EPA/ITAS

ITAS8-079 (2-9)

March 5, 1990

# FY90 Telecommunications Planning

# Network Vision Revised Report
Draft

Prepared for

United States Environmental Protection Agency
National Data Processing Division

Information Technology Architectural Support
Contract No. 68-W8-0083

Prepared by the Viar Team

Technology Planning and Management Corporation
Headquarters Park
Beta Building/Suite 220
2222 Highway 54
Durham, NC 27713

tpmc

Viar
& company

# 1.0 INTRODUCTION

The Environmental Protection Agency is chartered by Congress to protect the environment and human health. It performs this mission, in part, by collecting and processing expansive amounts of environmental data. The National Data Processing Division (NDPD) supports the Agency's mission by providing robust and reliable data communications services to the EPA and its environmental partners.

Environmental program data collection and information distribution requirements are constantly growing. New applications, image processing for example, have been introduced to improve the flow and enhance the value of Agency data. As requirements grow, network planners are challenged to optimize and improve network services.

A strategic telecommunication vision is a valuable planning tool. This 1995 telecommunications vision report describes the applications and communication services that support the Agency mission. It also describes the implementation plan that will create the network designed to deliver those services.

## 1.1 Background

The deployment of new technologies has created a revolution in the telecommunications, data processing, and Management Information Systems (MIS) industries. Low cost memory and micro-processors have changed the characteristics and economics of computing. Likewise, digital and fiber transmission technology, and Local Area Networks (LANs) have changed the characteristics and economics of communications.

The personal computer (PC), for example, has drastically changed the office-place. Utilizing micro-processors and LAN technology, PCs have altered the way in which workers prepare documents, perform calculations, and correspond with co-workers. New and emerging PC software will change the way we interact with data and other workers.

Further change will occur as information workers become familiar with existing and emerging technologies. Industry trends indicate that PCs and workstations will become standardized, more powerful, less expensive, and more importantly, easier to operate. In addition, PCs will communicate with a variety of host processor, LAN file servers, and other PCs. The PC will become the desk-top device of choice for many Agency users.

Technology enhancements are also affecting the telecommunications industry. High speed dedicated digital services (1.544 Mbps) and switched digital services (56 and 64 Kbps) are common throughout the continental U.S. - both commercially and via FTS2000. As fiber technology improves, the cost for these high bandwidth services will decrease rapidly, thus making high speed services available and affordable throughout the Agency.

New data and service requirements create a demand for additional bandwidth. Video, document distribution, file transfer, scientific visualization, GIS, and other applications can generate sizeable data streams. The future EPA network will require high speed digital services to satisfy the bandwidth demands.

Thus, NDPD anticipates an ever increasing demand for telecommunications services in 1995 and beyond. Satisfying the potential demand in an effective non-disruptive manner is the key to successful planning. The EPA's Telecommunications Vision for 1995 begins a process that anticipates future requirements, identifies technical solutions, and develops a network evolution plan. This vision will be revised annually to update the five year perspective.

## 1.2 Purpose

A strategic vision is a valuable planning tool. It helps managers formulate goals, establish directions, and allocate both human and financial resources. For NDPD's clients, it identifies the network services under consideration and the time-frames when they may become available.

The purpose of this report is to identify the available suite of data communications services in 1995 to satisfy mission-based and administrative requirements. Also identified are the technological and financial factors that will influence the types of services and their availability. Having identified these items, the report then recommends an orderly implementation schedule to create the network that satisfies the "VISION for Telecommunications".

Once approved, the vision objectives and the implementation schedule will become a guide for long-range data communications planning. An ongoing annual review will assure that the plan is updated each year to accommodate new EPA requirements and technology enhancements.

## 2.0 EVOLUTION OF TELECOMMUNICATIONS SERVICES

### 2.1 Historical Perspective

The EPA network has undergone significant changes since its initial deployment. Limited at first to punch card input and print line output, today's network transmits text, data, binary files, and graphics information.

Remote Job Entry (RJE) workstations, the first EPA communications device, transmitted punch card data to the host which, in turn, processed the data and returned printed reports. The RJE "computer room" was the information collection and distribution point for the remote sites.

The first evolution began with the introduction of the on-line, ASCII video display terminal (VDT). Using 300 bps dial modems, the VDTs communicated with the host through public data networks. The VDTs allowed individuals to enter and retrieve host data on-line. Although limited to line-by-line input and output, the ASCII devices were, nonetheless, the first step in connecting the information worker's desktop with the host processor.

The next step in the evolution occurred when the network was modernized to improve IBM host access. Full screen 3270 (or equivalent) display terminals became the Agency standard communications device. Dedicated data circuits connected the remote 3270 display devices to the NCC host. Full screen formatting and faster data transmission speeds increased the quality and quantity of the information delivered to the users.

This modernization program was completed with the implementation of a private X.25 network. ASCII VDTs used this X.25 network to communicate with IBM and non-IBM hosts (DEC and PRIME). The DEC, Prime, and LIMs machines communicated via the X.25 network as well.

Throughout the network's evolution, the primary network service objective has always been host(IBM, DEC, Prime, etc.) connectivity. Other network services, EMAIL (an external system), Bulk Data Transfer(BDT), micro-to-mainframe file transfer for example, were added to the existing networks to provide additional user capabilities.

## 2.2 Future Network Services

In 1995 the network will support a combination of traditional and new services. Many of the existing host connection services for ASCII VDTs, RJEs, and 3270 devices communication will still be present. Likewise, host-to-host services, (i.e., DEC-to-DEC), EMAIL, BDT, and micro-mainframe services will be available, although, perhaps in a somewhat different format.

New network services, including those exclusive to host processors, are integrated into the EPA networks. Slowly but steadily, the emphasis of these services will shift from host connectivity to information delivery. Network services as a result will expand dramatically to include the following:

**Document Distribution** - Distribution of editable word processing documents among registered EPA users.

**File Transfer** - Two-way, simple file transfer between PCs, LAN servers, DEC and IBM systems, and other processing platforms.

**National Extended LAN** - PC and workstation connection (where authorized) to any Agency LAN and their attached servers and hosts.

**Electronic Mail and Messaging** - Agency-wide distribution of electronic mail to LAN and host attached PCs and terminal devices.

**Directory Services** - User, data, and applications locator services.

**Video Conferencing** - Two way interactive and one-way multi-site broadcast video teleconferencing at all EPA major sites.

**Image Distribution** - On-line viewing and distribution of remotely scanned and stored documents.

**Off-Site LAN Access** - Dial-Up (Digital and Non-Digital) access to LAN applications (EMAIL, Calendaring, etc.).

**Application Peer Communications** - Program-to-program data exchange.

Other Services that will be available on a limited basis, include the following:

**Co-Operative Processing** - PC/LAN Server(s)/Host(s) distributed application processing.

**Electronic Conferencing** - Simultaneous multi-workstation screen image viewing and content manipulation.

**VSAT Services** - Remote site (hazardous waste site, disaster site) communications via portable, compact satellite dishes. Voice, data, and potentially video services will be supported.

**Electronic Distribution Services** - Electronic distribution of software, files, charts, graphs, or print images to one or multiple recipients (user or systems).

**Inter-Agency Connection Services** - FTS2000 packet and circuit connections for EMAIL and document exchange services among Federal Agencies.

**State LAN Connections** - LAN-to-LAN communications for States and Local Governments.

The combination of existing and new services will produce many tangible benefits for the EPA including:

- Work-at-home support programs
- Network-wide data access and data exchange
- Worker-to-worker data and document exchange
- Workgroup problem solving and consensus building
- Visual presentations of complex analytical results
- High network availability
- Responsive transaction and file processing.

For many EPA users, host access services are still the only network requirement in 1995. Others, however, are using a suite of network services - peer communications, cooperative processing, document distribution, etc., to perform their assigned tasks. In either case, the network provides consistent simple user interface.

# 3.0 INFLUENTIAL FACTORS

The EPA networks in 1995 are influenced by many factors including application requirements, workstation capabilities, communications technology, regulatory issues, and budget constraints. This network vision considers EPA data transmission requirements, technology trends, Federal Information Procurement Standards (FIPS) for the Government OSI Profile (GOSIP), emerging standards, FTS2000, and cost factors. This section of the report identifies the network applications that have the greatest impact upon the EPA network architecture. It also identifies the likely combination of carrier services, hardware, and software that will be needed to satisfy the requirements of future applications.

## 3.1 Application Factors

At present, the EPA network is designed to support communications for a large base of 3270 (full screen) terminal devices. These terminal devices typically submit transaction requests (@ 100-200 characters per transaction) to a host processor which responds with one or more output screen(s) (@ 200 - 2000 characters per screen). The 3270 is a keyed input device, and therefore can submit transactions only as fast as the operator can input the data. Consequently, the 3270's data generation capabilities are finite and predictive.

Intelligent workstations have created a new class of network devices. PCs and scientific workstations are equipped with communications hardware and software that can transmit and receive documents and files far larger and faster than the 3270 devices. In addition, PCs and intelligent workstations can exchange data with hosts, file servers, and other workstations. A network designed for PCs and workstations, consequently has inherently different characteristics than those designed for 3270 devices.

In 1995 the EPA network supports many familiar and several new applications. Those having the greatest network impact include the following:

**Document Distribution** - Local and wide-area distribution of editable word processing documents.

**Electronic Forms Generation** - On-line forms preparation and electronic routing.

**Distributed EMAIL** - Agency-wide distribution of LAN originated and host originated electronic messages.

**Image Processing** - LAN and wide-area distribution of scanned document images.

**Scientific Visualization** - Local and remote access to high resolution graphics from hosts, scientific workstations, and supercomputers.

**Geographical Information Systems** - Local and remote communications with regional and national processors that graphically depicts geological, demographic, and environmental data.

**Video Teleconferencing** - Near full motion, two-way interactive and multi-site broadcast video services for major EPA locations.

**Distributed Printing** - Host printer output distribution to high quality laser printers located at regional offices and other EPA facilities.

The impact of these applications on the communications network is twofold. First, network capacities are upgraded to accommodate bandwidth consuming services such as image and video. Second, connectivity options are expanded to support LAN to LAN and workstation to workstation communications.

### 3.2 Technology Factors

Many factors, including technology, influence the architecture and design of the Agency's 1995 network. In this section we identify those technologies - transmission services (switched and dedicated), hardware, and software - that are most likely to influence the Agency's future network directions.

**TRANSMISSION**

#### 3.2.1 Dedicated Circuits

FTS2000 provides the EPA networks high speed digital data services to all its major locations. In 1995, T1 (1.544 Mbps) and T3 (45 Mbps) service prices are approximately 1.5 times the 1990 cost for 56 Kbps and T1 services respectively. The Headquarters, RTP, and Cincinnati facilities are connected by T3 circuits. Regional offices and the larger Office of Research and Development laboratory sites are connected to the NCC with one or more T1 circuits (see FIGURE 1). State and contractor sites use 56 Kbps or fractional T1 data services as needed.

#### 3.2.2 FTS2000 Switched Services (ISDN)

FTS2000 supplies Integrated Services Digital Network (ISDN) to nearly all government locations by 1995. Switched 64 Kbps service prices average about $6.00 per hour, making them an affordable alternative to private dedicated lines. ISDN services are used to supplement the bandwidth of the leased line network during peak activity. In the event of a leased line outage, multiple ISDN connections are used to re-establish communications to Regional office and laboratory sites. FTS2000 ISDN services are also used by the EPA for infrequent or short duration inter-agency communications.

#### 3.2.3 Commercial Switched Services

Commercial ISDN services are generally, but not universally available throughout the continental U.S. in 1995. Where available, ISDN services are used by the home-workforce, contractors, smaller lab sites, state and local agencies etc., for infrequent or short duration communications. Like FTS2000 prices, commercial ISDN prices average about $6.00 per hour.

# BACK BONE TOPOLOGY

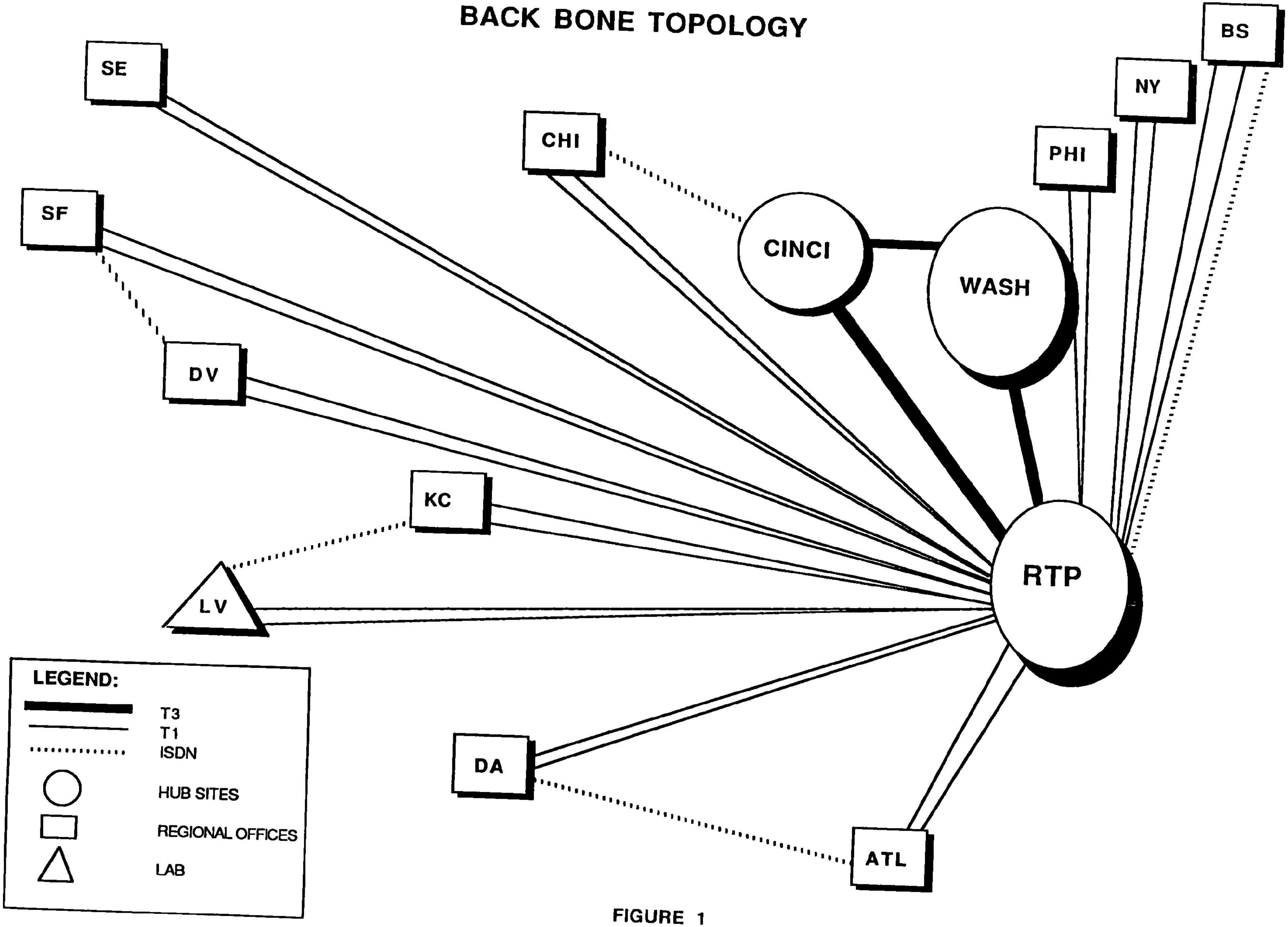


FIGURE 1

Some foreign countries are able to use international ISDN services to communicate with the EPA. Availability of these services in 1995, however, varies greatly among countries.

Analog dial services are still used in 1995, however, 9600 bps is the standard transmission speed. Slower data speeds, 1200 and 2400 bps, are only accommodated on a limited basis.

### 3.2.4 FTS2000 Packet Services

FTS2000 packet services connect the public, municipal and state governments, contractors, and others with EPA computer systems. The packet services are used to enter data, execute host transactions, exchange files, documents, and EMAIL. Other Federal Agencies that communicate infrequently with the EPA, are also connected via the packet network.

### 3.2.5 VSAT

Very Small Aperture Terminal (VSAT) services employ compact dishes and operate at data transmission speeds up to 1.544 Mbps (T1) in 1995. One-time and recurring VSAT costs are greatly reduced due to competition from fiber networks. Remote locations - hazardous waste sites, and environmental disaster sites - are linked via VSAT services where FTS2000 is not available. Critical EPA network links are backed up by VSAT in the event of FTS2000 service disruption.

### 3.2.6 Metropolitan Area Networks

Local telephone operating companies, as a means of expanding into the value added services marketplace, are providing high capacity fiber connections in major cities. Although availability is somewhat limited in 1995, the IEEE 802.6 Metropolitan Area Network (MAN) standards-based networks are viable alternatives to dedicated point-to-point circuits in major cities. EPA locations with campus environments, RTP and Boston for example, use MANs for interconnecting EPA LANs in different buildings. State offices and contractors located in cities with a significant EPA presence also use MANs for connection to the EPA network.

## LOCAL AREA NETWORKS

### 3.2.7 Transmission Plant

IEEE 802.3 (CSMA/CD) and IEEE 802.5 (token ring) local area networks are dominant, both today and in 1995. CSMA/CD LANs are preferred for laboratory sites while 4 or 16 Mbit token rings are preferred for office LANs. Both CSMA/CD and token ring LANs use twisted pair wiring for PC and workstation attachment.

Fiber backbone LANs are implemented at nearly all locations to interconnect departments and other LANs. Special purpose workstations, in some instances, connect directly to the fiber backbone. Backbone bridges, high performance LAN servers, and special purpose workstations are connected to the fiber via the 100 Mbps, Fiber Distributed Data Interface (FDDI) LAN.

## EQUIPMENT

### 3.3 1 Front End Processors

Front End Processors (FEP) are still an important network component, however, their role has diminished as extended LANs provide communication alternative. In 1995 the performance and throughput of FEPs is upgraded to accommodate multiple T1 connections, FDDI, and high speed channel interfaces, though all do not operate concurrently.

The FEPs are used for state SNA Network Interconnect (SNI), remote 3270 devices, RJE workstations, and token ring connections. Primarily used as an SNA concentration device, the FEPs are a mainstay for traditional IBM host communications.

### 3.3.2 X.25 Switches

As a requirement for GOSIP, X.25 is an important network architecture for the EPA in 1995. X.25 switches operate at all major EPA facilities and laboratory sites. They provide a variety of wide-area communications services for LANs, VAX processors, and host systems. Where extended LANs or ISDN connections are not practical, the X.25 network provides connection alternatives. A few state and other government Agencies are connected to the EPA X.25 network for host access, EMAIL, LAN access and other services.

### 3.3.3 Intelligent Nodal Processors

Intelligent Nodal Processors(INP) manage the wide-area connections and the bandwidth of the backbone network. INPs are installed at each of the EPA's major sites where T1 and/or T3 circuits are installed. A multipurpose device, the INPs combine the functions performed by LAN bridges, routers, and T1 multiplexors that were independent devices in 1990.

Communications intensive applications, video and scientific visualization for example, require the EPA to implement a high-bandwidth network (T1 and T3). The INPs perform the critical task of bandwidth management for host connections, LAN connections, video, and other services. Aided by simple, expert systems, the INPs dynamically allocate bandwidth to match service demands. When bandwidth demand exceed capacity, the INPs automatically acquire ISDN services to increase the aggregate bandwidth (see FIGURE 2). Peak period and unusual traffic loads are thus accommodated without upgrading or adding dedicated circuits.

### 3.3.4 LAN Bridges and Routers

LAN bridges and routers, an inexpensive means for interconnecting two or more LANs, are widely implemented in the future network. LAN bridges, efficient but limited as network controller, are used to link multiple departmental LANs within a building or campus. Interconnected LANs create the functional equivalence of a single, campus-wide LAN, or an "Extended-LAN". The Extended-LAN gives all authorized users access to all applications, files, and peripherals within the domain of the campus LAN.

Routers, inherently more intelligent devices than bridges, interconnect the campus LANs at major EPA facilities in 1995 to create a National Extended LAN. Routers control the wide-area data flow, and provide security, network management and other features essential to operate a national network. (FIGURE 3 demonstrates the relationship between bridges and routers.) Routers use the OSI standard routing protocols commercially introduced in 1993. This stable and internationally accepted LAN routing protocol makes it possible to extend EPA LAN connections to include states and other non-EPA sites.

# DYNAMIC BANDWIDTH ALLOCATION

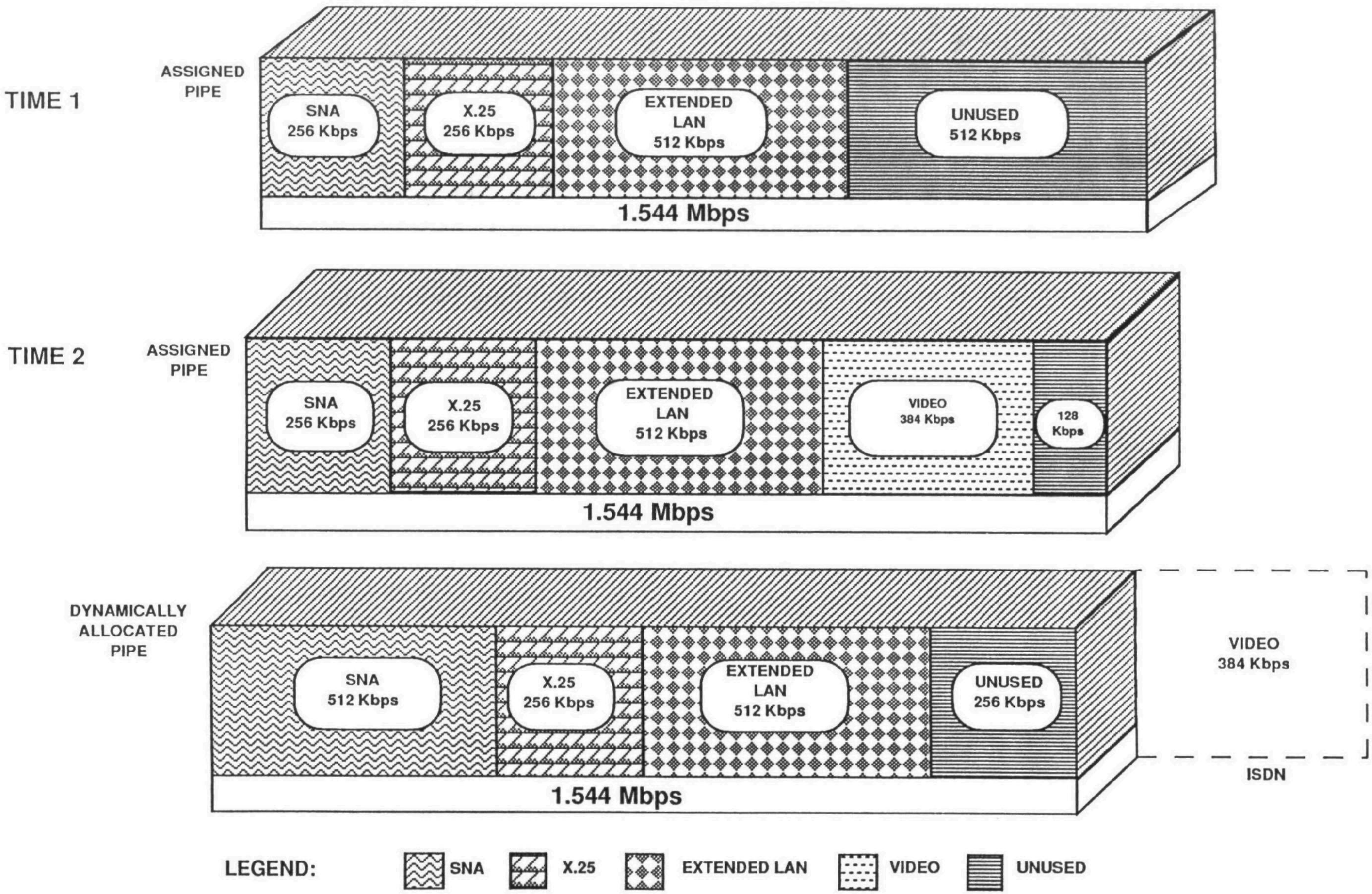


FIGURE 2

# NETWORKED LANS

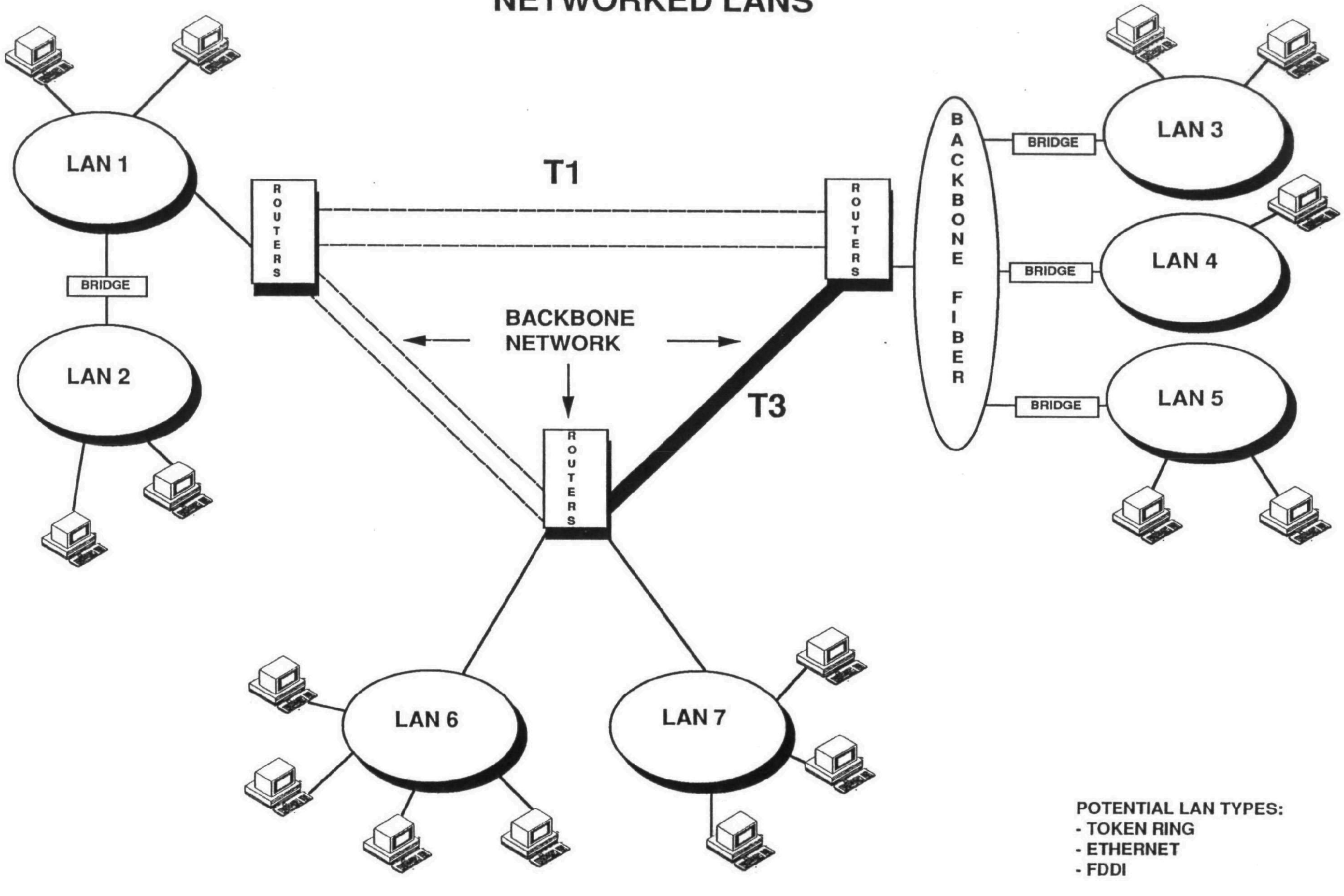


FIGURE 3

The national Extended-LAN also allows regional and headquarter officials to exchange documents and files as easily over the Extended-LAN as they could over the local area network. Remote data sharing, cooperative processing, document distribution, E-mail, and other network applications rely on the Extended-LAN to establish connections for transparent information distribution.

### 3.3.5 LAN Communications Servers

LAN users are required to access systems that are not connected to the Extended-LAN. SNA, X.25, and ISDN communications servers provide wide area communication for the LAN users and applications.

### 3.3.6 LAN Gateways

Token Ring and CSMA/CD LAN gateways are installed at sites where both are operational. The gateway provides transparent access to compatible software applications, files, and peripherals on both LANs.

## SOFTWARE

### 3.4.1 Wide-Area Network Protocols

SNA and X.25 network protocols are still the dominate, EPA network protocols. Inexpensive bandwidth in 1995, however, has reduced some of the cost constraints which have heretofore precluded the Agency from implementing other wide-area network protocols. The backbone network (comprised of T1 and T3 circuits), simultaneously, albeit independently, accommodates SNA, OSI LAN routing, and TCP/IP protocols.

### 3.4.2 FTAM

The OSI standard and GOSIP mandated application for File Transfer, and Access Management (FTAM) is widely implemented in 1995. The vendor independent, operating system independent file transfer application gives the Agency a consistent file transfer mechanism that spans all processing platforms including DEC, and IBM host, supercomputers, and LAN servers. PCs, for example, can use a LAN based FTAM program to up-load files to a DEC or IBM host or a supercomputer. Similarly, the NCC IBM hosts can use an FTAM application program to down-load files to a LAN server, DEC system or another IBM host. FTAM applications are resident on all Agency processor types (DEC, IBM, supercomputer, etc.), scientific workstation, and LAN servers. FTAM provides numerous features, such as security, accounting, remote file management, record and field level access in addition to simple file transfer.

### 3.4.3 X.400

X.400 applications, an OSI standard for message exchange mandated by FIPS, provide transparent electronic mail distribution services among the Agency's LANs and host-based EMAIL systems. External EMAIL services, FTS2000 mail for example, have an X.400 gateway service to communicate with Agency EMAIL systems. Enhanced X.400 standards are expanded to support document, binary file, and graphics distribution services in 1995.

### 3.4.4 Virtual Terminal

Data presentation and screen mapping services for character mode (line and full screen) terminals are standardized by the OSI Virtual Terminal application. In 1995, VT applications reside on the Agency's major processing platforms (IBM, DEC, etc.) and many LAN communications server platforms. VT allows a 3270, for example, to execute applications (written to support the VT interface) on the DEC and Unix systems.

### 3.4.5 Directory Services

X.500, the OSI standard for directory services and another GOSIP mandated application, has a prominent role in the Agency's future networks. Directories contain information concerning user, data, and application system characteristics. They also contain the corresponding network addresses where users, data, and applications reside.

Directory services provide transparent user, data, and application access in a decentralized network. Distribution services, EMAIL, and document delivery services for example, depend upon directory services to determine the network address for message, file, and data delivery.

### 3.4.6 Office Document Architecture

The GOSIP standard for Office Document Architecture (ODA) provides the Agency with a standard document exchange format. Simple documents (text and minimal graphics) are exchanged independent of the word processing package used to create the document. Internally, ODA has limited use since WordPerfect is an Agency adapted standard. Externally, ODA allows EPA to exchange revisable documents with states, other Federal Agencies, and parties that have adopted other ODA compliant word processing packages.

### 3.4.7 Computer Graphics Metafile

The GOSIP Computer Graphics Metafile (CGM) standard defines an independent format for graphics exchange. In 1995, graphics produced with CGM conforming applications can be viewed by other CGM conforming applications. A PC graphics application, for example, can view the output from a supercomputer graphics model providing they both use CGM. In the future, CGM allows graphics output to be distributed electronically to litigation support staff, legislative representatives, and states as needed to clarify or identify complex environment issues.

### 3.4.8 Electronic Data Interchange

The Electronic Data Interchange (EDI) standard defines a common electronic interchange format for sending and receiving common business forms. It is widely used for purchasing related activities (purchase orders, shipping notices, delivery confirmations, and invoices). By 1995, the Agency has adapted EDI to support its financial activities and superfund programs.

New electronic data capture methods are constantly under review to reduce the paper handling labor burden and improve data quality. If an EDI standard format for reporting environmental data can be developed by 1995, it will greatly expand the Agency's interaction with industry and commercial interest.

### 3.4.9 LU 6.2 and Cooperative Processing

LU 6.2 and Remote Procedure Call protocols allow the EPA to design application programs that execute on a variety of processors (PC, Vax, or IBM host). The industry defacto protocols take advantage of the processing power of the end systems (PCs or host) to create applications that have unique data exchange and file handling characteristics. Application tasks are divided and executed on optimized processing platforms connected via the network (local and wide-area).

In 1995 some EPA applications will use cooperative processing techniques which, in turn, generate transaction and data requests faster than human driven applications. Consequently, cooperative processing applications generate a significant wide area and local area workload for the network.

### 3.4.10 Client/Server SQL Models

Future implementations of Client/Server SQL models, tie together (at the application level) the data from LAN and host database systems. End system applications (the client residing on a PC or host) issue SQL queries that are forwarded from local to regional to mainframe databases (servers) as needed to satisfy the query request. The entire transaction is transparent to the end user and application program.

Client/server SQL models are another form of cooperative processing that generate transactions faster than existing terminal based application systems. Consequently, client/server SQL models also generate a significant workload for both the local and wide area network.

### 3.4.11 SAA

The System Applications Architecture (SAA) defines a set of guidelines for application development in the IBM processing environment. The architecture specifies common program interfaces, file handling techniques, screen management techniques, and communications interfaces. Applications adopting the SAA guidelines that are portable to various IBM processing platforms, including mainframes, minis, and OS/2 personal computers.

The impact of SAA is unknown at this time, however, the SAA concept for developing applications has potential network implications. First, consistent use of standard communications and database interfaces promotes data exchange across the network. Second, consistent interfaces streamline the development effort, allowing developers to generate cooperative processing applications quickly.

## 4.0 NETWORK MANAGEMENT

The burden of network management has increased with the implementation of intelligent PCs and workstations, LANs, peer communications, cooperative processing, and distributed databases. Whereas response time was once a function of the transmission and processing time for a single circuit, application, and database, in 1995 it will be a function of many components including LANs, networks, cooperative applications, local and remote databases. As the number and variety of network services increase, so too will the complexity of network management.

The management effort required to operate the EPA data networks in 1995 is massive. Even highly skilled operators and technicians cannot assimilate all of the information needed to maintain consistent performance in a complex environment of cooperative applications, distributed databases, and local and wide area networks. Intelligent, integrated network management systems are critical for successful network operation.

Proprietary aspects of each vendor's product and the large number of managed components preclude a single network management system from performing comprehensive, real-time, all-encompassing network management. As a result, future networks are managed by a coalition of proprietary and OSI management systems. The proprietary systems perform the product specific problem identification, isolation and resolution. These systems, however, will report significant events, line and equipment failures for example, to an umbrella management system that monitors the health of the overall network.

OSI Network Management (OSI/NM) standards are nearly complete in 1995, but they alone are not sufficient to meet all of the requirements for EPA. Network management products have implemented the OSI/NM protocol standard for NM data exchange (CMIP/CMIS). Proprietary systems use CMIP/CMIS to exchange data concerning significant events. OSI security, performance, and fault management standards have been fully defined in 1995, however, off-the-shelf products are not mature nor sufficiently robust to satisfy large network requirements.

Many skilled technicians, supported by special purpose network management applications software and hardware, are needed to operate and maintain complex networks. Despite the enhancements in technology, complex networks are still labor intensive and expensive to manage. Network management vendors IBM, AT&T, DEC, and EDS for example, are vendors that leverage their manpower, equipment, and expertise to market comprehensive network management services.

If we take a closer look at network management in 1995, the following characteristics are found:

### 4.1 Hardware / Software Fault Tolerance

Key network hardware devices (LAN servers, LAN gateways, INPs, X.25 switches, etc.) are built to tolerate hardware and software faults. They operate in locked-door, lights-out environments. Redundant processors, data transfer buses, memory units, and disk storage devices automatically assume operation when a hardware or software fault is detected.

Research Triangle Park, the EPA headquarters, and the Regional Sites, are equipped with Uninterrupted Power Supplies (UPS) for communications equipment and critical LAN servers. The UPS system protects the local servers and maintains remote site communication service during nominal power disruptions.

Application and operating systems software are designed to tolerate detectable hardware and software faults. Lights-out, unattended operation requires successful system and application software re-starts following service disruptions.

### 4.2 Software Distribution and Control

Communications and operating system software for network equipment, LAN servers, and national applications are validated, maintained, and distributed from a central location. Configuration software and executable code are electronically distributed to all sites. National application program changes are coordinated via the central change control process.

NDPD installed, operated, and maintained LAN servers support Agency standard communications software and national application software at each site. PC and workstation software releases and version number validation routines are used to ensure application consistency throughout the Agency.

## 4.3 Distributed Management/Centralized Reporting

Intelligent communications software (X.25, LU 6.2, etc.) allows the PC and workstation to establish and maintain both application and network management sessions. Poor network performance, application time-outs, high error rates, and lost connections are reported directly to the network management system. Device and application generated problem reports are required to manage the seamless connection, distributed processing environment of the future.

Specialized systems manage hardware, software, and communication facilities. SNA and token ring LANs are monitored and controlled by Netview. Other EPA network components (INPs, X.25 switches, modems, and multiplexors etc,) use their proprietary management systems for fault identification and correction. As significant events occur, the proprietary systems notify Netview according to pre-established reporting rules. Software generated alarms are forwarded to Netview as well.

A central management system oversees the operation of the entire network. The central system (e.g, Netview, EMA, or UNMA) collects significant event and activity data from each of the individual management systems (see FIGURE 4). The data is evaluated, filtered, and correlated based upon the relationships defined in the configuration database. The central management system uses this information to segregate the symptoms from the problems and suggest a restoration action when determinable.

Substantial processing power and disk storage are required to perform the central management functions. Expert systems applications diagnose network problems, manage configuration data, and collect and analyze performance data.

## 4.4 Problem Management

The central network management system, Netview, the modem diagnostic system, and the diagnostic system of the INPs cooperate in problem determination and problem management. Intelligent communications software in each of these devices detect and report problems, and attempt to re-establish connections and improve performance based upon available resources.

CENTRAL / DISTRIBUTED
NETWORK MANAGEMENT

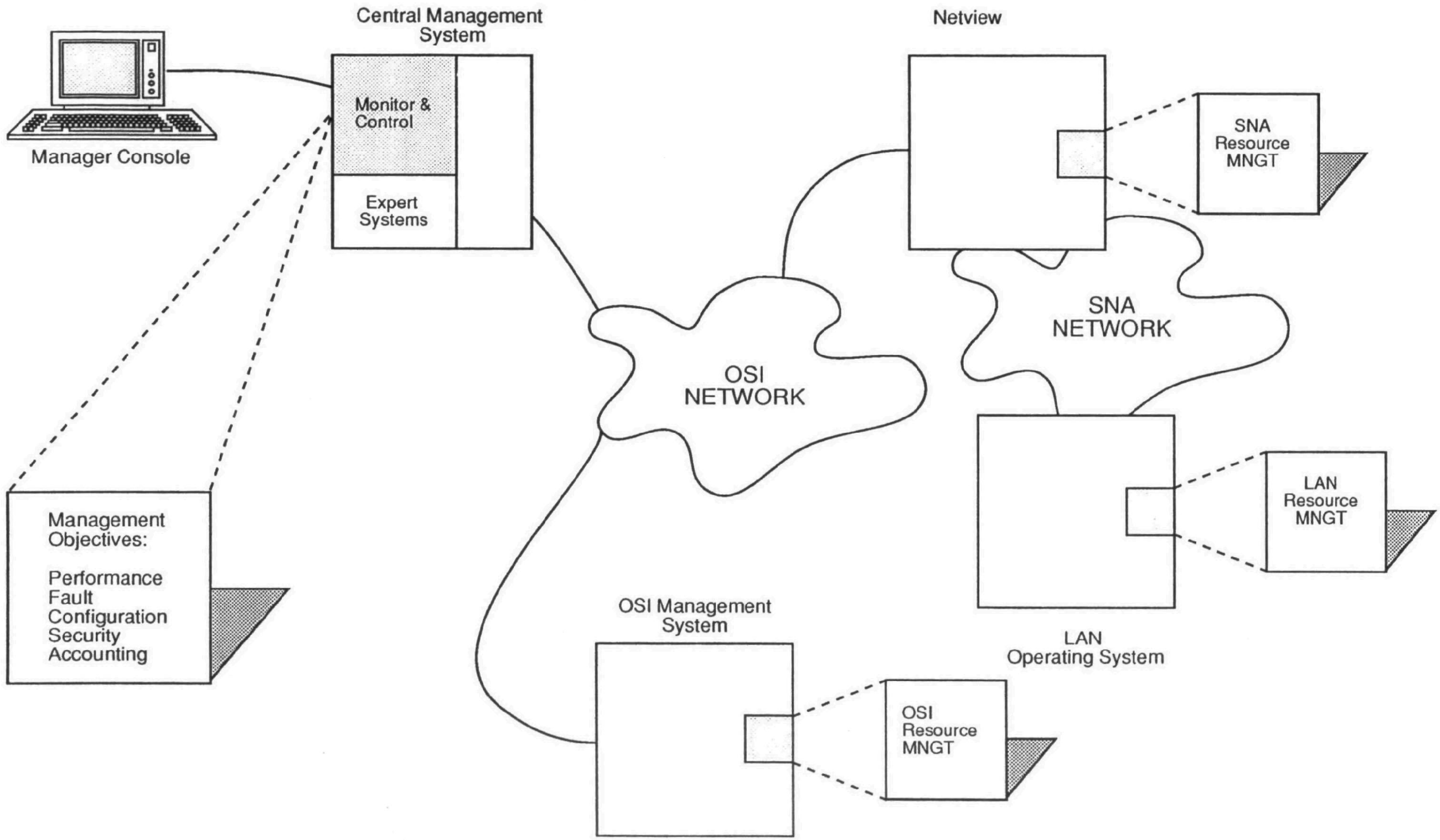


FIGURE 4

The central management system continually updates the network status. Service disruptions and recurring error conditions are forwarded to the expert analysis systems. Historical data of recurring events is analyzed to detect and avoid repetitious failures.

### 4.5 Change Control/ Configuration Management

Problem determination systems and directory services are heavily dependent upon an accurate configuration database. Automated systems generate much of the data, however, periodic manual updates and verifications are needed to guarantee complete accuracy.

### 4.6 Capacity Planning

Performance data collection tools are significant aids in capacity planning. Performance and utilization data are correlated with event data to produce a comprehensive picture of how and when the network is used and when it is used. It also depicts overall network utilization. The captured network usage data, along with new application data requirements, allow network planners to model various scenarios for adding and re-configuring services.

### 4.7 Accounting

Intelligent communication processors capture session and network usage data that is entered directly into network accounting systems. Directory services and configuration databases contain the data needed to correlate the utilization data to users.

### 4.8 Security

Switched (dial) network connections are more prevalent in 1995. An expanded community of dial-in users, a home work-force and public access for example, connect to the Agency backbone with inexpensive switched services. The expansion of dial-in services presents additional security risks.

EPA ISDN servers use the Automatic Number Identification (ANI) feature of ISDN to identify a caller's telephone number. Pre-subscribed and valid numbers are granted network access without an additional network signon. Calls which do not have a verifiable ANI are required to enter a network logon and password.

Regular and established users have security profiles integrated into the directory services. The profiles are compared to the network user address to determine signon validity at session initiation time. The directory services forwards an ecrypted version of the validated id to circumvent multiple log-in requirements.

**Summary**

As the options for connectivity, data location, and application location increase, so do the requirements for network management in 1995. The complex environment and endless possibilities for communications among intelligent devices make manual network management impossible. Automated network data management reporting systems, relational databases, and expert systems are adopted to cope with the demands of an Agency-wide network. The investment expense and expertise needed to perform comprehensive network management dictates that network management be conducted by contractors specializing in network management.

OSI network management standards are potential solutions to multi-vendor network management integration, however, political pressures have and will impede the development and implementation process. Furthermore, the standards process has difficulty keeping pace with new service offerings and technical advancements. Consequently, proprietary, expert system driven network management systems (i.e., Netview, EMA, etc.) are the vital management tools throughout the near future.

## 5.0 MIGRATION TO THE VISION NETWORK

New communication services will be added to the EPA network as service demands dictate and as affordable technological solutions become commercially available. New hardware and software will be introduced in stages so that neither users nor implementors are overwhelmed by massive change. An orderly migration will be needed to reach the goals established for the 1995 network.

A solid infrastructure will be needed to provide the services demanded in 1995. The Agency's local area and wide area data highways (LANs and backbone network) will be upgraded to accommodate the large volume of traffic generated by applications such as scientific visualization, image, and video conferencing. Fiber LAN backbones and powerful LAN servers will expand the capacity of LANs while T1 and T3 circuits will expand the capacity of the backbone network. On-demand switched digital services, ISDN for example, will further supplement the backbone network creating a network infrastructure that will be flexible and responsive to service demands.

Special purpose networks, Extended-LAN, video, and image processing networks, for example, will be built on top of the transmission plant foundation. New network services, including file transfer, document transfer, and cooperative processing, will utilize new and existing networks to deliver these functions to the EPA network users (see FIGURE 5).

Service delivery will be guided by user demand and commercial product availability. The users may want new functions, directory services for example, before commercial products are sufficiently mature to warrant implementation. FIGURES 6, 7, and 8 depict the EPA's service implementation schedule based upon the anticipated service demands and mature product availability. Note the dashed lines depict an initial deployment and testing phase, and the solid lines depict wide spread implementation.

A network modernization program will occur from 1990 through 1995. As part of that modernization program, the Agency will implement new hardware, software, network management, and transmission services. FIGURES 9, 10, and 11, depict the implementation schedules for these respective components.

Implementation schedules will be influenced by a variety of factors including, standards development, pricing, product maturity, service demand, and budgetary constraints. The schedules identify four phases of acquisition and implementation based upon today's understanding of technology viability and service demands. They are as follows:

- Study - white paper analysis of technology
- Evaluate - marketplace survey, alternatives and impact analysis
- Procure - procurement activities and contract(s) award
- Implement - phase 1 implementation, testing, and functional validation
- Support and Update - full implementation and ongoing support.

Once the five year implementation schedule has been approved by EPA management, it will guide future planning and budget activities in years 1992-1994.

# NETWORK SERVICES IN 1995

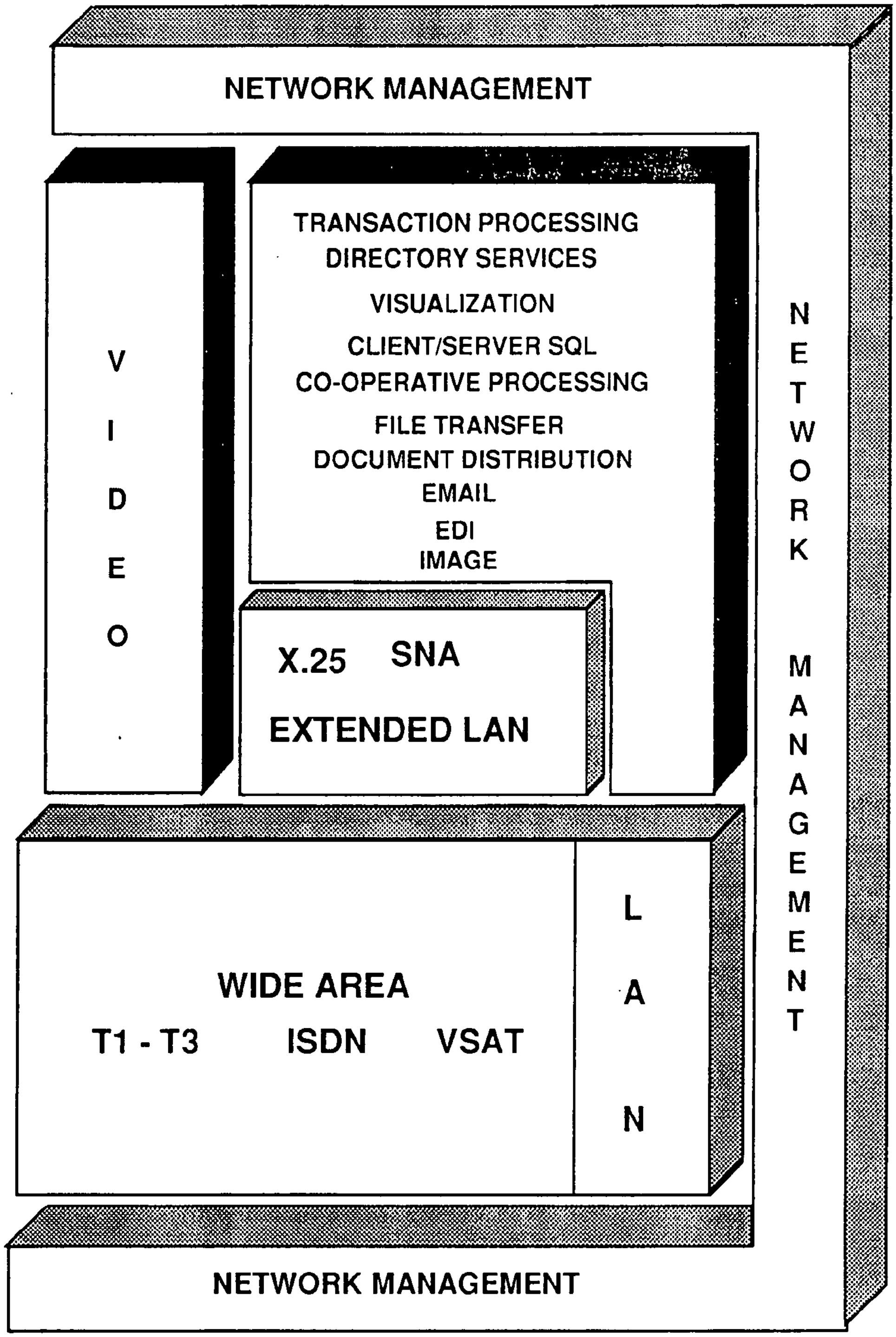


FIGURE 5

# TELECOM SERVICES

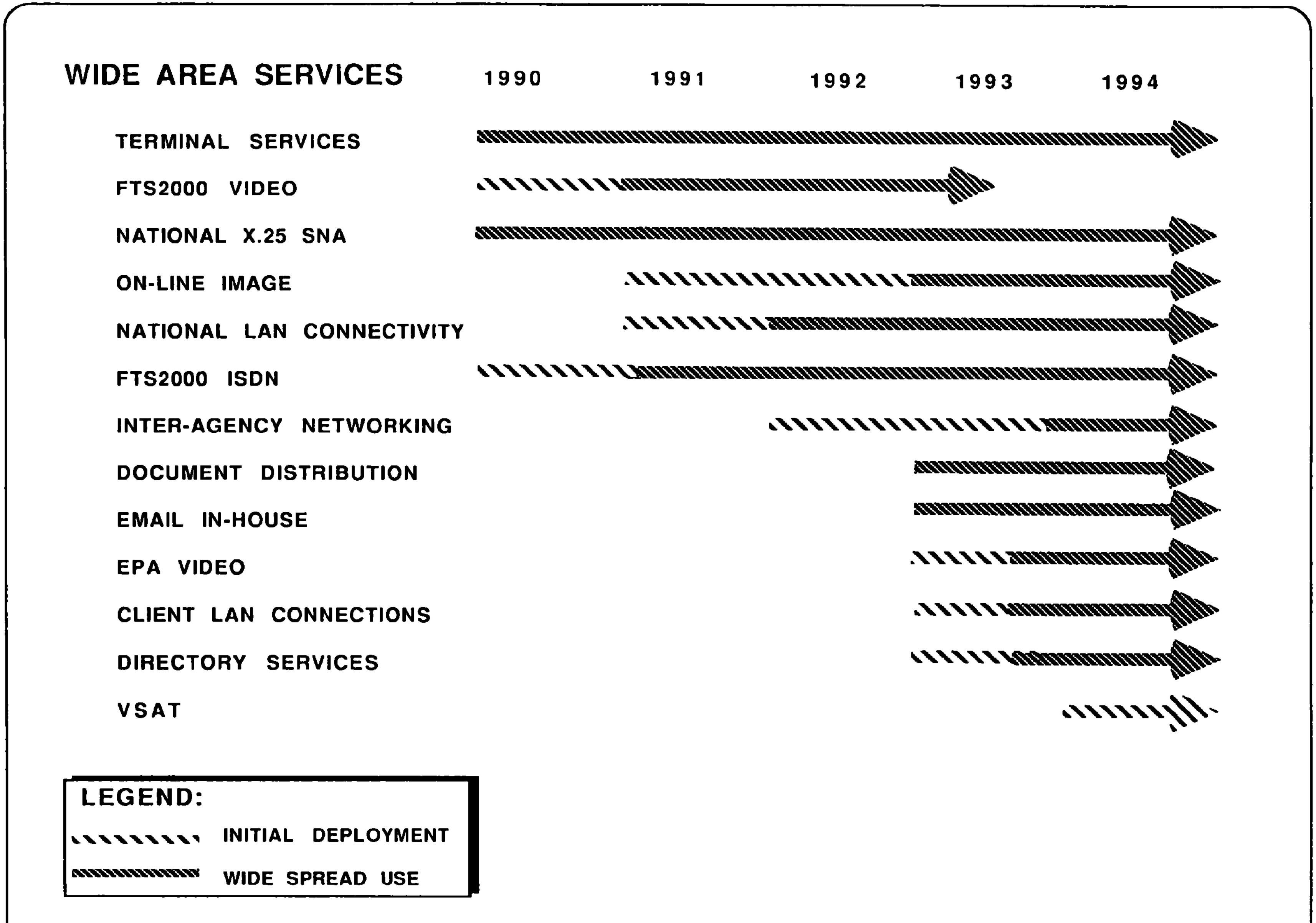


FIGURE 6

## TELECOM SERVICES

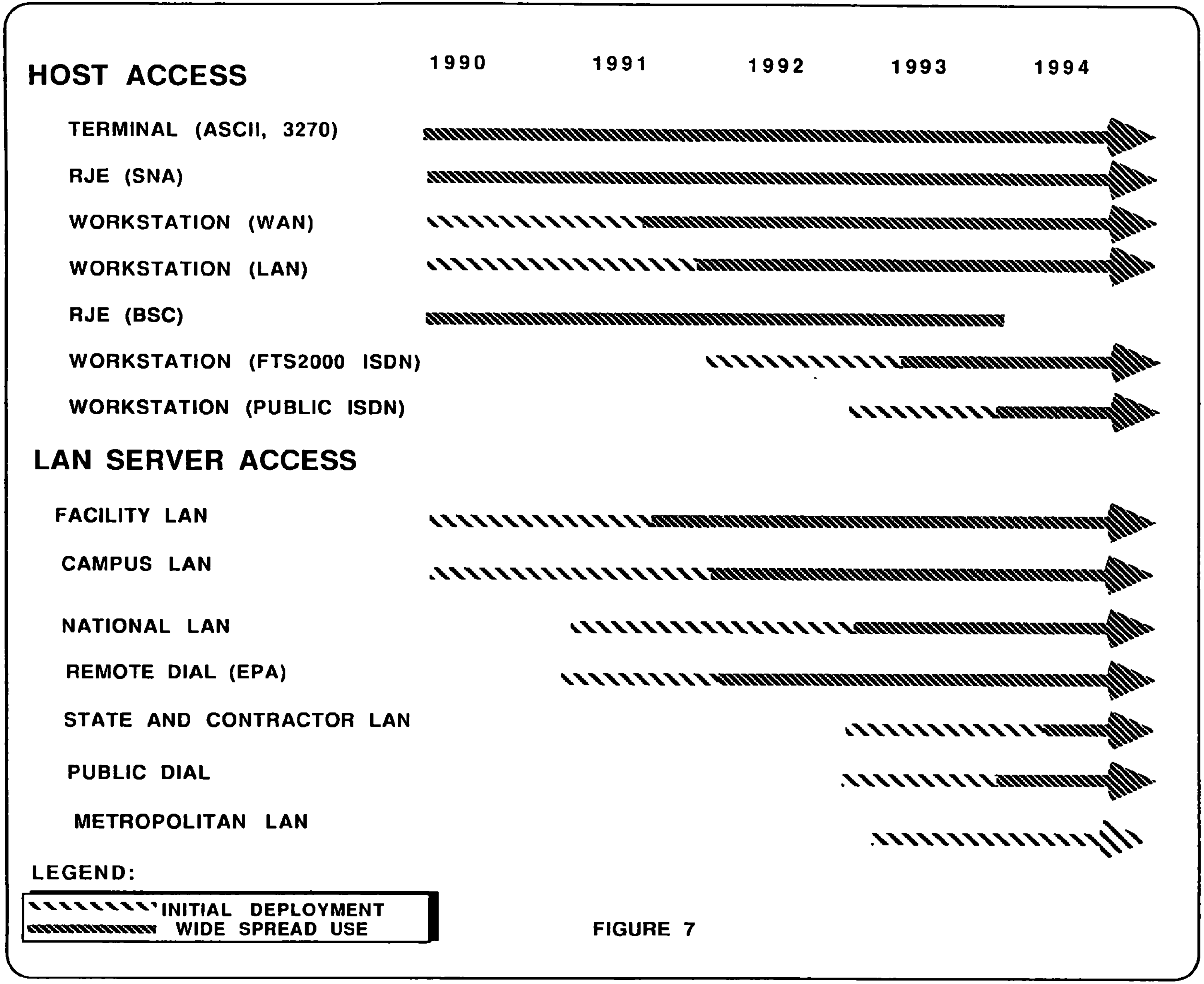


FIGURE 7

# TELECOM SERVICES

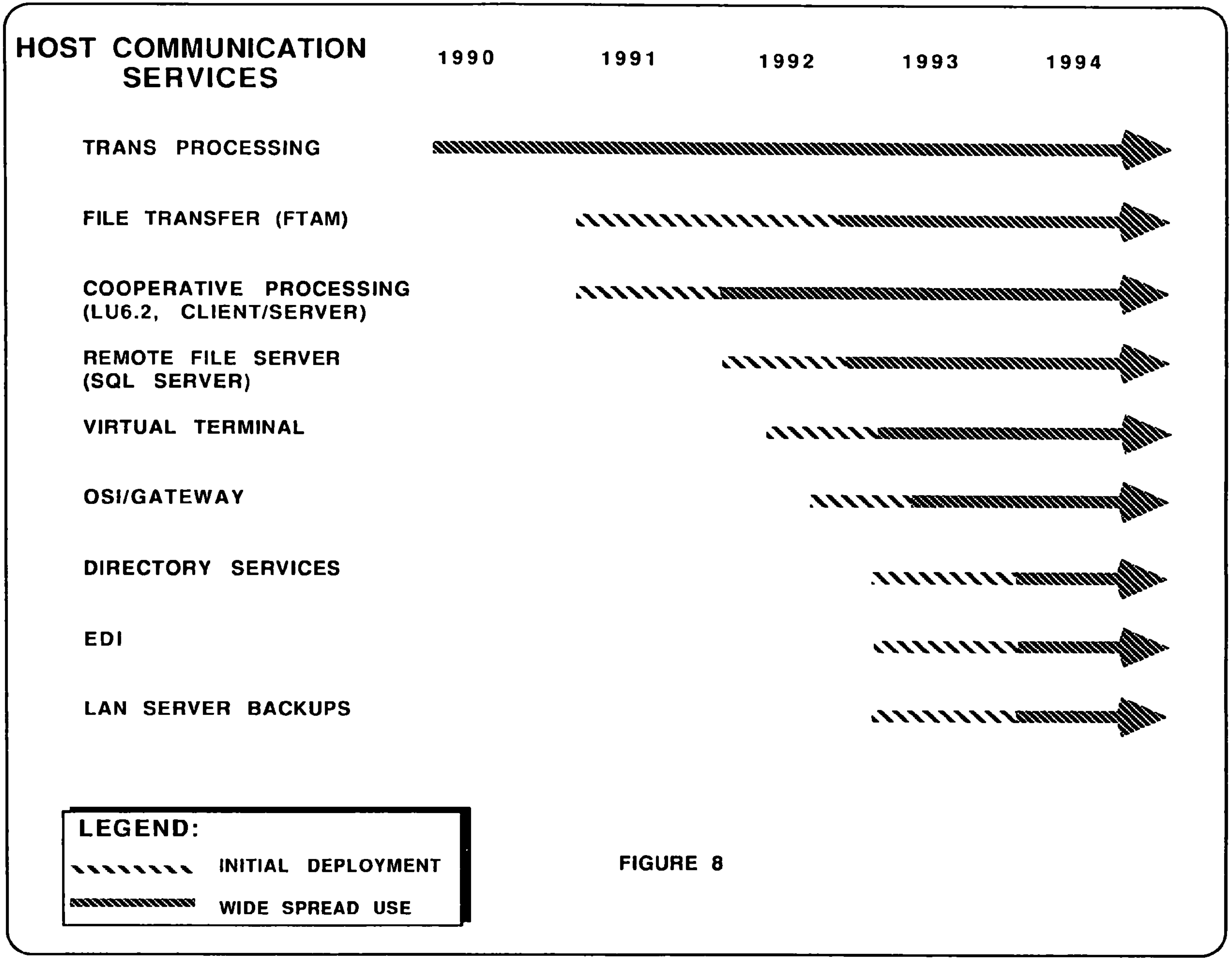


FIGURE 8

## MAJOR HARDWARE ACQUISITIONS

| Product | | | Year | | |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 |
| Campus Bridges | Implement | Support and Update | | Reevaluate | |
| WAN Routers | Study and Evaluate | Procure and Implement | Support and Update | | Reevaluate |
| INPs | Study | Evaluate | Procure | Implement | |
| LAN Communication Servers | Evaluate | Procure and Implement | Support and Update | | |
| FDDI | Study | Evaluate | Procure | Implement | Support and Update |
| X.25 Switches | Implement | Support and Update | | Reevaluate | |

FIGURE 9

# MAJOR SOFTWARE AND SERVICE ACQUISITIONS

| Product | Year | | | | |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 |
| X.400 | Evaluate and Procure | Implement | Support and Update | | |
| FTAM | Evaluate | Procure and Implement | Support and Update | | |
| Directory Services | Study | Evaluate | Procure | Implement | Support and Update |
| EDI | Study | Evaluate and Procure | Implement | Support and Update | |
| Cooperative Processing Software: LAN & Host | Study and Evaluate | Procure and Implement | Support and Update | | |
| Video Conferencing | | Procure | Implement | Support and Update | |
| T1 Circuits | Procure and Implement | Support and Update | | | |
| T3 Circuits | | Study | Evaluate | Implement | |
| 802.6 MANs | | | Study | Evaluate | Procure and Implement |
| ISDN | Study and Evaluate | Procure | Implement | Support and Update | |

FIGURE 10

# MAJOR NETWORK MANAGEMENT ACQUISITIONS

| Product | Year | | | | |
|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 |
| Proprietary Products (Netview) | Implement | Support and Update | | | |
| OSI Based Products | Study | Evaluate | Procure | Implement | Support and Update |
| NM Integration Tools | Study | Evaluate | Procure | Implement | |
| Expert System Applications | | Study | Evaluate | Procure and Implement | Support and Update |

FIGURE 11

## 6.0 CONCLUSION

In the 1980s the EPA modernized its telecommunications network to replace batch systems with on-line systems and replace line mode terminals with full screen display terminals. The modernization effort produced many tangible benefits including improved productivity, data collection, and information retrieval.

Standardization on the 3270 device and SNA was a key strategy for the 1980s modernization. Emphasizing the 3270 allowed the developers to write applications for a single terminal interface. SNA simplified the network design, upgraded terminal access speeds, and improved network support. As a result, service and reliability were improved.

As the decade proceeded, X.25 also emerged as a strategic communications vehicle for the Agency. ASCII terminals were migrated from public data networks onto the Agency X.25 network to improve service to DEC, Prime and EMAIL systems. DEC and Prime systems also took advantage of the X.25 network to communicate within their respective communities. As with the SNA network, the X.25 modernization greatly improved user services and support.

A new modernization plan will emerge in the 1990s. The proliferation of intelligent devices and the availability of discretionary computing and data storage sources will generate data transmission requirements that the 1980s network (designed for ASCII and 3270 devices) cannot accommodate. Image transfer, video, document interchange, and other applications will generate the additional data traffic that necessitates modernization.

Although reliable data communication services have always been important, in the 1990s it will become imperative. Computing and telecommunications will be integrated further into the workers basic job functions, creating a communication dependency that may have no substitutions. Electronic imaging and electronic document distribution, for example, will circumvent the need to photocopy originals and distribute paper copies. When electronic distribution methods displace paper distribution methods, the network must become extremely reliable.

Technological advancements will dramatically increase the number of telecommunication services and their potential transmission capabilities. At the same time, costs for these powerful and flexible services will decrease dramatically as fiber and computer technology continue to improve. As a result, while Agency services may increase tenfold from now until 1995, their corresponding costs do not increase proportionally.

The infusion of special purpose processing devices, LAN servers, scientific workstations and image processors for example, compound the problem of integrating data located on diverse computing systems. A mixed environment of state computer systems further magnifies the problems which inhibit data integration. The requirement to integrate data, internal and external, necessitates the adoption of standard application and data communication techniques. Of these standards, OSI and IBM's SAA embraced protocols, appear to be most advantageous to the Agency.

Standards development and acceptance, however, is a political process. As such, it can be fiercely competitive and very slow, sometimes taking four or more years to complete. Technological advances, however, are emerging daily thereby creating a service availability/standards gap which forces tough decisions concerning non-standard implementations.

By 1995, existing and emerging standards for telecommunications hardware and transmission services are well defined and available in off-the-shelf products. IEEE 802.3, IEEE 802.5, IEEE 802.6, FDDI, ISDN, T3, and other accepted standards make it possible for vendors to offer expansive transmission bandwidth for local and wide-area networks. EPA will use the high bandwidth services to support image, video, graphics, and Extended-LAN requirements. Standard network protocols, LU 6.2, SNA, X.25, GOSIP, OSI LAN routing, and ISDN, for example, provide the connections needed to support the various Agency terminal and processing platforms.

While transmission service options abound because hardware standards are widely accepted, software standards do not have similar universal acceptance. As vendors increasingly distinguish their products through software capabilities, they are reluctant to adopt standards that mitigate their competitive advantage.

Slow standards development not withstanding, the EPA must invest heavily in software to provide the file, document, and data distribution services the Agency needs in 1995. Software standards, LU 6.2, SQL Client/Server, X.400, ODA, CGM, FTAM, and others, are key components of the modernization plan. Additional investments in network management systems and directory services are also required to make network services reliable and transparent to the end user.

Thus the challenge of the 1990s will be the creation of a consistent software environment that fully exploits the information processing capabilities afforded by powerful CPUs and high speed telecommunications.