ISP

SNA Networks: Challenges and Opportunities

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SNA NETWORKS: CHALLENGES AND OPPORTUNITIES

ABSTRACT

This report was produced as part of INPUT's Telecommunications Planning Program. The research is based on a series of interviews with information systems and/or telecommunications users and vendors. These interviews provide the basis for an analysis of what is happening in system network architecture.

The report describes the nature of IBM's system network architecture, describes some of the competing products, briefly discusses the ramifications of the Open Systems Interface (OSI) model, defines the use of packet switching, and indicates the direction of this technology over the foreseeable future. The findings are summarized and a series of recommendations and conclusions are presented. The report also contains an executive summary in presentation format.

This report contains 59 pages, including 13 exhibits.

SNA NETWORKS: CHALLENGES AND OPPORTUNITIES

SNA NETWORKS:
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CONTENTS

SNA NETWORKS:
CHALLENGES AND OPPORTUNITIES

EXHIBITS

I INTRODUCTION

- This report is part of INPUT's Telecommunications Planning Program. It is designed to help senior managers and corporate executives assess the capabilities and limitations of IBM's SNA networks. This report:

  - Identifies SNA-related business requirements.

  - Analyzes current and anticipated SNA technology.

  - Evaluates some near-competitive and compatible alternatives.

  - Recommends to senior management some potential problems to consider and the opportunities available with SNA-related architectures.

A. PURPOSE AND SCOPE

- An understanding of Systems Network Architecture (SNA) is of paramount importance to the business community since almost all major suppliers of networking products and services are basing their future product lines and network control strategies around this architecture or its equivalent.

- SNA provides a unified, standardized approach to organizing (and controlling) networks containing intelligent communications processing equipment.

- The generalized objective is to develop an efficient and reliable architectural framework in which users can view complex communications-based computer systems without concern for the physical details of how a specific network function is organized.

- Since seventy percent of all installed architecture is SNA or SNA-related, a clear understanding of the capabilities and limitations of SNA is necessary, as well as an understanding of its associated protocols, such as X.21 and X.25. Similarly, the users should be aware of packet switching and its capabilities, as well as understanding the OSI reference mode. Only in this way can the user fully exploit the opportunities presented by these protocols and associated architectures.

B. REPORT ORGANIZATION

- This report is organized as follows:

  - Chapter I is an introduction.

  - Chapter II is an executive summary. It is formatted as a presentation for group discussions and emphasizes the key points within the report.

  - Chapter III is a technological assessment of the architecture and includes an analysis of packet switching, OSI models, and of the various ancillary protocols associated with SNA.

  - Chapter IV contains the conclusions and INPUT's recommendations for effective network architecture planning.

- The Appendix contains the questionnaire used to conduct the interviews.

C. METHODOLOGY

- The information contained in this report was derived from the following sources:

  - Interviews with senior telecommunications planning, vendors, and information systems managers and executives. The questionnaire used in the interviews is presented in the Appendix.

  - In-depth interviews with senior planning managers and executives. Copies of the questionnaire are contained in the Appendix.

  - INPUT's studies on telecommunications.

  - Open literature surveys.

- INPUT has taken the best practices and proposals found in the interviews and then subjected them to further analysis.

D. OTHER RELATED INPUT REPORTS

- Interested readers are referred to the following INPUT reports:

- Telecommunications Planning Methodologies, October 1984.

    - Defines and describes telecommunications planning techniques and processes, using the case example approach, and further identifies critical telecommunications planning issues.

- Telecommunications Annual Planning Report, November 1984.

    - An in-depth survey and analysis of the current state of the telecommunications industry, with emphasis on an assessment of the technology.

- Telecommunications Interfaces for the mid-1980s, December 1984.

    - An in-depth evaluation of telecommunications interfaces and their ancillary hierarchies, including reference models, protocols, and architectures.

- Annual Information Systems Planning Report, July 1984.

    - Evaluates information systems trends and graphically plots critical IS management issues.

- Impact of Communications Developments on Information Services Vendors, December 1981.

    - Analyzes changing communications technology and services as related to information services activities.

- Effective Corporate Planning in the Computer Services Industry, December 1980.

    - Examines the level and extent of corporate, market, industry, and product planning within the Computer Services Industry. Emphasis is on corporate planning efforts.

- User Communication Networks and Needs, November 1980.

    - Identifies and evaluates changes in user needs within the communications field, with particular emphasis on network problems and solutions.

II EXECUTIVE SUMMARY

- This executive summary is designed in a presentation format in order to help the busy reader quickly review key research findings.

- The key points of the entire report are summarized in Exhibits II-1 through II-8. On the left-hand page facing each exhibit is a script explaining the exhibit's contents.

A. SYSTEMS NETWORK ARCHITECTURE IS A POWERFUL NETWORK VEHICLE

- Since its announcement in the fall of 1974, IBM's Systems Network Architecture (SNA) has increasingly become the standard for data communications networking in an IBM mainframe environment.

  - Today, SNA is a powerful and flexible networking vehicle.

  - IBM introduced the 4300 series mainframe and more sophisticated intelligent terminal systems to enhance and take advantage of SNA's networking capabilities.

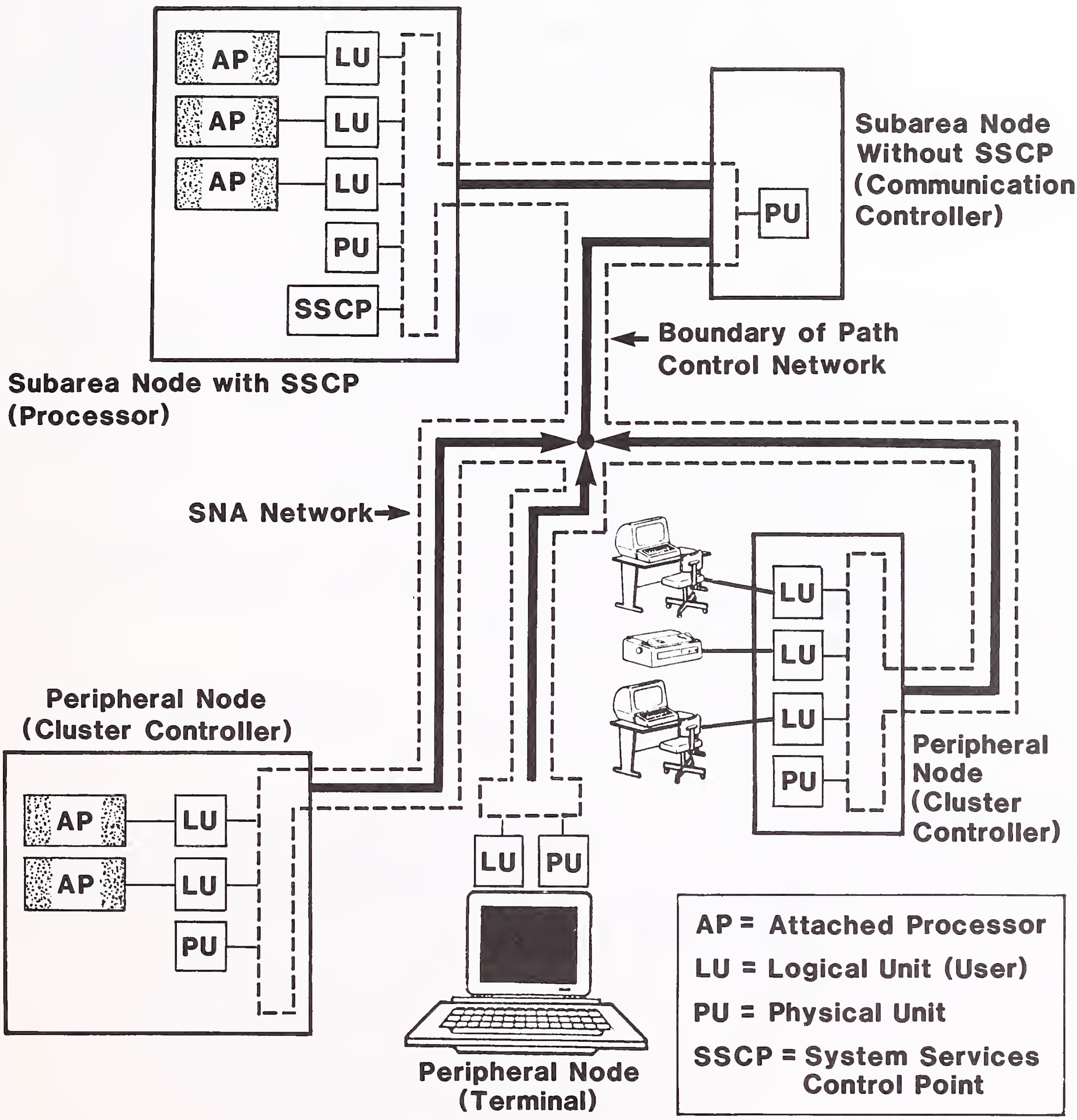
- The rapidly increasing spread of IBM's SNA and related SNA terminal usage is creating a standard for data communications network interfacing. As a consequence, non-IBM equipment manufacturers are being compelled to incorporate SNA capability in their products.

- To meet this growing user demand, many manufacturers are offering Systems Network Architecture and Synchronous Data Link Control (SNA/SDLC) capabilities, using hardware and software emulation techniques.

- As a result of this rapid growth in SNA-type equipment and network configurations, there is a fast-growing demand for microcomputer systems offering SNA emulation.

EXHIBIT II-1

SYSTEMS NETWORK ARCHITECTURE IS A POWERFUL NETWORK VEHICLE



B. SNA DEFINES A COMPLETE SPECTRUM OF FUNCTIONS AND PROTOCOLS

- At the present time, most 3270 systems employ the Binary Synchronous Communications (BSC) protocol for communicating with IBM host computers. 3270s employing BSC are, however, being replaced rapidly by 3270 terminal equipment employing SNA protocols.

- IBM will continue to set the standards for data network and terminal-to-computer communications for the foreseeable future.

  - IBM is migrating its customers to SNA in an effort to recapture a major share of the terminal market segment that was lost to non-IBM suppliers offering 3270 BSC emulation.

  - The movement from BSC to SNA is required for users to realize the full benefits of the SNA systems architecture.

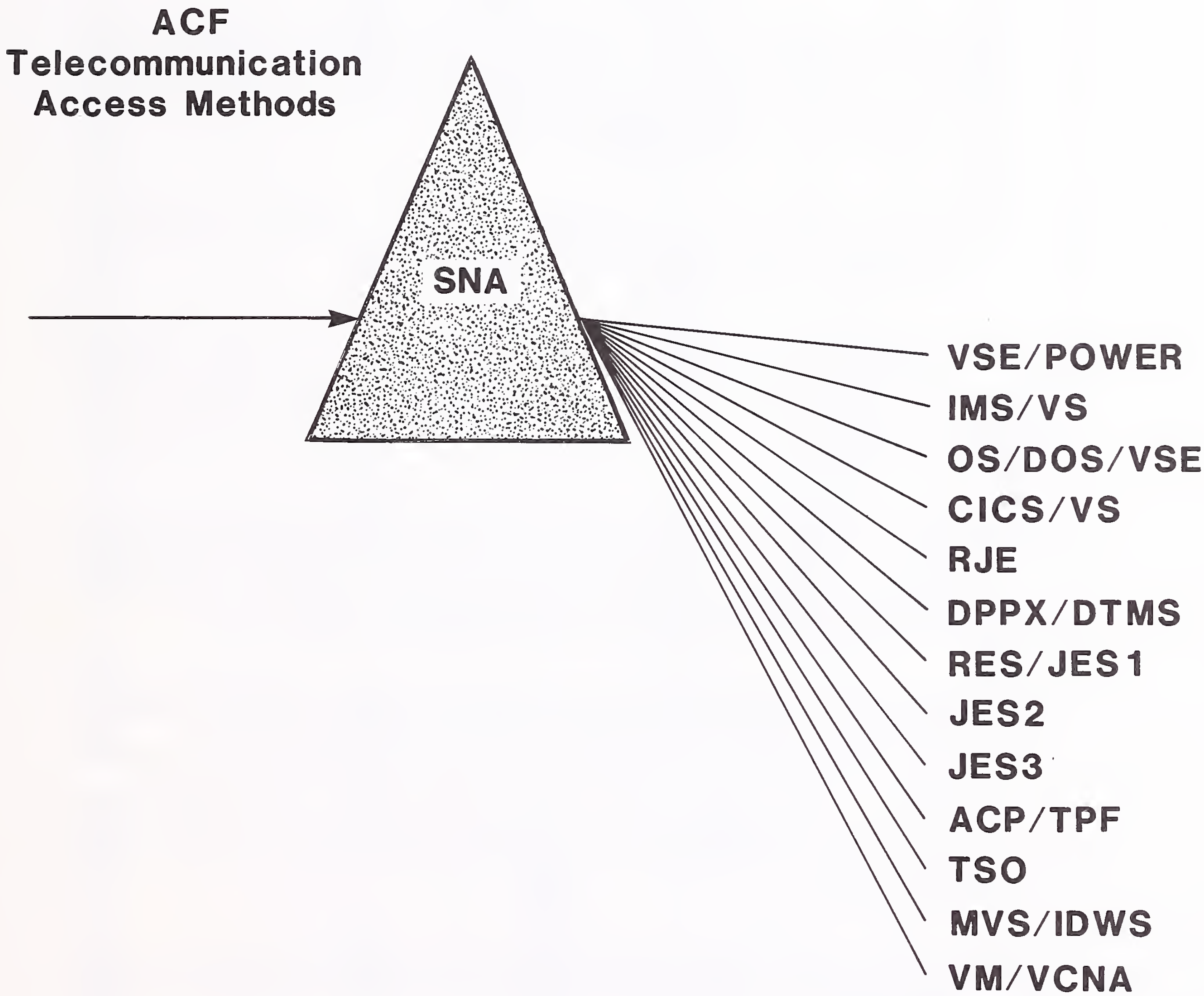
- Non-IBM manufacturers desiring to provide SNA interface compatability are required to perform more complex and costly design efforts than were required in developing BSC compatibility.

  - This is true since SNA deals with a considerably broader range of communications factors than does BSC.

  - While BSC is a protocol simply for transmitting data, SNA defines a complete spectrum of functions and protocols required to move information throughout the entire computer-based network, not just the communications link.

EXHIBIT II-2

SNA DEFINES A COMPLETE SPECTRUM OF FUNCTIONS AND PROTOCOLS



C. SNA IS COMPATIBLE WITH X.25 PACKET-SWITCHING NETWORKS

- In 1981, IBM announced a policy whereby SNA products would be developed so as to communicate over X.25 public packet-switching networks.

  - This X.25 interface policy on the part of IBM indicated IBM's adherence to user demands for flexible interconnection of various data networks and equipment on a worldwide basis.

  - The SNA-X.25 interfacing support from IBM paves the way for the computer communications explosion of the 1980s.

- The X.25 packet switching public network standard was developed under the authority of CCITT as part of a joint effort between Canada, France, Japan, the U.K., and the U.S.

  - X.25 calls for X.21 as the physical and electrical interface between the customer terminal equipment and the packet network. RS-232-C, however, is authorized under X.25 on an interim basis.

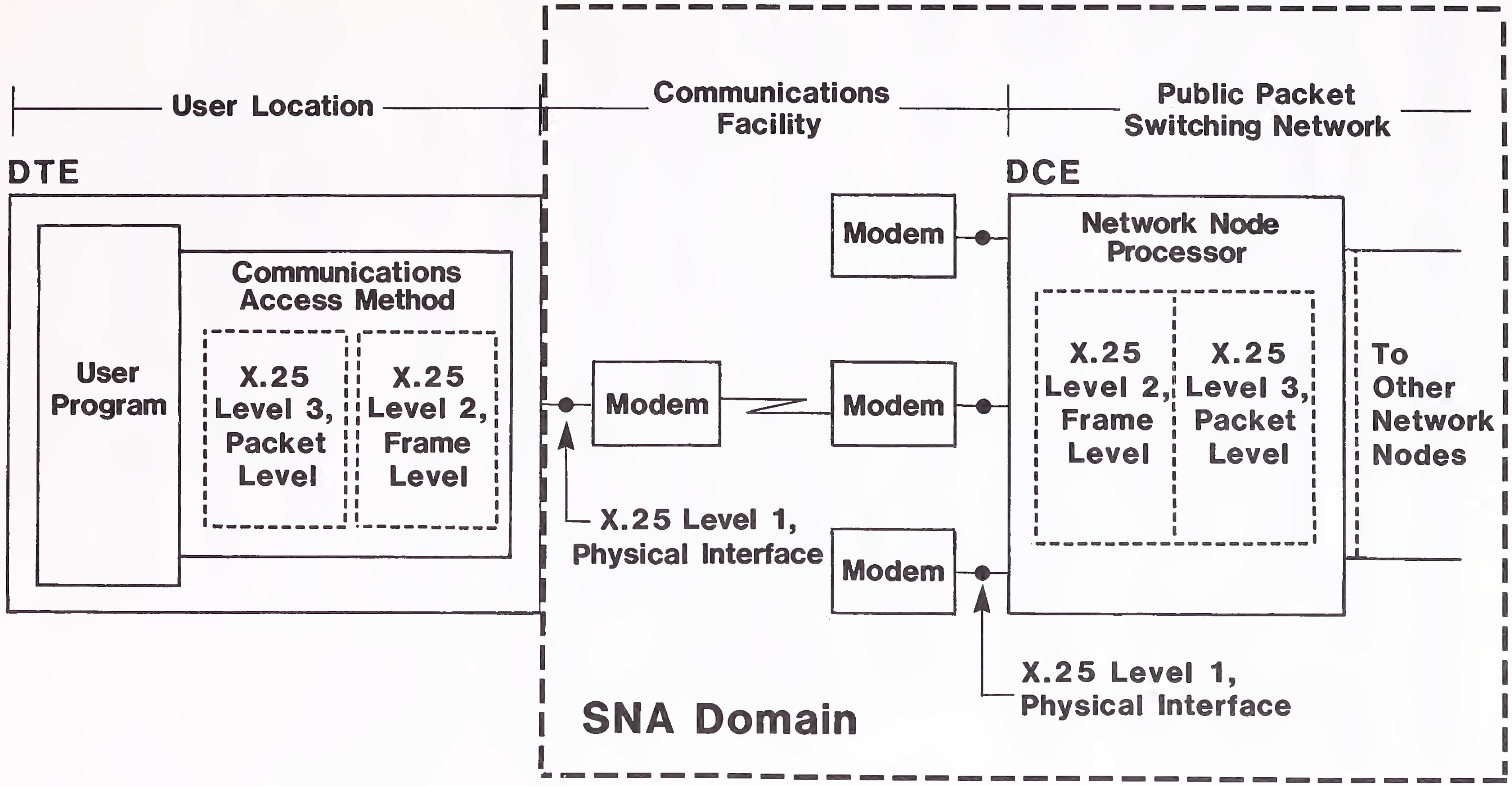
  - Higher-Level Data Link Control (HDLC) is employed as the communications link protocol under X.25. The packet serves as the message format. Also under X.25 are set-up procedures for controlling the packet (which consists of a user data message plus various control information).

- X.25 offers the user a functionally transparent network with elaborate error-checking capability.

- In order to provide X.25 support, IBM introduced the X-25 Network Control Program Packet-Switching Interface, a software package that operates with IBM's 3705 communications controller, and the Network Interface Adapter that converts the SNA link protocol (SDLC) in and out of the X.25 communications protocols.

EXHIBIT II-3

SNA IS COMPATIBLE WITH X.25 PACKET-SWITCHING NETWORKS



D. OTHER COMPANIES ALSO MANUFACTURE SNA/X.25 INTERFACES

- In addition to IBM, other computer manufacturers such as DEC and NCR have adapted their network architectures (equivalent to SNA) to interface with both X.25 and SNA. Many other computer manufacturers (such as HP and Data General) have also developed compatible software to allow their computer systems to handle both SNA and X.25 networking requirements.

- X.25 Releases 1 and 2 software allow for packet switching among various host systems and remote SNA cluster controllers.

  - X.25 Release 3 software provides host-to-host computer packet switching.

  - Other companies supporting X.25 packet network procedures and protocols to varying extents include:

    - DEC's Digital Network Architecture (DNA).

    - Honeywell's Distributed Systems Architecture (DSA).

    - NCR's Communications Network Architecture (CNA).

    - Sperry Univac's Distributed Communications Architecture (DCA).

    - Data General's DG/SNA architecture.

    - Hewlett-Packard's Distributed System Network (DSN).

    - Prime Computer's Primenet architecture.

EXHIBIT II-4

OTHER COMPANIES ALSO MANUFACTURE SNA/X.25 INTERFACES

DEC	DNA
Honeywell	DSA
NCR	CNA
Sperry	DCA
Data General	DG/SNA
Hewlett-Packard	DSN
Prime	Primenet

E. DEC'S ETHERNET IS THE LARGEST COMPETITOR

- Digital Equipment Corporation has announced a three-year program to support Ethernet protocols and link DECnet with IBM's Systems Network Architecture (SNA). Four Ethernet products have been introduced. The first was unveiled in 1982. The PDP-11-based DECnet/SNA Gateway computer was shipped in 1983 and is still undergoing field testing. Pricing should be announced after field testing is completed.

- The first systems to make use of the Ethernet products and SNA Gateway computer are the VAX family and Unibus-based PDP-11.

  - Subsequent applications will involve the DEC system 20 and the new Professional low-end microcomputers.

  - DEC has projected 1984 for the direct access to Ethernet by VAXs and Unibus-based PDP-11s.

- DEC is also going to be marketing a transceiver, coaxial cable, and an Ethernet communications controller for Unibus systems, as well as software support consisting of DECnet-VAX and DECnet-RSX software packages.

- DEC's Ethernet and SNA program will be implemented via Phase IV of DECnet. This new technology will result in a fourfold increase in network nodes--from 255 to over 1,000.

EXHIBIT II-5

DEC'S ETHERNET IS THE LARGEST COMPETITOR

- **Features:**
  - Branching Tree Topology
  - Digital Baseband Transmission
  - 1000 Nodes (Maximum)
  - No Limit on Number of Workstations
  - 10 Mbps Aggregate Throughput
  - CSMA/CD Access Method
  - Packet-Switched and Broadcast Address Methods
  - RS-232C and Ethernet Interfaces

- **End-User Applications:**
  - File Transfer and Storage
  - Message Switching
  - Protocol Conversion
  - Electronic Mail

- **Network Interconnections:**
  - External Host
  - X.25 Gateway
  - LAN of Same Type
  - LAN of Different Type
  - SNA Gateway

F. DEC'S GATEWAY SYSTEM OFFERS NON-IBM COMPATIBILITY

- The Unibus communications controller, called DEUNA, is priced at about $3,500 and became available in mid-1983. The controller performs data link functions for its associated Ethernet node, proper channel access, and retransmission attempts upon collision detection.

- Standard coaxial cable was supplied by the company starting in late 1982.

  - The DECnet/SNA Gateway allows PDP-11s and VAXes linked by DECnet to communicate with IBM computer systems.

  - Systems connected to the Gateway via DECnet can access the Gateway's optional software packages, which include network management, remote job entry capability, an interactive 3270 facility, and an applications program interface.

- The interactive 3270 module allows users to interact with an existing IBM application from a VT 100 CRT terminal, while the applications program interface allows users to write application programs on a DEC processor that can communicate with IBM host application programs.

EXHIBIT II-6

DEC'S GATEWAY SYSTEM OFFERS NON-IBM COMPATIBILITY

- **DEUNA is a New DEC Communications Controller**
- **SNA GATEWAY Links DEC and IBM Systems**
- **GATEWAY Provides Multiple Communications Functions**
- **Inter-System Communication Can Be at Application Levels**

G. THE OPEN SYSTEMS INTERCONNECTION (OSI) IS STANDARD

- In view of the obvious user demand for broad compatibility among the various major networking architectures, the International Standards Organization (ISO) has established a standard that it refers to as "Open Systems Interconnection" or OSI.

  - The OSI model consists of a seven-layer model: three lower layers representing the communications functions of a network, a middle layer to ensure the integrity of information transfer between sending and receiving computer systems, and three top layers relating to the actual processing of the information.

  - Computer manufacturers such as Honeywell and Univac have already indicated that they will support the OSI standard. It is expected that IBM will also eventually revise its SNA procedures to accommodate OSI.

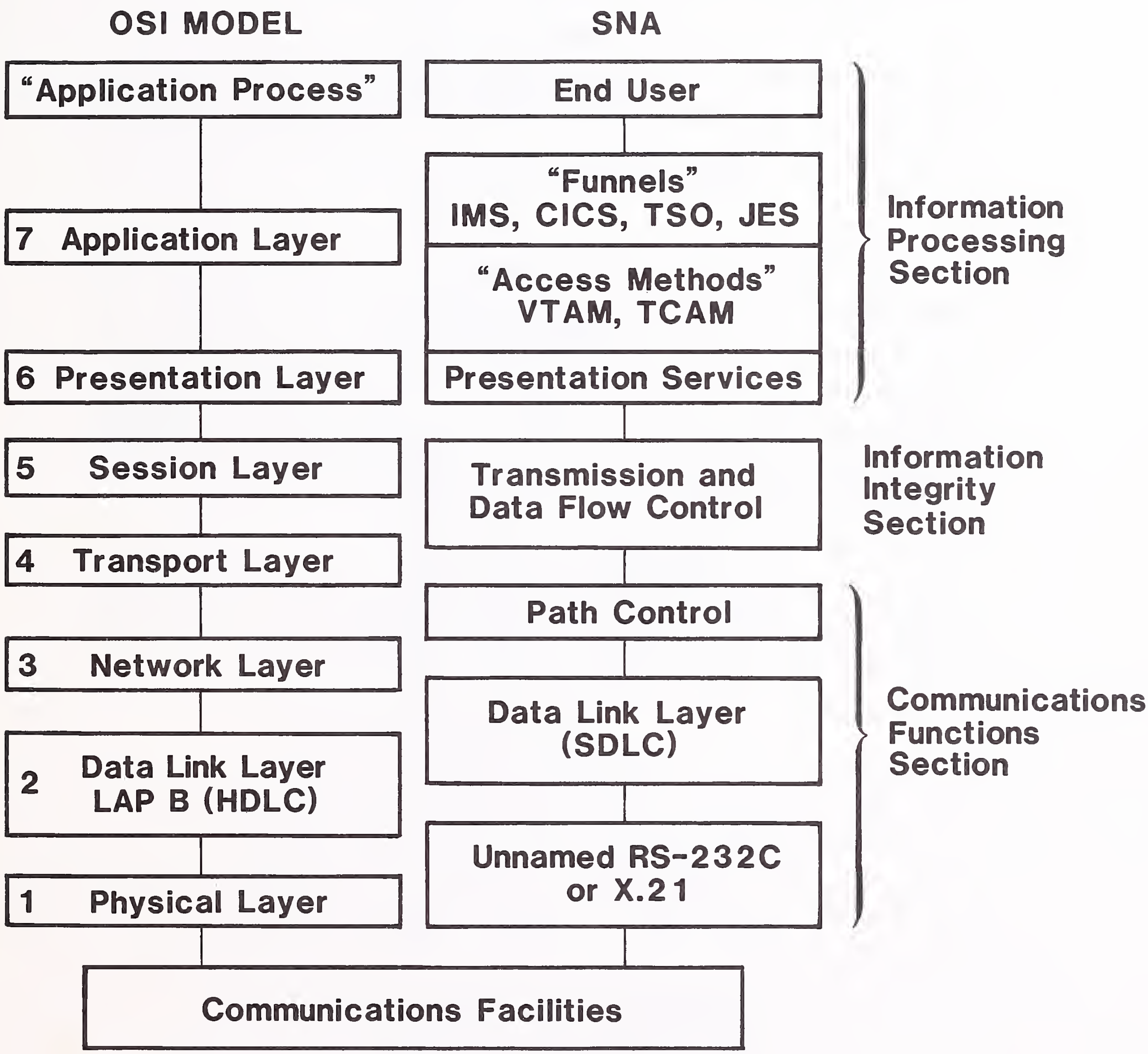
- The X.25 (and X.21) already comply with the three lower levels of the OSI standard.

  - It still remains to be seen, however, how the various equipment manufacturers will handle the higher layers.

  - SNA contains many of the functions specified in the higher levels of OSI and could, therefore, provide the fundamental basis for the networking environment of the 1980s and beyond.

EXHIBIT II-7

THE OPEN SYSTEMS INTERCONNECTION (OSI) IS STANDARD



H. SNA PROGRAM RECOMMENDATIONS

- Orient your SNA planning process toward using programs directly concerned with operating SNA networks, such as the following access methods: ACF/TCAM, ACF/VTAM, ACF/VTAME, and ACF/NCP/VS.

- Use major programs and subsystems (such as transaction processing systems and remote job entry programs) that help end users move data, transactions, and jobs through SNA networks, such as: IMS/VS, CICS/VS, DPPX/DTMS, and ACP/TPF.

- Remote job entry (RJE) programs for SNA networks and data management program components of an MVS or DOS/VSE system control program. Jobs can be submitted directly to OS from remotely located input devices where RJE subsystems are installed: OS/VS1 for RES/JES1, OS/VS1 with JES/RJE, OS/VS2 with NJE for JES2, OS/VS2 with JES3 for RJE, MVS/IDWS, DOS/VSE/Power, DPPX/RJE workstation facility, and OS/VS and DOS/VSE with JEP and FTP.

- Finally, IS management should know that there are three host-resident programs that support programs in other SNA nodes: SSP for ACF/NCP/VS, DSX, and HCF.

EXHIBIT II-8

SNA PROGRAM RECOMMENDATIONS

- Networks
  - ACF/TCAM
  - ACF/VTAM
  - ACF/VTAME
  - ACF/NCP/VS
- Transaction Processing
  - IMS/VS
  - CICS/VS
  - DPPX/DTMS
  - ACP/TPF
- RJE
  - OS/VS1 -- RES/JES1
  - OS/VS1 -- JES/RJE
  - OS/VS2 -- NJE/JES2
  - OS/VS2 -- JES3/RJE
  - MVS/IDWS
  - DOS/VSE/Power
  - DPPX/RJE Workstation
  - OS/VS -- JEP/FTP
  - DOS/VSE -- JEP/FTP
- Host-Resident Support
  - SSP -- ACF/NCP/VS
  - DSX
  - HCF

III TECHNOLOGY REVIEW/ANALYSIS

A. INTRODUCTION

- Systems Network Architecture (SNA) comprises the logical structure, formats, protocols, and operational sequences that govern information transmission through an IBM data communications network, i.e., the total spectrum of IBM networking.

- An important feature of SNA is the transparency provided to the network user for most communications, which are performed automatically in the SNA system.

    - Regardless of the size and complexity of the network, SNA permits the handling of many difficult communications problems and tasks with little or no operator intervention.

    - The system designer must take care, however, to ensure that the network employs the full range of SNA's communications and contingency management capabilities.

- SNA also provides for access to any applications program from any terminal in the network, automatic reconfiguration of the network, and automatic sharing of resources among host processors in the network.

- SNA fully supports the networking of distributed processors connected to one or more hosts. A broad variety of remote data entry capabilities is available from IBM for use with a wide range of distributed systems, such as the 8100 Information System, the System/38, the 3790 Communications System, the Series/1, and others.

- SNA achieves these capabilities through the implementation of certain IBM hardware and software products, which usually requires upgrading of existing IBM systems. This report outlines these hardware and software products and their intercompatibility.

B. CHARACTERISTICS OF SNA

- In general, the implementation of four elements can be said to distinguish an SNA network from a pre-SNA configuration:

  - Programmable communications processors.

  - Synchronous Data Link Control (SDLC).

  - A layered concept for each communications operation.

  - The implementation of certain SNA terminals.

1. PROGRAMMABLE COMMUNICATIONS PROCEDURES

- The implementation of an SNA network requires at least one programmable communications processor, such as the IBM 3704, 3705, or 3725 Communications Controllers. At least one such device must be attached locally to a host, to perform network control functions externally to the host. The host is thereby relieved of routine communications processing and permitted to concentrate on applications processing.

- In larger SNA systems, this separation of function permits the communications processor to shift its incoming data automatically to a different, and even remote host, in the event that its host fails. To a limited extent, programmable communications processors can control network functions without communicating with any host.

- Additionally, a single front-end communications processor can serve up to eight hosts, attached locally or remotely.

• In contrast, pre-SNA configurations have used either a 270X hard-wired line controller, or an Integrated Communications Adapter for communications line handling. (A 370X or 3725 running in emulation mode is really a lower cost 270X, not a front end.) Either device requires that host software and processing power be devoted to communications processing, a costly use of host time and memory resources. More importantly for SNA, neither device supports the SDLC line discipline, a key ingredient of SNA communications.

• IBM provides several different software products that run on the 3704, 3705, or 3725. These products, the choice of which depends on the degree of network functionality required, are detailed later in this report.

2. SYNCHRONOUS DATA LINK CONTROL (SDLC)

• SDLC is the IBM line protocol indigenous to SNA.

- SDLC is a bit-oriented discipline that can support half or full-duplex transmission, point-to-point or multipoint lines, and leased or switched facilities.

- Transmission speed is supported at up to 230.4 K bps.

- Each SDLC transmission is composed of one or more frames, each of which starts and ends with a flag bit pattern. Each frame contains an address and a control field. Each frame also provides for error detection.

    - Frames are sequenced, and up to seven frames may be transmitted before validation by the receiving device is required.

    - All unconfirmed frames are retained by the transmitter until confirmed, so that transmission can be restarted at the frame containing a detected transmission error.

- This degree of data link control primarily distinguishes SDLC from binary synchronous (BSC) transmission, the pre-SNA, character-oriented standard protocol which IBM announced with the System/360 in 1964.

- The control field carried in the SDLC frame indicates whether the message contains function management, data flow control, network control, or session control information. It also indicates whether the frame and message are supervisory or informational, sequenced or non-sequenced.

    - All control information is generated automatically and is transparent to the end user. SDLC additionally permits low-overhead communications between SNA devices once a communications link, or "session," is established.

    - This type of data transmission is termed the "record mode" of operations. BSC devices cannot communicate in this mode.

- In any SDLC link between two stations, the primary station controls all communications. The secondary station can only respond.

    - Although BSC transmission requires designation of master and slave stations for each communications operation, only SDLC permits a single station to be both a primary and a secondary station.

- An SNA device may communicate as a secondary station on one line, and as a primary station on one or more other lines.

3. ARCHITECTURAL LAYERING

- SNA provides six layers of control for every message that passes across the network.

  - A message passing from one application (terminal or program) to another must pass through all six layers at each end of the communications path. Some network functions, such as routing, involve only the lowermost layers of SNA control.

  - A message passing through an intermediate routing process between its source and destination passes through these lower routing layers twice at each routing node, once when the routing process receives the message, and once as it forwards the message toward its destination.

- Each layer has specific responsibilities in the handling of a message.

  - Each layer communicates directly only with its adjacent layers, those directly above and below it in the architecture.

  - Each layer acts upon information only from its parallel layer in the process at the other end of the session. Thus, network designers can change (update, revise, or improve) functions in any layer of the architecture without affecting the functions of other layers, as long as such changes are uniform in that layer throughout the network, and do not affect the ways that the layer passes information to (and receives information from) its adjacent layers.

- The uppermost two layers of the SNA interface, the Network Addressable Unit (NAU) Services Manager and the Function Management Data (MFD) Services, together provide session presentation services and application-to-application services.

  - Session presentation services include compression of data for faster throughput, and data formatting for presentation on specific terminal screens.

  - Application-to-application services include protocol translation and the synchronization of activities among transaction processing programs.

  - The NAU Services Manager and FMD Services layers also perform certain networkwide services such as configuration management, network operator communications, and the initiation and termination of sessions between applications in the network.

- Below the FMD Services layer is the Data Flow Control Services layer. This layer sets the send/receive mode of the session, is responsible for chaining and bracketing of messages, and provides some high-level error control.

  - SNA provides three alternative send/receive modes:

    . Full duplex, with concurrent flow of information in both directions.

    . Half-duplex flip-flop, in which stations alternate in sending messages across the session.

    . Half-duplex contention, in which stations at either end of the session contend for the use of the communications link, with one or the other prevailing according to an established convention.

- Changing ad bracketing is a way of logically grouping units of information into larger groups for more efficient transmission and error control.

    - A chain is such a grouping sent in one direction across a session.

    - A bracket is similar grouping established in both directions across a session to ensure that related units or chains of information (such as a request and its response) are handled properly.

- The Transmission Control Services layer paces the flow of information across a session, allowing a station to send only as much information across the session as its partner can handle at one time. Transmission Control Services can also provide encryption and decryption of data on request of the applications at either end of the session.

- The Path Control Network layer routes messages from their source to their destination, and controls the size of the data units actually transmitted across the network, segmenting long messages and blocking shorter messages for efficient transmission.

    - A sub-function of the Path Control layer's routing capabilities is the establishment of a class of service for each session according to parameters established by the communicating applications. A given class of service may provide higher transmission speed, better data security, or a more reliable connection.

    - The Path Control layer provides an additional form of message pacing to handle peak loads across the network.

- The lowest layer defined by SNA is the Data Link layer, which, for data transmitted across the network, formats messages into SDLC frames, and provides the error-control services of SDLC.

- For data transmitted between a channel-attached device and a host processor, the Data Link layer user IBM's System/370 channel protocol instead of SDLC.

- IBM has begun to implement specific protocols at the application layer, "above" the seven layers defined by SNA for general communications tasks.

  - The first such set of protocols, collectively called the Document Interchange Architecture (DIA), was announced in 1981, and attempts to define a high-level standard for communications among IBM's office automation systems.

  - The protocols comprise a layered series of application-level architectures, logically nested one within the other, each specific to one task in the automated office.

  - DIA underlines the whole application-level structure, and provides for the distribution and filing of documents.

- The unit of information in DIA is the Document Interchange Unit (DIU), a logical envelope similar to the SDLC frame.

  - All DIUs contain an identifier, a command field, a data field, and one or more document units.

    - The identifier enables the receiving application to reply specifically to DIUs that require a response.

    - The command field contains any DIA commands, such as orders to distribute or file the information contained in the document unit.

- The data field contains data, such as distribution lists or file locations, for the commands in the command field.

- The document units contain a document profile and the document contents, defined according to one of several Document Content Architectures (DCAs).

- The DCAs describe application-specific standards for such parameters as column tabulation, centering, and margin setting.

• Another layer of the DIA scheme consists of Graphic Codepoint Definitions (GCDs). These define specific character sets, or, more, precisely, the assignment of specific characters to each of the 256 eight-bit patterns available to define a character set.

  - Each set of 256 patterns is called a codepoint.

  - Codepoints define only the assignment of characters; they are insensitive to the content of the data. Thus, the graphic expression $1,000 in a U.S. codepoint is equivalent to the expression pound 1,000 in a British codepoint, regardless of the currency exchange rate.

• IBM's office architectures currently apply only to a small subset of the vendor's product line. However, office architectures indicate a likely future direction for SNA.

  - Similar application architectures, yet to be developed, will bring the SNA communications hierarchy from the cable interface to the user's fingertips in an orderly progression of layers.

  - End users will need to concern themselves only with the topmost layer; the rest of the network will be transparent.

C. SNA TERMINAL DEVICES

- A wide range of terminal products can be employed in an SNA system, although each device's degree of programmability and protocol support significantly affects its communications efficiency within the network.

- All IBM terminals that can be configured in an SNA network are categorized as either SNA or non-SNA terminals. SNA terminals are generally those programmable devices that support SDLC communications and the establishment and operation of sessions, allowing communication in the highly efficient record mode of operation.

- In keeping with the layered concept of communications, each SNA terminal contains a Physical Unit (PU), which handles the device's interaction with network communications, and one or more Logical Units (LU), which handle communications with the host's applications programs, or other logical units in the network.

  - In establishing a session with an SNA terminal, the PU is first contacted.

  - After necessary communications administration with the PU is accomplished, the addressed LU is then activated, and the session begins.

- The configuration of logical units within SNA terminals varies depending on the specific terminal model.

  - With the 3790 Communications System, for example, the 3791 controller contains the PU and an LU for each attached, separately addressable device in the 3790 system.

- Each device with an LU located in the controller unit is capable of initiating connections and disconnections independently, and communication with separate applications programs.

- In an SNA network, all PUs and LUs, including any accessible applications programs residing in the host, are known as Network Addressable Units (NAUs).

• The discussion of PUs, LUs, and NAUs (all of which are transparent to the terminal operator), would be meaningless except for its use in contrasting the network's handling of SNA and non-SNA terminals. BSC and asynchronous devices are non-SNA terminals, and contain no network-addressable units, but many such devices are accommodated in an SNA system nevertheless.

• The integration of these devices into the network requires their connection to an SNA device, usually a 3705 or 3725 Communications Controller.

  - For these non-SNA devices, the communications controller receives their input, strips and retains the control information fields of their messages, and then routes the messages accordingly.

  - Return messages are likewise reformatted, with the communications controller sending the message content with appropriate BSC or async control characters inserted.

• BSC and async message traffic is handled by the host on an exception basis.

  - The host is interrupted, and must search an interpret table before the BSC or async message can be processed.

  - The processing overhead, therefore, for non-SNA message traffic is considerable.

D. MIGRATION TO SNA

- Current non-SNA IBM users can gradually migrate to an SNA system.

  - To understand the system changes required, this section examines the software and hardware components required for an IBM user to achieve the minimal SNA configuration. Specifically, discussed are communications controllers and their software loads, host operating systems, and telecommunications access methods.

1. SNA-COMPATIBLE HOST OPERATING SYSTEMS

- Even the smallest SNA system requires an IBM System/370 (Model 135 or larger), 303X, 308X, 4300, or compatible processor operating in a virtual system mode.

- The currently supported IBM operating systems in which SNA can be implemented are: DOX/VS, OS/VS1, OS/VS2 (SVS), and OS/VS2 (MVS), OS/VS2 (MVS/XA), DOS/VSE, and SSX/VSE Systems (which include, as a subsystem, at least one of these operating systems).

  - The oldest versions of the operating system that supports SNA are:

    - DOS/VS, release 34.

    - OS/VS1, release 6.0.

    - OS/VS2 (SVS), release 1.7.

    - OS/VS2 (MVS) release 3.0.

    - OS/VS2 (MVS/XA), release 1.0.

- DOS/VSE, release 1.0.

- SSX/VSE, release 1.0.

- It can generally be said that any earlier IBM release that is still actively supported can be upgraded to a more current level that does support SNA.

- The user's choice of an operating system will depend on the particular system configuration and applications required.

  - Different operating systems, and even different releases of the same operating system, offer widely varying special utility capabilities and compatibilities. These systems likewise differ significantly in their support of particular remote data entry packages such as HASP, RJE, RES, JES, etc.

  - For established or new IBM users, existing system configurations will either support, or can be upgraded to support SNA, as long as one or more of the above operating systems is in place.

2. SNA TELECOMMUNICATIONS ACCESS METHODS

- Two IBM communications access methods support SNA and the operating systems previously mentioned. They are the Telecommunications Access Method (TCAM) and the Virtual Telecommunications Access Method (VTAM).

- Within each SNA host system, one of these access methods is required.

  - The communications access method is a key to achieving SNA and is a major component of the host operating system.

- The access method handles the interaction between the host application programs and the local communications controller (Function Management layer). Its functions are supervised by a System Services Control Point (SSCP) within the access method.

- The SSCP is actually the "switchboard" logic for the system and contains a matrix of defined communications parameters for each of the addressable elements in the network.

- The SSCP, like all the Physical and Logical Units in the system, is a Network Addressable Unit, and provides the necessary "bind" information for session establishment whenever a request is received from either a terminal or an application.

- Except for the 4300 processors, the basic communications access method is included with the operating system as System Control Programming (SCP), and is generated with the system. With the 4300 processor, however, IBM is providing unbundled operating software, and the communications access method, as with most other operating utilities, is separately priced.

3. TCAM VERSUS VTAM

- TCAM was IBM's first SNA communications access method, and is best suited for the IBM user migrating toward an SNA system.

  - TCAM provides more extensive support for IBM BSC and async devices than does VTAM.

  - TCAM would similarly best serve a user whose system is expected to maintain a wide variety of mixed BSC, async, and SDLC devices.

- VTAM, conversely, would best serve the user whose network uses, or plans to use, predominantly SNA/SDLC devices.

- VTAM provides for immediate access to applications within the host, whereas TCAM uses message handling queues more extensively.

- Basic VTAM supports remote communications controllers, whereas TCAM does not.

• As an SNA system grows, functional enhancements will need to be added to the access method, whether TCAM or VTAM. IBM provides several program products for this purpose.

E. ACF/TCAM AND ACF/VTAM

• Advanced Communications Function (ACF) was introduced by IBM in 1976, with a separate program product enhancement for both TCAM and VTAM. ACF/VTME, introduced later for the DOS/VSE operating system, provides similar capabilities for 4300-Series systems.

• The most significant capability of ACF is its added ability to interconnect different operating systems and different hosts, whether in the same or geographically different locations.

  - An additional program enhancement, the Multisystem Networking Facility (MSNF), is required for each access method involved in an interconnected network.

• The multisystem capability provides any supported terminal within the network with full access to any application program in any connected host.

  - The access method, in conjunction with the communications processor (loaded with a similar ACF program), provides network transparency to both the application and the terminal involved. The terminal operator need not even know which host controls the application he or she is using.

- Without the MSNF, terminal and line switching from one host system to another could only be achieved through host system operator commands or through user-programmed procedures.

- ACF additionally provides IBM users with a switched-line capability for remote SNA devices, support for remote communications controllers for TCAM in ACF/TCAM, and the capability for one host to assume control of an adjacent host's communications controller in the event of a host failure.

- Any user wishing to implement a fully-functional SNA network must consider implementing either ACF/VTAM, Release 3; or ACF/TCAM, Version 2, Release 3; or later. These releases, introduced in June 1981, contain the maximum range of SNA functions currently available. For example, only these releases provide for multiple SDLC links operating in parallel between adjacent 3705 or 3725 communications controllers.

  - These multiple links can be arranged logically into transmission groups, each of which provides a single logical path between controllers, essentially allowing transparent redundant connections over which data may flow.

  - This multiple active routing feature allows the transmitting communications controller to select among active links on a given path, providing backup service should one or more links fail to become overcrowded.

- ACF/VTAM Release 3 and 4 and ACF/TCAM Version 2, Release 3 also introduced the concept of virtual routing, by which an application can request, or be assigned, one of three priorities for transmission.

- The communications controller then queues incoming messages and releases them according to priority, invoking a time-out function to assure that low-priority messages do not age excessively.

- A session's explicit route across the network, combined with its priority, is that session's virtual route. (A session's explicit route is the path of its messages from source to destination over transmission groups between intervening communications controllers.)

- More than one virtual route may share a single explicit route.

- Additionally, these releases of the ACF access methods provide for multiple ownerships of a single communications controller by up to eight host processors, and the attachment of more than one communications controller via either channels or SDLC links.

I. MULTISYSTEM NETWORKING

- All the network elements defined to an SSCP comprise the SCCP's domain. An addressable unit may belong to only one domain, even if more than one access method resides in its host (as in MVS or VM/370 configurations).

- The MultiSystem Networking Facility (MSNF) makes cross-domain communications possible. The MSNF gives the access method the ability to determine the location of a foreign resource, to obtain from its access method the necessary "bind" information for session establishment, and then to initiate a session between an element in its domain and the foreign resource.

- The SSCP is but one resource of the access method. Other logical modules (such as the Message Control Program (MCP) and the software of the communications controller) work together to provide for the coordinated and efficient movement of message traffic into and out of the host.

2. 3704, 3705, AND 3725 COMMUNICATIONS CONTROLLERS

- A user must attach at least one local 3704, 3705, or 3725 Communications Controller before any SNA terminal devices can be configured. There is one exception to using a 370X or 3725--the 4331 processor is capable of supporting an eight-line Integrated Communications Adapter (ICA) that can accommodate SNA communications.

- From a migration point of view, a single entry-level 3705-80 could suffice for beginning an SNA system. The 3705-80 can support a single channel connection to a single host, and up to 16 communications lines.

- A fully configured 3725 can accommodate up to 256 full-duplex communications lines, and connection to up to eight host processors via channel attachment or SDLC communications lines. Thus, the 3725 may serve as a local communications controller for one or more hosts, while serving as a remote controller for others.

- IBM-provided software permits three different modes of operation for the communications controller, which provides for a staged migration toward achieving full SNA networking functionality.

- The Emulation Program/Virtual System (EP/VS) and the Emulation Program for the IBM 3725 (EP/3725), when loaded in a 370X or 3725 (respectively), causes the program to emulate a hard-wired 270X device.

  - A 370X or 3725 in EP mode does not support SNA, and cannot accommodate the attachment of any SNA/SDLC device.

  - Neither will it relieve the host of the communications processing burden incurred with a 270X or ICA.

- When SNA devices are introduced to a system with a communications controller operating in EP mode, the user will need to progress to the Partitioned Emulation Program (PEP) mode. This entails adding the SNA Network Control Program/Virtual System (NCP/VS).

  - The frontend under PEP operates in both EP and NCP modes simultaneously, as shown in Exhibit III-1.

  - The PEP mode permits its BSC and async communications lines to be converted to NCP control for EP one at a time. Until this conversion is complete, however, the host is still burdened with the control of the devices attached to the EP partition.

- When all devices have been defined to and brought under the control of the NCP partition, the EP is deleted, leaving a communications controller operating in NCP mode only. An SNA system is now in effect, as shown in Exhibit III-2.

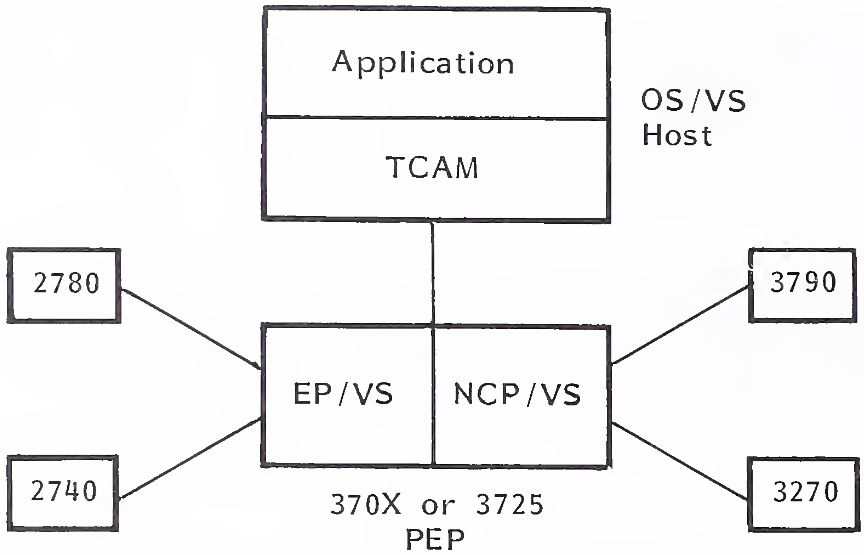
- NCP's primary function is to handle the data routing and transmission tasks of the network. It interacts with the controller's communications scanners and line adapters on one side, and the access method on the other.

- In addition to controlling and maintaining the lines and terminals attached to communications, such as polling, addressing, buffering, error recovery, code translation, character assembly and disassembly, speed selection, and line management, the NCP handles message switching to remote communications controllers, line error and other statistics, and performs a variety of diagnostic tests and tracing functions when network lines malfunction.

- A number of control parameters are available, and require specification by the user when the NCP is generated. These include:

EXHIBIT III-1

SINGLE SYSTEM: PARTITIONED EMULATION PROGRAM (PEP) MODE



SNA capability only for terminals under NCP control. Terminals under EP may only be BSC or async. Typical migration configuration.

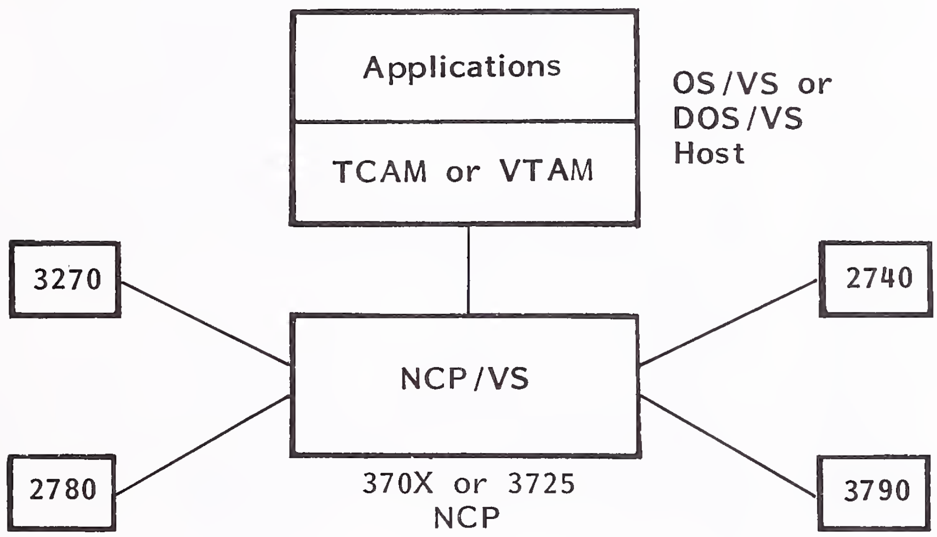
Access Method: TCAM. Only TCAM supports PEP mode.

Operating Systems: Any OS/VS.

Communications Controller: 3704, 3705, or 3725.

EXHIBIT III-2

SINGLE SYSTEM: NETWORK CONTROL (NCP) MODE



Complete SNA system. Host relieved of most communications processing. Terminals supported are mixed SDLC, BSC, and async.

Access Method: VTAM or TCAM.

Operating System: Any OS/VS or DOS/VS.

Communications Controller: 3704, 3705, or 3725.

- Number of times to try, and amount of time to wait for retransmission, in the case of transmission error.

- Alternate paths for unrecoverable error transmission.

- Maximum message and frame size.

- Number of SDLC frames to pass before requiring validation.

- Parameters for data pacing between the host and terminals.

• NCP maintains a close relationship with the host access method, and receives all the messages destined for a host application that pass through the communications controller.

  - The NCP ensures that a control information field precedes the message, and specifies the nature of the message and its destination for routing in the host.

  - The access method likewise sends control information and commands to the communications processor to request that the NCP perform certain functions.

• The different access methods permit varying degrees of support for the NCP and communications controller configurations.

  - Exhibit III-3 shows which host access methods support the different modes and configurations of the 370X or 3725.

  - It should be noted that only TCAM (or ACF/TCAM) will support either the EP or PEP modes of operation.

EXHIBIT III-3

HOST ACCESS METHOD SUPPORT

Communications Access Method	Emulation Program EP/VS or EP/3725	Partitioned Emulation Program-PEP	Network Control NCP/VS*	Multisystem Networking ACF/NCP/VS or ACF/NCP/3725	Remote Communications Controllers
TCAM, Levels 8, 9	Supported	–	–	–	–
TCAM, Level 10	Supported	Supported	Supported	–	–
ACF/TCAM, All	Supported	Supported	Supported	Supported**	Supported
VTAM, Level 2	–	–	Supported	–	Supported
ACF/VTAM, All	–	–	Supported	Supported **	Supported

* Not supported on the IBM 3725.

** ACF/NCP/3725 is supported only under ACF/TCAM Version 2 Release 4, ACF/VTAM Version 1 Release 3 (MVS only, with appropriate PTF), and ACF/VTAM Version 2 (MVS, VS1, and VSE).

- NCP or NCP/VS is the native operating mode of the 370X in an SNA system and is available as System Control Programming in a single-system environment.

  - The native operating system of the 3725 is ACF/NCP, which offers extended networking capabilities.

  - IBM also makes available an ACF program product for the 370X, ACF/NCP/VS.

- ACF/NCP/VS and ACF/NCP/3725 are adjuncts to the ACF versions of TCAM and VTAM.

  - ACF/NCP is required to achieve the multisystem networking capability provided by ACF/TCAM and ACF/VTAM, and permits networking to other hosts' 3705s or 3725s similarly loaded with ACF/NCP.

  - High-speed (230.4 Kbps) communications using SCLC link local 3705s or 3725s in a multisystem environment.

  - ACF/NCP also permits servicing two or more local hosts, or two or more access methods cohabiting a single, partitioned host, as shown in Exhibits III-4 and III-5.

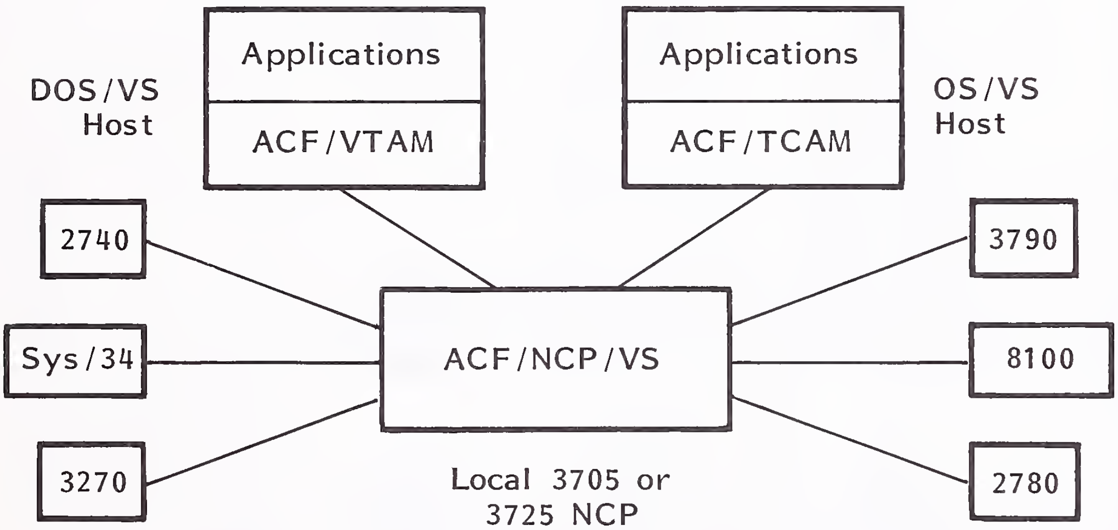
- The IBM X.25 NCP Packet Switching interface also runs as a software module under ACF/NCP.

  - It provides an interface through a 3705 or 3725 communications controller between an SNA network and an X.25 packet switching facility.

  - The interface, announced in 1981, requires a special Network Interface Adapter (NIA) in hardware to function.

EXHIBIT III-4

MULTIPLE HOSTS: SINGLE COMMUNICATIONS CONTROLLER



Multisystem configuration permits any remote terminal/system to access any application in either host automatically.

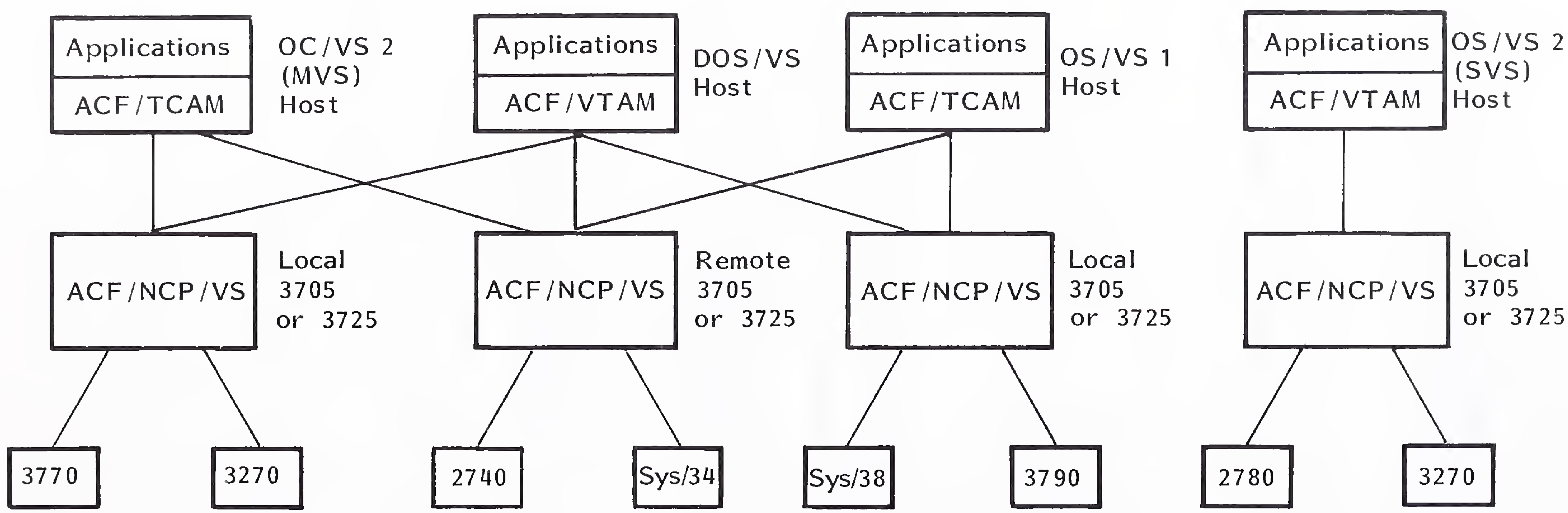
Access Method: ACF/TCAM or ACF/VTAM in each host.

Operating System: Any OS/VS or DOS/VS.

Communications Controller: 3705 or 3725; requires ACF/NCP/VS.

EXHIBIT III-5

MULTIPLE HOSTS: MULTIPLE COMMUNICATIONS CONTROLLERS



Large-scale SNA system; each host with a local 3705, interconnected via high-speed SDLC links. Access to any host from any terminal/system.

Access Method: ACF/VTAM or ACF/TCAM in each host.

Operating Systems: Any OS/VS or DOS/VS per host.

Communications Controllers: 3705 or 3725; each with ACF/NCP/VS.

F. HIERARCHICAL AND DISTRIBUTED SYSTEMS

- SNA's multisystem networking can eliminate the need for redundant applications, or redundant processors performing the same applications processing. Remote terminals seeking access to the same application, whether in the same or different systems, can all be directed under SNA to a single processor in which the application resides (as illustrated in Configuration D).

- This capability illustrates a centralized, or hierarchical approach to network configurations.

  - SNA can likewise support a decentralized, or distributed configuration.

  - In such a system, a portion of application processing is removed from the central location and placed at the location where work is performed.

  - While the centralized approach can save on hardware costs through the elimination of the need for redundant applications processing, the distributed approach can save considerably on costs of communications facilities, since transmission to a central host is minimized. (See Configuration C.)

- Several IBM standalone processors can be readily configured in an SNA system as remote distributed subsystems. The following IBM systems can perform varied remote data entry functions and support SDLC communications to a remote host. These systems possess widely varying degrees of processing power, applications functionality, mass storage, and attachable peripherals.

  - System/34.

  - System/38.

- Series/1.

- 8100 information system.

- 4331 processor.

G. NETWORK MANAGEMENT

- Not all network problems and contingencies are handled automatically by SNA with the software products discussed so far. For this reason, IBM markets separate program products that enhance the operation and network management of an SNA network. The IBM user needs to define and design the entire communications network completely before any physical devices are installed. The number of variables one must take into account is considerable and includes alternate routing for unrecoverable error transmissions, time-out routines, procedures to be invoked in the event of a processor failure, and others.

  - The capabilities achievable with the IBM access methods and NCP, if properly implemented, are extensive, but the functions these products perform relate only to routine communications management.

  - Users must provide for the efficient management of the unexpected, unusual, and sometimes disastrous communications problems that may arise.

- No matter how well an SNA communications system is planned and debugged, provisions should be made for manual operator intervention and control in the event of unusual network problems. Two network management program products run on either VTAM or TCAM systems, and support operator control capabilities.

- The first is the Network Communications Control Facility (NCCF).

  - It provides immediate operator access to program bases and services, access methods, and operating systems so that changes can be effected for network control and permits the establishment of changeable network operator stations, a customized and user-defined list of commands to support backup procedures, and other functions that support operator intervention into network operation.

- The other announced product, Network Problem Determination Application (NPDA), operates under NCCF, provides extensive error tabulation and recording, and automatically assigns probable causes to the errors it has recorded.

  - NPDA also permits user-written and user-defined operator commands and exit routines so that the network operator can screen and edit message and data traffic.

  - The latest release of NPDA runs as an on-line, interactive program under NCCF.

- An additional trouble-shooting facility, the Network Logical Data Manager (NLDM) collects and displays session-related information for SNA networks to assist in problem analysis. NLDM is also an interactive application.

- The IBM 2725 Communications Controller features a Maintenance and Operator Subsystem that can perform loopback modem and communications line tests when used with suitable IBM modems.

- Since over 70% of the available market currently uses SNA, companies not using it will be at a decided disadvantage in terms of future network interconnections and availability of large-scale data access. So pronounced is this effect that most other companies in the field are specifically designing SNA capabilities into their products, just to remain competitive.

IV CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

- An understanding of SNA and packet switching is important because high vendor interest is forcing development in that direction. It is still "the wave of the future."

- Users need to develop the capability to fully share all network resources, including lines, remote multiplexors, concentrators, terminals, and frontend processors, across all potential users, especially in a high-demand-oriented, time-variable environment.

- Such flexibility can only be achieved if there is a clear-cut separation of functional responsibility in the modules that control the network. In the architectural view of the network, different functions can be clearly associated with different logic modules of the network.

- SNA currently occupies more than 70% of the marketplace. Thus, it will continue to exert its influence over the rest of the 1980s, and well into the 1990s.

- IBM does not arbitrarily change protocols unless such changes are dictated by market demands.

B. RECOMMENDATIONS

- Make it a point to understand SNA, its use and limitations. Since SNA is very dynamic and constantly changing, an understanding of SNA and its options, features, and interactions could save a considerable sum of money to users who are committed to IBM and its software.

- Anticipate that packet switching usage will continue to grow and that the user base will expand with time; this will permit easy interface with various users and facilitate data transfer over long distances.

- SNA migration is tough. But remember that SNA is expected to expand in scope over time and many public network offerings are committed to it.

- The primary effect on the user will be easier access to computer power, at a significantly smaller cost. Thus, SNA is a very cost-effective solution to network problems.

- When migrating to SNA, encourage other vendors you do business with to provide an SNA interface. It could save you a lot of frustration and money later on, especially after all systems are firmly established.

- CCITT's X.25 protocol and OSI software/hardware layers should be studied in detail and used whenever applicable. The standardization achieved by implementing X.25 along with OSI layers should be cost-effective.

- SNA provides the key tool in creating a corporate data utility, allowing the user great access to any data base in any computer on the network. All this is available just by making a phone call into the system. Be aware of the security implications.

- Multiple-application communication is a primary goal of SNA migration: this will increase productivity, cost-effective sharing of computer and communications resources, and provide better backup of critical configurations.

- Recognize that SNA has its problems. Learn to either avoid them or live with them.

APPENDIX

SNA: Challenges & Opportunities

Survey Questionnaire

1. Name of Company ______________________________

2. Do you have or will you have extensive in-house private networks?

____

3. Do you use or require packet switching? ______________

4. Which transmission protocols do you use (or are planning to use)?

SNA ______

X.21 ______

X.25 ______

DECNET ______

Other ______

5. Do you know which protocol layers you are currently working with:

Data Link Control _____?

Path Control _____?

Transmission Control _____?

Data Flow Control _____?

Presentation (Code and Format) Services _____?

6. What will be your future network requirements? ______________

____

____

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