Glossary

Access - For the purposes of this document, the ability to purchase services that provide end-user telecommunication capability such as Internet access, video conferencing, and statewide business networking. (See **Equity.**)

ACLIN -Access Colorado Library and Information Network - A statewide network for access to library catalogs and a variety of other information resources, ACLIN is an Internet-based service which provides no-cost dial-up access and graphical Internet access statewide. ACLIN is operated under the auspices of the State Library that is a part of the Colorado Department of Education.

Advanced Services - For the purposes of this document, the most current technology available in urban areas. Examples include Asynchronous Transfer Mode, Integrated Services Digital Network, Frame Relay and Digital Subscriber Loop services.

Analog - A signal that varies in a continuous manner (as contrasted with a digital signal); typically describes dialup or leased lines using modems as end devices.

ANAP -Aggregated Network Access Point – A region where the analysis of services, both existing and proposed is centered. This analysis is focused on aggregation of circuits into a shared, multiple-use backbone providing greater bandwidth and capability than individual circuits are able to provide. For planning purposes, an ANAP is used to measure carrier service levels and the availability of telecommunication circuits in a surrounding geographic area. Also included are their anticipated short-term growth needs and the potential participation of other public sector and non-profit entities.

Anchor Tenant - A major client or business that can provide leadership and motivate additional participation for local investment in infrastructure and service development.

ATM – Asynchronous Transfer Mode - A cell switching transmission protocol based on 53 byte fixed-length cells. ATM, because of a process known as adaptation, is capable of transmitting multimedia services (voice, video, and data) on one network.

Backbone - The high-speed lines and equipment that form the primary pathways within a network. Backbone networks provide interconnection between other networks. In the context of this plan, the backbone connects the ANAP locations.

Bandwidth - A measure of capacity for a specific circuit, usually expressed as bits per second.

Backhaul – The practice of bringing demand to a service rather than bringing service to the location where it is required. A term used to describe the charges resulting from a circuit required to connect a location without requested service to a site where the service is offered. Backhauling adds considerable expense to network connections because it commonly uses circuits with that are priced by distance.

Capability/Capacity - Terms for the purposes of this document that describe the functional specification for a network location or ANAP. This functional specification is based on service used and bandwidth capacity.

Carrier - A Telecommunications provider registered with the Public Utility Commission that offers telecommunications transmission services.

CATI - Colorado Advanced Technology Institute

CCHE - Colorado Commission on Higher Education

CDE - Colorado Department of Education

CIVICS - Cooperative Interactive Video in Colorado State government - The CIVICs network provides video conferencing, distance education, and telemedicine capabilities to 48 sites located around the state. CIVICS provides two-way interactive video conferencing.

Circuit - A switched or dedicated communications path (or line) with a specified bandwidth (transmission speed/capacity).

Community Incentive Funding - A new term. Proposed funding to aggregate local traffic and develop telecommunications technology of various kinds (K-12, Library, Health, etc.) in Colorado communities.

CPE - Customer Premises Equipment – A telecommunications carrier term describing any equipment that is owned and operated by the customer. Typically, some type of network equipment is required to distribute the network to offices, buildings or other sites on a customer site.

DDN -Digital Data Network - A network created in 1989 to provide fractional T-1 services for government sites. The DDN consists primarily of DS-1 leased lines with some reliance on the digital microwave for alternate paths or redundancy. The DDN has approximately 65 nodes (served locations) and almost 430 circuits. DDN carries primarily data and video traffic for the ***SNA Network*** and the ***CIVICS Network***

Digital - A discrete or discontinuous signal which transmits audio, data, and video as bits (binary digits, zero or 1) of information. Digital technology typically describes technology that is more current and because of its capabilities offers higher speed devices or services.

DS-3 - A designation of circuit capacity. A DS-3 circuit has a bit rate capability of approximately 45 million bits/second, which is equivalent to 28 DS-1 circuits at 1.5 million bits/second

Equity - For the purposes of this document, the ability to purchase advanced telecommunication services, without significant cost penalty because of location.

Fiber Optic - A technology using high purity, hair-thin fibers of glass to transmit information (voice, video, data). The bandwidth or capacity of fiber optic cable is much greater than conventional cable or copper wire.

Frame Relay - A form of switching protocol used for wide-area network connectivity. Frame relay can be purchased specific data rates. It is commonly used today for data transmission, and much work is being done by vendors to provide service for voice and video.

IMC - The Commission on Information Management

Infrastructure - A term used to describe the existing form of an extensive, underlying technology which supports services or enables activities for a specific population or geographic area. For example, the State and Interstate highway systems, local water systems, the power grid, and the telephony network.

Internet - The global network consisting of many interconnected networks. The Internet connects computers at universities, research labs, government, commercial, and military sites around the world.

IP (Internet Protocol) – A network language developed by the Department of Defense and others, commonly known as TCP/IP. This protocol suite is not proprietary to any single vendor. The TCP/IP protocol is used on the Internet.

ISDN – Integrated Services Digital Network –An international standard for digital communication services. ISDN typically provides two 64,000 bit/sec channels that can be used for either voice or data. ISDN is commonly used as a dialup service.

ISP - (Internet Service Provider) - A commercial organization that provides access to the Internet via dial-up and dedicated connections.

LATA - Local Access and Transport Area- These areas were originally defined by the 1984 telecommunications divestiture and subsequent actions. The LATA is a regulatory and geographical area that determines carriers that can provide service within the LATA area and the carriers who can cross the LATA boundary and provide service between LATA's.

LEC - Local Exchange Carrier - An acronym that refers to the local service provider(s) for telecommunications services. In rural areas, these were traditionally independent telephone companies. There are two varieties of LEC in the new re-regulated environment: an **ILEC** (incumbent) has provided services in an area, is certified by the FCC, and meets the definition in 47 U.S.C. 251(h) as of January 1, 1998; a **CLEC** ("competitive" LEC) is a new, competitive service provider in an area.

Local Loop - A general term describing the telephone lines comprising the infrastructure between a user location or building the carriers' local central office. It is sometimes referred to as a subscriber loop.

Megabit - A measure of data transmission speed - 1,000,000 bits per second or approximately 125,000 characters per second.

MBPS (Megabits per second) - **Abbreviation** for megabit per second.

MNT - Multi-use Network Task Force

Multiple-use Network - A network infrastructure that uses shared capacity and purchasing power for many uses and customers. A multiple-use network also provides a potential for operation efficiencies and rapid expansion of capacity to accommodate increasing demand.

Network - A collection of hardware, software, and leased service resources used to establish, link, and switch communication paths between its terminals.

Non-profit (-user) - A non-commercial organization that is defined by the IRS as a non-profit.

OC-3 - A SONET data rate specification. An OC-3 circuit has a bit rate capability of 155.52 megabits per second.

Private/Public Partnership - A business strategy in which a public entity and a vendor or provider of services pursue mutual advantages in the ethical provision of services.

Private Sector - A non-government or public company typically a commercial business.

Public Sector (-user) - A government or government supported entity of some kind, such as a public library.

PVC - Permanent Virtual Circuit - In switched networks such as frame relay and ATM, PVC defines a logical defined circuit between two locations. A PVC is a path existing inside the cloud technology.

Redundancy - The ability to provide an alternate network path or backup equipment to avoid failure of service.

Scaleable - A term used to describe technology which can be "sized to fit" a range of locations from high demand to low demand areas. It also applies to providing services for diverse needs.

SNA Network - Systems Network Architecture- The SNA network uses the Systems Network Architecture (SNA) protocol, which is employed primarily by IBM-type mainframes. It generally uses a front-end processor as a main network device, and uses remote controllers to distribute messages to each terminal. The CITS data center is the hub site for the State SNA network.

SONET - Synchronous Optical Network - A high speed, fiber optic based telecommunication technology.

Switch – Hardware and software used to provide the ability to for a network to determine the destination of a frame or cell. The switch then routes the frame or cell through its hardware to the appropriate circuit for transmission. The capability of switch configuration in a local central office is a determining factor for the services and advanced technologies are available in that local serving area.

Subscriber Loop - The infrastructure that provides service from a customer building to the local central office network connection.

T-1 – (also known as DS-1) A classification of service. A T-1 circuit has a bit rate capability of 1.544 megabits per second, and is capable of carrying 24 single line telephone circuits.

TIIAP - Telecommunications and Information Infrastructure Assistance Program - A grant program from the U.S. Department of Commerce, National Telecommunications and Information Administration, established by Congress in FY 1994 to assist non-profit organizations and units of state and local government. These projects are often used to fund projects that contribute to the building of a national information infrastructure.

xDSL (- Digital Subscriber Line) - A new technology which can provide multi-megabit data services over copper subscriber loops.

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APPENDIX A

History, Legislation & Parallel Efforts

Introduction

The Commission on Information Management (IMC) recognized the need for an integrated statewide network a decade ago. With the assistance of the Department of Administration, Division of Telecommunications, this need led to the development of the existing Digital Data Network (DDN). The DDN network, implemented in 1989, consolidated existing networks of the time and laid the foundation for future network projects. Another benefit was improved service because of controlled implementation, planning and competent network design. The IMC continued its efforts by sponsoring a series of planning sessions focused on State Information Architecture. The result was a vision for seamless, electronic government that would provide citizens with the ability to access government anytime and from anywhere in the state.

Legislation

2.1 Senate Bill 96-102 Statewide Information Infrastructure

This legislation added language to C.R.S. (Colorado Revised Statutes) 24-30-1702.5 focused on the statewide information infrastructure. This legislation regarded the establishment of a statewide information architecture to provide "all services offered to the public either free or at a set price, that employed the statewide telecommunications infrastructure to provide for the benefit of the public or private sector, text, video, image, sound, or data."

The intent of the General Assembly was to sponsor the development of a statewide telecommunications infrastructure that linked urban and rural communities across the state and facilitated citizen access to government and public entity information. Applications that would be supported by this network were distance learning,

telemedicine, telecommuting, and access to government information. This infrastructure development initiative was aligned with local economic development through the availability of telecommunications services.

By statute, the Commission on Information Management (IMC) has been charged with the following duties:

- Develop and implement requirements for statewide information infrastructure based on present and future user applications.
- Review existing portions of the statewide information infrastructure to determine the areas of the state in which it exists, whether it is adequate and usable for present and future user applications.
- Define and initiate public-private partnerships for funding and building the statewide information infrastructure, with the understanding that the private sector will build the necessary portions of the infrastructure.
- Initiate a system to manage the network in the most economical and effective manner, including designation of a system usage manager.
- Oversee ongoing use of the statewide information infrastructure.
- Recommend, if necessary, further legislation and budget appropriations for ongoing implementation of the statewide information infrastructure.

Senate Bill 96-197 Technology Learning Grant and Revolving Loan Program

In support of distance and technology learning a new article, 11.5 was added to Title 23 of the C.R.S. This article introduced two new phrases, "Colorado's information technology infrastructure" and "Multiple-use network". The latter was defined as "a digital network capable of carrying integrated voice and video as well as text, graphics, and other electronic data between and among schools, public libraries, institutions of higher education, and state agencies."

C.R.S. 23-11.5-104 charged the Department of Higher Education, in consultation with the Department of Education and Information Management Commission (IMC), to "investigate all private and public multiple-use network alternatives and select one or

more multiple-use networks to connect Colorado schools, public libraries, and institutions of higher education for the purposes of enhancing instruction and information access."

Other Statutes

C.R.S. 24-30-1804 instructs institutions of higher education in Colorado that use telecommunications programs or operations, to cooperate in the establishment of a statewide telecommunications network. It charges the Colorado Commission on Higher Education (CCHE) to facilitate the establishment of such a network, by promulgating rules and regulations requiring one, in the event it has not been established by July 1, 1992.

The legislation (C.R.S. 24-30-1801) encouraged the "coordination of such facilities and services, particularly among the governing boards of the institutions of higher education, the Department of Education, and the school districts across the state, would result in improving education programs and a more cost-effective telecommunications system."

Parallel Efforts

Connect Colorado (C-squared)

A group that reflected the goals of Senate Bill 96-197 to bring services to all the schools in the state was Connect Colorado. This organization, conceived by the Department of Higher Education, was composed of higher education, state government, libraries, and K-12 representatives. Connect Colorado's goal was to address the need for an improved and extended telecommunications infrastructure. This was to be developed for improved and cost effective services to the citizens of Colorado. The group recognized that a single network could effectively meet the need for varied communication and information needs of government, health care, and education.

Connect Colorado identified these potential benefits.

- outreach to the citizens of Colorado through improved connectivity
- strong position to leverage prices and services
- encouraging private sector expansion of telecommunications services in the state

- encourage commitment to developing telecommunication facilities in local communities
- promote economic development
- commitment to ongoing planning and coordination

The success of Connect Colorado was dependent upon the following outcomes:

- establishment of strong public/private partnership
- well articulated and definite commitment from communities
- an approach to exploit and improve upon of the existing telecommunications infrastructure
- utilizing the extensive experience which exists in the state

APPENDIX B

Assessment

Overview

The purpose of this overview is to present an objective assessment of current state networks, and how they interact with the current telecommunications environment in Colorado. It will provide backup information used to aid in the formulation of the general strategies set forth in the main document. This section of the document should be considered a work in progress, and will be revisited and edited, as information that is more complete becomes known.

The State of Colorado has a number of single purpose networks. A single purpose network is one that is designed and implemented for a single application, department or program. Although this practice is not necessarily detrimental to the operation of the state network resource, it does have long term implications that are becoming evident. This assessment will begin the process of determining this effect, and will point out issues that will affect future network projects.

While some of these networks are aggregated, and operated over common facilities, there is limited unified planning to maximize this resource. The state departments and organizations must develop a broadened mindset resulting in the development of a unified effort to invest funds wisely. This effort must be focused on meeting the rising expectations of state agencies, institutions of higher education, local schools and libraries. The expectations of state government must be bonded with local community requirements for enterprise and business development.

Telecommunications has seen dramatic changes in technological capabilities. However, in order to realize the benefits of advancing technology, offering more services and increasing capabilities, the state must recognize the need to develop a stable infrastructure based on the best technology available. This should be considered a more favorable alternative to individually upgrading a series of networks to meet short-term demand. Through the simple tactic of unifying and focusing efforts, the State of Colorado can ensure that maximum value is achieved in the shortest period.

The Purpose

Contained in this appendix are the following:

- Assessment Methodology
- Current Status of Networks
- Current Projects and their Associated Budgets
- Write-ups From
    - Higher Education
    - K-12
    - Library
    - Health Care.

Summary

Only by objective assessment and constant re-evaluation of the ever-changing environment can the state develop a reasonable technology plan for the future. Through this iterative process, effective means of using new technology will be conceived for use by government entities for the capable delivery of services to the citizen. This section presents a first look at the current climate and begins to document the status of networking for future needs analysis.

Methodology

During the summer of 1997, the Colorado Information Technology Services (CITS) Division of General Support Services in conjunction with the Commission on Information Management (IMC) began an analysis of the states' telecommunications infrastructure. The analysis was focused on the function and structure of the existing government and higher education networks and the overall telecommunications environment within the State of Colorado.

Based upon the preliminary findings of that analysis, and under sanction of SB96-102, it was determined that an interdepartmental taskforce should be formed. The task force would investigate known issues, isolate new ones and prepare a statewide strategic plan to address the future development of telecommunications infrastructure and state networks. The Multi-use Network Taskforce (MNT) was formed in October 1997, and staffed with three full time members and five part time members. It was critical that members representing the Departments of Higher Education, Education (K-12), General Support Services, the Information Management Commission (IMC), State libraries, non-profit health care providers and the private sector be included in this group.

Areas of Emphasis

The MNT identified several areas for its initial focus. A primary focus was placed on a statewide business needs assessment to determine the future directions and needs of state government. This was accomplished by meeting with state government departments, higher education schools and organizations, the Department of Education representing the interests of K-12 education and libraries, and consultants working with the non-profit health care providers. Information gathered in this phase detailed the projects that were being considered, provided in the context of future technical and policy administration.

The personal interview notes and network diagrams gathered through this assessment process were compiled into a central knowledge base and were used to validate the

concepts comprising the strategy to assess the Statewide telecommunications infrastructure. In addition to personal interviews, an all-day meeting was held on December 11, 1997 for representatives of Higher Education, Education (K-12), State libraries and various BOCES's throughout the state. This meeting focused on the reaction of this group to ideas developed by the MNT, and gathered comments and valuable firsthand information. Additional information was assembled by reviewing the various department IMAP's submitted to the Commission on Information Management (IMC) related to or affecting a Statewide telecommunications infrastructure.

For the purposes of internal influences, a database containing circuit information for all State of Colorado entities was created. The development of the database is continuing and will be an on-going task. It is important to note that data presented from this database must be considered a snapshot of what is known at the time of printing.

Data fields in this database include circuit type, function, bandwidth, termination points, and monthly costs. This information is used to help identify the most appropriate points of aggregation and the effect on site cost of any action taken. The initial database development was focused on compiling the circuit information on all circuits known to CITS Telecommunication Services Group. It is the belief of the MNT that this represents approximately 60% of the existing state funded infrastructure. The additional network infrastructure identified through the business needs assessment along with the network components of future projects will be added to this database to provide a progressive picture of the States telecommunications infrastructure.

From an external perspective, the task of reviewing the strategic planning efforts of other states in the area of telecommunications began. The MNT reviewed the published strategic plans of other states. By doing this review, it was hoped that the State of Colorado would learn from the successes and failures of other states regarding telecommunications. The MNT used Internet research and telephone interviews to compile a library of reference material. This information will be processed and incorporated into the final plan where appropriate.

Other external influences were reviewed by meeting with the Public Utilities Commission staff; carriers, hardware and software vendors and local groups facing the challenge of

lack of advanced services. It is clear to the MNT that the development of telecommunications infrastructure is dependent upon regulatory issues such as network interconnect regulations and standards. Other equally important facets of the regulatory environment include discount rate indexing effecting competitive local exchange carriers, and the development of a universal service fund as suggested in the Telecommunications Act of 1996. The state PUC is beginning to evaluate the use of the state USF to fund advanced services. The MNT is supportive of this evaluation.

The MNT also met with representatives from various technology-based companies to determine product availability to assure that technical assumptions were backed by existing products. These vendors were asked to provide catalogs, product descriptions and company directions to the MNT. Surprisingly, some vendors chose not to provide requested information, or provided incomplete details of their companies and products.

A library of information related to the areas mentioned above will be maintained by the MNT as an ongoing reference source for future planning and coordination.

The Process

An interactive and iterative process has been developed as a mechanism for identifying the requirements of a statewide telecommunications infrastructure. This iterative process includes the following steps:

1. Gather/Share detailed telecommunications information;
2. Define/Challenge assumptions related to telecommunications infrastructure;
3. Document the findings
4. Repeat the process

This process will continue to foster the development of sensible strategies and tactics to ensure success of the plan. It will provide backup data for review by financial, technical and policy analysts.

Summary

By using this iterative process, the MNT seeks to provide a continually refined model of the telecommunications infrastructure resulting in increased logic for planning strategy. By design, every cycle of the process improves the assumptions and provides better information to decision-makers.

Current Status Of State Networks

The purpose of this portion of the appendix is to outline the status of state government networks. To facilitate this analysis, several parties were contacted and interviewed as described in the previous section entitled Methodology. This analysis, still in its preliminary form at this printing, does provide some insight into the successes and failures of state government network projects and development.

State Agencies

The following section describes how the various state agencies operate their networks. There are 19 state departments in Colorado. The MNT analysis has classified them into four groups depending on how they operate their telecommunications networks. The first group is general state government, the agencies responsible for the general services of the state. This group includes Labor and Employment, Human Services, Public Safety, Transportation and others. The second category is under Higher Education. This category includes the four-year colleges and university system in Colorado. The third is the community college system run by the Colorado Community College and Occupational Education System (CCCOES). Finally, the last group is the Judicial Branch and others. Each of these groups is somewhat autonomous in the planning, management and operation of their telecommunications projects and networks.

General State Government

The Telecommunications Services Group under Colorado Information Technology Services (CITS) in the Department of Personnel is responsible for assisting general state government agencies to design and complete their network and telecommunications projects. This group was formerly known as the Division of Telecommunications, and was an organization within the Department of Administration, now consolidated into the Department of Personnel. Telecommunications Services serves as consultants to the network staff from the various state agencies for many network projects. They also

operate the state Digital Data Network (DDN), the Colorado Information Network backbone (CIN), the CITS Data Center Systems Network Architecture (SNA) network and the Cooperative Interactive Video in Colorado State Government (CIVICS) video network. It is important to note that the responsibility for several networks such as those in higher education and Judicial were delegated from Telecommunications Services to the appropriate agency.

Telecommunication Services develops specifications for some statewide contracts such as routers, modems and other telecommunications equipment. It also analyzes orders and makes suggestions based on information provided to ensure that the state gets the best values for its investments.

Higher Education

Higher Education Networks are designed and implemented by the school or university needing service. Each college or university has either staff or outside assistance to plan and implement their networks. The main organizations in this environment are the University of Colorado, with campus locations at Boulder, Denver and Colorado Springs; Colorado State University in Fort Collins with extension services throughout the state, the University of Northern Colorado in Greeley, Fort Lewis College in Durango, Western State in Gunnison, Adams State in Alamosa, Mesa College in Grand Junction and the University of Southern Colorado in Pueblo.

Higher Education uses the Internet (Supernet Inc.) for much of its intercampus electronic mail and traffic. It is also a user of the CITS CIVICS network for videoconferencing and distance learning. The evolution of distance learning, telemedicine from medical and veterinary schools dictates the implementation of a high capacity higher education Intranet for the provision of these services. Another factor effecting the future of higher education networks is the deployment of Internet II, the next generation Internet. It will require high-speed advanced services between major campuses and to a major backbone network provider.

Community College Systems

In addition to the colleges and universities of the Department of Higher Education, Colorado also has a large community college system. Community Colleges are located at Sterling, Trinidad, Fort Morgan, Denver metro area, Pueblo, Lamar and La Junta. The community college network provides service between these cities and the Colorado Community College office in Denver. The network system uses the CITS CIVICS network for distance learning and videoconferencing. It also uses the DDN and carrier circuits to connect the various sites. CCCOES is connected to the Internet through Higher Education.

Judicial Branch and others

The other organizations not mentioned above are Judicial, K-12 education and the library systems. The Judicial network was developed at the departmental level. The Judicial Branch of government has staff and does network design, operation and purchasing separately from any other group.

The K-12 education network is largely composed of schools connecting to the Internet through an Internet service provider. Some are connected through the Department of Higher Education and others through the community college system. The Colorado Department of Education helps facilitate Internet connections and may serve as a technical resource to the school districts.

Many libraries are connected to Access Colorado Library & Information Network (ACLIN) through the Internet. ACLIN facilitates card catalog sharing through the Colorado Alliance of Research Libraries or CARL. The State Librarian administers ACLIN.

Backbone Network Services

The "backbone" network is the segment of the network over which telecommunications services are distributed to departmental networks. A telecommunications backbone is typically a high-capacity core network that carries traffic destined for other networks.

The vast majority of the state's networks are carried over telecommunications lines leased from private telecommunications suppliers. The state has operated a statewide microwave system primarily to support public safety radio applications for a number of years. Besides the Colorado State Patrol and local law enforcement, this system supports radio communications within the Department of Transportation (snowplows, highway equipment, etc.); Department of Natural Resources including the Parks and Wildlife divisions; Department of Corrections for communications within and between prisons; and Higher Education institutions primarily for security and maintenance applications. The microwave system has links to the systems in the states of Wyoming and New Mexico with a link to Utah currently in the planning stage. Another important role for the microwave network is to provide an alternate or redundant path in order to guarantee better up time for other statewide networks. For example, the DDN uses the microwave for redundancy of major backbone circuits.

A breakdown of the traffic carried on the microwave network shows that 59% is for Public Safety purposes, 17% supports the activities of the Department of Transportation, and the remaining 24% is used for all other traffic.

The state also has a connection to the Internet. The contract for Internet services was a joint activity of state government and higher education to aggregate need for discounted cost. This activity was highly successful in bringing quality services at low price for all.

The common carrier provided leased lines used for the networks are of various types. The technology list consists of analog leased lines with 9600 bits per second (BPS) modems and digital data lines commonly at DS-1 (1.54 million bits per second or MBPS) rates. Newer technology using frame relay methodology are most commonly supplied at

the 64KBPS (64,000 bits per second) or DS-1 rates, with DS-3 (45 megabits per second or MBPS) rates now available. The terms DS-1 and DS-3 are used here in place of the more commonly used T-1 and T-3 terminology; for the purposes of this document they describe the same technology. The latest technology is Asynchronous Transfer Mode (ATM) service that is capable of voice, video, and data traffic. These lines are acquired from a variety of suppliers with U.S. West being the predominant supplier. The state usually supplies the terminating equipment such as modems, Private Branch Exchanges (PBXs), routers, etc. that connects these leased lines. This equipment is commonly known as customer premise equipment or CPE in the industry.

Voice Communications

Voice communications is characterized by the public telephone network. Some refer to this as POTS (Plain Old Telephone Service) bringing to mind the old dial black telephones that everyone once had. The state currently supports 30,000 telephone numbers located throughout the state excluding Higher Education and their student populations.

Typically, CITS Telecommunications Services guides a department through the acquisition of an appropriate telephone switch and appropriate carrier service for the unit. The analysis done by Telecommunication Services determines whether the requirements are better satisfied by a small key system typically used for small offices or a larger PBX (Private Branch Exchange) commonly used in highly concentrated areas. The PBX at the Capitol Complex and the Kipling Complex are two examples of systems managed by this group. The voice management duties also include the state long distance telephone charges contract. Long distance charges as well as the charges for the State cellular contract are typically re-billed to agencies. The long distance contract annually passes through $3.5 million in charges at a substantial discount from normal rates by aggregating demand. In July of 1997, the state had one million minutes of long distance with 500,000 minutes billed by U.S. West, 400,000 minutes from MCI, and the balance over dedicated facilities for the state.

Analog Radio

While the microwave is digital, the normal radio communications are still analog. The state system supports approximately 9900 radios and related dispatch centers. The state has almost 8100 radios with the highest concentrations in Transportation (almost 2700), Natural Resources (over 1500), and Corrections (over 1600). Other departments using this service include Agriculture, General Support Services, Judicial, Education, Public Health & Environment, Higher Education, Human Services, Labor & Employment, Law, Local Affairs, and Revenue. The other approximately 1800 radios are located in city and county governments primarily in local law enforcement and fire protection. The Colorado State Patrol is currently in the process of transitioning from 17 dispatch centers down to five strategically located throughout the state.

The Federal Communications Commission (FCC) has reallocated bandwidth to support the new applications such as cellular telephony and personal communication systems. To satisfy the consequences of this action, the state must upgrade its radio network to meet new standards that take effect in the year 2005. One of the complexities of this mandate is that the standards force everyone to get to the same place at the same time. A mixed network of old and new technologies creates a number of problems when trying to share the same network.

Digital Data Network (DDN)

The Digital Data Network (DDN) was created in 1986 to combine and better facilitate the transmission of data traffic within the state. The DDN consists primarily of leased digital lines with some reliance on the digital microwave for alternate paths or redundancy. The DDN is a multiplexed network that consolidates low bandwidth applications such as SNA lines from the CITS Data Center, which are in the 9600 BPS range. This network, through route redundancy and diversity raised the average availability of the networks to the 99% range, and decreased costs by an average of 25%.

The Digital Data Network exists as a superhighway around the State of Colorado which relies on individual "tail circuits" to connect each agency to the super highway. The network relies on Time Division Multiplexers from General DataCom (GDC), and

consists of nearly 65 nodes and almost 430 circuits. DDN carries primarily low speed SNA network (9600 BPS) data and CIVICS video network traffic.

SNA Network

The SNA network is so named because it uses the Systems Network Architecture (SNA) protocol. It is the network architecture used to interconnect IBM type mainframes such as Hitachi GX-8624 at the CITS Data Center and generally supports the widely used 3270 terminals common to many departments. SNA is also used to connect the state mainframe to other mainframes for intercommunications.

The use and expansion of the SNA network has been discouraged, however, the state data center still has over 9640 devices identified as SNA devices. These devices are connected to 640 controllers running over 240 lines. On a sample day, this network was handling an average of 16,715 messages a minute between 7 a.m. and 4 p.m. The calculated average is 72 messages per line per minute. Ultimately the use of this protocol, at least on the backbone part of the statewide network needs to be phased out in favor of the State standard, which is the TCP/IP protocol. This network is currently being monitored by the NETCON 90 software for the purposes of identifying and troubleshooting problem lines. It should be noted that this is the most labor-intensive network currently operated by the State.

CIVICS Network (Video Teleconferencing)

The Cooperative Interactive Video In Colorado State government (CIVICS) network provides the delivery of interactive video conferences and classes to 48 sites located around the state. The network serves video applications (primarily at higher education institutions and correctional facilities). In the last year, CIVICS has grown from 17 to 48 sites with port hours increasing from 300 to 1146 per month.

Currently, most of this activity runs on the DDN. The CIVICS network offers two-way interactive video using at least 384KBPS of bandwidth. Due to the time division multiplexer technology used in the DDN, 384KBPS of bandwidth must be permanently dedicated whether or not a videoconference is taking place.

There are increasing capacity issues as demand grows for this service other than the bandwidth constraints mentioned previously. Under the current video bridging technology, there is a limit of three cascading ports when connecting multiple locations to the network. This means that there are limitations regarding the number of sites that can be connected to a conference.

The highest usage is for course delivery between colleges, universities, and community colleges. Currently classes are being taught remotely between university campuses. There is also a growing trend to connect with high schools around the state to increase the course offerings available. This is especially true in rural areas. The University of Colorado Health Sciences Center (UCHSC) is using this service to teach continuing education classes for nurses at remote locations around the state known as Area Higher Education Centers (AHEC). There also is currently a trial between UCHSC and the correctional facility at Limon. This trial will demonstrate the ability to perform remote medical consultation for prisoners by using video tools to connect the clinic in Limon with a doctor in Denver. Another use for video by the Department of Corrections is video teleconferencing, which will be used to training staff and inmates, as well as provide services for video arraignment, parole board hearings, and staff meetings.

Colorado Information Network (CIN)

This network is primarily based on Frame Relay technology from U.S. West Communications. It also uses the Department of Defense TCP/IP protocol suite as its primary protocol, but also routes Novell IPX and Banyan Vines. The use and expansion of the Novell and Banyan protocols has been discouraged under the state WAN (Wide Area Network) standards to simplify the operation of the network.

The CIN has network connections to most departments, and serves as a transport to the CITS Data Center mainframe and to the Internet. Through the CIN, departments with compatible network protocols can interconnect and communicate with one another. The CIN also connects the state network to the global Internet.

Due to the current state of technology, and the characteristics of the frame relay protocol, only data is carried over this network. Considerable work is being done by vendors to add multimedia services (voice and video) to frame relay. However, it is too early to predict the outcome of this endeavor.

Increasingly, agencies using network technology other than TCP/IP protocols have employed LAN gateways (with some success) to emulate the 3270 terminals used in the SNA technology. Other agencies using TCP/IP protocols have used TN3270 software on personal computers to achieve this goal with more success. These connections still only have the capabilities of a dumb terminal.

This network is monitored by the Open View network software from Hewlett-Packard using a protocol called SNMP (Simple Network Management Protocol). SNMP is an industry standard for monitoring and even managing resources on a network.

There are various structural components of the CIN network besides frame relay circuits. There is a high-speed fiber optic loop connecting the buildings in the Capitol Complex area. This fiber optic ring uses FDDI (Fiber Data Distributed Interface). FDDI is a network architecture using token passing mechanisms and is sanctioned by various standardization bodies.

There are currently more than 220 routing points on this network using primarily Cisco routers. The CIN has over 6000 countable devices attached to the network. It is difficult to obtain an exact figure about the total number of nodes attached to the network, as the nodes existing behind the various network gateways do not register in the network management systems.

A recent sample was run over three days to determine the amount of traffic on this network. The major nodes through which all traffic passes were specifically monitored for usage. Over three-day period, almost 12 billion packets of information passed through these routers. The router located at the data center sent or received over 8 billion packets in those three days. These numbers would give an average daily traffic of almost 4 billion packets. If you further narrow the day and assume that the majority of traffic

occurs between 7 a.m. and 4 p.m. then 7.35 million packets are being passed over this network each minute. This traffic volume is evidence of the high usage of this network.

The state web server (Colorado Homepage) uses the CIN to connect to the Internet. The web server is on the "open" CIN (OCIN), which is accessible to the Internet without restriction. The placement of the web server on this portion of the CIN is necessary to allow the web server to interact with web browsers connecting to it from all parts of the world. The major part of the CIN is behind a screening router serving to provide a barrier to Internet incoming traffic.

Asynchronous Transfer Mode (ATM) Network

A new network is currently being installed which will dramatically replace the capabilities of the current Digital Data Network. This new network relies on a technology known as Asynchronous Transfer Mode or ATM. This technology is also known as cell relay. ATM relies on re-assembling data into individual 53 byte cells. The advantage of grouping the data into a fixed length cell is that the hardware can easily detect the cell boundary, and can thus switch the cell very quickly.

ATM provides differing quality of service for voice, video, or data to be carried over the same network. These different qualities of service profiles are necessary to provide competent end to end service for each of the three applications. As mentioned in the previous paragraphs, technology has limited the transmission of different types of traffic over the same network. ATM has overcome some of these limitations.

The ATM technology allows for the creation of virtual circuits, which appear to the end user as dedicated connections between two locations. In reality, the network provides virtual paths between the two locations, and uses the paths to determine traffic routing. The advantage to this technology is that the network configuration can be changed quickly to respond to varying traffic demands. Changing a virtual connection only takes minutes instead of weeks or months to install new copper or fiber circuits. The ATM network is planned to be the backbone network architecture. ATM can be run efficiently on SONET (Synchronous Optical Network) at rates such as OC-3c (155mbps) speeds or over DS-3 circuits at 45 MBPS. The architecture can be scaled up to much higher speeds

such as OC-12 (622mbps), or scaled down to DS-1 technology to accommodate small offices or remote locations lacking high capacity facilities. Phase I of the ATM project is currently underway which will install this technology in the Denver metro area. Phase IB will extend this capability to Colorado Springs and Pueblo. Phase II will extend the ATM network to Grand Junction and Durango. The second phase will put in place the basic backbone required to support a unified state network.

Higher Education Networks

Since 1986 when the first higher education institution connected to NSFnet, Colorado higher education, institutions have been involved with state and regional networking. Westnet was formed to aggregate regional traffic from Colorado, Wyoming, New Mexico, Utah, Arizona and parts of Idaho. Higher education used NSF (National Science Foundation) grants and campus staff to develop POPs which became Colorado SuperNet hub sites. The Internet has become a way of life for higher education. The development and use of the World Wide Web has led to large amounts of Internet traffic on campus backbones. Higher education relies on the Internet for their statewide network. College and university campuses are large and disperse. Distributing Internet access over the entire campus requires robust LANs. Some colleges and universities are using video services to conduct classes and there are numerous classes offered over the Internet. In fact, at least two institutions offer degree programs over the Internet.

The Higher Education community is also a heavy user of the CIVICS network for teaching classes either at remote campuses or between campuses. The University of Colorado has a fiber optic connection between the campuses in Boulder, Denver, Colorado Springs, and the Health Sciences Center. There is currently a plan under way to upgrade the CU fiber network to an OC-3c (155mbps) Asynchronous Transfer Mode (ATM) network. This connection will span the existing campuses and the new campus for UCHSC at Fitzsimmons in Aurora. There is also a trial ATM project for high speed Internet connections currently being conducted by the University of Colorado, Colorado State University (CSU); Colorado School of Mines; University of Colorado at Denver and the University of Northern Colorado (UNC); and the National Center for Atmospheric Research (NCAR). Basically these institutions are connecting to the

Internet through a U.S. West supplied ATM "cloud" to the Boulder campus of CU. The traffic is then aggregated on a high-speed ATM link to NCAR.

The Community College System also has a statewide network connecting all of the community colleges in the state for both data and video transmissions. The video network, which is an extension of the CIVICS network, reaches 12 main campuses and their satellite campuses. At least three major campuses for Denver, Aurora and Arapahoe Community Colleges and their satellite locations are being added this year to the video network through the Technology Learning Grants.

Many of the Technology Learning Grants that were awarded this year will drive up network demand for more connections. These grants will affect the number of connections between higher education institutions and local school districts. The Poudre Valley School District is planning to connect using wireless technology with the Fort Collins campus of Colorado State University in order to gain a more robust Internet connection. The Red Rocks Community College is extending T-1 links to Park, Clear Creek, and Gilpin counties. The Connect Colorado in the Arkansas Valley project will connect CU, CSU, Lamar Community College, and Otero Junior College with 28 school districts. The grant received by the Mountain BOCES will connect Adams State College and the two campuses of Colorado Mountain College with 58 schools using T-1 leased lines from U.S. West Communications. The RMOTE group will connect Western State College in Gunnison with the Gunnison, Mountain Valley (Saguache), and Hinsdale County School Districts. This particular project uses leased lines to connect to the state network to route traffic to Gunnison, which may be an excellent model for the future. The project is also sharing microwave towers with the local cable television company in order to connect with the schools in Crested Butte. The WestCel group is connecting Colorado Northwest College (Rangely), Western State College, Mesa State College, and Fort Lewis College with 35 video centers located in 18 school districts, two vocational-technical centers and a library district. This will be an ATM network. The Southwest Colorado Interactive Learning Network (SCIL-NET) will use frame relay at T-1 speeds to connect 13 libraries, 12 school districts with Fort Lewis College and Pueblo Community College-Cortez. Initially these will be primarily 56,000 bits per second (56 kilobits or 56kb) connections used for Internet access.

School (K-12) Networks

Currently the Colorado Department of Education connects with and shares information with the 176 school districts in the state through the Internet. A survey completed in the fall of 1996 attempted to assess the capabilities and current capacities of the school districts in the state. That study revealed that 84.6% of the school districts have an Internet connection with approximately 75% of all schools having some type of access. The Internet access for a school ranges from 70.4% for elementary schools to 80.6% for middle/junior high schools to 84.4% for high schools. Within the schools the median was three rooms used for instructional purposes that had Internet access. Within the school districts, 36.4% have the schools and other buildings connected to a wide area network. Of the school districts, 32.2% were participating in a distance learning project or program. There is wide variation between school districts and their use of this technology. The primary uses appear to be Internet access and Distance Learning applications between either schools or schools and colleges.

Library Network

In 1992, the Colorado State Library created the Access Colorado Library Information Network (ACLIN) to link the participating automated library catalog systems in the State. The main advantage to do this was to make them accessible via no-cost local or 800 line dial-up to everyone in Colorado. ACLIN provides free dial-up access (text only) to almost every automated library catalog in the State and a large number of selected databases and Internet-based information resources. This totals more than 230 resources in all. Since ACLIN is Internet-based, its resources are also available, in a fully graphical interface, to Colorado residents who have personal dial-up accounts or other access to the Internet.

Colorado is one of the leading states in the country regarding statewide library resources networking. Recent state and national surveys indicate that 73% of Colorado public libraries provide Internet access to their patrons ("*Coloradans--and Colorado Public Libraries--Top National Internet Norms*"; FAST FACTS, ED3/110.10/136).

Network Assessment

The State of Colorado has a number of network technologies. While many of these do operate over the same backbone, there is limited cooperation and unified planning to maximize this resource. We now have a requirement to invest significantly in a unified network because many of these individual networks have been developed over the years to fill a specific need. By going forward in order to meet the rising demands and global expectations of state agencies, institutions of higher education, and local schools. The area of telecommunications has seen dramatic changes in the technological capabilities available. Rather than individually upgrading a series of networks by agency (including higher education), a unified initiative needs to be put forward, agreed to, and then implemented. This initiative will seek to ensure that Colorado does not spend more than is necessary to fulfill the stated demands for network technology. The obvious benefit is to unify and concentrate our efforts to ensure that the maximum value is achieved in the shortest time. Another benefit of this initiative is to avoid the continuing limitations of current networks that were implemented based on short-term demand over the years.

At the same time there does appear to be at least the presence of disparate state networks in every county in Colorado. These networks are not currently compatible and are using different and in some cases outmoded protocols. The level of capabilities tends to vary more widely when assessing the networks used by institutions of higher education and local schools. The greatest disparities are at the local school level. Some of these are currently being addressed by the Technology Learning Grants that are now being implemented. Because that process is just beginning in terms of actual installations, it is more difficult to determine where network technology is lacking.

The other essential observation is that the vast majority of this network traffic is currently running over lines supplied by the private sector. A query of the state's financial system showed that the state spent over $17 million with telecommunications vendors. The key to any strategy going forward will be to concentrate our buying power to create incentives for the private sector to upgrade their equipment and capabilities. One method to facilitate this buying power is the aggregation of network traffic to create high demand for more advanced network services. If the private carriers refuse to make the investments, preferring the guaranteed profits of the status quo

which currently allows them to charge for several separate telecommunications lines, then the state's network capabilities will suffer.

Vision of the future

Government Access

In late 1994 and early 1995, the Commission on Information Management sponsored a series of meetings that were aimed at setting an Information Architecture for state government. The result of those discussions, which included representatives from every department (primarily program people as opposed to just technology people), was a collaborative solution.

The vision for government was one of seamless or electronic government. Any citizen should be able to access government and its services no matter where you are located in the state and largely regardless of the time of day or day of the week. Accessing government would include not only mundane things like obtaining licenses, getting copies of birth certificates, etc. but extend to obtaining new skills through remote training or performing extensive research. A citizen would be able to request a copy of their birth certificate on line. A nursing license could be renewed directly with a few questions answered. An income tax form could be filed directly electronically with your refund being deposited automatically in your bank account. Training through the local school or community college could be delivered from any higher education institution offering that course and ultimately delivered directly to the student at home. Extensive research of libraries or the Internet could also be carried out anywhere. General information about government, data gathered by government agencies or higher education institution research would be instantly available. All of this capability should be provided seamlessly to the citizen without having to visit a particular location during "working hours". For those that are "technology poor", the same access could be obtained by visiting the local school, library, or college where public terminals could be available. This vision requires the adherence to common standards and for the most part use of a common network or seamless connections between networks.

Telecommunications Development

The other factor to be considered is the present state of telecommunications in the state. This factor most often dictates the technology chosen to fulfill the demands of network applications. The current picture is not a good one.

Colorado has a concentrated front-range population which is gifted in its telecommunications service menu. Carriers are not required by regulation to provide advanced services such as ISDN (Integrated Services Digital Network), ATM, frame relay, or other technologies. The main reason to compel development of these services is economics. The carrier must often balance the requirement for these services, the long-term impact on the financial resources of the carrier, and the impact to local rates of use to recoup the cost of the technical investment.

Rural Colorado, because of low population density, and remoteness is a victim of this situation. Many areas are served by small LECs (Local Exchange Carriers) that may not have the financial resources to provide advanced services required. This situation has impeded the development of the telecommunications infrastructure in Colorado.

In order to meet the vision of seamless government, a point of presence or Aggregated Network Access Point (ANAP) must be established in every county in the state. The state must act as an "anchor tenant" to the local community. This role will require the state to pay for a high speed connection with the local telecommunications carrier to meet its needs and to act as a focal point for the development of telecommunications around the ANAP locations. In order to cost justify high capacity connections to every county seat, the demand for telecommunications networks in each county must be analyzed and combined as needed. The state currently has four to six separate networks using separate telecommunications lines running into each county. Examples of the networks having presence in each county are the Motor Vehicle/Secretary of State network for the county clerks; the Colorado Bureau of Investigation network for local law enforcement; the Human Services network for county welfare offices; and the Judicial network for all of the courts and probation offices. Large networks also exist for Corrections, Driver's

License offices, Job Service Centers, Transportation, and Natural Resources (Parks, Wildlife, and Water Resources) offices. These networks need to be combined to create a single connection running at least at T-1 (1.54mbps) speed probably in ATM mode.

Also by acting as an anchor tenant, the state will order local loop services to connect its offices to the ANAP. This will increase the demand on the carrier to provide advanced services. In concert with the activities of the state, it is hoped that the local community will bond to create local groups to provide increased demand to further effect the economic balance in favor of advanced services.

As our society shifts toward the 21st century workforce, the state needs to position itself to support a remote workforce that for the most part is telecommuting. With the increasing congestion on our highways and the new much stricter EPA regulations for pollution, there will be rising pressure to remove the largest workforce in the state from the highways and streets of Colorado. Doing this reduces the pollution and congestion by moving state workers to their homes. Since much of the work in state government is information based, this move can be accomplished without major dislocations. In order to support the workforce an entirely different support structure must be created. Robust help desks to deal with any technical problems must be formed and trained. State office buildings must be turned into common space that is assigned each day to those who need time in the office. Files must be moved either to the home or to the office location for that day. The ability to deliver equipment and supplies to a home office must be created. Once this infrastructure is created, the geographical location of a worker should not matter. This will lead to further network demand in the smaller communities of the state.

The state must also upgrade its current capability to support its mobile workforce. This workforce currently relies on the analog radio system to support its daily activities. As mentioned above, new FCC regulations will force us to upgrade our systems. This required upgrade offers an opportunity to increase the capabilities available to this workforce through a technology known as Digital Trunked Radio (DTR). This technology will allow for better service to a remote worker in the field. DTR will allow for more dynamic configuration of communications and allow for the first time the cross connection of different parties. Currently the Colorado State Patrol, the Department of Transportation workers, and Wildlife officers are on separate radio channels without the

ability to talk to each other. With Digital Trunked Radio, these disparate workers could cross connect on a common incident such as an injured deer on a highway as the result of a landslide. Not only will DTR allow for better connections to local law enforcement and emergency medical services but to other local mobile entities such as school buses. Digital Trunked Radio is another layer within the state backbone that supports a mobile workforce.

Services must be centrally acquired and managed in order to ensure that the state network remains robust and compatible. Primarily by statewide contracts with private sector providers, a network can be built and fully developed. The autonomy noted in the previous sections can be preserved somewhat, but a new level of cooperation must be required in order to make sure that the maximum amount of network resource is aggregated. The state should stop the current trend to return to a series of separate and less robust networks. The state and each local community must recognize their common goal of providing a common telecommunications infrastructure throughout the state in order to achieve the vision of seamless or electronic government.