IBM Systems Network Architecture (SNA)

In this report:

Synopsis

Editor's Note
IBM Systems Network Architecture (SNA) continues to be a significant force in the industry. The phenomenal growth of LANs has not undercut SNA's pervasive presence in data communications because SNA gives users methods to extend centralized network management away from the mainframes to individual, LAN-based workgroups.

Report Highlights
Not only is SNA IBM's master plan for communications among IBM computers, terminals, and office systems, it is also the company's vehicle for interconnection with other industry-standard networks, such as X.25.

This report covers SNA's specifications for the structure of a network and the process of communications, including sections on Network Addressable Units, paths between nodes, SNA sessions, network management, office automation, and SNA architectural layering. Other sections explore the hardware and software in which IBM implements SNA and summarize its history.

To maintain SNA's position as a de facto data communications standard, IBM monitors SNA and makes changes and enhancements where and when necessary. IBM has consistently refined SNA since its debut in September 1974. This report reflects these changes and provides information on peer-to-peer networking, subareas and domains, and network management. To acquaint readers with IBM's attention to SNA from January 1990 to March 1991, Table 1 lists, by date, IBM announcements and enhancements relating to this vital architecture.

SNA's impact on the products and strategies of other vendors is reflected in Table 2, which chronicles SNA developments outside IBM. Prominent among vendors in Table 2 are many LAN vendors whose names are associated strongly with LANs: Banyan, Cabletron, cisco Systems, Novell, Vitalink, and Wellfleet.

—By Barbara Callahan
Associate Editor

Table 1. IBM SNA Activity from 1/90 to 3/91

1/23/90	Announced that its X.25 SNA Network Supervisory Function Release 3 features investment protection and supports the takeover when the NSF backup facility is not used.
1/23/90	Announced that its X.25 SNA Interconnection Version 2, Release 2, features improved system management by the XI activation without NSF and increased productivity.
1/23/90	Announced the availability of its System/88 Release 6 SNA and System/88 Release 6 SNA Token-Ring Link Manager programs.
1/29/90	Announced Information Network Support for X.25, TCP/IP for OS/2 Extended Edition, and X.25 Interconnection Version 2, Release 2.
2/06/90	Announced expEDIte/MVS Host, a host interface-licensed program, which can be installed in an SNA host processor to communicate with the IBM Information Network's Information Exchange Service.
3/12/90	Announced TokenWay 3174 cluster controller, which connects IBM Token-Ring networks to remote SNA hosts.
4/03/90	Announced System/88 non-SNA licensed programs, Release 10, and System/88 SNA licensed programs, Release 7, which feature support for 4968/4585 I/O adapters and SCSI adapter.
4/23/90	Introduced MAP, Ethernet, and FDDI LAN support, which provides Open Systems Interconnection/Communication Subsystem of SNA.
5/07/90	Enhanced its OS/2 Extended Edition to Release 1.2, which now features 3270 host sessions based on Presentation Manager and the ability to permit any OS/2 workstation to act as an SNA gateway.
6/19/90	Announced the VTAM Version 3 OSI Remote Programming Interface feature, which provides the same programming interface as OSI/Communications Subsystem and allows an SNA system to run OSI applications without installing OSI/Communications Subsystem.
7/03/90	Announced that SNS/SNA Gateway software from Interlink Computer Sciences will be offered through its Cooperative Software Program.

Analysis

Because of IBM's huge installed base of products, as well as those from IBM plug-compatible vendors, Systems Network Architecture (SNA) will continue as an important de facto standard for data communications for some time. In March 1991, IBM announced significant enhancements to SNA with the addition of Advanced Peer-to-Peer Networking (APPN) to the architecture. Clearly, IBM intends to keep SNA in the mainstream of its communications strategy.

Even with the emergence of OSI, SNA will continue to be a focal point in IBM's communications strategy. Last September, during IBM's announcements of OSI-based products, Ellen Hancock, IBM vice president and general manager, IBM Communications Systems, stressed IBM's commitment to SNA.

Nearly everyone who transmits data or builds equipment to transmit data comes into contact with SNA. The standard affects not only IBM and its users, but also those who want to establish connectivity with IBM mainframe-based information networks.

IBM intended SNA to serve as the catalyst to eliminate the disorder that had worked its way into several hundred products in its teleprocessing/data communications lines. By its cohesive architecture, SNA has fulfilled that goal. Since SNA's inception, IBM and its huge customer base have been capable of making decisive plans based on the predictable, gradual evolution of SNA.

SNA also provides for the distribution of certain communications functions to terminals and controllers; attachment independence via the use of a common (SDLC) protocol; device independence to allow applications software to be written

Table 1. IBM SNA Activity from 1/90 to 3/91 (Continued)

8/01/90	Enhanced its TCP/IP product for VM to feature network management capabilities based on SNMP to permit IBM mainframe users to centralize management of OSI, SNA, and TCP/IP networks.
8/21/90	Announced the AIX AS/400 Connection Program/6000, which allows users of RISC System/6000 workstations to communicate with, and access data from, AS/400 systems. The program provides 5250 emulation under SNA or TCP/IP.
8/21/90	Announced Version 3 of its 4680 operating system, which permits the controller to link to an SNA network as a Type 2.1 node and use the LU6.2 protocol.
9/05/90	Announced the 3172 Interconnect Controller Model 2 that attaches multiple LANs to multiple host computers. It supports SNA and FDDI.
9/05/90	Enhanced its 3745 Communication Controller for its SNA networks to improve performance and productivity.
9/05/90	Announced Release 4 for MVS/ESA, VM/ESA, and VM/SP, supporting direct communication between host applications and SNA devices on LANs.
9/05/90	Announced NetView Version 2, which features automation enhancements for easier troubleshooting, NetView Graphic Monitor Facility with integrated views of SNA network status, and LU6.2 for easier creation of network management applications.
9/05/90	Announced LAN-to-LAN Wide Area Network Program, which allows customers to connect remote LANs across existing WANs without adding telecommunications lines. It supports Token-Ring, PC Network, Baseband and Broadband, and Ethernet over SNA.
9/05/90	Introduced Micro Channel 370 Models 110, 112, and 114, which are the only IBM processors to take advantage of the SNA architecture's capability to distribute and install their own microcode in a distributed environment.
9/18/90	Introduced IBM X.25 Network Control Program Packet Switching Interface (NPSI) Version 3, Release 3 with ACF/NCP Version 5 Release 3, which operates in the IBM 3720 and 3745 communication controllers and provides enhancements to support SNA and non-SNA devices.
3/5/91	Announced the Advanced Peer-to-Peer Networking (APPN) architecture as an extension to SNA and SAA.
3/6/91	Announced agreements with Novell, Systems Strategies, Siemens Nixdorf, and Apple to allow them to use its Systems Network Architecture. All of the companies agreed to support APPN.

without regard to terminal and peripheral characteristics; and the reconfiguration of networks rapidly and easily.

In most network architectures, overhead is distributed away from the mainframe. SNA, however, uses mainframe-based software to control nearly all a communication's path and process. Control extends in both directions, from the input/output statements of an application program to the printer or screen of a user's terminal. IBM has modified its rigid hierarchical information networks, but SNA still requires the creation and maintenance of extensive network configuration parameters within various mainframe software components.

Conforming to IBM's policy of providing suitable migration paths for its customers, SNA also accommodates new products and techniques that incorporate backward compatibility with older, established products. This approach advances a marketing strategy committed to maintaining the company's installed base. The push toward SNA compatibility for all new products is strategic to IBM's long-term control of its existing revenue streams.

SNA Network Structure

SNA outlines the logical structure of an IBM network by setting the configurations of its nodes and the links between them and their relationship in an overall hierarchy of control. Essentially, mainframe hosts control SNA networks and communicate with each other as peers. SNA also outlines the logical progress of communications via a layered architecture of processes through which a message must pass.

SNA contains specifications for the devices or nodes in a network and for the paths between those

Table 2. SNA Activity from Other Vendors (3/90 to 2/91)

Alcatel Business Systems	Expanded its connectivity software for multivendor SNA networks with Communication Support Facility (CSF), a product that resides on the host system and reports network control and management information into NetView.
Alcatel France	Announced two communications software packages that conform to TCP/IP and OSI, enabling the direct connection of TCP/IP and OSI networks to SNA networks without passing through the central unit.
Applied Computer Technology	Enhanced its SNA Development and Test Facility, which now features testing over a token-ring network.
Aspect Telecommunications	Introduced SNA Gateway Software, which allows its ACDs to send caller information to IBM host computers running integrated voice/data applications.
AT&T	Introduced StarGROUP Software SNA gateways, which allow its Unix-based StarGROUP servers to act as SNA gateways to IBM systems; announced its SNA/3270 line, which uses ISDN to link IBM 3270 terminals to SNA terminal controllers; released additional products for users of IBM SNA networks, including 6544 Multifunction Cluster Controller, 6538/9 Display Terminal, ISDN 7506 Integrated Coax Data Module Display Terminal, and ISDN 3270 Coax Data Module.
AT&T Computer Systems	Announced SNA Networking Utility and Release 1.1 of StarGROUP SNA gateway.
AT&T Paradyne	Introduced 3610 and 3611 data service units, which feature network restoral capabilities, an SNA connection to NetView, and several multiplexing capabilities.
Banyan Systems	Announced Advanced 3270/SNA and Advanced 3270/SNA Graphics options for VINES.
Cabletron	Introduced gateways to IBM's NetView for its Remote LANVIEW and SPECTRUM platforms. SPECTRUM directly links to NetView through a built-in SNA gateway. The gateway for Remote LANVIEW/Windows ties into SNA via NetView PC.
Candle Corp.	Introduced Omegamon II for VTAM, an SAA/CUA-compliant performance monitor for IBM's Virtual Telecommunications Access Method, which analyzes performances of SNA networks.
Cincom Systems	Signed an agreement with Systems Center Inc., under which Systems Center acquired exclusive worldwide marketing rights to Net/Master SNA Network Management System.
cisco Systems	Announced a multiyear agreement with Brixton Systems to integrate SNA routing into internetwork routers.
COMPASS America	Introduced Network COMPASS, a management tool for analysis of SNA network operations.
CompuServe	Announced CompuMode, a CompuServe SNA/SDLC protocol conversion service. CompuMode provides dial-up access to IBM 3270 and 5250 environments via the CompuServe network.
Computer Network Technology	Extended CHANNELink line to support SNA terminal control units.
Data General	Enhanced its DG/UX operating system to Release 4.2, which features support for SNA software packages.
Digilog	Announced the Digilog 841 protocol analyzer, a disk-based system that decodes X.25, SNA, SS7, and ISDN.
Digital Communications Associates (DCA)	Introduced SDLC Gateway Server and 802.2 Token-Ring Gateway Server, two Macintosh LAN-to-SNA host connectivity products, which feature a choice of local or remote connections to the SNA mainframe; introduced MacIrmaLAN SDLC Gateway Server and MacIrmaLAN 802.2 Gateway Server, which provide Macintosh connectivity to the SNA environment and come in 16- and 64-user configurations; DCA and Microsoft announced the shipment of the DCA/Microsoft Select Communications Workstation, OS/2-based communications software that allows a single PC to access a variety of hosts and peer computers over IBM SNA networks.
Digital Equipment Corporation	With Systems Center, Inc., announced plans to develop an EMA access module for Systems Center's Net/Master SNA network management product to allow DECmcc Director to control IBM SNA networks; introduced the DECnet/SNA gateway for Channel Transport, which allows bidirectional exchange of information between systems on DECnet/OSI and IBM SNA networks.
Digital Technology	Introduced DTIX3270, a PC-based communications package that emulates IBM's 3174/3274 controllers and provides SNA/BSC X.25 gateways for linking NETBIOS-compatible LANs to remote IBM hosts.

Table 2. SNA Activity from Other Vendors (3/90 to 2/91) (Continued)

Eicon	Announced SNA Gateway Entry Level versions for DOS and OS/2, which lets PCs on NETBIOS or NetWare LANs connect remotely to IBM hosts via SDLC dedicated or dial-up lines, and SNA or non-SNA hosts via X.25 packet switched networks.
Gateway Communications	Introduced the ComSystem communications system, which provides realtime access to diverse systems and remote information, and can be configured as an SNA and/or X.25 gateway in NetWare or NETBIOS LANs.
GE Information Services	Announced Net-Connect 3270, an asynchronous SNA link for micro-to-mainframe communications that allows PCs to access 3270 applications on the host.
Groupe Bull SA	Enhanced its GCOS 8 operating system for the DPS 8000 and DPS 9000 mainframes with a range of products called Open Alliance, which enables interaction with Bull's open system product family, IBM SNA networks, and other vendors' systems.
Harris Adacom	Introduced the STRATEGY 9770 intelligent token-ring gateway, which integrates TCP/IP Ethernet networks with IBM SNA 4/16M bps Token-Ring environments; introduced the 9570 programmable SNA gateway.
Hewlett-Packard	Introduced HP SNA Distribution Services/XL interface between HP DeskManager and IBM OfficeVision MVS.
ICL Business Systems	Enhanced versions of PowerServer 386 systems, featuring an increase in clock speed to 33MHz, expanded disk storage, IBM SNA 3270 emulation, and NFS software based on Sun's NFS 3.2 release.
ICOT	Introduced OmniPATH Token Ring Gateway, which can handle 128 SNA sessions.
Informer Computer Terminals	Introduced the Model 213PT, a laptop SNA terminal
Integrated Micro Products	Introduced its XR 655 computer that features fault-tolerant X.25, TCP/IP, NFS, BSC, and SNA-compatible communications capabilities.
Interlink Computer Sciences	Announced an agreement with IBM that allows IBM's sales force to sell Interlink products, including its SNS/SNA Gateway Product family to IBM customers in Puerto Rico, Canada, and the U.S.; announced that the virtual machine version of its SNS/SNA gateway will support IBM's Virtual Sequential Access Method; announced that SNS/SNA supports IBM's 9371; acquired the program code and marketing rights to a TCP/IP-to-SNA gateway, developed by Advanced Computer Communications and renamed SNS/TCPaccess by Interlink.
Legent	Announced MetNet LU6.2, a software package enabling implementation for SNA-Digital interoperability software.
McDATA	Enhanced LinkMaster 6100E Ethernet-to-SNA channel server with support for TCP/IP.
Micom Communications	Introduced MB3-SNA multiplexer for IBM environments.
Mitek Systems	Introduced OpenConnect/IP Router software, which allows users to route and transfer data from one TCP/IP network to another over an SNA backbone.
Multi-Tech Systems	Introduced MultiCom3270/SNA, a remote IBM 3270 emulation system for IBM PC/AT/XT and compatible systems.
Navtel	Introduced 9410 Datacom Test Set, which decodes to Layer 3 for X.25 and SNA protocols.
NCR Comten	Announced Network Integration Service, which assists users in integrating standards-based networking with SNA; announced OSI software module, an option to its front-end processors that enables users to run OSI applications over an IBM SNA backbone network; introduced Comten OSI/Communications Processor, which allows users to integrate Ethernet LANs with existing SNA networks without gateways or bridges; introduced Comten 5645 processor, which supports four channel-attached, SNA-compatible hosts or NCR mainframe application processors; released SNA and OSI packages for the System 3000.
NCR Corp.	Released a suite of SNA and TCP/IP software.
NCR GMBH	Announced Net-Manager, an OSI-compatible network management software tool for NCR networks, token-ring, Ethernet, X.25, and SNA networks.
Netlink	Introduced SNA Link Software that allows a PC to serve as an IBM SNA router.

Table 2. SNA Activity from Other Vendors (3/90 to 2/91) (Continued)

Network Software Associates	Enhanced AdaptSNA 3270 terminal-emulation software package with Memory Mizer, which reduces the amount of memory required by the emulator from 200K bytes to 25K bytes or 20K bytes per workstation; enhanced AdaptSNA LAN Gateway, which features SNA 3270 emulation using 58K on each communicating LAN workstation; enhanced AdaptSNA LAN Gateway to support Novell NetWare LANs running IPX/SPX; announced an agreement with Future Soft Engineering in which the two will create a line of SNA connectivity software for the Windows 3.0 market.
Novell	Upgraded NetWare SNA gateway and NetWare 3270 LAN Workstation to provide a token-ring interface.
Oracle	Introduced SQL Net LU6.2, a suite of products that extends the Oracle relational database management system's support of IBM SNA networks to non-IBM operating systems and computers; announced SSQLNet LU6.2 communications software that extends IBM's SNA support to MS-DOS, VMS, AOS, and UNIX System V.
OST	Introduced PASS 25, a multiprotocol switch that supports X.25, X.21, X.32, videotex PAD, X.3, X.28, X.290 PAD, VIP, and SNA/SDLC.
Packet/PC	Announced Packet/FLASH bit compression software for its Packet/3270 emulation software for SNA networks.
Phaser Ssytems	Announced NetWare SNA Router, v2.15, which uses the IBM PU2.1 LU6.2 peer-to-peer protocol and allows the routing of NetWare packets via SNA as part of the NetWare platform.
Philips, The Netherlands	Announced the success of the first phase of a joint program with IBM, in which the two companies are investigating the transparency and connectivity of the Philips SOPHO-S ISPBX in an IBM SNA host and Token-Ring networks.
Progressive Computing	Introduced the LM1 Olympic Edition Protocol Analyzer for personal computers in IBM SNA and X.25 networks.
Proteon	Introduced the ProNet Communications Network Exchange 500, a RISC-based bridging router for the SNA environment.
Pyramid Technology	Announced IBM connectivity products for its UNIX-based line of MIS server systems, which include OpenNet SNA/3270 and BAC/3270, OpenNet SNA/RJE, OpenNet BSC/RJE, OpenNet LU6.2, and HLLAPI.
Rabbit Software	Announced Open Advantage Gateway, an SNA gateway that supports NetView; announced shipment of Open Advantage Series of SNA 3270, RJE, and APPC products for IBM RISC System/6000.
Racal-Milgo	Announced CMSView/II, a network management option capable of controlling SNA and non-SNA networks from any IBM NetView console.
Rockwell International	Introduced Contact Gateway inbound/outbound telemarketing systems that allow users to interface several ETS applications to the Galaxy ACD via SNA 3270 protocol.
Saratoga Group	Announced Desktop Seminar, a PC-based SNA tutorial program.
Siemens Data Systems	Announced Transit 3270, an SNA gateway facility for connecting WX200 UNIX-oriented workstations to IBM networks; announced 91862 Transit Token Ring adapter for its MX range of Sinix-based computers, which enables SNA emulations to be linked transparently to a token-ring LAN, and can connect serveral Sinix systems to an SNA host.
Spectographics	Introduced LanSet 800/3270dc, an X terminal that connects directly to an IBM 3270 controller to allow simultaneous communications within SNA, Ethernet TCP/IP, and UNIX-based networks.
Spider Systems	Announced that SpiderAnalyzer 320-R features support for SNA protocol to allow decoding of SNA through the Application layer of the ISO reference model.
Sterling Software	Announced the availability of SUPERTRACS/SNA and TRACS/SNA products for VSE and VSE/SP operating systems.
Sync Research	Introduced SNA Network Access Controller for Token Ring, which provides token-ring network connectivity for SDLC, BSC, and async terminals and cluster controllers.
Systems Center	Announced plans to enhance its Net/Master SNA network management system to provide multivendor network management, including support for IBM's LU6.2 protocol and an SQL database verb set.
Systems Strategies	Announced that Motorola has licensed its CommLink line of SNA communications software for the Motorola 88000 RISC microprocessor family, the Delta 8000; announced that Wang has licensed its SNA communications software for its DYNA-MIX Series, an SCO UNIX-based server family.

Table 2. SNA Activity from Other Vendors (3/90 to 2/91) (Continued)

Tandem Computers	Introduced DSM/SNA View management software.
3COM	Began shipping an OS/2 version of its Maxess Gateway, which provides for OS/2-to-SNA connections; introduced Maxess for Windows, a LAN-to-mainframe connectivity product that extends 3Com's SNA gateway capability to DOS client systems running Microsoft Windows 3.0 or/286 under any NETBIOS-compatible network operating system.
Tri-Data Systems	Announced Ethernet and token-ring LAN interface options for Netway 2000 SNA 3270 gateways for Apple Macintosh; announced support for Mitem Corp.'s Mitem-View communications tools for Macintosh computers via Netway SNA 3270 gateway line; enhanced Netway 2000 gateway for Macintosh with TIC-Connectivity Software Option and a token-ring adapter to support token-ring LANs and the Netway Advanced 3270 emulator.
Universal Software	Released AutoTrans, a bulk data handling software product that enables IBM mainframe users to send and receive data sets between host CPUs in an SNA/VTAM network environment.
Vitalink	Announced an agreement which authorizes Memorex Telex of Australia to become a major sales distributor and service provider for Vitalink's token-ring and SNA products in Australia and New Zealand.
Wandel & Goltermann	Announced the DA-30 multiport dual analyzer, which can be configured to support Ethernet, token-ring, X.25, and SNA/SDLC.
Wang Laboratories	Enhanced IDS (Information Distribution System) to Release 3.0, which features support for SNA communications over X.25 transports and SDLC.
Wellfleet Communications	Announced the Transparent Sync Pass-Thru, a software feature for its multiprotocol router/bridges that enables users to run synchronous traffic, such as IBM SNA and X.25, over a shared backbone network of bridge/routers.

nodes. Both nodes and paths are organized in hierarchies of several levels (see Figure 1). The hierarchy of nodes facilitates the distribution of functions under central control. The hierarchy of paths provides flexibility and redundancy in routing.

End Users

Under SNA, the term "end user" designates either a person or an application program communicating over the network with other end users. Application programs reside in IBM mainframes, cluster controllers, smart terminals, or personal computers. A person entering data at a remote workstation plus the application program being accessed are *both* end users. SNA does not distinguish among different types of users, which are defined externally to the network structure.

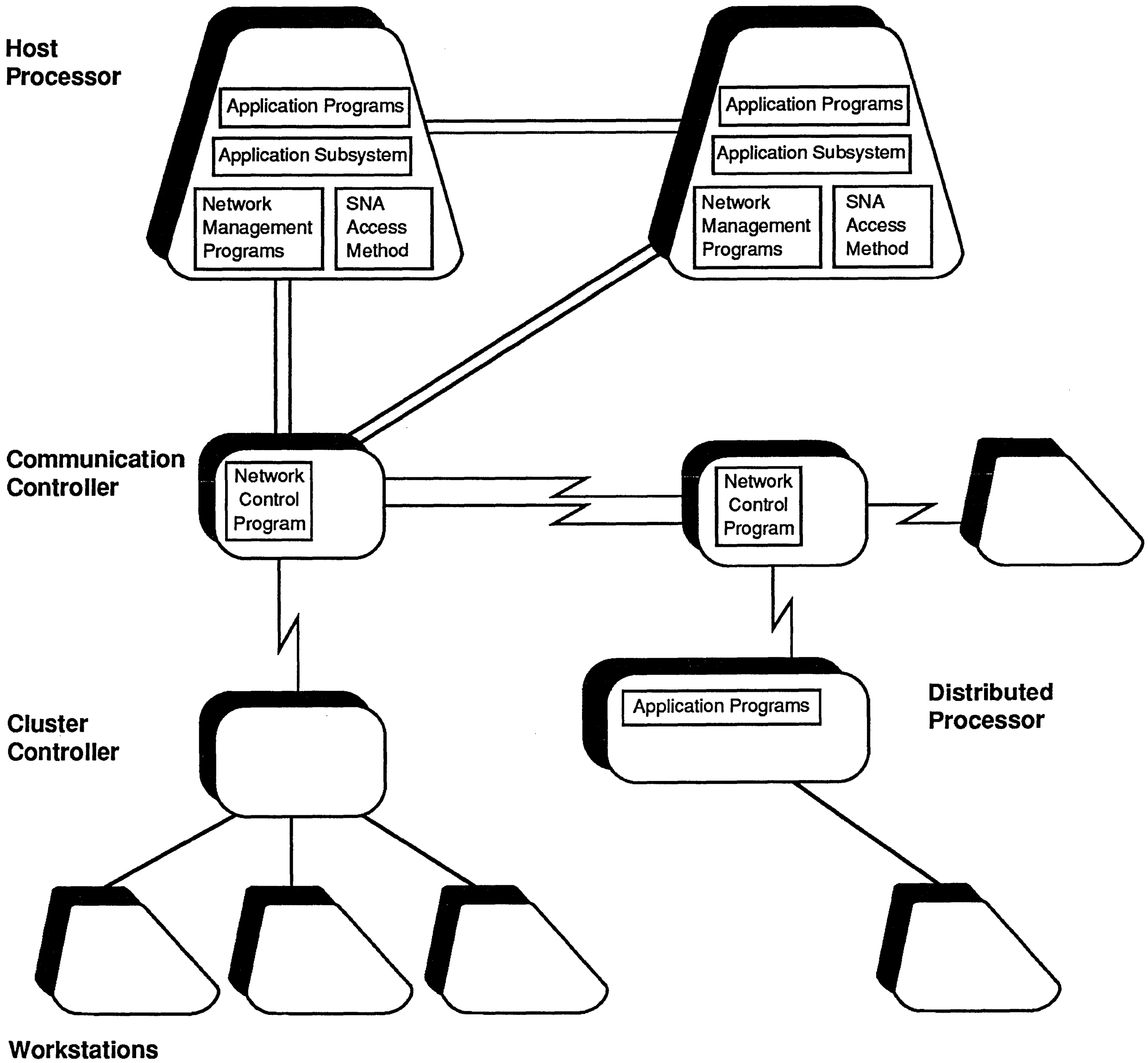
SNA Nodes

Each device in an SNA network controls a specific part of the network at its level of the hierarchy and operates under the control of a device at the next level.

IBM has specified six types of nodes in SNA, four of which belong to specific types of devices.

- *Type 5* represents a System/370 mainframe containing a Systems Services Control Point (SSCP) and ACF/VTAM or ACF/TCAM. Series/1, System/3X, and AS/400 minicomputers are excluded.
- *Type 4* represents a communications processor such as the IBM 3705, 3725, or 3745, which can operate as a front end to a host or as a remote communications processor.
- *Type 3* is not yet defined.
- *Type 2* units are generally end nodes with limited routing capabilities. Type 2 represents a terminal cluster controller, such as the IBM 3274 or 3276, or a remote batch terminal that supports SDLC.
- *Type 2.1* nodes are workstations, terminal controllers, or minicomputers that incorporate enough intelligence to establish peer-to-peer communications without mainframe intervention. IBM's Low Entry Networking supports peer-to-peer communications between Type 2.1 nodes.

Figure 1.
SNA Network Components



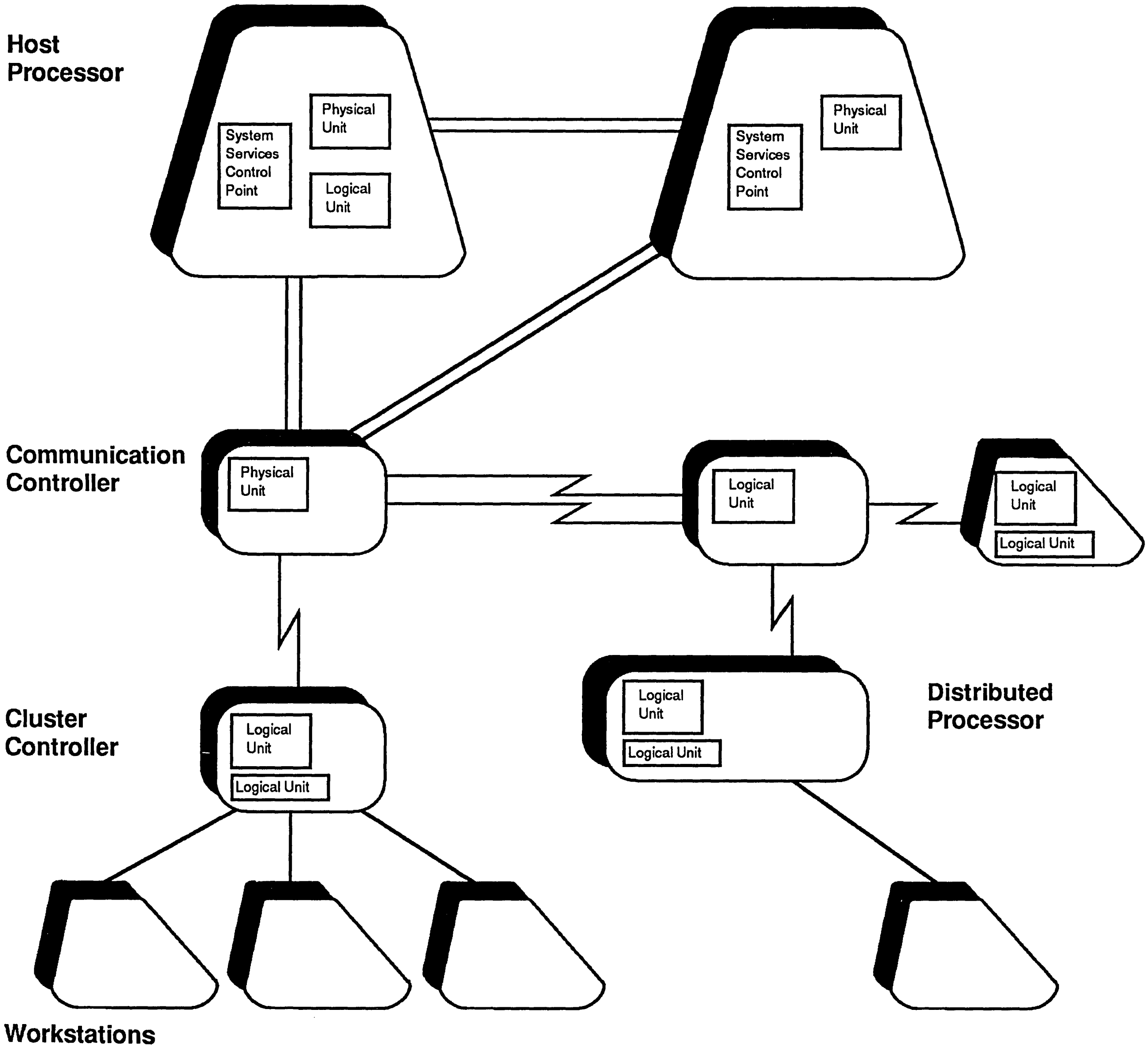
Components include host processors, distributed processors, communication controllers, cluster controllers, workstations, SNA access methods, applications subsystems, application programs, network management programs, and network control programs.

- *Type 1* is actually located in a 37X5 ACF/NCP controller and represents services for terminals defined as pre-SNA, such as asynchronous displays. Also represented are SDLC-supporting 3271 (Model 11) controllers and 3767 teleprinters. *Type 1 nodes are now obsolete.*

Network Addressable Units

IBM designates participating devices and programs in SNA as *network addressable units* (NAUs). An NAU uniquely defines and represents a device (terminal or control unit), a line, a program (application program in the host or cluster controller), a portion of an SNA access method, or a portion of an ACF/NCP 37X5. In an actual implementation, an NAU is a segment of program code that represents a specific device or program to the network. There are three general types of NAUs: System Services Control Point (SSCP), Physical Unit (PU), and Logical Unit (LU) (see Figure 2).

Figure 2.
Network Addressable Units (NAUs)



NAUs include logical units (LUs), physical units (PUs), and system services control points. NAU addresses identify their routing locations, enabling end users to transmit data to each other.

SSCP

An *SSCP* resides in the communications access method of an IBM mainframe or in the system control program of a small IBM computer. The SSCP contains the network's address tables, name-to-address translation tables, routing tables, and instructions for those tables. The SSCP establishes connections between nodes in the network and selects routes for communications between those nodes. It also controls the flow of information to ensure the network operates efficiently. In effect, the SSCP controls the network.

Some SNA networks have more than one SSCP. In a network with a single mainframe host, the computer may have two access methods operating in different partitions and controlling separate networks for different applications. In networks with more than one host mainframe, each host may have one or more access methods controlling parts of its network. In such cases, the SSCPs associated with the various access methods interact as peers; each controls a *domain* in the network. A domain consists of one SSCP per ACF/

access method, plus the physical units and logical units that the SSCP recognizes.

A major exception to the rule of peer-to-peer communications among SSCPs is the Gateway SSCP in the SNA Network Interconnection (SNI) feature. With that feature, a number of otherwise independent SNA networks communicate with one another through a single *Gateway.* An SSCP in the Gateway controls all communications between networks, acting as a master SSCP for the internetwork. SSCPs in the participating networks fully control communications within their respective domains and interact with one another as peers within their respective networks.

Physical Unit

A *Physical Unit* (PU) is a portion of a control program that defines a collection of services performed by the node for itself and the less intelligent devices attached to it. Since each participating device in an SNA network has one physical unit, for all practical purposes, node types and PU types are the same.

In programmable devices, such as host computers and communications processors, the PU is usually implemented in software. In less intelligent devices, such as cluster controllers or terminals, the PU is usually implemented in microcode or firmware.

In an SNA network, each PU generally operates under the control of the SSCP and serves as an entry point between the network and one or more Logical Units. Type 2.1 nodes, however, can establish direct, peer-to-peer communications by implementing their own session management, which can support single or parallel half-duplex sessions over multiple data links. The capability to communicate without mainframe intervention is a significant departure from original SNA strategy and is the key to the integration of personal computers and other intelligent devices into future SNA networks. To achieve this functionality, the LU6.2 must support Type 2.1 nodes. In 1987, IBM released enhancements that supported the integration of LU6.2s in T2.1 nodes into conventional subarea networks.

Logical Unit

A *Logical Unit* (LU) represents an end user to the network. Such an end user can be an operator at a terminal or an application program. The application may be a data entry task running at a terminal, a database update running in a host, or any process that serves as an end point to an SNA communication. The Logical Unit comprises those portions of the application program and the communications software that pass and translate information from the network to the application. The Logical Unit maintains and transmits information about its own status, such as its capability to communicate and its current communication activities.

LU6.1 was an early, somewhat successful attempt to define a level 6 Logical Unit. LU6.1 is sufficiently compatible with LU6.2; a bridge program can convert LU6.1 calls to LU6.2. This capability enables IMS applications to use LU6.2 facilities as they are developed.

LU6.2 is the level 6 Logical Unit that IBM has established as the standard for Advanced Program-to-Program Communication (APPC). APPC activates the definition of a session between an application program in a host computer and an application program in the same host, a different host, or an intelligent terminal (PU2.1). More significantly, sessions between two PU2.1 nodes, without host intervention, are also defined with APPC.

IBM enhanced support for LU6.2 with the introduction of Release 3.2 of Virtual Telecommunications Access Method (VTAM). Release 3.2 supports Type 2.1 peripheral nodes, OS/2 Extended Edition APPC, and APPC/PC Release 1.1. The major benefit of VTAM 3.2 is its capability to allow PCs, token-ring LANs, and minis to bypass the host and communicate with each other.

The number of Logical Units that can reside at a given Physical Unit depends on the type and function of the Physical Unit.

- *LU0* defines certain program-to-program protocols.
- *LU1* describes a session between a host application and a remote batch terminal.
- *LU2* describes a session between a host application and an IBM 3270 display terminal.
- *LU3* describes a session between a host application and a printer in the 3270 Information Display System.

- *LU4* describes a session between a host application and an SNA word processing device or between two terminal devices.
- *LU5* is currently undefined by the architecture.
- *LU6* describes Intersystem Communication (ISC), a session between application programs, usually in different host processors. Its two derivatives are LU6.1 and LU6.2.
- *LU7* describes a session between a host application and an IBM 5250 display terminal.

SNA Sessions

All communications in SNA occur within *sessions* between NAUs. A session is a logical, two-way connection between two NAUs over a specific route for a specific period of time. The connection and disconnection of any session, as well as any abnormal occurrences within the session that affect communications, are responsibilities of the SSCP.

SNA defines types of sessions. Most types describe sessions that last for short periods of time and perform some network control, diagnostic, or management function.

Types of Sessions

- *SSCP-to-PU sessions*—an SSCP requests status or diagnostic information from a PU within its domain, and the PU responds appropriately.
- *SSCP-to-LU sessions*—the SSCP requests status or diagnostic information from an LU, and the LU responds appropriately.
- *SSCP-to-SSCP sessions*—two SSCPs in the same or different domains communicate to exchange information. The two SSCPs can reside in different access methods within the same host computer.
- *LU-to-LU sessions*—two LUs exchange information. All end-user communication in SNA takes place over LU-to-LU sessions.

Sessions between Logical Units

SNA defines different types of LU-to-LU sessions for different functions, depending on the types of logical units participating and the nature of the communication between them. The definition of a session type specifies the protocols, character sets, and control functions for that type of session. IBM currently defines eight types of sessions between logical units. Since the logical units at both ends of a conversation must be of the same type, a given logical unit can participate in only one type of session. Also, the names of logical unit types identify types of sessions. An individual SNA session is characterized by its session type and by the characteristics of its virtual route; the combined definition is called a *session profile.* LUs at either end of a session can negotiate certain characteristics of the session profile, such as class of service and priority, before beginning the session.

APPC

APPC is IBM's term for a set of SNA facilities designed to provide enhanced support for distributed transaction processing. The goal of APPC is to provide complete interconnection compatibility for all levels of an SNA system below the application. APPC is one key to resolving the current PC-to-mainframe connection dilemma, which involves PCs emulating less capable 3270-type terminals to access mainframe resources. The emulation approach is inefficient for the mainframe and the PC because it forces each one to service the screen-by-screen transfer of data inherent in 3270-oriented communications. The problem becomes particularly acute when the PC initiates any type of file transfer; multiple PCs initiating file transfers while emulating 3270s can quickly overtax even a large mainframe.

The advent of intermediary departmental systems servicing local PCs has solved this problem. The addition of APPC capabilities, combined with the remote front-end control of PC LANs, may prove to be even more practical.

APPN

Advanced Peer-to-Peer Networking (APPN) is a distributed networking feature that IBM has incorporated into SNA for optimized routing of communications between devices. APPN simplifies the process of adding workstations and systems to a network, thereby enabling users to transmit data and messages more quickly. APPN also supports transparent sharing of applications in a distributed computing environment. Since APPN supports direct communication among users on a network, it facilitates the development of client/server computing, in which workstation users anywhere on a network can share processing power, applications, and data regardless of the location of the information.

APPN sharpens SNA performance by supporting more flexible workstation installation and faster communication between end users. Users can add APPN devices to existing SNA networks without disrupting the network and rewriting the operating system and other software because of APPN's nonhierarchical approach.

With APPN, the network architect defines points on the network (workstations or larger devices) as network nodes or end nodes. Network nodes serve as the backbone of the APPN network by providing directory services and routing communication through each other to attached end nodes. The multiple network nodes of an APPN network share many of the routing and control functions previously centralized in software in the host computer.

In addition, APPN unlocks the potential for fast and flexible communications offered by IBM's Advanced Program-to-Program Communications (APPC) protocols. APPN supports and enhances electronic mail, file exchange, and the sharing of those applications that conform to APPC protocols. APPC is the primary protocol for communication over APPN networks.

IBM has also incorporated APPN end node specifications into its published networking specifications, Common Communications Support (CCS), included in Systems Application Architecture (SAA).

APPN debuted in 1986 in networks of System/36 minicomputers. In 1988, IBM put APPN in the AS/400 midrange computer networks. In 1990, the company added APPN to the DPPX operating system and enhanced Virtual Telecommunications Access Method. In 1991, IBM extended APPN functionality to OS/2. The AS/400 and OS/2 support for APPN enables applications from the AS/400 to be accessed by PS/2 workstation users.

Subareas and Domains

Large SNA networks are addressed and managed through a system of smaller network units, similar to the public telephone network for voice communications. These units consist of subareas and domains. Subareas assign addresses to each NAU. Domains assign management control for each NAU.

NAUs have unique addresses for identifying themselves and sending messages in an SNA network. These addresses comprise a subarea address and an element address within the subarea. The subarea address identifies a large piece of the network, a *subarea*, to which each NAU is assigned. Subareas are like area codes in the telephone network. In addition, each mainframe comprises its own subarea (see Figure 3).

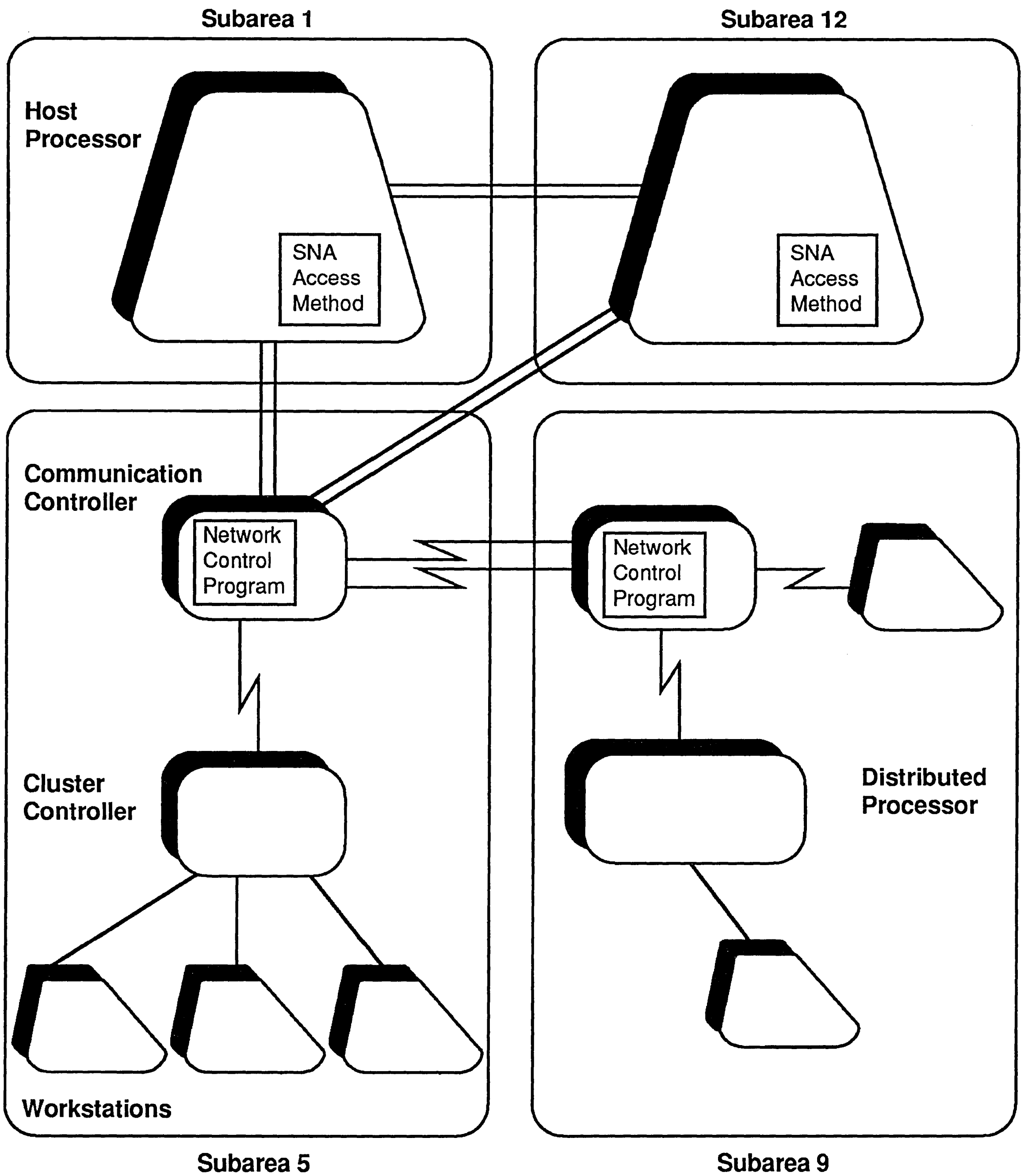
Systems programmers in organizations determine subarea addressing conventions. Subareas support a maximum of 8,000 addresses. In the early 1980s, however, IBM's larger users began running out of address space. SNA users solved this problem by:

1. Partitioning their SNA networks into smaller subsections through SNA Network Interconnection (SNI), allowing addresses in one SNA network to be mapped to addresses in another through a gateway. In this manner, different networks can have the same addresses. SNI provides access for up to 256 separate networks.
2. Expanding the element address. Although IBM extended the address field from 16 to 23 bits, the subarea address remains constant at 8 bits. Users can, however, expand the element address from 8 to 15 bits. This optional subarea extension adds overhead, however, to the datastream.
3. Establishing domains, which are groups of LUs, PUs, and other network resources under the control of a single SSCP (see Figure 4). A domain can consist of two or more subareas. Domains foster more sophisticated networking under SNA, such as backup in network failure, resource sharing, and multihost networking. A simple domain could contain a host computer, one communications controller, and a cluster controller and distributed minicomputer with attached workstations.

Paths between SNA Nodes

SNA defines a hierarchy among paths between nodes and, like most entities defined in SNA, the hierarchy contains physical and logical components.

Figure 3.
SNA Network Subarea

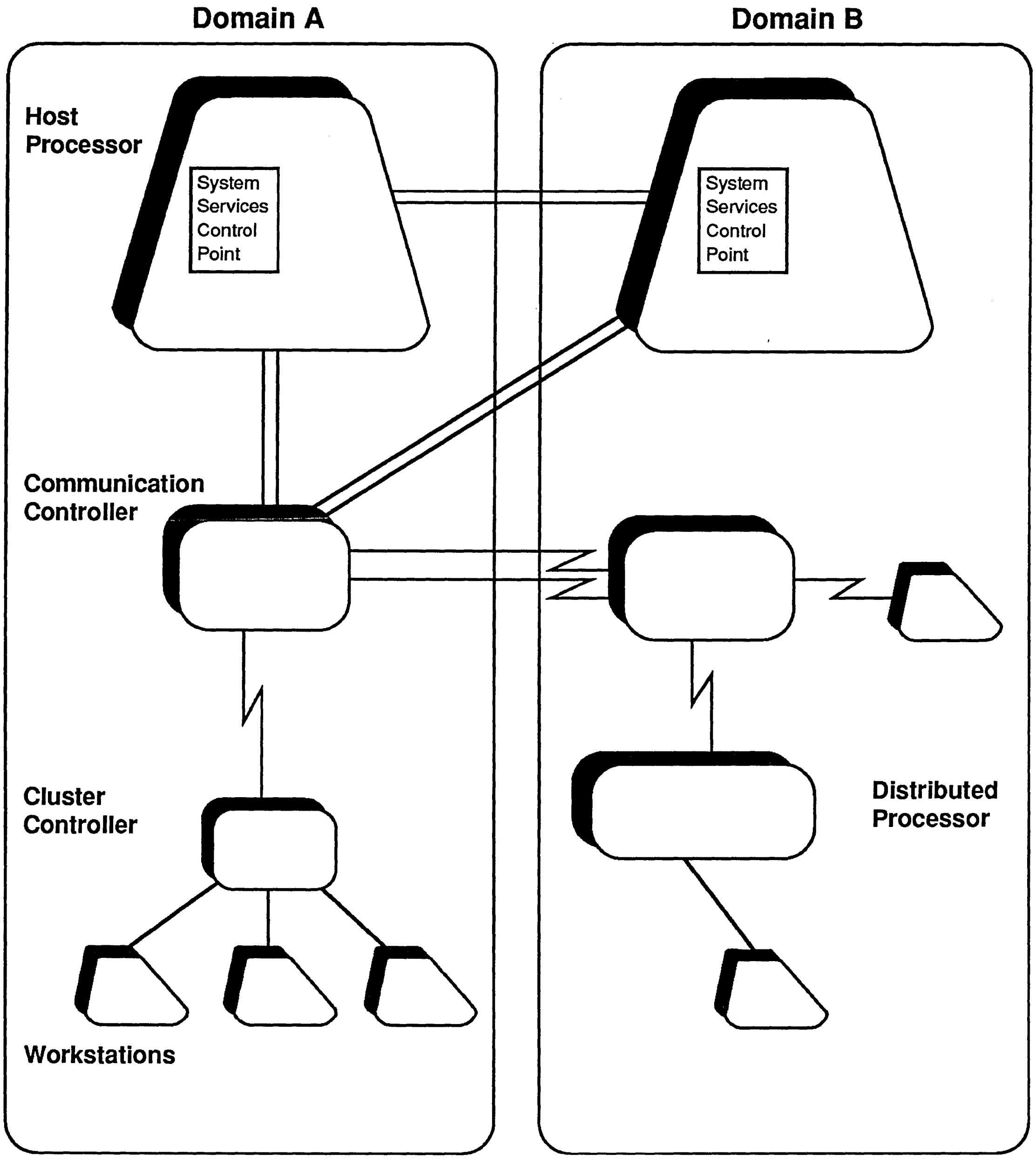


An SNA subarea consists of a host or communication controller node and its peripheral nodes.

SDLC Links: Devices in an SNA network can be connected over a high-speed I/O channel or a Synchronous Data Link Control (SDLC) link, which is IBM's data link control protocol. Pre-SNA protocols, such as IBM's Binary Synchronous Communications (BSC), and non-SNA communications techniques, such as start/stop (asynchronous), are supported—if at all—under SNA only for backward compatibility. IBM channel connections are essentially outside the concerns of data communications.

SDLC links connect communication controllers to one another and to terminal cluster control units, batch terminals, and some display devices. Depending on the requirements of an individual

Figure 4.
Domains



A domain consists of an SSCP and the network resources that it can control.

configuration, two communication controllers can be connected by a number of parallel SDLC links. Here, "parallel" refers to the parallel paths followed by the individual links—not to a parallel, byte-at-a-time communications technique. SDLC is a bit serial protocol. Parallel SDLC links back one another up in the event of one link's overcrowding or failure.

Transmission Groups: Parallel SDLC links between two SNA nodes can be arranged logically into *transmission groups*, which comprise one or more parallel links with the same transmission characteristics, such as data rate, delay, security, and likelihood of error. A transmission group appears to an end user as a single link; the communication controller decides which links within the transmission group will carry specific messages. The individual links are transparent to the user, who sees only the transmission group. With the IBM 37X5, users can establish up to eight transmission groups between any two controllers.

Explicit Routes: An SDLC link between a communication controller and a cluster controller or terminal is called a *peripheral link.* Since only one link at a time in SNA can connect a terminal unit to a communication controller, peripheral links cannot belong to transmission groups.

The simplest SNA networks—those controlled by a single host with a single front-end processor and no remote communication controllers—use only peripheral links to communicate with their terminals. More complex networks involving more than one host or more than one communication controller use transmission groups between the communication controllers and peripheral links between the communication controllers and the terminals.

In such a network, a transmission can be routed through more than one communication controller on its way from source to destination. Its path can consist of the channel from the host to the communication controller, one or more transmission groups between successive communication controllers, and the peripheral link between the last communication controller and the terminal. In SNA, the position of a path not including the peripheral link is an *explicit route*, which defines the physical characteristics of a specific path between two subarea-node end points in an SNA network; in SNA, these characteristics are called *class of service.* An explicit route, then, is a specific path between two end points that offers a specific class of service.

In an SNA network where there is more than one explicit route between two end points, the last communication controller in the path connects the destination end point over a peripheral link. The explicit route thus selected remains in effect for the duration of a session between two end points.

The individual transmission groups that comprise an explicit route are redundant by design; each can contain a number of physical links that can back up one another. Sometimes, however, an entire transmission group can become unavailable because of link failures or controller failure.

Virtual Routes: SNA's specification of the paths between subarea nodes contains one final logical element. The transmissions in a session between two end points can have one of three priorities. A transmission's priority governs its degree of access to an explicit route. A session's priority, plus its explicit route, is the session's *virtual route*, which defines the complete logical path between the subarea-node end points on an SNA network.

SNA Network Management

In IBM's view, network management encompasses:

- problem management, or managing a network outage from the time it is detected until the time it is resolved;
- performance and accounting management, which monitors the network's health, fine-tunes network operation to improve performance, and tracks system usage;
- configuration management, which takes inventory of network components and their logical relationships; and
- change management, which reconfigures the network to meet changing conditions.

NetView: IBM's NetView centralizes SNA's network management, providing uniformity and a single point of access to previously separate functions. It supports consistent use of program keys, application uniformity, and color graphics. IBM introduced NetView Release 2 in 1987, which made NetView easier to use, provided a higher level of automation, and offered distributed NetView application support. NetView Release 2 had an open architecture that supported linkages to many competitive hardware and software control elements. Using NetView, network managers can monitor network performance/response times, pinpoint hardware and software errors, monitor and test the status of analog lines, and configure the 3728 matrix switch and modems at remote sites.

In September 1990, IBM introduced NetView Version 2 Releases 1 and 2. NetView Version 2 Release 1 includes the NetView Graphic Monitor Facility, the NetView Bridge, and the NetView Installation Facility. NetView Version 2 Release 2 provides LU6.2 transport capability and enhancements to NetView automation features and extends the NetView Graphic Monitor Facility support to the VM/ESA environment. LU6.2 allows users to write network management applications that interact with NetView for SNA and non-SNA devices.

NetView/PC: NetView/PC, introduced shortly after NetView, is a multitasking personal computer subsystem that extends passive NetView *monitoring* functions to token-ring LANs and other communications systems or programs developed by users or third-party vendors. It provides application programs with the means to forward generic alerts not requiring unique support in NetView and participates in IBM's SAA. It also forwards Service Point Command Service (SPSC) NetView commands to NetView/PC applications and returns replies to NetView from the applications. NetView Release 3 extended NetView's capability to automate many of the control system's management facilities.

NetView also plays an important part in fine-tuning a network. The NetView Command Facility enables the operator to give VTAM commands and collect VTAM console data produced by TNSTAT, VTAM Internal Trace, and DISPLAYS.

NetView/PC Version 1.2.1, released in March 1990, extends NetView/PC's functionality. It has been enhanced to provide the NetView/PC Gateway function and the option of selectively installing NetView/PC, NetView/PC Gateway function, or both. Users can install the Remote Console Facility with these functions.

Office Automation through SNA

Through APPC, SNA extends its basic capabilities that support distributed office automation (OA) and related functions. IBM has concentrated OA in the mainframe environment (VSE, MVS, and VM operating systems), with links to IBM minicomputers, personal computers, and associated OA products. Its major OA offering is Distributed Office Support System (DISOSS), an application program of IBM's Customer Information Control System (CICS). DISOSS is a document management and distribution facility that uses two office information architectures to format and transmit text documents: Document Content Architecture (DCA) and Document Interchange Architecture (DIA), respectively. Increasingly, DISOSS products and third-party vendors use a facility called SNA Distribution Services (SNADS) to communicate with other DISOSS products over distributed office networks.

DCA is an APPC-based datastream that specifies a document's content. It translates human language into printed or displayed office documents. DCA defines type fonts, formatting, pagination, headings, and control information, for text transmission.

DIA is an APPC LU6.2 Transaction Services Architecture that specifies the protocols and structures for document interchange through an office network. It consists of several service categories that distribute documents or messages to one or more recipients; allow users to store and retrieve documents in a library; and process document applications, convert formats, and modify document descriptors.

SNADS is a set of Distribution Transaction Programs that runs in an APPC LU6.2 environment. It provides asynchronous communications, especially useful for OA applications. Although compatible with DIA, SNADS is the preferred method for distributing documents. The primary application for SNADS is electronic mail, making it IBM's alternative to the CCITT's X.400 protocol.

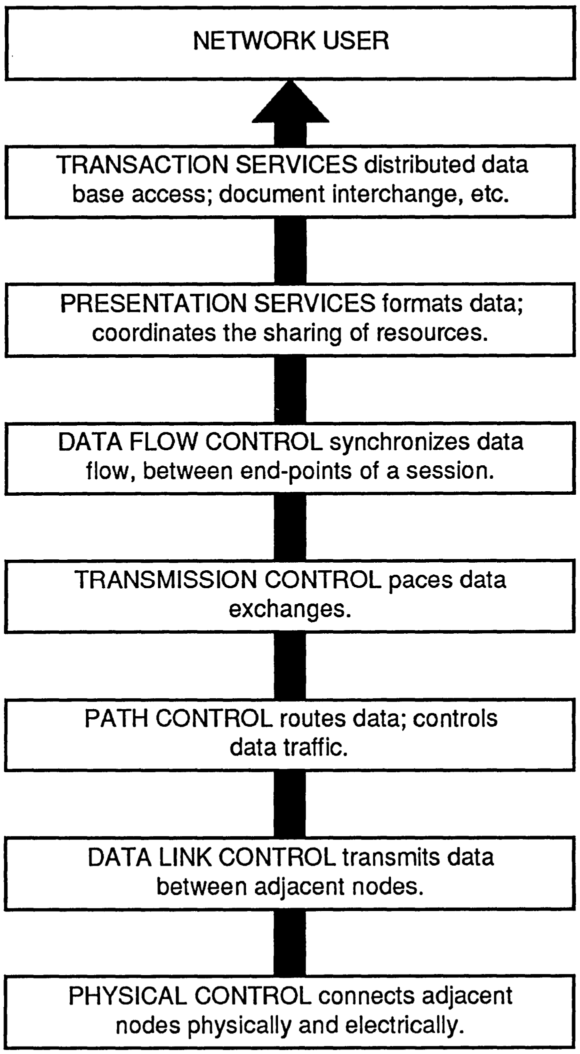
SNA Layers

SNA is a layered architecture, similar to—but not identical with—the ISO's Open Systems Interconnection (OSI) reference model (see Figure 5). The OSI model and SNA define seven functional layers. Specifications that correspond to some of the uppermost (Application) layers of the OSI model are imbedded in IBM's SAA architecture and not in SNA proper. SNA's seven layers correspond roughly to the following seven layers of the OSI model: Physical, Data Link, Network, Transport, Session, Presentation, and Application. There are differences in the handling of routing and in defining the boundary between the lower "transport system" layers and the upper "logical control" layers.

In a layered architecture, the communications process is divided into functional layers, each of which passes data to and receives data from the layers immediately above and below it in the architecture. A message passing between two end points must pass through all layers in the sending node, and again through all layers in reverse order in the receiving node. In some architectures, a message may pass through some of the lower layers each time it encounters an intermediate node.

Each layer deals with a message with a specific degree of intelligence and at a specific level of

Figure 5.
SNA Layers



abstraction. The Data Link layer, common to SNA and the OSI model, deals with a message as a stream of bits in a specific order. The Path Control layer in SNA (which includes functions of the Network layer in the OSI model) deals with a message as a packet of data addressed from an application in the sending node to an application in the receiving node. The NAU Services Manager in SNA (which corresponds to the OSI model's Presentation layer) deals with a message as a set of intelligible characters to be presented to the application from the network, or to the network from the application, according to a predetermined set of rules.

The division of the communications process into layers allows network architects flexibility in updating, revising, or correcting the communications process. Designers (and, sometimes, users) can alter the process at one layer without affecting the other layers, as long as the changes do not affect the way information is passed to and from the altered layer and its adjacent layers in the architecture, and as long as such changes are consistent throughout the network.

A layered architecture also allows the substitution of one set of protocols for another at the lower layers. To the processes at a given layer of such an architecture, all lower layers are simply part of the network. Thus, although some routing problems exist for more complex networks, the X.25 packet-switching protocols for the Data Link and Path Control layers of SNA can be substituted to allow SNA devices to communicate over X.25-based public networks. In some implementations of a layered architecture, processes at the upper layers can select which of several sets of low-level protocols they will use for specific communications.

From the bottom up, SNA's seven architectural layers are:

- Physical
- Data Link
- Path Control Network
- Transmission Control Services
- Data Flow Control Services
- Presentation Services
- Transaction Services

At each end point of a transmission, a message must pass through all seven layers. At each intermediate node, such as a communication controller, a message must pass through the three lower layers twice, once on receipt by the controller and once on retransmission.

The Physical Link Layer: The Physical Link layer is SNA's lowest and simplest layer. It deals with the physical and electrical interface to the telecommunications network and is distinct from the logical network layers above. The physical layer specifies connector characteristics and voltage and current levels. IBM does not promote much activity at this level, leaving interface specifications to the CCITT and other standards organizations. Many different interfaces are supported, and any can be used for SNA as long as they are embraced by IBM.

The Data Link Layer: Synchronous Data Link Control (SDLC) is one of four Data Link protocols defined by SNA. The others are S/370 channel, token-ring, and X.25. Some implementations of the architecture can support BSC, a pre-SNA IBM protocol still widely used, or non-IBM protocols such as the CCITT's HDLC or the various asynchronous line disciplines.

Structurally, SDLC is a subset of the CCITT's High Level Data Link Control (HDLC) link protocol, tailored to better serve IBM communications. SDLC is a bit-oriented, serial protocol, representing control information as the binary values of individual bits in predefined positions. Such protocols are much more efficient than earlier byte-oriented, serial protocols, which use the values of entire 8- or 16-bit characters to represent control functions. In a bit-oriented protocol, the information on the function of a series of bits need not be transmitted as data, since such information is contained in the positions of bits in the series.

The Path Control Layer: Routing and flow control are the two major functions of the Path Control layer. Routing takes place at every node on the path between two LUs on the network. At the beginning of a session, the sending and receiving nodes and all nodes in between cooperate to select the best available virtual route for that session. During the session, each node along that route selects the next available link in the selected transmission groups for each message within that session.

Every LU on a network has a *network name*, a mnemonic known to the end users and to applications that might communicate with that LU. The result of address layering is that an end user need know only the name of a terminal or process on the network to communicate with it; the end user need not know *where* that terminal or process resides in the network.

The routing function also assigns a class of service to each session. The SSCP passes a list of virtual routes meeting a requested class of service to the Path Control layer, which activates the first available virtual route in the list.

To improve transmission efficiency, the Path Control layer at each node along a session's path can *segment* messages—divide long messages into segments so the Data Link layer can transmit them in separate SDLC frames. The segmenting function ensures that the transmission facilities' efficiency does not depend on arbitrary message lengths.

The final flow control function of the Path Control layer is *virtual route pacing*, which ensures that traffic along a virtual route shared by a number of sessions does not overly congest that route.

The Transmission Control Services Layer: The Transmission Control Services layer paces messages for individual sessions. This *session-level pacing* function primarily ensures that a transmitting NAU in session with a receiving NAU does not transmit more data than the receiving NAU can handle. To perform session-level pacing, the two NAUs at either end of a session negotiate the size of a *pacing group* at the beginning of the session. A pacing group is the largest number of messages that the transmitting NAU can send before it receives a pacing response from the receiving NAU, telling it that it can resume sending. Session-level pacing occurs in two stages along a session's route: between the host NAU and the communication controller and between the communication controller and a peripherally attached terminal NAU.

This layer also performs encryption when the application program requests it. SNA offers mandatory and selective session-level encryption. Mandatory encryption encrypts all messages within a session; selective encryption codes only those messages identified by an enciphered data indicator embedded in the messages.

The Data Flow Control Services Layer: The Data Flow Control Services layer handles the order of communications within a session by establishing *chains* and *brackets* of data and by maintaining one of three *send/receive modes.*

A chain is a group of messages associated logically for transmission in one direction on the network. A bracket is a group of messages associated logically for two-way transmission on the network. The Data Flow Control Services layer establishes chains and brackets for two purposes: error control and contention control.

When an error occurs in one message of a chain of messages, the receiving node notifies the

Data Flow Control layer of the sending node, and the sending node then holds the untransmitted portion of the chain. If the LU detects the error and determines that a protocol violation caused the error, the session is terminated. If the application program detects an error, user error recovery occurs.

The three send/receive modes established and maintained by this layer are full-duplex, half-duplex flip-flop, and half-duplex contention. In full-duplex mode, each participating LU can transmit at any time, whether or not the other LU is transmitting. In half-duplex flip-flop mode, the participating LUs transmit alternately; at the end of a chain, the LU currently transmitting can pass permission to transmit to the other LU. (LU6.2 uses only half-duplex flip-flop.) In half-duplex contention mode, one LU is designated as dominant at the beginning of a session; either LU can begin transmitting at any time, but if the dominant LU is transmitting when the other LU attempts to transmit, the other LU must withhold its transmission until the dominant LU has finished transmitting its current chain.

Presentation Services Layer: The Presentation Services layer defines the protocols for program-to-program communication and controls conversation-level communication between transaction programs by:

- loading and invoking transaction programs;
- maintaining conversation send-and-receive mode protocols;
- enforcing correct verb parameter usage and sequencing restrictions; and
- processing transaction program verbs.

Transaction Services Layer: The Transaction Services layer, the highest architectural layer defined by SNA, implements the following service transaction programs in an SNA network:

- operator control of LU-to-LU session limits;
- Document Interchange Architecture (DIA) for document distribution between office systems; and
- SNA Distribution Services (SNADS) for asynchronous data distribution between distributed applications and office systems.

The Transaction Services layer also provides configuration, session, and management services to control the network's operation. SSCP-to-PU sessions use configuration services to control resources associated with the physical configuration. Configuration services activate and deactivate links, load same-domain software, and assign network addresses during dynamic reconfiguration.

SSCP-to-SSCP and SSCP-to-LU sessions use session services to establish LU-to-LU sessions. Session services translate network names to network addresses, verify user access authority, and select session parameters.

SSCP-to-PU and SSCP-to-LU sessions use management services to control the operation for the network. Management services handle network problems, performance and accounting information, network configuration, and changes in the network.

Specific protocols perform services equivalent to those of the OSI reference model's Application layer. The first of such protocols make up IBM's Office Information Architectures: the Document Interchange Architecture and the Document Content Architecture. Within SNA, these architectures use the Advanced Program-to-Program Communications services of LU6.2.

Implementing SNA

SNA Hardware

Host Computers

SNA originated as a communications architecture oriented toward centralized control by mainframes that use the System/370 architecture. It is evolving toward greater control of IBM systems that use different architectures. The IBM mainframes that support full SNA configurations are the System/370 and its direct descendants: the 303X family of medium-to-large mainframes, the 308X and 309X families of large mainframes, and the 4341 and 4381 mainframes. The 9370 superminis and the smaller members of the 4300 family (the 4321, 4331, and 4361) support limited SNA configurations through an integrated communications adapter (ICA) in place of a front-end communications processor.

IBM System/3X and AS/400 computers can function as hosts for small SNA networks of their own and as Type 2.0 or Type 2.1 intelligent terminals in mainframe-based SNA networks. IBM 8100 processors can perform as hosts in 8100-based SNA networks and as distributed processing nodes in mainframe-based configurations. The 8100 was, however, "functionally stabilized" by IBM in 1986, meaning that further development of SNA capability for the processor is highly unlikely and that customers are wise to abandon plans for 8100 processors in the future. All these systems can participate in distributed networks as peers, but can function only as terminals in networks controlled by mainframes.

System/88 supports several SNA programs including Release 6 SNA Licensed Program and Release 6 SNA Token-Ring Link Manager; System/88 Primary SNA; System/88 Secondary SNA; System/88 SNA-3270 Terminal Emulation; System/88 SNA Cluster Controller; and System/88 SNA Network Interface Support.

IBM Enterprise System/9370 (Models 10, 12, and 14) support entry points into an SNA network.

Communication Controllers

SNA communication controllers from IBM include the 3705, 3720, 3725, and 3745. The 3705, 3720, 3725, or 3745 can function as front-end processors for mainframes or as remote communication controllers. These devices use some version of ACF/NCP/VS when operating in SNA networks; they can also support pre-SNA and start/stop communications through versions of the Emulation Program and Partitioned Emulation Programming. Newer versions of ACF/NCP/VS support pre-SNA batch terminals through a program called Non-SNA Interconnect.

In September 1984, IBM unveiled the 3710 Network Controller, which concentrates SDLC and selected asynchronous and BSC protocols over SNA/SDLC and X.25 links. The 3710 is supported by SNA as a cluster controller and can share lines with 3710s and other SNA devices; it connects to one or more 37X5s and can transmit concentrated traffic over single or multiple upstream links.

The 3710 opened up SNA to the asynchronous world by providing an IBM-endorsed asynchronous gateway into SNA networks. The 3710 connects upstream to a 3705, 3720, 3725, or another 3710; it connect downstream to SNA and non-SNA devices.

The company stepped further into the ASCII world in 1985 by introducing the 3708 Network Conversion Unit. The 3708 is a 10-port unit that supplies line conversion, protocol conversion, protocol enveloping, and ASCII pass-through capabilities. It allows asynchronous devices to emulate IBM 3270 synchronous displays and printers. The 3708 operates with IBM's System/370, 303X, 308X, 3090, and 43XX processors; 8100 systems; System/38 and AS/400 processors; 3710 Network Controller; and Rolm's CBX II voice/data PBX.

In February 1988, IBM introduced the 3745, a front-end processor that demonstrates a substantially improved price/performance ratio over the 3725. The 3745 increases the number of lines that can be practically supported (as opposed to physically attached) and is entirely compatible with the 3720/3725 family. It improves capabilities for X.25 and Token-Ring LAN attachment.

The 3174 Subsystem Control Unit supports 208 SNA LUs on Models 11L, 11R, 12R, and 13R. For Models 61R and 62R, the 3174 supports 84 LUs. An optional 16/4M bps Token-Ring Network Gateway feature offered with Models 11L, 11R, 12R, 61R, and 62R provides data passage between an IBM SNA host and terminals attached to an IBM Token-Ring Network downstream of the 3174. In September 1990, IBM released 3174 Model H, which has enhanced system management capabilities that can IML SNA network 3174s from a central NetView operator's console.

In the March 1991 announcements, IBM introduced the *3174 Establishment Controller APPN Licensed Internal Code (LIC) feature*, which adds support for advanced peer-to-peer networking (APPN) to the existing communication capabilities of configuration Support-C of the 3174, Release 1. The APPN feature supplies the network node function of APPN, and the peer communication LIC feature supports the use of LAN applications on DOS workstations that are attached via 3270 wiring to the 3174.

In September 1990, IBM announced that the 3172 Interconnect Controller, in conjunction with VTAM Version 3 Release 4, can enhance the use of existing LAN resources within SNA. At the same time, IBM released Model 1 of the 3172, which supports SNA, as well as other multivendor protocols and Model 2 of the 3172 with an FDDI adapter that supports VTAM/SNA and TCP/IP data flows.

Terminals

Most IBM batch, display, and printing terminals support SNA communications at the PU1 level. A number of small IBM computers can function as Type 2 (3270) display terminals and as Type 2.1 intelligent terminals in mainframe-based IBM networks. These devices include the Systems/34, /36, and /38; the AS/400; the IBM 8100; the Series/1; the 3270 Personal Computer; and various personal computer models equipped with an IBM SDLC card or third-party terminal emulation card.

SNA Software

Operating Systems

Most SNA processing on IBM mainframes takes place in the telecommunications access methods that reside on those mainframes; the mainframe operating system performs few, if any, SNA functions. In general, standalone IBM operating systems, such as MVS/SP 1.3 (MVS/370), MVS/XA, DOS/VSE/AF, and VM/SP, support current SNA levels. Older standalone operating system versions, such as DOS/VS, OS/VS1, and SVS, have been phased out of development.

Originally, VM/SP hosts could not connect to SNA networks. This situation was temporarily corrected by the VTAM Communications Network Application (VCNA), which permitted considerable cross-connection for both SNA host-attached terminals and VM/SP host-attached terminals. Release 4 of VM/SP made VCNA obsolete due to a special VM/SP feature that allows VTAM to run under VM in native mode in the same virtual machine as other communications programs.

VM/SP, DOS/VSE, and SSX/VSE cannot support ACF/TCAM. Until recently, a special version of ACF/VTAM, called ACF/VTAME, was required for these operating systems to support SNA in smaller configurations with a communications adapter. By including equivalent NCP in the code that supported the integrated adapter, the newer versions of ACF/VTAM replaced ACF/VTAM for these systems.

In December 1989, IBM enhanced ACF/VTAM to improve SNA performance. In September 1990, IBM released VTAM Version 3 Release 3 for the company's VSE/ESA and VM/ESA operating systems and VTAM Version 3 Release 4 for MVS/ESA, VM/ESA, and VM/SP operating systems. Release 4 supports direct communications between host applications and SNA devices on several types of LANs, including those conforming to FDDI.

Operating systems on other IBM computers, such as DPPX and DCPX on the IBM 8100; CPF on Systems/34, /36, and /38; and OS/400 on the AS/400, can participate in SNA networks without a separate communications access method. The requisite logic is either part of the operating system or an operating system feature. In other words, the SSCP is built into the control programming of these operating systems. In networks with IBM mainframes as hosts, these systems communicate as terminals.

SNA Access Methods

A telecommunications access method provides a single interface to communications facilities for all application programs running under a computer's operating system. With an access method in place, application programmers need not write special sets of routines for each application. They must provide only input and output statements suitable for routines in the access method.

In SNA, the access method is the most important network software. In mainframe networks, both the SSCP and the PU type 5 are portions of the access method's code. The access method connects and disconnects sessions; maintains information on the configuration of the network; and gathers information on the status of the network's nodes, links, and activity of its sessions. Through a series of network management programs, the access method communicates with network operators and allows them to detect, record, and correct physical and logical errors.

There are currently two SNA access methods: ACF/VTAM and ACF/TCAM. ACF/VTAM is descended from the Virtual Telecommunications Access Method (VTAM), the first SNA access method. ACF/VTAM, specifically designed for SNA, is the only mainframe access method that IBM is now actively developing. ACF/TCAM is descended from an earlier SNA access method, the Telecommunications Access Method (TCAM).

The ACF designation stands for "advanced communications function" and has prefixed the names of all SNA access methods and network control programs since the introduction of multisystem networking. An ACF access method, either ACF/TCAM or ACF/VTAM, must exist in each host of any SNA network in which more than one IBM mainframe participates. The ACF versions of TCAM and VTAM were originally sets of enhancements offered separately from either basic access method. Both ACF/TCAM and ACF/VTAM are now marketed as complete access methods.

In general, VTAM handles communications more efficiently for the mainframe; it transfers messages directly between communicating end points. TCAM handles communications more efficiently for the terminals. It maintains messages in queues for transmission to applications and terminals, requiring somewhat less buffering at either end of the connection. TCAM also handles non-SNA communications more directly. With TCAM and ACF/TCAM, the access method itself provides the translations for start/stop terminals to participate in an SNA network.

With VTAM and ACF/VTAM, users must install the Network Terminal Option (NTO) to handle asynchronous devices. NTO is essentially an enhancement to IBM front-end system software and supports protocol conversion. ACF/TCAM allows the use of BSC terminals through the emulation program or partitioned emulation programming in the 37X5 communication controller.

In November 1983, IBM announced the SNA Network Interconnection (SNI) feature for ACF/VTAM, but not for ACF/TCAM, further encouraging ACF/TCAM users to follow the upgrade path provided by IBM through ACF/TCAM 2.4. The latest version of ACF/VTAM supports the full functions of ACF/NCP/VS and of the network logical data manager, the NetView software, and the latest SNA capabilities. Table 1 summarizes SNA access methods, the special features introduced with each version, and the operating systems compatible with each.

ACF/VTAM Version 3 Release 3 offers connectivity enhancements for type 4 and 5 and type 2.1 nodes. This version also provides enhancements to Logical Unit 6.2 and VM SNA console support. VTAM Version 3 Release 4 offers type 2.1 node multitail connectivity, dynamic I/O, ongoing LU-LU sessions, and LU6.2 selective data encryption.

Host Subsystems

A number of host subsystems support SNA applications under ACF/VTAM; a dwindling number also support ACF/TCAM. In SNA, a host subsystem handles part of the interface between the access method and certain kinds of communicating applications. For example, JES/2 or JES/3 for large mainframes, and POWER/VSE for smaller DOS/VSE systems, support the reception and spooling of batch tasks; likewise, TSO supports interactive timesharing.

SNA also permits sessions between applications subsystems in different domains. CICS-to-CICS and LU6.2-to-LU6.2 applications are supported by the Intersystem Connection feature (ISC), IMS-to-IMS sessions are supported by the multiple systems coupling feature (MSC), and JES-to-JES sessions are supported by the Network Job Entry (NJE) enhancement.

The most important host subsystem is the Customer Information Control System (CICS/VS), a general interface between IBM's database handler, DL/1, and data communications through ACF/VTAM. CICS handles interactive transaction processing; it also handles intersystem communications (ISC), SNA LU6, and advanced program-to-program communications, SNA LU6.2.

SNA Network Management Software

IBM provides a set of host-resident programs for network operation, error detection, error correction, and management. IBM's philosophy of network management requires centrally controlled configuration and error reporting for every aspect of the network, both physical (devices) and logical (sessions), from the logical unit at one end of a session to the LU at the other end. All SNA devices, including IBM modems, contain some facility that detects and reports errors.

The principal software component of IBM's network management system is *NetView*, introduced in 1986 to replace the Network Communications Control Facility (NCCF). With NetView, IBM combined all the functions of NCCF, NPDA, and NLDM into a single product. NetView also provides some functions of the VTAM Node Control Application (VNCA) and the Network Management Productivity Facility (NMPF). These products were combined under NetView to offer users a simpler, yet more complete method of network management. IBM has also introduced *NetView/PC*, a multitasking personal computer subsystem of NetView that serves as a gateway between NetView and other vendors' network management products.

NPDA runs as an application under NCCF. It records failures and degrading conditions on the physical SNA network and can initiate trace programs to find the sources of network hardware problems. NPDA operates through SSCP-PU sessions between the host access method and the network's physical units.

NLDM also runs as an application under NCCF. It records failures and degrading conditions on the logical SNA network. NLDM records certain relevant data on every session: the logical units participating, the session type, and the class of service. When it detects problems, or on command from the operator, NLDM records all header and trailer information from a specified session's message units. NLDM is most useful in tracking the causes of lost data and in resolving protocol incompatibilities between communicating LUs.

Running under NCCF, the *Network Management Productivity Facility (NMPF)* is a set of job streams, programs, and data sets that can aid network staff. NMPF helps personnel install, learn, and efficiently use many network software packages.

Two additional NCCF applications reduce the number of on-site personnel and are the first steps toward "operatorless" MVS/SP and DOS/VSE computer rooms. The first of these, the *Operator Communications Control Facility (OCCF)*, implements mainframe control from a remote location via a duplicate console facility. All sites must have ACF/VTAM, ACF/VTAME, or ACF/TCAM and 37X5 ACF/NCP. NCCF is, of course, a prerequisite, along with MVS/SP plus JES/2 or JES/3, or DOS/VSE.

Since ACF/SNA networks can become quite complex, they must be carefully monitored to achieve optimum performance. To facilitate this monitoring, IBM introduced another subsystem, the *Network Performance Monitor (NPM)*. Like NCCF, it runs as an ACF/VTAM application. NPM provides realtime monitor graphics and historical analyses of session data and operates as an online, interactive monitor and display facility. Another monitor system, the SNA Application Monitor (SAMON), provides MVS installations with the status of various ACF/VTAM applications in the network. It can provide the end user with information menus about the network's ACF/VTAM applications, including a broadcast facility to all SAMON terminals.

NetView Version 2 includes an LU6.2 transport capability, which enhances system management by providing central site access to non-SNA devices within an SNA network. NetView Version 2 Release 1 offers the NetView Graphic Monitor Facility, providing graphic capabilities to monitor SNA resources. NetView Version 2 Release 2 includes LU6.2 transport that allows IBM- and user-written applications on NetView to communicate with other applications.

A communications processor in Emulation mode performs a protocol conversion that makes the BSC terminals appear as SNA devices to the host. In IBM communication controllers running ACF/NCP/VS, users can run the EP in a separate memory partition from NCP in the mode called Partitioned Emulation Program (PEP). In PEP configurations, the portion of the network controlled by EP is functionally and logically separate from the SNA network.

Announced in March 1991, *NetView Distribution Manager Release 3 (NetView DM Release 3) for MVS* centrally manages a large SNA network. From a mainframe, it can send and install software or files on workstations or distributed systems anywhere in a network.

Another March 1991 announcement, *NetView Distribution Manager/2*, activates automated distribution and change management functions to host-connected OS/2 workstations, and to OS/2 or DOS workstations in host-connected or standalone LANs. The product implements a wide range of functions for SNA/DS, SNA/FS, and SNA/MS-CM.

IBM Information Network

IBM has taken the global approach to networking, and SNA is playing a vital part to accomplish this goal. The IBM Information Network provides marketing, service, and support in the United States and in 20 countries. Users can connect their SNA networks to IBM's international network to reach leased-line and dial cities in the U.S., Canada, Europe, and Japan. Countries with SNA connection capabilities include Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, and United States.

In March 1991, IBM announced that the APPN features for OS/2 and the 3174 would be used by the IBM Information Network in the networking services it offers customers, such as electronic mail, electronic data interchange (EDI), and access to a variety of business databases. ■