The Creation and Early Implementation of a High Speed Fiber Optic Network for a University Health Sciences Center

J.D. Schueler, M.B.A.
Joyce A. Mitchell, Ph.D.
Sylvia M. Forbes, M.S.
Ronald C. Neely, M.A.
R. James Goodman, B.S.
Daniel K. Branson

University of Missouri
Columbia, Missouri

Abstract

In late 1989 the University of Missouri Health Sciences Center began the process of creating an extensive fiber optic network throughout its facilities, with the intent to provide networked computer access to anyone in the Center desiring such access, regardless of geographic location or organizational affiliation. A committee representing all disciplines within the Center produced and, in conjunction with independent consultants, approved a comprehensive design for the network. Installation of network backbone components commenced in the second half of 1990 and was completed in early 1991. As the network entered its initial phases of operation, the first realities of this important new resource began to manifest themselves as enhanced functional capacity in the Health Sciences Center. This paper describes the development of the network, with emphasis on its design criteria, installation, early operation, and management. Also included are discussions on its organizational impact and its evolving significance as a medical community resource.

Introduction

The University of Missouri Health Sciences Center (HSC) is made up of many organizations on the MU campus and in the greater Columbia area. Major components of the HSC include the School of Medicine, University Hospital and Clinics (UHC), the School of Nursing, Mid-Missouri Mental Health Center (MMMHC), V.A. Hospital, and the Ellis Fischel Cancer Center. Except for Ellis Fischel, most of the HSC facilities are located within or adjacent to the UHC complex. It is this geographic area which has been selected for the first phase of the fiber optic network.

Other parts of the MU campus are served by a fiber optic backbone utilizing 16 Mbps Token Ring technology and managed by Campus Computing Services. This Campus Backbone is routed to over 65 buildings on the campus, and is accessed via a Token Ring-to-Token Ring bridge in each building. Local area networks (LANs) are in turn connected to the bridges; individual workstations or computer systems outside Campus Computing are not allowed direct connection to the Campus Backbone. As the Campus Backbone has grown in both size and use, it has increased in importance as a university resource. In addition to providing high speed access to university mainframe systems, it is also a gateway to the Internet and other significant networks under development.

Both policy and Token Ring architecture limitations restrict the number of bridges to the backbone. A single connection point for the entire UHC complex has been provided in the hospital telecommunications equipment center. The HSC, however, has over 3,000 employees and more than 2,000 students, residents, and trainees in a great many political subdivisions; combined with a number of other factors, this makes the effective utilization of the single Campus Backbone connection almost impossible without a great deal of planning and cooperation.

History and motivation.
Numerous LANs have been installed in the HSC in recent years. Most have been independently developed and managed, without centralized assistance pertaining to standards and guidelines. When functional responsibilities and geographic convenience have permitted, some of these networks have been interconnected, while others have remained insular. Where organizations have had requirements for data communication with the outside, e.g. mainframe systems and remote networks, their LANs have been fitted with gateway servers and similar products - again without much interorganizational coordination. As

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is the case at other institutions, many groups and individuals not attached to LANs have also requested access to MEDLINE and other tools upon which they have placed a high priority [1].

Task force methodology.
By 1989 it was apparent that a unified approach was required to address global data communications issues within the HSC. A Fiber Optic Task Force was appointed and given the mission of developing a comprehensive network plan for providing network access and services to the entire HSC. The committee was comprised of representatives from the School of Medicine, University Hospital and Clinics, the School of Nursing, Campus Computing, and Campus Telecommunications. Given the wide diversity of organizational philosophies and operating methodologies represented by the committee, its task of creating a network architecture which could effectively serve and still be acceptable to all interested parties was no trivial matter. On the other hand, having as much of that diversity as possible participate in the planning process was critical to the success of such an ambitious project.

Methods

Fiber optic criteria.
In very early meetings it was determined that a fiber optic backbone network should be created for the HSC. The experiences of Campus Computing in constructing the Campus Backbone were drawn upon significantly during this phase. To accommodate future implementation of the Fiber Distributed Data Interface (FDDI) standard, appropriate fiber optic components were selected. Fiber optic cable (62.5/125 micron multimode, 12 and 24 strand) and "ST" connectors were specified in compliance with FDDI specifications.

An architecture of "bridged rings" (Figure 1) was chosen. The Complex Ring, providing the HSC bridge onto the Campus Backbone, is jointly managed by the Hospital and the School of Medicine. This ring is the connection point for major geographic subdivisions of the HSC; it will also host centrally accessible electronic mail (e-mail) and possibly other applications in the future. The Medical School Ring serves all of the departments located in its portion of the UHC complex as well as the School of Nursing. The Hospital Ring similarly serves those departments which are in the southern half of the UHC, as well as for the Rock Quarry Center (RQC). The RQC, approximately a mile from UHC and connected to the Complex Node Room via 9 micron fiber optic cable, houses the Hospital mainframe computers and most of its MIS professionals.

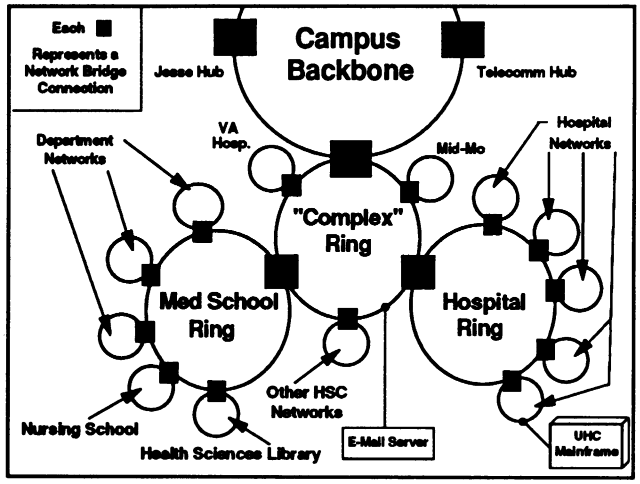

Figure 1
HSC Network Logical Design

Network topologies to be connected.
The network topology selected for the backbone is Token Ring. Even though the largest preexisting LANs are Ethernet, Token Ring has been chosen because it has already been adopted by the rest of the campus as a standard; other institutions have opted to standardize on this topology as well [2]. Many recently installed networks (as well as a number planned for the near future) *are*, however, Token Ring, greatly simplifying their backbone attachment.

Various methods for Ethernet attachment are being evaluated and more than one may be utilized in the early stages. The chosen method must be able to handle all of the following: Novell IPX/SPX, TCP/IP, DECnet, LAT, AppleTalk, and SNA. Some of the possibilities which have been explored include the IBM 8209 Bridge, routers from cisco Systems and Wellfleet Communications, and Novell Netware Bridges. Vendor claims notwithstanding, none of these has to date been shown to be "the" answer; non-support of the necessary protocols, performance limitations, excessive cost, or the lack of verifiable test results are all relevant factors.

Electronics requirements.
Beyond the Token Ring/Ethernet interconnection issues, the basic electronic equipment necessary to activate the backbone and provide connection points is relatively simple in the first phase. The facilities have been geographically segmented in such a way that wiring closets can be dispersed throughout the complex; any location with the potential of housing computer equipment is within 300 feet of a designated "area" wiring closet. Two major

node rooms have been constructed to serve these closets, one in the Hospital basement and the other on the first floor of the School of Medicine. Each area closet is connected to the appropriate node room by a 12-strand 62.5/125 micron fiber optic cable. In a Token Ring installation, an area closet will be bridged onto the Hospital or Medical School ring through the node room; the bridge machine will be secured in that location and fiber optic transceivers will be utilized to connect it to a Multistation Access Unit (MAU) located in the wiring closet. Because all user locations are within 300 feet of the closet (and thus within allowable Token Ring lobe distances), workstation cables and MAUs for departmental LANs can be located in the wiring closet for a simple installation.

Results

Cable plant installation.
Installation of the fiber optic cable plant began in September, 1990, and was substantially complete by the first of December. All activities involving this phase of the project were contracted to GTE North, Inc. which also supplies voice and telecommunications services to the University. While GTE personnel were installing cable, University Plant Engineering staff were engaged in renovating the space designated for the node rooms and area wiring closets.

Node rooms and wiring closets.
Each node room serves approximately 25 wiring closets and has been designed to accommodate that number of bridges and related devices. The initial design specifies an IBM PS/2 as the standard bridge connection; power, environmental control, and other improvements have been installed accordingly. The node rooms also have a number of equipment racks which are outfitted to house all of the required electronic and fiber optic equipment.

The peripheral (area) wiring closets have all been provided with electrical power and mounting space for fiber optic transceivers and network connection points, e.g. MAUs. Each closet also houses a fiber optic "premise box", which has external panels for the mounting of up to twelve "ST" style connectors, and internal racks for the containment and protection of the fiber optic splices.

"Connectorizing" and testing.
Initially one pair of fibers in each closet-to-node-room run has been terminated at each end with "ST" connectors. The unused fiber ends are housed in the premise boxes and node room fiber distribution panels. The cables were tested at wavelengths of 850 and 1300 nanometers (nm) for optical signal loss, and all runs tested well within the 4 db limit contained in the original specifications.

Initial attachments to the backbone.
In addition to the services which will be available as the network evolves, there are significant benefits for the organizations which are among the first to connect to the HSC backbone. A brief description of the networking activities of some of the early participants follows.

The Dean's Office.
The Dean's office has installed a 16 Mbps Token Ring network to support both its internal operations and an early connection to the backbone. This office has a critical need for constant communication with University administration offices and has historically maintained an SNA gateway to the mainframe. The Campus Backbone has assumed an increasingly important role in university-wide communications; access to this resource by the Dean's Office has thus become a very high priority.

Continuing Medical Education.
Continuing Medical Education (CME) is part of both University Extension Services and the School of Medicine. CME has some LAN services, with both Ethernet and Token Ring segments. It has not, however, been able to connect with other parts of University Extension. Its connection to the backbone will greatly facilitate this communication with other offices (both on and off campus) as well as providing a direct link to the Dean's Office.

The Biochemistry network.
The Biochemistry department is a part of both the College of Agriculture and the School of Medicine, and is housed in three main buildings which are approximately one-half mile apart. Due to this separation and logistical problems associated with it, high priority was given to developing a network for more efficient transfer of information within the department.

The department has recently implemented a 16 Mbps Token Ring network utilizing Novell Netware 386. This network is located on both the first and seventh floors of the Medical School, and a similar network is being constructed across campus. A student computing laboratory is being created, with all its workstations (as well as the building's offices) planned for network participation. Beyond the faculty and staff needs, the network will be used for computer-aided instruction during Biochemistry laboratory classes, and will additionally provide students the capability of completing electronic lab assignments and reports, creating scientific graphics and charts, using molecular biology and biochemistry software, and preparing manuscripts for publication.

A large interconnected Ethernet.
The largest existing network within the Medical School

consists of approximately 275 nodes over four LANs in the clinical departments of Family and Community Medicine, Medicine, OB/GYN, and Surgery. Both 10BASE-2 (thinnet) and 10BASE-T (unshielded twisted pair) cabling schemes are being utilized, along with 3Com multiconnect multiport repeaters and Synoptics concentrators. The newer portions of the network have been designed for SNMP network management. The networks are interconnected by Kalpana Etherswitches, which provide high performance local Ethernet bridging. One of these Kalpana units will provide the connection point for the HSC backbone through a router.

As this network has grown over the past few years a number of gateways, e.g. SNA and asynchronous communications servers, have been installed to provide access to certain external resources. The connection to the fiber optic network wiil reduce or eliminate the need for many of these gateways and provide higher performance as well as expanded access. Backbone attachment will also enable these departments to maintain access to the UHC mainframe Patient Care System (PCS); in the near future all PCS access will be routed through the backbone.

Molecular Biology computing facility.
The Molecular Biology DNA Core Facility became operational over the HSC network shortly after the installation of the cable plant [3]. Funded by grants from NSF and NIH, this facility was created to provide campus researchers with access to key molecular genetics databases, Genbank and PIR. These databases reside on an Apollo DN10000 system located on the sixth floor of the Medical School, within an Apollo Token Ring network. Additional Apollo workstations reside in several other campus buildings, with as many as 80 faculty members in twelve departments using the resources. The Campus and HSC networks provide critical (and transparent) integration of this widely dispersed, interdisciplinary project.

Discussion

Organizational diversity and challenges.
While the Health Sciences Center is comprised of many different organizations, the Hospital and the School of Medicine are the two largest political and economic subdivisions. It is the general consensus that a project such as the HSC network could have been neither conceived nor implemented a few years ago because of significant political differences. Over the past two years or so, however, a new and strong alliance has been created; the fiber optic project is a very real manifestation of this transformation.

While the relationship between the two HSC "powers" is excellent, there are vast differences in their methods of operations and management. The influence of such hospital-medical school organizational dissimilarity has also been reported by other network developers [4]. Early in the planning phase it was agreed that critical portions of the network would be jointly managed by Medical School and Hospital staff, and dedicated network managers have been hired by each organization to fulfill this requirement.

The Hospital provides patient care and ancillary services, and is operated in much the same manner as a similar commercial enterprise. It can, for example, finance its share of the fiber optic network through its normal capital budgeting process. On the other hand, the School of Medicine is a rather loose federation of some 35 departments and units, most of which are managed in a very autonomous manner. Some of the clinical departments are largely financially independent, while others must depend almost entirely upon University allocations. The School, which does not have a universal capital budgeting process, must fund its portion of the network more creatively (and with more political ramifications) than is necessary for the Hospital.

Implications for management of the network.
The differences in funding procedures have presented the first significant challenge. The Medical School must recover its share of the construction and operating costs by charging back to the individual departments. Because financial resources of the departments vary so greatly, there were considerable differences of opinion with respect to the chargebacks, and much discussion was necessary before the initial rate of $10 per connected station per month was established.

It is important that a balance be maintained between HSC institutional interests and departmental independence. The continued good relationship between the Hospital and the Medical School is critical to the success of the entire project, and it is equally apparent that certain network policies and procedures must be jointly administered. Conversely, the autonomy of Medical School departmental operations must not be overly compromised; the network is being provided as a value-added service, and as such must support rather than hinder the educational, research, and clinical missions of these departments.

In order that these challenges might begin to be met, specific network policies are being written. In many respects the policies are similar to those used for more traditional telecommunications systems; the physical plant and certain core services are centrally managed and supported, while the end uses of the facilities are largely unregulated and remain the responsibility of the using organizations. Ultimately the policies are directed toward the day when all members of the HSC will be able to communicate and share information over the data network just as easily as they can now exchange voice communications across telephone networks.

The future of the new community resource.
Properly funded and managed, the possibilities for the new HSC network are almost limitless. The long term goal is to provide true "any to any" connections throughout the network. This will enable users to freely share and exchange information in almost any form, without regard to the type of systems in use or to the physical location of needed resources. The development of truly integrated Hospital Information Systems, for example, becomes much more feasible in an environment which provides this degree of connectivity [5].

It is today's reality, however, that currently available hardware and software products do not provide the desired level of "seamless" connectivity [6], although a substantial portion of the industry's research and development efforts are being so directed. It is fortunately not necessary to wait for further product evolution before proceeding; current technology gives access to many centralized resources which will in turn provide substantial benefits:

- Interface to the UMC Campus Backbone
- Access to Hospital Patient Data
- Electronic Mail
- High Speed Internet Access
- Access to Molecular Biology Databases
- MEDLINE Access on the Network
- Student Computing Laboratory Facilities
- Image Processing and Transfer
- Physicians Decision Support Systems

The impact of all this new - *and usable* - technology on the HSC community is difficult to assess in advance and will require further study as the network evolves. The technical details of how some services (e.g. the communication of images) will be implemented on the network are not yet clear; other work on such topics [7] will continue to be examined and evaluated as appropriate. The network uses discussed herein appear to have great potential for improving the productivity of many people, and ultimately advancing the quality of patient care, education, and research. The realization of this potential in a politically diverse and economically challenging environment is the primary task which lies ahead.

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