Kentucky, set the tone for CAUSE87 with a Wednesday morning opening presentation expressing his commitment to the value of information technology in higher education. John G. Kemeny, past president of Dartmouth College and currently Chairman of the Board of True BASIC, Inc., spoke during Thursday's luncheon of new developments in computing for classroom learning. The concluding general session, Friday's Current Issues Forum, offered an exchange of philosophies about making optimal use of technologies on our campuses.

We were extremely fortunate to be at Innisbrook, a resort with outstanding conference facilities and great natural beauty (and weather)—a real distillation of the best of Florida.

Almost 800 people attended CAUSE87. Many of them described the conference, in their evaluation forms, as stimulating, informative, and memorable. We hope this publication of the substance of CAUSE87 will be a continuing resource, both for conference-goers and for those who will be reading about the conference offerings for the first time.

Wayne Donald
CAUSE87 Chair

Leveraging Information Technology

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Track V
Communications

Coordinator:
Stephen Patrick
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Communications is the backbone for the integration of technologies on our campuses. Administrators must consider strategies for total electronic integration, networks, and phone systems, with consideration of costs, implementation, and the impacts on campus communication. The papers in this track cover major areas of interest, including voice, data, and video communications.

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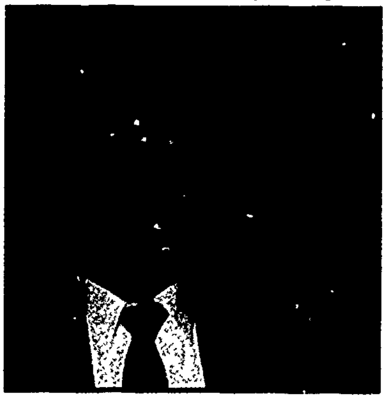
New River Community College



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UNIVERSITY OF Miami

A GLOBAL UNIVERSITY

UNIVERSITY OF MIAMI LAN: A CASE STUDY

Ruben Lopez and M. Lewis Temares

UNIVERSITY OF MIAMI LAN: A CASE STUDY

INTRODUCTION

The University of Miami's three (3) major campuses have installed digital telephone switching systems, as follows:

Campus	Location	PBX
Main Campus	Coral Gables	AT&T System 85
Medical Campus	Miami	AT&T System 85
Rosenstiel School of Marine & Atmospheric Sciences (RSMAS)	Virginia Key	ROLM CBX

The three switches were purchased in 1983 and installed in the last quarter of 1984. As part of the cabling task required for the Systems 85,the University had a spare 4-inch conduit installed at the Coral Gables and Medical campuses for future use. The conduit connects the major campus buildings. The University procured and installed a Local Area Network in this conduit and it serves as an inter-building "backbone" network carrying data communications, video and voice signals throughout the Coral Gables campus. The network is not intended for intra-building communications. It is the responsibility of the individual departments occupying each building to select and secure, with central facility staff aid and advice, the intra-building network.

Analyzing the current and anticipated requirements for a LAN on a university campus should include the following considerations:

- A survey of existing computers, data terminals, PBXs, Satellite Earth Stations and High Speed Links (T-1 carrier)
- An estimation of current data communications usage levels, and the future needs, derived from user interviews.
- An analysis of video and voice communications needs.
- An analysis of possible interconnection traffic between the LAN, PBXs and T1 carriers.
- An analysis of LAN alternatives and options.
- Recommendations for LAN requirements.

At the University of Miami we began by examining the organization, existing computer and terminal facilities, data communications traffic and the local area network alternatives in order to arrive at a set of recommendations for implementation. This paper describes this methodology.

Organization

Until November 1986 The Telecommunications Department reported to the Associate Vice President for Business Affairs while computing reported to the Associate Vice President for Information Systems. Today, both departments report to the Associate Vice President for Information Resources. The integration brought about a reorganization of computing and telecommunications by functions. Telecommunications was reorganized into a similar format as Infomation Systems with its selected functions and responsibilities assigned to three directors as follows:

- Information Networks Development
- Telecommunication Operations
- Accounting and Administrative services

The networks development unit is responsible for the development of new telecommunications revenue services for the University. This includes research, analysis, RFP preparations/evaluations and project management throughout the implementation of the new services.

The telecommunications operations unit is fully responsible for the daily critical activities of the Telecommunications unit including voice, data and customer services. There are four voice technicians servicing three (3) PBXs, and approximately 8,850 telephones. In addition, three (3) data technicians support the LAN cable plant, data terminals equipment (ASYNC and SYNC networks), data switching devices, and cable installations. Also, they are responsible for all the network interface units (NIU) installed on the LAN.

The billing and budget controls unit has five (5) people supporting functions such as sub-contractors, carriers, purchasing, internal and external billing problems and budget preparation and control.

The organization model used is a replicate of the structure the University of Miami followed in implementing its Long Range Information Systems Plan (LRISP).

EXISTING COMPUTER AND TERMINAL FACILITIES

As an indication of the present and future extent of data communications on all four (4) campuses, it is useful to review the existing computer and terminal facilities, and the growth projections for the future. With LRISP entering its fourth year, plans for the increase in on-line applications, which will have a direct impact on the volume of communications, must be carefully monitored and projected.

The University's computer center is located on the Coral Gables campus. At present, the major computers used at this location are:

- An IBM 3081-KX, a Univac 1100/82, and a cluster of DECs 8650 and 8530 are the three large mainframe computers, with the VAX cluster primarily used for academic/research computing, and the IBM 3081 and Univac sharing administrative and academic functions. An additional MICROVAX II is dedicated to instructional applications.

- An estimated 125 terminals, work-stations and/or personal computers are now located in the computer center building. The administrative network (SNA) has 1224 workstations and/or personal computers throughout all four (4) campuses and approximatelly 785 workstations and/or personal computers on the Asynchronous network.

There are several distributed departmental host computers networked in four (4) campuses attending specialized applications.

At present, most of the administrative computing applications operate in the on-line mode, while academic applications tend to be more on demand and batch oriented. The University's information system plans project a trend toward more on-line applications in both areas.

The development of on-line administrative applications software, in accordance with the Long Range Information Systems Plan (LRISP), planned procurement of additional DEC and IBM computational power and installation of more scientific and social sciences software, will greatly increase the data communications traffic flow to and from the Computer Center.

The Ungermann-Bass coaxial cable backbone network is viewed as the major vehicle for data communications to and from the Computer Center. With its installation, "private" hard-wire and/or Southern Bell leased data circuits were phased out, together with dedicated computer ports. With the LAN, communications data rates of 9,600 bps or higher are expected to become the standard, although existing lower speed asynchronous dial-up rotary service will be available.

With the LAN available, the data communications capability of the System 85 can be used for remote campus locations not connected to the

LAN because of cost and physical constraints. For occasional dial-up users whose level of use does not justify LAN connection, and for off-campus data communications to national networks or data bases, the System 85 is utilized through a T-1 carrier accessing our Satellite Earth Station at Virginia Key which is linked to the National Science Foundation "super-computers" network.

DATA COMMUNICATIONS TRAFFIC

Current Status

There are approximately 1,000 computer/terminal devices on the Coral Gables campus at present. If all of these devices were to communicate simultaneously over the same LAN (admittedly a worst-case scenario), the LAN "throughput" requirements would be as follows:

Average Data Rate per Terminal (1000 Terminals)	LAN Throughput
1,200 BPS	1,200,000 BPS
2,400 BPS	2,400,000 BPS
4,800 BPS	4,800,000 BPS
9,600 BPS	9,600,000 BPS
19,200 BPS	19,200,000 BPS

All of these, taken together, may reduce the LAN throughput requirements by an order of magnitude. Nevertheless, the worst-case calculations are useful in establishing upper ceilings for data communications.

Any estimate of future data communications traffic on the backbone LAN must necessarily be considered as valid only to an order of magnitude, since the traffic will be affected by a number of factors, many of which remain yet to be defined.

Among these are:

- The actual (rather than projected) growth of terminals and PC's on the campus.
- The rate of completion of on-line Computer Center applications programs.
- The upgrading of Computer Center facilities.
- The installation of departmental LAN's to localize some data traffic.
- Implementation of the Residential colleges and residence halls wiring plan to the "backbone".

Because of these uncertainties, and the rapid growth of dataprocessing facilities mentioned above, it is prudent to use estimates on the high side rather than the low side.

Topology and Data Rate

The LAN uses two (2) distint topologies a Star and Bus configurations with the Computer Center as the central node.

Assuming that one-third of the aforementioned devices (1000 terminals) might be communicating to the Computer Center at the same time on a single spoke of the LAN star, and also assuming that the average data communications rate is the 9,600 BPS that the Computer Center would like as a standard, the total data rate on that spoke would be:

$$330 \times 9{,}600 = 3{,}168{,}000 \text{ BPS}$$

With this assumption, a 3.2 MBPS throughput rate would be needed on that data path. More terminals or a higher average data rate per device would require a proportionately greater throughput rate.

The data rate per star path could be reduced by making more nodes and paths available, with a smaller number of devices connected to each node. This, however, requires more concentrators and node interface equipment, and therefore increases the cost of both hardware and cable.

LOCAL AREA NETWORK ALTERNATIVES

In order to specify a LAN which best meets the University's present and future data needs, an understanding of the alternatives is required.

There are a number of basic parameters which define a LAN, including the following:

- Physical Configuration or "Topology"
  - -Bus
  - -Ring
  - -Star
- Transmission Medium
  - -Twisted-pair
  - -Coaxial Cable
  - -Fiber Optics
- Transmission Mode
  - -Baseband
  - -Broadband
- Network Access/Control Method
  - -Collision Avoidance
  - -Token-Passing

In addition to such fundamental characteristics, a number of secondary LAN features also are very important, including:

- "Throughput rate," or how much information can pass through the network in a given time.

- Reliability, both of the medium itself and all of the necessary interface and ancillary devices.
- Flexibility and Modularity, or the capability to adapt both to future growth and changes in traffic requirements, without costly modifications.
- Cost, both initially and over the anticipated life cycle of the network.
- Comparability, with non-data communications requirements, such as video and voice traffic.
- Network Management capability, or the availability of equipment and procedures that facilitate the maintenance of the LAN.

At the lowest level, the University's backbone LAN can be viewed as just a passive distribution medium. No formatting, packeting or conversion of data would be supplied as part of the network. At the other extreme, the backbone LAN would be a complete networking system, providing, in addition to distribution paths, such functions as:

- Interface capability for all computer and terminal devices.

- Concentration and/or multiplexing of groups of devices at network nodes.

- Formatting and packeting of data at nodes.

- Establishing network access procedures, and controlling traffic flow, particularly for high-volume transactions such as file transfer.

- Converting protocols, both internally on the LAN and for interconnection to other LAN's or gateways to national and international networks.

The University preferred the maximum in LAN capability,i.e., the highest-level extreme. Practically, the cost of complete "universality," generally will dictate some reduction from the maximum. For example, the interface capability for all computer and terminal devices and the degree of protocol conversion may be limited to support of some finite number of types, rather than all.

A brief summary of the foregoing alternatives can be stated as follows:

- For the University's existing computer structure, a star topology with the Computer Center as the central node appears desirable. Emerging trends, however, such as the rapid growth of PC's on the campus, might indicate a need for a supplemental LAN with a ring or bus topology.

- The projected volume of data communications appears to indicate a need for more throughput capacity than can be provided by a single baseband LAN. A broadband LAN, or both a baseband and broadband, might be the solution.

- A broadband LAN could also accommodate video communications, including commercial CATV services and academic video programming. Alternatively, a separate coaxial cable for video could be installed along with a data LAN.

- A broadband LAN can provide lower data error rates than a baseband.

- If a broadband LAN is desired, fiber optics are not competitive at this time. For a baseband LAN, fiber optics and coaxial cable each have specific advantages and disadvantages.

- The cost of a broadband LAN is higher than a baseband type for the same number of nodes and terminal connections, because of the need for radio frequency (RF) data modems to place data signals on individually dedicated carrier frequencies.

- The cost of optional LAN features may dictate the establishment of several levels of requirements for the selection of a vendor, so that a cost-versus-capability tradeoff can be made.

RECOMMENDATIONS

The University's Committee overseeing the backbone LAN procurement made the following recommendations:

(1) The alternatives should be limited to a broadband LAN providing capacity for both video and data communications, or;
(2) A baseband LAN for the primary data mode, combined with a broadband secondary network for video communications, overflow and/or future data traffic.

If option one (1) above were selected, then coaxial cable should be the transmission medium. If option (2) were selected, vendors should be permitted to propose either fiber optics or coaxial cable as the medium for the baseband LAN, and coaxial cable for the secondary network.

Whichever option was selected, terminations should be made at each University building passed by the conduit permiting transmission and reception of both data and video. This implies bidirectional capability for both communication modes.

IMPLEMENTATION

A request for proposal was issued to different vendors for a Local Area Network to be installed in the empty conduit, and to serve as a "backbone" network for three types of communications:

- Data Communications between buildings.
- Video Communications between buildings.
- CATV service to the Residence Halls, and designated other locations.

After an evaluation was performed with the aid of an outside consultant, the vendor selected was Ungermann-Bass Inc..

- They proposed two separate networks:
  (1) Data/Video Networks--- Coaxial cable, broadband, with five two-way channels assigned for data communications. This same cable will provide 20 bidirectional video channels for instructional and academic purposes. Ungermann-Bass installed all amplifiers, power supplies, cable, passive devices, status monitoring equipment and headend equipment to provide a fully operational network connection for both data and video communications. It will connect to a designated location no more than 50 feet from each building.

  (2) CATV Network--- Coaxial cable, designated to provide up to 54 channels of CATV service and FM to all Residence Halls and other designated locations.

Problems encountered at installation included:

(1) Initial design and installation schedule was not correct and additional nodes and amplifiers were required.

(2) It was desirable to remove the CATV network from the negotiations with Ungermann-Bass and award it to Dynamic Cablevision to provide CATV service to the campus, without cost to the University.

HIGH SPEED LINK TO MULTI-CAMPUSES

The RSMAS campus has been linked, via a satellite transmit/receive earth station, to a National Science Foundation network. Researchers on the Coral Gables and Medical campuses were interested in also obtaining access to the NSF network. Thus, we purchased T-1 links to both Medical and RSMAS campuses. These links will be utilized for at least three (3) purposes:

- To permit users on the Coral Gables and Medical Campuses to share access to the NSF network link at RSMAS.
- To interconnect the Medical and RSMAS campuses to the major data processing facilities at the Coral Gables campus, for administrative on-line applications and other data communications.
- To reduce the cost of tie-lines and data circuits presently leased from the telephone company, and possibly also to consolidate some Direct Inward Dialing/Direct Outward Dialing trunk groups now being used for each campus PBX.

The original request for proposal included the T-1 link only. The terminal equipment combining the various signals at each campus into the T-1 data stream was to be procured separately. One of the options contemplated by management was a microwave link between the Coral Gables campus and RSMAS, and between the Coral Gables campus and Medical campus as one of the most effective transmission medium. Therefore, the requirements and performance of the request had a few restrictions allowing the vendors to propose other approaches.

The evaluation criteria took into consideration the following items:

- Experience: technical and financial capability of the vendor and major subcontractor.
- Cost, including:
  - initial installation cost
  - estimated lifed-cycle cost
  - cost of spare parts and maintenance
  - estimated additional costs to the University
  - estimated cost of future expansion
  - installation schedule

In order to properly ascertain the best alternative, we took into account planned growth at all campuses and using economic judgment as to which represents the lower cost, while providing full functionality to the University. In addition we took the fast evolution of technology into consideration such as ISDN.

LESSON LEARNED

The integration of voice and data has been confusing, frustrating, difficult to manage, but critical to our future. The diversified backgrounds among technical disciplines required budgetary salary adjustments, new job descriptions and organizational structures changes. The most interesting area is in the development of a common management approach to all of these vital assets. The greatest achievements will be in those institutions which use common systems management techniques across both data and voice networks.

The major management lessons we learned were:

1. Its harder to run a Telecommunications department than you think.
2. Skilled personnel understanding voice and data are virtually non-existent at any cost.
3. Telecommunications organization in universities are generally "order takers" and "service facilitators, not technologically knowledgable.
4. Telecommunications management is in its infancy, comparable to computer centers of the 1960's.
5. Rapid changes in technology demand as flexible a structure as information systems.

Neither business nor our institutions could get along without the collection and distribution of information through electronic networks. Our students and business executives call themselves "computer involved". This new wave must also be knowledgeable about telecommunications and become "communications involved".

DESIGNING AND IMPLEMENTING AN INTEGRATED COMMUNICATIONS ENVIRONMENT IN A SMALL COLLEGE

Charles S. Garratt, IV
Jack M. Lewis
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New River Community College
Dublin, Virginia

New River Community College has installed an integrated, state-of-the-art communications system which links voice, local area networks, asynchronous data, and synchronous data into a single campus-wide communications network. Access is provided in each office via standard phone jacks through a common cable system to voice phones, multiple local area networks, and multiple paths to an off-campus mainframe network. Topics discussed include planning strategies, dealing with state purchasing offices and vendors, supervising installation, cost analysis, system management, benefits and potentials of an integrated system, and applications for an improved data environment.

Designing and Implementing An Integrated Communications Environment In A Small College

New River Community College, a two-year college located in the beautiful mountains of Southwest Virginia, is part of the Virginia Community College System. With an enrollment of approximately 1800 FTE, it ranks among the larger of the small colleges in the system. The college is located within 25 miles of two major state universities: Radford University and Virginia Polytechnic Institute and State University.

Even though New River is among the state's smaller community colleges, it has a reputation as a leader in both educational and administrative use of technology. New River's programs in Process Instrumentation and Electronics Technology have an international reputation for excellence. In addition, a number of important management information systems developed at New River are now in use across the entire 23-college system. These include the Productivity Analysis System (PAS), the Generalized Accounting Reporting System (GARS), and major contributions to the on-line Student Information System (SIS).

Almost two years ago, New River began construction of a new building on campus. This construction necessitated a plan for providing telephone and data communications services to the new building. Rather than view this planning in its narrowest perspective of only providing service to the new building, the Dean of Management Services directed his staff to explore the state-of-the-art technology, the trends, and their cost, with the idea of providing a new communications environment for the entire college. The potential benefits to the college from this approach became evident early in the study. Throughout the process of study, design, acquisition, installation, and the use of the system, the benefits and potential have continued to grow.

The integrated communications environment provides the college a state-of-the-art system with the flexibility to provide to each user in the college the level of communication services required, whether this be a simple voice-only telephone, a personal computer tied into the local area network, access to the state mainframe network, or all of these services integrated into a single workstation. Indeed, this "workstation" concept has been the planning focal point for the system design. Using this concept, each individual at the college, whether student, faculty, staff, or administrator, is provided the level of service required by simply plugging the necessary equipment into standard phone jacks located throughout the college.

Understandably, New River is far from 100 percent implementation of this system, but the communications backbone is in place. Expanding to 100 percent implementation will require only the purchase of the equipment for each workstation, resulting in relatively low workstation-by-workstation expenditures since the big expense of the communication backbone has already been made.

One of the key elements of the college's integrated communications environment is the Local Area Network (LAN). Prior to the implementation of the new system, New River had two computing environments. As part of the state community college system, New River has terminals and printers tied into the state IBM mainframe network consisting of nine IBM mainframe computers located in five centers throughout the state. For data and/or processing intensive applications, such as the Student Information System, the college uses leased telephone lines to access this network. In addition to the mainframe network, many college offices and student labs have been equipped with personal computers (PCs). These PCs are used extensively for word processing, electronic spreadsheets, and locally developed data base applications. However, the college had a number of applications where data bases needed to be shared or where expensive resources were needed but could not be justified for a single user. These applications which are not cost effective on the mainframe are appropriate for a PC, particularly when resources can be shared. A LAN provides the interconnection vehicle for capturing the full power of the PCs on campus. Applications requiring shared data or shared resources are implemented over the LAN.

The design of an integrated communications network requires the careful selection of every aspect of the actual hardware to be installed. (See Figure 1 at the end of this report for an overall design of the system.) In wiring alone, one must decide on the type and number of jacks, whether to use twisted pair, coax, fiber, or a combination. New River chose to replace its entire cable plant, which had consisted of a mix of coax and old telephone wire. Each current or planned location with a phone or data connection was provided with dual eight-pin modular phone-style jacks. These jacks were connected to intermediate distribution frames with two unshielded, twisted-pair cables, each containing four pairs. For voice communications, the buildings were interconnected with 200- and 400-pair copper cable. Some of the inter-building data also use the copper twisted pair cable. For LAN and asynchronous data between buildings, multi-strand fiber-optic cable was installed.

The LAN chosen was AT&T StarLan, a one-megabit-per-second LAN capable of transmitting relatively long distances over standard twisted pair cable. At present, the AT&T StarLan software is used on the network, but the StarLan hardware will support a number of LAN operating systems, and an academic computer lab will be networked soon using the NOVELL operating system on the StarLan hardware. While the data transmission rate of the LAN is important, New River's research and experience have shown that the speed of the workstation and servers affects performance more than the LAN speed above one megabit per second. Along with speed, reliability is a critical factor in deciding which LAN to install. Most LAN vendors now advertise that their LANs work on standard twisted pair, some at up to ten megabits per second. However, the college's research indicated that only StarLan could reliably work over distances of around 800 feet without shielded twisted pair, and/or placing repeaters or extension units throughout every building on campus. With StarLan, New River has reliable LAN access from anywhere on campus, with all LAN connections in a building coming back to a single location within that building.

At New River, all voice communications are provided with a mix of digital and standard analog touch-tone phones connected to an AT&T System 75 on-premise PBX (Private Business Exchange). This all-electronic switch is typical of modern PBXs and allows the college to expand from its current 225 phones to 800 phones. With the System 75, college personnel are able to do all moves of phone equipment and to make changes of access and features. The "75" provides "call detail reporting" of all incoming and outgoing calls and logs them on a college microcomputer for use in traffic, service, and cost analyses.

The LAN and asynchronous data are connected to an AT&T Information Systems Network (ISN) packet controller for inter-building communications. While the System 75 has some data switching capability, the ISN allows the expansion of the StarLan network to thousands of PCs at any location on campus while maintaining a single logical network. The ISN also provides connection to an AT&T protocol converter from any building so that asynchronous terminals and PCs can access the state-wide mainframe network.

Besides the protocol converter, the college has other terminal and printer links to the state mainframe network. The two existing 3274-type control units have been converted to use twisted pair instead of coax by the use of coax-to-twisted-pair adapters. Now IBM 3278-type terminals can be moved as easily as telephones by plugging them into the same jacks as all other devices instead of running new coax.

Additionally, the college has installed a gateway on the LAN, which allows any computer on the LAN to access the mainframe network and emulate a 3278-type terminal. This through-the-LAN access replaces the dedicated terminal emulator board placed in the computer and gives the added advantage of having one machine which can be used as a stand-alone PC, as part of the local area network, and for access to the mainframe network. Since a telephone can also be plugged into the LAN board in the computer, it is possible to place all communications and computing services on a person's desk in one machine.

New River's solution is, at present, primarily a one vendor solution. This is partly by design and partly a function of the state purchasing procedures. After the planning was completed, a Request for Proposal (RFP) was prepared by the college. This RFP focused on the environment and function desired rather than on particular equipment. With the technology advancing so rapidly, the objective was to deliver an RFP delineating college requirements, while allowing the vendors the flexibility to propose their state-of-the-art solution. Since the desire was for an integrated solution which allowed for long-term growth, the decision was made to require vendors to propose solutions in which the vendor would provide, and commit to support, all equipment. By requiring the vendor to support all of the equipment, problems of blame shifting as any malfunctions arose were eliminated.

The college protected itself from being tied to one vendor completely in the future and from having an orphan system by following established standards (i.e., IEEE, NETBIOS, etc.). Therefore, the college effectively has a solution which can be multi-vendor in the future, but which will have a single vendor responsible for assuring the installation and operation of the core of the system.

Cost factors were an important consideration in the design of the integrated communication system. As Figure 2 shows (see end of this report), New River discovered that this integrated solution could actually be less expensive over a five-year period than continuing with the "traditional" disjointed, unintegrated approach. By assuming the responsibility for managing its own voice and data communications, the college was able to recover the cost of the system in fewer than five years. Actually the payback period is even less than shown because the comparisons in Figure 2 are for a voice-only solution (Centrex, the now predominant solution in the state). Had this solution been chosen, the college would have had the additional expense of providing data service to the new building and finding solutions to many applications which would make use of a LAN. Furthermore, there would have been the additional expense of providing improved access to the mainframe network.

New River was able to consider a state-of-the-art communication system because of a strategic opportunity. A new building was being built which required both voice and data communications and for which capital funds were available. Because the old phone system was expanded to its maximum capability, a new system was required just to meet the voice needs. As indicated previously, the currently "recommended" solution for phone systems in Virginia is Centrex. Since Centrex was bid as one response to the RFP, New River had cost figures to use for comparing a system with up-front cost, as opposed to one with continuing cost (Centrex). As it turned out, the system with the up-front cost was cheaper over a reasonable period of time (five years) and provided all the functions the college desired. However, without the capital to implement the choice, New River may not have been able to have the integrated environment.

As part of making the system cost effective, New River must be able to manage it. Actually the new system makes manageability easier and often less expensive than the unintegrated solution. Multiple paths to the mainframe have doubled the number of users possible with no additional leased line charges and at a cost substantially below the cost of purchasing control units and running coax. Resources such as hard disk and laser printers can now be shared and become cost effective solutions. Because of the close integration of the system, the college can now use laser printers to print output from the mainframe computers while providing laser printer service to PCs.

The call record data provided by the System 75 PBX allows the college to provide phone costs and traffic data to departmental managers. These data are very critical in making cost effective decisions about types of outside phone services; however, the college is careful to avoid a "big brother" atmosphere by treating the data as management information and allowing managers to use it within the general guidelines required by law.

Throughout the procurement process, New River had to educate a number of people that "just a phone system" was not the solution. Coupled with their need for an understanding of the technology involved was the purchasing agency's mandate to control cost. Even though substantial cost reductions were made through negotiation, the vendor receiving the final award was in the beginning the fourth lowest.

How then does one get a workable solution? One must have on staff, or as a consultant, one or more people who can read the actual technical specifications of the vendors' equipment and compare them with the desired function. Without a careful, line-by-line scrutiny of vendor specifications, New River could have settled for a less than complete or even an inoperable solution. Only one of the five vendors bid a system which met the college's specifications: the AT&T system now installed.

Once the award was made, attention was then directed to the installation. During the installation there are two points that were observed. The first was to make sure that the installation met the necessary fire, structure, and electrical codes. This includes little things, like the type of insulation on the cable jacket, to big things like floor loads and electrical hookups. For institutions following a similar procedure, if a separate inspector were available for this work, then he should be given a free hand to make sure the installation complies with the codes. Otherwise, someone in the institution must provide this overview.

In the case of performance criteria, one simple rule was followed by the college--"make sure it works before it is paid for." One piece of $10,000 equipment was finally removed and returned after the vendor spent six weeks trying to make it operable and finally determining that it never would work in New River's environment. The college also tried to run everything as much and in as many ways as possible. When the PBX was cut over, a problem in its operating software allowed a user to accidentally tie two long distance lines together if a busy signal was reached twice in a row.

Knowledgeable college personnel are critical to implementing state-of-the-art technology. These personnel will be of little use without an effective management structure. At New River, the Dean of Management Services had overall responsibility for initiating and managing the planning, purchase, installation, and use of the system. The actual day-to-day work was handled by personnel in the Computing Services Department (Communications has since been added to the name of this department). This includes installation of equipment and making changes in the phone system. A new person is being added to the Computing and Communications Department staff to handle most of the maintenance tasks. At present, the system is still under warranty, so much of the real maintenance is handled by the vendor. When the warranty year is up, the college plans to add a few critical components to maintenance contracts and have college personnel do the rest.

A computing and communication master plan is being developed to identify the applications and areas which can be served in the future. This plan will encompass every area of the college; therefore, an important step in this process will be to set priorities. As stated earlier, New River's integrated communications environment provides only the backbone. Many PCs remain to be brought into the LAN, and even though the access to the mainframe network is greatly expanded, it is not unlimited, so planning is important. In addition, the plan must have backing at the highest levels. Lower level support and supervision are necessary to make sure that data integrity is maintained and that resources are not abused. As with any new technology, training and education of users are also important.

As the college becomes oriented to the integrated communication system, it is finding varied uses for it. The first application brought up on the LAN was a package for the college Educational Foundation which provides the members of the staff access to a common data base for accounting and donor record keeping. The college will also be able to use a desktop publishing system which will give various areas of the college access over the LAN to laser printers and the software. Having desktop publishing on the LAN will allow the Word Processing Center staff, the Graphic Artist, and the Information Officer to work more easily together in preparing college publications.

While accounting for the college's state funds is handled on the mainframe system, a major effort is currently underway to automate the accounting of the funds received from local governments, grants, and federal financial aid. As with the Educational Foundation office, the LAN will allow a number of personnel to have access to a common data base and common software.

Additionally, an automated library system is planned where LAN workstations will replace the card catalog, and the catalog will be accessible over the LAN throughout the college and possibly even over the phone to the local community.

As resources become available, the academic PC labs will be placed on a LAN and joined over the LAN to PCs in the offices of the faculty teaching in various labs. This will eliminate the mechanical printer-sharing switches, allow instructors to download data to the LAN instead of making numerous copies, and allow instructors and students to exchange messages over the LAN.

While the new communications system does not change the applications on the mainframe, it does provide increased access. In the future, the college on-line registration will be extended to off-campus locations by dialing into the ISN and protocol converter. Faculty will have access to student records over terminals or computers in their offices to assist with advising.

With devices on the LAN which enable communication with the mainframe, other areas of application become possible. Printouts of reports generated on the mainframe can now be printed on the laser printers on the LAN. This is very useful for reports which are to be bound or which otherwise require high quality print. Other possibilities include downloading a "snapshot" copy of the student data base for local analysis, reducing the load on the mainframe and removing concern about data integrity. Another application being considered is an automated purchasing system which would allow requisitions to be prepared on a PC, moved over the LAN to the business office, and then communicated to the state system on the mainframe.

As a result of careful planning, and with much hard work, New River now has an integrated communications environment which provides for an almost unlimited range of computing and communications options and applications. However, none of what New River has done would have been possible had the college not had a number of technically astute and experienced staff members to handle the technical details. At many stages--from planning to implementing the system--had it not been for knowledgeable staff members, New River could have purchased a system which did not meet its needs, at best, or didn't work, at worst. A recent article in PC WEEK sums up the importance of personnel regarding LANs, but what it says applies equally to the whole communications solution.

> LAN-management skills cannot be developed at home in one's spare time. They require an understanding of integrated computer systems, a work group focus, an understanding of business, technical depth, dedication and more.
>
> Your choice of a LAN manager will mold the shape and character of your LAN, since its long-term value to your organization will be based on the LAN manager's software selections, installation techniques, maintenance, training, service, and development work.[1]

It seems that New River has been able to incorporate all the prime ingredients which will enable the college to make full use of the wide range of communications and computing equipment on campus now, as well as to take advantage of new equipment and technology of the future.

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[1]Del Jones, "Get the Best Value from Your LAN With These 10 Rules for Making a Buy," PC Week, 25 August 1987, p. C/37.

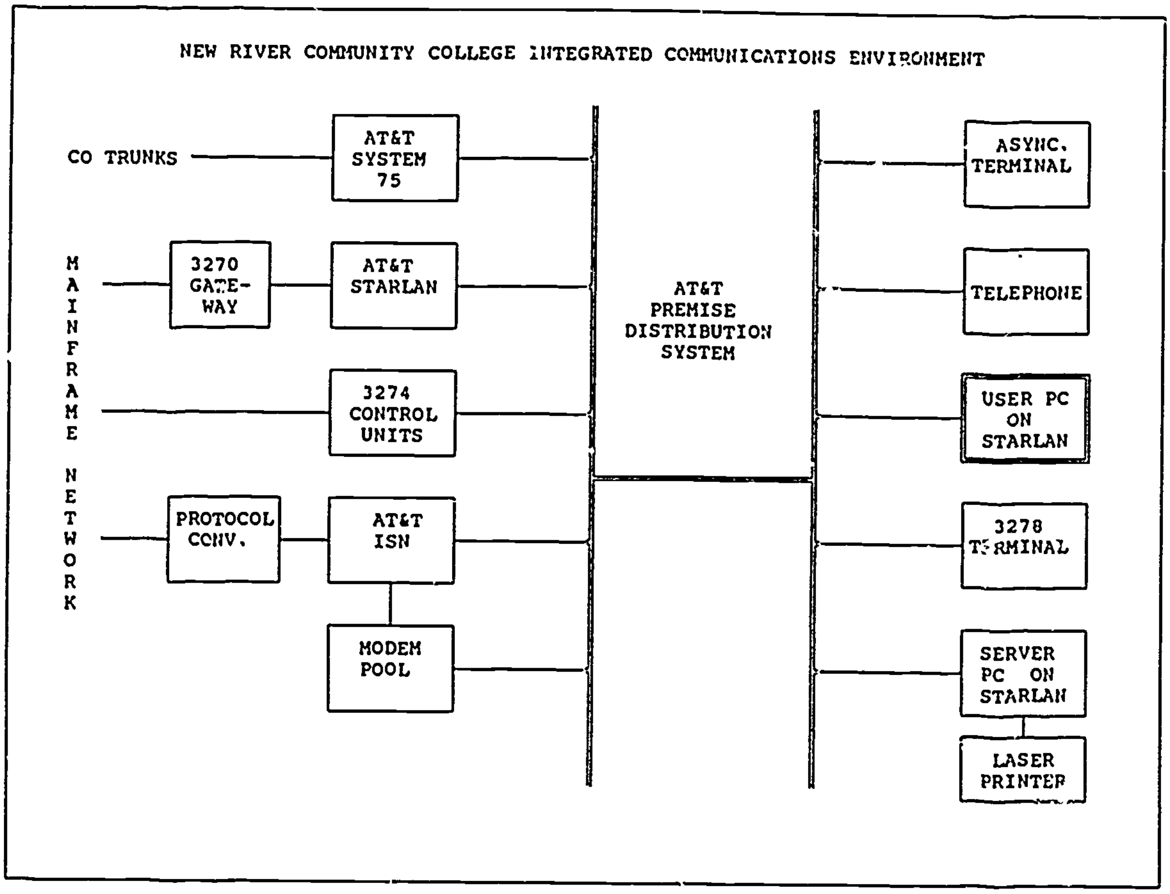

Figure 1

COST OPPORTUNITY

	VOICE ALL BLDGS	DATA ALL BLDGS	CHARGES FOR MOVES & CHANGES	INITIAL COST	ANNUAL COST	5-YEAR COST
OLD PBX	NO	NO	YES	--	$29,115	$145,575
CENTREX	YES	NO	YES	$176,502	$60,300	$478,002
NRCC'S INTEGRATED SYSTEM	YES	YES	NO	$292,000	$8,000	$332,000

* DOES NOT INCLUDE SCATS, TRUNK CHARGES, AND OTHER COST COMMON TO ALL ALTERNATIVES.

Figure 2

COMMONWEALTH OF MASSACHUSETTS HIGHER EDUCATION COMMUNICATIONS NETWORK A CASE STUDY

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ABSTRACT

The Higher Educational Communications Network (HECN) was implemented in June, 1987 for use by the 29 campuses of the public higher education institutions and the Board of Regents for the Commonwealth of Massachusetts. It is a private, statewide, packet-switched, X.25 network providing access from each campus to any other campus, the Regents Computer Network, and the state's data center. The evolution of the network from conceptual requirements through identification of alternatives and topological design to implementation and day-to-day management is discussed. The current performance is analyzed and future possibilities for enhancement are presented.

THE REGENTS COMPUTER NETWORK

THE BOARD OF REGENTS OF HIGHER EDUCATION

The Board of Regents of Higher Education of the Commonwealth of Massachusetts oversees the twenty-nine public college campuses which enroll more than 170,000 students and employ more than 14,000 faculty and staff. Its mission is to provide access to excellence in public education.

THE REGENTS COMPUTER NETWORK

The Regents Computer Network (RCN) is a central computing resource which provides computer and communications services and support to the Board of Regents of Higher Education and the 29 campuses of public higher eduction in the Commonwealth of Massachusetts. The Regents Computer Network reports to the Board of Regents and is located in Boston. It was established in 1973 by the Massachusetts State College Board to provide academic and administrative computing for the 11 state colleges. The Board of Regents was established in 1981 and assumed the responsibilities of the Massachusetts State College Board and its computer network.

HIGHER EDUCATION COMMUNICATIONS NETWORK

In the spring of 1985, the Commonwealth of Massachusetts mandated that the Board of Regents should acquire and implement a centralized payroll/personnel system for all of public higher education. In November 1986, the Board decided that the system would be run at the Regents Computer Network, that facilities would be provided to support the application there and that the RCN's communications capabilities would be expanded to connect all of the 29 affected campuses. The Regents Computer Network computing resources consisted of three CDC Cyber mainframes with associated storage and I/O devices. These mainframes were connected to the state college campuses and to two of the community colleges through a point-to-point circuit network which provided 9600 bps support directly from the campuses to the RCN in Boston.

While definition of the Payroll/Personnel System was delayed, the Commonwealth implemented a statewide accounting system (MMARS). The Board and the Commonwealth determined that the higher education institutions should utilize MMARS. Security and control made it attractive to have only the RCN directly connected to the Commonwealth's Office of Management Information Systems (OMIS) mainframes rather than each of the campuses. The campuses would hence be connected to the OMIS mainframes via an expanded data network, the Higher Education Communications Network (HECN), which linked campuses to the RCN to OMIS. These connections were scheduled to go "on-line" July 1, 1987. GKA was therefore asked to conceptualize network solutions, create appropriate specifications and assist in the procurement of HECN.

NETWORK REQUIREMENTS

The constraints applied to the design and specification of the Higher Education Communications Network were that it must:

1) Connect each of the 29 statewide campus units with the RCN data center.

2) Provide an IBM synchronous (SDLC) gateway (through the RCN) to OMIS for each campus unit which can support direct inquiry, updating and reporting of the data bases for central accounting and the data processing inventory.

3) Provide for academic and administrative processing capability even in the event of circuit failure.

4) Support the initial payroll/personnel system, the MMARS access, current academic and administrative applications, and accommodate new applications such as electronic mail.

5) Provide campus to campus connections for all campuses.

6) Be flexible enough to support connections with the different academic and administrative computers and protocols now in use and those likely to come into use in the future at the schools, the RCN and OMIS.

7) Accommodate a five-fold growth in applications traffic.

8) Provide a grade of service such that the transmissions associated with critical procedures like payroll can be handled for all campuses in a single day from data entry to check printing.

9) Preserve or improve the current user response time.

10) Employ a technology which will make the most efficient use of circuits, thereby minimizing the month-to-month operating cost of the network.

11) Incorporate provisions to assure access security for the Network.

12) Support error correction or mechanism to achieve a low native error rate to assure the integrity of all transferred information.

13) Carry all traffic between the 413 transport area (LATA) and the 617 LATA over T-1 circuitry.

14) Provide a gateway to the various public networks.

15) Include provision for automated network monitoring.

16) Permit phased implementation of the network.

17) Limit the capital cost of HECN to $650,000 in capital outlay.

DESIGN ALTERNATIVES

TECHNOLOGY

Voice and Data Integration

Higher education in Massachusetts would appear to be a strong candidate for the integration of voice, data, and even video. Four factors limit the potential for such integration: 1) T1 tariffs in Massachusetts are relatively high, requiring a high occupancy for cost justification, 2) inter-campus calls are a small proportion of the overall long distance traffic, 3) the largest campus has its own TI from Amherst to Boston and 4) the current prospect for inter-campus video transmission is even more limited.

Experience in other states suggested that the breakeven point for state-wide integration of communications required a broader base of traffic than just higher education (for instance all state agencies). The conclusion in Massachusetts was that integrated or shared voice and data networks were economically feasible only for the few locations with large enrollments and heavy student traffic; most campuses cannot justify T1 interconnections without combining additional state government traffic to and from the campus community. No mechanism exists to sponsor or force the latter option so the integration of voice and data was not initially a feature of HECN. It remains a viable evolutionary path for the future and its use requires no change in the network technology that was adopted.

Multiple Single Protocol Connectivity

The typical data network supports a single protocol and transmission rate. With the varied set of academic and administrative computers on the campuses in Massachusetts (Digital Equipment Corporation, Data General, Wang, Control Data, Prime, Burroughs, AT&T and IBM) to be interfaced to HECN, a diverse set of circuits and protocols could have been required. The addition of gateways to campus local area networks would only have complicated this picture.

The multiple single protocol approach would have led to a network of overlapping and incompatible circuits most of which would require individualized special handling before their transmissions could be passed on to any single or central computing facility--OMIS, the RCN, etc. This approach was avoided because it is extremely expensive for a network of low volume connections. The use of many circuits with differing protocols also sharply increases the opportunities for system failures and the difficulties of providing backup recovery facilities and procedures.

Mixed Protocol Connectivity

X.25 packet switching was selected as the most viable standard for addressing the problems of mixing protocols and line speeds over a common carrier. This standard provides a clear recipe for interfacing different individual vendor standards or protocols and is a mature technology which has been in use for more than twenty years in this country and abroad. The X.25 standard also provides for a circuit switching capability which can often be advantageously employed to balance loading and ensure connectivity when circuits fail by rerouting traffic. The X.25 packet scheme also provides a high level of error detection and correction and an exceptional efficiency in its circuit utilization (typically 80% versus 65% for binary synchronous links and 35% for asynchronous links). The use of packet switching appeared feasible for HECN and met the design criteria as well.

Other Alternatives

The alternatives to X.25 or a similar packetized approach included adopting one of the synchronous or asynchronous standards and utilizing specialized equipment on the campus to handle all protocol and speed conversions before passing the traffic to and from the RCN as a single protocol. Such a strategy again is quite expensive and introduces a relatively large number of different vendors into the network support and maintenance equation.

Another alternative receiving increased attention today is the use of small aperture satellite antennas (VSATs). This alternative has a high natural bandwidth (up to 256KBPS), can be full duplex, and can handle broadcast video, data communications, and even a limited amount of voice traffic. VSAT networks do require the use of a large (and expensive) central site antenna and transponder "space" on the satellite. However, this approach has the advantage of freeing the user from the escalating cost of leased lines and limiting the impact of equipment failures to a single site in most cases. Unfortunately, the economic breakeven point for such a network compared to a leased line network is between 75 and 100 remote locations (but this figure continues to fall).

It was therefore determined to build the network with a network backbone employing X.25 packet switching. This choice allows mixing a dedicated network with switched public services and even transmittal over a satellite network in the future.

NETWORK TRAFFIC

Having adopted a technology, a set of locations to be served and a set of design criteria, the topology and the bandwidth requirements can be determined. Tabulations at the RCN yielded information about the total volume of traffic from existing academic and administrative RCN users, the time they were connected to the network, and the maximum hourly rate at which this traffic was transmitted. While it was not possible to predict the actual traffic which would result from the Payroll/Personnel System or use of MMARS, working estimates were derived. These were averaged to compensate for local variance.

The bandwidth requirements were developed from the observation that data entry personnel average about one character entered per second (CPS) in an interactive environment (in this situation one character is entered for every three or four that are sent back from the computer). Using a fast entry rate of 2 cps, the campus staff size and sufficient entry stations to process all work for payroll, etc. in a day, one may conservatively calculate the average required bandwidth for each campus for the Payroll/Personnel System and MMARS transactions. These figures were then used to estimate the bandwidth and entry time required by each school. The figures were increased five-fold to compensate for growth and future applications.

The estimated bandwidths obtained were such that both current and future applications could be combined on a single, new network without degrading the user response time. The traffic for these applications combined were therefore used to size the circuits for the new network. The feasibility of combining old and new traffic on the new network allowed a portion of the older network equipment to be reused, thus limiting the capital outlay necessary to implement HECN.

NETWORK TOPOLOGY

The requirement to use T-1 transport between the 413 LATA and the 617 LATA meant that all existing circuits in the western portion of the state had to be re-engineered because the then current circuits connected directly to Boston (and were thus quite expensive). The most direct solution was to link each school to one of the existing T-1 end points in Springfield or Amherst using point-to-point leased circuits. Providing a second, redundant circuit would then insure that a connection was possible under almost all circumstances. This had been the practice in the RCN in the past. At the time of this design dial backup modems were being tested for use in the case of a circuit failure. Their use would eliminate the need for extra backup circuits.

A more economical means of achieving redundancy was possible. In the X.25 network, lines may be run from location to location to create a shared loop. Traffic may then be carried in either direction over this loop, so in the event of a single link failure there is a redundant path. This approach is less costly (fewer circuit miles) than duplicate circuits and can be engineered to achieve a measure of traffic balancing at the same time. The use of duplicate circuits is thereby avoided, although the use of such backup routes may result in slower throughput.

Two interconnected loops were used to connect all of the 413 locations and balance their loads. Redundancy can then be maintained to all locations and even within the T1 link to Boston. Since the University of Massachusetts at Amherst was linked to Boston by its own T1 and the State T1 was not yet available for outside use, HECN was configured using this inter-LATA linkage. The precise bandwidths and interconnections were calculated using a simple network model and the previously discussed traffic estimates.

In similar fashion it is possible to create looped circuits in the 617 LATA. The campus geography naturally divides locations into northern, central, and southern sub-networks after the metropolitan Boston locations have been isolated. In each of these cases consolidation, redundancy, and flexible access between sites have been achieved. Figure 1 shows the consolidated network and the metropolitan Boston circuits.

ACQUISITION

PRODUCT SELECTION

Historically, the RCN used an informal bidding system to acquire software and hardware. Preliminary negotiations, refinements of the statement of requirements and cost estimates were, in fact, pursued in this fashion with a group of 17 vendors selected for their experience with packet switching, or their breadth of communications offerings and their projected ability to support an statewide network in Massachusetts.

The source of the funds for HECN caused the actual procurement for the X.25 PADs and switches to go through the Commonwealth's Bureau of Systems Policy and Planning (BSPP) which is charged with administering all competitive data processing acquisitions. The existence of a large installed base allowed the RCN to "sole source" the modems. The competitive X.25 pad and switch procurement took a period of five months to complete including the final negotiations. The modem negotiations which were conducted by BSPP took almost as long.

IMPLEMENTATION

Prior to the product selection activities, environmental requirements were established for the campus-sited equipment and circuits were placed on order with AT&T and New England Telephone. Once the two vendors were chosen, (one for the pads and switches and one for the modems) implementation awaited only the conclusions of the contract terms negotiation. Each of the vendors was poised, ready to begin installation and training. During May and June of this period, it was necessary to devise several temporary measures to get the campuses "on-line" to MMARS for training and familiarization. A makeshift use of existing leased lines was employed.

The contract specified that installation must be completed within 45 days of the contract signing, and it was. An ambitious delivery and installation schedule was devised and each geographic "loop" was installed separately. Each "loop" was installed in just over a week. More problems were encountered with bringing up the new circuits than with implementing the network hardware. During implementation, the RCN staff began producing a network newsletter, "The HECN Update," which is circulated to all involved parties on the campuses and at state agencies.

ACCEPTANCE

One of the strong points of the final contract was the provisions for acceptance testing. During this period the network was tested to determine that every switch, pad, and option was functional. July and August are slow periods for academic and administrative utilization which simplified this task somewhat, but left unanswered the questions of performance under load. Terminal emulations and protocol conversion problems complicated the acceptance because it was not initially clear where the problems originated. RENEX protocol converters are used to convert the asynchronous traffic to SDLC for these connections to the OMIS (IBM) mainframes and MMARS.

OPERATIONAL PERSPECTIVES

The resultant network consists of 46 circuits. It contains 48 X.25 switches, 65 PADs, and provides approximately 725 campus ports to the network and 128 ports to OMIS.

OPERATIONS/PERFORMANCE

Technically, the normal operation of this network is no more complicated than traditional point-to-point or multi-drop networks. However, the routing parameters and options which provide the flexibility of the X.25 approach also introduce a measure of complexity to tuning the network's performance. Today, the average response time compares favorably with that of the prior network.

MANAGEMENT

Network management at the RCN allows the communications staff to monitor the performance and traffic of each PAD and switch in the network on a connection by connection basis either manually or automatically. The Codex network management system which the RCN already had in place allows the staff to monitor concurrently the line conditions and error rates on each circuit. The two "pictures" of the network are complementary and provide a good basis for prompt identification of most trouble situations - in most cases before users complain. The PADs and switches located on each campus can be remotely accessed from the RCN Control Center (over HECN or via dialup) for diagnosis and new parameter downloading where necessary.

BENEFITS

HECN not only provides access to the Commonwealth's administrative systems resources at OMIS, but also has created the necessary environment for unparalleled ease of data communications between campus computer systems and the potential for a new level of collective effort and benefit within public higher education in Massachusetts. Electronic mail and BITNET access have been extended to all campuses using the RCN computers and HECN access. Connectivity to the PLATO resource located on the University of Massachusetts at Amherst campus is also now available.

Yet surprisingly, there is frustration in the very successes of HECN in providing a mechanism for access to a much broader spectrum of educational resources. It was disappointing to find that the X.25 interfaces provided by most manufacturers do not yet provide the full promised X.25 functionality. Hence the direct computer to network interfaces have been limited to date. On the other hand, the anticipated difficulties of connecting local area networks to HECN have not materialized. The ISN (AT&T) at Fitchburg State College, DEC-net at Holyoke Community College and Southeastern Massachusetts University, and the data interface of the Rolm PBX at Northern Essex Community College were readily connected and are providing flexible interfaces.

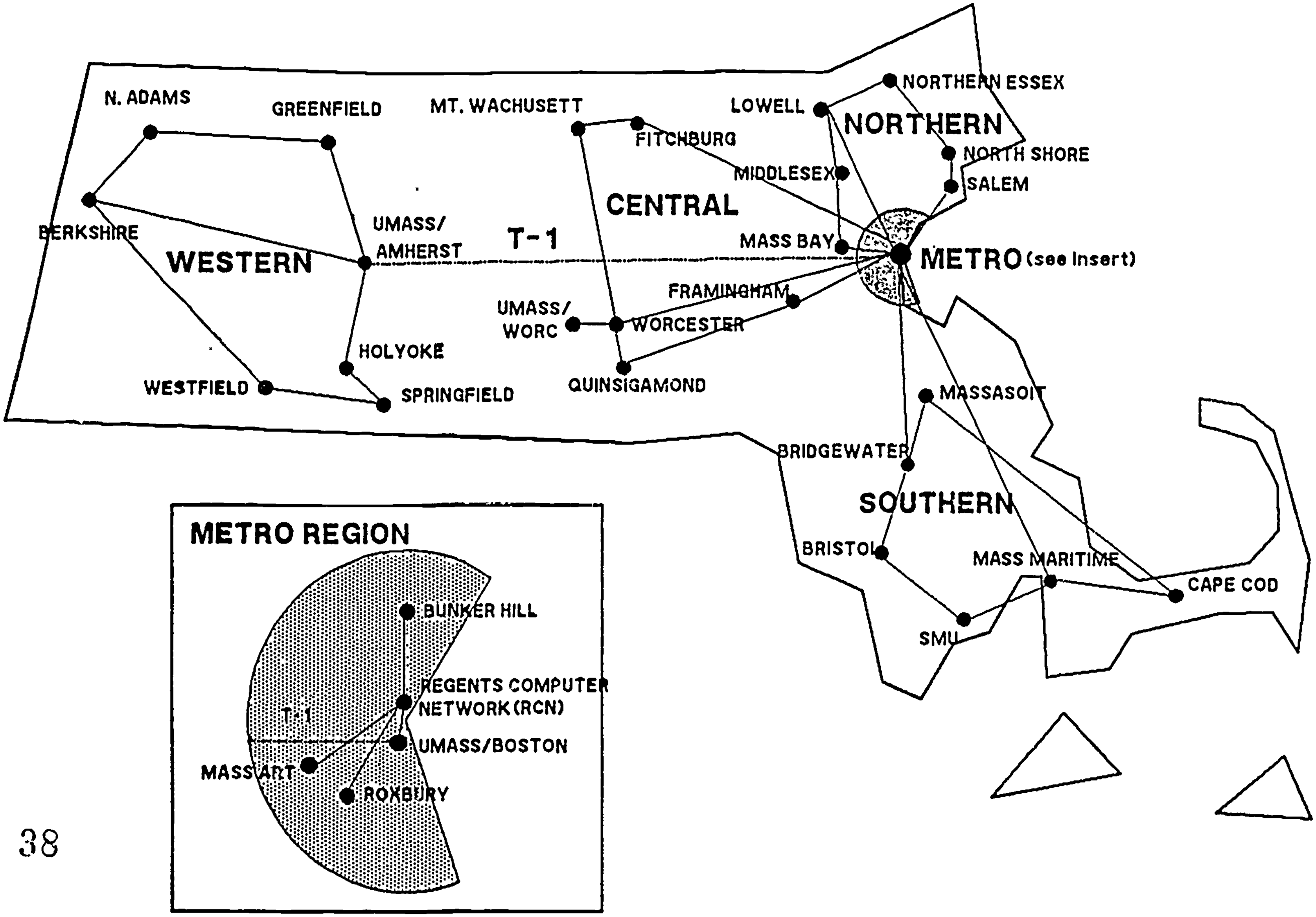
HECN is still a somewhat "techy" environment, requiring parameters and switches to be set from time to time. The network's electronic mail is bringing the academic and administrative community together as never before, but there are those key offices where it is still a problem to introduce the use of a terminal. We have been forced to realize that the network is more than the technology of HECN. It reaches beyond the PAD to embrace not only the terminal, but the user and potential user as well. Our user support services have had to move far beyond the simple explanations of how HECN works to understanding and assisting with the communications environment on the campuses. HECN is no longer a simple utility; it now embodies many attributes of a mission. Certainly higher education in Massachusetts will never be the same again.

FUTURE POTENTIALS

In the future, connection to more public networks is anticipated. In addition, there is the prospect of utilizing HECN to connect users to a super computer site as well as to serve other state agencies who need access to the same geographic areas served by HECN and to link all of the campus and state library systems. The throughput of the PADs and switches is sufficient with upgraded circuit speeds to accommodate these demands and those of potential applications which generate high traffic such as CAD-CAM or image transmission or a pronounced migration of state agencies onto HECN from their current dedicated leased line multi-drop networks.

The X.25 protocol lends itself to any type of integration. It can occupy one or more channels on a broadband circuit or it can be merged into an integrated voice and data packet transmission. HECN, itself, can even become the basis for a local campus network as easily as it connects terminals now between campuses. The resource for innovative connectivity and applications is present. It is now up to the RCN and the campuses to exploit this potential.

Higher Education Communications Network
Commonwealth of Massachusetts



A SOFTWARE DEFINED INTEGRATED T1 DIGITAL NETWORK FOR VOICE, DATA AND VIDEO

JAMES R. HILL

DIRECTOR OF INFORMATION TECHNOLOGY

DALLAS COUNTY COMMUNITY COLLEGE DISTRICT

DALLAS, TEXAS 75150

The Dallas County Community College District developed and implemented a strategic plan for communications that utilizes a county-wide integrated network to carry voice, data and video information to nine District locations. Designed by our consulting engineers, Diversified Communications Engineering, Inc., the network utilizes microwave, fiber optics, digital cross connect and T1 technology to provide the first software defined educational network to merge all three technologies into one common digital pipeline. The plan included planning and installation of new digital switches for voice, a packet switched-wide area network for data, and compressed video codecs for video teleconferencing and instruction. The presentation will cover the development of the strategic plan, the procurement process, the planning for installation, and the installation and implementation events. The network was installed and operational by May 1986 and has an anticipated 8 year life span.

THE ENVIRONMENT

The Dallas County Community College District is composed of seven campuses and two District offices providing educational support to all Dallas County residents. Campuses are located within fifteen minutes driving time from any residence. The District serves approximately 97,000 students per semester consisting of an equal distribution of credit and non-credit. Campuses vary in size from 5,000 to 25,000 students.

THE PROBLEM

In 1984, communication responsibilities for voice were managed by the District's Facilities Division and data by Computer Services. There were no video communications intra-district, but an extensive telecourse curriculum was distributed throughout the county by the local public television station.

Voice switches were on each campus and were leased from AT&T, with the lease expiring in July 1986. Data circuits were 56KB DDS circuits leased from Southwestern Bell. There were eight circuits running between each campus and the District Service Center where the centralized computing center was located. Costs for voice and data services were $1.2 million per year and had increased 40% over the preceding three years. Air time for telecourses was running $175,000 per year and increasing each contract renewal.

Costs were expected to increase for voice communications with lease expiration and increased growth projected. Data communication facilities were in need of expansion at two colleges and office automation needs would require significant new facilities. Strategic planning called for additional telecourse offerings as well as intra-District instruction and teleconferencing.

The problem was coming into focus with these events.

- Expiration of PBX lease
- Additional data communication needs
- Increased video demand
- Merging technologies
- Need to contain operating costs

THE STRATEGY

In July of 1984, Ted Hughes, Vice Chancellor of Business Affairs responded with two actions:

1) Placed responsibility for all data, voice, and video communications under Jim Hill, former Director of Computer Services and now the Director of a new division named Information Technology.

2) Formed a District-wide committee with Jim Hill as chair with the charge to examine District communication needs and develop a strategic plan for a communication network that would cover a five year time frame.

The Communication Network Planning Committee met for the first time in September 1984 with representation from all campuses and District offices covering a broad spectrum - President; Vice Presidents of Instruction, Students and Business; Faculty; Directors of Purchasing and Facilities for example

The Committee, realizing the technical complexities of such a network, attempted to become more knowledgeable through selected readings, vendor presentations, and attending a conference on communication planning. At the same time, each committee member was given the charge to meet with their respective campus administrative staff or District support area to develop a communication needs analysis for present and future.

It became obvious the complexity of the task, i.e. the use of voice, data, video and image, necessitated the use of a consultant. In March of 1985, the District requested proposals for a consultant, and selected Diversified Communication Engineering (DCE) from Austin, Texas to assist the committee. In June, the committee met with Saleem Tawil, President of DCE, and Carmen Armistead, an associate in the firm. Saleem and Carmen were both licensed electrical engineers, which proved to be critical in later procurement and implementation.

During the next 4 months, the committee, with assistance from DCE, developed strategic objectives from needs assessment developed by the individual committee members, and consolidated by discussions of the full committee. The objectives were:

- Provide control over resources for services and costs
- Develop an integrated network for
- Voice
- Data
- Video
- Image
- Accommodate the present as well as the future (8 years)
- Utilize new technologies, but with restraints (system concepts proposed must have been operational at least one year)
- Provide centralized resources for network control and support
- Adopt digital switching technology
- Must be economical with reasonable payback period
- Provide for video teleconferencing.

The consulting engineer, Mr. Tawil, with these objectives as the basis, provided a written report to the committee with his recommendations for our strategic plan. Included in the report were the design criteria for new systems; a financial and cost benefit analysis for each element of the proposed system; and options and alternatives with appropriate results/sequences. The consultant recommendations were adopted by the committee and presented to, and approved by, the Board of Trustees in November 1985.

THE STRATEGIC PLAN 1986 - 1994

The foundation of the plan was a software defined, integrated digital network providing voice, data, and video communication paths between all District locations. The location of the campuses within the county provided an ideal environment for a star design microwave network. Interfirst Plaza, at 72 floors the tallest building in Dallas, was across the street from the El Centro campus and was the logical choice for the physical hub with a direct line of site for microwave to all campuses.

Digital switches would be placed on eight sites with the District office sharing the El Centro switch. Data communications would not be switched by the voice switches, but would be accommodated by multiplexors or local area networks connected by the digital network to the main computing facility at the District Service Center.

While the physical hub was located in Interfirst Plaza, it was desired that control of the entire network be placed at the District Service Center 10 miles to the east. The key to this arrangement was to place a Digital Access Cross-Connect (DACS) switch atop Interfirst Plaza which would gather all the incoming voice and data digital traffic coming from the campuses and district offices and drop-and-insert the twenty four 64KB digital channels comprising a T1 channel to the appropriate outgoing 64KB channels. Video signals would be connected by digital codecs to 1.5MB T1 channels and routed from origin to destination. The DACS was like a "big switch in the sky" and could be programmed by remote terminal from the District Service Center to monitor and change routing patterns to best suit the District needs for any time period.

The capacity between eight locations and the hub at Interfirst was designed to handle six T1 channels, each of which could carry twenty-four 64KB Channels for voice and/or data, or one video channel. Sixteen T1 channels were designed for the route between Interfirst and the District Service Center to accommodate the heavy data traffic to the computing center; the detail recording of switch traffic; and the long distance traffic being centralized at that site. Five campuses and the District Service Center were to be connected to the hub by microwave. The downtown District administrative offices were connected to the El Centro campus under the street by fiber and copper cable. Fiber cable would then connect El Centro under the street to Interfirst. The Eastfield campus would be connected to the District Service Center with 1200 ft. of fiber cable and then routed over microwave to the hub.

The plan also called for acquiring a low-power TV license and an ITFS (Instructional Television Fixed Service) license to replace reliance on local public television and meet future video instructional needs for students and businesses in the county.

A study conducted earlier in 1985 indicated a strong demand for, and demonstrated need for, automating office support functions. Thus, the strategic plan included the procurement of necessary hardware and software to accommodate over five hundred Personal Computer workstations to utilize the integrated digital network. The workstations would be multi-functional performing stand-alone micro software; connected together for office support functions of word processing, electronic mail, calendaring and scheduling, and document storage and retrieval; and interfaced by the network to the mainframe computers for terminal emulation.

THE PROCUREMENT

Specifications for the digital switches, microwave, and digital cross connect were developed by Diversified Communication Engineering and the office support hardware/software and local data network specifications were prepared by DCCCD personnel. A two-phase sealed bid process was begun in February 1986. The first phase was designed to qualify prospective vendors and select finalists -- the pre-bid conference was attended by twenty eight vendors. Five finalists were chosen for the communication network and two finalists for the office support system from seventeen vendors submitting responses to the RFP. The finalists were asked to make half-day presentations to an evaluation committee to demonstrate their understanding of the project, their organizational experience, and their commitment at the local level to successfully implement.

Following the presentations, sealed bids were again submitted by the finalists. GTE of the Southwest was selected as the General Contractor for the communication network using NEC 2400 digital switches, Harris-Farinon microwave, and Rockwell DACS. GTE was chosen for their proven installation experience with complex systems and depth of local support organization. AT&T was chosen as the contractor for a wide area network called ISN (Information System Network). This network would connect over five hundred PC's with twisted pair and fiber cable through packet-switched nodes at each location to a central minicomputer at the District Service Center for office support. Administrative and educational data communications would continue to use multiplexors for now, but would be added to the ISN in the near future. Data General was selected as the office support vendor using an MV 20,000 minicomputer and CEO (Comprehensive Electronic Office) Software. The proposed communication network was approved by the DCCCD Board of Trustees in June 1986.

THE IMPLEMENTATION

The implementation started in June 1986 with bi-weekly planning/progress meetings conducted between the contractors, DCE Consulting Engineers,and DCCCD personnel headed by Jim Hill, Director of Information Technology.

Construction of the network began in August with the first two switches cutover in September. The remaining switches were installed October - December 1986 with the exception of El Centro, which had to be re-wired, and was cutover in February 1987. Concurrent with switch installation, microwave paths were being licensed with the FCC; under-the- street right-of-way was being acquired from the City of Dallas; lease space negotiated at the top of Interfirst Plaza for microwave radios, antennas and DACS; and fiber optic cable being laid. The office support hardware and software was installed in October 1986 and training classes started. The ISN network was installed and operational at each location by March 1987. In April 1987 the microwave equipment was cutover (had been delayed three months from plan for equipment delivery) and the entire network became operational.

In addition to the uniqueness of the software defined digital network using DACS switching, there are a few other significant aspects

- Four digit dialing throughout the Districts nine locations made possible by CCIS (Common Channel Interface System) hardware and software within the NEC 2400 switches

- The use of 56KB data modules used by the NEC switches to route data from the multiplexors and ISN nodes through the switch to interface with the microwave.

- Centralized control of the NEC switches, DACS, and ISN nodes from micros located at the District Service Center--in effect achieving centralized network control for troubleshooting, traffic analysis, and modifications to meet changing conditions.

SUMMARY

The network has been performing extremely well for the past six months and appears to be "rock solid". There are over 2000 telephones of which 550 are new digital instruments with many advanced features; 620 microcomputers serving as multi-function office support workstations; 650 administrative and educational terminals; and digitally compressed video instruction between the District Service Center and Cedar Valley campus all using the integrated services digital network between the nine District locations.

The new ISN wide area network currently supports the microcomputers on the office support network, but all data processing terminals will be added to the network in the next six months. ITFS (Instructional Television Fixed Service) licenses have been acquired and a three-channel system will be installed by May 1988. This will permit video instruction between all campuses, as well as to local business and industry under the direction of the District's Business and Industry Professional Institute. Teleconferences as well as any other video production can be downlinked from satelite and piped over the ITFS Channels to any location.

The District has not been able to obtain a low or high power television license which was planned to replace reliance on local station transmission. The FCC is not allowing any new applications at present, so the only alternative is purchasing the license rights previously granted to another entity. The District is vigorously pursuing this approach but has not been successful to date.

The economic benefit anticipated by the strategic plan looks firm, in that over two million dollars will be saved over the eight year projected life. This savings was calculated considering present use, when in fact projected growth can be handled more economically with the new system, thus realizing even greater savings.

The two and one-half years to plan, procure and implement a state-of-art communication network has been completed with hard work and proven results that puts the District in firm control of its resources. In retrospect, the key ingredients were

- A well represented District planning committee that did a good job in assessing need and developing objectives.
- a competent consultant (Diversified Communication Engineering, Inc.), i.e. an electrical engineer that designed, specified, and coordinated a very complex, but well engineered system.
- a general contractor (GTE of the Southwest) that had the expertise, track record, and local commitment to install and implement on schedule a unique, yet solid, private communication network.

The Dallas County Community College District is proud of the result and convinced that its strategic plan has become reality. The District can contain future costs attributable to inflation and growth; have greatly expanded capabilities and capacity, and benefit from significantly reduced expenses.

CAMPUS CONNECTIVITY WITH THE DATA/VOICE PBX

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Like most smaller colleges, Moravian College has struggled with the issue of interconnecting computing resources on campus. Most of the typical approaches to connectivity, including high speed data links, carry with them large installation and maintenance expenses. While there are areas in which these high speed links are essential, the basic goal of campus connectivity can be reached through a lower cost alternative - the data/voice private branch exchange (PBX). Nearly everyone has a telephone, and with the PBX anyone with a telephone has the necessary cabling for a data connection.

CAMPUS CONNECTIVITY WITH THE DATA/VOICE PBX

Introduction

Over the past few years it has become a given that college campuses will somehow interconnect all computing resources that exist within their boundaries. While we can all agree that the goal of allowing users in any location to communicate with any available system is a good one, numerous ways exist to implement the goal, many of which are incompatible with each other. Most of us are struggling with issues such as cabling standards, software protocols, and costs in providing complete connectivity.

At its simplest level, connectivity means access. From the user perspective the important thing is not the technical specifications underlying the access, it is simply having it. For most users access is simply being able to sign on to the library computer, or the main academic system, or their electronic mailbox, and so on. In some cases, the transmission of files and documents is also required. In a relatively few cases (at least at a liberal arts college!), more specialized requirements exist, such as advanced function workstation access and the transmission of megapel bit mapped graphics. Generally these more advanced requirements do not pervade the entire user community. Instead most users just want to get from point "A" to point "B" with a minimum of effort.

One solution to the general access requirement is the use of the data/voice private branch exchange (PBX) to switch data communications throughout the campus.

Telephones are everywhere. All campuses, no matter how small, have telephone service. All of these phones use simple, inexpensive twisted pair wiring. Many small colleges have found it economical to install their own phone system, using a PBX instead of using the local telephone system for internal campus service. The decision to use a PBX can open up not only new voice communications opportunities but also new approaches to data connectivity throughout the campus.

Computers, of course, are becoming as ubiquitous as the telephone. At some not so distant date, it will be the norm for faculty to have their own device - terminal or PC - on their desk. Many will also have them at home. Students and administrators, too, will have machines. Many campuses also find they have disparate computing facilities, including an academic computing system, an administrative computing system, a library system, departmental systems, and local area networks. The Voice/Data PBX can provide the link to allow a user in one location, using one device, to access any of these campus computing resources.

The Moravian College Environment

Moravian College is a small liberal arts college located in Bethlehem, Pennsylvania. Founded in 1742, by the Moravians who settled Bethlehem, the College is the sixth oldest in the United States. Moravian enrolls 1200 full-time students, 600 Continuing Studies students, and 60 at the Moravian Seminary. The College is split between two campuses, about a mile apart. The South Campus is in the heart of historic Bethlehem, and is home to the College's Center for Music and Art. About 50 students live on the South Campus, and about 16 faculty have offices there. The President's house is also on the South Campus.

Moravian offers programs in 39 areas, including degrees in Computer Science and Information Systems. The College has a strong liberal arts tradition. In the past few years the use of computers has grown to encompass many nontraditional areas. The Art department has a lab of Commodore Amigas, used in a specially developed graphic arts program. All students in the department of Education get extensive experience on Apple II computers. And in History and in Classics, professors are using IBM PCs to enhance their courses. The College maintains a lab of Zenith PCs and IBM PS/2s on an IBM Token Ring network. There is also an Ethernet network throughout the Hall of Science building, tying in all Computer Science faculty and machines.

All of the activity related to the data/voice PBX has occurred on the main campus only. The South Campus has a separate, voice only, telephone switch. Responsibility for the telephone system is split between the Director of Business Affairs, who has voice responsibility, and the Director of Computing, who is responsible for all data communications. Under Moravian's unified computing structure, the Director of Computing has overall responsibility for all computing. Reporting to him are a Manager of Administrative Computing and a Director of Academic Computing. The Director of Computing reports to the Vice-president for Administration.

The PBX as Central to Campus Connectivity

Over the past three years, the Academic Computing Committee has struggled to define approaches for connecting all academic computing resources on the campus. In its first incarnation the plan called for some sort of campus high-speed backbone network, linking all main administrative, faculty office, and classroom buildings. In this approach, no specific plan was created for student access from the dormitories. While the Committee, and later the Faculty as a whole, endorsed this plan, the realities of life at a small college have precluded its implementation. Most specifically, the costs of such a high-speed backbone are prohibitive at this time. While strongly supported by the Computer Science department, work on this plan has not been begun, other than in some small way by Computer Science itself.

While discussions about the establishment of a campus academic network were underway, two other events occurred. First, the administrative computing area installed a new computer greatly expanding the number of users who would be accessing administrative systems. In order to facilitate this, a new telephone system was also installed using a Rolm CBX II that supported both voice and data access. The idea was to lay the cable only once and to make it do double duty. Second, the microcomputer laboratory facilities were expanded. Because of continuing software distribution problems, the lab was networked in order to provide access to software via a file server. The network chosen was the IBM Token Ring. Twenty-seven computers, including sixteen Zenith PCs and eleven IBM PS/2 Model 30s were tied into an IBM PS/2 Model 80 as the server.

Suddenly, Moravian found itself with three campus computing networks, handling three distinct environments. It became clear that searching for "the One" campus connectivity strategy may have been a mistake. Instead, specific requirements were being fulfilled with very specific solutions. In Computer Science, where the need was for connectivity of three Unix based CPUs along with several advanced function workstations and faculty PCs, an Ethernet was installed, running SUN NFS over TCP/IP. This provides ten megabit access, allowing the transfer of very large files and images. In the micro lab, where faculty often hold classes and tell their students to all "push the enter key now" at the same time, the token ring has proven superior to Ethernet, even though Ethernet has higher nominal data speeds. The avoidance of collisions under the token ring improves actual throughput in the lab/classroom environment. Finally, in administrative offices, where the number of users has grown from eight to eighty in one year, access through the phone switch has provided flexibility and allowed the management of port contention to minimize systems connectivity costs.

The solution to the Moravian connectivity issue has become straightforward - allow specialized function networks where necessary, but tie it all together using the data/voice PBX. This will cut costs significantly by tailoring to the user exactly the type of access he or she requires. Since most users do not require high speed access at this time, the switch is the perfect solution for them.

Probably 90 percent of Moravian's users can have connectivity needs satisfied by the PBX.

Advantages of the Data/Voice PBX

While not sufficient to meet all connectivity needs of the College, the PBX has the ability to handle a large number of them. Access through the PBX is asynchronous at speeds up to 19.2K BPS. Any system capable of "talking" asynchronously can be directly attached to the switch, through any data-equipped telephone. Non-asynchronous devices can be attached via protocol conversion internal to the switch. Just like when using a telephone for voice, using the switch for data provides the user a direct point-to-point exclusive line for the duration of the session. When finished, the line becomes available for another user. Because of this switched nature, systems with different configurations and requirements can be accessed with the same device from the user's desk. Thus, the user can first access a DEC host, then turn around and log onto an IBM system, with the same inexpensive ASCII terminal or PC. And while he is accessing systems through the PBX, his telephone is still available for voice calls.

The use of the PBX affords some unique advantages over other connectivity approaches, in addition to the switching between systems. Some of the most significant include:

- Upon installation of a telephone system, the cable plant is already in place for data. The incremental cabling cost for data over voice is nil. Anywhere a telephone is placed a terminal or PC can be placed and connected. The only additional cost is the port, about $200, versus $500+ for other methods.

- Expansion of the terminal/PC network is easy. It is generally simply a matter of plugging the terminal or PC RS-232 interface into the appropriate outlet, if this was preplanned. Even if it was not, no additional wiring is needed, just the addition of the port. When an office moves, the cost of moving their data is just the cost of moving their phone access.

- Using the integrated data/voice PBX can provide a single vendor data/voice communications solution. This can greatly simplify problem resolution when the inevitable bugs creep up. As the lines between data and voice communications become less distinct in the future, this benefit can be significant.

- The voice and data travel over one single twisted pair of wire. Since most phone installations use four twisted pairs, there are three left over for future use at every phone jack. Given the directions of technology, these may become useful for other types of networking, including departmental Ethernets or token rings, or even slow scan video.

- Overall, using a PBX for data and voice is typically a lower cost solution than separating the two functions on different networks. Not only is duplicate cabling eliminated, but the data costs can ride on the voice costs. Typical per node costs are as little as $200, with no wiring cost.

Data Switching at Moravian

The Moravian College Computer Center provides computing support for both Academic and Administrative users. Administrative systems supported include two IBM System/36s and a DEC 11/45 which is being phased out as the former administrative machine. Academic machines include a DEC 11/70 for Computer Science and Academic Computing, and a Masscomp and a Sun 3/180 for Computer Science. The Academic systems are all running UNIX, and are connected to the Ethernet. The two System/36s are connected to each other via a 56K BPS Digital Services Adapter. The Computer Center also supports the main MS-DOS lab, networked on the IBM Token Ring, and nine Zenith PCs on the Ethernet.

All of the main Administrative and Academic systems are also connected to the data/voice PBX, via twisted pair wiring for the DECs and twinaxial wiring for the System/36s. Since the PBX is an ASCII device, no special requirements exist to attach the DEC systems. The System/36 uses a Rolmbridge 5250 Link Protocol Converter in the PBX to handle all ASCII to EBCDIC conversion. About 100 administrative and faculty users have terminals or PCs in their offices and are connected to the PBX through their RS-232 ports at 9600 BPS. In addition, many users in the Hall of Science are connected to the Ethernet.

Attached to the PBX are two groups of incoming and outgoing modems running at 2400 BPS. These are available to any user who needs access to resources off-campus from his or her office, or needs access to campus resources from elsewhere. These modems allow the user to access any Moravian system while off-campus that he or she may access on campus.

The user interface to the PBX is very simple. In the case of terminal users, switching on the terminal sends an off-hook signal to the PBX which then responds with a prompt asking the user which available system is to be called. The PBX then finds the next available port on that system and links the user to it. As far as the system is concerned, the user has a point-to-point, permanent local connection. For PC users the process is even simpler because the PC can run communications software that responds to all prompts automatically. Initially, the communications package Procomm is being used with PCs. For access to the System/36s specifically, a Rolm designed package will be installed on each PC to provide System/36 emulation.

The PBX provides a level of security that can be used to limit system access. Each data telephone location can be assigned an access level that must correspond with the level of the system being called. In addition, each system attached to the PBX can be assigned a password, which must be used when trying to call it.

Users who wish to call resources off-campus simply respond to the initial PBX prompt with the outside number they wish to call. The PBX finds an appropriate modem and places the call. In this way a few modems can be shared among a large number of users.

In all cases, if a resource is not available to be called - for example, all ports are in use - the user has the choice of being queued for the next port or hanging up and trying later.

A major concern at Moravian is to develop a single user interface to all campus networks, so that a user working from a PC in the office sees the same screens for sign-on that someone in the token-ring networked micro lab sees. The goal is that a user should be able to sit at any terminal or PC on campus and be immediately familiar with what he sees on the menu screens. So far, this has been achieved in the token ring lab and on the PCs attached to the Ethernet through the development of a network menuing system. While the underlying system commands may be different on different networks, the user never sees this and doesn't need to know any special commands.

Future Directions for Moravian

There are still a number of questions to be resolved in developing total connectivity throughout the campus. The most significant problem is in determining actual requirements and fitting the appropriate technology. Users do not always know their requirements, and will often either under or over estimate the type of access they need. A faculty Academic Computing Committee is charged with developing policy and directions for future connectivity growth. This committee has representation from many department that might be considered outside of the mainstream of computing. However, at Moravian, everyone is considered a potential user.

The Rolm PBX has become the hub of what will be a campus wide network, encompassing offices, dormitories, and the South Campus. The Ethernet will continue to be important, tying in those offices requiring high speed access. The micro labs will themselves be networked and bridged over to the switch or the Ethernet. Some of the directions under consideration are listed below.

Dorms. Moravian dorms do not yet have phones in every room. When these are added, the data will be added at the same time, using the Rolm switch and digital Rolmphone 120s with RS-232 ports. This would provide any student with the ability to tie in his own PC or terminal. As an added bonus, the Rolmphones will not work on the public phone network, making them useless to students outside of their dorm.

South Campus. By using a T1 link, data and voice can be multiplexed to the South Campus, providing an integrated phone system and allowing the Art Department lab and faculty/student devices access to the network. This will also allow the President enhanced access from at home, instead of his current 2400 BPS modem access.

New PBX. New Rolm technology has made the PBX 70% smaller and significantly faster in handling data communications. Ultimately, all phones will be replaced with the Rolmphones using a single twisted pair wire for data and voice, freeing up two thirds of the wiring in classroom and office buildings. Ethernet should be able to run on this wiring wherever necessary eliminating new wiring costs.

Library. Moravian is in the process of automating the library. The catalog and circulation system chosen will also be connected to the PBX, so that any user in any office can access library holdings.

Ethernet and Token Ring Network. All micro labs are or will be networked within themselves to provide local printer and file serving. These networks may be Ethernet or token ring or some other type, as long as the network bridges into the switch or the Ethernet. At present the actual bridging is done using asynchronous communications serving on the token ring and terminal serving on the Ethernet. Higher speed links are being investigated.

Conclusion

The process of interconnecting all computing resources is a difficult one, for both technological and political reasons. Costs can be very high, and there is some question as to cost/benefit justification. Certainly, in a small college like Moravian, the costs of wiring the campus with fiber optic cable, providing the finest in high speed data transmission, are prohibitive. The question we must focus on is what are the actual requirements, rather than what would be nice and sexy to have.

High speed networks like Ethernet and the token ring have their place on a campus like Moravian. However, it has become clear over the past few years that not everyone needs such a level of connectivity. The process of trying to fit the technology to the user requirements has led Moravian to discard the idea of one campus network in favor of a hybrid approach tied together by the PBX.

Ultimately, of course, the goal is simply to provide access - to give every user the ability to get on to any machine for which he or she has the authority to access. We must take into account a large variety of equipment and protocols, as well as specialized needs in many places. Rather than try to dictate to users a small list of supported machines and refuse to allow any others, Moravian is trying to be open. The hub of that openness is the integrated data/voice PBX. Use of the switch will give access at a reasonable cost throughout Moravian College.

A SIMPLE STRATEGIC PLAN FOR PROVIDING DISTRIBUTED COMPUTING RESOURCES TOGETHER WITH A TACTICAL PLAN FOR IMPLEMENTATION

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ABSTRACT

Both strategic and tactical plans for providing computing resources in a distributed environment can become too complex. The complexity may result in "lock-step" implementation strategies that do not allow the institution to adjust to changing technology. A simple strategic plan is presented that forms the basis for guiding all implementations. An equally simple tactical plan is used to develop and implement the strategic plan. The results of this planning process are exhibited in OSCEO, (One Stop Computing for Everyone), the University of Wisconsin-Stevens Point computing environment.

BACKGROUND

1. Description of University of Wisconsin-Stevens Point

The University of Wisconsin-Stevens Point (UWSP) is one of eleven four-year, non-doctoral campuses in the University of Wisconsin System. UWSP has a liberal arts orientation, and offers masters degrees in selected disciplines. There are approximately 9000 students of which about 1/3 live in University maintained residence halls.

2. Status of computing before OSCEO

Prior to 1984 and the development of the strategic plan and the implementation of OSCEO, UWSP had a single combined academic and administrative mainframe computing environment and a small and varied set of micro-computers. The mainframe, a Burroughs B6930, provided services through a point-to-point coaxial terminal system. There were about 100 administrative and 30 academic terminals. There was no general data-communications network. The micro-computers on the academic side consisted mostly of a set of stand-alone Apple II+'s and a small 3Com network of IBM PC and Zenith 151 micro-computers. There were a few micro-computers in administrative offices being used for word processing.

THE STRATEGIC PLAN

1. Graphical display of the plan

The Plan was developed graphically as opposed to a prose description (see Figure 1).

2. Discussion of the Plan's components

The Plan consists of five major "environments", the student operating environment, the faculty operating environment, the department operating environment, the college/dean operating environment, and the academic administrative operating environment. Each environment has its unique requirements for service and for data. The service requirements are represented by the arrows, and are meant to be suggestive rather than exhaustive. The data is represented by the open rectangles. There is a strong overtone of data sharing and general access throughout. The thread that runs through the entire graphic is the need for an adequate communications system to link operating environments to data and to other operating environments.

3. Sequencing/ordering of the Plan's major functions

A broad and flexible sequencing strategy was accepted. The highest priority was given to the student operating environment. Next came the faculty, with the idea of hooking the students and faculty into one instructional environment. The third level of development was grouped into administrative services and functions and had the department, college, and academic administration sequenced together.

THE TACTICAL PLAN

1. The tactical plan

The tactical plan consists of specific objectives to be accomplished in various time frames ranging from one to six years. Some examples are (i) network all computers in student laboratories, (ii) provide computers to all faculty and network them, and (iii) implement a campus-wide electronic mail system.

Our philosophy in implementing the tactical plan is to be opportunistic and develop that portion of the plan that can be funded at the time. We know that our base budget is insufficient to develop the total plan. However, we are simultaneously developing several parts of the plan. We look to grant funding and special university funding along with our budget to help us meet our goals.

2. Implementation of the tactical plan

We have used a variety of methods to implement the tactical plan.

The University has had a five year Title III federal grant to improve our computing environment. This has supported the purchase of equipment, but perhaps the most important use of this funding has been in the training of faculty and staff in computing. Training has ranged from half day sessions to full year retraining leaves for some faculty. This grant prepared the campus for the new computing environment and also purchased some of its components.

Partnerships with our major vendors have been instrumental in getting the support we needed to develop this environment. This includes major equipment donations from AT&T.

We are able to increase our investment in the computing environment by helping departments purchase equipment that fits well into the environment. When we offer attractive prices and support services, departments are reluctant to purchase other equipment. In some cases, we also leverage computing budgets by cost sharing with departments. For example, departments had to pay part of the workstation cost when workstations were obtained for all faculty.

3. "Growing pains"

There are many "growing pains" as the Plan is being implemented. The two most notable will be mentioned here. They are (i) problems associated with incomplete systems, or as it might be called, the missing link syndrome, and (ii) the need for coordination.

When an opportunistic approach to implementing the Plan is used, a strategy of optimizing individual steps is taken without regard for optimizing the implementation of the Plan as a whole. The result is that parts of the Plan are implemented out of what would be the "ordinary" systems development sequence. For example in the UWSP environment, the basic data networking communications backbone rode on the back of the telephone system. The next logical step after the acquisition of the backbone would have been the acquisition of the connecting links, and then the processors and micro-computers that would be the end devices on the system. Because an extremely good deal came along on micro-computers that permitted us to provide a micro-computer to every faculty member who wanted one, we implemented that. The end result is that currently, UWSP has stand-alone systems on faculty desks which are only being used at a fraction of their potential because are not yet connected into the data communications network.

As a result of the network, many areas developed their own applications, and we developed a very distributed application environment. Our central application development staff was distributed out to user departments. This resulted in a great increase in productivity and user satisfaction. However, it soon became apparent that some coordination would be necessary. We had to have some standards if we were to be able run a cost effective system in which applications could share data when necessary. As a result the Communications and Computing Networking Coordinating Committee, representing the major users and those responsible for running the network, was established. This committee reports to the Chancellor's cabinet and, in effect, takes the place of a chief information officer. Distributed computing requires coordination and cooperation among the users and the committee creates a vehicle for this.

THE UWSP IMPLEMENTATION

1. Backbone communication

The backbone data communications system came as a result of an RFP for a voice and data switch. AT&T was the successful bidder and proposed their Premise Distribution System of fiber optic cabling between buildings, and four pair of twisted copper wires within buildings, terminating four pair at each telephone jack (Figure 2). Voice and data each has its own switch: System 85 for voice, and ISN (Information Systems Network) for data. The result is a complete backbone wiring system which could connect each telephone jack to separate voice and data systems. All that is required is to hang the devices on the ends.

2. Multiple levels of communications networks

Our current implementation of the network is to attach each PC to a Starlan local area network. These networks are bridged through the ISN so that the network appears to the user to be one large Starlan. Through network servers we are able to provide our users a friendly menu driven operating environment.

Computers which cannot be Starlan devices attach as asynchronous devices to the ISN. Users access these computers from their PC's by terminal emulation. The ISN provides the connectivity service between Starlan and these computers.

3. The role of the workstation

Our workstation is an MS(PC)-DOS computer. It must have at least one full-size expansion slot for a Starlan board and should have 640K of memory to effectively use the software available on the network.

The workstation is a crucial element in the one-stop computing environment. We do not have terminals on campus. All computing resources are available at each workstation through stand-alone operation, services provided by network servers, or terminal emulation.

4. The need for coordination

In a distributed environment, control is replaced by cooperation. As indicated above, all involved in running the network and developing applications must work together to insure that the system will function properly and best meet the needs of all users.

5. OSCEO as of today.

The idea of "one stop computing" has been implemented at the student workstation. All the computing resources of the campus that are used for student instruction can be reached from any student workstation. A user interface in the form of a simple "point and pick" menu system has been implemented to assist students in navigating through the applications available. Figures 3 exhibits the menu presentation and shows the current level of resources available to the students.

Very little work has been done on the faculty, department, college/dean, and academic administrative operating environments. Most of the work to date has been on constructing the base data collection systems, e.g., student records system, financial systems, library automation. These data collection systems, when operational, will provide the service devices for constructing the appropriate operating environment within the Plan.

SUMMARY AND CONCLUSIONS

1. You too can do it

Distributed Computing For The Rest of Us

While it is not possible for a university with a small computing budget to have distributed computing like the "big guys", it is possible to get most of the functionality at a fraction of the cost. Here are the principles we have followed:

- Use "off the shelf" parts. Build your computing system from commonly available pieces which can be bid competitively.

- Keep the user on the smallest computer that will effectively do the job. The economics of computing has changed. Now, the smaller the computer the lower the per station cost.

- Give up some variety so that you can support what you do have well. Users may have to give up their "pet" hardware or software, but everyone gains in the long run from a limited but well supported environment. This is best accomplished by making the environment so attractive that users are reluctant to move away from it.

- Have good strategic and tactical plans, but be opportunistic in their implementation. Do not interpret the plan and its priorities so rigidly that opportunities which arise as a result of grants, vendor relationships, or administrative support are lost. If it fits the strategic plan, do it, and pick up the pieces later.

2. OSCEO for the future

Figure 4 provides a conceptual view of OSCEO's future. Four logical networks (all running on the same physical network) serving the three main constituencies will be developed. One network will be the person-to-person communications network. Here activities such as, electronic mail, teleconferencing, and joint document preparation will take place. The other three networks will be person-to-information networks. Each of these networks will have information applications added as needed, and can be thought of as a menu pick within the operating environment, connecting the person to the data/application. Each will add one more dimension in implementing the information aspect of the Plan that was suggested in the original graphic.

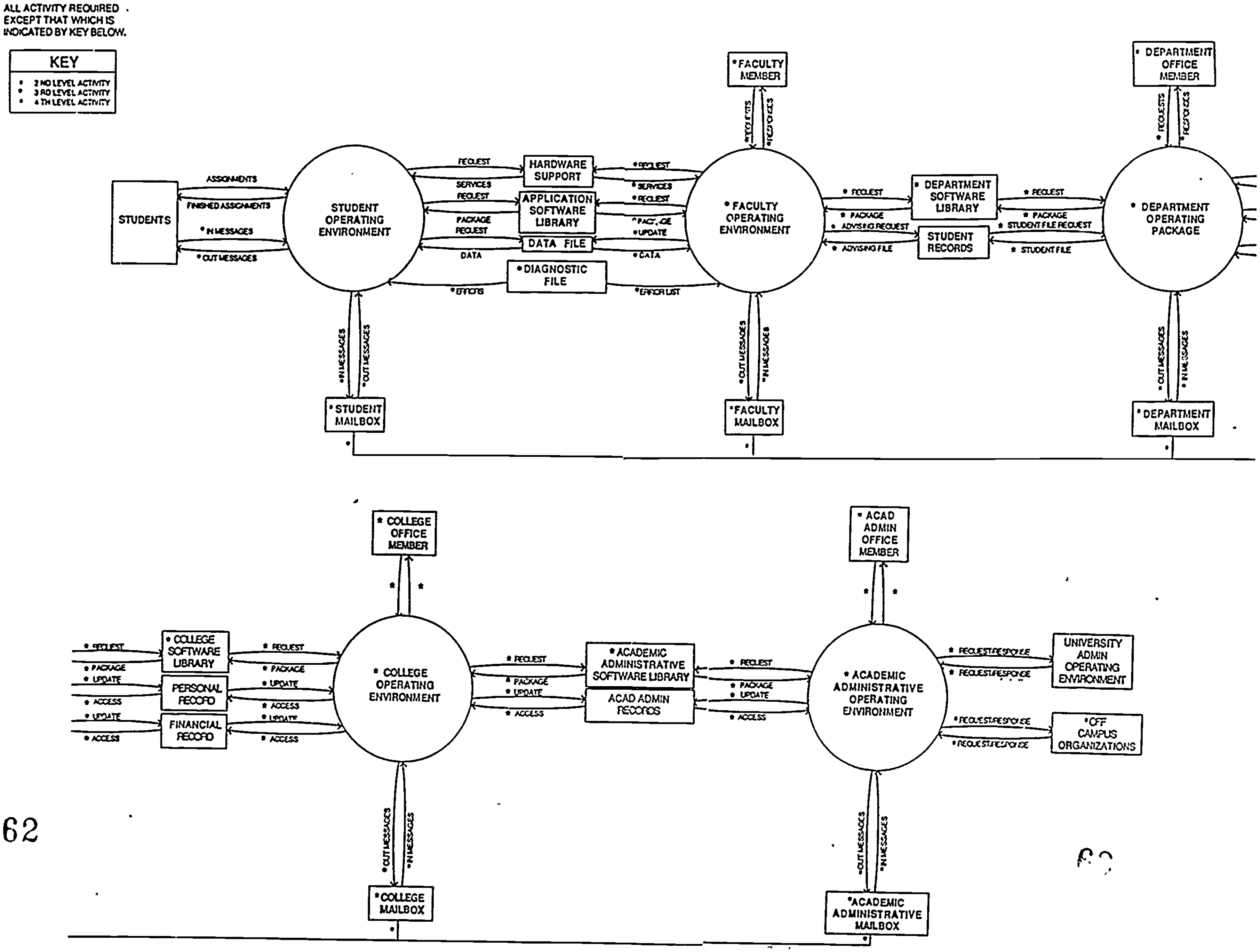
ALL ACTIVITY REQUIRED EXCEPT THAT WHICH IS INDICATED BY KEY BELOW.
KEY
* 2 ND LEVEL ACTIVITY
* 3 RD LEVEL ACTIVITY
* 4 TH LEVEL ACTIVITY
STUDENTS
ASSIGNMENTS
FINISHED ASSIGNMENTS
* IN MESSAGES
* OUT MESSAGES
STUDENT OPERATING ENVIRONMENT
REQUEST
SERVICES
HARDWARE SUPPORT
APPLICATION SOFTWARE LIBRARY
PACKAGE
DATA FILE
DATA
* DIAGNOSTIC FILE
* ERRORS
* ERROR LIST
* UPDATE
* FACULTY MEMBER
* REQUESTS
* RESPONSES
* FACULTY OPERATING ENVIRONMENT
* DEPARTMENT SOFTWARE LIBRARY
* ADVISING REQUEST
* ADVISING FILE
STUDENT RECORDS
* STUDENT FILE REQUEST
* STUDENT FILE
* DEPARTMENT OFFICE MEMBER
* DEPARTMENT OPERATING PACKAGE
* STUDENT MAILBOX
* FACULTY MAILBOX
* DEPARTMENT MAILBOX
* COLLEGE OFFICE MEMBER
* COLLEGE SOFTWARE LIBRARY
PERSONAL RECORD
FINANCIAL RECORD
* ACCESS
* COLLEGE OPERATING ENVIRONMENT
* ACADEMIC ADMINISTRATIVE SOFTWARE LIBRARY
ACAD ADMIN RECORDS
* ACAD ADMIN OFFICE MEMBER
* ACADEMIC ADMINISTRATIVE OPERATING ENVIRONMENT
* REQUEST/RESPONSE
UNIVERSITY ADMIN OPERATING ENVIRONMENT
* OFF CAMPUS ORGANIZATIONS
* COLLEGE MAILBOX
* ACADEMIC ADMINISTRATIVE MAILBOX

Figure 1

UWSP COMPUTER NETWORK

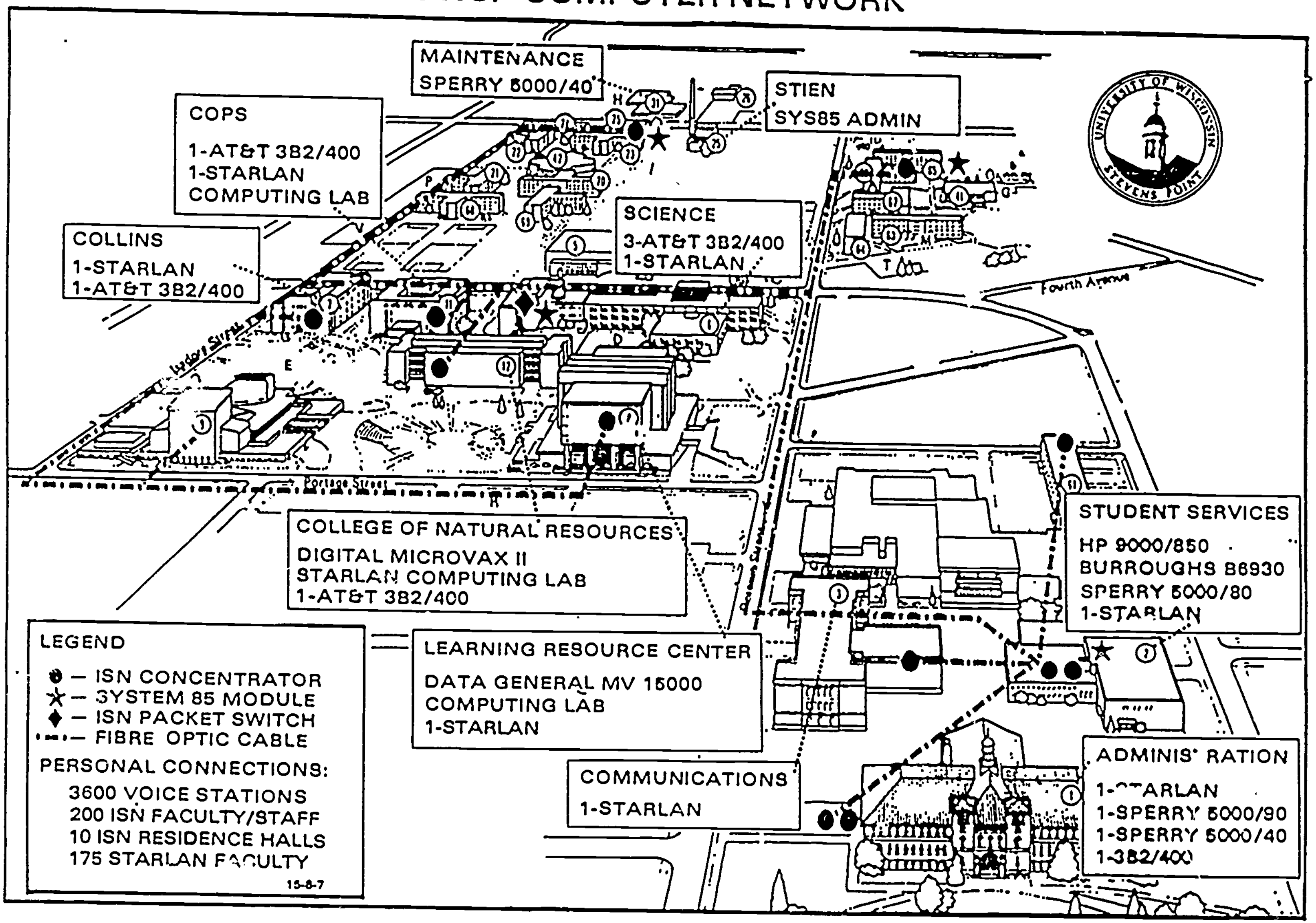

Figure 2

```
11:08:11                                                        11/23/1987
                 WELCOME TO THE UWSP STARLAN NETWORK

                            M A I N   M E N U
                            -----------------

              ==>  Program Development Menu
                   Terminal Emulation Menu
                   Application Software
                   Utilities Menu
                   Courseware Menu
                   SHART
                   Exit to DOS


F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection
```

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11:13:17                                                        11/23/1987
                 WELCOME TO THE UWSP STARLAN NETWORK

          P R O G R A M   D E V E L O P M E N T   M E N U
          -----------------------------------------------

            .==>  Previous Menu
                  FORTRAN Menu
                  COBOL Menu
                  Turbo Pascal
                  Turbo lister
                  Turbo Prolog
                  GW-Basic
                  Diskette Cleanup


F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection.
```

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11:16:55                                                        11/23/1987
                 WELCOME TO THE UWSP STARLAN NETWORK

          T E R M I N A L   E M U L A T I O N   M E N U
          ---------------------------------------------

              ==>  Previous Menu
                   EM4410


F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection
```

Figure 3

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11:17:41                                                        11/23/1987
                    WELCOME TO THE UWSP STARLAN NETWORK

                      A P P L I C A T I O N S   M E N U
                      ---------------------------------

                 ==>  Previous Menu
                      Word/Text Processing Menu
                      Data Base Menu
                      Integrated Packages Menu
                      Minitab
                      Lotus
                      List a file
                      Exit to DOS



F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection
```

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11:20:55                                                        11/23/1987
                    WELCOME TO THE UWSP STARLAN NETWORK

                        U T I L I T I E S   M E N U
                        ---------------------------

                 ==>  Previous Menu
                      Display a File Directory
                      Erase a File
                      Rename a File
                      Copy a File
                      Change The Default Drive
                      Change The Printer Association
                      Format a Diskette
                      Duplicate a diskette



F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection
```

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11:21:46                                                        11/23/1987
                    WELCOME TO THE UWSP STARLAN NETWORK

                       C O U R S E W A R E   M E N U
                       -----------------------------

                 ==>  Previous Menu
                      AIDE (8088 Assembler Package)
                      Expert Algebra Tutor
                      Language Tutor Menu
                      Microstudy
                      CIS362 Project area



F1 - Help                                         Return - Selects Item
F10 - Main Menu         Default Drive D:          ↑ or ↓ - Changes Selection
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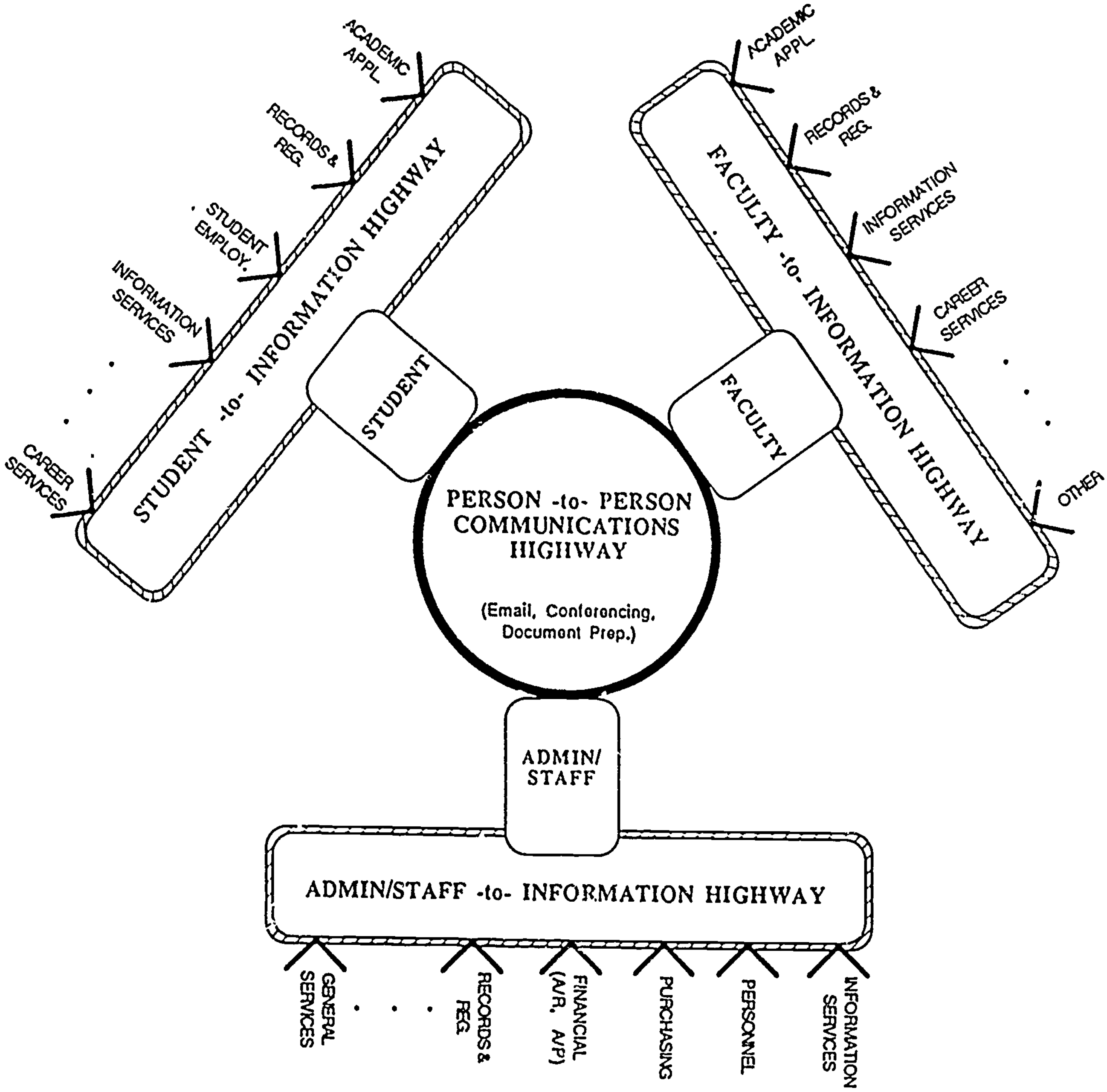
Figure 3 (cont'd)



STUDENT -to- INFORMATION HIGHWAY
ACADEMIC APPL.
RECORDS & REG.
STUDENT EMPLOY.
INFORMATION SERVICES
CAREER SERVICES
STUDENT
FACULTY -to- INFORMATION HIGHWAY
ACADEMIC APPL.
RECORDS & REG.
INFORMATION SERVICES
CAREER SERVICES
OTHER
FACULTY
PERSON -to- PERSON COMMUNICATIONS HIGHWAY
(Email, Conferencing, Document Prep.)
ADMIN/ STAFF
ADMIN/STAFF -to- INFORMATION HIGHWAY
GENERAL SERVICES
RECORDS & REG.
FINANCIAL (A/R, A/P)
PURCHASING
PERSONNEL
INFORMATION SERVICES

Figure 4

Strategies for Financing the University Communications Utility

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Abstract

Universities are realizing that in order to remain competitive, supporting information systems must provide for state-of-the-art capabilities. The problem of financing this battle with obsolescence is even more perplexing as, campus-by-campus, there is the realization that the entire communications infrastructure is significantly outdated. Recabling a campus and developing modern data, video, and telephone services can require millions of dollars in capital financing - typically $1000 to $3000 for every individual served by the utility. Concomitant increases in annual operating costs can also be significant. A university's choices for covering these expenditures include the reallocation of budget allocations, the establishment of a communications cost center with revenues from the resale of services, and the development of privately sponsored projects. In addition, improved management, improved planning, and new technologies offer opportunities for cost control and for funding of needed upgrades in facilities. These issues are examined in the context of Virginia Tech's strategy and experience in the financing of its communications network development activities. Projects include the recabling of the campus. the development and interconnection of departmental local area network, the development of private long distance capabilities, the development of the Virginia Tech - Corporate Research Center Teleport, and the development of other voice, data, and video communications capabilities.

The Price of Competitiveness

We gave a presentation at CAUSE84 on some of the technological choices relevant to the establishment of a university communications utility. We concluded that talk with the following statement:

"Risks are inherent in aggressively pursuing these opportunities. But perhaps the most significant risks belong to those not yet aware of problems inherent in old communications infrastructures relative to current and future demand. Their risk will be realized in terms of lost competitiveness."

Following that talk, we were asked by several individuals, "But how are you paying for that utility?" We will answer that question by briefly reviewing the rational for our efforts, the financing strategies utilized, and the application of that strategy in several communications development projects.

Strategic Thinking

Communications infrastructure affects institutional competitiveness. The long-term effect on competitiveness is determined by how efficiently and effectively that infrastructure shrinks distances and stretches time. One of the opportunities for colleges and universities is to reduce the cost of communications. However, in the increasingly competitive setting of higher education, the more important opportunities are to increase market accessibility and to create service differentiation.

Strategic Financing

Since Virginia Tech's Communications Network Services organization is operated as a cost recovery utility, two questions dictate its "strategic thinking." First, what facilities and services should it develop in order to advance the University's competitiveness? And, second, how is it going to pay for these facilities and services? The "strategic thinking," therefore, tends to be dominated by "strategic financing" issues.

Our short-term goals have been (1) to control costs, (2) to build the competence of the communications support organization, and (3) to educate constituencies about the opportunities and risks of being leading edge players in the communications game. The long-term goals have been (1) to develop a basic network architecture which would be functionally robust and adaptive to changing technology and (2) to create a financially stable, self-supporting utility. Appropriate and timely strategic positioning - with respect to making reasonable technological choices and to getting into the right markets - determines long-term financial stability.

Because of the self-supporting standard, every project and every organizational activity must contribute to the financial integrity of the utility. That "self-supporting standard" has been the price of aggressively developing our communications infrastructure - and, therefore, the price of improved competitiveness.

Financing Alternatives

Financing alternatives vary with the purpose and temporal aspects of the expenditures being financed. These may be classified as either operating expenditures or capital expenditures.

Operating Expenditures

Operating expenditures include all of those annually recurring costs necessary to support the communications utility. Included are costs for personnel and training, costs for maintenance, spare parts, contractual support, costs for leased services including video programming, long distance communications links and satellite time, costs for replacement and enhancement of facilities, and debt service costs.

Financing sources for operating expenditures are limited. For instance, it is generally not possible for a university to borrow funds to cover operating costs. The exception is the aggressive management of cash flow in order to cover temporary shortfalls in operating monies.

Operating expenditures are normally covered within a university one or more of three ways:

- "off-the-top" budgeting of the communications utility;
- connection and usage fees to the users of the utility;
- resale of "surplus" services to non-university users.

At most universities, tradition has led to "off-the-top" support for basic data communications services and usage charges to the user of telephone services. At Virginia Tech, however, users of data services are billed at an average rate of $25 per connection per month. Prior to the implementation of our own facility, telephone services have been charged directly to the users at an average price of $33 per station per month. Long distance services are billed to the user at an average rate of approximately 32 cents per minute.

Resale potential, including sales of voice, data, and video services, may be considerable. Potential buyers of these services include on-campus students. However, this market may also include off-campus students, non-university faculty and staff usage, private businesses, especially those in a university research park, and other public sector users, including other colleges and universities.

Capital Expenditures

Capital expenditures are so-called "one-time" costs. These are the monies that cover the "up-front" costs of equipment. This equipment, over its technological life, is expected to enhance productivity. In a utility, capital expenditures are evaluated in terms of revenue generating potential. Examples of capital expenditures include those for switching facilities, cable plant, satellite and microwave transmission facilities, network operations centers, communications rooms, telephones, and local area network hardware and software.

Financing options for covering capital expenditures within a university include the following:

- "off-the-top" allocations for specific projects to the communications utility;
- sponsored development funds from vendors, public agencies, and foundations;
- borrowed funds.

Reallocation of monies within a university may be the first choice for financing an investment in communications facilities. Most computer procurements are financed this way. However, there is little tradition for squeezing large amounts of money out of scarce university resources for communications projects. Newly established university communications organizations may find the competition for funds extremely intense.

Notable examples of sponsored development of a portion of required communications facilities include the University of Pittsburgh's "Campus of the Future" project, and projects at MIT, Carnegie-Mellon, and other universities. These projects have in common the considerable leverage of already established communications development efforts. The communications industry is quite competitive. Universities have the opportunity to use resources (personnel, funds, networking expertise, etc.) committed to projects and that competitive market to create joint development and sponsored development opportunities. Figure 1 summarizes current sponsored and joint development communication projects at Virginia Tech.

Figure 1: Sponsored Projects: FY 87/88 - FY 88/89

These are the current development projects which go beyond the ongoing effort to administer the communications utility.

Virginia Research Network: Funded by the National Science Foundation, for approximately $240,000. among researchers within the state, as well as providing access to external computing resources.

Computer and communications vendors are sponsoring multi-faceted joint development projects with Virginia Tech, providing over $2,400,000 in funding and equipment. The areas being investigated include:

- **Network Administration/Operations Center - This project involves developing a highly-distributed network administration center, to handle all of the facets of administration of a large-scale data communications, telephone and cable-TV company.**
- **Bridges and Backbones - Virginia Tech, in cooperation with product development laboratories, is investigating methods to create "bridges" between separate networks, as well as methods of developing a campus-wide "backbone" to tie all networks on campus together.**
- **The Electronic Library - Investigating ways of providing enhanced, remote access to libray services.**
- **Satellite Communications System Test Bed - The initial projects are to develop facilities for remote operation of the Virginia Tech - Corporate Research Center Teleport and to test a bridge linking two 802.5 networks.**
- **Electronic Mail for Every Student - This project is intended to create an electronic mail system that can be used by every student, faculty member, or administrator, regardless of what computing system they choose to use.**

Several alternatives exist for borrowing funds. These options are discussed below. The debt service on the borrowed funds could be paid from an annual "off-the-top" allocation of funds by the institution or as an annual operating cost recovered through fees to users.

Borrowing Alternatives

Because of the highly competitive communications market and the attractiveness of the college and university market, many vendors offer extraordinarily attractive financing options as a part of a major communication procurement.

Alternatively, newly established university communications utility may be to borrow funds from the institution or from a foundation associated with the institution. This second option becomes especially viable if a strong business case can be developed showing full recovery of the investment in a reasonable period of time and at a reasonable interest rate. The initial development projects by Virginia Tech's communications organization were financed in this manner. The University's finance and budget organizations have been extraordinarily innovative in obtaining funds for this purpose.

State institutions may have revenue bonds as an available financing option. This is the financing method chosen by Virginia Tech for its most recent communications projects. In gaining the support of the state for this financing, a strong business case had to be developed for each of the projects. These business cases were required to reveal realistic projection of capital and operating costs. They were also evaluated in terms of the reasonableness of revenue projections. In Virginia, "reasonableness" means extraordinarily conservative - a standard with which, in this case, we were very comfortable.

We borrowed $16 million via revenue bonds. We have been asked, "Doesn't this limit the technological choices available for the communications utility? Why didn't you borrow more?" The answer to the first question is that we are always constrained by what we have to spend; however, our job is to maximize what we get for that $16 million. The answer to the second question is that current expenditure streams for communications services within Virginia Tech, perceived to be near some limit, dictated the amount we could borrow.

Two borrowing options should be examined further by those needing financing for communications projects. The first is a lease-purchase agreement financed through a 3rd party financial organization (e.g. annual rates at -1%). A second option, which appeared available for certain types of communications projects (e.g. the development of teleport facilities) and to private institutions, was development bond financing. We have not evaluated either the availability or the viability of these two options since the last tax reform act.

Business Cases

Virginia Tech's Communications Network Services organization is responsible for the provision of all communications services (voice, data, video) to the University community. The major goal is to provide communications services which maintain and enhance the University's leadership position in the delivery of instructional, research, and extension services. To accomplish this goal, a concerted effort has been made to maintain a "leading edge" position with respect to advances in communications technology.

By fiscal year 1988/89, Virginia Tech will have installed communications facilities which provide state-of-the-art voice, data, and video services. As noted above, these facilities are being financed by $16 million in revenue bonds.

Digital Switch

A salient component of the project is the acquisition of digital switching facilities to integrate voice and data communications over our distribution system.

Perhaps the best way to define this initiative is in terms of what individual users of the system will see and experience. Most of the current telephones on campus, including the rotary dial, multiline sets, will be replaced with modern, multibutton/multiline digital sets. Each digital set will have numerous programmable buttons allowing users to tailor the telephone for individual needs. Such needs may include the ability to have multiple lines, to hold or transfer calls, to initiate conference calls from pre-defined lists, to query voice mail messages, and many others. All of the phones will have an intercom capability, a message waiting indicator, single button speed dialing, automatic redial, and line status indicators. The entire system, with its anticipated low-cost long-distance links, will be cost recovered through the per telephone station charges and through an overhead charge per minute for long distance usage.

A primary reason for specifying digital telephone sets is to provide for simultaneous transmission of voice and data over the same communications system. One way the data connection can be provided is through a connector on the back of the digital telephone set. An obvious advantage of this feature is the ease of data communications installations.

This project is allocated approximately $9 million for the implementation of an IBM digital switch and telephone system. Some of the design, management and installation work is being performed by Virginia Tech personnel.

The business case consisted of projections of variable costs and revenues over the technological life of the switch and station equipment. In order to simplify our explanation, we are presenting numbers based on a point-in-time picture of these projections. Figure 2 shows that at that point, we will be supporting 16,700 stations - 7,700 data connections and 9000 telephone connections. The cost component of our model, represented in Figure 3, includes annual debt service, operating costs, maintenance costs, and access costs. The debt service is calculated for a $9 million investment at 6% interest for 7 years. The difference between the $1,674,000 collected and the actual payment scheduled over 15 years represents our replacement fund fo. the switch and station equipment. The $675,000 in operating costs are primarily personnel costs related to the operation of our network control and network administration centers. The $1,125,000 for maintenance is the estimated cost, including personnel cost, of our self-maintenance program.

For the state of Virginia to approve the revenue bond authorization request, we were required to show that revenue exceeded projected costs of the utility. For our internal analysis, we were more concerned with the projected rate we would have to charge users. Figure 5 shows a rate of approximately $22 per month per data or telephone station. Given that our projected rates for connections was less than the average rate paid for communications connections, this project passed both the "revenue" and the "rate" tests. (Note, however, that we do not actually set a rate based on an analysis of a particular service in isolation from all other services provided by the utility. The Communications Network Services Department recommends a rate to the University Controller and Budget Office, which may either approve the rate or make adjustments to it based on University needs.)

Figure 2 Digital Switch Project Customers

STATIONS:		
	DATA	7,700
	VOICE	9,000
	TOTAL	16,700

Figure 3 Digital Switch Project

CAPITAL COSTS:		$ 9,000,000
Annual Debt Services		$ 1,674,000
OPERATING COSTS:		$ 2,800,000
	Operations	675,000
	Maintenance	1,125,000
	Access	1,000,000

Figure 4	Digital Switch Project	Recoveries
STATIONS:	16,700	
OPERATING COSTS:	Per Yr.	Per Mo.
$ 2,800,00 / 16,700	167.66	13.97
CAPITAL COSTS:	Per Yr.	Per Mo.
$ 1,674,000 / 16,700	100.24	8.36
TOTAL	267.90	22.33

Cable Plant

Another key aspect of this project is the development of a communications distribution infrastructure (i.e. cable and wire plant) that provides greater information transfer capacity. It is to be significantly less costly to maintain, and will be vendor independent with respect to digital switching systems and termination equipment (i.e. telephones, modems). The implementation of "The Virginia Tech Cable Plant Specification" will facilitate the development of local office networks and their interconnection with University network facilities. These local networks would provide megabit data transfer rates to faculty workstations. All data communications are presently recovered through a charge per data connection.

This project involves developing a long-range plan for networking, at very high rates of speed, for the entire campus. In addition, assistance and guidance will be provided to individual departments in the development of their own departmental network and the connection of that network to the University "backbone". By developing these individual networks in a consistent and standardized manner, interconnectivity will be greatly enhanced.

This project is allocated approximately $4.5 million for the implementation of the "The Virginia Tech Cable Plant Specification." All of the design and management and most of the installation work are being performed by Virginia Tech personnel at a savings of several million dollars.

The business case for the cable plant is very similar to that used for the digital switch. What is being "sold" to the customers of the utility is connections to the cable plant via an "outlet." Figure 5 shows the projected number of outlets at one point in the life cycle. It also shows the estimated costs. Our budget for interbuilding projects is $2.5 million. With about 20 percent of the projects completed, we are still expecting to be within those allocations for the entire project. Under annual operating costs, we have $90,000 allocated for personnel and material costs associated with maintaining the cable plant and $360,000 allocated for expansion and enhancement of the cable plant. The projected rate for an outlet, shown in Figure 5, is $3.17 per month. This would be added to the rate for connections to the digital switch or for a local area network connection.

Figure 5	Cable Plant Project	Recoveries
OUTLET CUSTOMERS:	TOTAL	24,000
OPERATION COSTS: (Includes expansion & maintenance costs)	Per Yr.	Per Mo.
$ 450,000 / 24,000	18.75	1.56
CAPITAL COSTS: (Annual Debt Service on $4,500,000)	Per Yr.	Per Mo.
$ 463,500 / 24.000	19.31	1.61
TOTAL	36.06	3.17

Video System

The campus-wide wiring infrastructure, the Virginia Tech Cable Plant, will include cable to all workspaces (offices, dormitory rooms, and classrooms) for video. The project will provide a rich array of video programming on this broadband cable system. Current plans are ,or 35 to 40 channels of programming providing access to instructional programs, teleconferences, and informational services. The video system costs are to be recovered through a charge per connection in dormitories and offices.

Video System: This project is allocated approximately $1.5 million for the implementation of a 64 channel video system. All of the design, management and installation work is being performed by Virginia Tech personnel.

Figure 6 shows the projected costs, revenues, and rate for video service. The difference between the calculated rate and the actual rate of $8 per month represents the University's subsidization of this facility. The rationalization for this subsidy is that classrooms will be provided with video facilities as part of the project. Therefore, dormitory students and office users of the system will be paying for the classroom related facilities.

Figure 6	Video System Project	
CAPITAL COSTS:	$ 1,500,000	
Annual Debt Service	$ 279,000	
OPERATING COSTS:	$ 540,000	
CUSTOMERS:	5,000	
OPERATING COSTS:	Per Yr.	Per Mo.
$ 540.000 / 5000	108.00	9.00
CAPITAL COSTS:	Per Yr.	Per Mo.
$ 279,000 / 5000	55.80	4.65

Long Distance Services

With a significant degree of integration of voice, data, and video services over this University network, it is economically feasible to develop private, long distance communications links to areas strategically important to the University. For example, Virginia Tech will develop a link between Blacksburg and northern Virginia, and possibly Richmond, which could be fully utilized over a 24 hour cycle for video, data, and telephone services. Such a link will cost significantly less than the amount the University is currently paying.

Figure 7 presents one view of our analysis of the long distance services project. It reveals our expected average cost, including the recovery of capital facility costs, per minute of this service. The projected price for these services is considered reasonable given our current average price of 33 cents per minute. (Our current average rate is calculated by including the estimated cost of unsuccessful calls - no answer, busy - into the rate provided us by our primary vendor.) Excessive recoveries would be used to reduce the other communication services, such as connection to the digital switch.

Figure 7 Long Distance Services Project

ADMINISTRATION	6.25 million minutes	
	+/- .94 million minutes	
STUDENTS	7.29 million minutes	
	+/- 1.82 million minutes	
TOTALS	13.54 million minutes	
	+/- 2.79	
Projected Rate versus Cost:		
	Average Cost per minute	.20
	Average Rate per minute	.28
	Difference	.08
Potential Surplus Recoveries:	$ 1,083,000	
	+/- $ 223,000	

Satellite Transmission Facilities

The Virginia Tech - Corporate Research Center Teleport, now consisting of a 9 meter C-Band transmit/receive earth station, is being expanded to include two additional facilities: a multi-feed receive-only earth station, which will receive programming to be distributed over the new Virginia Tech video system; and a KU-Band transmit/receive earth station, which will be utilized, experimentally, to provide communications capability to Northern Virginia, as well as by the Satellite Engineering group in the Electrical Engineering Department. This project is allocated $1 million. Also, a feasibility study is underway for the development of a Blacksburg - Europe link via an Intelsat satellite facility.

Five year life cycle costs for our C-band transmission facility are summarized in Figures 8 and 9. The service being sold is video transmit time in hours. We transmit graduate engineering and other courses, programs supporting our extension mission, and private sector transmission such as athletic events. Our actual usage for the past year was within 10 percent of the model projection (Figure 8). Figure 9 shows the required revenues and the calculated rate per hour for the facility. The 5-year average rate is consistent with the market price for such services. Our actual cost projections were high by about 15 percent. Also, we now are convinced that a seven year life cycle would have been appropriate, further reducing the the potential rate.

Figure 8 RATE MODEL: C-BAND TRANSMISSION FACILITY

Usage Forecast

	86/87	87/88	88/89	89/90	90/91	TOTAL
Instr	720	810	900	990	1080	
Test	60	72	72	72	72	
Total	780	882	972	1062	1152	4848
Other Public	180	270	383	589	943	
Private	30	45	90	120	120	
Sub-total	990	1197	1445	1771	2215	7618
Overhead	248	299	361	442	554	1904
Total	1238	1496	1806	2213	2769	9522

Figure 9 RATE MODEL: C-BAND TRANSMISSION FACILITY

Rate Calculation

	86/87	87/88	88/89	89/90	90/91	TOTAL
Personnel	$36843	$46774	$59268	$68930	$72378	$284193
Other Direct	$73456	$75606	$77864	$80234	$82723	$389883
Indirect	$5122	$5895	$6839	$7609	$7989	$33454
Depreciation	$127520	$127520	$127520	$127520	$127520	$637600
Total	$242941	$255795	$271491	$284293	$290610	1345130
Hours	990	1197	1445	1771	2215	7618
Rate/hour	$245/hr	$214/hr	$188/hr	$161/hr	$131/hr	$177/hr

Conclusion

Through the careful restructuring of the funding methods for current communications services, the aggressive use of financing options, and the application of comprehensive development plans, communications costs for an institution with a communications infrastructure that reflects the latest in available technology do not necessarily have to increase. Figure 10 shows our proposed rates for fiscal year 1989-90 for services based on facilities currently being implemented at Virginia Tech. Will departments be paying a smaller portion of their budgets for communications services? With our improved capabilities we think that current total communications expenditures will actually increase. This is because some departments do recognize the relationship between their competitiveness and their ability to transport information.

Figure 10 **Rates for Service**

	Market/Current	Proposed
TELEPHONE	$ 33	$ 25
DATA	$ 25	$ 20
VIDEO	$ 14	$ 8
Long Distance	.33/minute	.28/minute
CBand Transmit	$225/hour	$150/minute

References

Blythe, Erv, "The Cutting Edge of Network Technology," CAUSE/EFFECT, Jan. 1986.

Chew, Robert, "Value-Added Network Services For Universities," CAUSE/EFFECT, Mar. 1987.

Lilly, Judy L., "Organization for Communications Network Services," CAUSE/EFFECT, July, 1985.

Kumar, Prem, "Telecommunication Planning," Graduate School of Business, University of Pittsburgh, July 1987.

Toner, Michael A., "Why Do Nothing With Your Telephone System Will Be Expensive," CAUSE/EFFECT, May 1986.