STATE OF ARIZONA

Telecommunications Planning Study

for
Department of Administration
Telecommunications Section

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1. EXECUTIVE SUMMARY

This report provides an analysis of the network functional requirements of the communications services supported by the state's agency and education communities; and offers recommendations to support those services on a "utility" communications network managed and operated by a single state entity.

The network requirements were determined from conversations, interviews and materials provided to NTI by administrative agency communications managers, and those in the education community sensitive to, or responsible for, leveraging technology to advance the educational mandate.

There are economic and functional advantages to creating a state-wide "utility" network; the primary focus of the utility network should be that it provide "commodity" services to the agency/administrative end-user. Within this charter it will also be positioned to support the education requirement for both commodity voice and data services network-wide, and for wideband services between Phoenix and Tucson. The following recommendations are offered:

1) Implement a utility network who's primary focus is to serve the administrative agencies' communication requirements. Support "commodity" communications services, voice and data, that are deployed on a cost-justified basis.

2) Implement the utility network as a "hybrid" network - a mix of both private, CPE-based, and public network resources - and base the architecture and topology on the existing ITN network.

3) Extend the reach of the utility network to locations currently "off-net" by leveraging public-network voice and data inter-working options.

4) Evolve the utility network to support wideband services between Phoenix and Tucson.

Such a utility network would best address the expressed operational concerns of those responsible for supporting the agencies' needs; which were to address the:

1) increasing demand for <u>existing</u> services - growth of "traditional" network users for existing applications and services

2) emergence of "inter-departmental" applications and a requirements to interact with the other state and federal government networks and databases

3) emergence of a new "type" of application whose network support requirements are not addressed by the current network architecture and installed technologies. *(high bandwidth applications - e.g. imaging, file transfer, LAN-LAN, and support for "off-network" access to "on-network" services)*

4) implementation and management of the inter-agency application-set from an "ad hoc" organizational infra-structure *(e.g. planning, standards, access, performance support, and such implementation and management issues as project funding and manpower)*

An agency-focused utility network would also serve the education community by providing more cost-effective commodity services to support existing voice and low-speed data "education" services. There are a number of *education services*, voice and data, that could be carried on an *administrative agency utility network*, and doing so would both improve services to the education community and enhance the cost-effectiveness of a agency-based utility network. There are economic and functional advantages to supporting *these* education-based services from the utility network.

A "utility" function that addresses the needs of the education and administrative communities *equally*, from technologies available today, will not provide any economic or functional advantage over supporting two independent network thrusts. There is no unifying technological platform, *currently available*, to *cost-effectively* support the different mandates of these communities.

The mandate of an agency's communications organization is to support the administrative function by providing basic services at the lowest cost. The function of the communications services that support the educational mandate is to foster "equity" teaching services throughout the state, and to enhance the reach and effectiveness of the education process by leveraging communications technologies.

The objective of the agency networks are to provide "commodity" voice and data administrative services, and justify the deployment of those services on a "least cost of service" basis. The education networks serve a social and philosophical goal; and act to draw new business/scientific interests into the state while increasing the capabilities and reach of the education providers.

The agency-networks carry "traditional" administrative applications that are well supported by narrowband (DS0/T1) services. The education-networks carry, what we'll call for lack of a better term, "education" applications - video and computer-file transfer applications - that rely on significantly greater "bandwidth", typically "wideband" (T1/T3). And although the distribution networks parallel each other - that is they reach out to the same cities - the functional requirements imposed are different, as are the implementation and technological alternatives to cost-effectively support those requirements.

These networks serve different goals, are enabled by different technologies, support different application-set functional requirements, offer different implementation choices to management, operate to different service measures, and are optimized to different objectives; in essence they serve two masters. And, although there are no technological barrier to providing all services from a single network point-of-view doing so will not offer any operational advantage.

However, within the agency network environment there are *applications* with similar operational requirements that, taken together, define common functional requirements. These are the predominant applications on *every one* of the agency networks and they account for virtually all of the data network traffic. These are the "traditional" administrative applications; and the functional requirements of these applications could be satisfied within a single unifying architecture, on a "utility" network, offering "commodity" communications services.

Commodity services, are supported by commonly available technologies and external service providers; and are distributed over facilities providing low-speed (<56Kbps/DS0) to narrowband (1.5Mbps/T1) capacity. Commodity services fully support all of the existing and the new inter-agency applications, though will not adequately support most of the "imaging" applications envisioned for the future; these would require wideband services.

However, the "utility" network will evolve to support wideband services, at least between Phoenix and Tucson. The growing traffic volume of low-speed data and voice on the "agency-networks" between Phoenix and Tucson, if trends continue, will eventually cost-justify wideband (T3) capacity. The agency/administrative community, does not currently require wideband from a *functional* point-of-view, but will be able to *cost-justify* a wideband link on the "commodity" services utility network. Once implemented this wideband link will not only functionally support the needs of the emerging "imaging" applications, but also encourage the deployment of other wideband services such as: compressed video; database/file transfer; graphics.

With these points in mind, the recommendations in the body of this report focus on enabling three major utility network functionalities:

1) "off-net" access for voice and low-speed (<56Kbps) data services to both the agency and education community.

2) extending the reach of the network-based capabilities for voice, low-speed and narrowband (56Kbps/1.5Mbps) data services in the metropolitan areas of Phoenix and Tucson via the "hybrid" network concept.

3) facilitating public/private inter-working via an understanding of industry directions and standards for narrowband/wideband technologies to support T1/T3 (1.5Mbps/45Mbps) network requirements.

A conceptual level view of technologies that support the utility network requirements are presented as a separate appendix. An implementation plan should be developed after the state's review of the conclusions and recommendations made in this document; and after their decisions concerning directions, timetable and operational priorities. That plan would incorporate a quantitative economic analysis of the implementation choices; and we recommend this as the appropriate next step.

This report addresses the first phase of a utility network concept that will evolve as more powerful and cost effective communication technologies are made available. The most significant technology in this regard is fiber. Fiber, and SONET-based services, would support both "education" and "agency" applications from a single technological platform and enable a true utility capability. As a future consideration, as the cost of fiber-based services drop, the utility network could evolve to support broadband service; at least within and between Phoenix and Tucson.

2. STUDY OBJECTIVE AND PROCESS

This study was sponsored by the state of Arizona Department of Administration, Data Management Division, and performed by Northern Telecom. It relied on the participation of the communications management of the state agencies and educational community for its source of information. These managers graciously gave their time to discuss their current communications environment and their plans to support the needs of their end users.

The interviews lasted approximately one hour each and generally involved the manager and at least one member of the technical staff. The interview work sheet outlines issues that were discussed and is attached as **Appendix 1** to indicate the tone and nature of the conversations. **Appendix 2** is a list of those who participated and the documentation they provided us as background information for understanding the issues being addressed by their departments.

The tasks of the study were to:

1) Understand the goals and service philosophy of the Agency and Educational community.

2) Identify the communications needs, of each agency and educational entity, that serve those goals.

3) Understand the current and evolving application-set support requirements and the operational and functional requirements that this application-set impose on a network.

4) Propose an appropriate network architecture and enabling technology that supports the application requirements, and is sensitive to a number of operational factors: EG. cost; quality; standards; manpower constraints; management philosophy and organizational infra-structure.

5) Provide an implementation scenario and schedule for deploying the appropriate architecture and technology.

Our goal was to understand the application requirements and operational environment, and from this define the functional requirements of a network that would serve the total end-user community.

3. THE NETWORK ENVIRONMENT

This section discusses three network entities that serve the administrative and educational communities: the "agency services network"; the "education services network"; the ITN backbone network.

The "agency-networks" supports the communication requirements of the administrative departments: Administration, Corrections, Education, Economic Security, Land, Health Services, Public Safety, Revenue, Transportation, Water Resources, and Office of Attorney General.

The "education-networks" supports the communication requirements of the education community: K12 schools, school districts, community colleges and the university system.

The ITN network, Inter-agency Telecommunications Network, supports the voice and data inter-agency requirements by providing the communications highway that connects government offices across the state to the processing and administration center at the capitol mall in Phoenix.

The sections below describe the characteristics and distribution requirements of those networks. The figures referred to in this section are provided immediately following the section where they are first referenced.

3.1 THE AGENCY-NETWORKS:

Application Characteristics

The agency networks carry what can be called "traditional" or "administrative" applications. These applications generate virtually all of the current traffic on the agency networks. "Administrative" applications are the transaction-based database access and retrieval services that are characterized by - "a few characters sent down the line from the terminal and a screen full sent back from the host".

These applications are centralized, large database access, query/response applications. Characteristically, a user will initiate a transaction by sending a few characters (typically 10 to 100 characters) to the centralized host processing site, and the application will return a screen, or multiple screens, of information back (typically 100 to 2000 characters).

Application performance requirements are addressed by limiting the utilization on the link from the end user to the host processor. Line transmission rates are typically 9.6 Kbps, and when line utilization is kept low, typically below 25%, these networks will satisfy the performance criteria of the current applications set - average network transit time below 3 seconds.

These networks are characterized by applications that make similar demands on a pool of common resources. Each application, or transaction within an application, requires approximately the same amount, and kind, of network resource; they all make similar demands on the resource pool. Essentially, the network is supporting one kind of application; and can be optimized to support that performance requirement. And, conversely, to provide the acceptable overall network performance each transaction must require the same level and kind of network resources and service levels.

The *current* application mix conforms to this constraint, and therefore the current network architecture and technology, adequately supports the combined end user community.

The agencies *future* network requirements, as relayed to us by the agency managers, are very similar to one another. They are, to support, within the existing infra-structure and funding philosophy, the:

1) increasing demand for existing applications services - growth of "traditional" network users for the existing applications and services

2) emergence of "inter-departmental" applications and a requirements to interact with the other state and federal government networks and databases

3) emergence of a new "type" of application whose network support requirements are not addressed by the current network architecture and installed technologies. *(high bandwidth applications - e.g. imaging, file transfer, LAN-LAN communications)*

4) implementation and management of the inter-agency application-set from an "ad hoc" organizational infra-structure *(e.g. planning, standards, access, performance support, implementation and management issues)*

The agency-networks application-set and operational philosophy, taken together, constitute a well-defined set of network functional requirements. These applications can be supported within a single unifying network architecture and management philosophy and provide cost effective services to the agencies' end-users.

The Distribution Network

The agencies distribution networks are all very similar, and often parallel one another. They all provide support services from the single processing complex in Phoenix to the administrative offices in the field. Consequently these networks manifest similar topology and architecture, and taken together represent variations on the basic theme of "star" network. The range of those variations can be seen from the representations in figures 3.1, 3.2 and 3.3.

Figure 3.1 depicts the network of the department of Water Resources, which is a pure "star" network homed into the Phoenix processing center.

Figure 3.2 shows the network of the Office of the Attorney General, which is basically a "star" network with concentration centers at regional county seats where legal support service are provided. This network supports consolidation of network traffic, to reduce transport costs, and offers support for potential applications that require distributed processing/legal services from the concentration nodes.

Figure 3.3 represents another variation of a basic "star" network where the regional concentration hubs may also enabled some limited (or not so limited) *network* service capability: EG. alternate routing; contingency/disaster recovery services ("stand-by" back-up services from network/processing nodes is Flagstaff, Phoenix, Tucson). This is the department of Public Safety's network;, and reflects a well designed microwave-network.

If the agency-networks were overlaid onto a composite distribution network it would look like the one depicted in **Figure 3.4**. This represents the topology of the single network that would serve each agency's distribution requirements. That is, this network would reach to those locations necessary to support the total end-user community.

On this overlay network the total traffic volume carried from the node sites to the Phoenix center would be proportional to the number of end-users at the site. We mention what may seem a somewhat obvious point only because it is not the case on the education network where the traffic volume pattern is based on a *geographic* support requirement. For example, the bandwidth required to support an educational video application is independent of the number of end-users viewing it; whereas the bandwidth to support an administrative database access application is directly related to the number of users.

Figure 3.5 represents this overlay network's bandwidth requirements, and indicates the particular significance of the Tucson network node. The larger than "average" bandwidth requirement between Tucson and Phoenix is not surprising since every agency had staff and a field office in Tucson; and every agency network had a Tucson node. And, as we observed before, the traffic on the administrative networks mirror the end-user population at the node locations therefore, we have a particularly large communication requirement between these two major cities. The bandwidth requirement between Phoenix and Tucson currently constitute the dominant share of inter-site network traffic, and can be expected to experience the fastest growth because this is the bulk of the user community. And when new services are deployed, on a cost-per user basis, they are more likely to be deployed to these two "population-dense" locations. As an example: wideband services to support imaging applications will be "cost-justified" and implemented between Phoenix-Tucson, long before they are likely between Phoenix-Show Low.

Cost-justification is a valid service deployment criteria for a commodity services network, though it fosters *un*equal capabilities. That is, it encourages "cost effective" but *un*equal services to *selected* user-populations. But these are the largest sites and *precisely* were the *smallest* productivity improvement per-individual will have the *largest* overall impact; these are the locations that provide the greatest "return on investment" for the capital expended.

Dept. of Water Resources

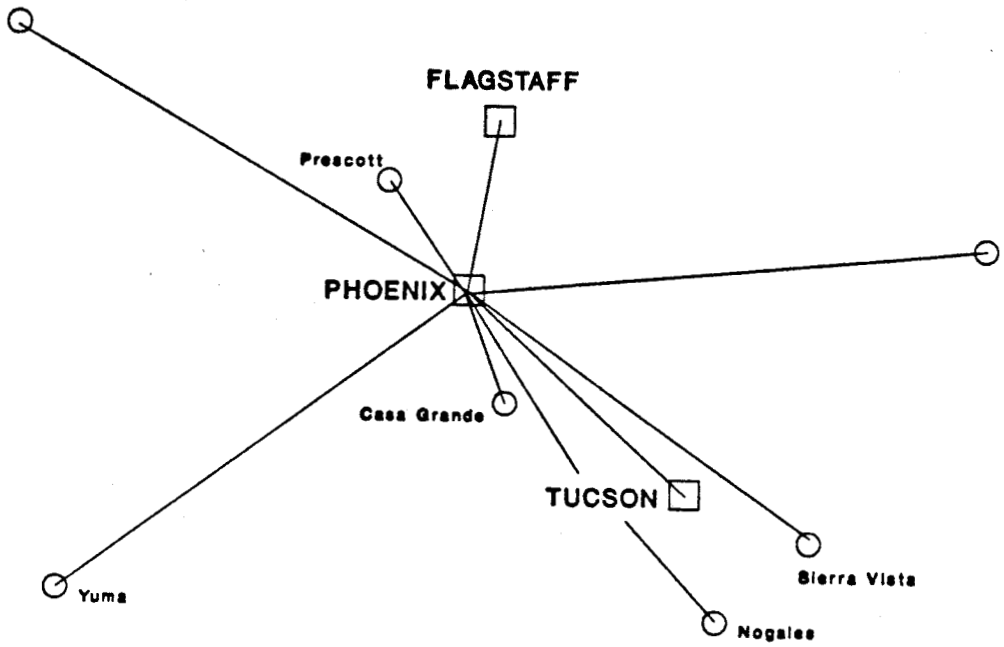


Figure 3.1

Attorney General
regional-based support services

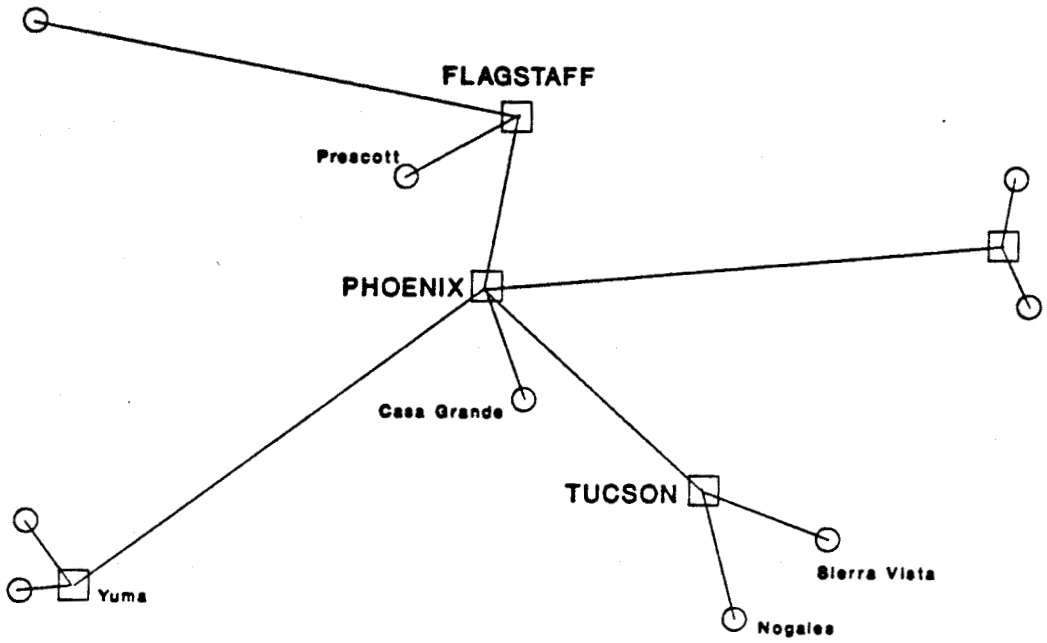


Figure 3.2

Dept. of Public Safety
DPS Microwave Network

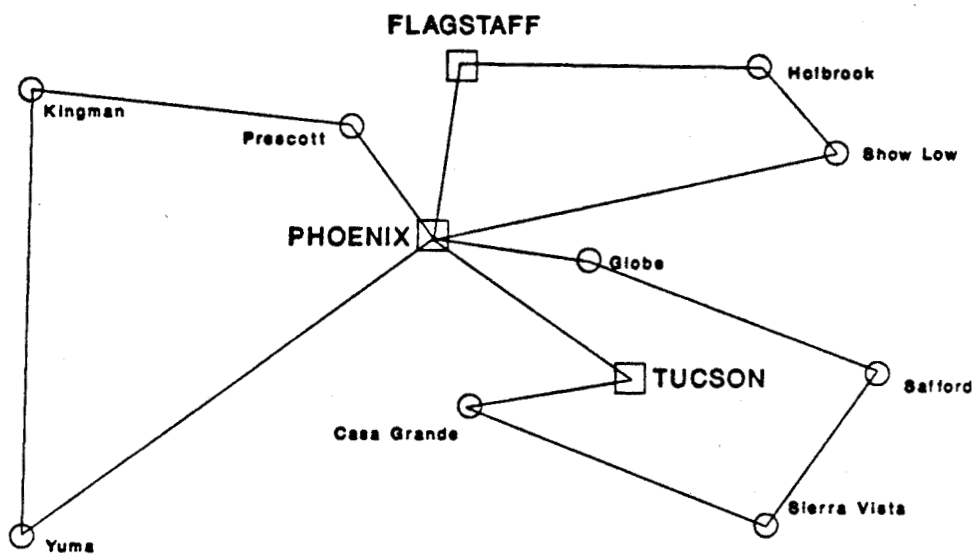


Figure 3.3

Generalized *"Agency"* Network Overlay
Composite Topology

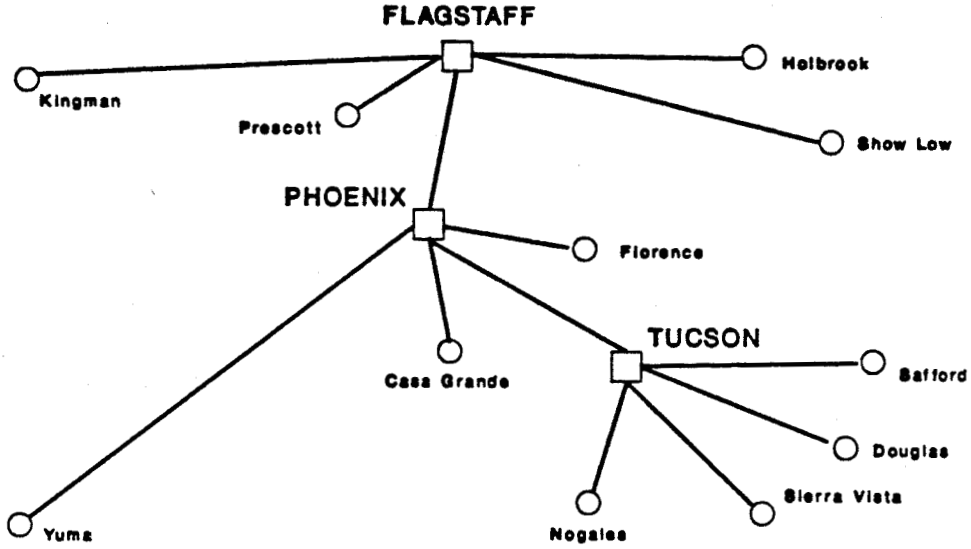


Figure 3.4

Generalized *"Agency"* Network Overlay
Composite Traffic/Bandwidth Flow

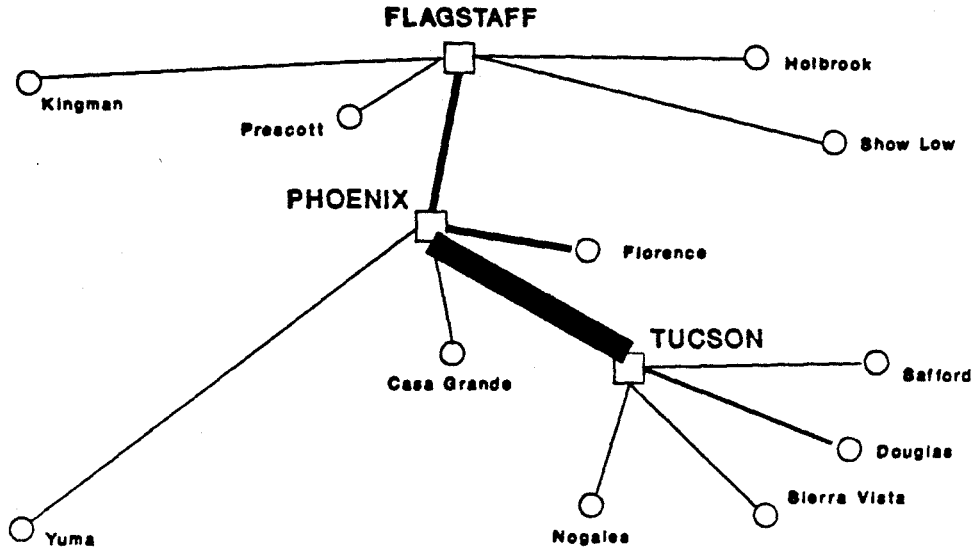


Figure 3.5

3.2 THE EDUCATION-NETWORKS:

Application Characteristics

The two dominant network requirements are to support "teaching" and "scientific" application services. The "teaching" applications rely on full motion, one-way video with two-way audio, distributed by satellite broadcast to a number of locations throughout the state. Satellite delivery of full motion one-way video is currently the method of choice, but compressed video over microwave or land line are being considered as potential alternatives for the future. Two-way full motion video would of course be a more effective teaching technology but can not be cost-justified state-wide.

The operational mandate of the "teaching" applications is to provide "educational equity". "Equity" is a concept where the quality of the teaching and quantity of courses available, across the state, will be the same; so that even the most sparsely populated communities will have access to the same educational experience. The "equity" concept depends on the ability to leverage communications technology to deliver the expert skills of a limited, centralized, pool of teachers. Under this social mandate satellite distribution is a very cost effect way to provide these wideband services to the end-user communities; and will remain a dominant distribution technology. *[As a means of comparing alternative methodologies for delivering "distance learning" **Appendix 3** offers a short summary of the capabilities of several technologies].*

The "scientific" applications are large data transfer services, that require wideband/broadband capabilities, and are enabled by LAN technologies and architectures. These applications can be supported within a campus-environment over appropriate transmission media (cable, or fiber), but there is a growing need (desire) to extend these capabilities between the universities; and within a single university to extend these services beyond the traditional campus environment.

Additionally, there are evolving educational (training and continuing technical education) and collegial (joint research and funding) relationship developing between the "high tech" scientific/industrial community and the university. Many of the applications that support this relationship will depend on wideband services. A communication network that supports this inter-working between the business and university communities is viewed as being as essential as *"roads and utilities"* to attract and keep high-tech businesses in Arizona.

Support for these services, "teaching" and "scientific", are critical to the education function. If technology can enable an otherwise unattended educational objective it is the responsibility of the educator to implement that service via that technology. This is a mandate where cost, though important, is secondary to delivering an essential service. The network is not primarily there to provide low-cost commodity services, but rather to enable a more "profound" social agenda.

The Distribution Network

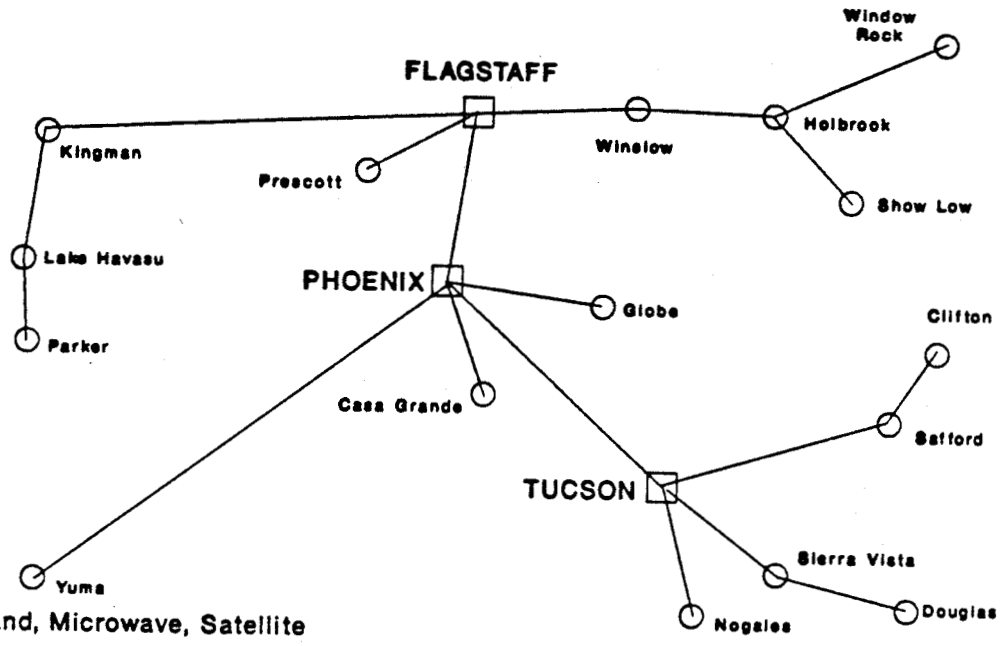
Figure 3.6 represents the topology of the AETC land and microwave network that enables the "learning at a distance" services throughout the state. This is the network that most directly supports "equity" educational services by delivering a variety of video-based courses to the sparsely populated communities. This network is an example of how the education community is leveraging technology to support it's educational responsibility and also serve the social policy of the state: IE. enabling the policy mandate to provide every child instruction in a second language.

Figure 3.7, represents the traffic pattern of the "equity" network. The supporting bandwidth requirement on the network are fixed by the application distribution technology, and is not proportional to the number of people actually using the service. That is, the communication requirement is not based on the *population* of the end-user community but rather only on the existence of an end-user; and the supporting network topology is based on *geography* not *population*.

Figure 3.8 represents the university community's "scientific" application network requirement. This is the type of network that would serve: NSFnet applications; LAN-to-LAN beyond the campus; inter-working between the university and business communities; inter-university services, which would to allow the university system to work as if on one campus. This is a wideband/broadband service network which would be necessary to support the functional requirements of the university community. *[It is depicted here logically; the physical link to Flagstaff would be through Phoenix].*

Clearly the network requirements of the educational community must be seen as separate from those that a "utility" network should aim to serve. There is no economic or functional common ground for trying to rationalize this network with the utility network requirements. Except, of course, if a utility *wideband* network existed where the educational mandate could be served, even if only between Phoenix and Tucson, the education community would be use it.

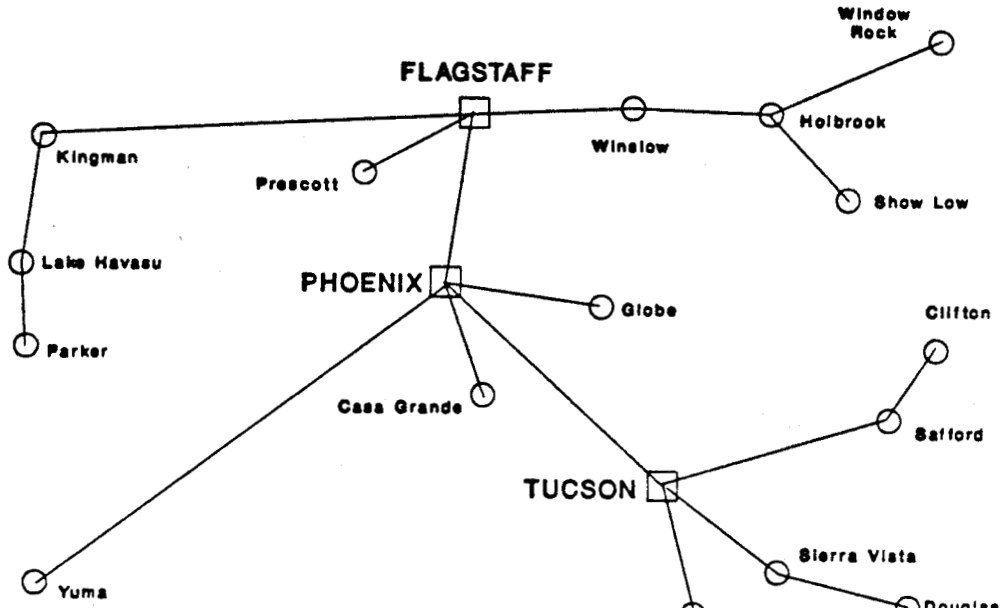
Education *"Equity"* Network
Composite Topology*



* Land, Microwave, Satellite

Figure 3.6

Education *"Equity"* Network
Composite Traffic/Bandwidth Requirement*

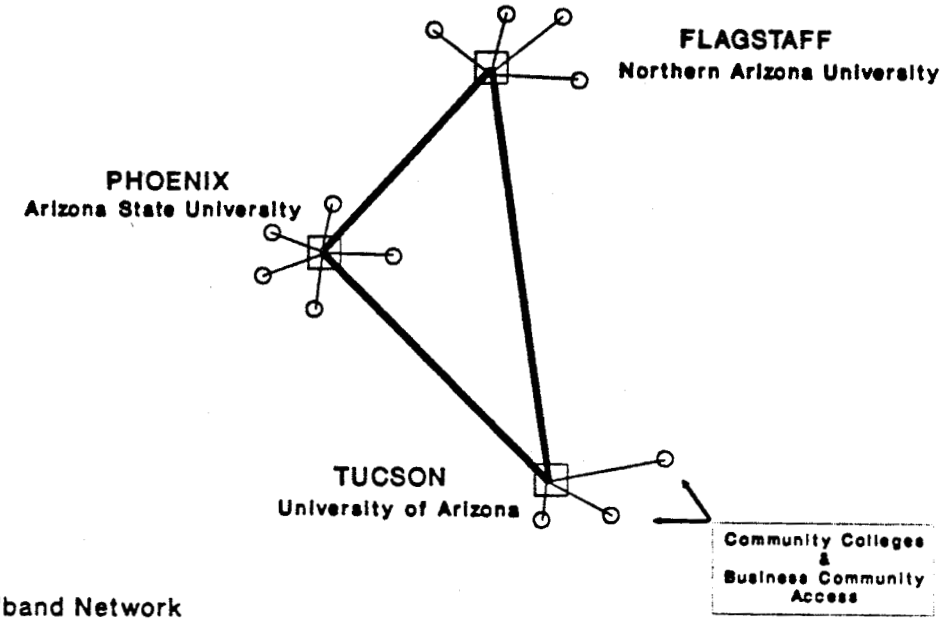


* Land, Microwave, Satellite

Figure 3.7

Arizona Universities

National Research Education Network *



* Broadband Network

Figure 3.8

3.3 THE ITN BACKBONE NETWORK:

The state-wide ITN backbone provides "commodity" voice and data transport services to the agencies in support of their applications requirements. It is managed by the single organization that is mandated to support "inter-agency" requirements, and therefore in a position to provide the management point of view required of the utility network service provider. The existing ITN backbone is deployed as cost-justified service and the geographic span of the existing network facilities parallel the overlay composite utility network.

Figure 3.9 depicts the 7-node ITN T1 backbone as it was proposed in January 1987 by FLUOR Technology, Inc. in a consulting report titled "Interagency Telecommunication Network". The topology reflects the traffic estimates that were *population*-based, and view the support requirement as flowing from the agency offices in the larger cities into the Phoenix capitol mall.

Figure 3.10 show the current status of the ITN network, and reflects how real-world needs have directed the priorities of the network implementation. The "de facto" criteria for allocating resources to service the agencies' communication requirement has resulted in the deployment of multiple T1 links between Phoenix and Tucson. This supports the bulk of the communications requirement for voice and data services to the ITN network user community.

Figure 3.11 represents a very important phenomenon which is the emergence of a data requirement from "off-network" locations to "on-network" service centers in the Phoenix and Tucson. There are currently T1 links from several offices within Phoenix and Tucson to the network nodes there. These T1 links support high-speed data services (narrowband DS0/T1 services) from the agency processing center at the capitol-mall; and suggests an emerging functional requirement to support Metropolitan-Area Network (MAN) capabilities. MAN services would support the growing population of agency-network users who are not physically at a network node site but who need "node like" services. Support for requirements for such new services as LAN-to-LAN within the city or across the ITN backbone, LAN-Host, high-speed data access to the ITN backbone, can all be expected; and will require that the network extend it's reach to "off-network" locations within the city and support not only low-speed but narrowband services as well.

Figure 3.12 represents the *current* situation in Phoenix and Tucson - multiple intra-city T1 spans hubing into the ITN backbone - and suggests the *evolving* "Metro-Hub" MAN/WAN network connectivity requirement. The dominant characteristic of the current requirement is a need to support "off-network" access to "on-network" services for dial-up, low-speed and high-speed services from dedicated leased or switched data transport facilities. But the most significant aspect of the situation is the emergence of a "campus-like" communication requirement in these two cities. One of the anticipated effects of supporting additional low-speed and narrowband services from *off* the network is its potential impact on access *to* the network. That is, the access bandwidth requirement to the public network may also eventual cost-justify T3.

Figure 3.13 represent the likely direction the network will take in the next few years; support of wideband services over a T3 link between Phoenix and Tucson.

There are currently four T1 between Phoenix and Tucson to support voice and data traffic requirements. Traffic on the network from data applications is anticipated to be growing at 15%-20% per year; and no one is predicting a decline in that rate for the foreseeable future. If these trends continue, data traffic volume can be projected to double in four to five years. Today a "non-discounted" Phoenix to Tucson T1 cost about $3,000 per month, a T3 about $23,500 per month. At today's rates the "break even" point for a T3 link (45Mbps) is at about *eight* T1 links (1.5Mbps); and the cost of "bandwidth" on the public network is declining.

Additionally, support of metropolitan-area services, like those suggested in **figure 3.12**, are likely to create a demand for equivalent services *between* Phoenix and Tucson. That is, there will evolve a *"functional"* requirement for this capability between those cities. Furthermore, even if no new *agency*-based traffic is drawn to the backbone because of this enhance capability it is likely that the universities would find an interest in a wideband service between the campuses; in fact, they could use that capability today, and likely would, and further cost-justify the inter-city wideband capability. But the agencies *will* use this wideband link, because it will support the imaging, and file transfer applications that are now being planned.

STATE OF ARIZONA
ITN T-1 Backbone Network
(as proposed 1/87)

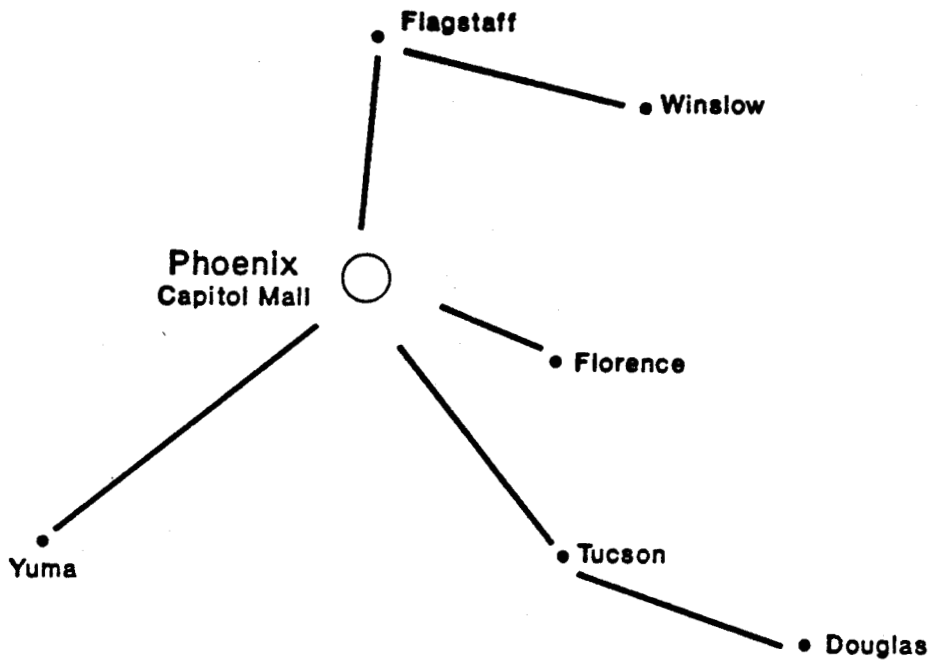


Figure 3.9

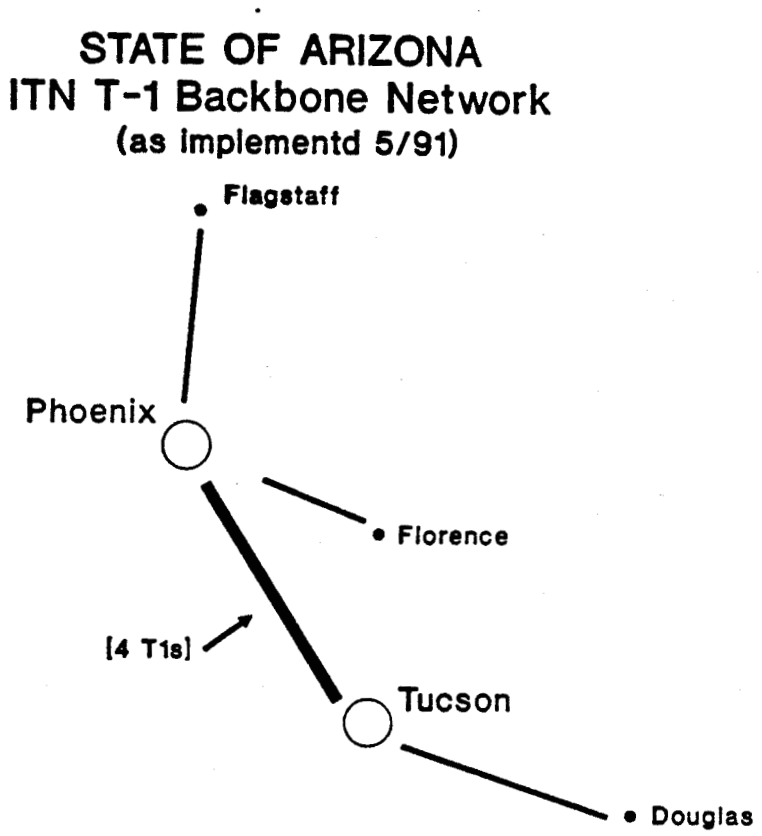

STATE OF ARIZONA
ITN T-1 Backbone Network
(as implementd 5/91)
Flagstaff
Phoenix
Florence
[4 T1s]
Tucson
Douglas

Figure 3.10

STATE OF ARIZONA
ITN T-1 Backbone Network
(as implementd 5/91)

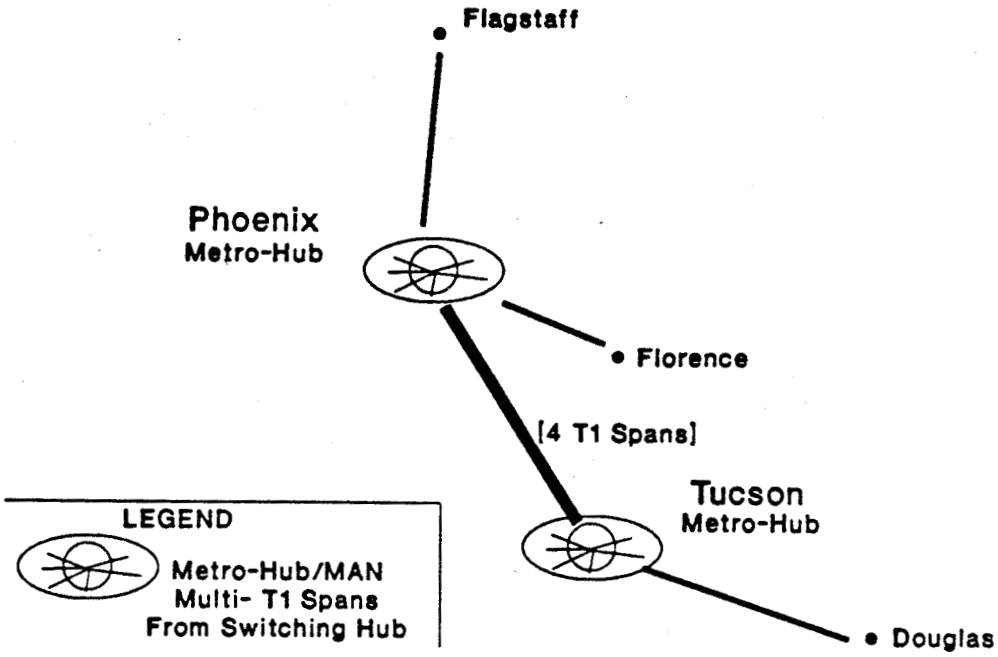


Figure 3.11

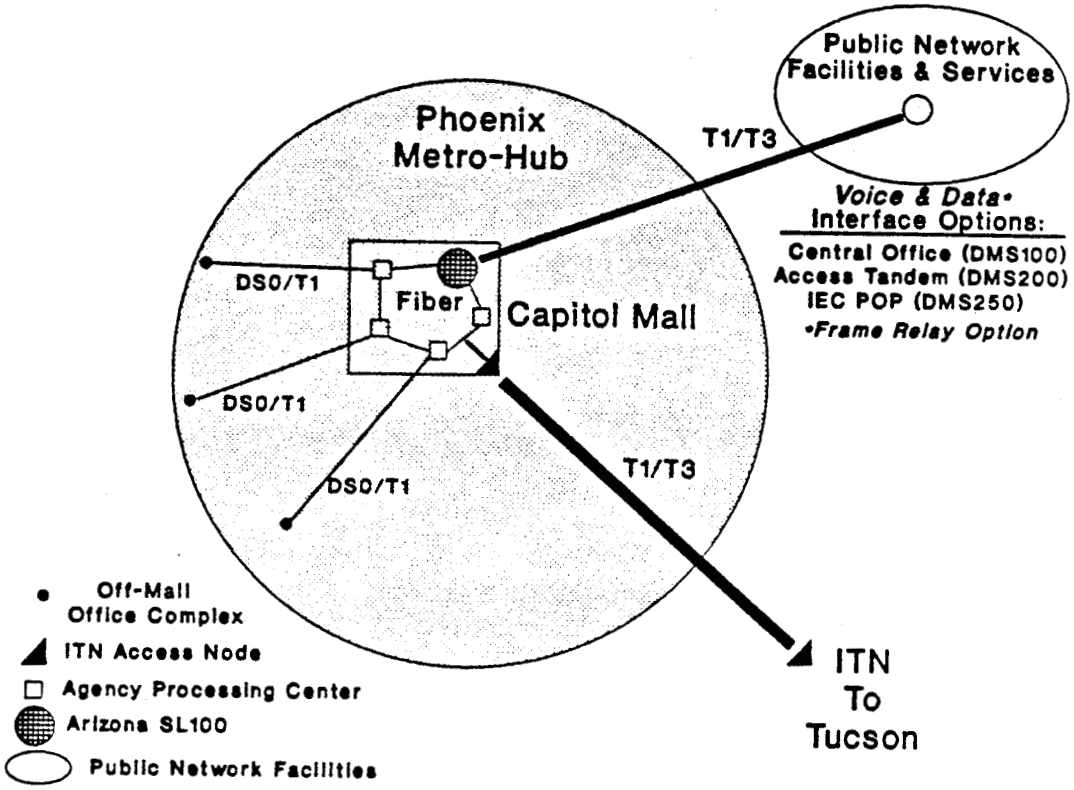

Public Network
Facilities & Services
Phoenix
Metro-Hub
T1/T3
Voice & Data*
Interface Options:
Central Office (DMS100)
Access Tandem (DMS200)
IEC POP (DMS250)
*Frame Relay Option
DS0/T1
Fiber
Capitol Mall
DS0/T1
DS0/T1
T1/T3
Off-Mall
Office Complex
ITN Access Node
Agency Processing Center
Arizona SL100
Public Network Facilities
ITN
To
Tucson

Figure 3.12

ITN Wideband Services Implementation

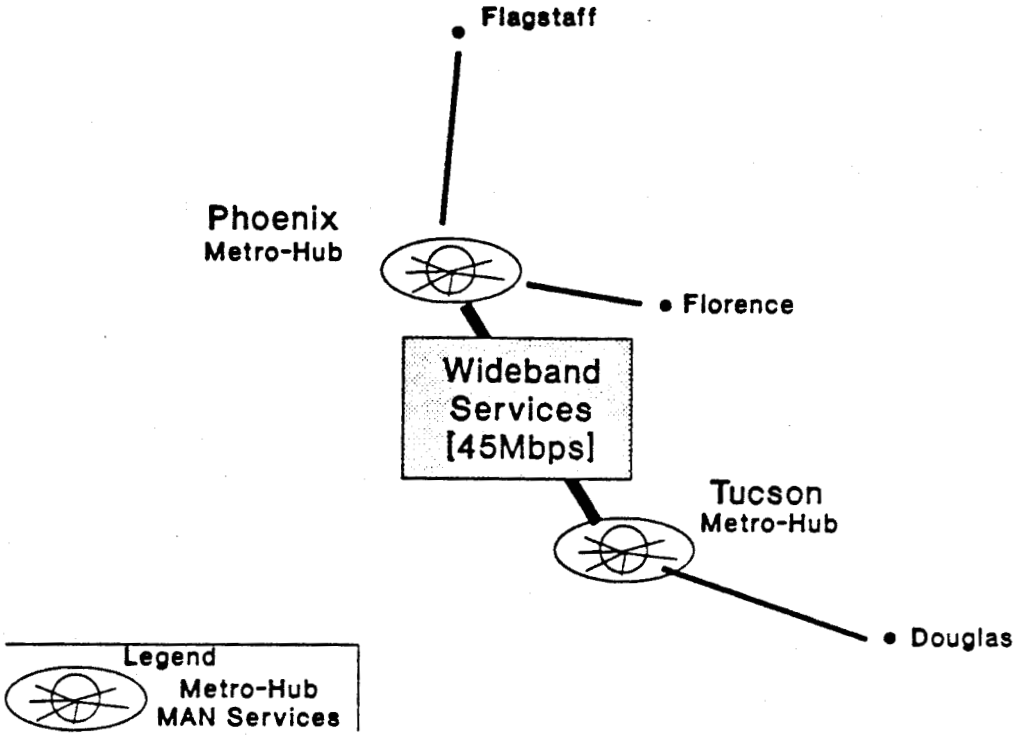


Figure 3.13

4. SITUATIONAL ASSESSMENT: THE UTILITY NETWORK CONCEPT

Situational Assessment

The mandate of the Agency-networks is to provide "commodity" services at the lowest cost. The mandate of the Education-network is to foster equity educational services throughout the state, and to enhance the education process by leveraging technologies.

The agency-networks carry "traditional" administrative applications that are well supported by narrowband (DS0/T1) services. The education-networks carry, for lack of a better term, what we'll call "education" applications - video and computer-file transfer applications - that rely on significantly greater "bandwidth", typically "wideband" (T1/T3). And although the distribution networks parallel each other - that is they reach out to the same cities - the functional requirements imposed are different, as are the implementation and technological alternatives to cost-effectively supporting those requirements.

These networks serve different goals, are enabled by different technologies, support different application-set functional requirements, offer different implementation choices to management, operate to different service measures, and are optimized to different objectives; in essence they serve two masters.

Although there are no technological barrier to providing all services from a single network point-of-view a "utility network" that addresses both communities equally will not provide any economic, or functional, advantage over supporting two network thrusts.

However, there *are* applications with similar operational requirements that, taken together, define common functional requirements. These are the predominant applications on *every one* of the agency networks; the applications that account for virtually all of the data network traffic. These applications are the "traditional" administrative applications, and are characterized by query/response access to centralized databases; and these are the functional requirements that are best addressed by a state-wide utility communications network.

The Utility Network Concept

The "utility network" concept would best serve the administrative agencies' situation and network functional requirements that, taken together, can most economically be served from a common architecture and operating philosophy. Furthermore, the communications budgeting philosophy - cost-justified "commodity" services - is supported by the utility network concept. The utility network should provide these cost-justified commodity services and focus primarily on the administrative agency end-user community.

Focusing on the "agency" requirements will not preclude utility network support for "education" clients. There *are* existing narrowband voice and data "education" services that would be more cost effectively provided to the educational community over a utility network. That is, there are a number of *education services*, voice and data, that could be carried on an *administrative agency utility network*; and doing so would both improve services to the education community and further enhance the cost-effectiveness of an agency-focused utility network.

Traffic volume demands for "commodity" communication services that support the "administrative" agency-network applications between Phoenix and Tucson are growing exponentially. Data traffic growth estimates of 15% to 20% per year are still reported on the agency networks; and the

inter-agency traffic increases are keeping pace, driven by new application requirements for inter-agency inter-working. If trends continue these volume requirements will eventually cost-justify wideband (T3) capacity between Phoenix and Tucson. The agency/administrative community does not require wideband from a *functional* point-of-view but will be able to *cost-justify* wideband on the major traffic carrying link of a "commodity" services utility network.

Once wideband capability is established additional agency-based traffic will flow to the network. A wideband link would support the "imaging" applications requirements between these on-network locations. Additionally, with "cheap bandwidth" (IE. cost/capacity) made available by the T3 the transport cost component of video conference services will no longer be an issue; and the long expressed desire for this service between Phoenix and Tucson could be more easily cost-justified. Additionally, T3 network functionality would support distributed computer processing center capability, for load-sharing and contingency recovery, if agency management wished to consider this network design alternative with Tucson as the second site.

Separate from the agency requirements is the education community's functional requirement for wideband to advance some of it's goals. The universities already have application requirements for wideband between campuses. But these requirements can not cost-justify a wide-area wideband network within the priorities of the educational budget; nor would this use of funds align with the stated primacy of "equity" in teaching services to the rural communities. So the universities constitute a community that could use, though not necessarily install and operate, a wideband "utility" network link between Phoenix and Tucson, and they would most likely prefer to be a *consumer*, not provider of these services.

With these points in mind, the primary focus of the utility network should be that it provide "commodity" services to the agency/administrative end-user, offering cost-efficient narrowband communications services; and secondarily, it should provide cost-justified narrowband and wideband services, both MAN and WAN, to serve the agency requirement for new services (EG. imaging). Within this charter it will also be positioned to support the education requirement for both commodity voice and data services - network-wide, and for wideband services between Phoenix and Tucson.

The Narrowband Hybrid Utility Network

The dominant utility network application is the "traditional" administrative application, characterized by query/response access to centralized databases; and this application can be effectively and economically served by "narrowband" transport (DS0/T1) technologies.

Narrowband transport services can be supported from either dedicated leased line or switched facilities; and the utility network should rely on, and leverage, public network-based switched services, where economically indicated, as a means of extending the *"reach"* of utility network services. Extending the reach of the network will expand the user-base for all network services and beneficially effect the economic of all services; but it also offers *managed* network functionally, standards and services to locations that are not now being served.

High-speed data transport services are also available from the public carriers, both LEC and IEC carriers. Switched 56Kbps (circuit switched) is available now and Frame Relay/Fast Packet data services are being readied to provide "usage-sensitive" data services where dedicated leased line services are not economical. Other CO-based "application" services - processing, routing, gateway to external network and database services - can be expected from the both IEC and LEC carriers as part of their Virtual Private Network (VPN) thrust, and should be seen as service alternatives, where they are economically attractive. These VPN services do not alter the "private-

network" status, and flavor, of the utility network, and the VPN services are managed and controlled by the utility network.

The utility network should be a *hybrid* network that incorporates public network *facilities* and *application services* to support the utility network operating philosophy. This *hybrid* network can be managed by a single state entity to serve the common objective of the agencies. Public carrier-based transport *facilities* extend the reach of the utility network by providing Public-network-based support for switched (dial-up) access to agency processing and network services that can not be cost-justify leased line access. Public carrier-based *application services* extend the reach of the utility network by providing public-network based applications that are not available, or cost-justified, from the private utility-network intelligence.

For the most part the primary implementation of the hybrid network concept will be to use public in-place facilities that are "usage sensitive", at "feature group" or other contracted below-tariff rates, to extend utility-network services to agency locations that do not cost-justify dedicated transport facilities or CPE-based hardware. But it also provides the state implementation alternatives that mitigate to some extent the constraints of capital budget or manpower; and it may be the quickest, or best, way to provide some specific services to some agency locations.

Utility Network Wideband Services

This utility network will provide *cost-justified wideband* services, and not be limited to just low-speed and narrowband services. The traffic volume requirements for "administrative" agency-network applications between Phoenix and Tucson are growing at a rate that, if the trends continues, will *cost-justify* wideband (T3) *capacity* in a few years. The agency/administrative community, which does not currently require a wideband network from an application *functional* requirement point-of-view, will be able to cost-justify wideband on a cost of service basis. This will allow the *"utility network"* to *functionally* support the agencies' emerging requirements for imaging, video conferencing, high-speed data and other LAN services over a wide area network (WAN); and also serve many WAN wideband education-network requirements.

The education community's interest in wideband on a utility network is not limited to the WAN capabilities between Phoenix and Tucson. They view with at least as much interest the availability of MAN wideband within Phoenix and Tucson. Certainly, WAN wideband between Phoenix and Tucson would support the universities and educational communities there. But the MAN services were of particular interest to the university community because it could effectively support inter-working with the scientific and business community. Two examples envisioned were: off-campus access to collegial work within research and funding organizations in the business/scientific community; and the delivery of "higher bandwidth" implementations of educational/teaching services to the employees of the business community, and the student population at community colleges. Certainly within a MAN/Campus-like environment there are two-way full motion "distance learning" technologies that can be deployed with the economic constraints.

Though a successful, cost-efficient, "utility" network will eventually attract and carry education-network wideband services it should evolve from the agency-network application requirements. Likewise, the general topology and network architecture of that network should evolve from the technology and facilities base of the network currently addressing inter-agency needs: the ITN backbone network.

ITN Network as progenitor of the utility network:

The utility network should evolve as a natural extension of the ITN network. Although the current application requirements of the agencies can be supported without a utility network, by existing technologies and "informal" de facto inter-agency inter-working arrangements, there are economic and operational advantages to supporting these inter-agency needs from a single organizational entity that is *chartered* to support the non-processing center based services, and the emerging requirements for new, enhanced network service, via the utility network concept. As a *chartered* entity the utility network organization will allow itself to take on an identity beyond that of being a circuit provider.

In it's simplest form the utility network is a transport network of multiplexers and T1 links, providing concentration and transport management services. The utility network concept though can evolve beyond the basic backbone transport service concept. In a slight variation of this basic theme the network access nodes can be enabled to make real-time decisions of how best choose from among several alternate of public or private service options, or bandwidth allocation schemes. In a more advanced form the utility network would implement a different levels of network processing/switching capabilities, network intelligence, in the different nodes of the network.

Whatever it's organizational vision and charter the utility network should encompass the concept that it is a "tiered-services" network, where different nodes support different capabilities. There currently is a physical structure in-place, and paralleled in the public network, to support three distinctly different levels, or types, of application services: dial-up, low-speed, and high-speed data (0-56Kbps); narrowband (56Kbps-1.5Mbps); wideband (1.5Mbps-45Mbps). There will be some agency locations where wideband services are supported, and others where only low-speed, or dial-up, data services are available.

The utility network should support these three levels of services from the nodes of the network. And conceptually, it can be view that there should be three types of network nodes, which for lack of better terms we'll call: "service center" nodes, "concentration" nodes, and "access" nodes.

"Service Center" would be the highest level node and would likely be implemented in Phoenix and later in Tucson. These nodes support MAN-type services and extend the reach of the network over a combination of dedicated and switched (public/private) resources; these are primarily narrowband capabilities to/from "off-network" offices and end-users. "Concentration" is the second level node and are envisioned at a number of locations where traffic volume and flow pattern suggest their value. There locations, primarily act to concentrate traffic onto the backbone and service networks; but can support optimized routing and service capability, depending on the operation philosophy of the network management. "Access" nodes are the end-user view of the utility network. These can be any device that allows "standard" access to the service network.

Figures **4.1**, **4.2**, **4.3** and **4.4** suggest a possible scenario where the three types of nodes are deployed to implement the utility network concept.

The general topology and architecture of the utility network is depicted in **Figure 4.1**. And, much like the 7-node ITN blueprint, follows the population centers of the state. However, there is a recognition that the services supported at different nodes will be different. That wideband services will be supported between Phoenix and Tucson (and possibly Flagstaff), and that narrowband (DS0/T1) will be supported over the nodes to other large cities; but that access from off-node, or at the less populated offices will be supported by lower-bandwidth services (**Figure 4.1b**).

Figure 4.2 represents the bandwidth requirements, and the anticipated future implementation of T3 on the Phoenix-Tucson link. Except for the Phoenix-Tucson link the backbone network will

likely be a narrowband network (T1). This will depend on the service philosophy of network management, and the economics of distributed processing, routing and gateway capabilities. If transport service cost drop significantly, there would be less need for "concentration" nodes and distributed services; and access point would then home-into Phoenix directly.

Figure 4.3 suggests the level of data support available on the network, and for the sake of argument lists locations where, at least from the education-network's point-of-view, end-user services are expected. A commodity utility network could support low-speed and high-speed data services to serve the K12 schools or community colleges requirement, as well as support the agency community data requirements. The functional support available from both public and private based implementations are appropriate to serve the overwhelming majority of application requirements.

Figure 4.4 indicates a possible implementation scenario on the hybrid utility network; and is based on the 7-node ITN backbone network plan proposed in January 1987. In this scenario there are two "service center" nodes in Phoenix and Tucson, and five "concentration" nodes in Flagstaff, Winslow, Florence, Douglas and Yuma.

The nodes in Phoenix and Tucson would not only provide wideband transport between these cities over the T3 link, but would also support city-wide MAN requirements (DS0/T1). Access to the utility network services would be supported from both private and public based facilities. These nodes would also provide "gateway" services to public-network services, and are points-of-presence (POP) to the LEC for "corporate carrier" based access. [Figure **3.12** is reproduced here to indicate the hybrid nature of the metro-hub. Access to utility network functional and management services over the public network from "off-net" locations is indicated at **A**, **B** and **C**].

The "concentration" nodes in the other sites implement a functionality-sets that depend on the management philosophy, economics and availability of specific services. The decision to implement a private-based concentration node over a public-based node will depend on the availability, economics and functional equivalence of the public capability. Certainly, if function requirements are minimal, for example if only multiplexing is required at these sites, then this will be widely available from the public provider at a price that can be compared to private based multiplexing. If local-site intelligence and routing services are also required, based on the evolving network service philosophy, then private-based resources may be functionally necessary to provide these capabilities.

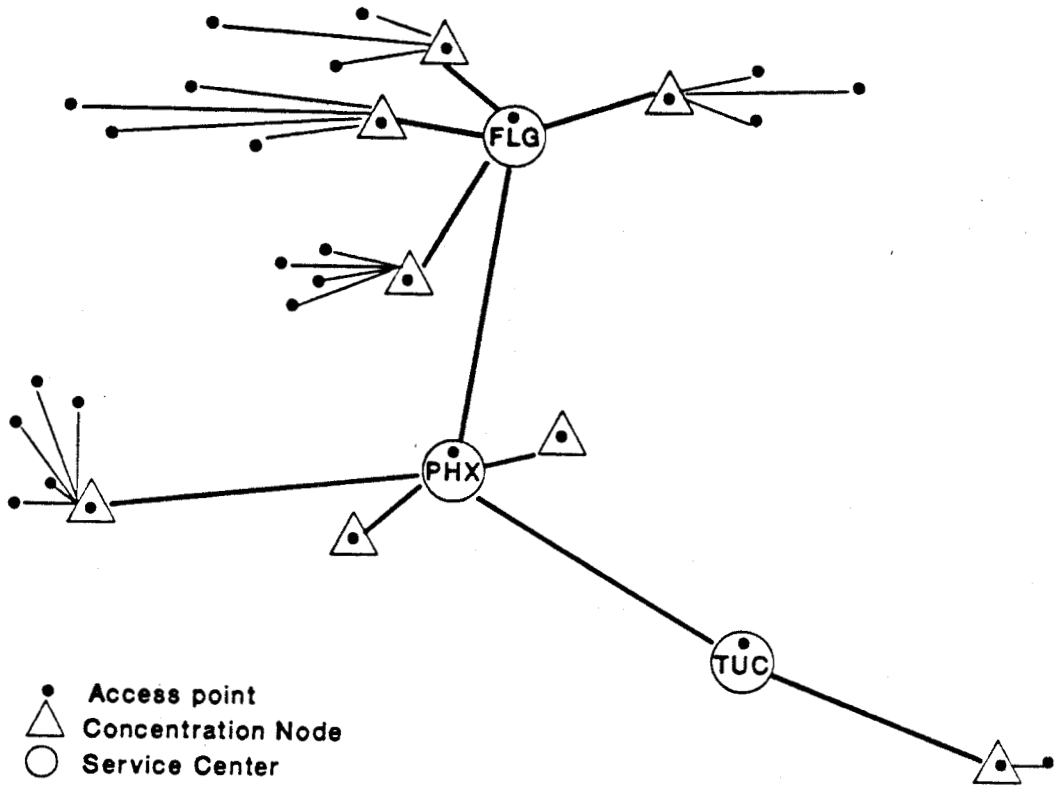

FLG
PHX
TUC
Access point
Concentration Node
Service Center

Figure 4.1

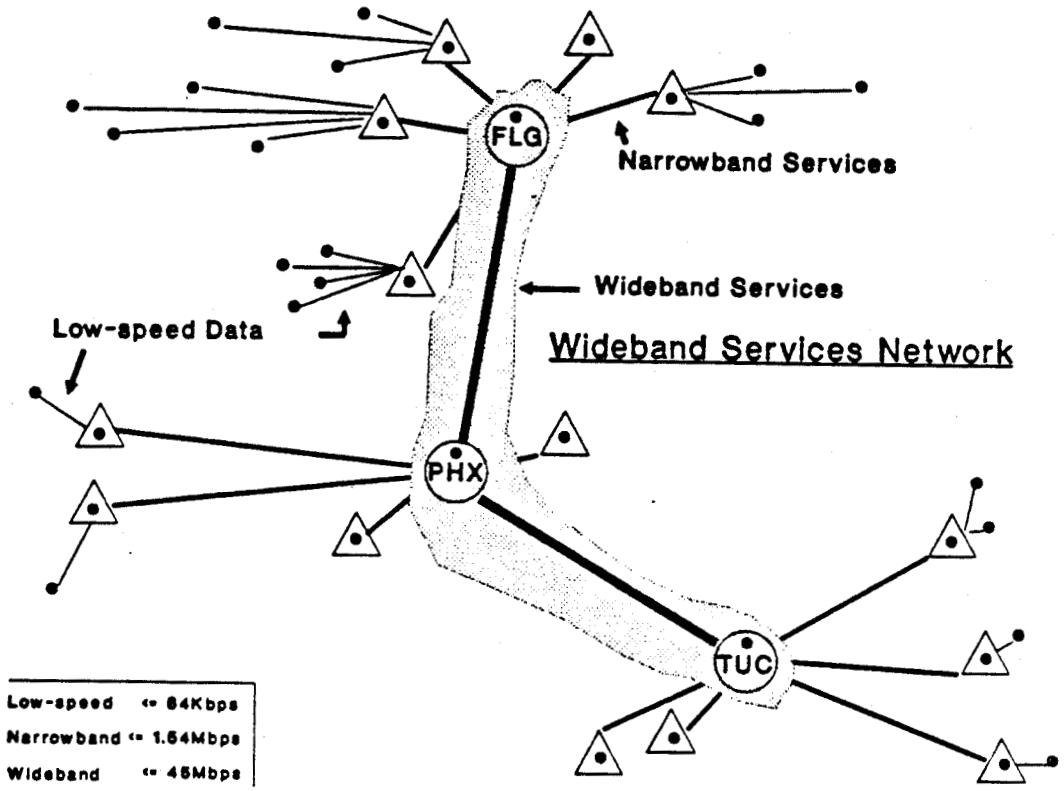

FLG
Narrowband Services
Wideband Services
Low-speed Data
Wideband Services Network
PHX
TUC
Low-speed <= 64Kbps
Narrowband <= 1.54Mbps
Wideband <= 45Mbps

Figure 4.1b

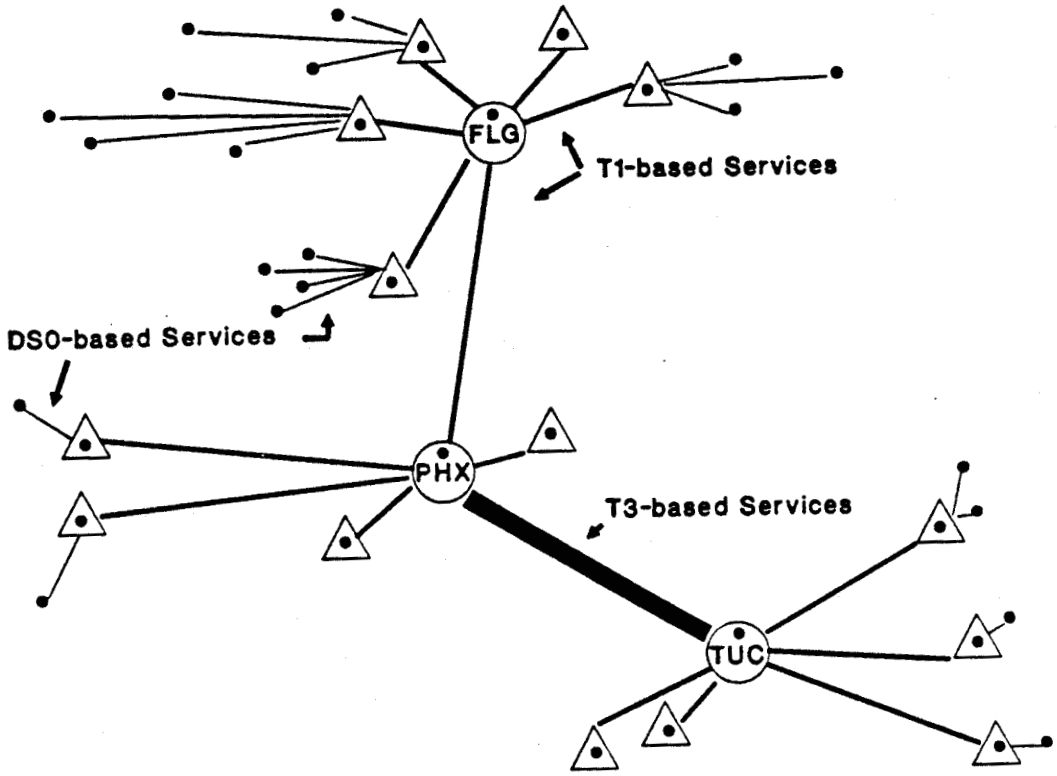

FLG
T1-based Services
DS0-based Services
PHX
T3-based Services
TUC

Figure 4.2

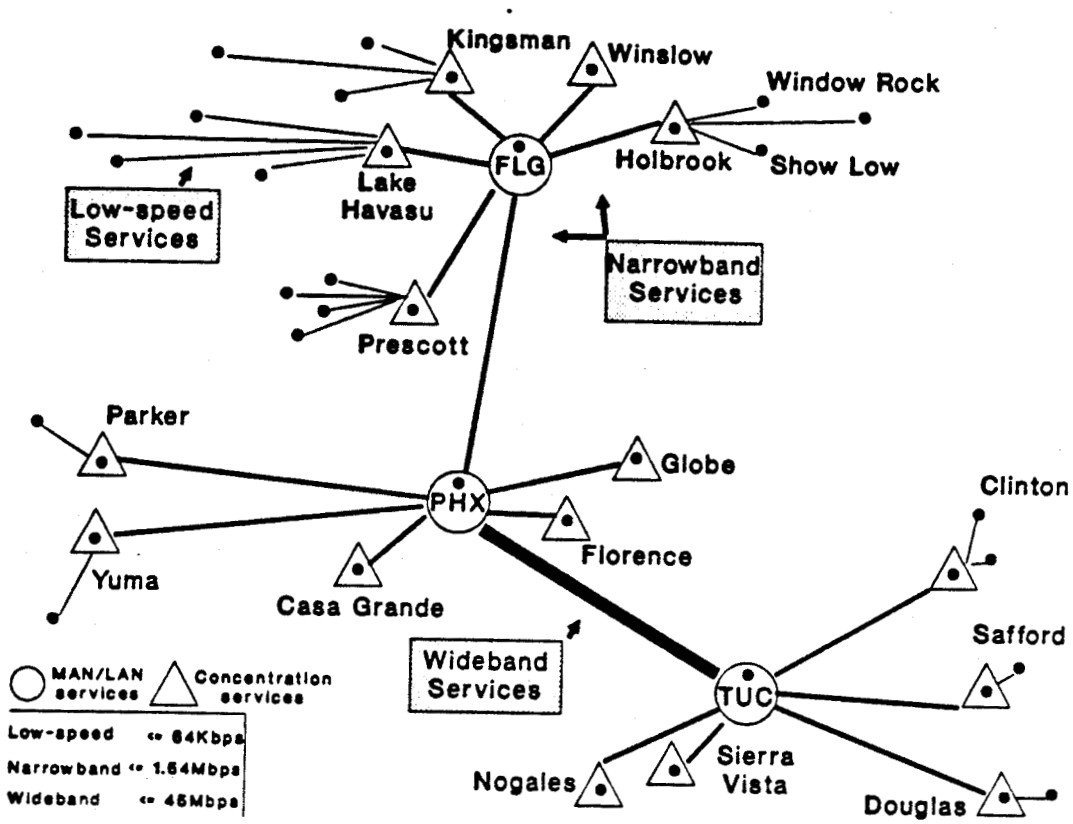

Kingsman
Winslow
Window Rock
Holbrook
Show Low
FLG
Lake Havasu
Low-speed Services
Narrowband Services
Prescott
Parker
Globe
PHX
Clinton
Yuma
Florence
Casa Grande
Safford
Wideband Services
TUC
MAN/LAN services
Concentration services
Low-speed <= 64Kbps
Narrowband <= 1.54Mbps
Wideband <= 45Mbps
Nogales
Sierra Vista
Douglas

Figure 4.3

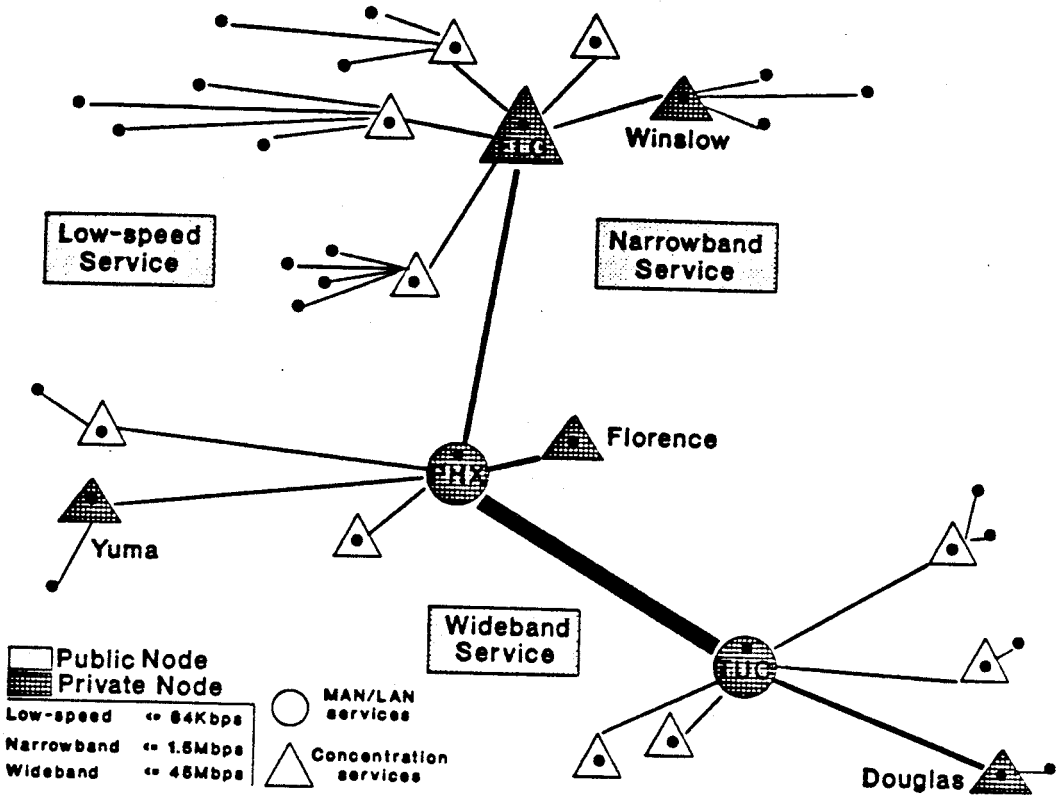

TUC
Winslow
Low-speed Service
Narrowband Service
Florence
PHX
Yuma
Wideband Service
TUC
Douglas
Public Node
Private Node
Low-speed <= 64Kbps
Narrowband <= 1.5Mbps
Wideband <= 45Mbps
MAN/LAN services
Concentration services

Figure 4.4

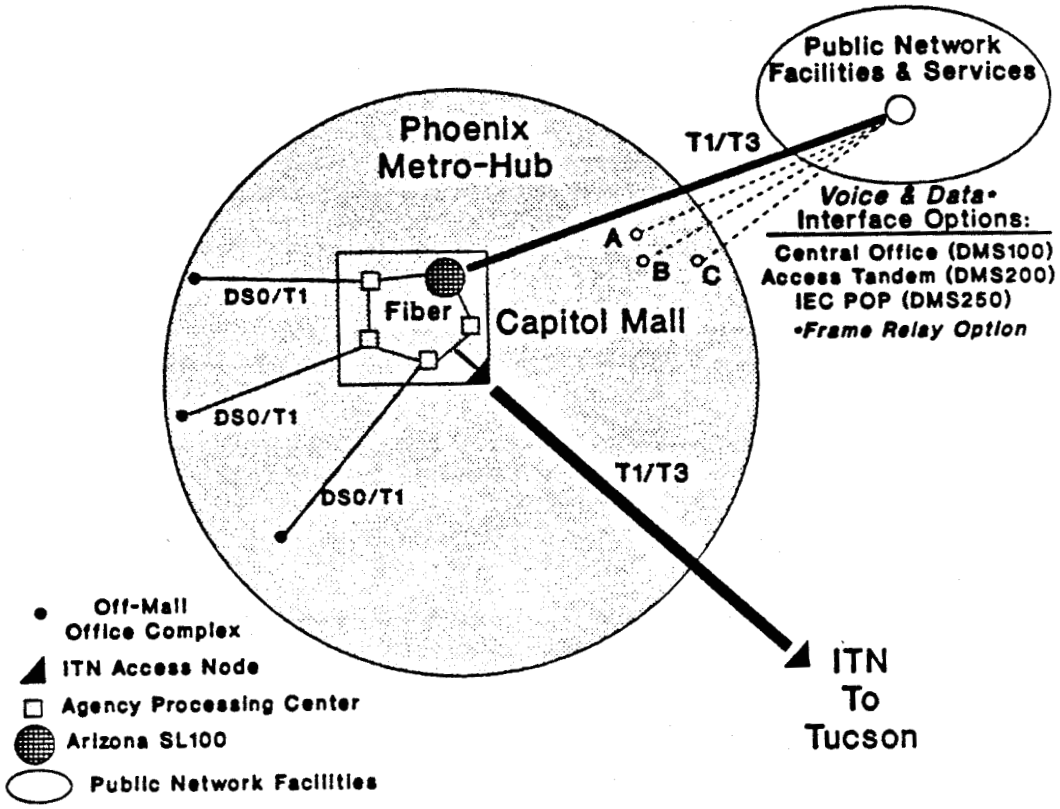

Public Network
Facilities & Services
Phoenix
Metro-Hub
T1/T3
Voice & Data*
Interface Options:
Central Office (DMS100)
Access Tandem (DMS200)
IEC POP (DMS250)
*Frame Relay Option
A
B
C
DS0/T1
Fiber
Capitol Mall
DS0/T1
DS0/T1
T1/T3
ITN
To
Tucson
Off-Mall
Office Complex
ITN Access Node
Agency Processing Center
Arizona SL100
Public Network Facilities

Figure 3.12

5. NETWORK RECOMMENDATIONS

Based on our analysis of the current and evolving network functional requirements, and our assessment of the operational environment we would offer the following recommendations as action items:

1) **Institute a state-wide communications "utility" network designed to support the agencies' administrative applications functional requirements.**

2) **Support "commodity" voice and data transport services only.** Offer the utility network as a means of improving the cost of deploying basic, traditional, currently available transport services; not as a means of providing additional functionality to the agencies (this doesn't seem to be a mandate for the agency networks). Become the equivalent of the "plain old telephone" service provider to the agencies, supporting inter-agency operability and lowest-cost services compared to external vendors of these services. Support narrowband (56Kbps/1.5Mbps) data services from the T1-based ITN network. Support low-speed and dial-up data via X.25 packet service. Address the K12 education community voice and low-speed/dial-up data requirements via these commodity services. Support new commodity-based application services; as examples: inter-agency E-mail and networked voice-mail.

3) **Implement the utility network concept from the current 5-node CPE-based ITN network.** Continue to support CPE-based solutions (multiplexers) and dedicated T1 access at nodes that cost justify "concentration" onto the backbone. Focus on the inter-nodal transport services only (initially); focus specifically on the backbone requirements between Phoenix and Tucson. Continue to deploy leased line to bring traffic onto the network nodes; begin to consider VPN and usage-sensitive public services to bring "off-net" low-speed data to the network nodes.

4) **Implement the Utility Network as a Hybrid Network.** The utility network should support the agency functional requirements from a mix of public-based and private-based resources. Some public-based "usage sensitive" offerings will support the agency requirement in the most cost-effective way; consider these implementation options. The hybrid network should enable functional equivalence, seamless inter-working between public/private implementations, and allow the state to make decisions that are based solely on the economics of functionally equivalent implementation options.

5) **Extend the "reach" of the utility network by leveraging Hybrid Options.** Deploy services beyond the 5-node ITN backbone. Investigate the capabilities and economics of public-carrier transport and VPN services to extend the utility network.

   a) **Implement the 7-node ITN model.** Investigate both lower bandwidth CPE-based options and public-network alternatives for Yuma and Winslow. Some of the possible service options are: CPE-based stat-mux; IEC/LEC or CPE-based packet service;

3rd-party Value Added Networks. If these prove attractive, consider other locations for these service options.

b) **Support Narrowband-based Metro-areas capabilities in Phoenix and Tucson.** Support On-net to Off-net access for low-speed (dial-up) and high-speed data (56Kbps) services. Consider supporting LAN/LAN requirements via dedicated or switched 56Kbps services. Support previously non-supported office complexes for voice and data services from VPN or corporate carrier service capabilities. Consider the university requirement of "on-net to off-net" services for voice and data access to the business/scientific community.

c) **Support low-speed data and voice services from public network access points.** Leverage the public network to provide network access for low-speed, dial-up, data services. Consider alternative dial-up access services with the public networks (EG. corporate carrier services). Offer low-speed data, and off-net/on-net voice support to the K12 education community. Manage, public network-based hybrid utility services from the utility network.

6) **Establish Access Standards that foster Public-Private functional equivalence and inter-working.** Consider X.25 as the standard for dial-up, and low-speed, data access to the utility network. Consider X.25 as the access standard to external networks. Consider Frame Relay Packet services for higher speed requirements - 56Kbps to T1. Investigate public-network availability and cost of Frame Relay/Fast Packet services. Investigate public/private technologies inter-working and compatibility.

7) **Deploy CPE-technologies that inter-work with public network-based technologies.** Avoid "niche" solutions; deploy technologies that are moving towards a common view. Support narrowband data (DS0/T1) services on-net between nodes via T1 multiplexers that plan to support Fast Packet/Frame Relay services. Support the transport and aggregation of low-speed requirements (<56Kbps) to the other network nodes, and onto the backbone from a X.25 packet switched technology. Support access to "external" networks and network services via public-based X.25 packet services.

8) **Develop capabilities that foster choice in service and access options to the public-networks.** Consider expanding the role of the existing SL100 and make it the utility network gateway to the public service providers via a "corporate carrier service" implementation. The capitol mall-based SL100 can look to the public network as either a LEC Central Office (CO) or Access Tandem (AT) or as an IEC Point of Presence (IEC-POP). This would offer the state several options to manage, access and inter-working with public network resources.

9) **Support wideband services between Phoenix and Tucson.** There are currently four T1 circuits between Phoenix and Tucson. Support for predicted traffic growth will cost-justify a T3 in four or five

years. At that time install T3 and support wideband services to both the agency and education communities.

10) **Develop a peer-relationship with the public network service providers.** The state should develop a relationship with the public providers that drives the deployment of needed services and capabilities. The state should obtain the "technology and services roll-out" plan of the service providers - LEC, IEC and 3rd party VAN providers; and it should implement it's CPE-based technologies from an understanding of these schedules and technologies.

11) **Build the organizational charter and inter-agency infrastructure that will foster an operational sensitivity to the *agencies'* needs, yet serve the management mandate of the *state*.** The organizational charter must reflect the functional mandate to support all inter-city, and "off-net/on-net" transport services for voice, data and compressed video services to the agencies.

APPENDIX 1

INTERVIEW WORK SHEET

Agency Mission & Focus

- Business Focus and end-user needs
- Organization structure, operating environment
- Current Business Services Focus
- Current Business Planning - Next 3 years
- Role of Communications in Support of Business Plan
- Communications: Planning & Implementation
- Communications: Measures of Performance / Success

Agency Application Portfolio:

- Current Application Portfolio
- Constraints and Bottlenecks to Services
- Future Application Portfolio
- Constraints to Future Services Deployment
- Performance Measures: End-User Services & Agency metrics
- Finance: Capital & Expense Budgets
- Processes: Budgeting and Justification (ROR, Cost reduction, operating necessity, etc.)

Agency Operating Environment:

- Communication's Organization, Manpower Skills, and Operating Environment
- Services Distribution Network Requirements
- Current Enabling Technologies
- Restrictions to Services (manpower, budget, technology, organization, infra-structure)
- Future Services: Technologies Platform
- Communications Planning Environment (intra-dept)
- Performance Measures: End-User and Departmental
- Finances: Capital & Expense Budgets and Processes

Inter-Agency Issues & Operating Requirements:

- Current Inter-Agency Requirements
- Future Inter-Agency Plans
- Inter-Agency Technology: Platform, Standards, Inter-operability, Functional Equivalence
- Inter-Departmental infra-structure: how are inter-agency service requirements, and project, planned, implemented and operated
- Inter-Agency Network Management Issues
- Performance Measures: End-User services and Departmental metrics
- Finances: Capital & Expense Budgets and Processes

Communications Network Management Issues:

- Agency Management: Future Vision
- Current network management: Philosophy & methods

Management Requirements Vs Methods and Tools
Communications Usage Tracking & Billing Philosophy
Security
Backup/Disaster Recovery
Managing Multiple Technologies: Copper, Cable, Satellite, Microwave, Fiber
Managing Multiple Application Networks: LAN, MAN, WAN
Manpower Requirements: levels and skills
Objectives and Measures: Financial, Services Deployment, Performance Metrics

Network Descriptive Information

The following is a partial list of the type of supporting documentation that would help us develop the quantification to support the decision processes. If this type of information is available we would like each agency to provide it, on a confidential basis, so that we can include it in the analysis.

Network Descriptive Data: Quantifiables & Decision Factors:

- Drawings, charts, topology of current network
- # of network users by location (major sites only)
- # staff/centralized?/ access/interface to users
- Staff skills requirement/breakdown
- Current applications delivered to sites
- Traffic growth anticipated (traditional)
- Traffic/Technology Impact of new service/applications
- New Application service descriptions & performance requirements
- Availability of Parallel Service Networks
- Capabilities/Constraints of Parallel Service Networks
- "Buying Transport Services" Issues:
  - Another State Agency Vs External Sources
  - Inter-departmental operation & Ownership

APPENDIX 2

INTERVIEW PARTICIPANTS

EDUCATION:

Arizona Board of Regents
Dr. Arthur Ashton: Special Assistant for Strategic Planning

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Robert Leach: Director of Telecommunications
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Department of Corrections
Robert Sharpe: Manager, EDP Program Management

Department of Education
Kathryn Kilroy: Administrator, Technology Services
Edward Sloat: Deputy Associate Superintendent, Research & Development

Department of Economic Security
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Roy Merrill: Manager, Technical Support

Department of Land
Lynn Larson: Administrative Service Officer
Bob Miner: Technical Support Specialist
Curtis Overall: Supervisor, Computer Operations

Gary Irish: Manager, Systems and Programming

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Robert Cooper: Manager, EDP
John Smalling: Manager, Systems and Programming
Jack Wiechert: Technical Support Specialist

Department of Public Safety
Curt Baer: Manager, Telecommunications Bureau
Curt Knight: Manager, Telephone and Data Services

Department of Revenue
Darold Barnese: Manager, Systems and Programming
Randy Lyon: Manager, Technical Support

Department of Transportation
John McDowell: Manager, Information Systems
John Amidon: Manager, Technical Support

Department of Water Resources
Frank Secondo: Manager, Information Systems
Howard Billings: Technical Support Specialist

Office of Attorney General
Jeannie Miller: Director, Computer Services
Peter Hays: Technical Support Specialist

REFERENCE DOCUMENTS:

Department of Administration: State of Arizona Automation Report (1/91)
Department of Education: Arizona Telecommunications Survey Report
Department of Health Services: Management Information Systems Three Year Plan 1990 -1993
Department of Transportation: Information Services Group Three Year Plan 1990 - 1993
A Study of Resource Sharing in the state of Arizona - Optimizing Library Dollars (7/90)
Arizona Education Telecommunications Cooperative: A Report for a State-wide Network (1/90)
Arizona Public Schools Instructional Programming Needs Update (TII Report 2/90)
Educational Issues in Arizona: "Building Learning Bridges Through Technology" prepared for the AETC by Norman Wagner, Ph.D. (9/89)
Education Telecommunications in Arizona: A Recommendation of the Needs Subcommittee of the Telecommunications Task Force of the AETC (4/88)
TIEDS (Technology Integrated Educational Delivery System) A K-12 Master Plan for the infusion of technology into Arizona schools in the Teaching/Learning Environment (7/90)

INTERVIEW NOTES

AETC (ARIZONA EDUCATIONAL TELECOMMUNICATION COOPERATIVE)

Dominant Application/Support Requirements (Now/Future):

Full motion analog video (teaching)
Inter-University high-speed data services
K12 voice and data services
Inter-community college data services
Network connectivity (voice and data)
State-wide MAN network service

Issues and Concerns:

Needs access services to Public Switched Network Service (PSN)
Needs access to other agency (state/fed) databases and services
K12 data needs not being served
Needs video connection to universities (teaching)
Needs data access to universities (high-speed)
Need data access to K12 (low-speed)
Need MAN connectivity/functionality around community colleges
Wants "integration" of voice and data services
K12 need data access between K12 and access to external data services

Operational Constraints:

Budget
Manpower constraints
Wants to use not own/operate communication services

Planning:

imaging
large file transfer (records, certification info)

Unresolved Need/Issues or "wish" list Services:

Needs physical state-wide communications network to connect universities, community colleges, public schools (K12) and government agencies. Would like that to be "seamless" network, as easy to use as telephone network. Would have to serve multiple applications, and multiple technologies. (i.e. broadband utility network - Fiber/SONET-based services)

OFFICE OF ATTORNEY GENERAL

Dominant Application/Support Requirements (Now/Future):

LAN support services within Phoenix and Tucson
LAN to Host services
Legal support (Voice and Data) from field offices in Phoenix and Tucson
Environmental Law (database access to external services)
Legal Database access (other states, federal, external services and private law offices)

Video conference
Low-speed data access to host (<56Kbps)
Dial-up access to external services and database (eg. legal reference libraries)
High-bandwidth data transfer (document and image)
Voice mail
Text mail
50% (or more) of communication requirement is off network (voice and data)

Issues and Concerns:

Reduce paperwork
Integrating different technologies (wang, IBM, external hosts, external networks)
$300,000 budget for capital expense

Operational Constraints:

Budget
Manpower
Planning environment (no long term planning)

Planning:

growth of word processing
imaging applications
Document transfer applications (high-bandwidth)
More inter-agency/inter-working requirements

Unresolved Need/Issues or "wish" list Services:

Tucson may become regional support center and require more communications and computer inter-working/support
Hard to get new things to happen
Often Re-active not Pro-active on technology
No formal budget/allocation process, hence no effective technology planning process

DEPARTMENT OF EDUCATION:

Dominant Application/Support Requirements (Now/Future):

Broadcast quality Video (full motion analogue)
KU-band satellite "looks good"
Need to improve process (teaching/learning tools)
Need to reduce paperwork/process
Teacher certification
Adult education
Inter-agency requirements (administrative, reporting)
Inter-state/federal requirements
Access to external educational services: federal and other state govts; research networks; library services; document transfer services

Issues and Concerns:

Standards (TC/ICP)
Application inter-working just becoming an issue
LAN/LAN communications
EQUITY: how to address/support

DOE does very good planning on uses of technology but has no budget to spend on technology (grants/external funding sources)

Operational Constraints:

No budget
No support manpower to operate services

Plans:

"Imaging" applications (fingerprint info on teachers)
Satellite Kit for schools: for about $5,000 per school - downlink, monitors, PC to operate, modem and phone line to CO

Unresolved Need/Issues or "wish" list Services:

Teleconferencing
Wide are network between universities (broadband)
Access to external educational services: federal and other state govts; research networks; library services; document transfer services
DOE wants DOA to operate/manage statewide service network

DEPARTMENT OF CORRECTIONS:

Dominant Application/Support Requirements (Now/Future):

Inter-agency reporting and database access (HRMS, AFIPS)
Mainframe application support
Large state-wide CICS/3270 application/network with state-wide regional concentration
Data network vehicle to reduce cost of operations ("one new application saving $10,000/month")
Growth of voice traffic (paralleling growth of correction system population)
LANs are beginning to be installed
Evolving new "distributed" services

Issues and Concerns:

Operational Constraints:

Inter-agency inter-working (eg. inter-agency data transfer via tape; or batch dump, etc. limited functionality)
Inter-agency inter-working (eg. security)

Plans:

Image processing and new image application deployment over the network (fingerprint)
More volume on network: (eg. "Florence today one T1, Florence 1995 two/three T1 supporting administrative growth (HRMS, AFIPS); plus even more if image applications centralized")

Unresolved Need/Issues or "wish" list Services:

DEPARTMENT OF PUBLIC SAFETY:

Dominant Application/Support Requirements (Now/Future):

- Analog microwave system moving to digital
- Microwave support to other agencies (56Kbps)
- Emerging inter-agency applications
- Inter-agency reporting applications (HRMS, AFIPS)
- Inter-Federal government applications
- Security/Encryption
- High-bandwidth application coming (imaging)
- External database and services (security)
- Video (but, security)

Issues and Concerns:

- Security is number one operational issue
- Capacity of analog system is "max'd out"
- moving to digital backbone
- Planning for large bandwidth applications (image)
- Security on Fiber questioned
- Security concerns will preclude many of the public network, and utility network service options (NTI concern not expressed by DPS)
- Standards

Operational Constraints:

- Hardly a constraint DPS is only agency with large staff to support their communications network

Plans:

- Digital microwave backbone
- Planning for new application requirement (imaging and other wideband/broadband services)

Unresolved Need/Issues or "wish" list Services:

- Way to make use of non-DPS network options and not breach security concerns (NTI concern not expressed by DPS)

DEPARTMENT OF WATER RESOURCES:

Dominant Application/Support Requirements (Now/Future):

- Inter-active to Host applications (CICS)
- LAN to Host (Token ring/3745)
- Inter-agency reporting (HRMS, AFIPS)
- Traffic growth on the CICS network
- Large database applications coming (geographical system information - batch transfer to processing center at mall)
- Inter-agency batch requirements
- Growing need for "conversational" access and transfer (replace batch)
- Image applications would tax existing transport capability
- Need dial-up services (low-speed) to office automation system (PRIME)

External database info provider to other agencies and Federal database systems
USGS large bulk transfer requirements

Issues and Concerns:

Operational Constraints:

Low-speed services only services available to some locations

Plans:

Imaging application support (over CICS network?)

Unresolved Need/Issues or "wish" list Services:

Video conference to Tucson

DEPARTMENT OF TRANSPORTATION:

Dominant Application/Support Requirements (Now/Future):

New high-bandwidth applications envisioned (transponders, automated traffic sensing, etc.)
Tucson district office requirements growing
Tucson as local net gateway to ITN backbone and mainframe
Large file transfer applications
Inter-agency inter-working (growing list of inter-agency database applications)
External data base applications with 50 state government and federal government (history file access and batch update applications)
External database applications to Insurance companies)
Magnetic tape (mandate) access/transfer applications
Large and growing transactional application support on CICS network

Issues and Concerns:

Standards on external database access and transfer
Standards within inter-agency database applications
Budgeting/Planning for inter-agency applications
Support requirements of new planned image applications (transponders)
Agency ownership of shared data in inter-agency database applications
Management responsibility in inter-agency applications and distribution

Operational Constraints:

Budget
Manpower to own and operate a communication network
Technology capability exceeds network capability (remote access to/from transponder, license plate imaging to database applications)

Plans:

growth of CICS data traffic
New traditional applications
New high-bandwidth applications coming
Smart card driver's license
Imaging applications (transponders)

Unresolved Need/Issues or "wish" list Services:

Video (compressed video OK)
Standards between agencies and External database sources and applications

WASHINGTON SCHOOL DISTRICT:

Dominant Application/Support Requirements (Now/Future):

Need more telephone and fax
Need to support Inter-library loan
Inter-exchange of records (effect of migrant and seasonal nature of population)
Data (low-speed) to Host (WANG)
Need stand-alone micro-computers, apples/PC, commidore 64, Amiga, anything
Need site specific LAN to support PCs
Need inter-site LAN (low speed) between schools
Need comprehensive plan and funding
Need some inter-connect to state and federal agencies
Need upgraded voice services (auto-attendant, voice mail, telephones in classroom, call waiting, LAN for on-site data connectivity and external network access - switch/in house wire ok as LAN)
One way video/Two way audio (language instruction)
Basic Intra-district communications / Some inter-district
Inter-agency access: Education, Courts, DOA, etc.

Issues and Concerns:

Funding/Budget
95% of current budget goes to every day needs (eg. salaries)
Telephones to classroom
Data (low-speed) between schools/libraries
Low-speed data to community colleges and universities

Operational Constraints:

Does not want to own network
No Manpower or focus to be operator of communication/computer services

Plans:

1st step: computers in the classroom
2nd step: on-site connectivity (LAN - maybe switch as LAN and gateway)
3rd step: Inter-site networking (intra-school district)
4th step: Long distance network (inter-schooled district and beyond)

Unresolved Need/Issues or "wish" list Services:

Telephones to classroom
Data (low-speed) between schools/libraries
Low-speed data to community colleges and universities
data services to external database (library/educational services)
More enlightened use of available technologies to augment the education process (computers to automate repetitive drill learning; visual/graphic to

augment text; access to wider pool of teaching services via communications)

A single state-wide network operated by a single agency would be a "dream"

BOARD OF REGENTS:

Dominant Application/Support Requirements (Now/Future):

Need to support University network applications - NAU, ASU and UA
Need access to other state educational network
Need access to NSF network
Need video conferencing capability with universities in Arizona.

Issues and Concerns:

See major enrollment growth in the next two decades and the need for extensive inter-connection of education institutions for data, video and imaging needs.

Operational Constraints:

Plans:

AETC as focal point for statewide education telecommunications view open to creative solutions that will encourage the development of a network that will meet education needs.

Unresolved Need/Issues or "wish" list Services:

Sources of financing an education telecommunications network.

ARIZONA STATE UNIVERSITY - KAET (EDUCATIONAL TV CHANNEL 8)

Dominant Application/Support Requirements (Now/Future):

TV Educational programming broadcast via Satellite
College/University classes (broadcast)

Issues and Concerns:

TV Picture Quality
Need to broadcast shows where quality of picture same as entertainment TV quality (hold audience (eg. compressed video will not do)
Need to broadcast more courses, volume and variety (eg. more air time, more channels)

Operational Constraints:

Plans:

More broadcast time, more broadcast course

Unresolved Need/Issues or "wish" list Services:

Cable delivery of course work (broadband to student)

Possible two-way inter-active if broadband/cable

NORTHERN ARIZONA UNIVERSITY (NAU)

Dominant Application/Support Requirements (Now/Future):

EQUITY via Satellite and microwave distribution network
Full motion video broadcast to the rural part of state
Choice and quantity of education courses to address needs of rural communities (particular emphasis/charter)
Video/satellite courses (rural area of state)
Extensive satellite/microwave capability
Extension support for A & M programs to farming/ranching community
Carry (video/teaching) nursing master's program from ASU and UA
Foreign language initiative - Teaching/language

Issues and Concerns:

Funding/Budget - with more could do more

Operational Constraints:

Want more extensive reach, more network
Want to broadcast more course, more air time, reach more people
Analog microwave - would like to more to other technology

Plans:

Extending reach of system
More course more air time
more analogue microwave
Explore use of VBI (vertical blanking interval) of TV signal to carry bulk and inter-active data applications via TV broadcast
Data-share with other universities

Unresolved Need/Issues or "wish" list Services:

Needs satisfied via variety of technology
Eventually needs satisfied via "telephone-like" services (once broadband network in place)
Fiber-based broadband network Flagstaff, Phoenix, Tucson
Broadband WAN between NAU, UA, ASU (appear as single campus from data, image, video and voice point of view)

UNIVERSITY OF ARIZONA (TUCSON)

Dominant Application/Support Requirements (Now/Future):

Broadband application support for teaching
Broadband support for medical imaging to hospital and between med. schools
Broadband support for scientific application support inter-university applications
NSFnet application support within metro-area to bridge between networks and off-campus communities (ie.to external/off-net scientific/business community for research sharing and TV quality instruction. Network =

"roads and utilities to attract and keep high-tech, high-quality business in state.

Extend high-band broadband data services for medical/scientific community needs (eg. all observatories linked for data collection and simultaneous resource access - gigabits of data)

Teaching (full motion video, beginning to think about compressed video, but not there yet)

Medical imaging applications to support Medical school/nurse teaching across hospital (university hospital and private hospitals)

Large database transport (batch)

Video conference capability (needed)

Issues and Concerns:

Standards (video codex for conferencing)

Need technology/communications ties to business/scientific community

Operational Constraints:

Funding/Budget

Network operations/staffing not really part of charter

State-wide telecomm infra-structure not in place

Plans:

Unresolved Need/Issues or "wish" list Services:

Broadband WAN to support universities-wide campus (NAU, ASU, UA)

Broadband to remote research facilities

Broadband to other educational institution outside of Arizona

Scientific application network to research facilities throughout state (observatory example, university-wide parallel processing computer network, etc.)

Extend reach of campus-like communications network to business communities for teaching and research inter-working (keep high-tech business in state, keep high-quality employees "Roads and Utilities")

Single organization for statewide communications services (AETC-based)

DEPARTMENT OF ECONOMIC SECURITY

1. Agency Mission: Welfare

2. Focus (1-5 years):

3. Role of Communications:

4. Major Application (Communications-Based) Portfolio:

Current:

- Voice - via DOA (Phoenix Mall only)
- Child support system (LANs + gateways + 3270 emulation)

- AZTEC - Food stamp program
- Long term care
- Unemployment insurance
- Job services
- FMCS (Financial Management Control System) - accounting
- Developmental disabilities
- Child/audit protection services
- Training environment

Growth/New:

- Imaging: none, but would like to use it for UI documents
- Video: none, because not cost effective; but would like to have it in Flagstaff, Yuma, Tucson and ??

5. Inter-Agency Requirements:

- DOR (host-to-host)
- ADOT (host-to-host)
- DOA (host-to-host)
- City of Phoenix - SNI (Series/1)
- Federal/HUD - SNA
- Federal/IRS - dial ups

6. Operating Environment:

- Uses DPS (Dept of Public Safety) microwave services to Tucson, Navaho reservations, etc.
- 168 locations state-wide (line speeds < 9.6Kbps)
- Hitachi EX100 (88 MIP machine) - may be adding EX/80 with 50 MIPs
- 3745
- 3725 (2)
- DPS 6
- S/36
- AS/400
- Wang
- NBI (word processing)
- satellite link to Martin Marietta for Federal interstate unemployment insurance
- SNA/SDLC
- Netview 2.1
- 30 LANs: Novell Netware, Ethernet, Token Ring ARCNET
- gateway with 3270 emulation
- 1500 workstations
- Fiber Token Ring on the Mall
- IBM LAN Manager
- 350 controllers
- 4878 terminals (75% remote) - access to multiple hosts
- 890 printers

DEPARTMENT OF EDUCATION

1. Agency Mission:

- provide K-12 educational services equitably/fairly to the State. 80% of all students are within the metropolitan areas. Colleges/universities are not under the DoE.

2. Focus (1-5 years):

3. Role of Communications:

4. Major Application (Communications-Based) Portfolio:
Current:
. Video - studio for training and teleconferencing; uses satellite on Ku-upband
Growth/New:
. Voice processing - ACD and application for searching databases
. Imaging - used to store/retrieve teacher certification information (diploma, photo, finger prints, etc). Need to be accessible in both Phoenix and Tucson.
. Would also like to have ability to transfer/access student transcripts across schools
. ASAP (Arizona Student Assessment Program) - creates/administer standardized testing for students

5. Inter-Agency Requirements:
- need for interagency electronic mail
- connections to other state's agencies and to the federal government

6. Operating Environment:
- Installed base:
  . 1 DPS 6+ with 28-30 terminals connected, primarily use for batch processing
  . 125 connections on an Appletalk LAN
  . 7 Ethernet (either thin Ethernet or 10baseT) LANs running 3Com NOS; interconnected via TCP/IP
- Network management Philosophy: would like the DoA to manage the networks
- Access to New Technology: would like to connect to the fiber network in the Capitol Mall

DEPARTMENT OF HEALTH SERVICES

1. Agency Mission:
- services the public health needs of all Arizonans
- consoldiates several agencies into a single department with responsibilities including:
  . maternal and child health programs
  . communicable disease control
  . laboratory services
  . behavioral health services

2. Focus (1-5 years):
- a lot of programs listed in the three-year plan, but actual implementation will be done according to availability of funds

3. Role of Communications:
- significant

4. Major Application (Communications-Based) Portfolio:
Current:
. Voice - POTS, provided by DOA
. Various computer applications
. WIC (Women, Infants & Childred) program - prints food stamps remotely to 105 branches (fixed and mobile sites)
Growth/New:

. FHAMIS (Family Health Automated Management Information System) - being implemented in conjunction with Ernst & Young. It is an on-line system that links data from various DHS programs. A lot of the WIC functionalities will be migrated to this system once it is implemented,

5. Inter-Agency Requirements:
- AHCCS (Arizona Health Cost Containment System) using tapes
- DOA via link
- DES for census projections (birth/death)
- DOT via tapes for death information

6. Operating Environment:
- Installed base:
  . 1 IBM 4381
  . 2 DPS 6+ to be combined into a DPS 6000
  . 2 NBI word processing systems (to be converted)
  . · uses DOA's DPS 8, but is converting to own systems as funding permits. System connected to a DPS 6+ via 19.2 Kbps link
  . 56 Kbps link connect to state hospital to access PACE (Patient Accounting and Clinical Enquiry System) and TRACTS, a record tracking system.
  . dial up FAX machines
  . LANs & PCs in various agencies: 4-EMS (Emergency Medical Service), 1-FHS (Family Health Services), 1-State Lab. LANs are either Ethernet or Arcnet, and interconnected via bridges and comm servers (3Com)
  . no imaging - considered too expensive
- Considers service provided by DOA to Department poor

DEPARTMENT OF LAND

1. Agency Mission:
- manage the state's land (9.5M acres) and maximize the revenues (lease, sale, minerals) from those land
- manage and protect other resources such as water rights, hydrology, state and private forests, etc.
- manage state prisons and cemeteries
- responsible for the fire fighting function

2. Focus (1-5 years):
- no real/major changes except for the GIS (geographic information system), which is a database that contains various layers of geographic info. Datafor certain layers of the GIS will be provided by different agencies, and the GIS is to be available to all agencies as appropriate.

3. Role of Communications:
- since the GIS will be made available to other agencies, there needs to be a means to allow other agencies' PCs, workstations and other communicating devices to access the host where the GIS resides.

4. Major Application (Communications-Based) Portfolio:
Current:
. Voice - currently has POTS; just converted to touch-tone system recently. Do not see a need for any major features in the near future.

- GIS - at initial stages, but data for certain layers available
- Land title database

Growth/New:

- GIS - it will continue to grow as data on more layers are added to the system. The Arizona Geographical Council (chaired by Ben Froehlich) is the planning committee for the system. Data for some layers will be provided and maintained by other agencies (have not decided how to implement it yet). Also, as the system grows, so will the number of access to the system.
- Video - no real needs except for getting video images of land

5. Inter-Agency Requirements:

- will require more networking with other state agencies as the GIS grows in function and capability.

6. Operating Environment:

Installed base:

One Ethernet LAN connecting the following:

Prime 6350 running ASLD (admin system) and ALRIS (=GIS), it is also connected to other devices through local lines and multiplexor.

1 Compaq 386 (for ALRIS)

1 Sun Sparcstation running UNIX (for ALRIS)

1 136-user NTS terminal service (for ASLD)

One four-port multiplexer (4x9600) connecting Prime to Tucson office, Game & Fish, and Forestry

Overall, about 220 devices (including ASCII devices, 36 PCs) attached to Prime with 170 users.

Comm Staff: Voice network currently maintained by DOA as voice service is provided by them; but has not been happy with problems; feel DOA could be more responsive. LAN managed by own personnel (1 person).

Network Management Philosophy: does not mind network(s) managed by others (DOA)

Major New Services Deployment: GIS

Access to New Technology: would like to expand LAN and also connect to Fiber network in the Capitol Mall using TCP/IP

DEPARTMENT OF REVENUE

1. Agency Mission:

- Enforce tax law of Arizona fairly and equitably
- Provide input to Legislature for tax law

2. Focus (1-5 years):

3. Role of Communications:

4. Major Application (Communications-Based) Portfolio:

Current:

- personal income tax
- corporate income tax
- witholding tax system
- tax collection
- accounts receivables

- sales tax
- property tax

Growth/New:

Interested in the following:

- Tax: electronic filing
- Imaging: tax return scanning
- Video: training and conferencing
- E-mail: state-wide

5. Inter-Agency Requirements:
   - DES: child support skip tracing
   - DOA: HRMS and corporation commission
   - DOT: controller, skip tracing
   - Land: property tax info inquiry

6. Operating Environment:
   - FAX - individual machines, not networked
   - Imaging - none
   - Training - done via tapes
   - E-mail - via PC networks
   - Hitachi 40 MIP mainframe
   - 3705
   - 3274 cluster controllers
   - Proteon Token Ring LANs with Banyan, 9 servers (all in Phoenix or Tempe, leased line connected with Banyan comm server)
   - Unisys system running BTOS, standalone
   - System/37
   - 1000 3270 emulation terminals (250 in field)
   - 400 PCs, 260 of them LAN attached
   - 200+ laptops
   - SNA
   - Token Ring attachment to FEP
   - 3B/20
   - two dial up lines for program maintenance
   - fiber backbone within building
   - Netview
   - RACF - security

- Would consider DoA managing their backbone
- Budget: no change
- Plan: open new offices (not budgeted), expand LANs, consolidate Tucson, no new apps

DEPARTMENT OF TRANSPORTATION

1. Agency Mission: organized into 5 division:
   (1) Highways - plan, design, maintain and construction project management of state highway system. Also has test lab that sends results back via dial up and leased lines. Has four district offices (P, T, F, Prescott) each with LAN (about 20 PCs). LANsare host based, but sometimes tied together using comm server.
   (2) Motor Vehicle - 3 areas: licensing, title registration and import tax (17 ports of entry)
   (3) Administrative Services - telecommunications, others
   (4) Transportation Planning

(5) Aeronautics - same functions as Motor Vehicles, also run Grand Canyon Airport

- HR is a separate function reporting directly to DoA.

2. Focus (1-5 years):

3. Role of Communications:

4. Major Application (Communications-Based) Portfolio:
Current:
. finance
. licence plate checking (via transponders)
. truck weighing
. GIS
. geodesic position system
Growth/New:
. By 1992, connect all 50 states for commercial licence issuance
. smart card for driver's licence, can carry different info

5. Inter-Agency Requirements:
. DoA - HRMS
. DPS
. Dept of Justice (later)
. Land - GIS
. DoR
. DES

6. Operating Environment:
. SNA/IMS
. Bisync
. Approx. 66 million transactions/year (5 M/month)
. IBM 4300
. Amdahl 5990
. 3745
. Netview
. controllers
. Wang WP
. DEC

- will have justification and RFP to tie to other agencies.
- believes that level of automation will increase

Summary of telecommunications-based distance learning methods

The table on this and the next page gives very general information about several of the most common distance learning methods. The information in the table is not meant to be exhaustive, but gives approximate characteristics and costs as guidelines *only*.

	Voice teleconferencing	Audio-graphics teleconferencing	One-way satellite/cable networks (public)
Method	Two or more sites connected into a teleconference. Everyone hears everyone else. Paperwork mailed or faxed.	Two or more sites connected into a teleconference. Everyone hears everyone else. Graphic information transmitted to each site's PC via telephone lines. Annotations to graphics transmitted with graphics.	High quality video of instructor and class aids transmitted to subscribers. Great variety of courses and enrichment programs available. Easy for schools to use.
Equip.	Telephones, conference bridge.	Telephones, PCs, scanners, printers, video cameras, data lines.	TV monitors, satellite/microwave/ cable hookup, telephones.
Costs	Bridge. Purchase at $1000-$2000/port or rent on a per port per minute basis when needed. Plus line charges.	PC and peripherals (< $5000) plus s/w from $3500-$5000. Line charges from $15-$30/line/hour.	$1,000-10,000 for satellite downlinks. Subscription fees from $2,000-10,000; may include peripherals and maintenance. Special programs may cost extra. Cable installation from $18,000-$25,000/mile; <$10,000 for receiving site equipment. Cable maintenance <2-5% of system cost.
Advantages	Real-time voice communications. Equipment and operations are relatively inexpensive, easy to use.	Real-time voice/data communications. Most sites already have PCs, scanners, printers and video cameras, so s/w may be only extra cost. Graphic images sent easily and quickly.	High quality video of instructor and class aids. Great variety of courses and enrichment programs. Easy for schools to use. Satellites not restricted by geography.
Disadvantages	No video. Mailing or faxing all visual aids inconvenient.	No live video of instructor. Not all phone systems support this equipment.	May be unable to interact with instructor during class; if students can interact, it's by phone, usually WATS lines. Subject to curricula and schedules of course providers. 2-way video is not an option; teachers cannot see students; students cannot see other students. Large number of students per class. No local control.

	Microwave networks (private)	Compensated-motion (compressed) video	Full-motion video using digital fiber
Method	Privately owned microwave networks. Courses and programs developed for specific students.	Two or more sites connected into a video-teleconference. The teacher can see and hear students; students can see and hear the teacher and other students. Second camera transmits image of visual aid.	Two or more sites connected into a two-way, full-motion, video conference. The teacher can see and hear students; students can see and hear the teacher and other students. Second camera transmits image of visual aid.
Equip.	Microwave transmit/receive system, monitors, phones.	Video codecs for transmission/ reception, monitors for classrooms, high speed telephone lines.	Video codecs for transmission/ reception, monitors for classrooms, fiber plant.
Costs	Transmit site cost of $60,000 plus tower (up to $50,000); receive sites <$10,000 plus tower ($3000-$50,000). Lease/purchase agreements may be an option. Insurance, maintenance, repairs between 3-5% of system cost/year. Costs can be reduced by limiting number of transmit sites.	$60,000/site plus line costs. Lease/purchase agreements may be an option. Costs are expected to drop rapidly as technology improves. Line costs start at about $30/line/hour; usually 2 lines required.	$10,000-$50,000 for classroom coders/decoders, plus monitor and microphone costs. Lease/purchase agreements may be an option. Costs are expected to drop in the future. Fiber installation plus usage. Line costs about $30-70/mile/month.
Advantages	High quality video of instructor and class aids. Curricula controlled locally. Generally low teacher/ student ratio.	Real-time voice and graphic communications. Teachers and students see and hear each other. High quality voice communi-cations. Quite easy to use. Local control.	High quality video of instructor and class aids. Teacher and students see and hear each other; students hear and see other students. Easy interaction. Can transmit voice/data/graphics. Local control.
Disadvantages	Geographic limitations. May need extra personnel to manage system. Expansion is expensive.	Video is not full motion; may not be appropriate for courses requiring action or high levels of observation.	Cost for network facilities may be prohibitive. Fiber may not be available; if available, may be expensive. Depending on configuration, expansion may be quite expensive.

APPENDIX 4

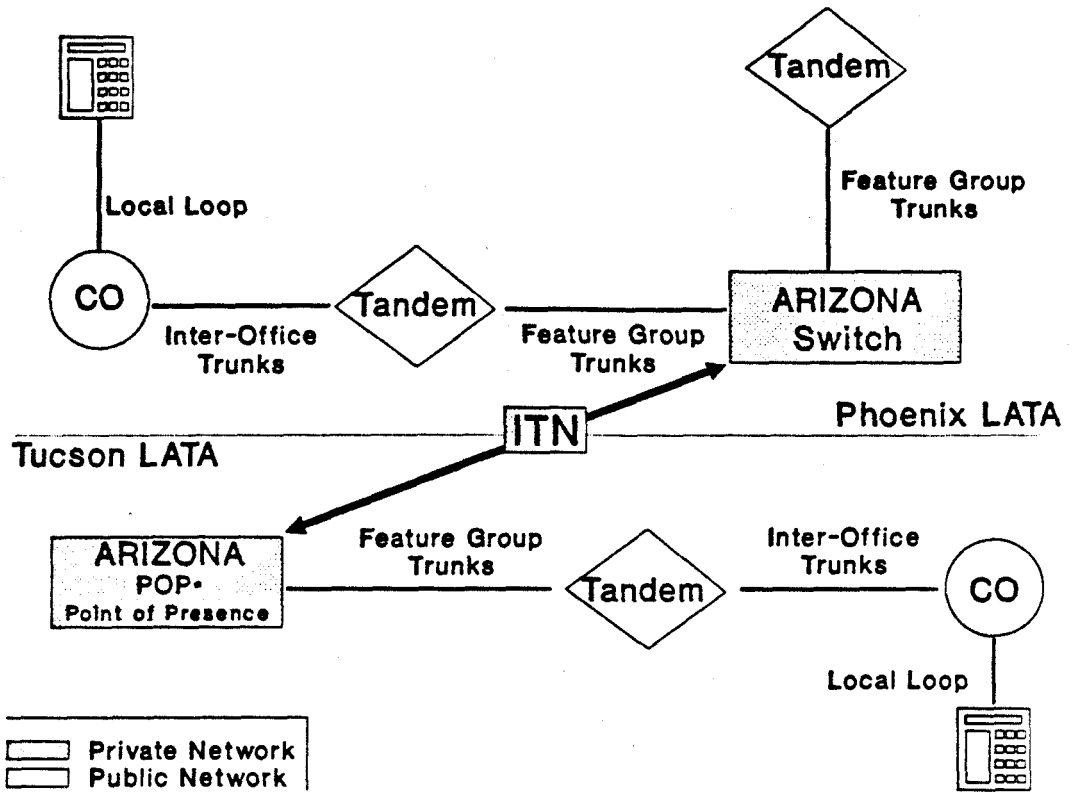
FEATURE GROUP SERVICE ATTRIBUTES & COSTS

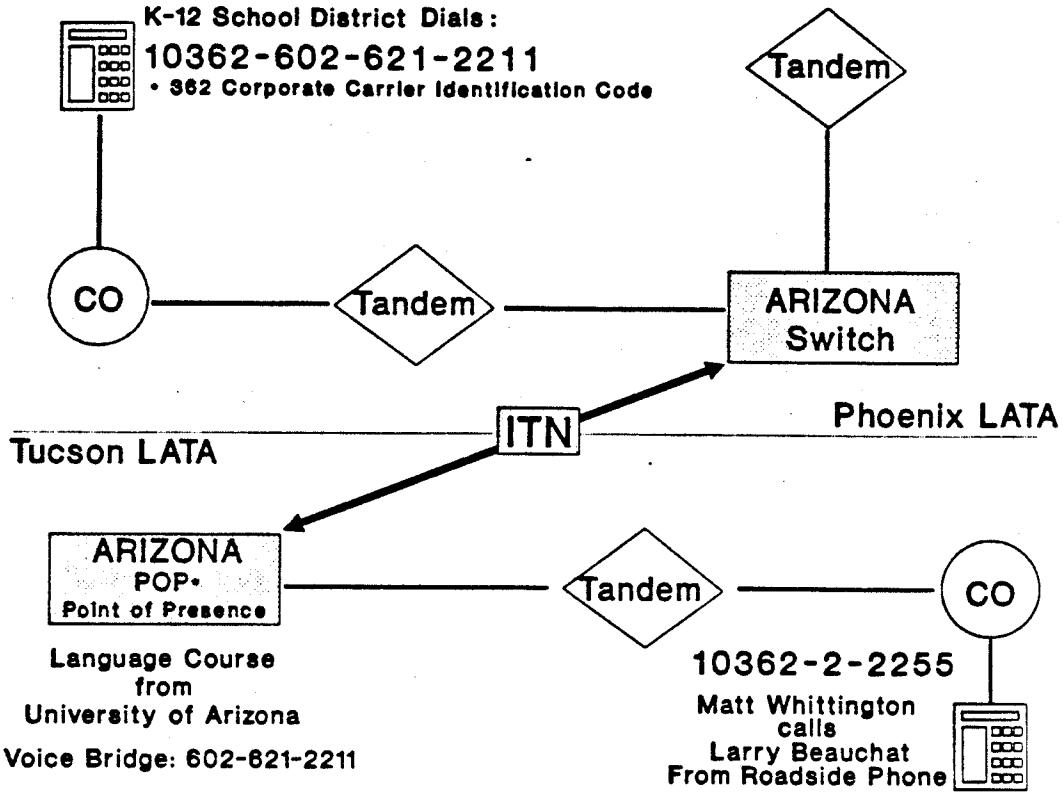
Appendix 4 provide an implementation example of "corporate carrier" services, which can be a "least-cost" way to support a number of on-net/off-net access requirements and enables hybrid network inter-working between the utility-network and the LEC-network.

Becoming a "corporate carrier" requires that the state CPE-based switch be able to implement public-network signaling protocol on a specific trunk group connecting their SL100 to the public network. These trunks are called "feature group" trunks. With "corporate carrier" status the state could carry "dialed" traffic between the public network and utility network at the minimum usage-sensitive tariff. These are called "feature group" tariffs; and rather minimum cost way to implement access to the utility network from the public network.

[The SL100 can implement peer-peer signaling protocol to both class 4 and class 5 offices; that is, it can look to the public network as either a LEC Central Office (CO) or Access Tandem (AT) or as an IEC Point of Presence (IEC-POP)].

A number of services requiring access to utility network services over the public network could be supported via "corporate carrier services"; and by doing so these sites become, in the functional sense, "on-network" locations. For example, something as simple as less expensive voice services to support the two-way audio portion of a "distance learning" teaching applications will extend the number of hours that the school district could provide those service to the remote classroom. And dial-able "narrowband" (DS0), or low-speed data service, between community school district offices and the universities, or to other school districts, over public network facilities, could be offered within the concept of a "corporate carrier" service implementation. Access would be charged under the feature group rate structure, with access denial when service usage exceeds a specified spending cap. The figures in Appendix 4 depict some of concepts of a "corporate carrier" implementation, and provides a summary of the current rate structure.


Tandem
Local Loop
Feature Group
Trunks
CO
Tandem
ARIZONA
Switch
Inter-Office
Trunks
Feature Group
Trunks
ITN
Phoenix LATA
Tucson LATA
ARIZONA
POP•
Point of Presence
Feature Group
Trunks
Tandem
Inter-Office
Trunks
CO
Local Loop
Private Network
Public Network


K-12 School District Dials:
10362-602-621-2211
• 362 Corporate Carrier Identification Code
Tandem
CO
Tandem
ARIZONA Switch
ITN
Phoenix LATA
Tucson LATA
ARIZONA POP• Point of Presence
Tandem
CO
Language Course from University of Arizona
Voice Bridge: 602-621-2211
10362-2-2255
Matt Whittington calls Larry Beauchat From Roadside Phone

FG #D

Usage Sensitive Rates

- Local Transport (Rounded Up):

$ .015 /minute	0 - 25 miles
$ .023 /minute	25 - 50 miles
$ .033 /minute	50 - 100 miles
$ .050 /minute	100+ miles

- Local Switching:
  $ .0098 /minute

- Common Line:
  $ .00885 /minute

- Misc. Charges

$ .0011 /call	800 Service Access charge
$ .0080 /call	Network Blocking Charge

• Arizona Intra-State Tariff

APPENDIX 5

TECHNOLOGY IMPLEMENTATION RECOMMENDATIONS

This section presents some thoughts and observation and a conceptual level view of technologies that support the utility network function; it also discusses several implementation issue the state should be sensitive to. Quantitative information, addressing the specific nature and cost of any implementation choice can be provided at a future time when decision on the utility network have been made. The intent of this section is to raise some issues and define some of the technology choices that serve to implement the recommendation given in the previous chapter of this report.

We avoid addressing the voice network choices to make more clear the area of most immediate concern to the state: supporting the data requirement.

The key to an implementation plan is that it put the state in a position to take advantage of evolving service and technology options; and not lock the state into technologies or long term service arrangements that limit choice or functionality.

To a certain extent this can be mitigated by the natural evolution, and market tracking, that successful service and technology providers all exhibit. Product technologies evolve to support the services required. We believe that in the future, voice, video, data and other types of traffic will be supported by one switching technology. Traditional CPE-vendors will evolve their products to encompass newer switching technologies, standards and protocol like cell switching, ATM (asynchronous transfer mode) and SONET (Synchronous Optical Network). Traditional CO-vendors will migrating their products to support LANs, and protocols like FDDI. Both vendors will attempt to address their market, which they now see as the same market, and support voice, video and other high speed protocols. These technologies are evolving towards each other and it is likely that in the near future the distinction between say a multiplexer and a packet switch will be quite blurred.

Another service trend is that telephone companies are moving aggressively into the data area. Evidence of that trend are the pending service offerings for Frame Relay packet service to support narrowband (T1) now and wideband (T3) in the future; and Switched Megabit Data Service (SMDS) which is a wideband offering. Therefore, high-speed, and wideband public network-based data services will become part of, and an alternative to, CPE-based private network data services.

CRITERIA FOR UTILITY NETWORK IMPLEMENTATION

Based on our understanding of the current and future data communications requirements we have developed criteria for evaluating the technologies that support the utility network concept. Those criteria are:

> It must meet, or be able to evolve to meet, all or most of the data communications requirements of the State agencies and institutions. One of the expressed requirements is to be able to interconnect and have access to host computers across agencies.

The implementation should take advantage of existing equipment and/or network(s) already in place today to minimize costs. For example, the fiber ring on the capitol mall and the ITN.

The implementation should be based on international and/or industry de facto standards as much as feasible. This will facilitate the connection of the utility network with other networks (public and private) to provide access to endpoints outside of it. Also, it will allow different vendors' equipment to work together in the same network when needed.

It must be flexible: in other words, the network can be expanded easily in the future and be able to support new applications when required. Also, the implementation can be done in phases without interrupting service to the end users.

The strategy should be of low risk: it should use proven technology and more importantly, the network can evolve to encompass new technology without obsoleting most of existing equipment

The network must have high reliability and availability

The network should be managed centrally so that network management expertise can be centralized and not dispersed, thereby reducing the cost of managing the network

The network should be secure

EVALUATION OF ALTERNATIVE TECHNOLOGIES

We evaluated several technologies to find a "best fit" for the needs of the State. Our conclusion is that the utility network should encompass, and inter-work with a mix of different technologies. In this section we describe and evaluate several of the alternative technologies that were candidates to serve the utility networks data needs.

Routers

In the past few years, LANs have been proliferating in the private data communications environment. It is estimated that within a few years, 70% of all PCs will be connected via LANs. Routers were invented to interconnect PC LANs and thereby the concept of LAN internetworking - LIN. Some people build LAN/WAN/LAN networks using routers only, while others use a combination of routers and multiplexers. Some also look at it as one of the components in a hybrid network. How they are used and viewed depend on the size and type of the network.

At this stage of the technology, routers are boxes that facilitate the interconnection of LANs. Therefore, it is efficient and works quite well for relatively small, homogeneous (consisting only of PC LANs) LINs. It is also relatively inexpensive. However, as the primary component of a data network, it has the following shortfalls:

It cannot support large networks because it has limited networking and routing capabilities

supports only a limited number of types of devices (that is, protocols).

implementations are mostly proprietary; also, support of standards is minimal.

limited security

limited capabilities in network management and control

In the future, we believe that router vendors will evolve their products to overcome the above shortfalls. Not only that, they will probably expand the scope of routers to become intelligent network nodal processors. But for the next two to three years, the above shortcomings will prevent routers from being the main component of a heterogeneous WAN even though they serve as a very useful building block in such a network.

Frame Relay

Frame relay is a connection-oriented protocol designed to support the transmission of LAN and other data traffic at speeds up to T1 (1.5Mbps) now, and with an evolution path to support to T3 (45Mbps) within the next three years. It is a technology that can be deployed on existing public-network facilities, in that it can be implemented on a "wire-based" distribution scheme. A consortium of vendors, currently about 40 companies, have announce product directions that embrace frame relay standards and implementations. Most major T1/T3 multiplexer vendors are part of this consortium. Frame relay has evolved from traditional X.25 packet protocol but it is more efficient than X.25. It is currently marketed as a replacement for dedicated private line (its called virtual private line) and is used primarily as the public-network based protocol for interconnecting LANs or other high-speed data applications - supporting services over leased, or usage-sensitive T1 arrangements.

Frame relay encompasses the first two layers of the ISO OSI model, and as such, it is an interface protocol to be used for DTE-DCE interfacing. Functionalities on top of frame relay must be incorporated before it can be used for networking. Such is done by router and multiplexer vendors in a limited fashion. Because of the limitation of routers, frame relay plays an important role in a network. Note that unlike SMDS (see below), upgrading to frame relay is usually done via software, therefore the evolution (of a network) to frame relay is relatively simple.

For interconnecting LANs that do not have the need to communicate with entities outside of the LANs, a router/frame relay combination can be used to interconnect them via either a public frame relay service or over frame relay interfaces on the utility network. The choice of public versus private implementation will depend on traffic characteristics, tariff, and network management philosophy.

Switched Multimegabit Data Services (SMDS)

SMDS is a connectionless, cell-based protocol defined for speeds of T1 and above. As a service, it is being positioned as a regional or metropolitan-area offering and as such , it has limited reach geographically. Unlike frame relay (which can be implemented via a simple upgrade to existing equipment), implementing SMDS requires adding both new software and hardware. Also, very few vendors, compared to frame relay, have announced the support of this protocol to date. It may play a role when users migrate to broadband ISDN to support voice, video and other data traffic within a single switching fabric. However, we do not see that happening within the next few years.

Therefore, we believe that implementing SMDS in the near future will not only be an overkill, but also expensive and risky.

Fast Packet Multiplexers

Fast packet is a concept rather than a particular technology. Based on that concept are two technologies: frame relay (DS0 to DS3 access) and cell switching (DS3 and above). Under frame relay are services and products employing the frame relay protocol. Under cell switching one finds end user capabilities such as broadband ISDN (ATM) and MAN (802.6, SMDS).

There are fast packet implementation that are proprietary and in those cases, the term "fast packet" is being used loosely and does not have any significant meaning. Because it creates market hype, more and more traditional T1/T3 multiplexer vendors are claiming that their products uses "fast packet". Fast packet or not, the multiplexers today and in the near future are bandwidth managers. Some may incorporate routing and/or LAN support in their boxes to expand their scope, but in the near future, multiplexers will remain the product that aims to manage backbone bandwidth while allowing other functionality to be built on top of it.

OPERATIONAL CONCERNS

This section describes some of the operational concerns that must be address in this implementation plan. Some of them are technical in nature, while others political. The issues are as follows:

(1) Buy-in of Implementation Plan by All - since this will be a state-wide inter-agency network, an agreement among all parties involved will be needed before proceeding with the project. Sometimes getting the agreement can be difficult because different organizations may have different networking goals and objectives. Nevertheless, this is a very essential step.

(2) Clear Goals & Objectives for the Network - goals and objectives for the overall utility network must be set and prioritized before proceeding with the design and implementation of the network. This is because different objectives result in different design and implementation, and as a result, different costs.

A case in point is redundancy versus cost: when designing a network, there is always the trade off between providing redundancy and minimizing costs. Sometimes increasing reliability and redundancy will result in an increase in costs. For example, there are currently four T1 trunks between Phoenix and Tucson. A failure of one of them will mostly likely not interrupt service. As traffic grow in the future, it will be more economical to replace the T1 links with one fractional or even full T3 link. For redundancy/reliability reasons, there should be a routing scheme that supports distributing portions of that traffic along different paths; a way of routing several "trunk groups" of T1 equivalents along a different route. Such a configuration, and service options will depend on the choice or carrier, and their flexibility in pricing and servicing their clients needs; alternative service options will not necessarily result in higher costs.

(3) Integrated Network Management - with a hybrid network like the utility network, it will be essential to be able to manage/administer the whole network from one platform rather than using multiple platforms (separate ones for each vendor's equipment in the network). Therefore, when evaluating a WAN equipment vendor, determine the level of flexibility and interoperability of its network management system. For example, does it support OSI network management capabilities (CMIP/CMIS), does it interoperate with SNMP (Simple Network Management Protocol) and NetView, and does it have any simple means to allow proprietary network management subsystems of other networking devices (e.g., routers, multiplexers, gateways) to interoperate with it. We believe that for complex and mission critical networks such as the utility network, it is very important to be able to manage a network pro-actively rather than reactively. And having an integrated network management system is certainly a step in the right direction.

(4) Responsibility for Managing the Network - it is also critical to determine at the outset which organization(s) will manage the network. Not only does it play a role in determine the network configuration, it also defines the infrastructure necessary to manage the network. One approach is to manage the network centrally and entirely by the Department of Administration. This approach is more efficient if the network is not very big: one can centralize/consolidate technical expertise in one location to manage the network, dispatching people to local sites only when necessary. However, this means that all agencies will give up at least partial control of their own network and rely on the DoA to manage it instead.

Another approach is to have the DoA act as the overall network manager, but at the same time, divide the network into virtual private networks (VPN) according to ownership, with each VPN managed by the respective owning agency or department. This approach works well if the network is relatively large because some regionalization of network management expertise would be required anyway regardless of whether VPNs exist or not. An advantage of this approach is that each agency retains control, to a large extent, of its network.

For a network the size of the utility network, we recommend that the centralized approach be used initially because it is more efficient (requires fewer people) and therefore cheaper to do. At a later date as the network grows bigger, the VPN approach can be considered.

(5) Product Evolution - as mentioned above, technology is changing at a very rapid pace. And to some extent, it is driven by new applications. Equipment that satisfies today's needs may be inadequate to meet the requirements a few years in the future. Therefore, one of the criteria used to select equipment/vendor is that the vendor should have an evolution plan for the product to encompass the required switching technologies for the future, and that evolution must not obsolete products bought today.

IMPLEMENTATION RECOMMENDATION SPECIFICS

More than one technology will be required to support the utility network but both traditional packet switching and Frame Relay packet switching offer several advantages that address the expressed operational criteria for the network; both of these technologies:

consolidates bandwidth usage, resulting in savings in facilities costs

allows users to access multiple endpoints via virtual circuits (and thus eliminate most needs for multiple point-to-point physical lines), further saving facilities costs and enhancing flexibility in user connectivity (e.g., allowing users to have inter-agency access)

are standards-based and support access to networks implementing other standards; and as such it facilities internetworking and fosters hybrid solutions (public-to-private, private-private)

support most equipment already in place

are flexible and easily expandable; can also support network applications such as X.400 (Message Handling System) and X.500 (Directory Services) with lower costs

are low risk because it is proven technology; also, the trunking protocol between nodes are usually very efficient (of course, that is vendor dependent)

have high reliability and availability (depending on vendor)

have excellent centralized network management capabilities

In addition to the Frame relay/packet switched WAN, other types of networking device will be needed because of the diverse types of data communications devices that need to be supported in this network. Such devices include multiplexers, routers, LAN gateways and PADs (packet assembler disassemblers). Taken all together, they provide LAN/WAN, LIN, WAN/WAN and the equivalent of MAN switching (at lower speeds) in the utility network.

Basic WAN Configuration

The basic WAN configuration might consist of interconnected Frame Relay/packet switches at major regional expertise hubs such as Phoenix and Tucson, and possibly other locations. The packet technology are placed in those locations for two reasons: (1) they are the centers with the most number of connecting devices and therefore, where most traffic are generated and terminated, and, (2) probably it will result in the minimum of facilities costs. However, it is possible that additional packet transport devices may be needed in other locations to meet cost, performance and redundancy requirements.

Inter-switch trunking for those regional expertise hubs will be taken from bandwidth in the existing ITN. This can be done via assigning the required bandwidth through the T1 multiplexers existing in those locations. Depending on the resultant traffic, additional T1 circuits may be needed between those locations.

Remote locations, such as county seats, can be connected to the appropriate regional expertise hubs (via DS0/T1 lines) using appropriate PADs or other devices, depending on the protocols that need to be supported in those locations.

Even though the WAN does not support MAN standards such as SMDS directly, together with other networking devices described below, it provides the equivalent of MAN capabilities albeit at lower speeds on the utility network.

Fiber Ring on Capitol Mall

The fiber ring on the capitol mall is another part of the hybrid utility network. It should be used as the vehicle to attach those LANs, terminals (via terminal servers), and other communication devices that are within reach of the ring. When configured properly, this will allow the devices to communicate with each other, thereby allowing inter-agency communication to occur over the ring. The fiber ring should be connected to the WAN by LAN gateways using the X.25 protocol. This will provide connectivity between the fiber ring and the rest of the utility network. When set up properly, devices attached directly or indirectly to the fiber ring will be able to access other endpoints on the network outside of the ring.

Other LANs

Some packet switches support native LAN architectures directly. For those products, LANs can be attached directly to them. If the packet switch selected does not support LANs directly, there are other means to connect them to the utility network as described below.

For LANs that have only LIN (LAN interconnecting network) requirements, i.e., they only need to interconnect with just LANs, there are a few ways to satisfy that requirement. The first way is to use a public frame relay service to interconnect them. The cost effectiveness of this approach depends on the amount of traffic and the tariff of the service.

The second approach is to interconnect them using routers terminating on the packet switches using the frame relay protocol. Various packet switch vendors have announced the support of frame relay on their products.

The third approach is to use LAN gateways with X.25 as the interface protocol to connect to the WAN. This not only allows the LANs to communicate with each other, they can also do so with endpoints outside of the LANs. Therefore this is the recommended approach. Note that this should also be the approach to interconnect LANs that have requirements to communicate outside of the LANs.

Dial-Up Access

Dial-up ports can be provided on the PADs and at the regional expertise hubs to allow non-dedicated access to the utility network. Users such as the K12 schools, outside business, agencies from other state governments can gain access to the utility network via these dial-up ports. Different levels of access can be assigned to different users to allow them access to different applications on the network.

Connection with other Networks

If needed, the utility network can be connected to a public packet network via X.25. It can also be connected to other private networks via the same protocol. With such internetworking capabilities, access into and out of the utility network can be provided thereby extending the reach of the network tremendously.

NEW NETWORK APPLICATIONS

With a utility network in place, new applications can be implemented on the network and made readily available to users. Through our interviews, we found that there is a desire and also the need to have some form of electronic mail system across agencies. If used properly, an e-mail system should reduce the amount of paper used while allowing the business to run more efficiently. Currently, e-mail systems are used by some agencies (usually on LANs); however, they are all standalone systems.

E-MAIL

We recommend that the State implement a standards-based e-mail system on the utility network; such a system will conform to the CCITT X.400 standard for e-mail. By conforming to standards, one can exchange e-mail with other networks (e.g., corporations, Federal Government) thereby providing new ways to communicate with others. Another advantage of using X.400 is that it provides the basis to support other network applications such as X.500 (directory services) and EDI (Electronic Data Interchange). EDI allows the interchange of not just messages, but also documents and files.

When acquiring an e-mail system, one should find out how many different types of mail gateways the system supports. The function of the gateway is to provide conversion and routing of e-mail between X.400 and "foreign" e-mail systems (e.g. PROFS on IBM mainframes) within the same network. The more types of gateways supported, the more flexible the system: this means that more people can retain their existing e-mail systems and yet able to communicate with the people outside of their systems.

Another desirable characteristic to look for when acquiring an e-mail system is reliability, which is quite important if it is to be the primary vehicle through which people exchange messages. Some vendors have implemented their e-mail systems on fault tolerant computers, and that is certainly something worth considering.

VIDEO CONFERENCING

There is a certain amount of State business-related travel between Phoenix and Tucson, and most of the people interviewed felt that some of the travel can be replaced by video conferencing. However, they were concerned that the quality of the video may be low and that the cost too high. In realty, video conferencing technology (compression techniques and coding/decoding) has advanced significantly in the last couple of years while cost has gone down drastically. Today's video conferencing equipment can use a fraction of a T1 circuit (Nx64K, but typically 2x64K) to provide decent picture quality, and images of presentation overhead can be transmitted statically and shown on a separate monitor. The combination of relatively low equipment prices (as low as $30,000 per unit) and transmission costs leads to a fairly quick return on investment for video conferencing systems. Some users are reporting payback periods of two years or less.

We recommend that video conferencing capability be implemented in both Phoenix and Tucson initially. The bandwidth for such can be taken from the existing ITN T1 circuits between those two locations via the T1 multiplexers, and it need only be allocated upon demand.

Again, standards play an important role in the purchasing of video conferencing equipment. Currently vendors implement their own coding/decoding and compression algorithms in their products because no standards existed and video conferencing technology was advancing at a very rapid pace. As a result, equipment from different vendors do not work together. Recently, there have been a lot of standards activities in this area, and as a result, a usable standard for video conferencing (CCITT H.261, otherwise known as Px64) may be forth coming. The standard at this point only addresses the video portion, but not the voice nor multipoint conferencing nor encryption. Work in being done to resolve those issues. Therefore, when purchasing video conferencing equipment, ask the vendors what their plans are for incorporating standards in their products and how current equipment can be upgraded to support those standards as they become available.