Report of the Network Advisory Committee (NAC) of the 1996-97 Computing Activities Council (CAC)

Executive Summary:

This report responds to the charge by Chancellor Ferritor to study and research the multimedia network resources and requirements of the University of Arkansas, Fayetteville, to develop a technical recommendation and plan for a campus network upgrade." The committee reports the following:

The UARKnet Network is a crucial element of the campus infrastructure, providing statewide outreach and critical information technology services for the teaching, research, service, and administrative mission of the University's flagship institution.

Network technologies and capabilities are continuously evolving, and UA must continue to upgrade its network and computing infrastructure.

The existing network handles only data formats (requiring the translation of video and voice to data, and resulting in primitive video and voice output); the new network must provide voice and video formats along with data formats, and it must provide higher speed access to distributed servers and to forthcoming state and nation-wide high bandwidth networks.

The upgrade scenario outlined will cost approximately $7,000,000. This estimate depends on the scope, phasing and duration of the project, and the vendors selected.

Problems and limitations with our existing network structure and funding mechanisms prevent future growth and advancement. A coordinated, centrally-funded strategy is required.

UARKnet cannot be prudently upgraded and maintained in a piecemeal, ad hoc manner. There is a significant cost in "standing pat", which will require additional spending to maintain existing functionality that is already

inadequate for UA's present and future needs.

The Dean's Council and the Vice Chancellors have been briefed on this project, and both bodies recognized the importance of the broad recommendations of the Network Advisory Committee (NAC.)

The Network Advisory Committee and Computing Services, with the assistance of Physical Plant, are prepared to move forward with this work. The success of the project depends on the leadership of the administration and involvement of constituencies throughout campus.

Note: This is an evolving document, as our work in researching and establishing recommendations for upgrading UARKnet is ongoing. We have set our policy and overall infrastructure recommendations, but the technical recommendations and costs will necessarily be refined as implementation goes forward.

Introduction

The University's commitment to the growth of the UARKnet network has prompted innovative developments in campus-wide communication services and information resources. The network's success has positioned this flagship campus as a state-wide leader in information technology, providing students and faculty with world-class research tools, generating new grant dollars for research projects, and accelerating the development of streamlined automation systems for conducting University business.

Students, faculty, and staff depend on UARKnet as a core University resource, as important as classrooms, laboratories, offices, telephones, and electricity. In a little less than eight years since the original Network Advisory Committee made its initial recommendations, the campus network has grown to connect over 95 buildings and nearly 6,000 individual computers. Over the past few years access to information, maintenance and growth have been identified as critical issues. These issues are relevant to current (data) as well as future (video and voice) applications which are requiring our campus to replace the existing network with a high-bandwidth network.

In November, 1996, a new Network Advisory Committee was charged by the Chancellor to "study and research the multimedia network resources and requirements of the University of Arkansas, Fayetteville, to develop a technical recommendation and plan for a campus network upgrade (as specified by the Computing Activities Council 1995-96 Report to the Chancellor, Recommendation #6)." The charge stated further:

The committee membership will be appointed by the Computing Activities Council Chairman and approved by the Chancellor.

This subcommittee will work in open meetings and consult campus personnel who have expertise in both technical and policy issues to assure broad and appropriate input.

The Network Advisory Committee shall report its findings with recommendations for action to the Computing Activities Council.

The NAC, Co-Chaired by current Computing Activities Council Chair, John Forney, and the Director of Computing Services, Bob Zimmerman, is composed of representatives from every college and unit involved in support of the

network. This group collectively brings a solid base of networking expertise. Members are: David Douglas (CISQ), Dennis Brewer (CSCI), Jim Gattis and David Summers (ENGR), Ken Leverington (Telephone Services), Jim Swartz and Jacqueline O'Dell (GRAD ED), Frank Graham (PHPL), Brenda Wideman (AFLS), Chris Abel (LAW), Janet Parsch (LIBR), Donnie Dutton (CTED), Dave Stefferud (FULBRIGHT), and David Merrifield, Craig Brown, and Susan Cromwell (COMP).

Work Process

The NAC has met on a weekly basis since December, 1996, and has addressed both technical and policy issues. Four different networking technology vendors made presentations to the committee to describe the upgrade options available to the University. Working with this information a technical subcommittee of the NAC has prepared a model for a new core backbone, given certain assumptions regarding design. Variables for the project include, but are not limited to: 1) funding and timetables for completion of the project, and 2) a process for establishing priorities and timetables for bringing buildings on-line to the new backbone.

The committee made an initial report to Chancellor Ferritor (4/10/97), met with the Dean's Council (5/7/97) to seek their input and make certain that channels were established so that the specific planning required for backbone design considerations and cost estimates would include all of the units & application requirements, and finally briefed the Vice Chancellors (5/29/97) to apprise them of its direction and solicit their support and suggestions. In each case the broad recommendations of the NAC were viewed favorably. The committee promised a full report to Chancellor Ferritor by June, which he indicated he would pass on to incoming Chancellor White. During the summer the committee members will solicit input from their respective campus units to assure that appropriate application requirements are addressed in the design and implementation of the upgraded network.

Existing Network Problems and Limitations

The steady growth of the network and changes in technology and required application support have resulted in the following problems which must be addressed efficiently, economically, and quickly (see Appendix C for specific cases):

There is inadequate access for students, faculty, and staff from dormitories, classrooms, labs, offices, fraternity/sorority houses, and off campus (i.e., dial-up).

UA's architectural guidelines for construction have not provided adequately for network infrastructure.

Users experience dropped network connections due to overloaded subnets (local area networks within and among certain buildings).

Fiber between buildings cannot support a reliable, maintainable, fault-tolerant backbone for the entire campus. Some fiber has been used for other services besides the data network, such as video surveillance (UAPD) and climate control systems (PHPL).

Expansion options within buildings are limited due to lack of centralized wiring closet electronics.

In the past lack of centralized funding for these critical areas, coupled with increased demand for greater access, resulted in a piecemeal approach to network growth. This growth has propagated the development of dysfunctional areas within the network and increased University costs by wasting resources and staff support. The resulting problems from inadequate bandwidth, over-extension of building networks, and outdated electronics have created limitations which prevent the University from implementing the following:

Interactive video and other multimedia distributed learning environments, such as satellite downlink distribution and desktop audio/video conferencing.

Scientific and research applications that require large-scale image manipulation/transmission.

Administrative document image sharing.

Participation in state and national high-bandwidth networks (ARKnet II and Internet 2) set to offer high-speed connections within Arkansas in 1998.

Recommendations

The NAC has determined that it is necessary to undertake a major infrastructure project to install, replace, and expand the campus network system's electronics, fiber-optic cabling, and building wiring to provide for the information system needs of the campus today and in the future.

We recommend the following:

1. Adopt and implement a coordinated campus-wide plan for upgrading and maintaining the shared computer network immediately. This plan should assume the provision of fiber connections to the network backbone for all campus buildings and the adoption of ATM (Asynchronous Transfer Mode) networking technology standards.

2. Provide funding centrally for all network components including fiber, copper, and all associated electronics up to the wall outlet. This would include backbone wiring and electronics, and building wiring and electronics. (See Section VI for components and associated costs.)

3. Establish and maintain campus-wide networking standards so that all new buildings, and all building renovations beyond a certain cost (to be established), provide for computer networking including wiring closets, wiring trays, and completely terminated cables according to a standard in the Physical Plant Guidelines for Construction. (Physical Plant and Computing Services have already established mechanisms for coordinating ongoing work, and are now revising the Physical Plant Architecture and Engineering Guidelines for Construction--See Appendix F.)

4. Establish a permanent Network Advisory Committee reporting to the Chancellor through a revamped Computing Activities Council (see Appendix G for proposed charge and composition.) The Computing Activities Council Planning Subcommittee is currently developing a proposal to revise the charge and composition of the entire CAC.

Proposed Schedule/Work Plan

At this time, we anticipate that it will be necessary to install, replace, and expand the campus network system's electronics, fiber-optic cabling, and building wiring. To refine the proposed backbone design and cost summary presented below, the technical committee will complete or has completed:

Building Analysis to Determine Core Switch Locations for Backbone

Determination of Campus Locations Needing Additional Fiber Runs

Summary of costs for electronics replacements (our committee requires input from upper administration to establish timetables, priorities, and available funding.)

Report identifying dysfunctional buildings on the UARKnet Network

Report on student access (a recommendation for distribution of resources for dorms, labs, fraternity/sorority houses, and off-campus dial-up is being forwarded to the Chancellor from the Computing Activities Council.)

Updated wiring standards in Physical Plant Architecture and Engineering Guidelines for Renovation and New Construction (ongoing--see Appendix F.)

Many of these tasks are completed with this report, while others are ongoing.

Proposed Components of Network Upgrades and Costs

The backbone design model and cost summary, presented in the graphics on the following pages, assumes that we will replace our existing data-only network with one that can support a multimedia environment of data, audio, video, and telephony to all 95 buildings on campus. Some core locations require higher bandwidth and more complex switches than others, and the costs reflect a choice of products that provide the flexibility necessary for a fault-tolerant backbone network.

[Image]

[Image]

While some portions of this project are actually parallel and dependent on the administration's priorities, we have found it useful for our own discussions to define them as a series of phases with associated costs.

Implementation Schedule by Phases

Phase I: Install switches, fiber, and electronics to create the core for initial deployment of a new backbone.

Phase II: Complete testing between switches; add the first ATM Ready buildings (CTED, BELL, ADMIN, REYNOLDS) and others that are determined to be priorities during this phase.

Phase III: Connect fiber cable to new backbone hubs and connect hubs to all buildings.

Phase IV: Add building electronics to extend core to all buildings.

Phase V: Rewire all buildings for access to UARKnet II, the new UA network.

ATM Ready indicates that the appropriate wiring (Category V) is in place and in-building LANs are capable of making use of the ATM (Asynchronous Transfer Mode) switch which will replace the existing UARKnet router.

Expenditure Summary by Phases and Years

	Year 1	Year 2	Year 3	Year 4	Year 5	Phase totals
Phase I & II:	$1,575,000 (100%)					$1,575,000
Phase III:		$64,000 (50%)	$64,000 (50%)			$128,000
Phase IV:		$1,300,000 (33%)	$1,300,000 (33%)	$1,300,000 (33%)		$3,900,000
Phase V:		$243,330 (17%)	$486,670 (33%)	$486,670 (33%)	$243,330 (17%)	$1,460,000
year totals:	$1,575,000	$1,607,330	$1,850,670	$1,786,670	$243,330	

Estimated Total Project Cost: $7,063,000

Estimates based upon the following assumptions: current prices of electronics, $150/port for building wiring, and full multi-function support to all buildings.

Models for Sustaining Costs

In a change from past practice (see Appendix A for a description of the current funding model) the NAC recommends that centralized funding should provide for network fiber, associated electronics, and wiring from the closet to the desktop; departments would be responsible for replacing individual computer network interface cards (existing cards are often compatible with the upgraded network.) The deployment strategy of the upgrades will be established by the Network Advisory Committee (see Appendix G.)

The NAC recommends consideration of various methods of funding, including:

1. A one-time grant through the state legislation.

2. Raise funds through the University Foundation.

3. A combination of outside grants and matching funds from the University.

4. Each campus unit make lump sum payments to a central fund.

5. Collecting payments on a "per network drop" basis.

6. Collecting payments through invoicing for phone service.

7. Collecting fees on a per credit hour basis from students.

8. Assessing network impact fees on all new construction.

Conclusion

The NAC has studied and researched the multimedia network resources and requirements of the University of Arkansas, Fayetteville, to develop a technical recommendation and plan for a campus network upgrade. We believe this effort is an essential priority of the campus community, and Computing Services and the Computing Activities Council are prepared to implement this planned upgrade with leadership from the campus administration.

Appendix A: History of UARKnet Growth and Previous Funding Model

In the spring of 1989, Computing Services implemented the recommendation that came from an ad hoc Network Advisory Committee, appointed by the Chancellor, to: 1) evaluate network backbone technologies, 2) provide a budget estimate for implementation of a new network, and 3) establish the funding model for backbone and departmental network growth.

The efforts of the committee and the funding that resulted from the Chancellor propelled rapid change which spread modern network services across campus at a rapid pace. The thinking in 1989 which established the funding model was appropriately conservative at the time, depending upon a readiness to use the network. Both the funding and prioritization for attachments reflected this philosophy. Units who were the most ready, and who had the most money to proceed, also happened to have the largest number of workstations ready to make use of the network. Units who did not have computers ready to use a network did not proceed with in-building wiring and network electronics in the initial phases of the network.

The funding model proposed by the ad hoc committee designated centralized funds to provide backbone development, expansion and maintenance. Using initial funds one router was placed in the Band Building and five others were placed in building locations strategic to the design of the network. Within the three year implementation phase central funds had paid for extension of the backbone to every academic building. The funding model proposed that all other network expansion expenses were to be funded by departments requesting network connectivity. Therefore the network cards in the machines, the building wiring and drops in each room, networking electronics within the building that provide the interface to the routers, (and in some cases even the extension of fiber to the building) were paid for by individual units.

By about 1990 electronic mail had become the standard communication vehicle for all staff and the administration. By 1992 the wiring of faculty offices had become a priority for most departments, though due to the funding model, growth depended on individual unit maintenance budgets to proceed. In 1993 a recommendation came from the Chancellor through the Computing Activities Council that electronic mail and Internet access be available to all students.

While the funding model prevented the campus from over-building at a time when it could not be predicted how pervasively the network would be used, it also adversely affected decisions for network growth. Due to the dependence

on each unit's budget for departmental network attachments, departments could only allocate small portions of their maintenance budgets, year after year, to provide the connectivity they needed within their buildings. This resulted in many areas on campus whose local networks have been "piecemealed" over the past 4 years, adding too many drops on a subnet or wiring segments that are too long, causing unreliability and loss of connectivity.

In spite of inefficiencies with the growth of the network within buildings, the central funding for the backbone itself did result in a very reliable network with the capacity for considerable growth had we maintained access to the fiber for data only. Through this funding, the backbone routers have maintenance coverage which keeps the network responsive 24 hours a day, 7 days a week.

Appendix B: Campus Locations Needing Additional Fiber Runs

The University campus network has grown to include a substantial amount of fiber connections to buildings. Unplanned uses for fiber from the initial backbone cabling for distribution through key locations on campus has now resulted in the lack of available fiber needed for certain types of data and non-data connectivity.

For example, if a Continuing Education video downlink needs to be transmitted from CTED to BADM, the fiber runs required for this connection go from CTED to BELL to BAND to BADM. There is no available fiber from BELL to BAND and none between BAND and BADM. Another example is the downlink now available at the new Poultry Science building. Any connection from POSC must include a fiber from ADMN to the campus fiber hub in BAND. There is no fiber available between those two points let alone lack of fiber to other areas such as BELL, Old Main, BADM, etc.

Network connectivity at the Farm is still based on the microwave link created in the late 1980's. At that time, the only connectivity requirements were offices in Food Science and an Entomology lab. Since that time, nearly every building at the Farm has network connectivity. Although the initial Farm network only included faculty and staff from the Dale Bumpers College of Agriculture, Food and Life Sciences (AFLS), it now includes entire buildings populated by people who have little or no affiliation with the College. This portion of the campus network is serviced by a 10Mbps Ethernet microwave link. This can no longer support the current bandwidth needs for the Farm, and cannot support the enhanced functionality proposed for a new campus network. This microwave link should be replaced with a fiber run.

These are only a few of the most obvious examples based upon service requests that have already been made. There are other locations on campus not able to utilize various aspects of data and non-data communications due to lack of available fiber. In conjunction with the ranking role of the proposed permanent Network Advisory Committee (described in Appendix G), a more complete needs study will be required to locate and suggest priorities for additional fiber runs.

Appendix C: Dysfunctional Areas of the Campus Network

Due to the overwhelming interest and the piecemeal growth of our campus network, many areas of campus now have networks that no longer function properly. These "broken" networks are typically caused by too many users on

the same part of the network, or media (wire) problems because of segments that are too long or damaged, or both. Our most severe problems are in the following areas:

Subnet 52 provides network connectivity for Vol Walker, Peabody Hall, Student Development, Memorial Hall, Graduate Education, and a small Ethernet segment in Agriculture. This subnet is scheduled for dividing into smaller pieces in June '97. This will rectify the problem with too many users on the same network. We may still have some media problems in Graduate Education due to the extensive network now in that building.

The HPER facility has a difficult floor plan for the old style networking (10Base2, or thin Ethernet). Traditional solutions for growing a 10Base2 network have been exhausted. Now that more areas within this building require network access, a re-wire and redesign is needed.

In the Administration Building work spaces have been added beyond the building's original design, with the network expanding accordingly. Media problems exist in at least three major areas, Human Resources, Business Affairs, and Financial Affairs. This building is being rewired and new building electronics are being added with completion scheduled for the second week of June 1997.

Kimpel Hall also has expanded its network beyond what 10Base2 networking specifications permit. A re-design of this building is required. Changes may be extensive enough to warrant consideration of complete building rewiring.

Although Old Main does not have a 10Base2 network, there are distance problems on the north side of the building, particularly on the upper floors. A redesign is needed to change the wiring closet distribution points. Also, this building was wired before there was a high-speed Ethernet specification (CatV). In order to support the higher bandwidth applications such as video distribution, the old wire will need to be replaced with Category V certified wire, wall jacks, and patch panels.

Several other buildings are also experiencing problems. They do experience intermittent outages, but not at the rates of the buildings listed above. These other problem buildings include Hunt Hall, Hotz Hall, and Administrative Services.

Appendix D: Upgrades to Electronics (Summary of Vendor Options)

3Com, Bay Networks, Cabletron, and Cisco were asked to present their campus-wide backbone electronics solutions to the following NAC defined objectives:

Migration from existing data-only backbone to one that can support data, video, audio, and telephony transmissions. Video support must include support for full motion, broadcast quality as well as compressed video transmissions.

Upgrade backbone while supporting existing building LANs (Local Area Networks.)

Upgrade wiring and electronics within building LANs to make use of new backbone.

Ability to deliver 10Mbps Ethernet, 16Mbps Token Ring, 100Mbps Fast Ethernet, Asynchronous Transfer Mode (ATM), and 1Gbps Ethernet to the desktop.

Show a phased approach for campus migration.

All of these vendors provided presentations that addressed all the issues we specified. Although there were expected differences, each vendor described a method for an initial backbone (only) replacement using our existing fiber. However, additional fiber would be needed to provide a truly fault-tolerant backbone. With one exception, all vendors would require additional backbone fiber for fault tolerance implemented as a partially or fully meshed (redundant) ATM network.

The upgraded backbone will not support the additional functionality alone, however. Without upgrades to building LANs and the backbone connections to them, no one can take advantage of the new backbone capabilities. All vendor presentations addressed this issue as well in their equipment discussions and migration phases.

Generally the presentations showed a common approach for campus migration divided into two broad steps: 1) change the backbone, and 2) phase in changes to building LANs. There were greater differences among the proposals for backbone upgrades than for upgrading building LANs. Equipment costs for the initial backbone changes ranged from approximately $660,000 to $990,000.

Estimates for fiber runs needed for a redundant, partially meshed backbone core are $440,000. On-going backbone equipment maintenance fees range from $29K to $58K, annually.

The cost estimates above do not reflect costs for any of the wiring or electronics expenses required for building LAN support. Extending ATM functionality to a building will require an equipment only expense starting at $13K to $60K per building, depending upon size and desired functions.

Appendix E: Network Implementation to Add Required Functionality and Correct Current Problems

Though we could not know in 1989 how pervasive the network would become or how many services it could deliver, we are now better able to predict trends and future requirements. The NAC strongly believes that the new network must provide multimedia services across the backbone, taking us from a data-only resource to a rich media resource (video, audio, and telephony, as well as data). This kind of network requires a phased-in replacement of our existing backbone technology:

Provide fiber to all campus buildings: Initial implementation of UARKnet paid for the initial installation of 12-filament fiber. While this was anticipated to be ample for the data network growth, certain services (other than the backbone data network) immediately claimed portions of the fiber for environmental controls, security video systems, etc. Today, there are areas of campus where all 12 filaments are used and certain new network functions cannot be deployed (such as the satellite downlink distribution from Poultry Science or Continuing Education). Appendix B and the diagram on page 7 describe campus locations where additional fiber runs are needed.

Identify and address immediate priorities for distressed local area

networks: There are areas on campus where building wiring needs to be fixed. In every case, additional electronics will be required; in some cases, wiring replacement will be required. And, in one instance--the north campus (the Farm)--a wireless connection to the campus network must be replaced with a fiber run.

Establish and enforce new network wiring standards for the entire campus: A team of technical experts from the campus are developing new wiring standards and working with Physical Plant to incorporate new wiring requirements in the Physical Plant Architecture and Engineering Guidelines for Renovation and New Construction.

Upgrade backbone electronics: The backbone upgrade will require the implementation of a vendor-supplied electronics technology which must be bid (Appendix D provides a summary of vendor proposals and associated costs.)

Establish and implement a Campus-wide Network Requirements Plan: While the Physical Plant Architecture and Engineering Guidelines for Renovation and New Construction will incorporate new networking standards, for existing buildings not scheduled for remodeling it will be necessary to conduct a preliminary needs assessment for each building (including a rough estimate of cost, time, and materials for wiring and electronics) to be performed by a team including appropriate personnel from Computing Services, Physical Plant, and a representative and/or information technology technical support person from each building. Computing Services will develop a survey instrument to assess needs. A final plan will be developed for each building, including a true cost estimate. Guidelines for upgrading existing buildings will include bringing wiring up to the standard of sufficient fiber to the building, electronics that enable ATM standards, and Category V (Cat V) wiring to the workstation.

Appendix F: Developing Campus-wide Communications Wiring Standards

In order to provide the best wiring infrastructure for future growth and extended functionality of our campus network, new standards are required for any new wiring being done on campus. A campus team of technical specialists (for example, representatives from Physical Plant, Network Services, Telecommunication Services, Engineering and others responsible for major components of the campus network) will develop these specifications to be included in the Physical Plant Architecture and Engineering Guidelines for Renovation and New Construction. This guide is provided to all architects and contractors preparing bids for construction on this campus, and with the inclusion of the telecommunications specifications, we can ensure that any new construction will be consistent with the campus standards for networking and telephony.

Examples of standards include, but are not limited to:

EIA/TIA 568A Commercial Building Telecommunications Cabling Standard specifies building wiring requirements ranging from how exterior cabling enters the building, to design requirements for equipment rooms, to wiring requirements to the desktop.

TSB-36 specifies requirements for high performance Unshielded Twisted Pair (UTP) wiring.

TSB-67 specifies how a contractor must test UTP to certify that it will

perform as required by the University.

When PHPL first receives notification of new construction and a Project Coordinator is assigned, Computing Service's Network Services Manager will be notified. PHPL and NWS representatives will meet with the architect/contractor and the requesting department/unit. This will allow an analysis of the project's network needs. Any clarifications regarding our campus network wiring standards as documented in the Physical Plant Architecture and Engineering Guidelines for Renovation and New Construction will also be resolved in those meetings.

PHPL and NWS staff will review building specification changes throughout the process of creating the final building specifications. PHPL and NWS must sign-off on acceptance of the final draft of building specifications prior to proceeding to any further work.

Appendix G: Ongoing Network Advisory Committee of the CAC

Proposed revised charge for the NAC:

Make recommendations on how to address immediate and pressing network wiring and equipment needs

Develop guidelines for use in ranking campus network wiring and equipment needs

Rank campus priorities and projects for addressing network-related problems

Advise on funding and cost allocation for network-related issues

Lead and support the development of a campus master wiring plan, including a project timetable

Advise and support network services

Committee Composition:

Computing Services network services manager

Policy and Technical Representatives from colleges and units

Physical Plant Representative familiar with status of construction/electrical projects

Telephone Services Representative