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# SNA Perspective

The single source, objective monthly newsletter covering IBM's Systems Network Architecture

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# APPN: Key in IBM's Networking Blueprint

On March 25, 1992, IBM unveiled its networking blueprint for the 1990s and beyond and announced many products and statements of directions that build on that blueprint. The major networking elements of this announcement are shown in Table 1. *SNA Perspective* sees APPN as a key component in this blueprint and the centerpiece of these announcements.

Because of the significance of this announcement and its APPN components, we are devoting the entire issue to it. In this first article, we review the major components of the announcement; discuss the significant implications of APPN and the networking blueprint for IBM; note several APPN issues including security, performance, and network management concerns; examine APPN past and future evolution; discuss APPN interoperability support and strategy—including IBM's new networking blueprint and multiprotocol transport network (MPTN) direction; review old and new VTAM and NCP node Type 2.1/APPN support; discuss fourteen peer features and advantages of the new VTAM APPN support, including meshing of subarea and APPN network directories, elimination of PATH table definitions to add APPN nodes, and statements of direction for APPN border node and APPN session routing over channel connections; describe several APPN-supporting features to be offered in the future for NetView and note APPN support still required in NetView.

*(continued on page 2)*

# APPN Insights and Design Clues

APPN evolved from the need in the early 1980s to support the networking needs of what IBM then called small systems—primarily minicomputers and, increasingly, personal computers. Although originally termed an SNA extension, APPN today is properly called a networking architecture.

This article provides our readers with a rare treatment of APPN. SNA users unfamiliar with APPN will get a good grounding. All readers will get insights into several aspects of APPN not widely understood inside or outside of IBM. These insights include design clues to reduce TDU flows, specifics of optimal route selection, and lucid descriptions of the four types of APPN searches. LEN node, APPN end node, and APPN network node are described. We discuss four APPN node services: configuration services, topology and routing services, directory services, and session services.

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## March's APPN Implications

The announcement of VTAM APPN support in itself is quite significant. However, considering it together with other announcements made on the same day, previous APPN developments, and interoperability implications with TCP/IP and OSI, *SNA Perspective* believes these signify that APPN is a key centerpiece architecture through the 1990s and beyond. The implications are far-reaching for several reasons:

### Networking Elements of IBM March 1992 Announcements

***Product/Programming Announcements***

Advanced Communication Function/Virtual Telecommunications Access Method (ACF/VTAM) Version 4, to be shipped for testing to selected customers by end of 1992. Date for general availability will depend on testing, but *SNA Perspective* expects it about the middle of 1993.

VTAM APPN support: APPN end node and network node on VTAM V4 for MVS and SOD for VM. APPN network access through NCP, 3172, and channel (SOD) connections.

Composite network node (CNN) based on APPN support in VTAM V4 and a future release of NCP. A VTAM node with APPN and its NCPs, if any, appear as one APPN node. Replaces composite LEN node.

Networking Services/DOS (NS/DOS). Includes an 80K version of APPC and APPN end node.

Limited dependent LU support over APPN in VTAM V4: will support LUs in nodes directly attached to their boundary function nodes.

***Statements of Direction* and Preannouncements***

Network Control Program (NCP) SOD. A future release will, with VTAM V4, support composite network node (CNN). Note: NCP will *not* contain APPN network node or end node; it will only participate in CNN. *SNA Perspective* expects announcement by September 1992.

VTAM APPN border node SOD. Allows cross-network network node connections.

APPN session routing over channel-to-channel support SOD.

VTAM and 3174 SODs for dependent LU server/requester support across APPN.

APPN support on AIX SNA Services/6000 SOD. APPN end node and network node and CPI-C.

NetView SOD. A future release will support several features for APPN. An OS/2-based network management product in the NetView family will support APPN management.

TCP/IP SOD. TCP/IP sockets support over SNA using LU 6.2 (SNAckets).

CPI-C over TCP/IP work in progress. IBM working with a customer to develop prototype application.

APPN on NetWare joint development. Strengthening of partnership with Novell to include APPN network node on NetWare.

* Note: For IBM, a statement of direction used to always mean the product was at least two years away. Today, in many cases, the timeframe is much shorter, even as little as three months.

***Dates***

APPN on 6611 router. Availability date of first quarter 1993, given with full announcement details expected later this year.

APPN network node licensing. Date given for licensing network node source code (2nd quarter 1992). Contents of and availability date provided for developer's kit (first quarter 1993).

***SAA Expansions***

Inclusion of APPN network node and TCP/IP in SAA CCS. ■

*Table 1*

- Pervasive. APPN is pervasive across, and unifies, IBM's enterprise, departmental, and workstation platforms.
- Strategic. APPN is a key strategic networking architecture to enable the computing paradigms of the 1990s and beyond.
- Interoperable. APPN is well positioned to provide interoperability between Systems Application Architecture (SAA) and AIX systems for networked applications over SNA, TCP/IP, and OSI.

Several issues are still outstanding, including performance impacts of dynamic networks, increased security concerns, limited NetView support of dynamic environments, concern about user response to phased release timeframe, limited 3270 support, and constraints of VTAM APPN support being only in ESA. These are further discussed below under Issues and Implications.

It should also be noted that, although we focus on APPN in this article and although IBM considers APPN strategic, the company also assigns a very high priority to supporting OSI, TCP/IP and other protocols which are included in the networking blueprint.

## APPN Continuing Evolution

As Figure 1 indicates, APPN continues to evolve. The next level of APPN has been informally been called enhanced APPN or APPN+ by IBM. IBM has also discussed a further generation, which it has so far referred to informally as APPN++. In should be noted that, from the perspective of IBM's networking blueprint, it is probable that the company will develop its high bandwidth support, including standards-based support for cell and packet routing, in such a way that all protocols, not just APPN, will be enabled by its implementation.

**APPN.** The current level of APPN is now pervasive across the SAA and AIX platforms and provides peer networking throughout the host, midrange, and workstation environments. This level of support is provided in 1992 and 1993.

**APPN+.** APPN+ will provide a fast packet capability in the 1993-1994 period. It is highly likely that APPN+ will also support standard interfaces such as frame relay. In addition to the general features in Figure 1, APPN+ will also probably include logical unit (LU) 6.2 transport for LU 2 and other dependent LU sessions, increased network management capabilities, and improved intermediate node routing.

This fast packet capability will be part of a high performance routing (HPR) feature in APPN+. *SNA Perspective* believes that HPR will be based on a rapid transport protocol (RTP) that supports fast connection setup with data and which will be block, not byte, oriented. HPR will preserve all of the current SNA benefits of virtual route (VR) with priority provided through RTP.

**APPN++.** APPN++ will be the transport basis for multigigabit connections and is planned for phase-in during the 1994-1995 period. APPN++ is likely to

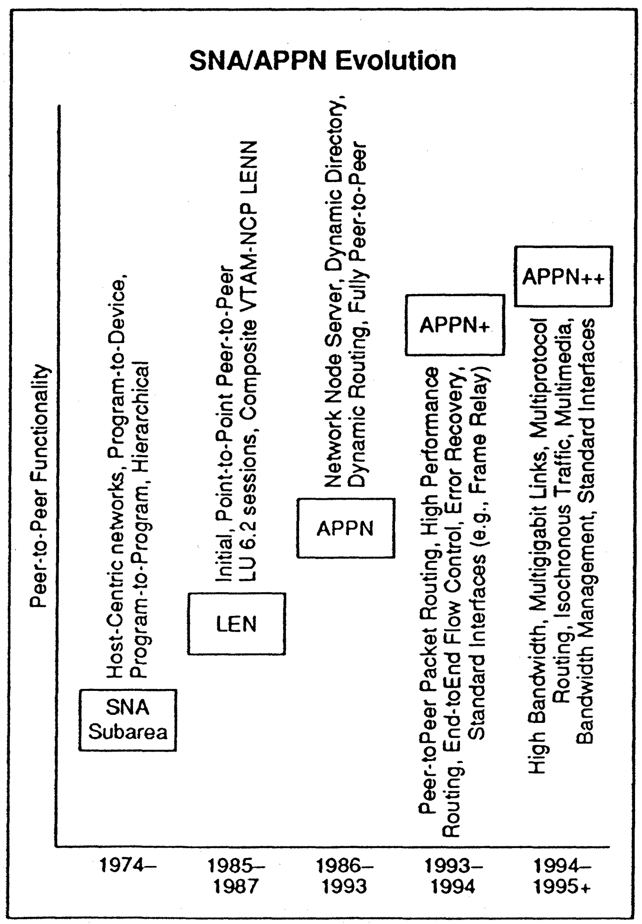


*Figure 1*

be a standards-based fast packet set of routing protocols. APPN++ will probably include fast packet at multigigabit speeds, dynamic bandwidth management, support for all distributed computing models, and multimedia support. User applications requiring the very high bandwidth that will probably be supported by APPN++ include photorealistic image, freeze-frame video, full-motion video, high definition television, sonogram, 3-D medical images, scientific visualization, and compute-intensive, modeling-based business applications.

### APPN Is Platform-Pervasive

APPN in VTAM has completed IBM's strategic transition to support peer-to-peer networking across all primary SAA and AIX platforms. These products are shown in Table 2.

### APPN Is Key IBM Networking Architecture

APPN is a key IBM networking architecture enabling the computing paradigms of the 1990s and beyond. Again, however, we note that IBM will also address these to significant degrees with OSI, TCP/IP, and other protocols/interfaces/environments as appropriate. These emerging paradigms include the following:

- Client/server computing
- Distributed transaction processing
- Distributed database
- Distributed file systems
- Process-to-process communication
- Single system image computing
- Fast packet and multigigabit transport

### APPN Positioned to Provide Interoperability

APPN's pervasiveness across platforms, IBM's transformation of SNA to a peer architecture, and IBM's unified infrastructure for emerging computing paradigms are each significant achievements. However, these do not, in themselves, address the requirements of users with distributed, heterogeneous networks.

End users and their applications cannot generally interconnect and share resources among dissimilar networks. Redundant network infrastructures within an organization have been a costly result of this situation. For example, between the same two locations, an SNA network may transport SNA data, a separate TCP/IP network transports TCP/IP data, and a further OSI network transports OSI data.

### User Needs in Heterogeneous Environments

Seven user requirements in these increasingly unnavigable waters include:

- Application support by function. Supporting applications based on their functions and not their underlying protocols.

**APPN Implementations in IBM SAA and AIX Platforms**

**VTAM APPN support.** Introduced in March 1992 with Advanced Communication Function/Virtual Telecommunications Access Method (ACF/VTAM) Version 4 (V4) and includes composite network node (CNN).

**AIX SNA Services/6000.** Statement of direction (SOD) announced in March 1992.

**6611 router APPN network node.** Statement of direction in January 1992.

**NS/DOS.** Announced in March 1992 with APPN LEN node only.

**OS/2 Version 2 Communications Manager.** Introduced in October 1991.

**Networking Services/2** (NS/2). Introduced in March 1991 to run with OS/2 EE Version 1.3.

**3174 APPN.** Introduced as a microcode feature in March 1991.

**APPN for DPPX/370.** Introduced for Distributed Processing Programming Executive/370 on the ES/9000 in September 1990.

**APPN for OS/400.** Introduced as integral to OS/400 on the AS/400 in 1988.

**APPN for System/36.** Introduced in June 1986.

**APPN (end node only) for System/38.** Introduced in June 1986. ■

*Table 2*

- Application portability across platforms. Allowing these applications to run anywhere on the networked or internetworked environments.
- Transparent network infrastructure. Allowing applications to send and receive standard calls to and from a network interface so the selected network infrastructure is transparent to the application, end user, and application developer.
- Resistance to obsolescence. Providing reliable, architecture-based solutions to incompatibility problems in order to transcend product life cycles and promote resistance to platform and operating environment obsolescence.
- Network management. Developing and managing heterogeneous networks as a single network.
- Common adapters. Consolidating heterogeneous network protocols and traffic over common adapters, enabling reduction or elimination of redundant network resources.
- Common transport. Providing common transport end-to-end across heterogeneous subnetworks.

## IBM Networking Blueprint

In March, IBM unveiled two basic approaches to interoperability in its networking blueprint:

- Multiprotocol routing through the network across a backbone supporting multiple protocols
- Multiprotocol gateways permitting transport of multiple protocols over a single backbone protocol

IBM believes that a multiprotocol backbone provides the greatest flexibility in multivendor and multiprotocol networking topology. However, in some networks, a particular protocol may be preferred for the backbone, and this requirement can be addressed by the use of gateways using the common transport semantics function depicted in Figure 2.

## APPN and the Networking Blueprint

*SNA Perspective* believes that APPN is important to either of these environments. In the first approach, by introducing peer networking throughout the SNA environment, SNA traffic will be able to be routed by network processors in the same way as other prevalent wide area network protocols. This is recognized by announcements of future support for APPN on several vendors' multiprotocol routers in addition to IBM's. However, if a gateway approach is preferred, APPN is a key protocol supported by the IBM direction to providing a multiprotocol transport network (MPTN) as shown in Figure 2.

## MPTN for Common Transport

Figure 2 shows a model for MPTN with several possible APIs—including CPI-C (conversational, send/receive model), RPC (process-to-process, call/return model), and message queueing interface (MQI; messaging model)—which provide interfaces into a wide range of upper-layer services. These, in turn, can be transported using APPN, TCP/IP, or OSI. In conjunction with MPTN, APPN is expected to increasingly provide the transport basis for TCP/IP and OSI applications as well as SNA applications.

An MPTN is a collection of single protocol transport networks (SPTNs), each of which has its own transport protocol. These SPTNs may be interconnected through groups of nodes with application-

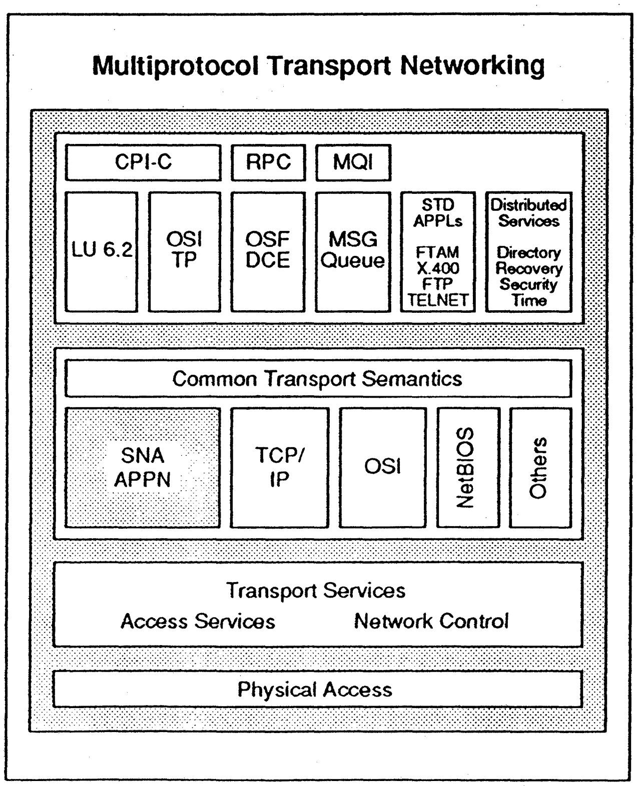


*Figure 2*

specific gateways, such as IP routers in a TCP/IP network. MPTN will support logical, end-to-end connections as well as datagram services. End users and their applications will be unaware of the protocol or collection of protocols selected to transport their data across the network. The significance of this approach is that MPTN would be able to provide an any-to-any connection.

One MPTN implementation would be a multiprotocol server rather than a gateway. For example, such a server could provide support for SNA, OSI, and TCP/IP and would interconnect client workstations that support, respectively, SNA, OSI, and TCP/IP. The actual MPTN routing function would likely maintain as unique the transport addresses used in each protocol group.

An MPTN gateway could be used to connect multiple SPTNs to create an integrated heterogeneous network. One constraint of such a gateway is that it would probably be limited to the set of transport characteristics common to all participants (for example, normal data, no record boundaries, full-duplex connections).

*SNA Perspective* believes that APPN, using the MPTN approach, will gradually become a transport mechanism of choice to interconnect heterogeneous distributed applications and their respective SPTNs. There are several reasons for this:

- APPN provides a reliable and robust connection approach, more reliable and robust, in many opinions, than either TCP/IP or the ISO Transport Protocol Class 4.
- APPN is evolving into a fast packet architecture, capable of supporting multigigabit speeds and dynamic, peer-to-peer networking with multimedia.
- Sockets over SNA (SNAckets), which was discussed in a statement of direction in March 1992, is a specific and significant example of APPN's ability to provide underlying transport, in this case for TCP/IP socket addresses. *SNA Perspective* believes this is the first of many such multiprotocol routing capabilities to emerge using APPN.

## Prior Peer Networking in VTAM and NCP

To establish a context for the VTAM APPN support announcement, it is useful to trace the evolution of peer networking in IBM hosts.

### *VTAM V3R2, NCP V4R3/V5R2*

In June 1987, IBM introduced ACF/VTAM V3R2 and ACF/NCP V4R3/V4R3.1 (3725) as well as ACF/NCP V5R1/V5R2/V5R2.1 (3745/3720). These included a host/NCP composite low entry networking (LEN) node. Specific VTAM V3R2 features related to peer networking included:

- VTAM APPC API. This introduced the LU 6.2 Advanced Program-to-Program (APPC) API directly in ACF/VTAM. Its most important aspect was that host interprogram communications, which were previously restricted to Customer Information Control System (CICS) and to a less than elegant adapter for Information Management System (IMS), were made available to all application subsystems. [This benefit of this approach was shown in September 1990, when IBM introduced the SAA CPI-C interface into MVS, CICS, IMS, and TSO-E. All of these application subsystems, since then, support CPI-C calls to and from VTAM APPC and resident application transaction programs. Later, in 1991, APPC was added to NetView.]
- Type 2.1 node support. Type 2.1 node support was the VTAM V3R2 basis for providing composite (subarea) node support for LEN node. This original host/communication controller peer networking feature introduced support for independent LUs as well as parallel sessions (both of which were supported only for LU 6.2). Nonhost LU 6.2 LUs could be defined as independent of the System Services Control Point (SSCP) and could therefore issue session BINDs to other host or nonhost LUs. With independent LUs, no SSCP-LU control session existed and a SSCP-PU control session was optional (e.g., needed for transport of network management data to NetView and support of downstream-attached dependent LUs). Parallel

sessions were supported between host and nonhost type 6.2 LUs, where multiple concurrent sessions and their corresponding conversations could be active between a single LU pair.

- Dynamic table replacement. VTAM V3R2 introduced a MODIFY TABLE command that allowed replacement of Unformatted System Service Table (USSTAB), Logon Mode Table (LOGMODE), Class of Service Table (COSTAB), and Interpret Table (INTERPRET) entries without having to halt or restart network VTAMs or NCPs. These table replacements can be performed globally or selectively.
- Dynamic PATH table update. This enables subarea path changes to be rendered without inactivating or regenerating NCP and used VTAM library dynamic PATH update members.

Dynamic Table Replacement (for USSTAB, LOGMODE, COSTAB, INTERPRET) and Dynamic PATH Table Update were not actually dynamic in the sense that table changes require discrete system definition and are not modified dynamically as a function of downstream configuration changes. However, they significantly improved system availability over prior versions, where subarea network table changes required at least partial disruption of data traffic to make changes.

### VTAM V3R3, NCP V5R3

In October 1989, IBM introduced ACF/VTAM V3R3 and ACF/NCP V5R3. From the perspective of peer networking, two major functions were introduced in addition to the initial VTAM V3R2 and NCP V4R3/V5R2 peer support:

- Type 2.1 node boundary function support. Boundary function controls nonsubarea node access into a subarea network. For VM hosts, Type 2.1 nodes had more options for connecting to VTAM—via X.25, the ES/9370 Telecommunications Subsystem Controller over SDLC leased/switched lines, and the ES/9370 Token-Ring Subsystem. VTAM V3R2 and NCP V4R3/V5R2 only supported nonhost Type 2.1 connections to the host through an NCP.
- Casual connection. This feature enabled adjacent NCPs to interconnect as Type 2.1 nodes and allowed VM VTAM nodes to connect to either adjacent NCPs or VM VTAM nodes as Type 2.1 nodes.

### VTAM V3R4, NCP V5R4

In September 1990, IBM introduced ACF/VTAM V3R4 and ACF/NCP V5R3.1 and V5R4. From the perspective of peer networking, three major functions were introduced:

- Type 2.1 node boundary function was added for MVS as had been introduced for VM VTAM with ACF/VTAM V3R3. MVS boundary function support was through 3172s.
- Dynamic network access. VTAM V3R4 eliminated, to a great extent, previous system generation requirements for devices attached through leased and switched lines. Type 2.1 nodes could access a subarea network over multiple connection without prior LU predefinition to VTAM. This node Type 2.1 LU feature with VTAM V3R4 worked with the non-native network connection (NNNC) capability and, in so doing, removed many instances that previously required coordinated system definition across networks.
- Multi-tail support. VTAM V3R4 also introduced support for dynamic switched definitions for both SSCP-dependent and SSCP-independent LUs and physical units (PUs). Reusable model definitions for dial-in PUs and dependent LUs were also introduced in concert with a configuration services installation exit routine. Multi-tail implies that, for APPC, any boundary function can be used for connection into a subarea with no definition required.

## VTAM APPN Support

VTAM APPN support was introduced along with ACF/VTAM V4 in March. VTAM APPN support adds APPN network node and end node into traditional subarea environments. VTAM V4 was announced for MVS with a statement of direction presented on VTAM V4 for VM.

### Composite Network Node

IBM also stated that, at the time VTAM V4 ships, a then-current release of NCP will work with VTAM APPN support to provide a function called composite network node (CNN). CNN provides to the APPN network the appearance that a given VTAM APPN network node and all of its associated NCPs are one (composite) APPN network node.

### VTAM APPN Support With or Without NCP

VTAM can be a standalone APPN network node (without NCPs) and can connect to APPN networks via an integrated channel adapter (ICA) or through the 3172. A VTAM APPN network node need not own NCPs; it is a configuration option. A VTAM APPN end node never includes NCPs, although it can attach to NCPs as part of a composite network node. An NCP can only be part of composite network node, never an APPN node by itself.

### APPN Network Node in SAA

IBM also announced the inclusion of APPN network node into SAA Common Communications Support (CCS). APPN end node had already been added to SAA CCS in March 1991. ACF/VTAM V4 for MVS/ESA now provides a full implementation of CCS APPN end node and network node protocols.

### Features and Advantages of VTAM APPN Support

There are many advantages to VTAM APPN support. Below, we list fourteen features and functions that we feel deserve mention and discuss several of them in detail.

**APIs.** All APIs are fully supported, including CPI-C, APPC API, 3270 (SOD), RPC, and MQI, and existing operator and network management interfaces will continue to operate

**Subsystem and Operating System Impacts.** There is no apparent impact on subsystems and their applications. This is significant because past VTAM enhancements have often required upgrades in application subsystem software levels in order to provide the full degree of promised improvement. However, on the operating system side, VTAM APPN support requires an ESA level of MVS and, when announced, VM.

**Dependent LUs.** IBM announced support in limited configuration for dependent LUs (LU 0, 1, 2, 3) across APPN in VTAM V4 and made a statement of direction to enhance this support in a future release. Support will be provided in VTAM V4 for a dependent LU in a 3174 or other node attached directly to its boundary function VTAM/NCP node, that is, over a single hop. The statement of direction discusses the mechanism to support a dependent LU supported by a node attached anywhere in the APPN network, that is, multiple hops away from its owning boundary function.

The dependent LU support in VTAM V4 requires no changes to the connection between the LU and its boundary function node nor to its target application. The dependent LUs can also be existing dependent LU emulators such as 3270 gateways. It provides broad support for dependent LU features including SLU-initiated sessions, queuing session requests, autologon, third-party initiation, printer release request, etc.

The statement of direction discusses two elements for dependent LU support: the dependent LU server (DLS), which will be implemented in VTAM, and the dependent LU requester (DLR), which can be a 3174 or other node supporting dependent LUs. As the DLS, VTAM will provide the SSCP function for dependent LUs by communicating with DLRs. Products implementing the DLR function will have an LU 6.2 session upstream to the DLS in VTAM. The LU 6.2 pipe or control session will carry control flows for dependent LUs. The DLR will receive the control flows enveloped in an LU 6.2 session, open the envelope, and pass the traffic downstream.

As an additional benefit, these dependent LUs need not be predefined in VTAM because the DLR owns the LUs as APPN resources and will register them to VTAM's directory using APPN.

This statement of direction indicates that APPN network node support added to the 3174 in March 1991 may have been a sleeper announcement—this could provide a new lease on life for the beleaguered 3174 (see "3174 Hard Hit by Gateways," *SNA Perspective* February 1992) and is an early signal to competing vendors such as McDATA, IDEA

Courier, and Memorex/Telex of a requirement to support APPN. On the other hand, router and gateway products from vendors licensing APPN network node may still prove more popular with users than the 3174 option.

The full dependent LU support over APPN, when available, will prove a boon for users with large installed bases of 3270 devices who wish to preserve their investment in 3270 applications and staff experience and yet have them participate in the relative freedom afforded by APPN dynamic networking.

*SNA Perspective* believes that lack of dependent LU support to date has restrained many users in their decision to migrate to APPN. Because many users will continue to use most existing 3270 applications indefinitely, even over peer networks, we think IBM's addition of this dependent LU requester/ server support as soon as possible is critical to the success of APPN.

**Meshing Subarea and APPN Directories.** VTAM APPN support will transform APPN Locate flows to subarea cross-domain flows (CDINIT, DSRLST, etc.) or vice versa. Therefore, VTAM will provide seamless directory and session setup procedures across APPN and subarea networks including SNI.

**Central Directory Server.** VTAM APPN support will provide a central directory server function for APPN networks. When a VTAM network node is configured as a central directory server, it will advertise this fact when it sends topology updates for the node; when other APPN network nodes recognize that a central directory server exists in the network, they will forward resource search requests to it unless the resource location is known. The central directory server will check whether the resource location is known to itself or to other central directory servers in the network before it resorts to a broadcast search mechanism to find the resource. When it learns the resource location, it will cache the information to satisfy subsequent requests. Thus, broadcast would be done only once for a target LU (rather than by each network node). VTAM normally has a larger database than other network nodes, so the resource caches would be kept longer. Also, VTAM will also store the database on the disk so that it can be reloaded during network restart. To further avoid broadcast searches, a feature called central resource registration will have VTAM application LUs registered in central directory servers with their status (active/inactive).

**PATH Table Definitions Eliminated.** The benefits of eliminating PATH table definitions to add a new VTAM APPN network node or end node are discussed in the sidebar on page 10.

**Migration From Subarea Addressing to APPN Addressing.** Subarea networks use preassigned local and network addresses. Local addresses are used between a VTAM/NCP boundary function and a peripheral node (e.g., PU 2 and PU1). VTAM local and network addresses are assigned during major node activation and NCP local and network addresses are assigned at NCP generation. Also, these subarea addresses persist between sessions until changed by a manual system generation process.

APPN networks, on the other hand, use local addresses for routing on a session-oriented basis. That is, APPN addresses are assigned at session activation and released at session termination. These temporary addresses are conveyed in a format identifier type 2 (FID2) transmission header as session identifiers. These sessions IDs, in turn, are associated with a specific session and with a specific transmission group between adjacent nodes. (A transmission group is currently equivalent to a single link in APPN.) Therefore, if an LU 6.2 session is established between LUs residing in nonadjacent APPN nodes, there would be two separate links involved for the end-to-end connection and two separate session IDs would be used for two separate session stages running over two separate single-link transmission groups. Each of these session IDs is called a local-form session identifier (LFSID). Further, an APPN network-wide identifier is established; this is called a fully qualified procedure correlation ID (FQPCID).

**VTAM APPN End Nodes Reduce Searches.** When VTAM hosts are configured as end nodes, they will not be searched for unknown resources. These VTAM end nodes will register all LUs that

# Benefits of Eliminating PATH Table Definitions to Add VTAM APPN Network Nodes

Figure 3 provides a simple example of some of the PATH table entries that must be arbitrarily made in order to add a new VTAM subarea (VTAM 40 in Figure 3) to an existing host subarea SNA network. For the newly added VTAM subarea to support sending SNA data to the other three subareas, PATH statements have been made in VTAM 40 to arbitrarily define connections over transmission groups (TGs) in explicit routes (ERs) which are in turn part of virtual routes (VRs).

In subarea SNA, a virtual route is logical, full-duplex association between a pair of endpoint subarea nodes which is defined to support an LU-LU session. Each virtual route further defines an underlying pair of reverse-direction explicit routes. Each explicit route is a simplex, physical path between the endpoint subareas defined within a virtual route. TGs, in turn, are logical, full-duplex connections between adjacent subarea nodes in one or more explicit route.

Any addition, deletion, or modification of node or link resources in these subarea networks may require that all corresponding and interlocking table entries be changed accordingly. In large and complex SNA networks (Figure 3 shows a very simple network) these changes consume inordinate budget, time, and expertise, often across multiple data and cost centers.

Figure 4 indicates that, if the same four hosts as shown in Figure 3 have VTAM APPN support, the need to configure PATH tables is now eliminated. This is an important feature of APPN network node which begins, for the first time, to provide the truly dynamic PATH table initially foreshadowed by VTAM V3R2.

This is a simplified example because it does not include any NCPs, though it does demonstrate how operational costs may be reduced. In many cases with APPN, NCPs still require PATH definitions and PATH definitions among subarea nodes in a CNN are required. Existing PATH definitions need not be changed for already existing subarea routing networks.

This feature is significant for several reasons:

- PATH tables and their continuing maintenance are highly complex and error-prone in sizable subarea networks. Elimination of the need to manually generate and maintain PATH tables in VTAM APPN support is one of the most significant single IBM networking announcements in the past 10 years.
- Many subarea networks, APPN networks, and subarea/APPN hybrid topologies are defined as single logical entities that encompass multiple data and cost centers. Subarea networks may also span multiple networks through SNA Network Interconnection (SNI) gateways. In all cases, any system definition changes (PATH changes especially) require close coordination between center managers and programmers. The virtual elimination of the need to coordinate PATH changes in complex environments will greatly simplify network definition and dramatically reduce the network generation cycle time and cost. ■

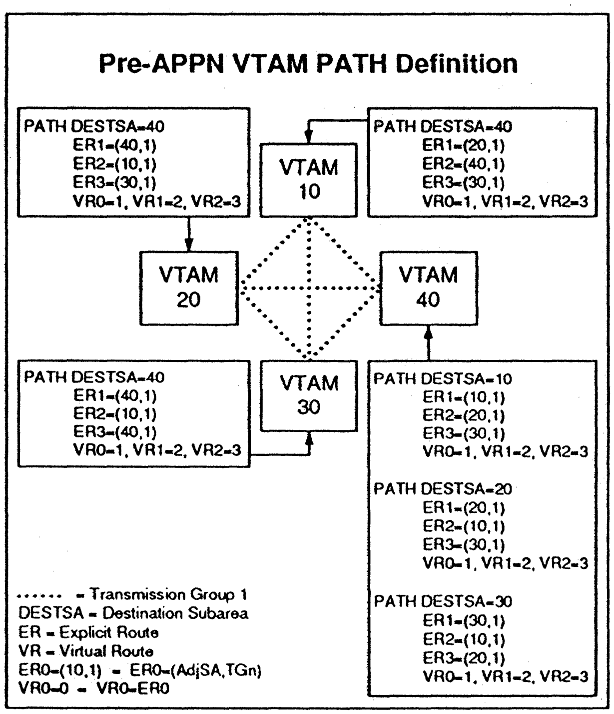


*Figure 3*

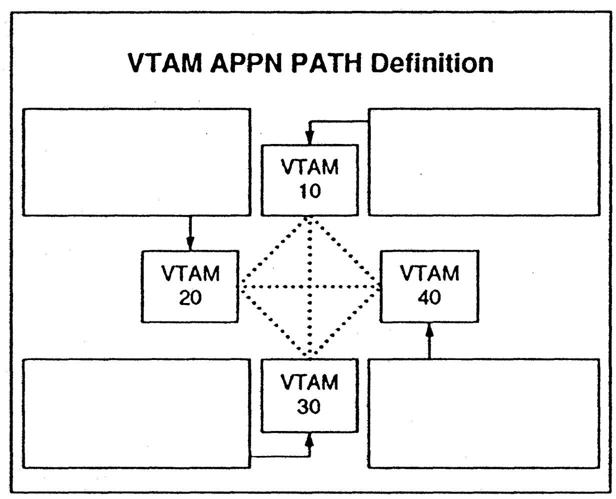


*Figure 4*

can potentially be search targets to their network node servers. Thus, data hosts need not perform networking functions; they can focus their resources on application processing. Decreasing the number of network nodes will also reduce overall network traffic for resource searches.

**Cascaded Searches.** In subarea networks, cross-domain session intiation requests (CDINITs) are not rerouted to other hosts, even if the CDINIT receiver knows that the target LU is located on an adjacent host. Therefore, a host must search every host it is aware of individually for unknown resources. The APPN directory search mechanism allows search redirections, known as cascaded searches. In the case above, the receiver of a Locate request will reroute the request to all adjacent nodes. This reduces the number of CP-CP sessions required compared to the SSCP-SSCP sessions—a VTAM end node needs only a pair of CP-CP sessions with its network node server.

**Session Startup Cross-Domain Overhead Reduced to Two Flows.** There are eight to ten cross-domain flows for a normal session setup and termination across SSCP-SSCP sessions, in addition to BIND and UNBIND flows. On CP-CP sessions, it can normally be reduced to two flows. To further reduce session setup overhead, VTAM may forgo sending Locate requests all the way to the destination if it knows the resource location and has the information for LU 6.2 session establishment.

**APPN Uses Host's Concurrent Processing.** Since APPN components can take advantage of S/390 multiple processors, Locate processing and session setup in VTAM APPN network nodes is faster and can reduce recovery time after a network failure.

**VTAM to NetView Data over CP-CP Sessions.** As discussed later in this article under Network Management, network management data, with VTAM APPN support, can flow over CP-CP (APPN) sessions rather than SSCP-PU sessions as currently required. The CP-CP interface is expected to be more efficient for session traffic.

**Statement of Direction for VTAM APPN Border Node.** A subset of border node was originally introduced with OS/400 V2R1 as Release 1 Border Node in April 1991. The architecture has been enhanced to implement it in VTAM V4. VTAM APPN border node functions will enable:

- LUs in one APPN network to establish sessions with LUs in another APPN network
- Search requests across network boundaries
- Isolation of network topology information between adjacent interconnected APPN networks
- Session problem determination flows across adjacent APPN networks

A VTAM APPN border node functions as a network node in its native APPN network and also connects to an adjacent network node in another APPN network. Two APPN networks are distinguished by their unique network IDs. Previously, only LEN nodes, APPN end nodes, and composite LEN nodes could connect two APPN networks because two network nodes with dissimilar network IDs could not directly connect. The VTAM APPN border node will appear as a network node in the non-native network topology database of another VTAM border node or a network node to which it is connected. VTAM APPN border node enables any number of APPN networks to interconnect and is designed to allow unlimited intermediate networks to exist between the endpoint networks.

**Statement of Direction for APPN Session Routing over CTC.** A future release of VTAM will provide support for APPN session routing over channel-to-channel (CTC) connections.

## *Other March Networking Announcements*

Several network management announcements are discussed in the next section. Other related APPN and networking announcements in March 1992, in addition to VTAM APPN support and network management, include:

### APPN on DOS

Networking Services/DOS (NS/DOS) includes APPN LEN node and a much smaller version of APPC (about 80K) than APPC/PC. Because of the continued low market share of OS/2 compared to DOS and DOS-based systems like Windows, *SNA Perspective* sees this DOS support for APPN, even at the LEN node level, as an important concession on one hand (supporting other than its strategic workstation operating system) to increase market penetration of APPN on the other.

### Developing APPN on NetWare

IBM and Novell announced joint development underway to include APPN network node on NetWare. *SNA Perspective* believes APPN on NetWare will provide a valuable market incentive for APPN migration.

### More, But Not All, APPN Licensing Details

In March 1991, IBM announced that it would publish APPN end node protocols. In January 1992, the company stated its intent to license network node and in March, announced several details regarding the licensing of source code for APPN network node protocols. Licencing will begin in the second quarter of 1992 and the developer's kit will ship in the first quarter of 1993.

### 6611 Router APPN Date

At the announcement of the 6611 router in January 1992, IBM issued a statement of direction to add APPN network node capabilities. In March, the company provided an availability date of first quarter 1993. IBM has still not made a full announcement, including pricing and configurations, of APPN for the 6611. We expect its formal announcement in or before September 1992.

### TCP/IP Interoperability

**TCP over SNA.** Capability for TCP sockets applications to communicate with each other over an SNA network using underlying LU 6.2 sessions was announced. *SNA Perspective* likes its internal working name: SNAckets. We like the concept even better and the example it provides of interoperability options to come from IBM.

**CPI-C over TCP/IP.** IBM stated that CPI-C would support TCP/IP transport as well as SNA and OSI. The company is working with a customer to prototype an application to support this. Not quite far enough along to rate a statement of direction, but *SNA Perspective* has been recommending this move for some time (see "IBM's Leading Communication APIs Face Off," *SNA Perspective* March 1992).

**TCP/IP in SAA.** IBM announced the inclusion of TCP/IP in SAA CCS. Although there is much industry debate over the importance of SAA as such, *SNA Perspective* believes that the inclusion of TCP/IP in SAA is at least symbolic of its strategic importance to IBM and further signals IBM's commitment to interoperability within its networking bluprint.

### RS/6000: APPN and CPI-C

IBM made a statement of direction to add APPN end node and network node as well as a CPI-C interface to AIX SNA Services/6000. This is a further integration of SAA and AIX.

## Network Management

Management services components had been defined in the APPN architecture that are essentially the same as those defined for subarea networks. Because APPN network management is not yet as thorough as for subareas, some features are not supported in APPN such as Response Time Monitor. See the January 1992 and February 1992 issues of *SNA Perspective* for an analysis of IBM network management for subarea and peer networks.

In March 1992, IBM made a statement of direction to enhance support of APPN network management. This will be through APPN network management features which provide integration of APPN topology and APPC accounting data. These functions will include:

- Dynamic collection and display of APPN network topology
- Existing remote operator control applies to VTAM APPN resources
- Collection facility for APPC accounting data

This additional NetView APPN support will work with a future release of NetView and with future capabilities of OS/2 V2 and Communications Manager. To provide these functions, IBM will add topology and accounting manager functions in NetView and alert focal points and topology and accounting agents in Communications Manager. The accounting data collection function is a welcome addition, as it will enable collection of APPC accounting data for sessions and conversations and write these data to Systems Management Facility (SMF) records which, in turn, will assist network cost center managers in the arduous task of allocating network resource costs on a usage basis. However, it appears that some of the features discussed will require operator intervention or redundant efforts.

APPN network management enhancements must keep pace with APPN enhancements. Otherwise, users can install networks that they cannot effectively manage. *SNA Perspective* believes that IBM has significantly enhanced APPN with the March announcements but NetView APPN support, both current support and this preannounced functionality discussed in March, does not yet have commensurate functional capability. Nonetheless, these NetView APPN features will represent a positive step toward providing dynamic network management for APPN environments.

# Issues and Implications

*SNA Perspective* believes VTAM APPN support and the related announcements of March 1992 represent the most significant networking announcements from IBM in the past ten years, since the introduction of LU 6.2 under CICS in 1982. In addition to the APPN focus, IBM commitment to support for multiple protocols, interfaces, and environments was reiterated in the company's new networking blueprint.

The implications of the APPN announcements are far-reaching for several reasons:

- APPN is now pervasive across enterprise, departmental, and workstation platforms.
- APPN is a key IBM networking architecture to enable the computing paradigms of the 1990s and into the next millenium.
- APPN will increasingly provide interoperability for SNA, TCP/IP, and OSI networked applications. This will be based on IBM's networking blueprint and its MPTN direction.

### Outstanding Issues

Several outstanding issues remain to be resolved, including:

- **Performance bottlenecks.** VTAM and NCP tend to create bottlenecks thus impeding performance in congested subarea networks. This tendency may be exacerbated in dynamic APPN networks where there are no predefined PATH and class of service table entries. Enhanced intermediate node routing is not expected until APPN+ in 1994 and dynamic bandwidth support is not expected until at least 1995 with APPN++, so these performance considerations are likely to remain in these next few critical years of APPN market penetration. Several suggestions for more efficient user APPN network design are provided in the second article in this issue.
- **Security concerns in dynamic networks.** Security is an ever-present issue in all networks. The notion of introducing dynamism into mission-critical network resources increases the possibility of unwelcome application access and tampering. It is critical for network designers and management to ensure that protective measures such as userID, encryption, applicationID validation, end user authorization, and XID validation are enforced.
- **Focal point must become host independent.** Products for all the major network management disciplines must be tested by significant IBM users and iteratively enhanced for dynamic, peer-to-peer networks in a middle-out approach to design—featuring user involvement at all stages of major product design, development, and testing. The preannounced NetView offerings for APPN support are a step in the right direction. Truly dynamic APPN awareness and expert systems logic must be incorporated

into NetView and all APPN network nodes as soon as possible. That is, the actual focal point intelligence and function must become host-independent. This is a challenge because it is concurrently critical to centralize network management data collection.

- **Timeframe of phased releases.** *SNA Perspective* applauds IBM's efforts to reveal its long-range APPN strategy to assist users in planning. However, in the face of TCP/IP's blossoming popularity and its ongoing technical enhancements through the standards process, APPN has a short window to make a name for itself in the market and a long cycle of enhancements to include what users have been requesting for years.
- **ESA APPN constraints.** VTAM APPN support will require ESA operating system levels. This means that users with previous iterations, such as XA or SP, will need to migrate to ESA before they can take advantage of these APPN features, which, in user's eyes, significantly increases the total cost of APPN migration.
- **Support for Dependent LUs.** Limited support for dependent LUs has restrained and will continue to restrain many users' decision to migrate to APPN. Most existing 3270 applications will continue to be used indefinitely, even over peer networks. IBM must fulfill its dependent LU requester/server statement of direction in APPN as soon as possible.

## Conclusions

Taken together, these announcements are revolutionary for IBM networking. Many challenges remain, but we see APPN being positioned squarely as IBM's pivotal networking integration architecture through the 1990s and beyond. IBM is also reponding to user input by strenthening its commitment to support TCP/IP and other protocols, which was expressed in this announcement through the IBM networking blueprint.

*by Thomas J. Routt* ■

*(continued from page 1)*

## LEN Node

All APPN nodes are based on IBM's node Type 2.1. LEN node is the least functional of the node T2.1 expressions. LEN provides for a basic, peer-to-peer connection between a pair of adjacent Type 2.1 nodes over one or more links. There can be no intermediate nodes between the two LEN nodes that contain the LUs to be in session. LEN nodes provide the minimum functions required to make a connection between the adjacent nodes, establish a session between adjacent LUs, and transport data.

LEN node has been implemented in VTAM/NCP, AS/400 OS/400, System/36 SSP, System/38 CPF, System/88 OS, Series/1 EDX V6 or RPS V7.1, RS/6000 AIX V3, RT PC AIX V2.2, PS/2 OS/2 EE, and PC with NS/DOS or APPC/PC under DOS. LEN connections can be established over SDLC, token ring, X.25, and Ethernet.

## APPN End Node and Network Node

APPN end node is similar to LEN node in that an APPN end node can only directly connect to another APPN node if the two are adjacent. It can, however, connect to multiple network nodes, with one functioning as its network node server. Further, APPN end nodes do not provide services for other nodes such as directory services or routing.

In contrast to LEN node, APPN end node contains a Control Point (CP) that enables communication over CP-CP sessions with an adjacent network node. From there, the LU in an APPN end node can communicate with LUs in remote, nonadjacent APPN end nodes or network nodes because the APPN network node contains an intermediate routing function.

### Connecting APPN Networks

Prior to the 1993 delivery of VTAM APPN support and composite network node (CNN) described in the first article in this issue, it is already possible to interconnect subarea and APPN networks. These connections can be made either as a pair of APPN networks connecting through a transit subarea network configured as a composite LEN node or as a pair of subarea networks connecting through an APPN network. A primary limitation, however, is that while LU 6.2-LU 6.2 sessions can be established across these dissimilar networks, they cannot establish CP-CP or SSCP-SSCP control sessions across the dissimilar networks. This is because, prior to VTAM APPN support, VTAM and NCP only support a composite LEN node function.

APPN network node supports peer communication between nonadjacent Type 2.1 nodes and provides distributed, dynamic directories to enable LUs in nonadjacent Type 2.1 nodes to gain access to each other. APPN network nodes also provide adaptive routing functions since optimum routes are calculated as a function of previously specified class of service (COS) definitions.

### *Major APPN Components*

Figure 5 shows the major components of APPN network nodes and end nodes. The APPN architecture is designed to interwork with LU 6.2 APPC. Therefore, APPN CP-CP control sessions are bound as LU 6.2 sessions. Both APPN and APPC are predicated on enabling networked applications in distributed control environments.

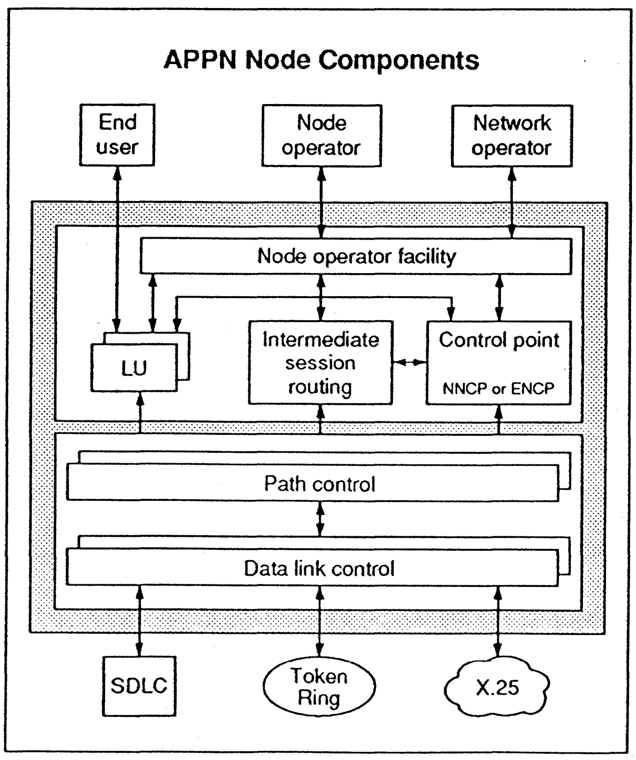


*Figure 5*

Figure 5 distinguishes three major APPN node components: Node Operator Facility (NOF), Network Accessible Unit (NAU), and path control network (path control and data link control layers).

### *Node Operator Facility*

NOF provides an interface between the node operator and CP components which, for example, allow the node operator to activate and deactivate link stations, define/delete LUs, query CP regarding status of links and other node resources, and receive diagnostic data. Node operators can be either human operators, command files, or transaction programs.

### *Network Accessible Unit*

LU, intermediate session routing, and CP shown in Figure 5 are APPN NAUs. (Depending on context, intermediate session routing can also be considered part of path control.) The NAU set of APPN node components is based architecturally on the upper layers of SNA: transaction services (layer 7), presentation services (layer 6), data flow control (layer 5), and transmission control (layer 4).

The LU behaves as a logical port into the network and can be defined as either SSCP-independent or SSCP-dependent. The intermediate session routing (ISR) NAU provides a session connector manager and a session connector. The CP NAU is made up of three elements: configuration services, session services, and address space manager (ASM).

### *APPN Node Services*

APPN node services include configuration services, topology and routing services, directory services, session services, and network management.

## *Configuration Services*

The configuration services component of an APPN node CP manages all local node resources including links to adjacent nodes. Specifically, CP configuration services is responsible for node configuration definition including types of data link control, ports, adjacent link stations, attached connection networks, adjacent nodes, and link activation, nonactivation, and deactivation.

Figure 6 illustrates a possible configuration services sequence in which an APPN network node (NN1) is added to an existing APPN network consisting of three network nodes (NN2, NN3, and NN4).

The assumptions for the example in Figure 6 include:

- NN1 is defined with a separate link/TG to each of NN2, NN3, and NN4.
- Each link is defined as switched SDLC with Modulo-8 frame sequencing.
- Network node CP1 (NNCP1) separately negotiates link station roles with NNCP2, NNCP3, and NNCP4.
- In each negotiation, NNCP1 becomes the primary link station and therefore controls the link by sending SDLC commands and receiving SDLC responses.

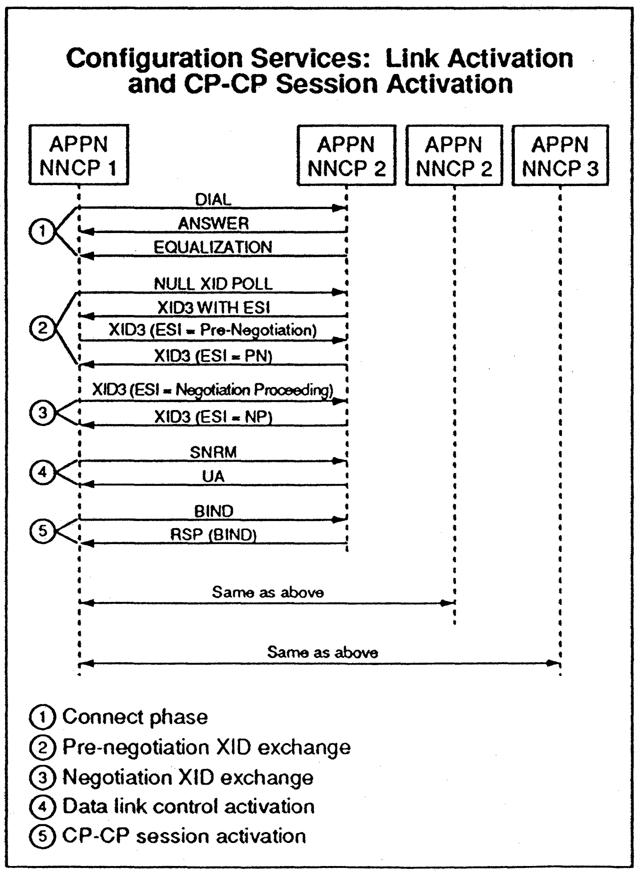


*Figure 6*

Link activation and subsequent CP-CP control session setup proceed in phases. The connect phase is optional depending on the link—APPN supports SDLC switched, SDLC dedicated, token-ring 16/4 Mbps, X.25 switched virtual circuit, and X.25 permanent virtual circuit. In Figure 6, the connect phase consists of dialing, answering, and modem equalization.

The prenegotiation exchange identification (XID) phase is also optional. If used, it begins with XID polling. APPN supports the use of a null XID poll to determine if the adjacent link station is active. An active adjacent link station responds to a null XID poll by sending a Format 3 XID (XID3) with an exchange state indicator (ESI) set to "prenegotiation." An APPN link station can be configured as either primary, secondary, or negotiable link station.

The negotiation XID exchange phase is used to determine which link station will become primary and which will become secondary. This is useful because negotiation of link station role significantly reduces time-consuming system definitions of adjacent nodes. In this phase, the XID3 ESI is set to "negotiation proceeding." In this phase, node properties communicated to adjacent nodes include:

- Adjacent link station (ALS) name
- CP capabilities (network node or end node providing link services)
- CP name
- Link characteristics
- Subarea PU name (if appropriate)
- Product set ID
- Node capabilities (parallel link/TG support, data link control support)

The actual link station role negotiation proceeds through comparison of a 32-bit field call nodeID which is comprised of a product-specific block number and an ID number unique in the APPN network.

## Topology and Routing Services

Topology and routing services (TRS) is a component of the APPN node CP. Its purposes are: create and maintain a topology database (topology database manager), select optimal route (route selection services), and maintain the class of service database (COS manager).

Actual computation of the optimal path is conducted by route selection services (RSS), which generates a route selection control vector (RSCV) containing the best route through the APPN network to support a specific LU-LU session. RSS-calculated inputs to this process include data stored in multiple internal and external databases which, in turn, are managed by other TRS subcomponents. Upon TRS initialization, NOF passes these node parameters:

- Node type (network node or end node)
- Node CP name
- Node network ID
- Class of Service/Transmission Priority Field (COS/TPF) option
- COS database file name
- Topology database file name

### Optimal Route Calculation

TRS calculates the best route by comparing the actual node and TG characteristics against the required route. In this process, qualitative node and TG characteristics are converted into quantitative node and TG weights. Actual and required node and TG characteristics are stored in topology and COS databases, respectively. TG characteristics include:

- Link speed. The range is from less than 4.8Kbit/sec to greater than 2Mbit/sec.
- Cost per connect time. Not used for dedicated SDLC, token ring, or X.25 permanent virtual circuit.
- Cost per byte. Not used for dedicated SDLC, token ring, or X.25 permanent virtual circuit.
- Security class. Seven levels ranging from nonsecure to Tempest level.
- Propagation delay. LAN least; satellite greatest.
- Three user-defined fields.

TRS topology and COS databases maintain node and mode characteristics. Node characteristics include:

- Route addition resistance (RAR). The propensity of an intermediate node to function as one.
- Virtual routing node (VRN). Not an actual routing node; used by end node
- Congested
- End node routing resources depleted
- Network node routing resources depleted
- Intermediate routing service supported
- Border node functions supported

Mode characteristics include:

- Mode description name
- COS
- Maximum number of sessions
- Maximum number of conversations
- Locally controlled sessions
- Pre-established sessions
- Inbound/outbound pacing: fixed or adaptive
- Maximum length of RU for sessions

Once a CP-CP session has been activated between network nodes, a conversation is established between the network node topology database managers (TDMs) in adjacent network nodes. (CP-CP sessions can only be defined either between a pair of network nodes or between a network node and an end node.)

Figure 7 (see page 18) provides an overview of the mechanism whereby topology data are exchanged between APPN network nodes. Each network node TDM creates and broadcasts topology database updates (TDUs) about the node itself and all locally-owned TGs to other network nodes. TDUs are carried in LU 6.2-architected General Data Stream

(GDS) records in GDS variable X'12C2'. TDUs convey node characteristics, TG ID, and data link control signaling data.

Figure 7 shows NNCP1 in the process of joining the APPN network. The figure depicts TDU exchange in network node TDM conversations, which are allocated in the CP-CP control sessions established at the close of the sequence shown in Figure 6. Before a network node joins an APPN network, its local copy of the topology database contains only its local resources. Upon connection to the adjacent network nodes (NNCP2, NNCP3, and NNCP4 in Figure 7), it receives a copy of the current topology database and also generates a self-descriptive TDU which is then broadcast throughout the network.

TDUs are exchanged whenever a network node local topology database is updated. Updates can be triggered by changes in node or TG characteristics or by activation, deletion, or restoration of links to adjacent nodes.

### Design to Minimize TDU Data Flows

A major design consideration here—especially in the case of the incorporation of sizable VTAM/NCP resources into an APPN network—is how to minimize the data flows for TDUs. There are several mechanisms to deal with this potential performance problem:

- Design the APPN network with a small number of network nodes. End nodes do not maintain or exchange topology data. One design approach would be to define the majority of APPN nodes as end nodes which access the resources of relatively few network nodes.
- Define several network nodes but designate a subset of these as topology and directory servers. (Note that IBM has not discussed the concept of topology servers, but *SNA Perspective* believes it would be an efficient approach.) This would dramatically reduce TDU flows.
- Define several virtual routing nodes (VRNs). TG updates are not broadcast if the TG to a network node is activated or deactivated across a VRN. Therefore, VRNs can be used across LANs or X.25 to reduce system definition and TDUs.

Several APPN features already limit TDU propagation:

- Network nodes propagate TDUs to adjacent network nodes. However, a network node does not retransmit a given TDU back to the network node from which it received the TDU.
- Each node and TG in a network topology database is assigned a unique resource sequence number (RSN). RSNs are incremented to the next even value whenever the owning network node creates a TDU for that resource. The RSN enables a network node that receives a TDU to determine whether the network node has or has not received that update earlier. This is the little-known mechanism for termination of broadcast TDUs.

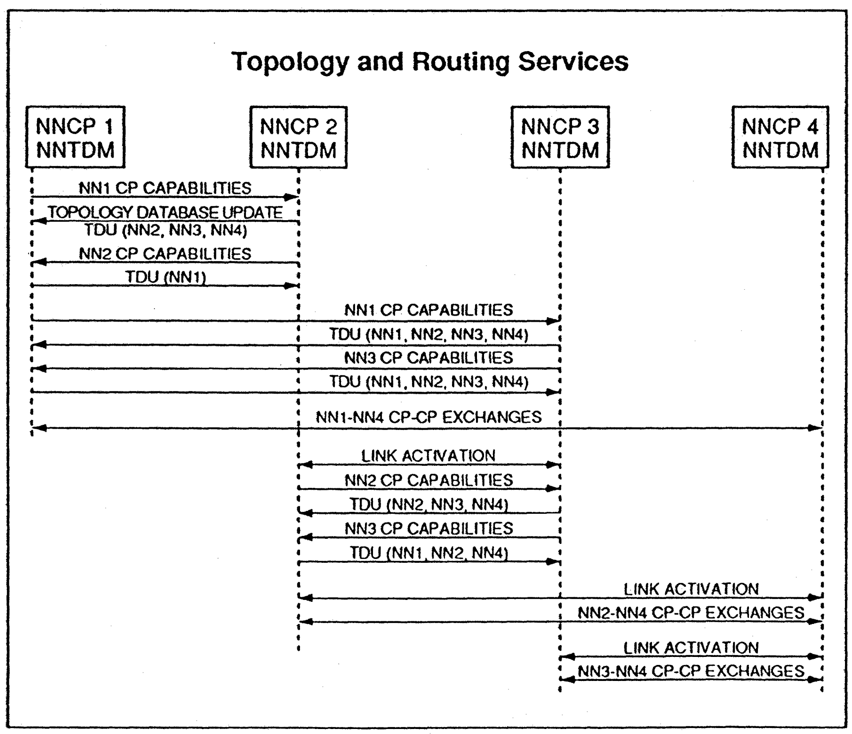


*Figure 7*

- Flow reduction sequence numbers (FRSNs) prevent retransmission of large topology databases following temporary link outages. Records are maintained at each network node of what data have been previously sent to each adjacent network node. If a link fails between network nodes, FRSNs are exchanged over the link on reactivation of CP-CP sessions and, thus, only new information is exchanged.

## Directory Services

Network nodes define a local directory database to maintain awareness of network resources and their location. Directory services maps network resource names to the CP names of their network node locations. Known resources may either be located in local nodes, adjacent nodes, or nonadjacent nodes.

### Directory Entries

From the perspective of a network node, all end nodes and their resources are incorporated in a directory. Directory entries can be system-defined, registered, or cached.

**System-defined directory entries.** APPN network resources may be defined by system-defined directory entries. These are created by node operators. (Refer to Figure 5 for an illustration of the relationship between node operators and the node.) Once a resource is locally entered, the network node server distributed search facilities can be used to locate it.

**Registered directory entries.** These are temporary entries in the local directory database of an APPN network node. Registered directory entries represent the local LUs of an APPN end node for which an adjacent APPN network node acts as a network node server.

**Cached directory entries.** These are resource locations retained by network nodes as a result of requests such as resource Locate requests. Two significant risks in caching are that it may result in unwieldy local database entry sizes and may include resource entries which are no longer current. A network node deletes cached entries for the end node resources for which it provides network node services upon deactivation of network node-to-end node CP-CP sessions.

### Searches

A logical concatenation of multiple network node directories occurs when CP-CP sessions are established between them. This generates a "virtual" or distributed directory database. In this case, each network node can first search for a resource in its local directory and, if not found, can use the "locate search request" to search the directory databases of all other network nodes in an APPN network.

Many users are under the mistaken impression that APPN nodes must always use a broadcast search to locate LUs in nonadjacent nodes. If that were true, the impact of such overhead on network performance would indeed be enormous. Although overhead in a dynamic APPN network can be higher that in a statically defined, traditional SNA network, it is not as bad as that. Actually, four types of resource searches are supported:

- LEN node locate search
- APPN end node locate search
- Broadcast search
- Directed search

**LEN node locate search.** Since LEN nodes do not support CP-CP sessions either between themselves or with an APPN network node, LEN node searches are restricted to a local directory database.

**APPN end node locate search.** This search request is in the form "Locate_Message." It initiates a local APPN end node directory search for the named resource. If the search is unsuccessful, the APPN end node directory services generates a "locate search request" which is forwarded to its network node server. If the network node server succeeds in locating the requested resource, it returns a "locate search reply" to the APPN end node.

**Broadcast search.** If, in the previous case, the network node server is unsuccessful is locating a resource requested by an APPN end node, directory services at the network node server forwards the "locate search request" to all adjacent network nodes. This is known as a broadcast search. Any downstream network node receiving this broadcast search request will further propagate it to all its downstream network nodes. It will not reply until it has received either a positive locate reply or negative responses from all the local nodes it serves.

**Directed search.** If a broadcast search is successful, the network node server that initiated that search locally caches the locations of the LUs involved in the sessions. Any future request for a session between that same LU pair results in a positive find in that server. That server then constructs a route selection control vector (RSCV) containing all the session path information and presents it back to the requesting node. The requesting node then sends a directed search request to verify the location of the destination LU. If the target LU is no longer at the cached destination, a negative result to the directed search request is returned and the requesting network node server initiates a broadcast search.

APPN searching can also be made more efficient by use of central directory servers. These are discussed in the first article under the section describing VTAM APPN support.

## Session Services

APPN session services are responsible for CP-CP sessions, LU-LU sessions, and for the generation of fully qualified procedure correlation identifiers (FQPCIDs) and local-form session identifiers (LFSIDs). Session services coordinate with configuration services and keep configuration services up to date with regard to sessions.

The session connector manager (SCM) interfaces with the LU session services component as well as the CP address space manager (ASM) to set up all the details necessary to construct an LU-LU session. To construct a session, SCM would:

- Negotiate the maximum request/response unit (RU) size allowed for the intermediate node
- Negotiate the type of session pacing and corresponding window sizes
- Construct a session connector instance with a corresponding FQPCID for the end-to-end, LU-to-LU session
- Calculate an LFSID used by the session on the incoming TG from the downstream node
- Calculate an LFSID to be used by the session on the outgoing TG to the upstream node

## Network Management

APPN network management components, issues, and concerns, were discussed in depth in the February issue of *SNA Perspective*. Aspects and issues of the March 1992 announcements are discussed in the first article in this issue.

## Conclusions

We reviewed APPN's predecessor LEN function and its current structure-as APPN end node and network node. We discussed components and functions of APPN node services. We provided several network design suggestions to improve performance by reducing TDU flows. We presented the specifics of how APPN selects optimal routes, which can assist the user in specifying appropriate route requirements. We clearly described the four types of APPN searches, so that the user can configure APPN nodes to take advantage of search efficiencies. The reader is now more familiar with APPN than most SNA users or even IBM staff and is also armed with practical suggestions for planning or enhancing an integrated SNA and APPN environment.

*by Thomas J. Routt* ■

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