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ABSTRACT

Seven papers are presented from the 1994 CAUSE conference track on networking and information sharing among higher education institutions. The papers include: (1) "Integrated Statewide Infrastructure of Learning Technologies," focusing on the University of Wisconsin System (Lee Alley); (2) "Designing and Implementing a Network Architecture Before It Becomes Obsolete," which notes relevant issues faced by the University of Pennsylvania (Noam H. Artz and Ira Winston); (3) "Future-Proofing Your Campus Network," which describes the installation of a structured cabling system at Brevard Community College (Florida) (John Walker and Lew Brashares); (4) "Multi-Network Collaborations Extending the Internet to Rural and Difficult-to-Serve Communities," which focuses on asynchronous transfer mode (ATM) Internet technology (E. Michael Staman); (5) "ATM: Reality or Pipe Dream," which focuses on ATM development at Washington University (Missouri) and the University of Nebraska-Lincoln (Douglas Gale and others); (6) "Personal Data Delivery on Campus Networks," which discusses developments at Cedarville College (Ohio) (David L. Rotman); and (7) "Implementing a Campus Networking Infrastructure," which examines developments at Southern Methodist University (Texas)(Barbara Blair Wolfe). (Some papers contain references.) (MDM)

ED 401 860

New Opportunities for Partnering

CAUSE 94

Track IV
Networking

Coordinator: Douglas S. Gale

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Proceedings of the 1994 CAUSE Annual Conference

November 29–December 2, 1994
Walt Disney World Dolphin
Orlando, Florida

ERRATUM:

The text of papers IV-4, "Multi-Network Collaborations: Extending the Internet to Rural and Difficult to Serve Communities," and IV-5, " ATM: Reality or Pipe Dream," have been reversed. Pages now numbered IV-5-2 through IV-5-8 should have been numbered IV-4-2 through IV-4-8, and pages now numbered IV-4-2 through IV-4-11 should have been numbered IV-5-2 through IV-5-11.

Integrated Statewide Infrastructure of Learning Technologies

Lee Alley, Ph.D.
Associate Vice President for Learning and Information Technology
University of Wisconsin System Administration

The University of Wisconsin System includes all public higher education in the state, excluding local technical colleges. The UW System has about 120,000 students on 26 campuses. There are two doctoral degree granting institutions and ten comprehensive universities, each headed by a Chancellor. An additional institution, whose chief executive is also a Chancellor, is UWExtension. Finally, the UW-Centers is a single institution, also under a Chancellor, with 13 two-year academic campuses throughout the state. These Centers campuses feed into the other UW institutions.

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Foundation: Why are we doing this?

Consider the case of Chris, a student of the University, and an employee of one of the state's leading firms. Her employer gives her one afternoon off each week to drive to the nearest campus of the university system, to take a course in Japanese language.

Let's trace a recent afternoon at the campus for Chris. Each Wednesday afternoon she first attends the one hour lecture on Japanese. Afterword, she goes to the library to copy information needed for a student team project for the course. Then she stops by the language lab for an hour to use some special software packages that help practice Japanese reading and writing skills. From there she hurries to the Student Services Center for an appointment with an advisor who will help her go over her overall degree plan and progress toward graduation. Then it's off to the campus computer lab, to work on her part of the term paper for the student team project. As the last on-campus task of the day, she walks over to the student union to meet with her fellow students on the project team.

From our "customer's" point of view, we have been in the distance education business all along, with students leaving family, work and home behind to go off to college in some distant place. But things are changing. Growing numbers of our citizens now expect, and need us to deliver a full-spectrum educational experience closer to home, job and family.

This market demand, or at least anticipation of it, is spawning increasing numbers of ventures to sell education delivered over networks. But there is a difference between "education," "knowledge," and "information." Selling Internet access to databases and other recorded information can be just that, information. Use of live or recorded video of lectures might offer a higher level of information, along the lines of what we might call packaged knowledge. But what Chris is doing in her several separate visits to class lecture, library, student advising, laboratory, computer lab, and a meeting with fellow students, more closely resembles our *traditional* sense of a rich educational experience.

That is all well and good, as far as it goes. It recognizes what we have all come to realize, that a university <u>is</u> an information system. But the traditional university campus is <u>not</u> an "integrated information system." As we look to the future, for both on-campus and off-campus, what we look for in our learning technologies is an integration of the diverse traditional elements of the university information system (libraries, computer labs, etc.).

Our <u>objective</u> is:

> *Better access to higher quality learning for all our students, both on and off campus.*

Our <u>vision</u> on how to accomplish that is:

> *Integration of digital versions of the full spectrum of traditional instruments of education, delivered to the student's multimedia desktop computer.*
> *This includes concurrent multimedia access to:*
> > *digital libraries;*
> > *automated and simulated laboratories;*
> > *online classroom instructional media;*
> > *telecommunications for team work;*
> > *high level interaction with professors; and*
> > *student support services.*

But not all entrants into the higher education business share these objectives and visions. The historical national infrastructure of universities has been tied together by their cross-cutting academic disciplines, professional membership societies, and institutional consortia. This is now joined by an interstate commerce in higher education. Venture capital now hungrily stalks new markets for digital delivery of a wide definition of "information", including Hulk Hogan reruns on demand, home shopping, and "education sound-bytes" via pay-per-view.

Meanwhile, American industry has finally discovered the commercial value of education as a method to leverage existing "human capital" in the work force. In the "information age" education will certainly not provide the basics of food, clothing, etc. However, it will provide an essential boost to an economic system which depends increasingly upon a more highly educated workforce. Industry does not often wait for the pace of innovation in Universities. They want it just in time, just in that place, and just that way. There appears to be an emerging trend toward large employers, especially high tech firms, going out and buying up universities. This "vertical integration" of education into the corporate structure will measure the true valuation industry places upon higher education. Both in terms of amount of value, and in what type of education is valued.

Universities, especially public institutions, are not in the business of distributing information as a simple one time product. Our students are our customers, not just a product. Universities are not simply value-added resellers of high school graduates. Our "ace in the hole," our strong suit in dealing with those who would offer simply video taped "freeze-dried education," is that we are uniquely able to offer a fully rounded educational environment. An integrated educational environment that coordinates all facets of a systematic education: lectures; library and computing services; student services; lab access; etc.

The components of this full-spectrum educational environment being developed by the University of Wisconsin System are described in the following section. These components are more "programmatic" in the sense that they focus on end-user service applications. We will describe a number of projects for building the information technology infrastructure needed to support this systematic approach to education. In aggregate, about $20,000,000 is being spent on this coordinated program of upgrades to the information technology infrastructure.

Building Blocks: What are the usage components being integrated?

The primary end-user component applications that drive the information technology infrastructure are described below. These component applications are all considered essential parts of the overall educational environment, and therefore, strategic plans for any one application component are interdependent with the plans for all the other components. The spectrum of "educational environment applications" is made up of:

1. Classroom instructional technology and media
2. Library automation and access
3. Automated student support services
4. Automated and virtual laboratories
5. Distance education
6. Business support services

An important factor in all these application areas is Systemwide sharing and coordination. The key to such a statewide collaboration is the availability of inter-campus networking facilities. At present these facilities vary by application, with some provided over the Internet, and others via dialup or leased telephone lines. The University System Administration, and the individual institutions, have invested substantially in a number of inter-campus networking arrangements. These include: WiscNet, the state's primary Internet service; WisLine, a permanent-line audio conferencing system used extensively for business meetings and instructional support; WisView, a sophisticated audiographics system for instruction; a number of emerging regional video conferencing systems; and statewide coordinated public TV and public radio educational programming.

At the (last mile) campus level, the UW System is completing two major projects to place a fiber backbone network on each campus. These interconnect campus buildings. In addition, the UW System is in the process of major upgrades to intra-building wiring in the highest priority buildings. A Systemwide wiring standard has been developed to provide for the uniformity and minimum performance of these wiring projects.

Classroom instructional technology and media includes the electronic systems used directly in, or in direct support of, classrooms. This includes items such as networked classroom computers, display equipment, connections to the campus network, instructor podium system, as well as the pre-developed digital courseware that "runs on" those systems. This courseware includes both software and stored information or instructional modules.

At the core of the overall strategy, UW System has been fortunate to establish an important ongoing funding stream of about $5 million per year for classroom modernization. Most of these modernization projects involve substantial upgrade of the classroom instructional technology and media.

All the chief librarians of the UW System institutions, and the UW System Administration's Office of Learning and Information Technology work in close collaboration. The UW System succeeded in obtaining a major legislative appropriation for a Systemwide upgrade of the institutions' library automation systems. As part of this project, the librarians have committed to working closely together toward using the same library automation system (NOTIS). The UW System libraries have begun implementing a shared, distributed library for all students and faculty at all the campuses to have equal access to. In addition, this has allowed coordinated selectivity of individual institutions to decide which subscribed digital holdings (such as periodicals indexes) to mount locally, which to leave to another campus to mount, and which to access from commercial providers and peer institutions in other states.

The UW Office of Learning and Information Technology has recently arranged for several campuses to proceed with a pilot project for statewide full-text/full-image document retrieval. This project will examine usage behaviors, service quality and user satisfaction, network capacity requirements, costs, etc.

The UW System takes extraordinary pride in reflecting the culture of the state in providing the highest quality support services to its students. An important aspect of the UW System has been a concern for the needs of students transferring between institutions within the UW System. For this reason, the UW System has established a uniform Systemwide Transfer Information System. A host Gopher machine has been placed at each UW institution, and standardized Gopher-based reference information is being established at each site for students to access remotely. At the end of Phase I, the TIS provides simple transferability and equivalence cross references between UW institutions. Subsequent phases will bring added user-customized intelligence to the system.

A companion to the Transfer Information System includes the Degree Audit System being installed at a number of institutions. This helps students evaluate their progress toward degree at their home institution, in addition to how they would fare if transferring to another UW institution.

The UW System has recently given formal commitment to standardizing on the SPEEDE national standard for electronic student transcripts and associated inter-campus processing transactions. This will help Wisconsin citizens with inter-campus transfers between UW institutions, as well as aiding in the students' holistic educational experience, by inter-connecting the student records at K-12 and technical college campuses.

An important basis for these consistent UW Systemwide student support services is the ongoing program for stewardship of "common systems." A common systems committee was established recently, to help identify and recommend those learning and information technology systems which should be established for uniform Systemwide usage.

More and more of the laboratory experiences of students is computer based. This lends itself to increased use of "virtual electronic laboratories" for some student instruction. As these labs become more automated, or simulated, it becomes more and more realistic to provide student access from off campus, from other campuses, and Systemwide. There is often a blurred boundary separating "instructional classroom system" from "virtual electronic laboratory systems." Some examples of these remotely accessible electronic laboratory experiences include: physiology of the ear and computer simulation of hearing losses; on-screen dissection of laboratory animals, with real time feedback on technique and student observations; experiments in musical composition; and language practice and style analysis.

However, while there is considerable progress being made in isolated, anecdotal cases of remotely accessible automated laboratory systems, there has not yet matured a critical mass of these systems to constitute a major percentage of such laboratory experiences required for the typical undergraduate. This is an area we are watching closely, and expect to see much progress in the future. While the advent of low cost live interactive video does offer some prospect of added remote access to (especially hostile environments) lab practices, the availability of truly unmediated remote access to automated lab experiences is still quite far off in many areas. Meanwhile, we will continue to pursue those areas of progress as they come into existence.

As in most other states, Wisconsin's leaders in government, business, and higher education have begun to expect significant improvements to equal access to education "any time, any place, in any form." However, it is likely that no state has a deeper, longer term tradition of commitment to support of the individual citizen. Wisconsin had the first public radio station. The first Public Service Commission in the nation was established in Wisconsin, reflecting the state's commitment to the social agenda of making public services equally available to each citizen. Few statewide multi-campus university systems have a separate institution, headed by a chancellor, dedicated to extension and statewide outreach.

This attitude of statewide equal service to all is reflected in "the Wisconsin Idea." This ideal holds that "the only boundaries of the University are the boundaries of the state." As such, the recent advances in telecommunications technology engineering, costs, regulation, and public expectation have found an extraordinarily fertile ground in Wisconsin. The primary budget initiative for the UW System in the current legislative appropriation cycle was for distance education, with aggregate funding requests totalling about $30 million. This initiative includes new building facilities, electronic systems for distance education, faculty support staff, course redevelopment funds, and funds for faculty development.

Meanwhile, a number of distance education telecommunications facility development efforts have already been organized and underway. Several UW institutions have joined or helped form regional distance education consortia with nearby K-12 and technical college campuses. The UW-Extension organization has re-allocated a major portion of ongoing funding to help establish a Systemwide distance education "common ground" network.

Finally, the UW System has begun to consolidate a number of the most consistent and uniform "backroom" administrative systems operations. The University of Wisconsin Processing Center was established recently, to provide Systemwide payroll, accounting, personnel and other automated services. This UWPC is governed by a board consisting of institutional business officers and also the UW System Office of Learning and Information Technology. It is expected that additional administrative operations which are done at the UW System Administration will be migrated to this consolidated processing center.

<u>**The Players**: Who is doing this, and how?</u>

How does all this tie together? First and foremost, we must recognize that the student's view of the university is one of the few which spans the holistic collection of our various components. While we staff and faculty inside the structure tend to see the institution in limited slices, fragmented by the organizational hierarchy, the student comes into direct contact with every major component of the university.

Therefore, one of the best ways to integrate the whole of our various information technology activities is to see the university through the eyes of our students ("customers").

However, besides this conceptual discipline, a more concrete forum is needed for stewardship of the whole of information technology. The UW Learning and Information Technology Executive Council was recently established. This LITEC's role is three fold: Systemwide plans, policies, and standards for information technology. LITEC was carefully designed to be program-driven, with cognizance of technological considerations. Therefore, LITEC membership includes users of information technology, in student services areas, business services, and libraries, as well as chief academic officers. In addition, membership includes information technology experts in computing, educational media, distance education, and library automation. Because of the close cooperation with other state agencies related to K-12, technical colleges, etc., those non-UW agencies are represented as well.

The nature of things in Wisconsin is such that the University acts in closer collaboration with peer state agencies than in most states. In addition, the telecom providers have taken a very proactive role in the state.

Wisconsin's Education Communications Board is charged with coordinating statewide telecommunications for all public education. Although the ECB's prime early mission focused on public broadcasting, recent expansion of the role of "telecommunications" in our public affairs has brought the ECB into even greater prominence.

In Wisconsin, the Department of Administration plays a very central role in procurement, contracting and aggregation of statewide telecommunications arrangements for education and other state agencies. The UW System is cooperating with the Department of Administration on a statewide project to redesign and recontract for most of the telecommunications in the state from roughly 1997 through 2005. This "Bignet" project is expected to consolidate a number of previously separate network arrangements, for which their respective technologies have begun to converge. This major statewide networking initiative is expected to involve about $150,000 over a five year period.

Wisconsin is served by about 150 telecommunications companies. Of these, Ameritech provides roughly 87% of the phone lines in the state, in 17% of the state's land area. GTE is second largest provider. The Wisconsin Independent Telecommunications Systems is an alliance of these numerous providers. Both WITS and Ameritech have begun to play a substantial role in the state, by virtue of a number of very progressive partnership initiatives, as well as in their interactions with State government in redrafting telecommunications regulations.

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University of Pennsylvania

CAUSE94

November 28, 1994

Designing and Implementing a Network Architecture Before it Becomes Obsolete

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With the rapid advances in networking technology and the exploding demand for network access, resources, and services, Penn finds itself needing a new network architecture as it works to complete its present one! Through the work of a small but dedicated group, the campus is following a careful, structured methodology to develop its next-generation network. A partnership was forged among individuals responsible for major campus-wide client/server initiatives, representatives of the major schools, and the separate organizations responsible for telephony and data/video communications. To keep the campus community informed, World-Wide Web is used to publish not only finished products of the project, but work-in-process as well.

Introduction

Networking has changed significantly at Penn since the early days of Gandalf boxes and IBM 3270 terminals. It took decades for the telephone to be considered an essential instrument appropriate for ubiquitous deployment. In a mere twenty years, data networking has evolved to become as mission critical to the academic enterprise as any core piece of Penn's infrastructure. Consider:

> *Virtually every school at Penn uses the campus network, PennNet, in its teaching, from simple electronic messaging and conferencing to promote student-faculty and peer interaction, to entire electronic courses taught for credit. Faculty, however, often will not use the network during class presentations until it is as reliably as their overhead transparencies.*
>
> *Data communications are now essential to research in many, if not all, academic disciplines as a means to quickly exchange data or ideas, submit proposals to sponsors, or harness the appropriate resources for experimentation and inquiry. And research continues to push the envelope of technology every day.*
>
> *Telecommuting and mobility will become increasingly important to students, faculty and staff as the University seeks ways to become more energy-, environment-, and efficiency-conscious. Robust data communications, integrated with better telephony and video, will enable this location independence.*

But also consider that PennNet was never architected to provide services as reliably, quickly, or broadly as users have come to expect. To meet this challenge, the Network Architecture Task Force was charged in March, 1994 to assess the current state of data, voice, and video networking at Penn, and to make recommendations for changes to these architectures during a three to five year planning cycle.

Membership and Organization of Task Force

The Task Force is made up of individuals from across the University. One of its two chairpersons comes from the central computing group, the other is the computing director at one of Penn's major schools. This sense of partnership is critical to the success of the project, since PennNet is a campus-wide asset. The other members of the committee, while not selected for strict purposes of representation, represent a broad set of individuals from around the University with differing technical backgrounds. Two important criteria guided the selection: individuals either needed to have something concrete to contribute, or had something they needed to learn.

For perhaps the first time, the Office of Telecommunications, which is responsible for telephony at Penn and reports through a different Vice President than data communications, is a full participant in this planning process. The University's contract with Bell Atlantic for Centrex services expires during the course of the planning period, so the Task Force is examining options for its replacement. Other members of the committee include additional networking directors from other schools (Arts and Sciences, Wharton School), computing directors from other units (like the Library), as well as other individuals from various central computing departments (networking, academic computing services, central MIS group).

The Task Force was charged by Penn's Network Policy Committee, a subcommittee to the campus' computing advisory board. This committee not only receives regular updates, but is available to grapple with policy questions that have the potential to slow the Task Force's progress.

A small sub-committee of the Task Force was formed to craft the architectural alternatives (see methodology section below), since this step is best performed by a relatively small group initially with its work exposed over time to more and more individuals. The two co-chairpersons, along with the Manager of Network Operations and Manager of Network Engineering in the central networking department formed this sub-committee.

It is important to recognize the overlap with other efforts at Penn, and the coordination that is constantly required of the Task Force chairpersons. At Penn, the network architecture is seen as just one piece of a larger, inter-related architectural puzzle. Similarly, some sections of the network architecture are being developed primarily by other Task Forces and groups. Some relevant efforts include a recently-started DCE Task Force; our ongoing Project Cornerstone, which focuses on administrative systems and processes; Access 2000, our initiative in the area of library systems; and our E-mail Task Force, which focuses on a number of electronic mail, netnews, and office automation issues.

Technical Architecture Methodology

Network planners often believe they "know what is best" for the campus without bothering to ask. Many, in fact, have turned as conservative as the data center manager of the 1980's who safely bought "whatever IBM had to offer." In the 1990's, the once-"maverick" network manager is playing it "safe" by buying whatever CISCO and Cabletron have to offer.

Definition

A technical architecture is a blueprint for making technology choices. In the words of the GartnerGroup, it is a process and not a product. The crucial objective is to improve the performance of the enterprise. A technical architecture is *not* a platform from which to preach a certain methodology or justify a predetermined technical direction.

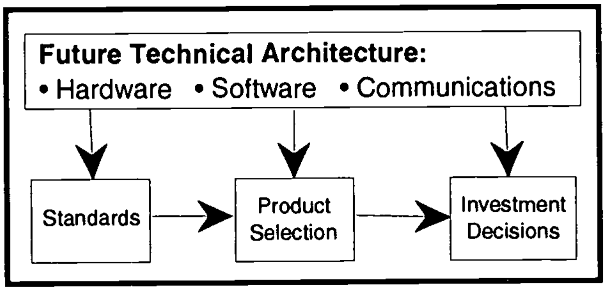

Figure 1 - **Components of a Technical Architecture**

Generally speaking, a technical architecture consists of the hardware, software, and communications components of an organization. From the architecture flows the standards (including policies and procedures), product selections, and ultimately the investment decisions of the enterprise.

Developing a Technical Architecture

According to the methodology being followed at Penn, four major factors are considered when developing a technical architecture:

- University Direction and Business Requirements - First and foremost, the technical architecture must satisfy the University's needs. It must support the University's academic and administrative objectives. Care needs to be taken not to deploy technology simply for technology's sake.

- Principles - The University has developed a set of principles, or beliefs, that together provide direction for information systems and technology. Project Cornerstone, Penn's multi-year effort to improve administrative information and systems, developed principles in the administrative domain. A set of principles which apply to academic information technologies is currently being developed. Generally, principles are meant to remain relatively stable, unless major changes in University philosophy or direction occur.

- Current, or *de facto* Architecture - Regardless of how it came to de deployed, the current, or *de facto* architecture is nonetheless the major starting point for any new architectural initiative. The existing architecture must be documented and understood, for both its strengths and weaknesses, before work on a new architecture can begin. The current architecture of PennNet , the University's telephony network, and the University's video network have been documented.

- Industry and Technology Trends - To assist in identifying the new architecture it is necessary to have a base of information about the technologies and industry trends that are both popular and emerging in the marketplace. Vendors, as well as experts and consultants, have been invited to supply this information via briefings and reports. The Task Force has been collecting and synthesizing this material from a number of sources:

    - Regular review of material from the GartnerGroup, the Internet and other sources.
    - Briefings from major network technology vendors, with an engineering rather than marketing focus, during the summer/fall of 1994, including Fore Systems, Cabletron, DEC, and AT&T.
    - Formal and informal exchange of information with experts and our counterparts at other institutions.

This set of data assists the team in developing a set of architectural alternatives which are presented to University management with a cost/benefit analysis and recommendations for implementation.

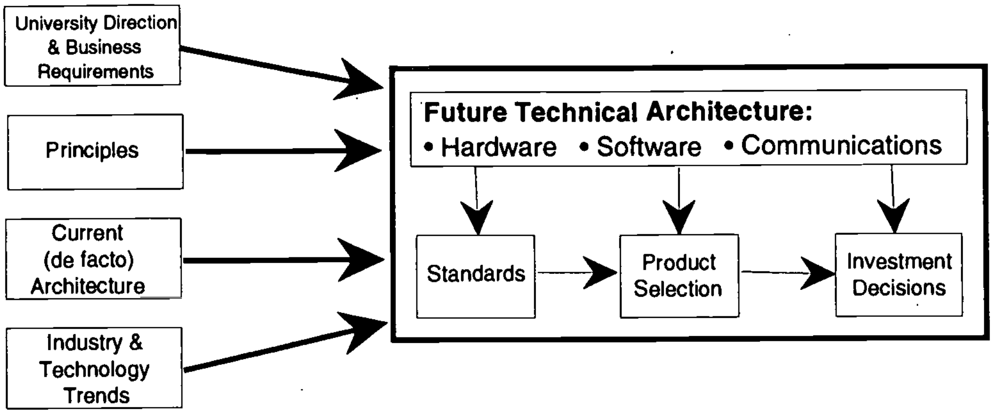

Figure 2 - **Developing a Technical Architecture**

Scope of the Architecture

The technical architecture is made up of a number of components. At Penn, the network architecture will not define every component at the same level of detail. It is expected for the current effort that data networking will be more developed than either voice or video. Other efforts will have to follow in these two areas to define their architectures in more detail.

Data networking will include models for both the physical networking topology (from Internet gateway to the desktop device) and the services that use that physical network (e.g., protocol stacks, LAN strategy, DCE, end-user networking products). From these models will flow the standards and supported product lists to be adopted campus-wide.

It is important to provide an architecture that enables access to the network and its services to as close to 100% of the University community as possible, while recognizing that a small percentage of aggressive users will likely require more sophisticated connectivity or services than the mainstream, and a percentage of less sophisticated users will be satisfied with substandard facilities.

The potential convergence of video, voice and data technologies is high on the minds of task force members. Relevant factors include:

- Increased digitization of services (versus more traditional analog implementations) leading to increasingly common media and wiring standards
- Arrival of multimedia technologies that will synchronize data, audio and video in a single application
- Increased interest in and use of video conferencing
- Increased potential and use for voice-response system integrated into traditional business applications
- Crossover in offerings beginning in the commercial marketplace among traditional data, voice and video providers

The Task Force is monitoring these developments and assessing their impact on the architecture.

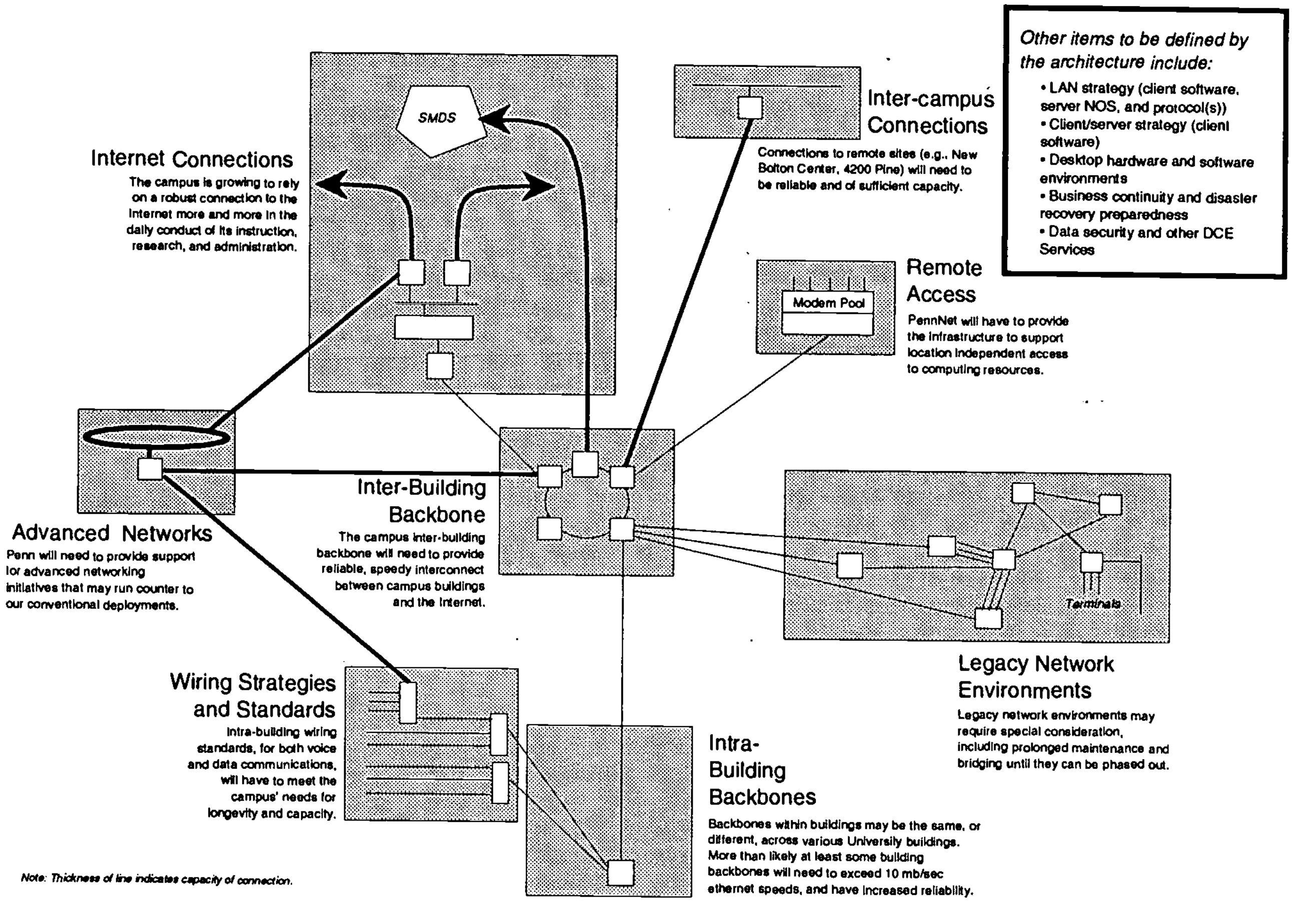

Figure 3 - **Network Architecture Template**

A template for the network architecture is found in Figure 3. The goal of the architecture effort is to define alternative strategies for each of these areas. Major components of the architecture include:

- Connection to the Internet and other wide-area networks
- Inter-campus backbone (e.g., New Bolton Center, Center for Judaic Studies)
- Inter-building backbone
- Intra-building backbone
- Wiring and media standards (e.g., wireless)
- Workgroup computing strategy, including appropriate client and server software, Network Operating Systems (NOS), and protocols
- Enterprise computing and communications strategy, including appropriate desktop software to be compatible with various enterprise-wide initiatives
- Institutional file system that might be required by workgroup or enterprise computing strategies
- Remote access strategy, for home and "on the road"
- Desktop hardware and software environments for networking
- Business continuity planning and disaster recovery preparedness
- Network information security, including network-wide authentication services
- Role of legacy network environments (e.g., ISN, terminal servers)

Developing and Articulating Needs

The Task Force spent considerable energy in an initial analysis of the campus' needs for networking technology and services. Wider discussion of these points is now required. While it is tempting to simply say "more *whatever* is better," the Task Force has attempted to be more precise in anticipating the campus' needs and describing those needs relative to each other. Two important points need to be made:

Elements out of Penn's Control	Elements, like the reliability and capacity of the Internet beyond the campus' boundary, that are out of Penn's control can have a substantial impact on users. Steps can be taken in some cases to either minimize Penn's reliance on these resources, or provide redundant or back-door methods of securing reliable service.
Test Bed for Experimentation	Given the rapid changes in information technology, and the rapid expansion of our collective knowledge base, Penn must be positioned to use new technology in an appropriate and timely manner for the greatest pay-back from the most prudent investment. Penn must have a formal mechanism for testing new technology for potential production use or campus-wide deployment

Figure 4 below displays a framework for understanding these desired network functions which are described below. The four core needs -- accessibility, reliability, capacity, and capability -- appear close to the center of the diagram. Their supporting needs appear around them. The main categories are defined as follows:

1. **Accessibility**: The ability to access network resources whenever and wherever desired. To use a metaphor from another utility, electrical power is available and accessible by-and-large whenever and wherever it is needed, and both the power companies and builders accordingly work together to anticipate and meet needs.

2. **Reliability**: The consistency and quality with which the network performs its tasks and provides its services. An important component of Reliability is the set of services that allow the network to be managed and that allow for prompt trouble-shooting and maintenance. We currently lack clear language that allows customers and service providers to even consistently understand what constitutes a network "outage" or "failure." We also lack clear measures that allow us to determine whether the network is living up to its expected or planned targets of operation, while recognizing that individual services provided by departments may become unavailable regardless of the state of the network.

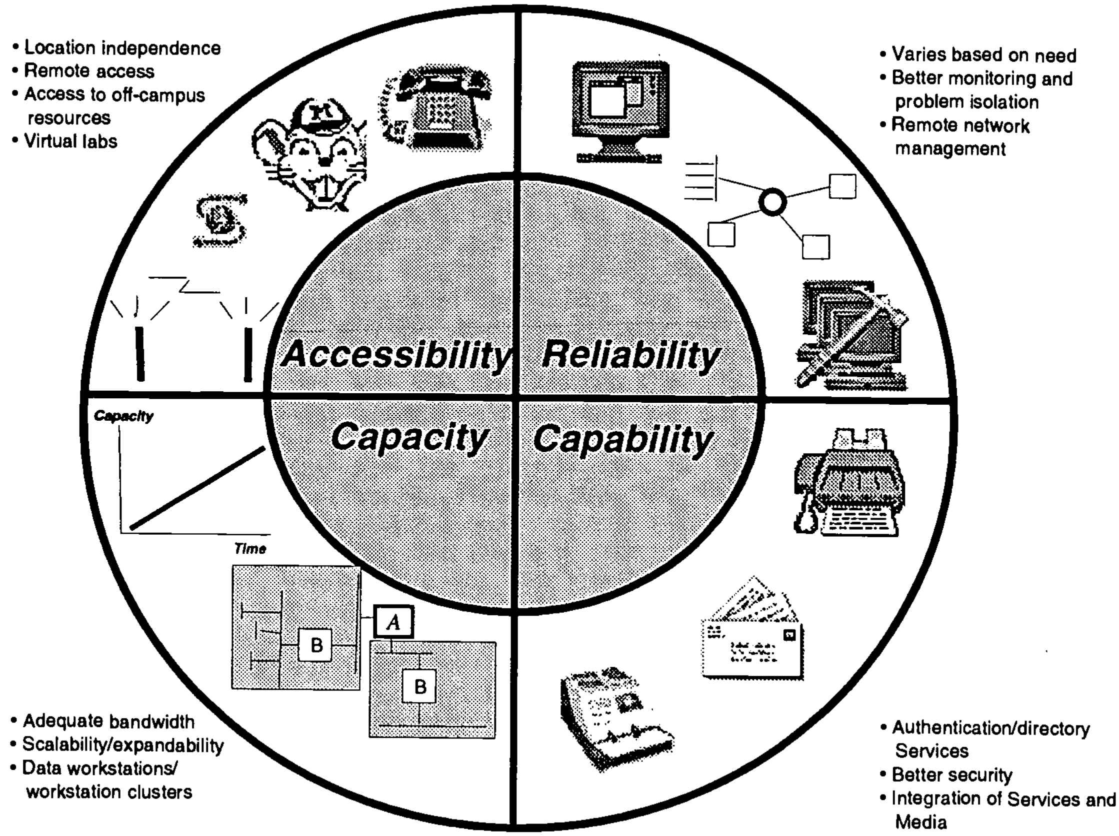

Figure 4 - **Desired Network Functions**

3. **Capacity**: If the network is thought of as a highway (or pipe), and bandwidth as its capacity for travel or use, the goal is to ensure sufficient ability to travel on or use this highway with an acceptable level of performance to complete a given operation. The new architecture must be sufficiently scalable to accommodate a connection for *everyone* while recognizing that new users will phase in over time.

4. **Capability**: Given sufficient capacity, the network must have the capability to support the necessary services. Authentication/directory services control access to network resources, and inform users about where to find those resources and other users. In an evolving multi-media world, PennNet must provide services using less traditional media, and recognize the convergence of traditional data, audio and video services.

Assumptions help to bound the set of possible architectures to a more reasonable set, and help focus the search for solutions. The Task Force developed a set of working assumptions that continue to evolve as the project evolves. Some examples include:

TCP/IP	TCP/IP will continue to be the enterprise-wide networking protocol. OSI protocol is not, and will not, become significant.

Higher Bandwidth to Homes	The choice of offerings of infrastructure to provide higher bandwidth to homes will become increasingly available during the planning period.
Dorm Connectivity	All dorms will be wired by the end of the planning period.
Bandwidth Demand	Demands for network capacity and services will continue to increase at a dramatic rate (estimated to be at least 50% per year) for the foreseeable future. Sudden increases in demand due to discrete events or new capabilities will require a quick response in added capacity to meet demand.
"Killer Apps"	"Killer Apps" (perhaps desktop video-conferencing?) will change network usage patterns in ways we cannot predict.
Inter-building Communication	The campus per-building subnet model still seems valid.

Developing Alternatives: "Myths" of Network Planning

Penn has found that a small group of individuals must work closely to develop alternative architectures. Using the template (Figure 3 above), a sub-set of the Task Force worked on brainstorming different levels of the architecture: inter-building communications, intra-building communications, migration strategies, etc. The vendor presentations helped to inspire critical thinking and visioning. Interestingly, these discussions highlighted a number of common misconceptions, or myths, about network planning in the 1990's:

Myth 1: Ethernet is Obsolete

It appears that ethernet has life in it yet, evidenced by the movement toward switched (versus shared) ethernet, and the likely dominance of greater-than-10MB ethernet over the next several years.

Myth 2: Network Electronics can "Trickle Down"

The market for network electronics is changing rapidly. It is common today to assume that these components have a useful life of three to five years, and that they can be migrated from sites requiring more aggressive solutions to sites requiring less aggressive solutions to prolong their life. Product lifecycles are shrinking quickly, and it appears that old network electronics, especially electronics that cannot be remotely managed, have no place in the infrastructure.

Myth 3: When in doubt, always lay fiber

The jury is still out on whether fiber to the desktop is necessary or even wise. The market seems to have embraced category 5 twisted pair copper wire as the standard, with potential for transmission speeds exceeding 100MB/sec on this wire.

Myth 4: ATM will dominate in the next few years

It is not clear how soon virtual circuit networks (like ATM) will become the new paradigm in networking. While virtual circuit networks support real-time services better than packet switching networks, they fail to run today's protocols robustly enough to support the large installed base of applications.

Myth 5: An Architecture can last for five years

Various components have very divergent lifecycles making network planning increasingly challenging. Product lifecycles are now measured in weeks and months instead of years. An architecture that takes too long to implement is destined to become obsolete before its time. It is useful to plot a technology migration path within which one is able to skip steps in order to minimize obsolescence.

These are just some of the issues the Task Force has struggled with, and about which, in some cases, has not yet reached a conclusion.

Building Consensus and Marketing the Architecture

A critical piece of the architecture process is building consensus as recommendations develop. Penn is an especially decentralized campus with strong, independent schools who will build their own infrastructures if they do not feel well-served by the central computing group. Additionally, the central computing group is ultimately dependent on the schools to fund its activities.

Technical architecture efforts face the double problem of needing to keep technical managers around the campus informed and up-to-date, while figuring out how to market the ideas to the financial and business managers who ultimately need to be "sold" on the need for the investments. It is common for managers, especially when the investments are big, to consider the problem "taken care of" after a one-time purchase. At Penn, the original network infrastructure was funded through a bond purchase whose repayment extends until 1999, though the equipment purchased is already obsolete. Managers must be educated to view investments in technical infrastructure as ongoing, evolving purchases.

The Task Force chairpersons decided to use the World-Wide Web as a vehicle for documenting the process and outcome of Task Force activities. Works in process as well as draft and final "products"of the task force are maintained in a WWW server available for wide viewing on campus and across the Internet. This goal of "full disclosure" removes any fear that a given constituency may have about not being included in the process - all they have to do is consult the on-line documentation and comment as appropriate. All meetings are announced in the Web. Agendas are made available before meetings, and notes are made available after meetings. All products of the task force are immediately available for comment, and are likewise accessible by vendors to assist them in preparing for technical sessions on campus.

The project became amazingly self-documenting. When it became clear that a traditional needs document was necessary to effectively explain the objectives and interim conclusions of the Task Force to the various advisory boards and business managers, it became very easy to make the leap from notes to a formal document since all the important information had already been electronically "published" via WWW. This step of marketing early to financial decision makers is critically important: first it is necessary to explain the project, then prepare cost estimates in ways they can understand.

Conclusion

Developing a network architecture is an ongoing process. Market pressures and short lifecycles make decisions about directions, standards, and products increasingly difficult. The key to avoiding obsolescence is to plan continuously, keep abreast of technology developments, and engage the campus whenever possible.

Penn is currently developing its architectural alternatives, building its cost model, and developing the necessary recommendations to present to the campus early in 1995. Progress can be monitored in the World-Wide Web with the URL **http://www.upenn.edu/ITI/it-initiatives.html**, Information Technology Architecture branch.

"Future-Proofing" Your Campus Network

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Brevard Community College has completed the installation of a structured cabling system that will meet the institution's voice, data, and video communications requirements through 2010.

By adopting the ANSI/TIA/EIA-568A structured cabling standard, institutions can maintain maximum reliability for the present and flexibility for the future, making the cabling system an asset that will outlive several generations of computing and data communications equipment.

This paper discusses:

- the benefits of a star topology structured cabling system.
- how the college developed its plan for using legacy coax, UTP, and multimode fiber media.
- the administrative issues surrounding installation of the system.
- communicating video over coax, STP, UTP, multimode and single-mode fiber.

STRUCTURED CABLING: A STRATEGIC ASSET

Development of a strategy for moving voice, video and data around campus is an important part of any institution's over all plan for information technology. Selection of the right strategy is not a trivial task to be relegated to the lowest bidder; this is the legacy one leaves to ones successor.

Spending time and other resources on selection of a structured cabling system makes sense because

- cabling is a long-lived asset that will out last several generations of software and electronics.
- cabling will facilitate or impede adoption of new high bandwidth communications services (whatever they may be).
- according to a Frost and Sullivan, 70% of on-premises networking problems are attributed to the physical layer (even though it accounts for just 5% of networking costs).
- cabling is geographically distributed around campus, making it difficult to troubleshoot and expensive to replace.
- schools rarely abandon facilities so they can derive full benefit from a long-lived investment.

The IT administrator's challenge is to handle many issues under uncertainty and under budget. These include the selection of media and access method and choice of a strategy to handle video, wide area network connection, and bandwidth crunches.

CABLING SYSTEM DESIGN SHOULD SUPPORT THE INSTITUTION'S MISSION

If money were no object, the obvious data network media choice for educational institutions would be fiber-to-the-desk. However, most educational institutions need to identify the least costly system that will support their mission.

For example, a research university or medical school would need hundred megabit bandwidth sooner than a community college. In contrast, students, faculty, and staff in the humanities are heavy users of productivity software that runs well at 10 Megabit per second (Mbps) Ethernet speeds. Distance education does not tax the capacity of the on-premises cabling system because the video teleconferencing system performance is constrained in the near-term by the wide area network links.

It makes sense to meet early with the facility planning administrators to identify buildings that need better than

Ethernet data speeds today or will be migrating to Asynchronous Transfer Mode (ATM) speeds in 3 or 4 years. ATM service will support voice, video, and data at rates of 25 to 622 (but principally 155) Mbps.

BREVARD COMMUNITY COLLEGE

Brevard Community College (BCC) serves approximately 15,000 students in degree programs on four campuses in central Florida. From term to term, 10,000 to 20,000 other people will take courses for enrichment and skills improvement. The college also The college provides affordable freshman and sophomore education and has certificate programs in the allied health professions and computer science and technology. Brevard County is the home of Cape Kennedy, so students and citizens expect ubiquitous access to technology.

DETERMINATION OF SYSTEM NEEDS

One recent project is the construction of a new library. In order to stretch its resources, Brevard Community College shares its library with the University of Central Florida and the Solar Energy project. The library is multimedia capable to permit use of all its resources by students on campus and in the community. Video materials are being encoded in MPEG files and moved onto a RAID storage. Work stations play back the video through Mosaic running under Windows NT version 3.5.

The library also offers Internet connections to the college community. Finally, students on and off campus can take courses through the college's educational TV station, which is transmitted among the four campuses over microwave.

Across much of the campus, computer applications, both current or anticipated in the next two years, are text-based productivity applications, so the campus is Ethernet now. In the library, however, the system needs to support video/media teleconferencing for remote reference assistance. Brevard is installing switched 100 Mbps Ethernet in 1995 to support the video/media teleconferencing under TCP/IP.

DESIGNING STRUCTURED CABLING SYSTEM

The cabling system design for the library was started after the architect had the building design well underway. The designer, a consultant with Florida's College Center for Library Automation (CCLA), which is networking Florida's 60 community college libraries, was forced to take some relief do to the placement of the wiring closet. The college had decided in 1990 that all new communications networks must conform to a structured cabling standard.

ANSI/TIA/EIA-568A, THE STRUCTURED CABLING STANDARD

The Electronic Industries Association (EIA), its affiliate, the Telecommunications Industry Association (TIA), and the American National Standards Institute (ANSI) have developed standards for structured cabling systems for use in commercial and other enterprises. The standard, known as ANSI/TIA/EIA-568A[1], is recognized as the specification upon which cabling systems and components are designed[2].

The standard dissects the cabling system down into six distinct subsystems:

Entrance facilities	Equipment room
Backbone cabling	Telecommunications closet
Horizontal cabling	Work area

Three cabling system choices for building premises media in both the backbone and horizontal subsystems are: unshielded twisted pair (UTP); 150 ohm shielded twisted pair (STP), commonly known as the IBM Cabling System; and optical fiber[3].

Each structured cabling system possesses particular bandwidth capability. The committees responsible for developing application standards, generally the Institute of Electrical and Electronic Engineers (IEEE) and ANSI, work within these bandwidth limitations when designing their applications and encoding schemes.

New applications are designed based on the standards for the physical layer. This provides benefits for both the developer and the user. The developer knows that a large installed base can economically purchase his or her products; the user knows that new products will run on the cabling system in place.

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[1] The current (December 1994) standard is actually ANSI/EIA/TIA-568. In very early 1995, this standard will be replaced by ANSI/TIA/EIA-568A, so this designation is used here.

[2] John Crandell, "Built for Speed and Built to Last" (LAN Computing, June 1994).

[3] EIA/TIA-568 Standard: A Reference Guide to the Commercial Building Telecommunications Cabling Standard (Skokie: 1994), p. 8.

Star Topology and System Components

The physical layout of the system can also impact its long-term utility. A star cabling topology can be used in both the backbone and horizontal subsystems. This topology is quite common in the horizontal cabling but not necessarily in the backbone.

The star topology in the horizontal simplifies moves, adds, and changes, trouble shooting, and management. The benefit of star topology in the backbone is that, through the use of network segmenting equipment like routers, the network can be more easily controlled and administered from one central point.

This is key especially as schools move from Ethernet to switched Ethernet and ATM, which are based on a switching hub concept.

ANSI/TIA/EIA-568 is an Evolving Standard

In 1991, the EIA/TIA-568 standard described UTP (for data use up to 16 MHz, called Category 3) , STP, and multimode optical fiber (commonly known as FDDI grade fiber). Later in 1991, Category 4 and Category 5 UTP (for data use up to 100 MHZ) were described in Technical System Bulletin (TSB) 36. In 1992 and 1994, Category 4 and 5 connecting hardware and patch cabling standards were described.

In early 1995, expected changes include introduction of higher performance STP-A and single-mode fiber. Legacy 50 ohm thinnet and thicknet coaxial cabling for horizontal and backbone cabling for Ethernet will be "grandfathered in" in the 1995 standard.

BENEFITS OF STRUCTURED CABLING

Structured cabling saves money and increases system performance. The cabling system is independent of communications services (listed below), thus allowing an institution to migrate from AppleTalk to Ethernet to ATM as applications demand, without changing the cabling.

Voice	SNA
Ethernet	100 Mbps Ethernet
Token Ring	FDDI
AppleTalk	ATM

SELECTION OF MEDIA: UTP, STP, OR FIBER

Media selection involves a high degree of uncertainty because replacement of cabling in place is expensive and disruptive. How is one to make a reasoned choice when ten years equals two technical generations? Although we cannot see over the technical horizon, we know that certain laws won't be repealed. Some are laws of physics, and some are laws of economics.

The laws of physics show that although fiber is technically superior to UTP in almost every way, UTP supports ATM, the next major networking scheme.

UTP is currently the most popular media used in business. The developers of software and hardware will make products for the information superhighway aimed at large, profitable markets like business. If an educational institution's cabling system is similar to a business's, equipment will be available to the institution at competitive prices.

UTP: Supporting Services From Voice to ATM

The acceptance of UTP cabling for Local Area Networking (LAN) was a watershed event. Ethernet running over coaxial cable was victim to installation, maintenance, and management problems, and Ethernet was losing ground to Token Ring as the access method of choice. The adoption of the 10Base-T Ethernet standard helped give Ethernet new popularity.

The telephone world has used UTP since the turn of the century, so telecommunications administrators are familiar with its design and installation. The 10Base-T standard nurtured the move to wiring concentrators or hubs, with all the performance, cost, and management benefits they bring.

The ANSI/TIA/EIA-568A standard categorizes UTP by its electrical properties and applications.

Category	Test Frequency	Application
3	16 MHz	Voice and data applications to 10 Mbps (Ethernet; Manchester encoding)
4	20 MHz	Data applications to 16 Mbps (Token Ring; Manchester encoding)
5	100 MHz	Data applications to at least 155 Mbps (ATM; multilevel encoding)

Categories 1 and 2 are not recognized by ANSI/TIA/EIA-568A and are used for plain old telephone service (POTS) and for low speed data communications, respectively.

New data encoding schemes allow unshielded cable that has been tested to only 100 MHz to support ATM at 155 Mbps. Whereas Ethernet and Token Ring use an encoding method that communicates one bit per hertz, ATM uses encoding schemes that communicate multiple bits per hertz. Therefore, ATM will be able to communicate 155 Mbps at working frequencies of 32 or 78 MHz over category 5 UTP.

It is important that the cabling and associated components all provide equivalent performance. A structured cabling system is like a chain, and overall system performance is limited to that of the weakest link. In order to have the system perform at the desired level, connecting hardware that meets TSB 40 specification must be used and installed per instruction. Sloppy installation causes a Category 5 system to perform at Category 3 level.

UTP cabling is a natural for horizontal cabling with its ability to support voice as well as data. Its use in the backbone is permitted, but electrical properties limit its distance to 90 meters and its bandwidth is much narrower than fiber, coax, or STP. You can buy Category 5 twenty-five-pair backbone UTP, but Category 5 high density connectors are not yet available.

STP-A: The Best Copper Cable and Proof that Structured Cabling Works

The 150 ohm STP-A has superb electrical properties due to its heavier wire gauge size (22 AWG vs. 24 AWG for UTP) and its shielding. Both the cabling and its connectors are tested to 300 MHz.

Although it is not reflected in the standard, STP can support Ethernet and Token Ring at distances up to 150 meters. In addition, with the correct video baluns, STP-A can carry 550 MHz of broadband video concurrently with data on 16 Mbps Token Ring.

Because of its cost, size and rigidity, STP-A is not common in educational institutions outside of the mainframe computing environment or where the institution was an early adopter of Token Ring.

STP does, however, prove the efficacy of structured cabling. An IBM Cabling System (tested to 20 MHz) installed by the far-sighted ten long years ago in 1984, will probably support tomorrow's 100 Mbps Twisted Pair-Physical Media Dependent, or Twisted Pair Distributed Data Interface (TP-PMD or TPDDI) and ATM. One manufacturer warrants their earlier design product to carry ATM.

Fiber: In the Backbone and Riser and for Near-term Highest Speed Data

The rapid growth of fiber optic cabling installations on campus is due to fiber's technical superiority over copper cable in almost every aspect. The obstacles to a fiber installation used to be the craft sensitivity of the connections and the cost of the electronic components. Thanks to training and better component design, fiber is now in many ways easier to install than twisted pair cabling, and small projects are undertaken by college personnel. And electronic component prices are falling. Fiber makes both economic and technical sense in the campus environment for backbone and riser applications.

Fiber is vastly superior to copper cabling in terms of bandwidth, attenuation (distance), immunity to electromagnetic and radio interference, security, strength, and weight. Because two of the four campuses are spread over large sites, and because Florida has truly spectacular lightning displays, fiber was indicated for all inter-building communications.

Multimode fiber's bandwidth is 500 MHz-km, which provides the advantage of hundreds of megabits of data over several kilometers. Although its laser-based electronics are more expensive than those for UTP or multimode fiber, single-mode fiber has a bandwidth of hundreds of gigahertz-km, giving it capacity to do both high speed data and broadband video over long distances. The telephone companies use single-mode fiber to achieve data transmissions rates up to 2.48 gigabits per second.

Although the ANSI/TIA/EIA-568A standard limits multimode fiber to horizontal cabling distances of 90 meters, this is under review as electronics vendors' specifications indicate fiber will actually perform at distances of two or three kilometers.

It is good practice to include single-mode fiber when multimode fiber is being installed as a backbone especially between buildings. The marginal costs for adding single-mode fiber in a composite cable, adding many gigahertz of capacity, are very small.

Coax: For Broadband Video This Year

Video can be carried baseband (one channel's worth of video on one cable) or broadband (multiple channels on a single cable). At this time, while baseband can be carried over UTP, STP, coax, and fiber; full broadband video is limited to STP, coax, or single-mode fiber.

If you have a need for channel switching in the dorm room, classroom or office, enhanced performance Category 5 UTP, with appropriate baluns, can carry up to 26 channels of video over short distances of 100 meters or less. STP with special baluns or coax will carry 80 or more channels. Although single-mode fiber has the bandwidth to carry hundreds of channels, the sending and receiving electronics are still prohibitively expensive.

Multimode fiber carries just four channels before compression. Category 5 UTP carries one channel up to 400 meters with special baluns. These alternatives make sense if one does channel switching remotely.

SELECTION OF SPECIFIC CABLING FOR SPECIFIC AREAS

Fiber's advantages offer the greatest payoff in the backbone and the riser, but UTP's flexibility, low cost, and ability to handle voice indicate its use in the horizontal.

Application standards for UTP cabling systems usually express performance requirements in terms of a minimum Signal-to-Crosstalk Margin (SCM) requirement, also called Attenuation to Crosstalk (ACR), which takes into account signal loss and interference (near-end crosstalk or NEXT). The minimum SCM requirements are set based on the needs of sending and receiving electronics for signal strength and clarity.

There are Category 5 UTP cables available from several vendors that significantly exceed the NEXT requirements of ANSI/TIA/EIA-568A. The allowable values in Annex E of the standard call for a difference of greater than 10 dB between the attenuated signal and the interference caused by NEXT talk. These enhanced Category 5 cables provide an additional 12 dB of margin. The additional "headroom" insures that the system will perform even if real world considerations impinge on the installation.

IMPLEMENTATION ISSUES

EIA/TIA-569: Some Place for the Cabling

The structured cabling standard assumes that the buildings meet the requirements of EIA/TIA-569, the architectural standard for spaces, raceways, and wiring closets. Older buildings force compromise, but all new construction and renovation should adhere to the EIA/TIA-569 standard.

There is room to take relief in some parts of ANSI/TIA/EIA-568A, and there are no TIA/EIA police, but variances increase the probability that the system will not be able to accommodate some new communications technology in the future.

The consulting engineer should specify that the TIA/EIA-607 standard for grounding be closely observed. Grounding problems may cause the communications system to no work at all, or worse yet, may cause intermittent failures or safety problems for people and equipment.

Installation

One reason that businesses and institutions have adopted UTP is its ease of installation. A contractor must observe UTP's 25 pound tension limit, minimum bend radius, and termination instructions. Failure to do so increases NEXT and attenuation and reduces available bandwidth.

Fiber cable is more forgiving during pulling, supporting 200 pounds in tension and being easier to terminate than it used to be. However, care is still required to keep connections within their 3/4 dB loss budget.

Testing: Getting Your Money's Worth

Since potential sources of problems are spread across campus, hidden in conduits and behind faceplates, testing each end of each link or segment ensures you get what you paid for.

The testing standards for Category 5 UTP have not been finalized, so institutions depend on tester manufacturers to have the latest values from Annex E of ANSI/TIA/EIA-568A, which will be released as a TSB in 1995, programmed into the test device. So long as the principal performance parameters of continuity, NEXT (from both ends), attenuation, and return loss are tested and recorded, the institution can reasonably assess the quality of the installation and will have a baseline for future maintenance[4].

As current uses like Ethernet and voice communications use only a fraction of the cabling's capacity, testing and warranties protect the school through the delay between cable installation and the initiation of ATM service.

EIA/TIA-606: System Administration

Once the cabling infrastructure is installed, the system will become disorganized unless energy is expended on its maintenance. Label all terminations (both in the closet and at the information outlet) and document all runs and subsequent moves, adds, and changes.

The EIA/TIA-606 Administration standard describes a color coding scheme for the cross connect field labels and guidelines for record keeping. In addition to the EIA/TIA-606 color scheme, manufacturers offer cables and components in many colors. Unless there is consistency across the campus installation, all this color will lead to confusion instead of reducing it.

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[4] Mike Longo, "Practical Considerations of Structured Cabling Installation" (Un-published paper).

BUYING THE STRUCTURED CABLING SYSTEM

Getting Technical Assistance

While the ANSI/TIA/EIA-568A has gone a long way toward simplifying the area of structured cabling systems, it does not take into account additional considerations such as structured cabling system choices, network applications, configuration issues and financial considerations involved with selecting a system. Design can be done in-house as it was at BCC, by a consultant, by the integrator, or a structured cabling vendor.

Long-term Warranties

After the general design was complete and specific products chosen, Brevard sought a vendor and a contractor who could offer installation with a 15-year warrantee. Given the service life needed from the system and the fact that capital funding is sporadic and maintenance funds are tight, the college elected to reduce risks wherever possible and to cable just once. Several vendors offer long-term performance warranties. Even with the time value of money over 15 years, the college decided to take the warranty.

RECOMMENDATIONS: WHAT WE LEARNED.

1. Bring decision makers and stakeholders into the planning process early.

2. Spend sufficient management attention and resources on the structured cabling system.

3. Adopt the ANSI/TIA/EIA-568A series of standards to reduce the chance of obsolescence.

4. Unless distances or near-term applications require the bandwidth of ATM before ATM is available at popular prices, use UTP in the horizontal.

5. Use multimode and single-mode fiber in the backbone and riser for distance and bandwidth, especially between buildings.

6. Get a warranted installation.

7. Test each circuit from both ends and document the results.

8. Adopt an automated process for administering the cable network.

MULTI-NETWORK COLLABORATIONS EXTENDING THE INTERNET TO RURAL AND DIFFICULT TO SERVE COMMUNITIES

Dr. E. Michael Staman, President
CICNet, Inc.
Ann Arbor, Michigan

PREFACE:

The Rural Datafication presentation was based in large part on Dr. Staman's recent testimony before the US House Committee on Science, Space, and Technology. The following is the written text of the testimony.

Committee on Science, Space and Technology
U.S. House of Representatives
Washington, DC
Hearing on The Technological Transformation of Rural America
July 12, 1994

Testimony of:
Dr. E. Michael Staman, President
CICNet, Inc.
Ann Arbor, Michigan

Mister Chairman and members of the Subcommittee:

Your invitation to participate in today's hearing came during a time when we at CICNet have increasingly found ourselves engaged in a number of forums discussing rural America's access to the National Information Infrastructure (the NII). Thank you for the opportunity to discuss theseissues in with you.

The growth of both the number of users and the applications of the Internet (that element of the NII which is available and working effectively today) has astounded even those of us who have been its most optimistic proponents for many years. It has grown from a resource used primarily by the research and education sector as recently as five years ago to a significant force within the nation's business sector today. It will become a major element of our global competitive posture within the decade.

Perhaps the best way to clarify its status at present is to quote directly from the July 7th, 1994 issue of *USA TODAY*:

"Across the USA, thousands of companies are tapping into the mother of all computer networks -- the Internet -- to find job candidates, communicate with customers, work out technical problems and peddle their wares. ... Having an Internet address is rapidly becoming a requirement for doing business, ..."

As with the deployment of all national infrastructures in the history of this nation, we need to insure that all citizens participate fully in both the evolution and the promise of this new resource. Its potential to transform the way we work, communicate with each other, and even enjoy portions of our leisure parallels the potential of virtually every other massive infrastructural change, whether it was the development of the railroads in the early 1800's, the electrification of urban areas in the late 1800's and rural areas in the mid-1930s, the establishment of telecommunications connections in the late 1800s, or the development of urban and interstate transportation in the early to mid-1990s.

My comments today will focus on barriers to access to the NII that exist within rural America, and on several key initiatives needed to further encourage and enhance rural acceptance and use of the NII. For the record, I have submitted several additional documents which might be of interest to the committee. Specifically:

1. A paper discussing CICNet's Rural Datafication Project. This project has been funded by the National Science Foundation.

2. A report on CICNet's second annual conference on Rural Datafication. These conferences, the most recent of which involved approximately 350 people, literally from around the globe, has become one of the key forums at which people gather to discuss problems related to extending and using the National Information Infrastructure in rural America.

3. A working paper discussing several of the issues which we believe to be of critical importance as the nation continues its evolution to a National Information Infrastructure.

4. A document containing the full text of my report in response to your invitation to present testimony, from which my comments today will be drawn.

So that my comments might be presented in the correct context, I need to begin with a description of my organization, CICNet, and CICNet's owners, the major research universities throughout a portion of the midwestern United States.

THE COMMITTEE ON INSTITUTIONAL COOPERATION

The "CIC" in CICNet stands for "the Committee on Institutional Cooperation," a thirty- five year-old collaboration among the following universities: the University of Chicago, the University of Illinois at Urbana-Champaign, the University of Illinois at Chicago, Indiana University, the University of Iowa, the University of Michigan, Michigan State University, the University of Minnesota, the Pennsylvania State University (the most recent member), Purdue University, the Ohio State University, Northwestern University, and the University of Wisconsin-Madison. There are over 75 separate and unique collaborations currently operating under the aegis of the CIC.

These institutions serve the region and the nation on a truly impressive scale. Collectively they account for more than 17% of the Ph.D.'s awarded annually, approximately 20% of all science and engineering Ph.D.'s, in excess of $2.5 billion in externally funded research annually, and over 17% of the holdings of the Association for Research Libraries. With an aggregate total in excess of 500,000 students, 33,000 faculty, and 57 million volumes within their libraries, these institutions are truly a resource which consistently enhances both the quality of life and the global competitiveness of both their region and the nation.

In 1988, CICNet was founded as a CIC not-for-profit corporation to provide inter-institutional CIC-university network infrastructure and network access to the National Science Foundation Network (NSFNET). Today, in addition to all of the CIC universities, both Argonne National Labs and Notre Dame University participate in CICNet Board of Director activities. As part of the CIC community of activities, CICNet is now part of the infrastructure providing NSFNET connectivity to over 400 colleges and universities, commercial or other organizations throughout its seven-state region of operations. A recent study indicated that approximately 20% of the traffic on the United States Internet backbone (NSFNET) came from throughout the CIC region. Given the above, and the rural community and economic development activities that are part of the mission of many of the CIC-universities, it should be of little surprise that these universities would encourage CICNet to move in directions designed to increase both NII access and services for rural areas.

RURAL DATAFICATION IN AMERICA

Several years ago CICNet, in collaboration with NSF-sponsored networks in eight states ranging from New York to Iowa, was awarded $1.3 million by the National Science Foundation to conduct a project that we entitled "Rural Datafication." The intent of the project is to find ways to create Internet infrastructure and services in difficult-to-reach and difficult-to-serve user communities. It was, and is today, the only project of its kind in the nation -- focusing on strengthening the ability of state networks to deliver services to rural communities while simultaneously attempting to develop workable solutions which scale to vast geographic regions and huge user populations. The state networking organizations now participating with CICNet in rural datafication activities include INDnet (Indiana), IREN (Iowa), MICHNet (Michigan), MRnet (Minnesota), netILLINOIS (Illinois), NYSERNet (New York), PREPnet (Pennsylvania), WISCnet (Wisconsisn), and WVnet (West Virginia).

During the course of the project we have been in contact with citizens from throughout the nation, held several national and regional conferences focused on rural access and services to the NII, and participated in forums on the topic in Minnesota, Oregon, West Virginia, and Iowa. We have learned a great deal during this process. I would like to discuss four of the most important topics with you today.

I have entitled the first topic "common themes." There are common themes which occur whenever the topic of access in rural America is discussed. They focus on the need for equal and affordable access for all citizens, the need for pro-active community and economic development strategies based on telecommunications technologies, the creation of enhanced training and support for the large percentage of the population which has yet to understand the potential of an NII, the development of improved information services which both serve and stimulate communities as they contemplate the promise of the NII, and the need to insure that somehow rural America participates fully in the services which will be made available via the NII.

This last "theme" is particularly critical, and is not well understood either in rural America or in Washington. As the "superhighway" increases in capacity, steps must be taken to insure that same capacity is available throughout the land. Polices or practices which create high performance, robust infrastructure in urban areas or within selected segments of our nation while simultaneously creating low-speed, low-performance infrastructure in the remainder will actually serve to exacerbate an existing problem of "information haves and have nots."

It is becoming clear that, marketing and public posturing to the contrary, depending only upon market forces to deliver high-quality, supported, information infrastructure and services to rural America will result in both a long period of time for such services to become available and a further exacerbation of the problem. The worst thing that we can do is "wire 'em for dial access" and proceed to install fiber-based infrastructure only in locations where market forces (read, return on investment) would normally justify such investments. We are not yet at a point where market forces will best serve our national agenda of equal access for all citizens.

The second topic that I would like to discuss with you is best described as "the uniqueness of unique-user communities." While somewhat obvious if one were to think about it for only a moment, this topic is of interest to rural America because there is little in our public policy which seems to recognize its existence and importance. Actual uses of the information and services which are available even today via the network turn out to be different for different communities. That is, like all infrastructure and all communities of users, the needs, goals, and uses to which the NII will be put by groups such as the native American community are vastly different from those of, say, the agricultural community, public libraries, K-12 education, youth groups, small businesses and the like.

Understanding these differences and developing strategies accordingly will accelerate the time when the promise of the NII becomes real for these communities. Such an effort will require the involvement of our universities, the communities involved, and the government. A critical element of any initiative in this area is the support and services that can be provided by the nations NSF-sponsored mid-level networks.

The third topic is "local ownership." Ownership of the problem by those most directly affected -- the nation's towns, communities, and their concomitant citizens' groups -- combined with the now rapidly evolving groups of "virtual communities" -- is critical to the success of the NII. There is probably not, nor should there be, sufficient discretionary revenues within the coffers of either our states or the federal government to meet the needs for the kinds of high-performance infrastructure that will ultimately be required by every city and town in America, and the absence of such infrastructure to the edge of any community will inhibit the development of appropriate infrastructure within.

By creating strategies which cause local ownership we will enhance local investment, creating a dynamic which will hasten the day when the NII is truly part of the fabric of the nation. There is little doubt that such local ownership will result in better and more appropriate solutions at the local level, and that solutions developed and funded locally will be more effectively used than something developed without local involvement or investment.

We should be careful not to confuse the messages of affordable access and suitable capacity in Topic #1, "common themes", and the "local ownership" theme of Topic # 3. To accelerate the evolution of an NII which extends not only to every city and town, but also to individual homes and businesses, we must BOTH insure that our telecommunications carriers deploy adequate infrastructure to support NII applications AND create strategies which cause communities, their citizens, and local businesses to experiment with and understand the power and potential of an NII. While seemingly a delicate balance, accomplishing both goals will accelerate the immediate uses of existing infrastructures and community interest in investing as new infrastructure becomes available.

The final topic involves "building on existing efforts." We should not forget or ignore the fact that there are already, and in some cases have been for many years, ongoing efforts at community development using whatever technologies are available. For instruction in the problems and successes related to these initiatives one need only contact individuals at places such as Eastern Oregon State College, which is attempting to serve citizens resident in some 42,000 square miles, West Virginia University, which contemplates training some 2000 teachers in the use of the Internet during the next three years, or Virginia Polytechnic and State University, which is using its "Blacksburg Electronic Village" project as an endeavor to bring the entire citizenry of a single town into the NII movement. At CICNet, a "Building Electronic Communities" project is attracting inquiries from around the world, and one can now find
initiatives similar to those above in many pockets throughout the land. Their hallmarks are the involvement of volunteers, universities, usually some state or federal involvement, and sometimes (but, unfortunately with increasingly less frequency) mid-level networks.

We have examples and models upon which we can build, and whatever polices are developed should encourage and enhance initiatives such as those cited above.

POLICY IMPLICATIONS

Both he NII goals of the current administration and NII services to rural America can be accelerated by several important policy initiatives. Initiatives are required which guarantee affordable access, stimulate the expansion of capacity at the local level, and create local leadership and ownership of this new and unique resource. In the process, market forces need to continue to evolve naturally while, simultaneously, initiatives are developed which stimulate enhanced volunteerism, the continued role of our universities, and the contributions of the not-for-profit mid-level computer networks. I have recommendations in three areas: pricing, infrastructure, and services. Specifically, the following should be created:

1. An environment in which access will be affordable for all citizens. In the process of creating such an environment, avoid usage sensitive or time-based pricing. Citizens will, I believe, pay a fair price for volume (flat rate proportional to available capacity), but experimentation and innovation, two critical elements in creating an environment

in which we can realize the promise of the net, will experience a premature and tragic demise if discouraged by the burden of usage-sensitive pricing.

I would like to carefully place this recommendation in context. The NII will grow to encompass the cables coming into people's homes, and they will want to buy movies and other services across the NII. It is only reasonable that they pay the going rate for each of these services. But what is most critical is that the following three elements are maintained: flat-rate charging for basic access to all network services, such as those now on the Internet that are free; freedom from any bundled extra services included by the carrier in the price; and freedom to pick and choose services offered by vendors across the network, and to pay for them directly to the vendor, with no involvement by the carrier.

2. An infrastructural environment in which communities can and will assume ownership of their elements of an NII fabric. This is important because there are clearly insufficient financial resources to develop federally funded infrastructure to every city and town in America. Modest community and economic development programs which have as their foundation the same imagination and leadership shown by the National Science Foundation when it created the "Connections Program," however, will stimulate significantly community involvement and the investment required to make a full NII a reality. At the individual community level the initial investments necessary for proof-of- concept and demonstration activities are not large, and I believe that modest stimulation via federal programs will both create the initial investment and ownership, and larger local investments as local leadership and citizenry begin to realize both the promise and potential of the NII.

3. A services environment in which those organizations which choose to continue to foster and develop community and economic development can do so with renewed vigor and strength. Volunteerism, the role of not-for-profit organizations, the very special activities of organizations such as Eastern Oregon State College and the CIC universities, and the unique contributions that can continue to be provided by many of the nation's mid-level networks must be preserved if rural America is to realize the promise of a national information infrastructure.

Finally, and perhaps most important, we need to create an environment in which local communities can and will create services of their own. Services such as community information servers, structure providing access to health care information, activities to create virtual electronic communities of interest which encompass and then extend beyond local communities to a global environment, and initiatives which bring the digital library and other globally-based information resources to the desktops of individual citizens represent the promise of the National Information Infrastructure. We should never lose sight of these goals as we work very hard to make the NII a reality and a sustainable resource for the nation.

I believe that our government has an opportunity transform America in ways which parallel the transformations resulting from the Rural Electrification Act of 1936. I would like to close with a quote which I have used in other publications. It describes that impact much more eloquently than any which I could develop on my own.

"As late as 1935 ... decades after electric power had become a part of urban life, the wood range, the washtub, the sad iron and the dim kerosene lamp were still the way of life for almost 90 percent of the 30 million Americans who lived in the country-side. All across the United States, wrote a public-power advocate, "Every city 'white way' ends abruptly at the city limits. Beyond lies darkness." The lack of electric power, wrote the historian William E. Luechtenberg, had divided the United States into two nations: "the city dwellers and the country folks"; farmers, he wrote, "toiled in a nineteenth-century world; farm wives, who enviously eyed pictures in the Saturday Evening Post of city women with washing machines, refrigerators, and vacuum cleaners, performed their backbreaking chores like peasant women in a pre industrial age."
... from a description of the US before the Rural Electrification Act of 1936. (Robert A. Caro: The Years of Lyndon Johnson: Path to Power, Vintage Books, 1981, p. 516.)

Our opportunity and our responsibility are both clear. Thank you, again, for the opportunity to participate in this forum. I stand ready to provide additional information today and, of course, will respond to similar requests in the future.

E. Michael Staman

July 12, 1994

ATM: Reality or Pipe Dream

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Abstract

Since the early 1980s, campus networks have generally been based upon shared backbones. In this paradigm, traffic from individual users is aggregated on backbone networks and each user gets a share of the backbone bandwidth. That paradigm is rapidly becoming inadequate to meet growing user demands.

This paper describes the strategies developed at Washington University and the University of Nebraska-Lincoln to transition our campus networks to Asynchronous Transfer Mode or ATM technology.

Paradigm Shift

Since the early 1980s, campus networks have generally been based upon shared backbones. In this paradigm, traffic from individual users is aggregated on backbone networks and each user gets a share of the backbone bandwidth. That paradigm is rapidly becoming inadequate to meet growing user demands.

While the original motivation to move towards higher speed "broadband" networks was new applications such as multimedia and client server, those applications have happened more slowly than anticipated and the current motivation for broadband networks is traffic aggregation and LAN interconnections.

While it is difficult to quantify the growth in peak bandwidth demand or even average bandwidth utilization on a campus network or local area network, there exists good data on the growth of average bandwidth utilization on the NSFNET, the primary component of the Internet backbone. That growth is shown in Fig. 1.

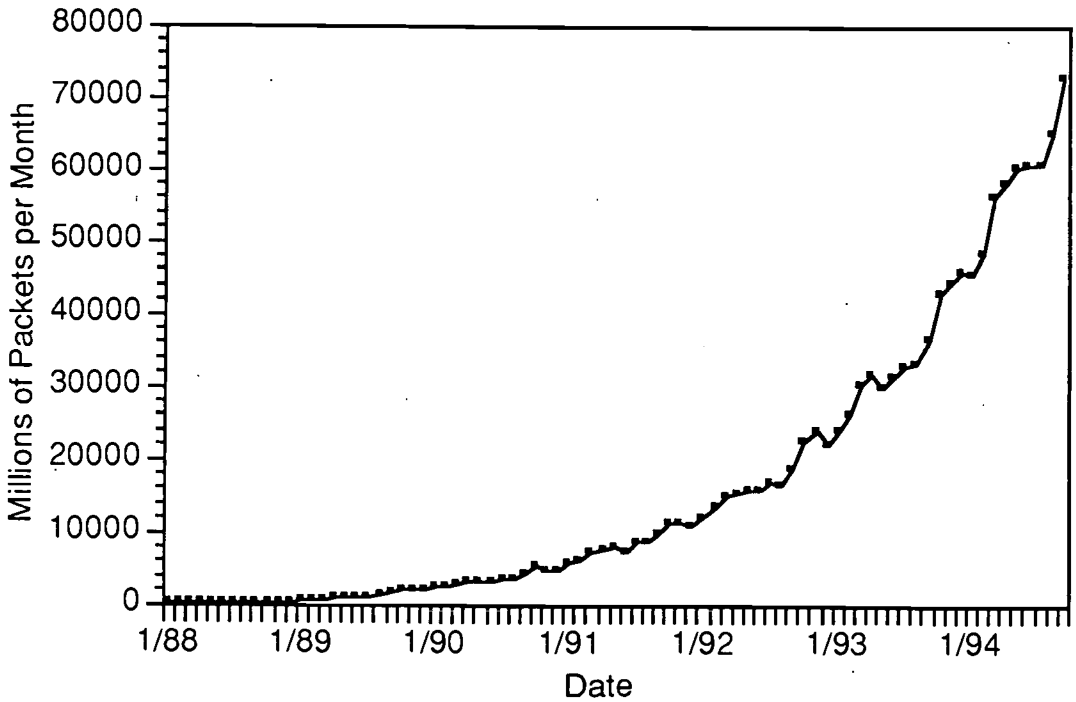

Fig. 1. Packets per Month on the NSFNET

It is reasonable to assume that the grown of campus network traffic parallels the growth of the NSFNET since the NSFNET is the composite of the intercampus Internet traffic.

The composition of that traffic is changing. In addition to the growth that is resulting from a larger user base, the network is being increasingly used to transfer multimedia information using software such as "Mosaic." This shift is illustrated in Fig. 2.

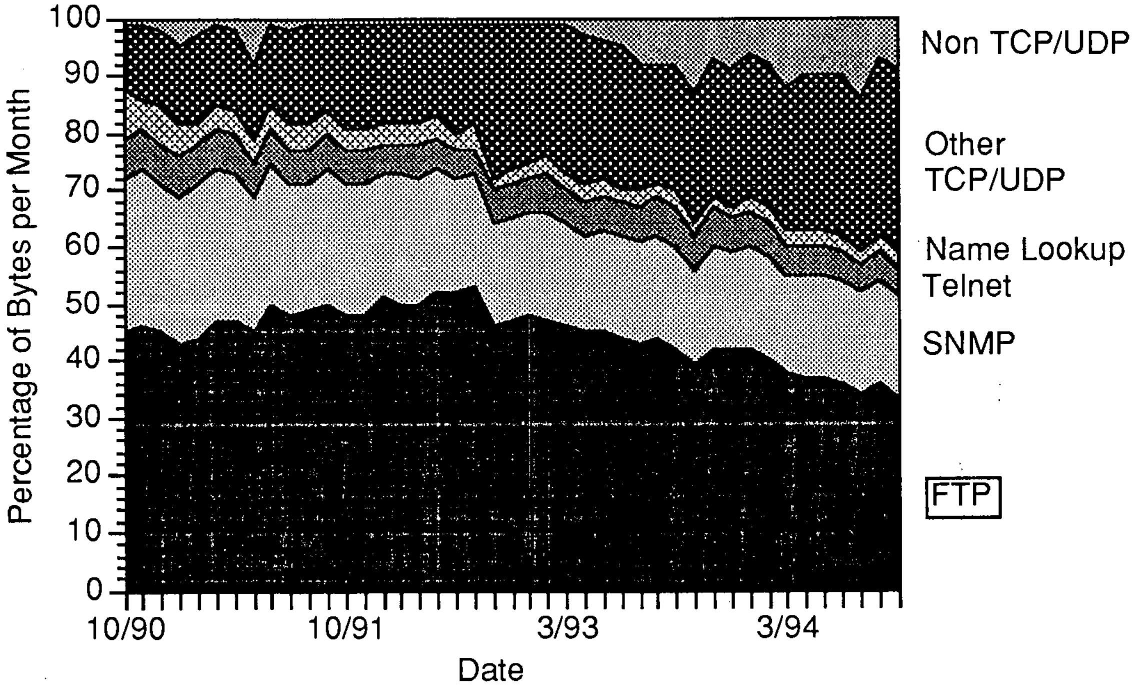

Fig. 2. Percentage Utilization of Bytes on the NSFNET.

It is clear from the data that the traditional uses of the Internet, file transfer (FTP), electronic mail (SNMP) and interactive logons (Telnet) are a decreasing portion of the utilization of the Internet. The growth in "Other TCP/UDP Services" can be attributed to multimedia applications such as "Gopher" and "Mosiac." Separate data indicates that Mosaic has been growing at 61% monthly since its inception.

Not only do we feel that bandwidth requirements will continue to increase at their historical rate, we are also concerned that historical growth patterns may not adequately reflect the bandwidth requirements of interactive multimedia. In other words, the projections that follow may be far too conservative! Our campus experiences have indicated that multimedia creates a quantum jump in bandwidth requirements.

In an attempt to project the future bandwidth requirements of campus networks, we have extrapolated the historical growth of the NSFNET through the remainder of this century. Our assumption will be that the growth of campus peak and average bandwidth requirements will parallel or exceed the historical growth of the NSFNET. That extrapolation is shown in Fig. 3.

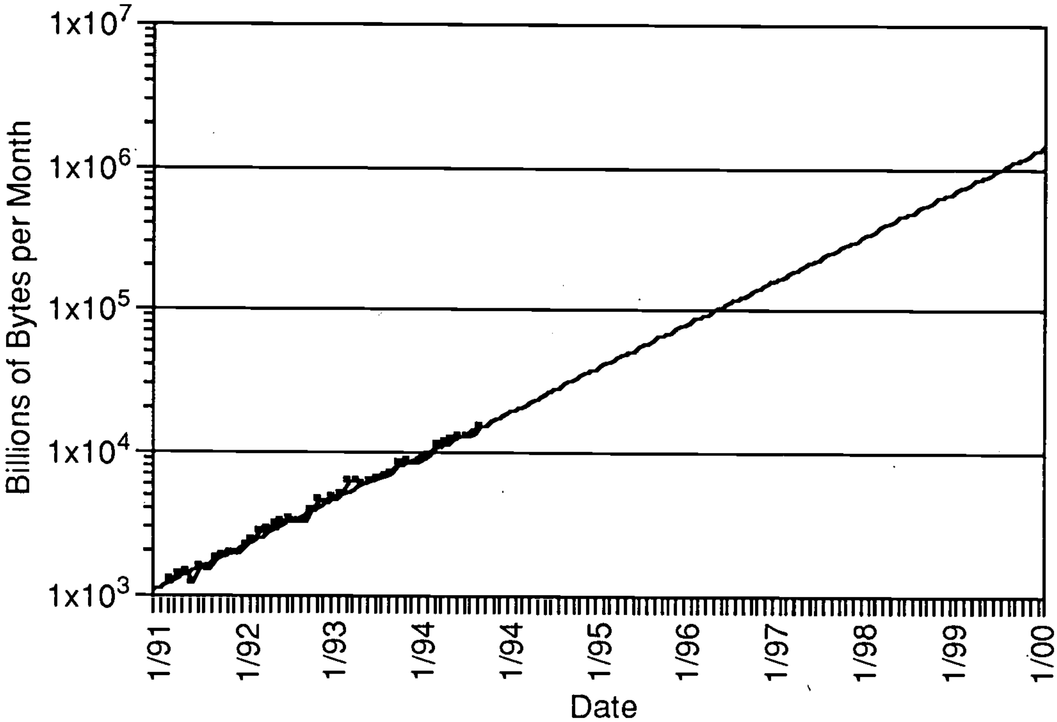

Fig. 3. Extrapolation of historical NSFNET traffic.

The data clearly indicates bandwidth increases of two orders of magnitude (a factor of 100) by the end of the decade. Many campus networks, including the University of Nebraska-Lincoln and Washington University, have already reached the point where shared bandwidth backbone architectures are no longer capable of meeting user demands. Bandwidth increases of two orders of magnitude cannot be accommodated with current architectures. Many campus networks will reach this point within the next few years.

The most obvious solution is to increase the speed of the shared backbone. Unfortunately, the cost of increasing the speed of a network that spans hundreds of kilometers is not easily accomplished. Using current technology it is very expensive to increase the speed of shared backbone networks one order of magnitude. There are no technologies available or proposed that provide two orders of magnitude increase for wide-area shared backbones.

Current technical solutions to this bandwidth problem all involve reducing the dependence on "shared backbones" and a migration towards dedicated bandwidth.

Alternatives to the Current Paradigm

There are a number of alternatives to the current shared backbone paradigm. By segmenting current routed backbone networks, we can effectively reduce the traffic on the shared backbone component. Ultimately, however, such techniques reach a point where more fundamental changes are necessary.

Switched Ethernet. Switched ethernet utilizes a star wiring configuration to extend 10 Mbs links from a high speed central switch (several hundred Mbs) to distributed equipment. In a typical campus environment, these distributed units might be distributed routers and strategic computing resources. This strategy suffers from two limitations. The first is that it is not scalable. Ultimately the 10 Mbs (or 100 Mbs fast ethernet) link to the distributed units will be overwhelmed. The second is that ethernet is not isochronous. That limits the use of the technology to data and low grade video or voice. In our opinion, switched ethernet should be regarded as a transition strategy.

Switched FDDI. Switched ethernet utilizes a star wiring configuration to extend 100 Mbs FDDI links from a high speed central switch to distributed equipment. In a typical campus environment, these distributed units might be distributed routers and strategic computing resources. This strategy suffers from two limitations. The first is that it is not scalable. Ultimately the 100 Mbs link to the distributed units will be overwhelmed. The second is that FDDI is not isochronous. Again, that limits the use of the technology to data and low grade video or voice. In our opinion, switched FDDI should be regarded as a transition strategy.

Asynchronous Transfer Mode. Asynchronous Transfer Mode or ATM is a fundamentally different technology. It is connection oriented, whereas ethernet and token ring are connectionless. It is scalable in multiples of 51 Mbs through several Gigabits per second. It was designed to carry voice, video, and data traffic. It represents a unifying force in that it provides services to workstations, computers, networks, homes, video stations, and telephones and is supported by both the computer and telecommunications industry.

Problems Associated With ATM

If ATM is so great, why isn't it being adopted everywhere? First, it isn't ready yet. There are no large ATM networks in operation.

Second, the standards for ATM are still evolving. In particular, the standards for LAN emulation have yet to be finalized. Institutions have a substantial investment in current LAN's. Any successful transition strategy must provide for operating existing networks over ATM.

Third, standards for quality of service (QOS), which is necessary for providing video and voice services is still evolving.

Fourth, standards are not yet in place for linking equipment from different vendors.

Fifth, video and voice may not use ATM technology. Video and voice are both very mature technologies and are very cost effective. The cost savings offered by an integrated technology may not be sufficient to offset the efficiencies already developed in specialized voice and video transmission systems.

Sixth, LANs may not convert to ATM. The availability of inexpensive higher speed LANs, such as 100 Mbs ethernet, will reduce the demand for a transition to ATM. Standards have been developed for isochronous ethernet (IEEE 802.9). Multicasting bandwidth reservation will be available through enhancements of traditional TCP/IP.

Transition Strategies

The fact remains that there are no alternative to ATM that will meet the projected bandwidth requirements by the end of the decade. Both Washington University and the University of Nebraska-Lincoln began a transition to ATM technology several years ago. The transition strategies developed at both institutions have three components. The first is to deploy a wiring plant capable of supporting both future ATM technology current non-ATM technology. The second is to deploy transition architectures that will meet current campus needs while ATM technology is maturing. The third is to deploy ATM test bed networks to develop expertise and experience.

Wiring Plant

Given unlimited resources every location would have available STP, UTP, Coax, single-mode fiber optics, and multi-mode fiber optics. Cost and physical constraints imposed by retro-fitting existing buildings requires a more modest approach. At Washington University the following set of guidelines have been adopted.

UTP: Level 5 UTP is installed at all locations. Where possible, multiple sets of two pair cables are installed but 4 and 8 pairs cables are also used. All cables are terminated at level 5 using punch down blocks in the wiring closets. Level 3 punch downs can be used for phones. When practical, the enhanced level 5 cable is used (sometimes called 5+ or level 6).

Cable Runs: A 90 meter rule is used from the punch down block to the jack on the wall. This leaves 10 meters of cabling for connections to the host and the hub. Multiple punch downs on a cable run are avoided requiring some home running of cable.

Wiring Closets: Wiring closets now contain hubs and required ventilation and power. Sufficient space in required for the equipment and maintenance access.

Additional Station Cabling: Coax (CATV) is installed in residence halls, lounges, conference rooms and classrooms. Mutli-mode fiber is also installed in classrooms and conference rooms. Where possible, the fiber is left unterminated to reduce costs, but in many cases the difficulty of post termination (short leads) requires the fiber be terminated during installation. If open conduits are available for future installation only the copper is installed.

Vertical Wiring: Both multimode and single mode fiber are installed to every wiring closet. In some cases two or three floors will share a closet. Level 3 trunk cable is pulled between floors for telephone. A common fiber de-mark consist of 18 multimode and 6 single mode fibers.

Campus Wiring: The campus is divided into sectors each with a major fiber hub and several minor fiber hubs. Sectors are interconnected with 96 multi-mode fibers and 48 single mode fibers. The resulting topology is a inter-connected multiple star network. From this topology rings and buses can be created if needed. The major hub room will contain substantial equipment and additional attention is given to space and environmental considerations.

Development and Training: Installation of ATM capable networks requires close attention to level 5 installation standards. Early training of engineers and technicians is critical for a successful installation.

Legacy Systems Support: In nearly all cases, existing asynchronous lines (terminals) and ethernet connections are re-established using the new stations wire. Telephone trunks were installed at level 3 to provide connectivity to centralized building hubs or traditional asynchronous data circuits including fire alarms, security, and physical plant controls.

Existing fiber rings and ethernet circuits are re-established by appropriate jumpering of the fibers at the major and minor hubs. If possible baseband ethernet cabling is left installed, if not ethernet is moved to fiber in a star configuration.

Transition Architectures

The second component of our transition strategy is to deploy a transition network architecture appropriate to the demands from users for more bandwidth and greater network capabilities. Differences between campuses will result in different architectures. Washington University has deployed switched FDDI, switched ethernet, and collapsed backbones. The topology of this deployment, shown Fig. 4 on the next page. The network consists of inter-connected stars; the same topology will be used for ATM. Networking privacy, a feature of ATM technology, is currently provided to the user by deploying secure hubs. The new generation of these hubs simplify the management of a privacy enhanced network.

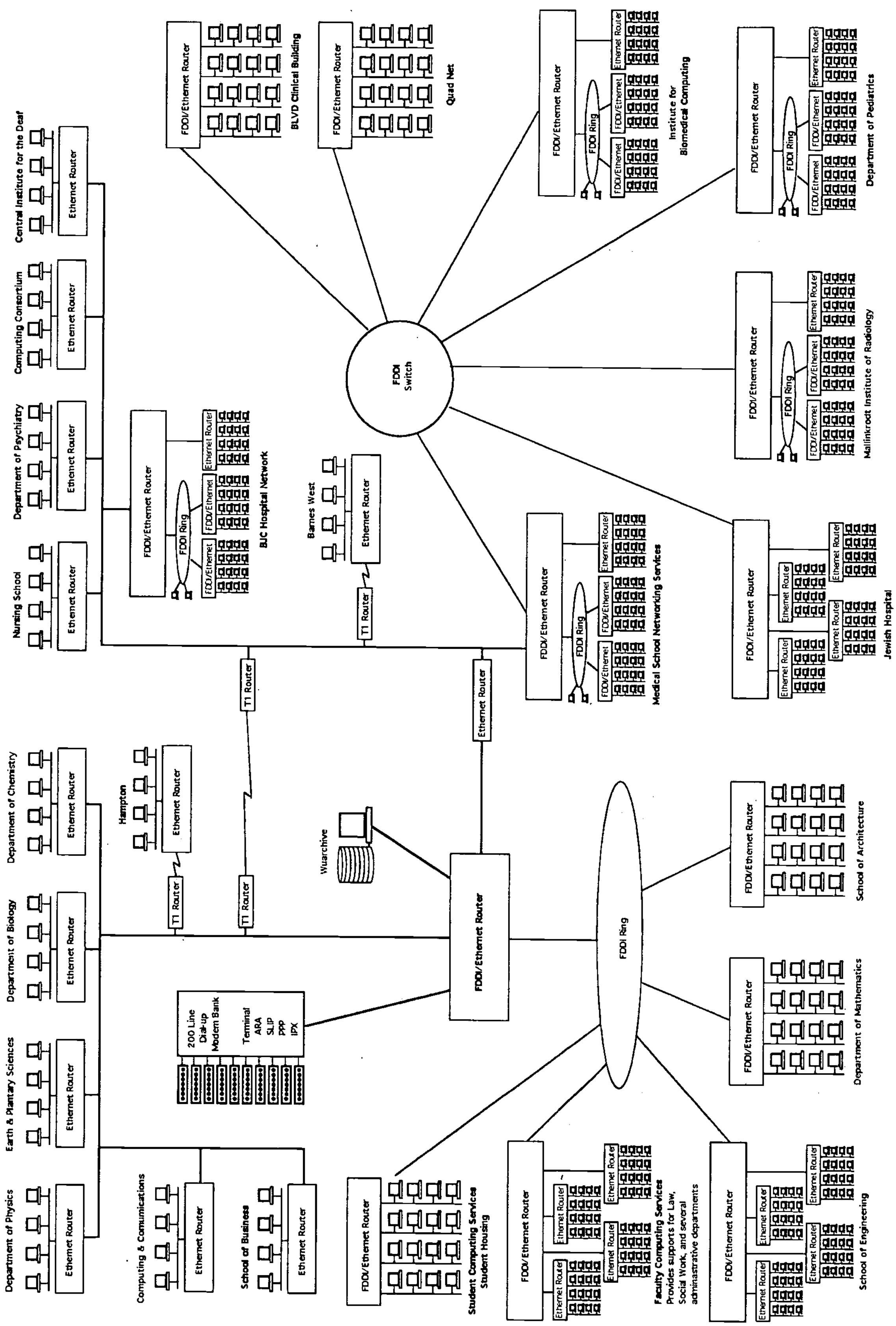

Fig. 4. Washington University Campus Network - Nov 1994

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At the University of Nebraska-Lincoln, bandwidth requirements track several years behind those at Washington University and allow a different transition strategy. UNL plans to by-pass both switched ethernet and switched FDDI and deploy ATM switching technology; Washington University has used FDDI switching as an interim step. UNL feels that enhancements and further segmentation of its current network will allow the campus to "get by" until ATM technology matures sufficiently for its adoption in a production environment.

ATM Test Beds

ATM technology is new and both campuses have deployed ATM testbed networks to gain experience.

UNL ATM Testbed: The UNL testbed is a joint project of the Computing Resource Center, the Department of Computer Science, and the University Library. The testbed is shown in Fig. 5.

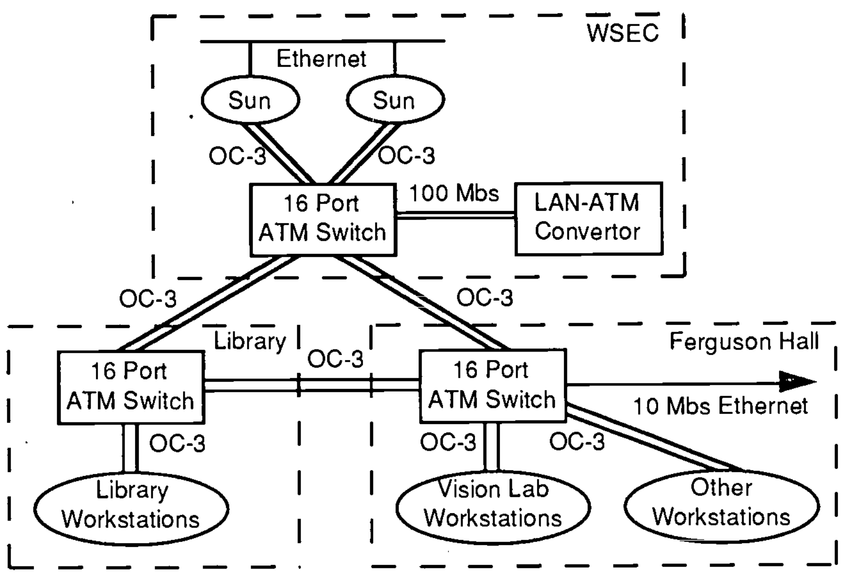

Fig. 5. UNL's ATM testbed.

Washington University ATM Testbed: The Washington University ATM network is shown in Fig. 6 on the next page. The switch speeds range from OC3 (155Mb/s) to OC192 (10Gb/s). Most of the OC3 switches are deployed, others will be added as they become available. The network is designed to bring ATM to the desktop. The figure shows a variety of hosts that contain commercial ATM SONET interface cards and other hosts utilizing a device called a multimedia explorer. This device supports bi-directional broadcast quality NTSC video and CD quality stereo sound through external ports. There is also an ATM host interface. The multimedia explorer is used for multimedia applications development on the ATM network.

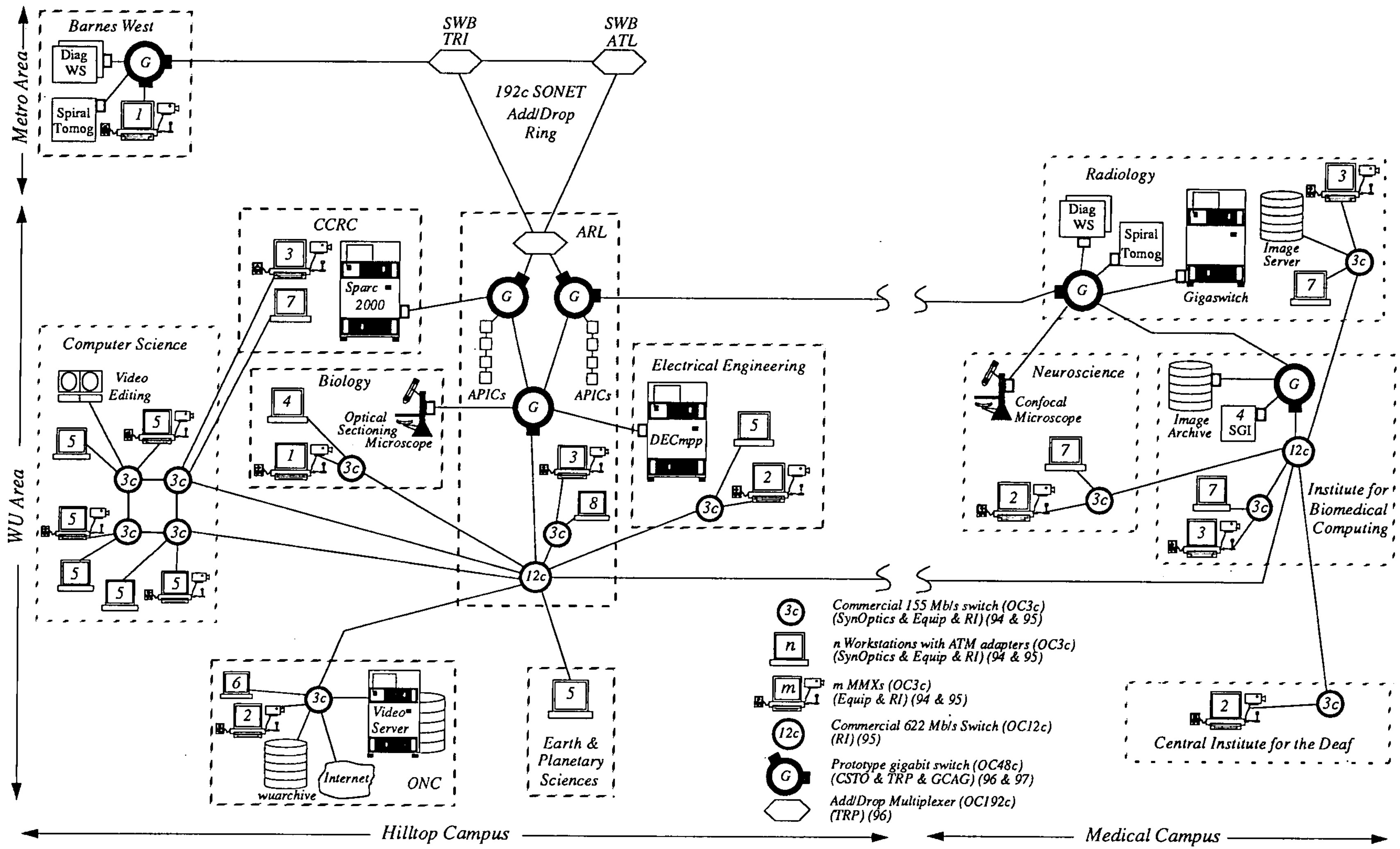

Fig. 6. Washington University ATM Testbed

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Selling ATM - The End Users View

As a scalable and secure technology, ATM solves many network engineering and management problems. End users, however, will be reluctant to pay more money to adopt this technology if they do not perceive that they are receiving new and innovative services. The argument that "we need to do this to keep your email running the way it always has" is not likely to generate support for additional network expenditures.

At both Washington University and the University of Nebraska-Lincoln, we feel that the development of new applications such as multimedia and remote collaboration (teleconferencing, telemedicine, distance learning, etc.) is an essential part of any ATM networking plan.

To complement ATM technology Washington University has identified applications in Neuroscience, Radiology, Biology and Hearing where the strength of the ATM technology can make a solid contribution. The networking research group in the Applied Research Laboratory in the School of Engineering is working with these researchers and several prototype applications are operational.

At the University of Nebraska-Lincoln we have created "New Media Center" dedicated to supporting the development of multimedia applications in instruction. That facility includes two completely equipted classrooms as well as a staffed media development area.

Personal Data Delivery on Campus Networks

David L. Rotman
Cedarville College
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Abstract

This session is designed to share some techniques being used at Cedarville College for the delivery of information to individuals. Our customers (students, faculty, and staff) have an expectation of convenient and rapid access to information. Providing non-confidential information via CWIS systems mets part of this customer expectation. This session will explore means of delivering confidential information and some basic transaction processing over the campus network.

Pesonal Data Delivery on Campus Networks

As computer networks become more pervasive on campus and the various campus constituencies become more accustomed to using those networks, expectations grow regarding the use of computers to access information. In fact, the development of some campus networks is the result of an emphasis on delivery of information. Cedarville College's campuswide network was designed on the basis of such a vision [Cedarville College, 1991]:

> Cedarville College is committed to providing its faculty, staff, and students with an integrated, broadly-accessible information, voice, and video communications technology infrastructure.
>
> To this end, the College should:
>
> 1. Assure that its personnel and students can access and maintain, through appropriate technology, the information necessary to fulfill their roles;
>
> 2. Continually assess information technologies and seek to implement appropriate hardware and software that enhances individual and organizational effectiveness;
>
> 3. Make available to personnel and students instruction and reinforcement in the use and application of information technologies; and
>
> 4. Foster an environment that encourages responsible use of technology, yet maintains a sensitivity to technology's effects on its users and their environment.

Goals for Information Delivery

As suggested in the vision statement above, two primary goals for information delivery have been identified: ready access to information and providing information which meets the needs of individuals within the college. *Ready access* means that individuals will be able to obtain information they need when they need it and where they need it. In an ideal world, students should not have to leave their residence hall room to obtain reference materials, prepare assignments, or conduct business transactions. Faculty members should be able to prepare teaching materials, do subject-area research, and develop service opportunities from their offices. Similarly, staff members should have access to institutional information from their own work areas.

Providing information meeting the needs of the individuals means that adedquate information should be provided and that tools should be available for screening and manipulating that information according to the needs of the user. Sufficient information must be provided. As delivery of information increases, more attention must be given to making that information relevant to the individuals receiving it. Individuals need to have enough information to do their work, without being overwhelmed by information which is unrelated to their work.

Constraints

There are both legal and practical constraints on the delivery of information. While finances can be a very real limiting factor, there are other factors which may limit delivery of information or affect the form in which that information is delivered. *General security* is a major factor in designing information systems. Some applications need to be restricted to selected groups of individuals so as to ensure the integrity of transactions. For example, certain individuals should be able to initiate general ledger transactions easily while other members of the general college community should not have this capability. Enforcement of general security is both a quality-control issue (limiting access to those persons who are qualified to use the access) and a fraud-avoidance issue (limiting access to minimize the risk of falsified records).

Besides general security issues, there are *privacy issues* which are particularly relevant to the college environment. Privacy issues can be specifically mandated or a matter of insitutional policy. The Family Educational Rights and Privacy Act (FERPA) limits what portions of student's records may be made available to various constituencies. Directory types of student information can be made available to the general public. An employee may obtain any and all student information, provided the information is based on a "need to know." Parents of an adult child may not have access to their child's records without written authorization or written proof of their child's IRS dependency status. Data which fall outside the purview of FERPA may still be restricted due to institutional policy. For example, general ledger information may be considered confidential in many private colleges.

A third constraint on the delivery of information is the institutional approach to *accessibility*. Some data must be made available to certain classes of individuals (e.g., federal crime statistics), but there are no clear requirements for how this access is to be provided. The institution has some latitude in deciding how easy to make the access. Having a document available in a central campus location may suffice in some situations, whereas some institutions will choose to make the access even easier by making this information available over the Internet. For security and public relations reasons, an institution might provide easy access to persons on campus, but block access to that information from off campus.

Another constraint in the design of information delivery is the desire to *preserve human contact and dignity*. The information system designer must continually weigh the impact of the technology on the users: Will this system increase or decrease person-to-person contact? Will this system make people feel like they are being treated as machines? Will this system improve the quality of the work environment (e.g., reduce monotony) for the people who use the system?

Cedarville Environment

Cedarville College has implemented a campus-wide network which is based on a philosophy of making information available to people who need it *when* they need it and *where* they need it. The outworking of this philosophy is a design which called for installation of network computing in each office and each residence hall room over a three-year period ending in 1994. The network currently connects all faculty offices, all classrooms, and 95% of the residence hall rooms. The college provides a computer and printer in each residence hall room, so that resident students have immediate access to the network as part of their educational experience. Commuting students gain access in public laboratories or via modem.

Cedarville College Network Environment Fall, 1994	
Student enrollment	2378
Full-time teaching faculty	137
Full-time staff	210
Networked computers	1200
Network configuration	Novell Netware 4.02 12 servers Ethernet in each building Collapsed TokenRing backbone

Cedarville's Information Delivery System

The system design at Cedarville divides information delivery into three categories: public information, confidential information, and transaction processing. Public information is information which is widely accessible (though the access may be limited to on-campus use only). Confidential information is information which is restricted to certain individuals within the college community (e.g., grades may be seen by the student and the student's advisor). Transaction processing involves the updating of databases where the user does not have direct access to those databases.

Data Access Models for Confidential Information and Transaction Processing

Administrative data capability can be provided to the college community in two different ways: by allowing direct access to the system containing the data or providing indirect access to that system. In the Cedarville College situation, a decision was made to provide access indirectly. Provision of direct access was deemed to present a large security risk and unnecessarily increase the workload in the computing center. Providing direct access would have required creating individual login accounts for each person and then establishing rights for those accounts. Through indirect access, authentication is handled on the Novell network rather than on the administrative host system. Using a model with some client/server characteristics, the requested information is passed from the host to the network without the user having to login to the host.

The Cedarville system utilizes a requestor program on the network, a transfer processor on the network, and a server program on the host, as shown in Figure 1 below. The requestor program verifies the identity of the requestor and writes the request to a directory on the network. Users have write privileges to this directory, but do not have file-scan or read privileges. The requests are moved from the network to the host system by the transfer processor. Once on the host system, the requests are processed and the results are returned via electronic mail.

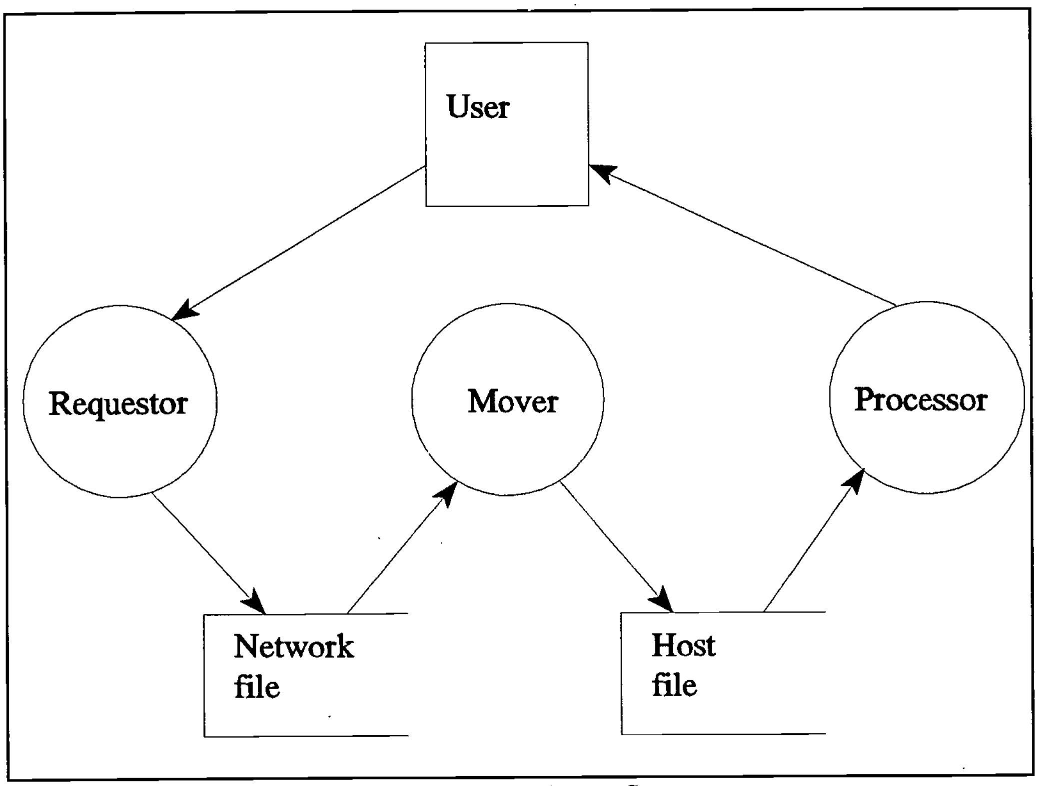
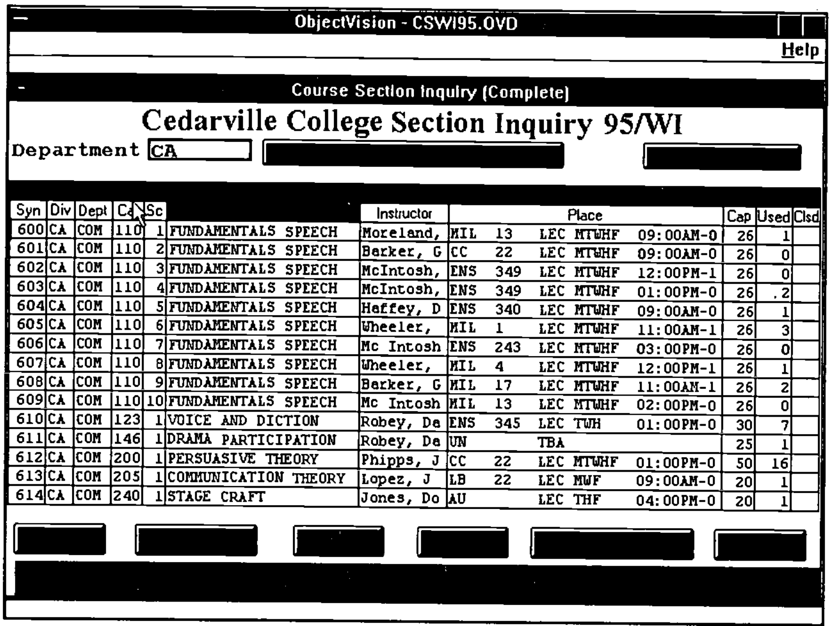


Figure 1 Cedarville College Information Delivery System

Public Information Examples

Two examples of public information delivery are shown below. These items are available to anyone logged into the campus network, merely by clicking on an icon.



Syn	Div	Dept	Ca	Sc		Instructor	Place	Cap	Used	Clsd
600	CA	COM	110	1	FUNDAMENTALS SPEECH	Moreland,	MIL 13 LEC MTWHF 09:00AM-0	26	1	
601	CA	COM	110	2	FUNDAMENTALS SPEECH	Barker, G	CC 22 LEC MTWHF 09:00AM-0	26	0	
602	CA	COM	110	3	FUNDAMENTALS SPEECH	McIntosh,	ENS 349 LEC MTWHF 12:00PM-1	26	0	
603	CA	COM	110	4	FUNDAMENTALS SPEECH	McIntosh,	ENS 349 LEC MTWHF 01:00PM-0	26	. 2	
604	CA	COM	110	5	FUNDAMENTALS SPEECH	Haffey, D	ENS 340 LEC MTWHF 09:00AM-0	26	1	
605	CA	COM	110	6	FUNDAMENTALS SPEECH	Wheeler,	MIL 1 LEC MTWHF 11:00AM-1	26	3	
606	CA	COM	110	7	FUNDAMENTALS SPEECH	Mc Intosh	ENS 243 LEC MTWHF 03:00PM-0	26	0	
607	CA	COM	110	8	FUNDAMENTALS SPEECH	Wheeler,	MIL 4 LEC MTWHF 12:00PM-1	26	1	
608	CA	COM	110	9	FUNDAMENTALS SPEECH	Barker, G	MIL 17 LEC MTWHF 11:00AM-1	26	2	
609	CA	COM	110	10	FUNDAMENTALS SPEECH	Mc Intosh	MIL 13 LEC MTWHF 02:00PM-0	26	0	
610	CA	COM	123	1	VOICE AND DICTION	Robey, Da	ENS 345 LEC TWH 01:00PM-0	30	7	
611	CA	COM	146	1	DRAMA PARTICIPATION	Robey, Da	UN TBA	25	1	
612	CA	COM	200	1	PERSUASIVE THEORY	Phipps, J	CC 22 LEC MTWHF 01:00PM-0	50	16	
613	CA	COM	205	1	COMMUNICATION THEORY	Lopez, J	LB 22 LEC MWF 09:00AM-0	20	1	
614	CA	COM	240	1	STAGE CRAFT	Jones, Do	AU LEC THF 04:00PM-0	20	1	

Figure 2 Public Information, Course Enrollment Inquiry

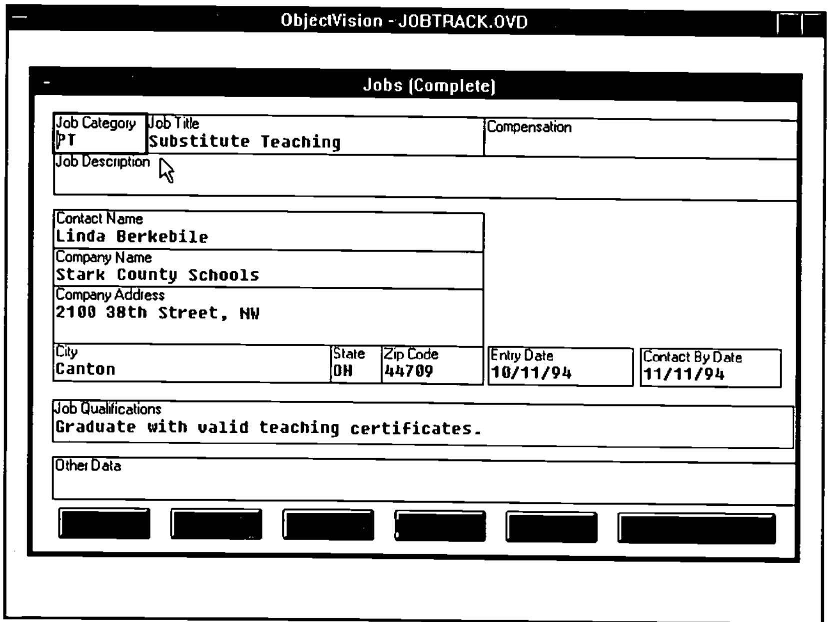


Figure 3 Public Information, Employment Opportunities

BEST COPY AVAILABLE

Confidential Information Examples

Using the Cedarville information delivery system, students may copies of their class schedules, unofficial transcripts, current account balances, statements of their accounts, and their chapel attendance records. Faculty members may request schedules and transcripts for students. Work is in-progress to provide degree audit capability for both students and faculty. The figures below show the requestor screen for faculty and a sample retrieval of a transcript.

```
Data Requestor

 1. Student Data Sheet
 2. Unofficial academic transcript
 3. Account balance
 4. Student account statement
 5. Chapel attendance record
 6. Academic transcript for a student
 7. Schedule for a student

Enter selection number or ESC to quit:
```

Figure 4 Confidential Information, Requestor Program (Faculty Version)

```
From:      Registrars Office
To:        rotmand@cedarnet.cedarville.edu
Date:      Wednesday, November 9, 1994 6:49 am
Subject:   Data server request: TRANSCRIPT

Cedarville College Data Server          DATA.SERVER.TRANSCRIPT
11/08/1994                                          07:02:34AM

ID: 9999999
Johnson, Henry William
345 South Main Street
Chicago, IL 60601-9999

  TERM  COURSE      TITLE                CREDS GR RP TERM  CUM
- ----- ----------- -------------------- ----- -- -- ----- -----
I 92/FA ENG  110 11 COMPOSITION I         5.00 C+    2.200 2.200
        GSS  100 01 FOUND SOCIAL SCIENCE  5.00 C-
        MATH 171 05 COLLEGE ALGEBRA       4.00 C+
        PEF  199 06 PHYS ACT & CHRIST LI  2.00 B
I 93/WI COM  110 03 FUNDAMENTALS SPEECH   5.00 B-    2.133 2.168
        GSCI 190 01 CALCULUS FOR BUS/SOC  5.00 C
        HUM  140 01 INTRO TO HUMANITIES   5.00 C-
```

Figure 5 Confidential Information, Electronic Mail Response

Transaction Processing Examples

At this point in time, two types of transaction processing are provied on the network. In one type of transaction processing, a particular group has write privileges to a database while another group has only read privileges. In the other type of transaction processing, none of the users has write privilege to the files.

The "faculty schedule" system is an example of transaction updating by a privileged group. Preliminary faculty schedules are built on-line using the registrar's course schedule. Faculty members can then add office hours, committee meetings, and other comments. Students have inquiry-only access to this database.

The "late pass" system is an example of transaction processing where none of the users has write privileges to the database. Prior to leaving campus for a weekend or overnight trip, students enter destination information using a VisualBasic program. Upon their return, the students record their return dates and times. Both the initial entry and the entry upon return from the trip generate transactions for the database. The "data mover" routine detects these transactions and does the updating of the network-based files. Appropriate individuals (head residents, deans) can query these network-based files to determine the students' destinations and expected return times.

Schedule

Name/Home address
Bonenberger, Omer
238 Bridge St.
Cedarville OH 45314

BONENBERGER

	Bldg	Room	Phone
Office	WI	116	7788

Home phone 513-766-5466

	Monday	Tuesday	Wednesday	Thursday	Friday
8		EDUC*393*01		EDUC*393*01	
9		EDUC*393*01		EDUC*393*01	
10	Chapel	Chapel	Chapel	Chapel	Dept mtgs.
11	Office	EDUC*393*01	Office	EDUC*393*01	Office
12		EDUC*393*01		EDUC*393*01	
1					
2	EDUC*350*01		EDUC*350*01		EDUC*350*01
3	Office	Office	Office	Office	Office
4					
5					
6					
7					

Comments This schedule is good from Sept. 21 to Nov. 8.
After that date, I will be in clinical field experience
until 3:00 pm on most days

Figure 6 Transaction Processing, Faculty Schedules

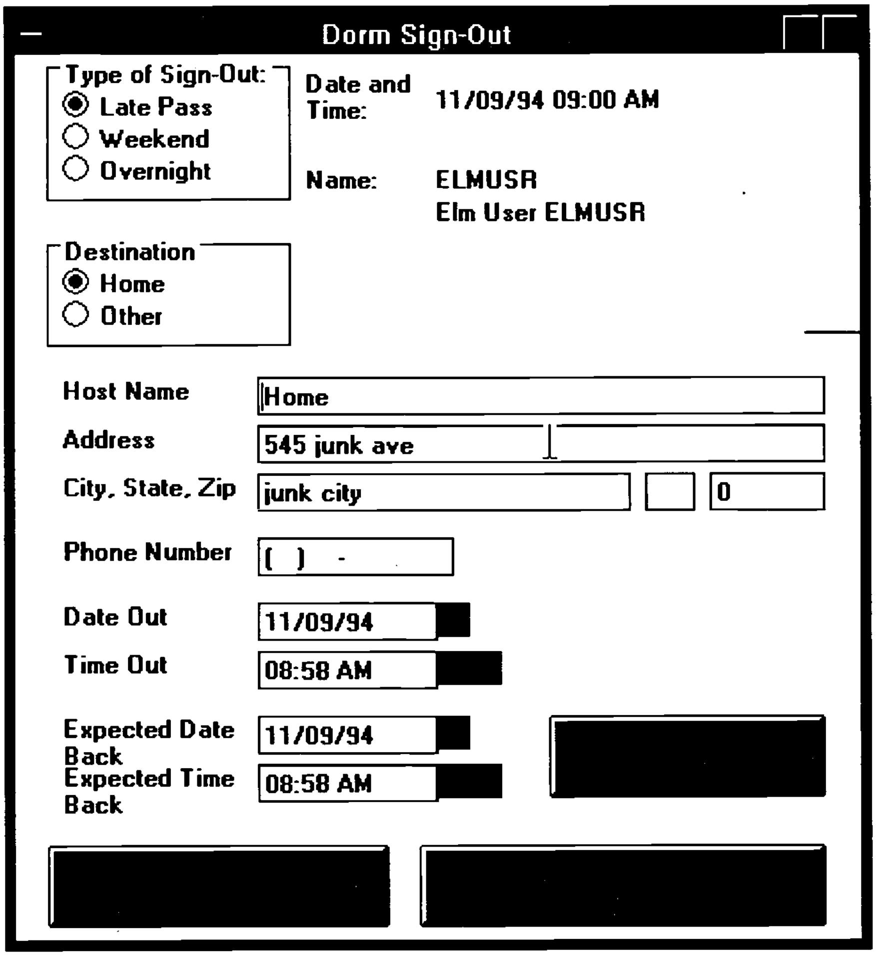


Figure 7 Transaction Processing, Inquiry-only Access

References

Cedarville College. 1991. Cedarville College Information Resources and Technology Task Team Final Report 1990-1991.

Cedarville College. (no date). Family Educational Rights and Privacy Act (FERPA): Cedarville College Policy.

IMPLEMENTING A CAMPUS NETWORKING INFRASTRUCTURE

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Southern Methodist University

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Most higher education institutions have an aging infrastructure that greatly hampers the use of modern computing technologies. This session will discuss the implementation of a campus-wide solution for the networking infrastructure needed for the 1990s at Southern Methodist University, a medium sized, private institution. Topics include evaluating alternatives, selecting a strategy for the environment, and getting the job done successfully--buying and installing a cable plant; constructing closets; dealing with asbestos; transitioning old voice and data switch technologies; installing an integrated telecommunication management system; and, seeking funds, space, and faculty support. The combined management of voice and data communication greatly simplifies the politics and provides economies in allocation of staff. Expansion of the Internet to each desk top and campus-wide client-server applications are now possible.

INTRODUCTION

Many colleges and universities have already implemented a campus networking infrastructure, particularly those that are large research universities. These projects began in the early 1980s when it became clear that communication infrastructure was not going to remain the purview of the telephone companies. But many medium sized and smaller institutions may find that their infrastructure is incomplete and does not cover all their buildings including dormitories. Others may find that they are still dependent upon old telephone wire and modems for most locations excepting island areas that are served by coaxial cable and cluster controllers.

If the goal is to get every desk top on campus connected to the "information superhighway" at 10 to 100 megabits per second, you may find that much work needs to be done on infrastructure before computers can be connected. You may also be interested in replacing legacy administrative applications with modern, client-server applications. Without a means for universal connectivity on the campus, some locations will be unable to participate in the newly designed environment.

This paper and presentation describe how a medium sized, private university was able to accomplish these goals. Southern Methodist University has 7,500 full-time equivalent students, a 160 acre campus four miles north of downtown Dallas, and 60 buildings on the campus proper. Alternatives that were evaluated are identified. Hopefully, you will find some ideas here that you can apply on your campus to improve the communication infrastructure so that it does not hamper computing growth and development.

The orientation of this information is from the point of view of improving management. It is not meant to present technical details of what might be the best information or communications technology, but rather how management can be improved with proper infrastructure and software. Emphasis is placed on the management of the telecommunication and data communication infrastructure with the professional staff using software tools to better serve the needs of the faculty, administration, and students. Integrating traditional telecommunication staff into a computing organization is a management challenge because of the different cultures. Until this is accomplished, voice and data communication are not truly integrated. A telecommunication management system is necessary to preserve and maintain major investments in infrastructure and to minimize the growth in staff that can be required for an expanded cable plant and electronics distributed across campus.

The technology leader has immense problems on a campus if the buildings were built many years ago without infrastructure to support 10 to 100 megabit data communication, funding is quite limited, and the administration has great trouble in understanding your unhappiness with the situation. Modern computing with powerful workstations communicating with remote servers both on and off campus using multimedia technologies was unheard of even ten years ago. Now, the faculty and administration expect that these technologies can be had through some magic on our part and the purchase of some electronics. Access to the "information superhighway" is a right, an academic freedom. Most faculty and administrators do not understand that access from every desk top requires much work and investment of time and financial resources.

BACKGROUND OF THIS CASE STUDY

This story begins more than five years ago. Southern Methodist University is an oasis in the city of Dallas. Even though it is part of a metroplex of four million people, it goes about its business of educating traditional, 18-22 year old students somewhat oblivious to the technological changes in its midst. The situation five years ago is described below.

Cable Plant

Some of the telephones failed when it rained. This failure was due to old copper wire that had been installed when the buildings were built or when telephones were first required for business purposes. Data communication was being accomplished on copper wire that was telephone wire or that two entrepreneurial subcontractors were installing as demand required, charging the university $50 per hour for their time plus materials. These installations were occurring in an ad hoc fashion, not following any design or plan. They did not conform to any standards of either the electrical or communication trades. Any look into a telephone closet in any building on campus caused rational people to shudder. Only long hours of working by trial and error led to any changes in service.

Telephones

The telephone switch was a leased AT&T Dimension 2000 that was nearly out of ports. It continued to operate only because of one employee who juggled its capacity to meet campus needs and worked closely with maintenance staff from AT&T. AT&T charged the University $76 per hour. Many business offices on campus contracted separately with Southwestern Bell for business lines because the University telecommunication office could not meet their needs. The dormitories were served for voice communication by Southwestern Bell Centrex; data communication for these locations was not considered.

Data Communication

An AT&T ISN network owned by the University provided data communication for administrative computing applications. Its major electronics were connected by limited fiber optic cable in the steam tunnels. Additional capacity was not available without purchasing additional hardware from AT&T. This product was no longer being promoted by AT&T. The gerryrigged copper plant of the subcontractors supplied communication within the buildings. Access to administrative computing applications operating on mainframe computer was limited to those locations that had AT&T ISN networking. These were usually the major administrative offices, such as the registrar, finance, development, and so on, and usually only the locations previously designated as doing data entry were connected. Consequently, it was not possible to promote and support ad hoc queries by user locations or other interested administrators. Most faculty communication with computers was through modems that were quickly consuming the limited AT&T Dimension 2000.

Internet Access

Access to the National Science Foundation Network (NSFNet), also later known as the Internet, did not yet exist on campus. Only Bitnet access was available and it was used very little by the academic community and was unknown to the administrators. Only the Engineering School was pressing for NSFNet access. It had installed some fiber for its own use and was successfully experimenting with ethernet. It was clear that this requirement was about to spread to the sciences and elsewhere on campus and the infrastructure did not exist to deal with it.

Asbestos and Space

The steam tunnels that connected all buildings and seemed the likely conduit for a cable plant were filled with asbestos. An initial estimate was $3 million for removing the asbestos from the tunnels. The mechanical equipment rooms where most of the copper plant terminated often had hazardous asbestos. It was suspected that many of the buildings had asbestos in normal surroundings that would endanger workers doing installation as well as the University employees. Strict rules for the appearance of the campus as "Collegiate Georgian" limited what could be visible. The existing telephone switch room was limited in size. The only possibility for expansion was the space occupied by the three telephone operators.

If there is one good view of the situation five years ago, it was that the University was not committed by any prior poor choices in technology. It hadn't made any decisions about computing and communication technology for five years. In that time networked computing and powerful workstations had become accepted and preferred over the centrist mainframe environment. We just had a long way to go to catch up.

ALTERNATIVES AND STRATEGIES

It is easy to conclude that a new cable plant was required in all campus buildings and that it should address both voice and data communication for the next ten to twenty years. A new and larger telephone switch was needed by the administration. The students in the dormitories should be included in the new system. Asynchronous data communication connections needed expansion. Demand for ethernet access was within two years of reaching the state of a "roar" from the faculty. Already the campus computing advisory committee had sent the president a report with the top priority being the installation of more fiber for data communication. But how would a private institution that did not have a balanced budget at this time and was facing constant threats of declining enrollment deal with these problems? How could this work be funded? We left this question for later resolution. First we needed a complete plan and price.

The only alternative for attacking these problems seemed to be to do the project all at once with one prime contractor. The project would have "critical mass" to obtain funding and it could be accomplished within a reasonable time frame. This approach was risky; there were many opportunities for failure. The other alternative of doing this project incrementally, one or a few buildings at a time, seemed endless, and we could never have modern computing. If selling a "critical mass" project failed, we could always return to an incremental approach. About seven campus buildings had been extensively remodeled or newly built in the past three years and had reusable inside cable. The University libraries were attempting some incremental cable plant improvements that could fit into the larger project.

Hiring a Consultant

With all these goals for the project and its high risk, it seemed wise to enlist the services of a telecommunication consultant. Such a person, with the proper credentials, can lend credibility to the selection process, can assure that a contract is negotiated that is favorable to the buyer, and can assure that some details are not overlooked that may jeopardize successful completion. I recommend that you shop carefully for such a consultant, asking colleagues or calling institutions where you know projects have been successful.

You should also evaluate your own skills and those of your staff, and within the university. Do you have people who can serve as experts in data communication? Is the physical plant staff able to assist in cable plant and construction? How capable is the legal staff and do they have any technical expertise? How much problem will it be to get administrative and board approval? Do you need someone to manage this approval process? Do you need someone to manage the acquisition process? Do you need implementation monitoring or supervision? Answering these and similar questions will enable you to assess what consultant can best meet your requirements.

You may need several consultants, each with different skills and purposes--perhaps one for the selection process, another for construction, and another for writing the contract. Depending upon the procedures at your institution, you may need to write a request for proposal or a bid specification to obtain the consultant, or you may be able to search out the best possible person through your personal network.

At another university, I had previously worked with a consulting firm that had the needed skills. I wasn't sure about all skills on campus, but I knew I needed help on the acquisition and selection process. The president needed convincing since he wasn't sure about why I was so intent on this project when he had dial tone. I was sure he had not yet discussed anything with the Board of Trustees. A study done four years earlier by AT&T for the University, though dated, offered some validity for my claims of eminent collapse of the infrastructure. I found money for the consultant by changing the leasing contract on the AT&T Dimension 2000 from monthly to annual. The president approved hiring the consulting firm that I requested, and we began.

Deciding on the Vendor

In a very political environment and with large amounts of money to be spent, a representative committee from across the institution was needed to choose a vendor. Minimally, the committee should include people from finance, housing, deans offices, faculty, physical plant, library, and the best technical people from computing and communication. At SMU, this amounted to 12 people who spent at least 200 hours each spread over one year beginning in the summer of 1989.

The activities included meetings to identify requirements and evaluation criteria, to review written materials, and to contact vendors. We began by visiting all major vendors, telling them what we had in mind, and letting them tell us about their products. We were educating ourselves about the market and possible approaches. The committee discussed our goals with the consultant and what we could reasonably expect from the marketplace. We developed a list of about 25 potential vendors. The consultant took major responsibility for writing the Request for Proposal (RFP) based upon his experience at other universities. However, the committee added its requests and nuances before the RFP was sent out in November 1989. Requested responses were due in February 1990.

Because of the asbestos problems, we could not let groups of vendors into many areas, including the steam tunnels, in order for them to provide accurate pricing. We stated that all vendors were to assume that the asbestos problems would be addressed by the university prior to their work in order to provide a standard environment against which to evaluate their proposals. However, we clearly told them that we had not determined how we would deal with the asbestos and that those costs would be separate from the requested pricing. We showed them a video tape made by University staff in the steam tunnels so that they would know the extent of the problems. Not only was there asbestos, but there were several locations where steam and water pipes constricted passage and possible space for the large copper cables. The Physical Plant Department was very hesitant about having these large copper cables to contend with in doing electrical, heating and cooling maintenance.

The Request for Proposal was very general and solicited creativity on the part of the vendors. It asked for a cable plant and a telephone switch with asynchronous data capability to replace and expand the AT&T ISN network. It definitely encouraged data communication at higher bandwidth but our survey of the market did not support getting anything greater than one megabit per second from any of the vendors who could provide a telephone switch. It requested separate pricing for administrative buildings, dormitories, Greek houses located adjacent to University property, and university owned apartments located somewhat further but still adjacent to the campus proper. The tunnel system only served the administrative buildings and the dormitories. It did not extend to the Greek houses and the apartments. The vendors were to propose how to cable to the more remote locations. Because of the asbestos problems, we also asked for pricing for trenching the campus so that we could compare these prices to the cost of dealing with the asbestos in the tunnels.

Only six vendors submitted responses to our Request for Proposal in February of 1990. All committee members read all proposals and we prepared lists of questions for each vendor. The consultant also had his questions. Five vendors were asked to spend two hours meeting with the committee to answer questions. The sixth vendor's proposal was quite inadequate compared to the others so we chose not to waste his time. In April 1990, we met and democratically voted based upon an agreed set of criteria as to the first and second choice. The committee's vote was nearly unanimous on the first choice vendor and we received a majority vote on the second.

The Technical Services Agreement for Design

Once the committee had selected the first and second choice vendors, the University approached the first choice vendor in the fall of 1990 asking if he would enter into a Technical Services Agreement in order to do the detailed system design and to work with the University in planning how to deal with the asbestos problems. The consultant recommended this procedure so that the University would have a complete picture of the situation before making a commitment by signing a contract. The Board of Trustees and the President backed this cautious strategy. There was no guarantee to the vendor that the University would proceed with the full project, both because of the unknowns in dealing with the asbestos and also because the University had not yet determined how it would pay for the project. The first choice vendor, who was the manufacturer of the voice and data communication switch, agreed to enter into the Technical Services Agreement for $200,000, and we proceeded in good faith that we could solve the problems.

Vendors must design systems as part of the process of responding to RFPs to provide pricing. However, since only one of them gets the work, this design is not necessarily detailed enough for the customer to review and for the vendor to do the work. Usually the detailed design is done after the contract is signed. The vendor then argues with the customer over what is included and excluded, thus requiring contract amendments and escalation of price. The process of paying the selected vendor before contract signing for the detailed design work assured us that we could review and question all aspects of the design before implementation, that we could jointly address the asbestos issues and find solutions, that we would get experience working with these people to assess how they might perform, and that the University could fully assess the products and apply them in the best way.

The detailed design and asbestos issues took about one year from the date of signing the Technical Services Agreement. The University contracted with an engineering firm to survey all campus buildings to locate asbestos. After about four months, the University had drawings of all buildings that identified asbestos in floors, ceilings, and walls, including window chalk and paint. The vendor hired a consultant who identified procedures to meet federal and state regulations that needed to be followed to work in the tunnels and mechanical equipment rooms. The University's Health and Safety Officer was very much involved in approving these procedures. In order to minimize cost, we jointly decided that it would be less expensive to exit the tunnels adjacent to the mechanical equipment rooms by digging new entrance facilities to most buildings. The cost of building communication closets was far less than the cost of precautions required in the mechanical equipment rooms. There was also great fear that dislodging asbestos in these rooms would cause it to get into the air handler systems and thus become distributed throughout the buildings endangering faculty, staff, and students. To minimize costs, the motto became to avoid the asbestos rather than to deal with it directly.

The vendor provided pricing and drawings for ten scenarios in response to a detailed Request for Quote (RFQ) that was part of the Technical Services Agreement. The RFQ refined the specifications of the earlier Request for Proposal but held the vendor to his pricing of the RFP. The University eliminated putting the communication system in the apartments and doing any trenching on campus after the RFP process. We determined that the scope would minimally be all 60 administrative and dormitory buildings but we were still interested in further pricing for the Greek houses. The ten scenarios combined administrative and dormitory buildings using various combinations of copper and fiber optic cable with and without the Greek houses. We added options for data communication at both one megabit per second and ten megabits per second with the fiber cable plant that this vendor was now able to provide for selected scientific and engineering locations. These combinations of data communication and cable plant options resulted in ten scenarios.

Defining the Scope of the Project

In March of 1992, the vendor submitted ten designs with drawings and complete pricing that included:

- installing all copper and fiber optic cable outside buildings terminating in the building distribution frame closets (outside plant),
- installing all cable inside buildings from the building distribution frame closets to intermediate distribution frame closets through risers and then to the wall jack (inside plant),
- constructing building distribution frame closets and intermediate distribution frame closets within 90 meters of all wall jacks,
- digging new entrance facilities to buildings where required,
- dealing with all asbestos issues,
- remodeling the switch room including all electrical and air conditioning and installing a new main distribution frame for cable with new entrance facilities provided by the local Bell operating company,
- providing a digital voice and data switch and all related electronics,
- providing a voice mail system from a third party vendor, and
- providing a telecommunication management system from a third party vendor.

This pricing was firm enough that we felt we could confidently ask for these moneys and deliver the project within budget. We now built a budget for the entire project and estimated operational costs with a model over a ten year life cycle.

The Greek houses were not uniformly on University property, the relationship with each varied greatly, and for 850 students the approximate cost would have been $1.2 million, a cost that could not be recouped except over about 25 years. We discarded the idea of including the Greek houses. Installing the copper cable plant in the steam tunnels would be very difficult and consequently very expensive. The physical plant staff were very happy to see a fiber optic cable alternative. When we reviewed the pricing, the fiber optic cable plant in the steam tunnels was about $800,000 less expensive than the copper, even accounting for the construction of the larger closets, and electrical, and environmental work to house the distributed line modules. The fiber optic cable plant in the steam tunnels also better positioned the university for future technological developments.

A communication switch has line cards that service groups of ports. These are generally resident within the cabinetry of the switch. With the fiber distributed line modules, these cards are located remotely in each building. Communication to these modules is over fiber optic cable since it needs to be at high speed. Having some of the switch electronics in every building complicates the management of the infrastructure. Each line module is connected to two fibers and provides 32 voice and data ports. Buildings on campus do not require more than 250 ports with most requiring considerably less, so these modules provide great flexibility in configuration for our circumstances. However, if power fails in a building, the telephone system fails unless power is supplied to the modules by battery backup in every building. We reasoned that because of the climate and other reliance on electrical service, a power failure would cause people to abandon a building in a short time. We decided to provide one hour batteries on the distributed line modules in administrative buildings and two hour batteries in the dormitories.

This distributed infrastructure requires larger building distribution frame closets and space is always at a premium on college campuses. Because of the elapsed time, space was often reallocated and we needed to renegotiate. At SMU, central control over space allocation does not exist, so discussions and compromises ensued, many after the contract was signed thereby requiring contract modification. Some building administrators wanted access to building distribution frame closets. We were resolute that we could not be responsible for voice and data communication in buildings when access to these closets was not controlled. We reached agreement in all cases, but this issue continues to surface as units want to "control" their data communication or local area networks.

We recommended the fiber optic cable plant in the steam tunnels and fiber risers in the science and engineering buildings. It was difficult to justify taking the fiber further toward the desk top since departments did not have any computers that could connect to it. For the copper cable plant within the buildings, we considered both level three and level five unshielded twisted pair copper. Level three was rated for 10 megabit per second data communication with intermediate distribution frame closets located within 90 meters. Level five was rated for 100 megabits under the same conditions. The cost was 15 cents per foot more for level five, so we decided to recommend level three. Today, these prices have changed and level five should be less expensive. However, today level three is being rated at 51 megabits per second with ATM (asynchronous transfer mode) technology. Of course, if you can afford it, level five should probably be used today.

Once the fiber optic cable plant was selected, the price for options for data communication became insignificant compared to the system price. Therefore, we opted to try the vendor's new product for 100 megabit per second data communication between selected administration buildings. We chose to implement the highest technology option that was not the most expensive.

Drafting the Contract

The University's legal department had never written a contract for this kind of construction, so the assistance of the consultant was essential. Occasionally, the legal department would contact outside legal sources for advice and consultation. Another consultant from the same firm took major responsibility for drafting the language with the legal department critiquing and adding their flavor and style. Much of the discussion occurred though conference telephone calls with each party having a draft copy. The contract was drafted with concurrence from all parties in three to four months.

The contract focused only on implementation and possible problems that might arise. Since all detailed design work was complete, it could be very specific about what were the deliverables and the timetable. It incorporated all necessary language about dealing with asbestos; the contractor agreed to follow all applicable laws and the buyer was not liable. Liability insurance and performance bonds were established. Some of the contract features included incorporation of all previous proposals and responses from the vendor, nine milestone payments tied to work completion, acceptance test procedures, system performance criteria linked to milestone payments, and definitions of warranties and training programs for University staff.

Gaining Consensus

Now that we had a detailed plan and a draft contract, we needed to sell it to the President and the Board of Trustees. The recommended financing was to sell bonds in conjunction with refinancing some existing bonds. The financial people were able to build their plan based upon our budget projections and a ten year life cycle model for expenses and revenue from selling long distance service to students. However, we had selected a small vendor and the Board was worried about placing so much reliance on them. Board members were quite concerned that we did not get a response to our Request for Proposal from a particular large company, that the local Bell operating company had not responded, and that another local company had not submitted a response. So we needed to either get additional responses from them or find out why not.

We had been concerned earlier about getting a response from the large company that would only deal with us through distributors. In fact, at one time we had expected five different distributors to submit a proposal using this vendor's equipment. We had delayed the date for submission of responses to the RFP until this vendor's new product was announced. However, in following up later, we discovered that their switch would not fit into the limited space we had for a switch room. Consequently, we had not received any proposal using their equipment.

The local Bell operating company relished the opportunity to be invited to submit another proposal. They had led us to believe that they were going to submit a proposal in February 1990 but declined to do so one day before the due date. However, we stipulated this time that they must provide a fiber optic cable plant in the steam tunnels; they could not use copper cable. After three months, they returned with a proposal that cost $3 million more than the price from the first choice vendor.

The other local company had not responded because the asbestos scared them and they didn't want to deal with it. So after a delay of some six months, the University signed the contract in December 1991. One lesson to be learned here is that even if you think you have covered all bases in getting vendor responses, your Board of Trustees may require additional measures at the last minute, thus delaying your best efforts.

One of the inadequacies with the above process of getting the contract signed was the lack of involvement of the faculty. Articles appeared in the computing center newsletter to keep them updated, but the day to day design work, contract negotiation, building financial models, and convincing the administration and Board of the value and need for infrastructure somehow did not interest the faculty. Updated information was provided regularly to the campus computing advisory committee. The process of getting commitment for the project dragged on for two years, and as a result, no one thought anything would happen. The student newspaper occasionally picked up some tidbit and went into attack mode. The project would produce an invisible product with the exception of a new telephone on each desk. It was not even possible at this time to reconvene the selection committee that had been educated about the products and issues. The faculty representative was on sabbatical, the deans representative had left the University, and the staff from finance and housing had retired. Somehow, the faculty did not remember that their highest priority for the University articulated in their 1989 report to the president was more fiber optic cable in the steam tunnels. The faculty and deans continue to grumble about the cost of this project even as they use its products. A project can be a thankless job particularly if it takes a long time and is largely invisible.

GETTING THE JOB DONE

The Timetable

Beginning in 1992, implementation commenced in earnest, 2.5 years after project inception. The cutover date for phase one, the administrative buildings, was Thanksgiving weekend of 1992. The dormitories were phase two and needed two summers of scheduling for installing building wire with cutover scheduled for mid-August of 1993. Most of the outside plant work needed to be completed before phase one cutover because administrative offices existed in some of the dormitories and the buildings were not in clearly separate areas on campus. The fiber optic cable and 50 strands of copper per building for alarm and security circuits were installed without incident. New entrance facilities were dug with major disruptive activity occurring at night. Construction of building and intermediate distribution frame closets proceeded in parallel. The major issues here were renegotiating space for the closets and changing the construction plans accordingly. Never count on space until you have occupied it.

Refining the Counts

Even though we thought we had excellent counts for stations and equipment in the contract, it had been nearly two years since the preliminary survey had been done as part of the design work of the Technical Services Agreement. Another survey was needed and this time, since the contract was signed and it was apparent that work was really going to happen, everyone asked for a great deal more than in the original design. We ended up with approximately 1,000 additional jack locations and 100 additional telephones. These were easily incorporated into the schedule and the contract and costs fit within the allowable contingency.

Gaining Cooperation

Enlisting the cooperation of the many diverse groups on a campus is one of the biggest problems in attempting a campus-wide project. We did not have anyone with central control over space so we needed to create a group of building and departmental representatives who would deal with the contractor. We needed another group that could speak for how voice and data communication would be used for various groups. These tended to be the lead secretaries and administrative assistants. We had another group that met regularly called the College Computing Coordinators who represented technology interests and provided support services within the academic units.

Each college has a financial officer who was very concerned about what these new services would cost. Telephone and data communication services are cross-charged to the units, so if their costs were going to increase, they needed to have the additional funds. The controller dealt with this group of financial officers. He was also in charge of the bond sales, and he had closely scrutinized the projected budgets and models. He was very important in assuring everyone that their financial status would not be jeopardized. You need a financial partner in the institution who can work with you when you undertake these large projects.

You also need many people across the campus who will come to meetings, undertake information gathering on where jacks are needed and who needs what kind of telephone and data communication equipment, and generally spread the word about what is going on. The staff are your best allies. Work with everyone of them who will talk to you or your staff. Alienate no one. The faculty are generally too busy to pay attention except to criticize if they are inconvenienced.

Performance of the Prime Contractor

We were very fortunate that our prime contractor was local and was heavily motivated to do an excellent job for us. They were anticipating the University to be a reference site for future marketing and we were quite agreeable. However, we faced some very vocal criticism for our selection. Dallas seemed to be a very small town when everyone voiced an opinion of this contractor and one came to wish that the contractor was from Tokyo. It appeared easier to buy from the Japanese in Dallas than to buy Dallas.

We had biweekly status meetings with the prime contractor with the consultant available on a conference telephone call. The prime contractor's program manager took responsibility for the agenda with the University writing the minutes. The University's representatives to these meetings included the physical plant, the construction supervisor, voice and data communication staff, and University management. The contractor always included the program manager, staff that supervised the sub-contractors, the lead data base designer early in the project, and the lead person for the telecommunication management system later in the project. Usually the local Bell operating company sent a representative to the first part of the meeting to assure coordination with them. Others were invited as appropriate.

Our only criticism of the prime contractor's work was the oversight of their subcontractors, who sometimes did an inadequate job. The contractor, however, always remedied the situation in a timely fashion. We let them handle these situations and by withholding payments for milestones, we eventually had satisfactory resolution of all issues.

THE TELECOMMUNICATION MANAGEMENT SYSTEM

The most difficult issue was the telecommunication management system. We knew we were in uncharted waters with our desires for software to accomplish this objective. A private university that is not large does not want to hire many specialized technical people for which it cannot have full-time work. Neither does it want to rely on contractors who can bill for many hours for trivial work. Staff who can do many jobs with the support of software would be ideal. Another view of the telecommunication management is that it is a large management information system. The cable plant, the station locations, the equipment, the people and their billing are all interrelated data bases that communicate in order to run the system. In addition, a telephone switch processes the calls and must report what it does to these data bases. Moves, adds, and changes are made in the field and must be reported in these data bases. Most telecommunication staff do not have this view or the background to assess the problem in this manner. If you view the problem in this way, what you want is software that is called a telecommunication management system. With such in place, you can use more generalized staff who will use the management system.

Selection

The telecommunication management system was part of the contract with the prime contractor. During the Technical Services Agreement period we had jointly viewed many vendors' products. Unfortunately, many were mainly billing packages or mainframe products that reflected telecommunication operations of the 1970s. We were looking for something different and were, therefore, prepared to take some risks. We wrote the contract incorporating the best package that we had found. However, we had great misgivings about it since when the third party vendor arranged a demonstration in Florida, the customer had never put any data into the system. Indeed, all fields were empty of information so it was difficult to judge its operation. One of our criteria for a telecommunication management system was that it should communicate with the switch. The switch sends it records of calls in real time that are rated and stored for monthly billing. Moves, adds, and changes are made through the telecommunication management system software and the switch is automatically updated in its information and function. The prime contractor assured us that this functionality would be provided by their staff working in conjunction with the third party vendor.

Shortly after the contract had been signed with the prime contractor, their relationship with the third party telecommunication management system vendor disintegrated. The prime contractor suggested another package that was under development, would operate on an IBM RS6000, and would fully communicate with their switch. They wanted to work with this company, wanted us to work with them, and were willing to risk their milestone payments to assure us of their good faith. The software was not yet developed enough to view it. The company doing the development was very small and owned by one person. Under normal circumstances, these were reasons to reject the substitution but we agreed to change the contract with some price concession and the contractor's risk of milestone payments.

The Telecommunication Management System as a Tool

From the University's viewpoint, the telecommunication management software should be used from the onset of the implementation process. Data should be collected, wires and cables should be laid, telephone numbers assigned, and all should be documented through the telecommunication management system. Ideally, it could load its data into the switch just before cutover. However, as implementation proceeded, so did software development. By the time of the administrative cutover on Thanksgiving weekend of 1992, an early copy of the telecommunication management system had been loaded on the IBM RS6000 and the telephone operators could look up telephone numbers on it and use this information to transfer calls. However, all data had been separately loaded into the switch and the management system so there were often errors and discrepancies.

Communication With the Switch

The telecommunication management system became the single biggest problem for the project, but, of course, it was not unforeseen either by the prime contractor or the University. The prime contractor had several problems with the switch software communicating with the management system software. When we thought these were solved, we needed to work on getting the data coordinated between the two. Then another software bug arose and we worried about diverging data bases, later followed by more coordination. Sometimes we needed to stop using the management system for certain functions. Sometimes the switch couldn't provide certain information. It took about nine months, a normal gestation period, to get these communication problems resolved. As time moved on we needed to involve the third party vendor more and more as the debugging became more their problem and appeared more subtle to the prime contractor.

Billing

Our second most visible and critical need from the management system was billing. The third party vendor claimed that was his "bread and butter" and he really could do this. Since we had cutover the administrative area first, billing at this time was only processing internal cross charges for equipment and long distance. After several fits and starts at processing bills, we managed to get December through May processed by the University's fiscal year end on May 31, 1993. We believed this billing was largely correct. But we needed to process student bills by September 30, 1993 and we could not tolerate any errors or problems. We also needed the switch and management system to communicate so that a student's long distance service would be terminated if his monthly billing exceeded $200. The third party vendor, the prime contractor, and the University worked feverishly over this summer to assure that all went smoothly in the fall, and it did.

Work Order and Trouble Ticket

The work order and trouble ticket part of the telecommunication management system was the last part implemented. Its features were based upon having a complete cable plant data base that the prime contractor assured us had been entered as the plant was installed. We hadn't used it nor had the prime contractor maintained some of it for nearly a year. The longer data are unused, the less usable they are. The staff seemed to hate this part of the software, continually claiming it was unusable and didn't work. Management was skeptical because the prime and third party contractors said it worked and it could be demonstrated. They ran extensive training classes and you could see the software work. Here is where we get into cultural and perceptual issues.

The third party vendor insisted his software worked fine and the University staff claimed it didn't. Some of the prime contractor's staff that worked at the University were skeptical. The prime contractor sent in a supposed impartial staff person from their organization to investigate why this software was so difficult to use. After three days on site and the preparation of a report, everyone sat down to analyze the situation. The University could do several things to better utilize the software and over time the third party vendor could improve the software functionality of the screens, the data on them, and how they interacted. But the fundamental data and functionality were there. The University had organized work in the traditional fashion of having individuals perform some tasks and then handing off the work to others for additional tasks. The system was not designed for this hand off--one staff person could see the work through from placing the work order to closure. However, the staff person had to understand all the processes that were taking place. Some of our staff did not have this conceptual skill level. The University needed to reorganize some jobs and define tasks differently.

The University had hired two cable plant people during this project who were traditional telecommunication workers. We needed to reorient their thinking into being data base maintainers rather than people who tinkered in wiring closets. The cable plant data base must reflect what exists on campus or the work order software cannot operate properly in assigning cable pairs, and so on. The software tells the workers what needs to be physically done, rather than having the workers make those decisions. This is a big change.

Staffing Requirements

By summer 1994, we believed that we had accomplished the goal of having a telecommunication management system working in conjunction with a few good people to operate a 7,000 port voice and data communication system. The organization for this size system is: an associate director who is in charge of all voice and data communication for the campus, including the ethernet network that does not use the switch; an assistant administrator who is largely responsible for all billing; two cable technicians; two switch technicians; 2.5 telephone operators (0.5 less than three years ago when we had 2,300 ports); three clerks with one primarily handling student service and long distance, one for administrative moves, adds, and changes, and one for voice mail with all cross trained to cover for each other. All of these staff intensively use the telecommunication management system. They cannot do their jobs without it now. We do fill in with some additional support from the Help Desk that takes requests for services and answers basic operational questions. This can be quite hectic in the fall when the students first come to campus and do not understand the telephone and voice mail systems, but usually these activities calm after two to three weeks.

Staff Integration

The telecommunication staff are fully integrated with the computing staff and work together not only because their responsibilities overlap for data communication but also because the computing staff are primarily in charge of the hardware and software of the telecommunication management system. It was our first production system operating on a UNIX-based platform. It has real time and batch production requirements. The telecommunication people are learning about these aspects of computing systems and the management information system people are learning about the data bases that drive a campus infrastructure and functions that make a telephone call--very small, high volume transactions with high dollar volume cost to the University. In general, the management information system people think the design and implementation of the telecommunication management system to be primitive by their standards. The telecommunication staff don't really think they are doing their work by sitting at a computer entering and changing data. But they have worked well as a team and have made this project very successful for Southern Methodist University, for the prime contractor, and for the vendor of the telecommunication management system.

WHAT NEXT?

Voice Mail and Culture

What are some other worthwhile ideas to be passed on from this project? The cultural changes to a campus from the installation of voice mail should be noted. Many offices on our campus had secretaries that answered telephones and wrote little pink slips. Just because technology enables another mode of operation does not mean that the old disappears. One faculty person objected to having a light on his telephone to let him know he had a message. He wanted it removed! Others flatly refused to use voice mail. However, some jumped on board and loved it from day one. Within the computing center alone, an organization of about 60 people, we freed up 0.5 full-time equivalent staff from answering the telephone for people. We all used voice mail with an option for a human. Quickly most chose to leave a message and we all worked to positively reinforce this behavior by calling back. After six months, I believe a vote would have been overwhelmingly positive. When the students got into voice mail in the fall of 1993, there was no turning back. They loved it and used most features.

Data Communication Escalation

With a universal cable plant, the demands for data communication increased more quickly than anticipated. Ethernet had existed in the engineering school for many years. A 56 kilobit per second link to Internet was installed in 1989 and upgraded to 1.54 megabits per second in 1991. Several academic buildings had some fiber that had been installed with the AT&T ISN system. Some of these academic locations outside of engineering were connected and as the cable plant was installed in 1992, we began connecting a few more academic locations. By the time of cutover at Thanksgiving of 1992, many faculty and staff preferred ethernet to asynchronous data communication. We tried to limit the scope of the ethernet installations for a while so that we could complete the project that was underway. The clamor for ethernet continues today even though we already have about 1500 ethernet ports with many of these serving multiple connections. The continual change in technology means that new requirements will be generated even as the old are being implemented. The next technology will probably be ATM (asynchronous transfer mode) with some universities already involved in pilot tests. This technology will enable the multimedia communication that all will expect shortly.

Beginning in the late 1980s and continuing through the time of this project, many departments installed Novell networks that could not be connected campus wide without an outside cable plant. With the completion of the infrastructure, these networks can now be connected to the campus backbone network and to the Internet. These networks and their management that have operated autonomously must now cooperate and interoperate with some central coordination. This integration process in physical and software connectivity and in management is underway, often with some stress to the units and to the central organization.

Scholarship

The most significant change to the campus was the possibility for the faculty to participate in the scholarly activities of the day. The on-line library catalog could be accessed from their desk tops. Faculty do not need to walk to the library and they have access through the Internet to scholarly materials worldwide. They can use electronic mail as easily as voice mail. They can collaborate with colleagues worldwide from their desk tops. They can easily reach campus communication systems and computers from home through the new modem pool. Asynchronous communication will be with us for a long time, especially when we must rely upon the local Bell operating company, despite preference for ethernet. Faculty can be continuously available to students through electronic communication and the use of bulletin boards as part of their teaching techniques. A new interest developed on campus for improving instruction through the use of technology. The University library took over much of the instruction for the faculty on the use of Internet as a means of promoting the use of information resources worldwide. Many changes have occurred on the campus in the past two years, and none of these would have been possible without the new infrastructure.

Replacing Administrative Systems

The University is now able to consider the replacement of its legacy mainframe systems with the possibility of implementing new systems in the "client-server" mode. The mainframe systems were designed in the 1970s and represent the methods of doing business of this period. The University can evaluate new ways of doing business because its communication has changed. The integration of electronic mail, document transfer, voice mail and numerous other technologies with powerful desk top machines means that the way business is conducted can be changed or "re-engineered" to better serve students and faculty. Over the past year, the University has conducted a project with a consulting firm to evaluate how this might be done. Preliminary plans have been developed and are under study. Without a powerful communication infrastructure, none of this would be possible to implement. It did take time and the commitment of many to get here. We are hopeful that these investments in technology will continue in higher education and that we can be helpful in these processes.

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