An application of network management at a large computing service

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Productive operation of a large computer network serving multiple user facilities in conjunction with several host sites requires the use of network management. As treated here, network management includes an array of such methods as communication systems management, problem management, change management, and inventory management. In this paper the use of some of the management techniques is described as they apply in an education support facility network. The setup of the facility is first described; then some of the techniques for managing its operation are presented.

Any large computing system that serves hundreds of users by means of remote terminal devices and accesses a large number of host applications is certain to present many challenges in its operation. If additionally, however, the hardware and software must be frequently updated to the latest types and versions available, the challenges become more interesting. Furthermore, if most of the actual users of these services change on a weekly basis, the complexities of the network operation can become serious.

Such a situation exists within the education center environment of IBM's National Accounts Division (NAD), the marketing unit serving IBM's largest customers. Most customer technical education and IBM field personnel technical training within NAD is provided by the Department of Technical Education through various education centers located in many major cities throughout the United States as shown in Figure 1.

Computer service for laboratory exercises and for course development of classes is supplied to the Department of Technical Education by an NAD facility known as Education Computing Services (ECS), located in Dallas, Texas. ECS evolved from a consolidation of small data centers that originally numbered more than 20. A network of data communication links from ECS to the teaching locations provides access from terminal devices to computing services distributed across several central processors in Dallas—four IBM 3033 systems and one 3032 system (Figure 2).

Currently, over 600 classes requiring laboratory and demonstration exercises are taught to over 20 000 customer and IBM personnel per year. As the complexity of the requirements has grown, so also has the sophistication of the hardware, software, networks, and particularly, the management control systems that are available. The need for effective communication systems management also increases as the network grows. IBM's Systems Network Architecture (SNA)[1] permits the independent development and growth of application-oriented host computing systems and their communications systems. In a similar fashion, system management techniques apply in unique ways to the central computing facility and to the communications network.

This paper describes the ECS network as an application in which some of the challenges and some of the solutions related to managing an information systems network are represented.

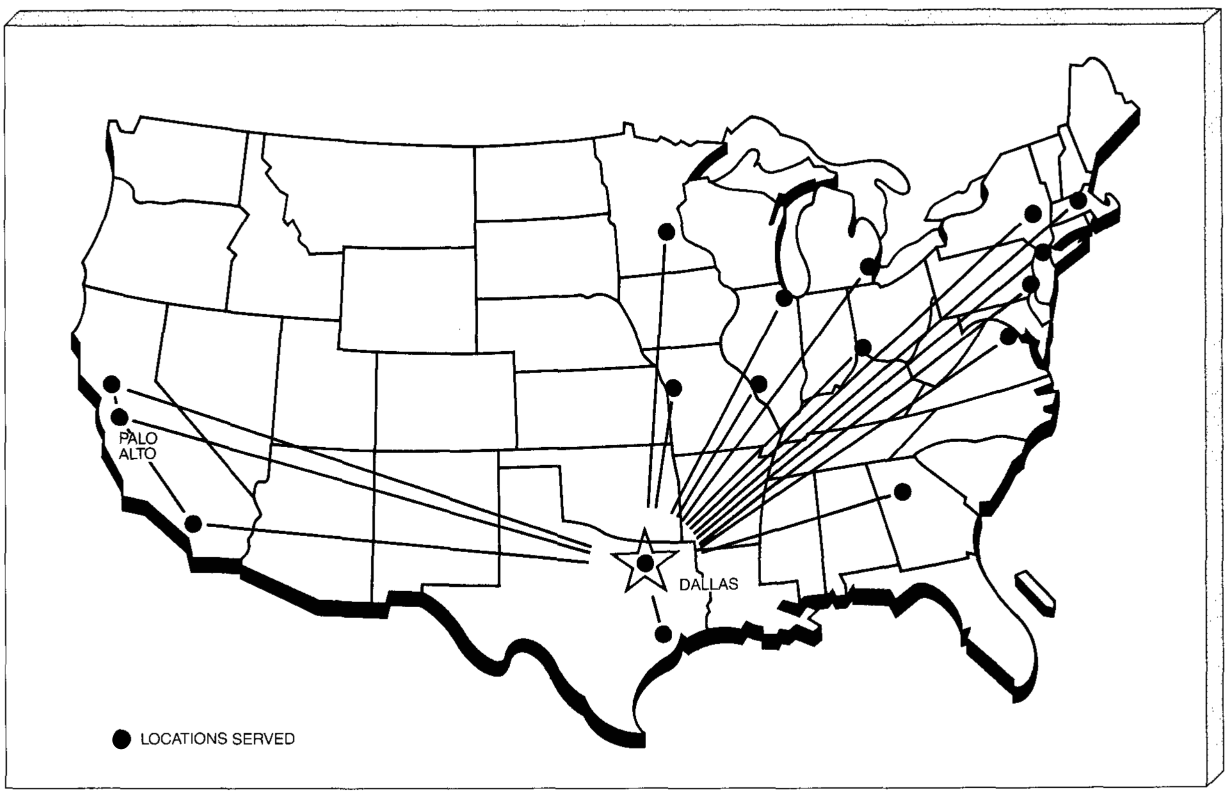
The ECS network

An information systems network is established to support the remote user. The network encompasses everything necessary to provide a connection from the user to a host computing service, including the terminal devices that are the user's interface to the computing facility, terminal control units, modems or equivalent devices, the data communication link facilities, and the communication control units attached to host computers.

A network permits a "remote" computing facility to appear to the user to be "local." The network should be as unobtrusive and transparent as possible while providing service from the host facility. If the host is giving simultaneous service to other users and even if multiple hosts and applications exist, it should be of no import to each individual user.

Supported locations. The ECS network currently spans the continental United States to support the education centers (Figure 1). Four are Advanced Education Centers (AECs), with larger staffs and facilities. High-technology courses are offered at the AECs and are generally scheduled more fre-

Figure 1 Education Computing Services network



quently than in the other cities. Thus, terminal facilities and communication links to these centers are more extensive than those serving the smaller centers.

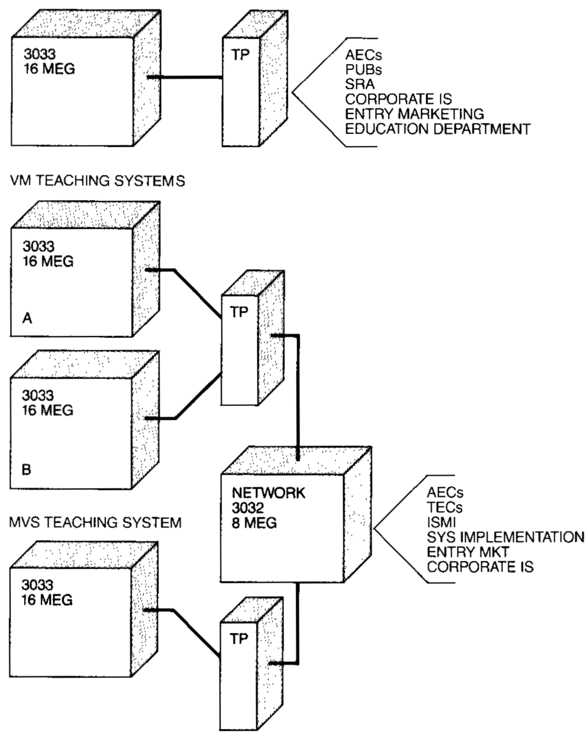
Smaller education facilities are known as Technical Education Centers (TECs) and typically contain about half the terminal facilities of the larger centers. ECS also supports the IBM Information Systems Management Institutes, Marketing Training, and Corporate Information/Systems for development and teaching.

The ECS host computers in Dallas are also interconnected to the National Data Center facility of the IBM Information Systems Group in Palo Alto, California. This interconnection was established in 1980 because of the commonality of the cities served by the two host sites. This combination has reduced communication costs by establishing subnets from each host and then providing interhost traffic over fewer lines at higher speeds.

An information network is established to support the remote user.

The eastern and central portions of the country are tied primarily into Dallas and the west coast locations attach to Palo Alto. Data traffic can travel from a terminal connected to one host and then be forwarded to the second host for processing. This routing is referred to as "cross-domain" traffic. The high-speed links between the two hosts are "cross-domain links." Since all such service is provided using SNA, locations can reach either host location on a terminal that can alternatively be in session with either one of the hosts. Currently other hosts can be accessed from the network either through the Multisystem Networking Facility (MSNF) of the Advanced Communication Function/Virtual Telecommunication Access Method (ACF/VTAM) or the

Figure 2 ECS hardware configuration



VM/Pass-Through Facility[2] of the VM-based host systems.

The leased-line communications network serving the AEC and TEC locations is augmented by switched-line (dial-up) facilities at the Dallas and Palo Alto host sites. These facilities are provided so that courses may be conducted with computer-based exercises at other than education center locations by way of a dial connection.

Terminals. The types of computer terminal devices traditionally used by students in IBM education courses have been batch remote job entry (RJE) workstations and interactive keyboard/display workstations. Many courses use batch job lab exercises. Punched card decks are prepared and modified by students using keypunches and are then transmitted to the host systems using remote batch workstations. The printed output of an assembly, compile, or execution performed at the host is then returned over the network to the printer at the remote workstation. ECS service level objectives specify return of batch jobs to the user in 15 minutes or less. This implementation is a network-enhanced version of the earliest laboratory exercises that required a computer system at the teaching location, where the students used card readers and line printers that were directly attached.

The use of interactive display terminals was originally limited to those courses in which such terminals were a key part of the course lab exercises. Interactive display terminals are now, of course, far more familiar to most students in their own organization's day-to-day activities than are keypunches. In keeping with this industry trend, most lab exercises are prepared using displays as the most effective job preparation tool. The displays may be attached to the host via the network through a display controller or may be connected to distributed data processing systems, such as the IBM 8100 Information System or 4300 computer system. Output is returned over the network to the submitting student's display terminal, to a line printer attached to a controller, or to a nearby distributed processor. Display terminals used on the ECS network are primarily components of the IBM 3270 Information Display System.

ECS is typical of many installations using a large network.

The display controllers and the batch terminals are Synchronous Data Link Control (SDLC) models which allow line sharing by interactive and batch terminals, permitting better utilization of the network facilities. VTAM in the host computer and the Network Control Program (NCP) in the communications controllers are the primary communications control software at ECS.

The display systems were recently converted to the IBM 3274 Control Unit with IBM 3279 Color Display Stations and associated 3287 Printers with color capability. 8100 Information Systems with IBM 8775 Display Terminals are attached as distributed processor systems for student job preparation as well as serving as laboratory systems. Other terminal types used for special purposes include the IBM 6670 Information Distributor, the IBM 3767 Communication Terminal with printer/keyboard capability, and the IBM 3101 Display Terminal with asynchronous dial-up capability.

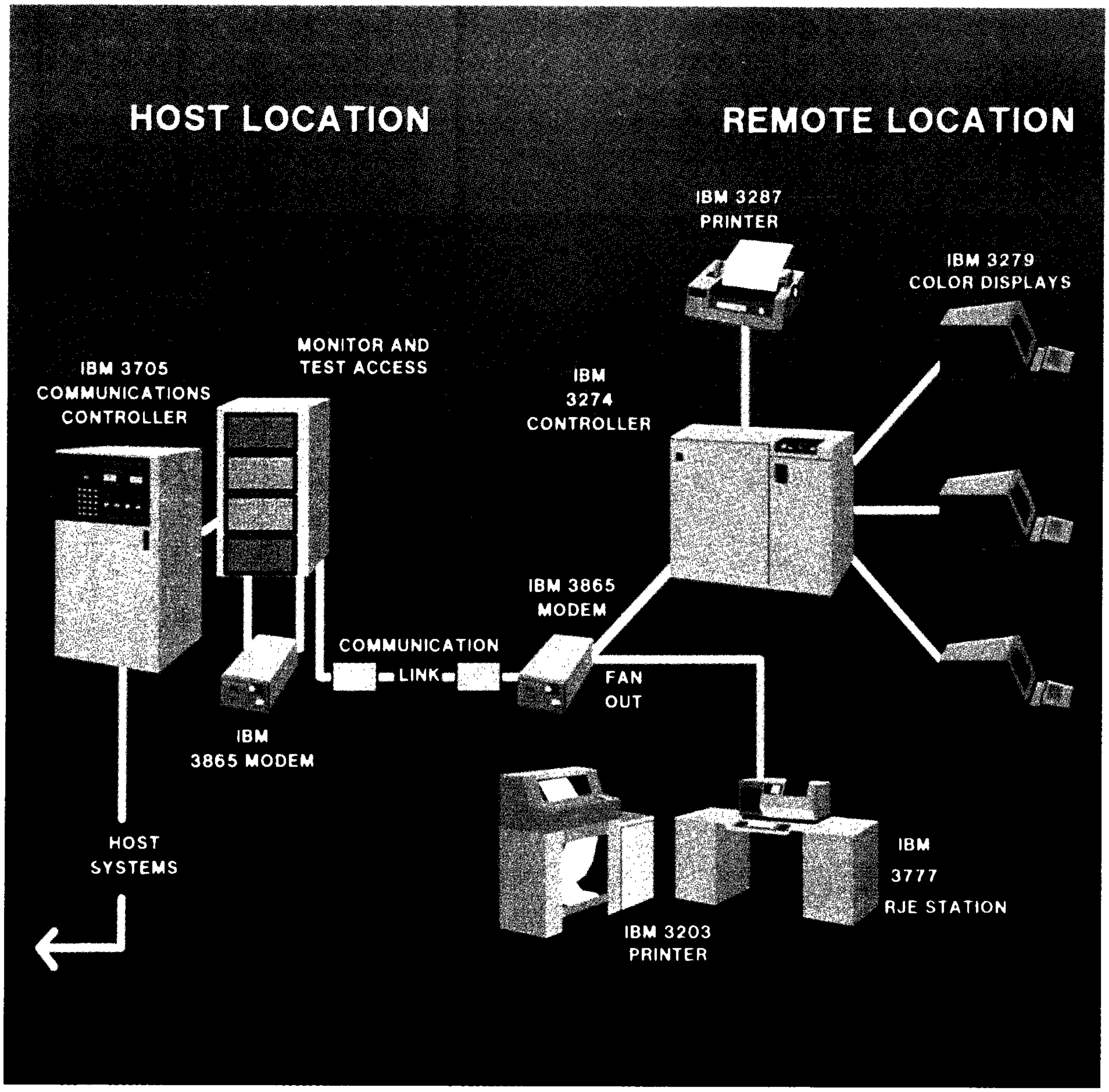
The configuration of terminal equipment at any of the education centers on the network usually consists of multiple batch and interactive terminals. These units connect to the network through a modem to a communication facility linked to the nearest major host on the network, as represented in Figure 3.

Data communication links and modems. The data communication facilities utilized by the ECS network are mostly voiceband private lines (type 3002) with modems on each line. Currently the network is primarily using IBM 3865 Modems, which are microprocessor-based and have significant diagnostic capability that is exploited by SNA-based communications control programs. Reference 3 presents a detailed discussion of this interaction. The new IBM modems,[4] the 3863, 3864, and 3865, permit monitoring of the status and testing of the modems and the lines in the SNA environment using the Advanced Communication Function/Network Control Program (ACF/NCP), with the Network Communications Control Facility (NCCF) and the Network Problem Determination Application (NPDA) programs. (See the later discussion under "Network Monitor and Test Facilities.")

Features available on modems such as the IBM 3865 permit the user to split a physical communications path into several logical paths of lower individual speed. This technique is called Data Multiplexing (Figure 4). For example, in the case where an IBM 6670 Information Distributor may not require 9600 bits per second (bit/s) to maintain throughput requirements and a standard Binary Synchronous Communication (BSC) 3271 Control Unit does not operate at 9600 bit/s, the two units may use individual 4800-bit/s subchannels on a single 9600-bit/s link from a particular education center to one of the systems in Dallas.

As the ECS network has progressed in implementation of SNA, the use of the modem fan-out feature has expanded. On the 3865 modem this allows attachment of up to three teleprocessing control

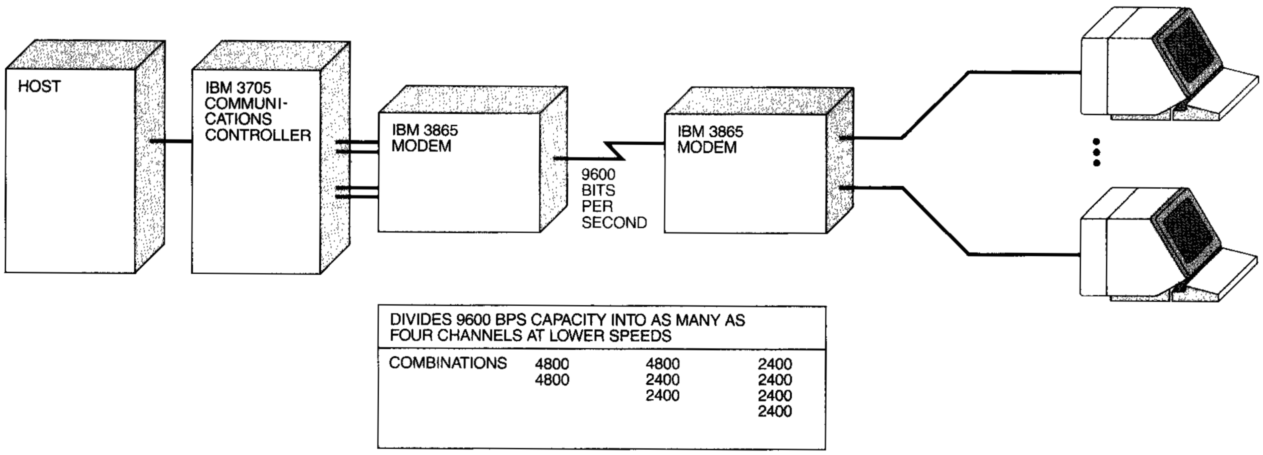
Figure 3 Typical configuration for a single remote link to an education center



units to the communication link, each operating in multipoint mode (alternately) at the full line speed capability of the modem. The ECS configuration contains many links where both an IBM 3777 Model 3 RJE terminal and an IBM 3274 Model 31C display controller are supported on a single line from an education location to the host (Figure 3).

In addition to voiceband analog lines, another type of data communication line now in use by the ECS network and many others is digital communication service such as provided by American Telephone and Telegraph's Dataphone® Digital Service (DDS). With DDS the information stays in digital-coded form from the remote terminal equipment through

Figure 4 Data multiplexing



the network facilities into the communications controllers at the host computing facility. Digital facilities are available at the typical data rates of modems but are also available at 56 000-bit/s data rates. Circuits with the 56 000-bit/s rate are utilized on portions of the ECS network and provide very efficient links between communications controllers. Such links are currently installed between Palo Alto and Dallas. They are also used to attach a remote communications controller at the IBM Marketing Training Center near Dallas where many workstations and cluster controllers are installed in a single building. The Palo Alto-to-Dallas link is thus a cross-domain link between hosts, whereas the remote link in Dallas provides a concentrating function of many low-speed links in the SNA-based network over fewer high-speed digital links.

Host services

ECS is typical of many installations using a large network. Thus it is worthwhile to examine the range of host services required by the individual users of the ECS network to understand some of its complexities and challenges. The students participating in the lab exercises, the instructors and administrators preparing, conducting, and supporting those courses, and ECS with its responsibility to provide and support the host computing and network services, together represent extensive and varied host services requirements (Figure 5).

The ECS network now provides Multiple Virtual Storage (MVS) service and Virtual Machine Facility/370 (VM/370) service, including support for the Conversational Monitor System (CMS), the Disk Operating System/Virtual Storage (DOS/VS), and Operating System/Virtual Storage 1 (OS/VS1). In addition, a third major host service, the VM-based Education Development System, is part of the network and provides computing service for class preparation and course development by the instructors and for instructor support.

A user's terminal may access various host facilities under control of the user at the terminal.

MVS host services. Host services provided on the MVS system include the language services of Assembler, COBOL, FORTRAN, PL/I, and APL; the utility services of Sort/Merge, data management, distributed systems host preparation, and command facilities; TSO (Time Sharing Option) with general-purpose time-sharing capability providing conversational remote access to the MVS environment; the data base/data communication products, Information Management System/Virtual Storage (IMS/VS), Customer Information Control System/Virtual Storage (CICS/VS), Generalized Information System/Virtual Storage (GIS/VS), and their many related supporting products. (See Figure 6.)

The MVS communications control software includes Job Entry Subsystem 2 (JES2) and ACF/VTAM with related support programs. Since the MVS-based host system provides the foundation for the operation of most of the ECS network, JES2 and VTAM are of particular significance in understanding the many facets of network management.

VM host services. The VM/370 host teaching systems provide the environment for classes on Virtual Storage Extended (VSE), OS/VS1, and special MVS systems. The VSE support includes the POWER/VS and CICS/VS subsystems, and the COBOL, PL/I, and RPG language support. The OS/VS1 systems running in the VM/370-based computing systems provide the guest operating system base for the Virtual Machine/VTAM Communications Network Application (VCNA) interface. The MVS systems running as guest operating systems on the VM-based hosts provide the basis for manipulation and testing of multiple MVS-based systems used in the lab environments in the Dallas and Washington education facilities. Students generate, test, and modify elements of their own tailored VTAM or Telecommunications Access Method (TCAM) components and systems. This configuration permits such activity without adversely impacting the operational systems for the on-line education network.

Other guest operating systems which are run in the VM/370 environment include migration and test MVS systems and the MVS system used as the base for teaching JES3 (Job Entry Subsystem 3) classes.

Other services provided on the VM/370 teaching hosts include CMS supporting conversational system facilities, and the Remote Spooling Communications Subsystem (RSCS) for batch input-output either to remote batch terminals or over the system interconnection facility of Network Job Entry Facility (NJE) to the MVS-based SNA network terminals (Figure 7).

Figure 5 ECS systems and network configuration

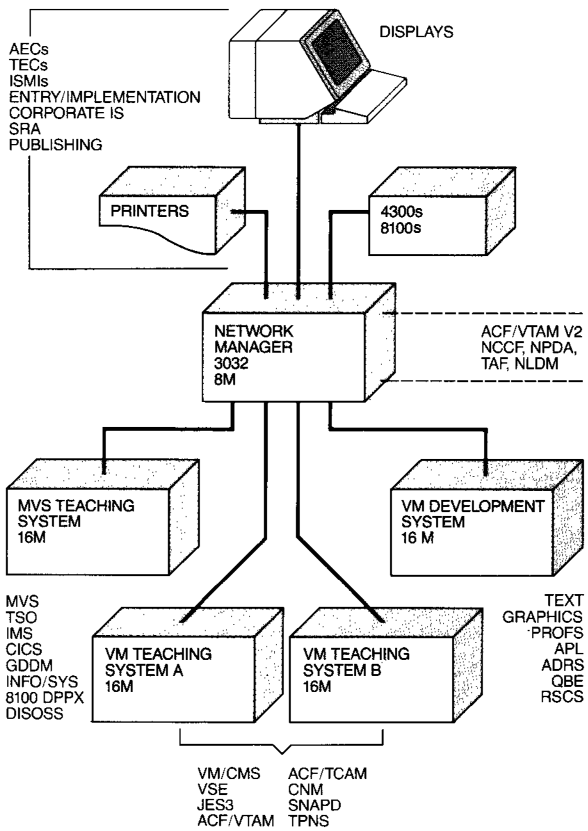


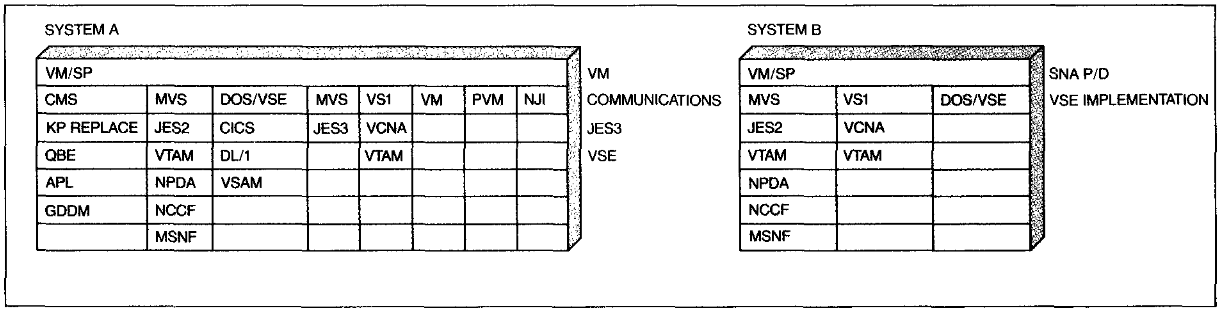
Figure 6 MVS host services

MVS/SP1			
VTAM	TSO	CICS	IMS
NCCF	GDDM	DMS	DATA DICTIONARY
NPDA	APL	DISOSS	
INFO	BASIC		
	INFO		

MVS
IMS
CICS
8100
GDDM
STORAGE SYSTEMS
OS IMPLEMENTATION
CORPORATE I/S

Education development host services. The VM/370-based computing system and associated network identified as the VM Development System serves the particular needs of course developers, text and self-study course publishers, and certain adminis-

Figure 7 VM/370 host services



trative and planning functions within the National Accounts Division education departments. The support subsystems particularly emphasize text preparation and editing, including these program facilities: A Departmental Reporting System (ADRS), Query-By-Example (QBE), APL, Professional Office System (PROFS), and support for various graphics terminals. The network for this development activity is essentially separate from the networks supporting both the MVS- and VM-based teaching systems, although interconnect facilities are in place (Figure 8).

System interconnections

The host systems of ECS are interconnected to permit user terminal access to multiple functions on multiple hosts. A user's terminal may access various host facilities under control of the user at the terminal. When ECS first began operations, the host site made the facility connections by switching communication lines to any of several host services. (See Figure 9.)

User access to multiple services is a valuable facility. If all terminals were dedicated to specific functions, much more hardware would be required at each education center. When the switching is controlled at the host site, the user's flexibility is reduced. Each type of system interconnection utilized has a particular impact on the management of the overall network of which they are also a part.

Multisystem Networking Facility. The Multisystem Networking Facility is a feature of ACF/VTAM which in conjunction with ACF/NCP/VS enables terminal logical units in one host processor domain to communicate with application program logical units in other host domains. A helpful overview is provided in Reference 5. An active example of this cross-domain communication results from the network consolidation established between the host sites in Dallas and Palo Alto. Terminals that are "physically" attached via network facilities to a communications controller at one of these two sites may, as required, establish a cross-domain session

VCNA provides the interface between an SNA network and VM/370 host facilities.

with an application in the other, more distant, site over the high-speed communication link between the two host locations. (For a description of another migration to SNA and the impact on network structure and management, see Reference 6. An earlier description of controlling a network of distributed CPUs from a central site is contained in Reference 7.)

Network Job Entry. Job networking is a facility for transmitting batch jobs and files from one host processor to another across network facilities. NJE for JES2 provides for job networking in an SNA environment.[8] Terminals anywhere in the network may submit jobs or files to be routed to any processor in the network. Similarly, job output files on any network host may be routed to terminals on another host.

Remote Spooling Communication Subsystem. The Remote Spooling Communication Subsystem (RSCS) of the VM/370 systems provides support for batch input/output for workstation terminals on the associated VM network and for batch traffic between interconnected VM/370 host systems.[9] The education network links the VM/370 teaching systems to the MVS teaching system with its NJE facility. Most batch workstations at the education center teaching locations are connected to the SNA network controlled by the MVS hosts. If batch jobs require execution on one of the VM/370 hosts, the NJE-to-RSCS interconnections forward the job and return the output to the submitting location, or any other location chosen by the originator.

Virtual Machine/VTAM Communications Network Application. VM/370 system users were limited to BSC and start-stop (asynchronous) or locally attached terminals until the VCNA program product became available. This limitation required the ECS network to support BSC for VM/370 users while the MVS-based network and terminals migrated to the SNA architecture and SDLC protocols. BSC support required that dedicated lines, controllers, and terminals be attached to each education location needing access to VM/370. One alternative, used in some situations, was to provide for the switching of those facilities by host site operators between communications controllers on the VM or MVS hosts as the class lab requirements changed, often quite dynamically. The switching was error-prone and a scheduling problem.

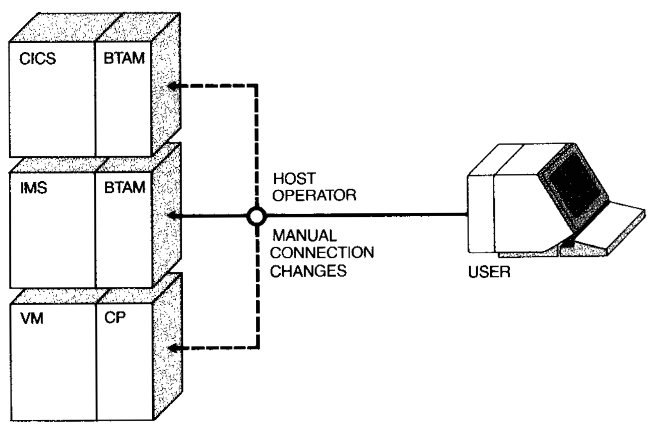
VCNA provides the interface between an SNA network and VM/370 host facilities. It is an application program[10] that provides an interface between VM/370 console support and the application program interface of ACF/VTAM. It provides VM users the advantages and capabilities of participation in a multisystem SNA-based ACF network. At ECS, VCNA consists of a VTAM service machine (VSM) using an OS/VS1 guest operating system supporting ACF/VTAM in each VM host. The VSM communicates with Console Communication Services of VM/SP (Virtual Machine/System Product).

Interactive terminals on the MVS-based SNA network of ECS can now establish sessions with the

Figure 8 Development host services

VM/SP						
PVM	RSCS	VS1	CMS			
		VCNA	TEXT EDITING FACILITIES		GRAPH.	PROFS
		VTAM	APL	SCRIPT		
			QBE			
			ADRS			
			ISPF			
			SQL			

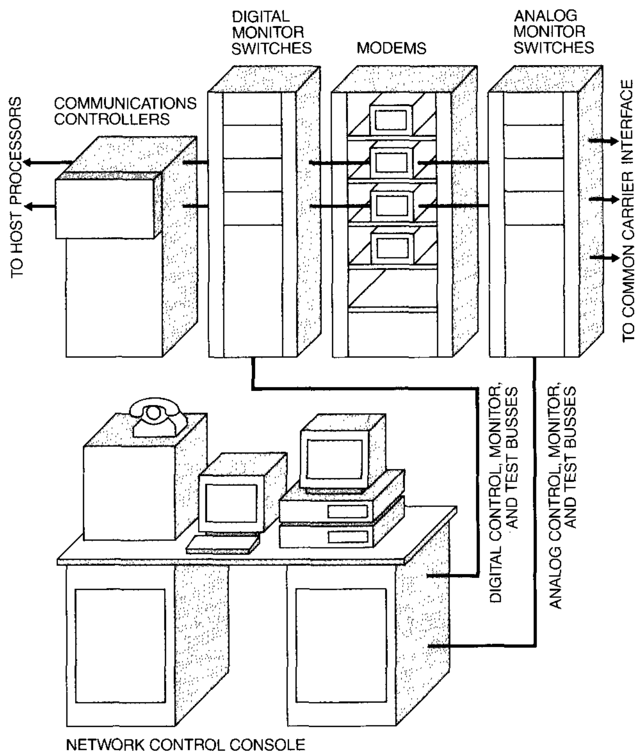
Figure 9 Early ECS multifunction support



VM/SP system services without use of facilities switching. A significant operational advantage from the problem management perspective is that all the MVS/SNA network diagnostic techniques can be applied to these facilities. We no longer must use the differing techniques of operation and diagnosis in the VM and MVS network environments. SNA techniques are considerably enhanced over earlier BSC diagnostics. Also, the SNA implementation provides greatly improved intermittent error recovery.

VM/Pass-Through Facility. For network or local interactive terminals that are attached to VM/370 systems, the VM/Pass-Through Facility provides remote access to other host facilities that support the IBM 3271 and 3274 Control Units over BSC lines. This program product supports connection from VM/370 terminals to other VM/370 systems or to OS/VS2, OS/VS1, or DOS/VSE host systems.[11]

Figure 10 Host communication facility schematic layout



When connected, as at ECS, to the SNA MVS host from a VM/370 teaching system, the VM/Pass-Through user has full 3270 BSC access to hosts on the SNA network. Each VM/Pass-Through BSC line supported in 3270 mode from the Pass-Through virtual machine will allow a maximum of 32 active users to concurrently share that line. In other network environments, VM/Pass-Through can serve as a first step towards full participation from VM/370 in a developing SNA network.

Communication facilities for host interconnection. Host system interconnection utilizes communication links between IBM 3705 Communications Controllers. These interconnections for the ECS systems are established using a mixture of medium-speed (voice-grade 9600 bit/s equivalent) and high-speed (equivalent to 56 000 bit/s) links. Some of these links are provided by communication common carriers, and some are implemented with local attachment features available on the controllers, determined by the physical locations of the communications controllers on the various host systems.

Network monitor and test facilities

The facilities available at the central host site for network monitoring and testing are consolidated primarily at the Network Control Center (NCC). Although some of the software facilities are available and controllable from other display terminal locations, most are invoked from the NCC consoles. Multiple techniques are generally needed during problem investigation and management. The NCC is the center of these activities. This centralization also tends to reduce the occasions when several individuals may be working independently on what may be the same problem.

Multiple techniques are generally needed during problem investigation and management.

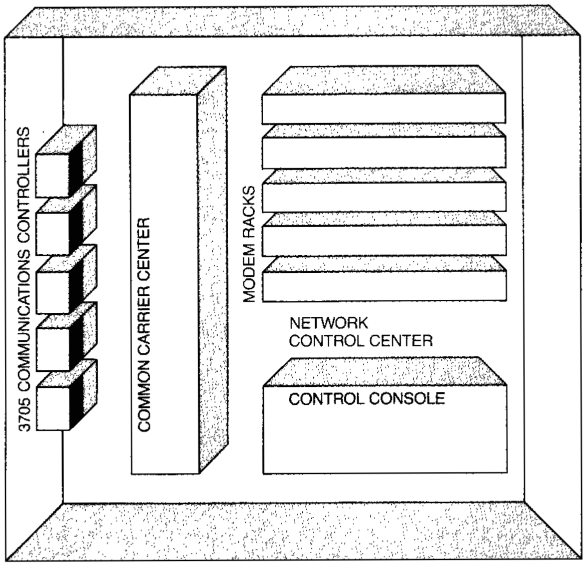
Facilities layout. The control center for the ECS network is currently organized around a Multiple Access Switching System (MASS+)® supplied by T-Bar® Incorporated. An early version of this system installed when ECS moved to Dallas has been expanded several times. The MASS+ configuration provides convenient access to both the analog and digital interfaces of essentially all modems at the central network site. This access permits the control center to attach monitor and test equipment on the busses brought to the control console under operator terminal control. The analog and digital interfaces of each modem are connected to MASS+ switch assemblies and are thus kept physically removed from the often busy console area (Figure 10).

The control terminals for the line selection on the MASS+ system and the analog and digital test equipment are the focal point for much network diagnostic activity. Analog monitoring is provided at the console by panels from T-Bar that include a signal level meter and an audio amplifier/speaker set. Digital monitoring and test use Spectron®

(Northern Telecom, Inc.) D-601 and D-901 Datascopes and a D-502 Datascope and associated T-511 tape unit. It is possible to use the Datascopes as an on-line monitor or for analysis of previously recorded line data from either another or the same incident.

Near the network control console are located display terminals providing console capability for the four major systems: MVS/teach, VM/teach A, VM/teach B, and VM/Development, as well as MVS/TSO and NCCF access. The modem area has modems arranged in enclosures with provision for eight modems each on individual shelves. The equipment enclosures housing the T-Bar analog and digital switch assemblies for the individual lines are grouped centrally within the modem area so that cable lengths are kept short (Figure 11).

Figure 11 Modem area layout



Digital monitor and test. The Datascopes provide indicators for display of the individual digital interface lead status. This often provides very useful diagnostic information in conjunction with the actual transmitted and received data on the video display. For convenience in analyzing the data as communicated, the display can be set to show only the transmitted or received data or to show both. If the data is being recorded for further evaluation, both directions of flow are recorded, with either or both capable of being displayed. Troubleshooting at this data analysis level requires knowledge of the line conventions and protocols and error indication characteristics of the hardware and software involved.

The selection of the line to be monitored or tested is controlled through the microprocessor of the MASS+ by the operator at the line access control console. Line selection is determined from the network configuration inventory sheet.

Whereas the D-601 Datascope provides data and interface lead monitor and recording capability, the D-502 and D-901 models include microprocessor-controlled interactive troubleshooting capability. The user may code programs to analyze data content or to count and time events. The Datascope may be programmed to simulate either the remote terminal or the central communications controller. The primary ECS application of the programmable capability has been to test new line, modem, and remote controller/terminal facilities prior to the installation of the host and communications controller facilities.

Analog monitor. The analog monitor panel at the network control console permits the NCC operators to display the signal levels on the transmit or receive side of the analog lines. Signal level is indicated in units of dBm (decibels relative to one milliwatt of power into a 600-ohm load). The nominal values of signal level are as specified by the communications carrier, typically a zero dBm transmit level and a minus 16 dBm receive level at the demarcation point. A speaker is available with the signal level meter so that the characteristic sounds of the modems and lines may be monitored. Often the sound of the transmissions can provide real clues to problems, based on the operator's previous experience on the circuits. An example of technical control at another installation is given in Reference 12.

Modem tests. Most modems used on data communications networks currently provide both for a self-test of much of the internal circuitry of the modem and for circuit end-to-end and "wrap" tests to confirm operability with other modems. The self-tests are typically able to recognize certain types of failure but a "satisfactory" test result does not assure the absence of a problem. Similarly, a series of end-to-end or remote-loop-back tests may indicate a problem, but again "satisfactory" test results do not assure the absence of any modem-based problem. Most typically, however, successful completion of the end-to-end and/or remote-loop-back tests tend to absolve the communication link of all but very intermittent problems.

Both the self-tests and the modem-to-modem tests of the modems depend upon test signal generation and detection circuitry within the individual modems. For the self-test, the test signal (a repeating data pattern) is generated within the modem, sent through the transmit circuitry, looped internally from the modem's transmit to receive circuits, and then decoded in the receive circuitry and compared to the original test signal. An end-to-end test or remote-loop-back test will use a generated test signal from one end. This signal is sent over the communication facility and either decoded at the distant end for comparison or looped around through the modem at the distant end and transmitted back to the originating modem over the communication facility for comparison with the original test data.

With the newest IBM modems, this type of modem and line test can be initiated with proper program support either by the NCC operator using the NCCF and NPDA facilities[13] or by the IBM network software. If temporary line quality degradation restricts data throughput at the normal data rate, the NCC operator may manually reduce the data rate by switching to half-speed operation from the central modem. This change may permit communication to continue and also may provide useful diagnostic information.

The NPDA Version 2 program product is specifically designed to assist network control personnel in performing problem management.[14] The program can present situation alerts about potential problems. It collects and interprets records of detected events and statistical data originating in those hardware and software components providing such information. At the operator display terminal, information is made available that aids in identifying the component causing a specific event. Also indicated are the probable cause of the described event and the recommended action to be taken to correct or override problems caused by the event. Accumulated statistics about temporary errors can be displayed to assist in analyzing performance degradation or intermittent failures. NPDA maintains the historical data base of alert, event, and statistical information with "filtering" capability to limit the types of data recorded or subsequently displayed. NPDA also provides an interface to the Information/Management data base for transferring problem data to initiate an entry in the INFO problem management system.

The operator, through NPDA and NCCF, can initiate modem self-tests and display link status and remote data terminal equipment (DTE) interface status information for links with the IBM modems. This facility requires appropriate ACF/NCP/VS communications controller programming. Among data that

Many software trace facilities are available on a system such as the ECS network.

can be made available to the network operator from NPDA are the counts of temporary errors, error-to-traffic ratios over time intervals, an indication of line quality, and certain other status data as seen by each of the (IBM 3865) modems. Alert-type messages provided by NPDA can serve as warnings of potential problems, whereas the availability of the historical data base, along with the probable cause and recommended action details, may significantly enhance problem resolution. These test facilities can provide the operator with information necessary to initiate corrective action before the user is aware of a problem, in some cases.

Operator display consoles. The just-described NPDA capability using NCCF functions makes use of the operator display consoles for very specific monitoring and testing. There are other more general ways in which the NCCF and system consoles may be used in displaying and controlling the network-related systems.[15]

When network personnel use the NCCF consoles to control VTAM resources in the network, at times error responses or codes will indicate abnormal status. This error information may be adequate to indicate a probable source of problems. In other instances, operator displays of communication link component status may isolate areas of suspicion, such as the failure of one of two display controllers on a line.

Many software trace facilities are available on a system such as the ECS network. When tracing, the actual data captured may be very similar to the actual data viewed on the digital line monitor devices discussed above. The amount of agreement will depend upon the interface at which such tracing takes place and its selectivity. The software traces offer the convenience of interpreting information as it is presented at the system interface. Specific data may be selected and extracted from a trace collection run. In this network environment, the most typically used traces are the VTAM traces by individual logical unit. This selection limits the data collected to that relating to a specific display terminal, for example, rather than to all traffic on that controller or some larger portion of the network. Additionally available, as necessary, are I/O, line, and buffer traces. Most of the host subsystems, including IMS and CICS, also have trace capabilities which may be invoked. Somewhat similarly, the other host systems, VM, DOS/VSE, OS/VS1, CMS, RSCS, provide particular software trace capabilities.

The flexibility and convenience of use of display consoles by the network personnel are considerably enhanced through the Terminal Access Facility (TAF) feature of NCCF Release 2.[16] This allows NCCF to communicate with CICS/VS, IMS/VS, the Host Command Facility (HCF) for the IBM 8100 Information System, TSO, and remote NCCF systems. The facility allows any combination of these subsystems to be controlled or accessed simultaneously from one NCCF terminal, thus reducing the need for separate terminals for each subsystem.

Dumps of the various software subsystems either may result from a detected problem situation or may be requested by the system or network operators as a means of providing more complete data regarding an apparent failure that may be affecting network users. These are most often handled by the system operators in conjunction with technical support staff members.

A major advantage of the SNA architecture and implementation is that most network-related problem isolation activities can be invoked using the VTAM-based diagnostic facilities rather than those based on the particular application facilities in use by the particular network user experiencing difficulty. This ability to pursue network problem management in relative isolation from the various application interfaces and techniques has been a significant step forward.

Communication systems management

Communication systems management may be described as a systematic approach to managing and controlling a set of resources to distribute information to users via a data communications system to meet established objectives. The emphasis on user orientation is quite logical, since the satisfaction of the user's needs is the reason for installing the network and all applications in the first place. There are two major areas in the communication systems management discipline: the control of the network and the larger, overlapping control of the data processing environment. Network control is that set of procedures, hardware, software, documentation, and staff related to problem determination and resolution with respect to the network. System management control is that set of procedures, organization, and data that address the management of the overall computing system in order to provide satisfactory service to users within the otherwise imposed constraints. An extensive presentation on this overall topic with further references is provided in Reference 17.

The resources of the ECS network are managed and controlled on several levels.

Network control. The resources of the ECS network are managed and controlled on several levels. When user questions and problems arise relating to the use of ECS services, a user's first point of reference is at the terminal. User guides and reference materials are provided at each site to answer many routine queries. If the local information does not suffice, the ECS User Interface Group (UIG) serves as the first level at which the user interfaces with the ECS center. They handle all user calls including questions, hardware and software problems, and requests. The UIG hands queries to the responsible group within ECS. Subsequent levels are the Network Control Center (NCC) and the technical staff members responsible for the network.

User information. Since the turnover from week to week of individual student users of the network terminal facilities is very high, most problem reporting is initiated by instructors conducting the labs at the education centers. Thus, for their use, ECS maintains a user guide for the MVS and VM host teaching systems. Included is detailed, tailored information on the use of terminals on the ECS network as well as references to standard documentation, such as IBM operating procedures manuals. The user guide also covers user standards and conventions that apply to the use of the network and host facilities, including terminal sign-on and input submission procedures Other sections in the user guide present general information, user standards, remote terminal considerations, and user information for each of the major subsystems.

Site configuration documents are also important. Proper labeling of terminals and control units at the education centers is necessary to aid in communicating problems to the host. Good user site documentation and basic symptom checking aids in the rapid identification and correction of trouble. Simple checks such as for "power on" and proper cable interconnections frequently lead to resolution of user problems.

User information in the form of "help" screens represent the third major source of guidance. A VTAM "help" application, available to the user on the display terminal, reviews the procedure for sign-on to each of the major subsystems and also identifies to the user the VTAM network name for the particular terminal device in use. This is a convenient summary for the user and also confirms access to the controlling VTAM host system. Additional screens of information for major subsystems are also provided.

User Interface Group. The UIG at ECS provides the "help desk" function to ECS users. A single phone number helps to alleviate the traditional user uncertainty of whom to call under a variety of circumstances. An automatic call sequencer device not only assists in proper handling of incoming calls by the UIG, but also permits the use of prerecorded messages for callers regarding systems status, anticipated outage durations, or center closing information.

Display terminals are provided to allow each of the major systems and subsystems to be monitored and controlled. Essentially any function that a system operator can perform may also be performed by the UIG. Display and control are provided for the MVS SNA network through NCCF. Similar display and control of VM network lines and controllers are provided by special programs interfacing to the operator functions of VM and its communications control programs. Many user problems are handled by displaying the status of the identified terminal, controller, or line and issuing appropriate activation or restart commands. Network-related calls that are not resolved at this level are then passed to the NCC. A key objective is to resolve the user's problem while he/she is still on the phone, if at all possible. One of the features of the UIG approach is that information concerning more widespread hardware, software, or other outages can be made known to all the UIG personnel and readily made available to all other callers who are affected.

Problem management input may be provided by participants at all levels in the problem resolution process.

Reference manuals and materials are provided in the UIG area, including the MVS and VM operator and user guides, the network layout sheet which defines the network configuration, and the UIG network-related procedures. Telephone calls are logged to record and track the nature and disposition of calls. This information, along with the traffic data collected by the automatic call sequencer, permits evaluation of UIG responsiveness to the calls received.

Network control center. Network problems are escalated to the second level by switching user calls from the UIG to the NCC. The NCC is located in view of the modems and contains the control console and display terminals for the network. The control console provides the communication line monitor and test facility. The display terminals provide system access for the NCC. The NCC operators may display and control the network status and access the communications network management applications, such as NCCF, NPDA, and the Information/System.

Problem activities of the NCC operators typically begin with gathering and recording the additional identification and symptomatic information relating to the communication-based problem. The operator may at this point repeat previous display and activation steps while employing the data monitoring equipment at the network control console. If service is not restored or the problem is not identified early in this sequence, the NCC operator will proceed to a diagnostic sequence to localize the failure. Modem tests, line tests, possible modem and line swap-outs, and evaluation of additional error symptoms at the remote and host locations may follow. The tools employed depend on the type of modems and lines involved.

If at some point in diagnosis the best evaluation indicates that the communication line is either out of specification or out of service, the NCC calls the responsible servicing organization. Records of diagnostic steps taken and service calls placed are entered in the problem management Information/System data base. This data base is actually part of the larger control system described here as "Systems Management." NCC operators continue to work with the user or the location coordinator to circumvent the outage as appropriate to the situation. Some amount of redundancy exists to permit such circumvention.

Technical staff. If isolation and identification of the problem source have not been achieved within a short period using the above techniques, a network technical support staff member assumes problem responsibility. This is the third level of support.

The support staff members have advanced training and experience in all aspects of communication hardware and software. They have primary responsibility for supporting the teleprocessing access methods, evaluating and applying software maintenance, and planning and controlling the installation of all changes to the network. Tools typically utilized by the support staff members include the real-time communication line analog measuring and digital data display. Off-line analysis of traces and dumps performed by the support staff members may supplement the on-line assessment. The intent of the third-level activity is to completely resolve and correct a reported problem or isolate it to an area where a specific repair action will be taken by others. Subsequent to such referral out, the available bypass/backup procedures may be invoked as appropriate.

Summary of network control. Problem management input may be provided by participants at all levels in the problem resolution process. On apparently straightforward problems as well as the more difficult ones, it can be of real future value to document the incident and its resolution. The UIG is informed of general problems to permit the better handling of subsequent calls. Data reduction and analysis of the captured incidents can aid management in spotting trends, such as service problems and deteriorating facilities.

With respect to network management, significant topics from system management disciplines are often referred to as communications network management.

Among the more significant results of the network control hierarchy is that network users always know where to start in problem or inquiry pursuit and can expect an orderly escalation of support involvement. This tends to best utilize the abilities of participants at all levels and standardize the interfaces to the problem management system.

System management controls. System management controls are a collection of those disciplines that seek improved management of computing systems in order to provide satisfactory service to system users. Significant elements include tools, techniques, organization, and data for the management of problems, change, recovery, performance, capacity, and the reporting of aspects of the overall system. With respect to network management, significant topics from system management disciplines are often referred to as communications network management. Problem and change management and inventory or configuration management will be discussed with respect to the ECS network. These are a subset of the disciplines that exist for control of the entire data processing complex and its distribution system.

Change management is designed to recognize the impact of system and network changes.

Manual procedures. The earliest implementation of communications network management procedures at ECS was essentially based on manual methods. Problem tracking and management require the logging of incidents, their follow-up, and ultimate resolution. Historical information on previous problems can be of significant value in resolving subsequent recurrences or similar symptoms. It is also used to establish trends. Proper logging also can prevent the opening of subsequent incidents against the same problem.

The Teleprocessing Incident Report form used at the NCC is similar in format to the reporting form used for general system incidents, but with provision for communication circuit identification information and details concerning follow-up with common-carrier personnel or the personnel of other service suppliers. Review of previous incident records was handled on a manual search basis. Tracking of problem resolution progress was the responsibility of NCC operations. Exceptional situations were reviewed informally in meetings with staff support and IBM Field Engineering representatives. Trends were difficult to spot or analyze.

Change management is designed to recognize the impact of system and network changes. Every change needs to be evaluated, carefully controlled, and publicized. The first implementation of a manual change control system involved impact analysis, planning, and notification through informal discussions among members of the staff. The key control documents in the manual system were a change request form and a TSO data set maintaining a summary of the pending requests. The working versions of the request form and the summary data set served as input and control for management review and change notice generation. Publication and distribution of the resulting change notices for changes related to communications networks served to advise users and staff of the scheduled implementation of such changes.

Inventory management for the network has remained a manual procedure, although the data has been kept on line on the systems as well as in hard copy at the network operating positions. The documentation consists of files containing data in a location sequence of communication circuits, terminal and modem equipment on each circuit, the logical names or subchannel addresses of lines and controllers, and polling addresses and numbers of ports on remote controllers. Additional reference data such as remote location coordinators and special modem settings are also included. This document (Figure 12) is the primary network detail reference that is used by UIG, NCC, system console operators, and staff members. Similarly maintained are other, more specialized documents that assist in network planning and control, such as communications controller inventory, showing the allocated and available line set positions and characteristics; network interconnect diagram, showing all intersystem connections, line set and channel identifications; network monitor and control system digital and analog interface positions; and inventory of modems and terminal controllers. This level of network configuration management continued to meet the needs of ECS systems through early 1983.

Much redundancy is built into the ECS network. More lines and controllers, for example, are installed than the data transfer rates would dictate, thus permitting alternate paths for rapid recovery in case of unit or line failures. As a result, some of the connectivity features provided by the inventory application cannot be fully exploited.

Figure 12 Sample TP layout sheet

```
                                        DALLAS EDUCATION COMPUTING SERVICES (ECS) TPLAYOUT SHEET          BELL INTERSTATE 555-4171
                                                                                                            "  INTRACITY  555-1121
                                                                                                            "  DIGITAL    555-7457

                                                                                                          F.E. DISPATCH   555-7250

LOCATION        RMT * T/B *   COM/CABLE I MASS *                                  * T/B *   TELCO CIRCUIT #  * TEL *      REMOTE     *
 NODE ID      EQUIP * DIG.*   3705      I POS. *           COMMENTS               * ANA.* MODEM         SHELF * BD# *      PHONE#     *
*************************************************************************************************************************************

   PHILADELPHIA TEC 1700 MARKET ST.                                                                                 PHILADELPHIA
                                                                                                              215-555-
*************************************************************************************************************************************
ESPH1L                * 001 * BLACK 7     POS C *                                 * 102 * FDEA  12345-001     * D1  * TRMNL LOCN      *
ESPH1C1 = 3274-01C * SNA * A5             "  A * ESPH11P1 IN POS. 4 IS A PRINTER  *     *                     *     * 7-555-1234      *
ESPH1101-23           *     *                  *                                  *     *                     *     * CONTACT NAME    *
                      *     * 3705A            *                                  *     * 3865           9/3 *     * 7-555-4321      *
*************************************************************************************************************************************
ESPH2L                * 021 * BLUE 14     POS C * REMOTE 4 = ESPH2R1 ON LINE 4    * 103 * FDEA  12345-002     * C12 *                 *
ESPH2R1 = 3777-3      * SNA * B6-B7       "  A *                                  *     *                     *     *                 *
ESPH2C2 = 3274-51C    *     *                  *                                  *     *                     *     * TRMNL LOCN      *
ESPH2C3 = 8100        *     * 3705A            *                                  *     * 3865           9/4 *     * 7-555-3412      *
*************************************************************************************************************************************

   PHILADELPHIA CUSTOMER SUPPORT CENTER    1700 MARKET ST.                                            PHILADELPHIA CSC

                                                                                                              215-555-
*************************************************************************************************************************************
ESPR1L                * 204 * BLACK 19    POS C * RUNS TO PALO ALTO VIA DALLAS    * 166 * FDEA  12345-003     * F15 * TRMNL LOCN      *
ESPR1R1 = 3777-3      * SNA * OCO         "  A *                                  *     *                     *     * 7-555-2341      *
ESPR1C2 = 3271-12     *     *                  *                                  *     *                     *     * CONTACT NAME    *
ESPR1C3 = 8100        *     * 3705B            *                                  *     * 3865          16/7 *     * 7-555-3214      *
*************************************************************************************************************************************

   POUGHKEEPSIE    BLDG 005 SOUTH ROAD                                                                              POUGHKEEPSIE

                                                                                                              914-555-
*************************************************************************************************************************************
PG DEV INT            * 100 * BLACK 2     POS C *                                 * 054 * FDEA  54321-010     * A11 * TRMNL LOCN      *
 LINE 050             * BSC * 030         "  A *                                  *     *                     *     * 7-555-9999      *
                      *     *                  *                                  *     *                     *     * CONTACT NAME    *
```

Information/Management. The computerization of the network and system management controls was undertaken during 1981 and 1982 using first ANMP (Account Network Management Program)[18] and then Information/Management features of the Information/System program product. Information/System is an interactive retrieval program that provides the base for the companion features Information/MVS and Information/Management with Information/Access capability.

Information/Management is the feature particularly relevant to communications network management. It provides integrated problem management, change management, and configuration management applications.[19] ECS has been implementing the problem management features that support reporting, tracking, and resolving problems for the entire data processing complex and for the network. Also, the change facility that supports the process of planning, coordinating, and monitoring of all system and network changes is being implemented.

The implementation of the Information/Management support for problem, change, and configuration management is based on the same network information but provides far more control through interactive applications that ensure proper data capture, status monitoring, organized planning, and maintenance of history.

ECS conducts weekly status meetings to review the areas of problem and change for the entire department with respect to performance and plans. The meetings serve as an important coordination and review function, whereas the interactive applications of Information/Management provide dynamically available control information. The integration of the applications can relate problem, change, and configuration information and permit multiple use of previously stored information. Problem entry initiation from the NPDA program facility particularly promotes easy and accurate entry of network problem data.

The basic data in the three network management control areas remains little changed from the manual implementations, but the integrated control provided by the newer systems contributes to enhanced communications network management.[20]

Network control in operation

The major elements of communication systems management provide specific approaches to reduce the impact of network outages through careful planning, documentation, and control procedures. Nevertheless, network incidents do occur and must be handled as expeditiously as possible. To highlight and illustrate the ECS network control procedures, scenarios of some typical incidents are here constructed.

Information/Management is the feature particularly relevant to communications network management.

Line outage. It is approaching late afternoon of a Wednesday in New York City. Students at the Advanced Education Center (AEC) have been working on their class lab problem assignments in preparation for discussion on the following morning. Each of the three concurrent classes have earlier been sharing the interactive display terminals on a scheduled basis, and many of the lab teams are now finished for the day. Those students now finishing up are awaiting the hard copy output of their computer runs for tomorrow's class review.

The education center workstation operator becomes aware that one of the two batch remote job entry workstation terminals, an IBM 3777 Model 3, is not printing, when both are expected to be sharing the print load. An attempt to request a display from the terminal keyboard of the queue of jobs awaiting printout from MVS/JES2 results in no response and the observation of an error message on the terminal display panel indicating a communication error.

As the first step in troubleshooting from the remote location, a quick check of the interconnections and setup of the terminal and its associated communications equipment is made. In this case, the visible signal and power cable connections appear correct and secure, and the switch settings are all normal according to the associated operating instructions.

The user is now expected to contact the UIG of ECS using the help desk phone number. Although it is late afternoon in New York, it is an hour earlier in Dallas and three hours earlier on the west coast, so there is still much system activity on this typical Wednesday. A caller may be put on hold briefly by the call sequencing equipment. The New York operator gives the Dallas contact the location, contact name, and phone number, and the VTAM network name of the facility having trouble. Also given is a description of the apparent problem and any error messages or unusual symptoms along with any diagnostic steps already taken. At the UIG, the contact refers to the network configuration layout sheet to confirm the terminal type, network logical names, and circuit number of the facility in question.

Using the NCCF display terminal access to the MVS/VTAM system, the UIG contact checks the host view of the status of the New York terminal, ESNY4R1, and line, ESNY4L. In this case, the terminal indicates "pending contact." The UIG contact then varies the line and terminal "inactive" and initiates reactivation of both. Since the terminal does not properly activate, the contact transfers the call to the next level of support for this apparent communications problem, the NCC. The NCC operator is passed the pertinent identifying details and records the data on the Teleprocessing Incident Report form.

The network configuration layout sheet includes essential reference information for all remote facilities including the selection addresses to be used for monitoring both the analog (line side) and digital (host controller side) interfaces of the ECS modem on this New York circuit. The New York line currently in trouble is accessed as digital position number 040 and analog position number 002. Thus, by selecting these addresses, or their mnemonic equivalents at the control console, the ESNY4L digital interface is presented to the Datascope input and the analog interface is made available at the analog monitor panel. The NCC operator initiates restart of the New York line and RJE terminal again while monitoring the result on the Datascope. While the display confirms that normal response to polling does not resume from the terminal, the characteristic sound transmitted by the host modem through the audio monitor speaker indicates to the operator that the host modem is not synchronizing with the corresponding modem in New York. A check of the transmit and receive carrier levels from and to the Dallas host modem confirms that the levels are within normal range (zero dBm transmit and minus 16 dBm receive). Since the modems appear audibly to be attempting to retrain with both transmit and receive levels nominal at the host end of the circuit, a strong possibility exists that the matching modem in New York is not "seeing" or responding to the carrier signal from Dallas.

The network configuration layout sheet includes essential reference information for all remote facilities.

With the guidance of the NCC operator the modems at each end are run through their self-test sequence to isolate the problem source to the signal path between Dallas and New York or to the receive circuitry of the New York modem or to the transmit circuitry of the Dallas modem. Both modems in this instance pass the self-test, which exercises much of the internal circuits. The NCC operator then places a call for service to the appropriate communications common carrier. This series of diagnostic actions and the resulting call initiation are recorded on the incident report for follow-up.

Since the time is late afternoon in New York and the second workstation printer is adequately handling the current output print load for the remaining student teams, no bypass action is planned at this time. Dallas operators will be on site until about midnight New York time and can keep in touch with the common carrier service personnel to track and confirm subsequent corrective action. Status information should be available for early-shift Dallas ECS operators tomorrow morning to contact and, if necessary, follow-up with New York AEC personnel.

Later that evening, the common carrier calls and the incident is subsequently cleared. The relevant specifics of the incident and its resolution are recorded in the trouble report and most particularly in the Information/Management problem control data base for statistical and future symptomatic analysis.

Line degradation. Another illustrative example of fairly typical network diagnostic activity involves a circuit to the Chicago AEC which supports both an IBM 3777 Model 3 RJE terminal and an IBM 3274 Display System Control Unit. The modems used on this link are the IBM 3865 modems with the fan-out feature at Chicago so that both terminal controllers may connect to the remote modem and operate in a logical multipoint mode. Thus, both units can be operated at 9600 bit/s and share whatever proportion of the total throughput capability is dynamically required by each. This is a much more efficient utilization of facilities than limiting each, for example, to a maximum transmission capability of 4800 bit/s through data multiplexing. It is also more efficient in the utilization of host facilities since a single communications controller port can serve both remote controllers. Since the microprocessor diagnostic capabilities of these modems are supported through the NPDA and NCCF facilities of the SNA communications environment, more status information and control are available from the host site.

During the noon hour in Chicago, students from several of the classes at the AEC have returned from lunch early to take advantage of the available display terminals in the student terminal room. Several observe that the response time at the display terminals is irregularly slower than experienced earlier when all terminals were in use. Although some students are running through the VCNA interface to the VM system, and others are running TSO on the native MVS system, all users on the same control unit are experiencing a slowdown. Interested in making productive use of this breaktime, one of the students calls the help desk at ECS in Dallas to inquire of the system status. Since there is no identified system-wide problem at this time, and the line and controller are active, the call is referred by the UIG to the NCC operator.

Upon recording the preliminary call information, the NCC operator determines the monitor selection addresses for this circuit to be digital number 045 and analog number 023. Viewing the digital traffic on the Datascope display indicates that communication is in fact taking place, to both the display controller, ESCH3C1, and the printer terminal, ESCH3R2. Analog indications show normal signal levels on transmit and receive. Using the NCCF-connected display terminal to access the NPDA files, the NCC operator determines from the statistics display that the error-to-traffic ratio has been running relatively high over the last few minutes for this line. This display shows the transmitted and received traffic, temporary error counts, and error-to-traffic ratios for recent time intervals.

The NCC operator can display the most recent link and modem status.

Since the modems provide Link Problem-Determination Aid (LPDA) facilities in conjunction with the ACF/NCP/VS support of NPDA, it is now possible to invoke the problem detection support provided in this environment for communications network management. Reference 21 illustrates specific examples of the use of the commands and responses as well as overall system requirements. The NCC operator can display the most recent link and modem status through the NPDA data base. In this case, the most recent entries show an increased number of line "hits" and a deterioration in line quality as evaluated and reported by the local and remote modems. Insofar as all possible current status information is desired, the NCC operator can initiate through the NPDA facility a request for a link status test which reports the results of self-tests at both the local and remote modems and extracts the current link status as recorded by both in terms of hits and line quality. (For more details on IBM modem LPDA capability, see Reference 3, which includes specific illustrations of an earlier level of NPDA.)

Since these results indicate poor line quality and satisfactory self-tests of both modems, the NCC operator decides that a call should be placed to the communications carrier. In order to provide the best possible throughput and response capability on this circuit while awaiting corrective action, the operator manually selects the half-speed option on the host modem, which also signals the Chicago modem to drop to half-speed operation. This mode significantly reduces the error recovery attempt overhead for both the batch and interactive terminals on this line. The operator in Dallas has performed link problem isolation and initiated a bypass without any hands-on participation by the students or instructors in Chicago. Obviously, there may well be an interruption to service on this link while corrective action is performed by the communications company. If it appears that such service outage may jeopardize the afternoon lab schedules of the classes in Chicago, it may be preferable to have operation continue at the reduced rate on this one line and perhaps have some of the display terminals moved to another available controller on another facility.

As in all such network-related incidents, the information is recorded in the problem management system for tracking and evaluation. Similar problems may be handled more efficiently in the future, and better procedures for isolation and bypass may be documented and perhaps more nearly automated. Reference 22 contains extensive notes on problem determination techniques in an ACF-SNA environment.

Concluding remarks

From the perspective of the education centers, there is a growing requirement for terminal capability. Those locations still using some monochrome display terminals will be continuing their conversion to the color display and printer equipment. Now that VM/VCNA has extended the MVS SNA network access to the VM-based teaching systems, essentially all remote interactive terminals will access the teaching systems over an integrated network. This significantly enhances network management by standardizing the operating techniques across these facilities.

It is expected that an increasing number of distributed processors will be utilized throughout the education locations, eventually operating as additional SNA hosts. At the same time that this trend enhances the computing capability available at the education location, it also places additional system management requirements on both the host and remote locations.

For those education locations with larger communication facility requirements, we are in a position to consider the expanded use of remote communications controllers. Major network facility economies and enhanced reliability may be achieved through the multiplexing effect of the remote concentrators. For example, one site that originally had 27 lines for voice-grade connection to ECS is now served by 56 000 bit/s digital circuits with a remote communications controller, resulting in a large cost saving on line charges.

The transparency provided by the SNA network will buffer system users from adverse impacts.

The changing environment of communication common carriers and the availability of newer technologies such as digital transmission, satellites, optics, and other wideband approaches will be investigated to deliver service to the users. ECS will complete the conversion to IBM 3865 modems on the network to gain their enhanced operating and diagnostic capabilities. ECS expects to further evaluate the implementation of the switched network backup capabilities of these modems. Particular locations may achieve enhanced reliability through the availability of this backup.

Host-site central processors and application programs will continue to change significantly. It is expected that the transparency provided by the SNA network will buffer the education system users from any adverse impacts. Other hosts will likely be connected to the network, but the user is only interested in the availability of desired applications, not the location of the system providing that application.

ECS will implement a front-end Communications Management Processor (CMP) as the network driver during 1983. All network functions may then be consolidated within this system. It will be backed up by the MVS processor, which can acquire and control the network resources should the CMP machine fail. An introduction to the CMP approach as a part of Communications Management Configuration is given in Reference 23.

ECS expects to test the enhancements of the network systems that detect, log, alert, and analyze problems and assist in their isolation and correction. Imbedded software tools may not alleviate the need for specialized network monitor and test equipment. The ECS support staff expects to evaluate developments in these tools and techniques, particularly as communication technology also changes.

ECS will extend implementation of the interaction of the major elements of Information/Management, including configuration management. Automation through predefined operator control sequences and more extensive guidance information will be pursued.

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