SNA Perspective

Volume 12, Number 10
October, 1991
ISSN 0270-7284

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

Serial Tunnelling: Spoofing Your SNA Network

SNA networks become increasingly intertwined with other network types as users' multivendor networks are internetworked. This article discusses products and strategies from vendors of multiprotocol routers which are designed to operate in SNA networks—both traditional subarea and APPN.

Most vendors of multiprotocol routers have expressed their intention to accommodate SNA in their internetworking plans by providing a multi-stage roll-out of IBM connectivity products (see *SNA Perspective,* April 1991). The eventual goal of these companies seems to be to provide some level of native SNA routing support—APPN and subarea node types.

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IBM's Marathon Runner: The Communication Controller

SNA Perspective could make a loud splash by joining the chorus predicting the demise of the communication controller. But we won't because we don't believe it. The IBM 3745 communication controller certainly faces challenges from a wide range of products and protocols inside and outside of the company, including IBM's own 3172 Interconnect Controller. We do not believe it will be the omnibus communications node, but then no single product from any vendor will serve *all* needs. The communication controller is being adapted to continue to serve many data communications needs of SNA users, and the many 1991 announcements have given a clearer picture of its future.

This article reviews the evolving role of the communication controller, from supporting BSC, SDLC, switched lines, X.25 and LANs to multiprotocol routing and emerging WAN technologies such as frame relay and SMDS. We examine some of the challenges from multiprotocol internetworking products and discuss some tradeoffs in replacing communication controllers as internetworking nodes. TCP/IP and OSI support as well as APPN directions for the 3745 are reviewed. We will look at several types of 3745 connectivity and assess their role and importance in today's SNA networks.

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Multiprotocol Router Accommodation of SNA

Cisco Systems of Menlo Park, California unveiled a five-phase strategy for IBM connectivity in January. Proteon, Inc. of Westborough, Massachusetts announced in June a three-stage SNA strategy to accomplish SNA routing. Vitalink Communications of Fremont, California announced initial SNA products in September and detailed its strategy at that time for routing of SNA

Due to the extreme complexity of SNA routing and the unclear future path of SNA networking, most of these vendors are either planning or providing simple, short-term solutions to accommodate SNA. Multiprotocol router companies that have either announced or released products that support SNA traffic include Cisco Systems, CrossComm, Proteon, Vitalink, and Wellfleet.

All of these simpler short-term solutions address SNA at the data link level. Strictly speaking, SNA doesn't even specify the architecture of the data link layer—it merely assumes that a reliable, connection-oriented data transport mechanism exists beneath the path control layer. This decoupling of SNA from specific data links has resulted in the ability to transport SNA across a variety of media—serial lines using SDLC, token-passing networks using token ring, and contention networks using Ethernet. It is this characteristic that is being exploited by multiprotocol vendors.

Tunnelling of SNA Serial Traffic

The method many current vendors use to support SNA devices is a safe and relatively easy technique known as *serial tunnelling*, also commonly referred to as synchronous passthrough. Since the data link protocol that IBM uses on serial links is Synchronous Data Link Control (SDLC), this method is sometimes called SDLC tunnelling.

(The term *tunnelling* merely means that a complex network with all its own formats and protocols is treated as a simple channel for the delivery of data.)

Using serial tunnelling, any serial link that is used to connect two IBM systems together can be replaced by a pair of routers and their interconnection network. This method will typically be used to connect 37x5 communication controllers with remote, SDLC-attached 3x74 establishment controllers. But it can also be used for connecting intermediate 37x5 communication controller subarea nodes. These two placement points for SDLC links are shown in Figure 1.

The flexibility of serial tunnelling extends beyond the SNA subarea network shown in Figure 1. Because the serial tunnel is insensitive to the characteristics of the source and destination devices, serial tunnelling can also be used to connect the nodes of an Advanced Peer-to-Peer Networking (APPN) network.

Benefits of Serial Tunnelling

At first, it appears that this technique merely adds communication components to the network and therefore increases its complexity rather than simplifying it. After all, why would a customer want to replace an inexpensive pair of modems and a simple serial line with a pair of moderately expensive routers and their interconnection network? The answer lies in an examination of corporate networks after a decade of LAN integration.

Serial Tunnelling Options in SNA Subarea Networks

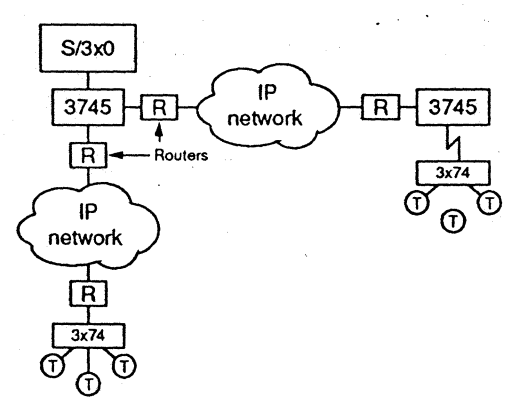

Figure 1

Many companies today connect their geographically dispersed LANs with multiprotocol bridges and routers while maintaining a separate SNA backbone network. This requires two distinct wide area connections—one for each network. Often, the interconnected LANs are in close proximity to the SNA nodes. In this case, the two separate remote links can be collapsed into a single wide area network connection by using a multiprotocol router that supports both LAN bridging/routing and SNA serial tunnelling. This consolidation of wide area links is shown in Figure 2. The situation depicted in that diagram is today's prime motivation for multiprotocol routers to provide some kind of support for SNA traffic.

Serial Tunnelling Mechanics

In the case where serial traffic is tunnelled through an IP network, the frames are encapsulated within IP packets. However, as mentioned above, SNA assumes that the underlying data link is connection-oriented and can deliver SNA data in a reliable manner. Since IP is an unreliable connectionless network protocol (e.g., it may discard packets during peak load conditions), using IP by itself will not suffice. By convention, transport protocols that use the underlying IP networking services provide the end-to-end reliability.

The most common transport level protocol used with IP networks is the Transmission Control Protocol (TCP). TCP is a reliable, stream-oriented transport service that maintains a virtual circuit across an IP network and guarantees an ordered delivery of TCP packets. As a result, SDLC transport across an IP network usually means that SDLC frames are actually carried inside TCP packets, which, in turn, are inside IP packets. This successive layering is shown in Figure 3.

The heart of the serial tunnelling support on multiprotocol routers is the operation of the specialized ports that act as the interface between the SNA devices and the internetwork. This pair of ports—one at each end of the serial tunnel—provide two major operations:

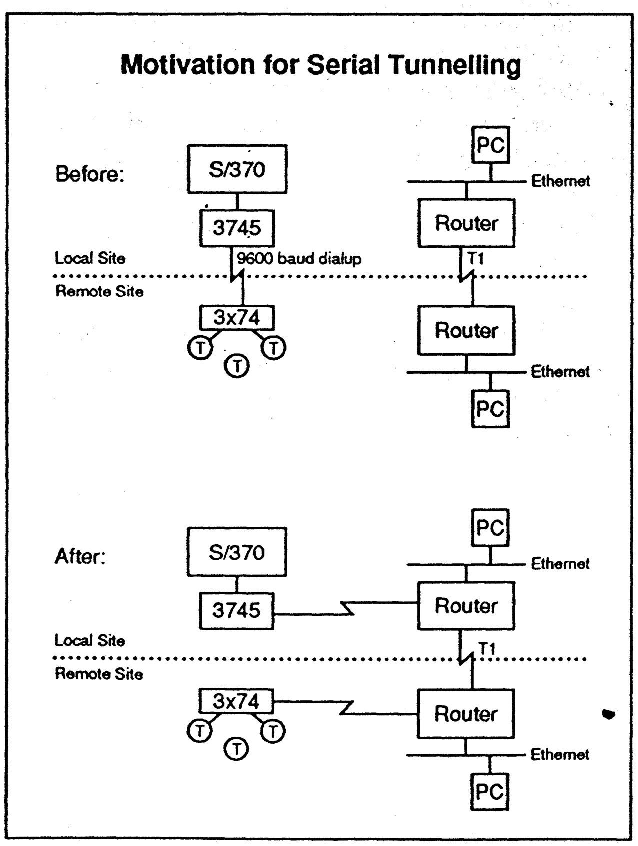

Figure 2

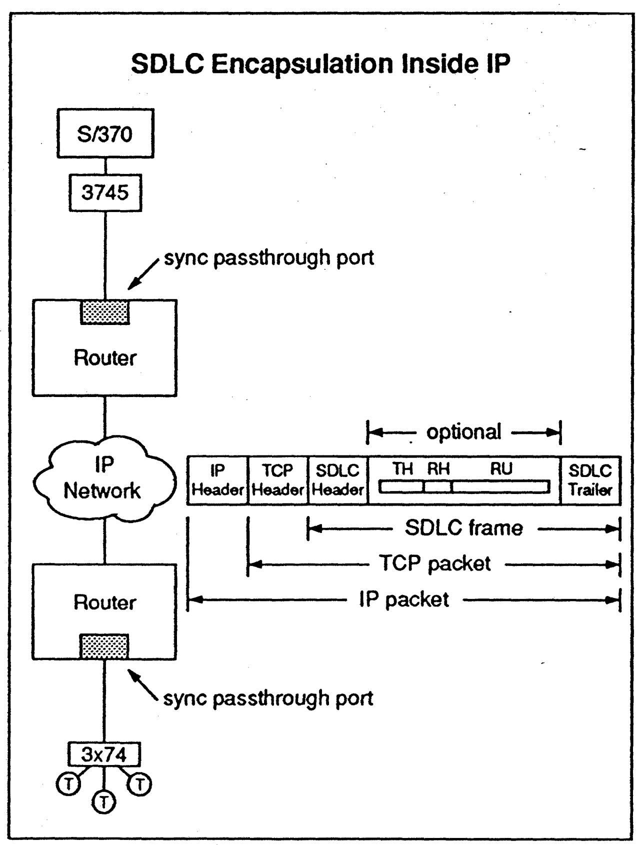

Figure 3

- Locally, they provide an interface into the tunnel for the SNA devices
- Remotely, they communicate with each other across the network in order to make the tunnel transparent to the devices at either end

The first operation is rather simple—the interface at the router must be able to both send and receive SDLC control and information frames. As noted above, these frames are then encapsulated in TCP/IP packets and sent across the network.

The second operation is where the multiprotocol vendors provide significant added value. How the tunnelled traffic is mapped onto the underlying internetworking services varies with each vendor. Mapping a virtual circuit–oriented architecture like SNA onto an internetworking architecture presents some interesting challenges and, depending upon the implementation, may or may not affect the SNA end user.

Tunnelling's Impact On the SNA End User

The IP network "cloud" in Figure 3 could be, in reality, a rather complex set of diverse paths across different types of media. This, together with the fact that the IP network architecture is totally connectionless and datagram-oriented, means that there is a completely nondeterministic delivery system beneath SNA.

SNA was designed with the assumption that a reliable, connection-oriented data link mechanism existed beneath the upper layers of the protocol, and that the SNA data link control layer provided tightly bounded, deterministic delivery of packets. This inherent assumption in the design of SNA is violated with the tunnelling of SDLC packets across IP networks. The effect of this mapping of services from one network architecture to another on the end user results, at best, in variable response time and, at worst, in session outage.

Variable response time is the curse of system administrators—being perhaps even more frustrating than consistently poor response time. With a virtual circuit architecture like SNA, placing higher performance media and components into an overloaded communications path between the end user and the mainframe will always result in quantifiably lower response time.

Obviously, adding higher performance media in an IP network improves the overall performance of that network. But, since the architecture permits the routing elements to discard packets when a node gets overloaded, there is effectively no way to guarantee elimination of the nondeterministic behavior of IP networks. In a large IP network with a potentially large end-to-end delay, this becomes a critical problem.

The primary SDLC link station (usually at the host end of the SDLC link) maintains an idle timer to ensure that the secondary SDLC link station (usually at the establishment controller end) responds to polls within an adequate amount of time. If the secondary link station does not respond quickly enough, the host assumes that the link has failed and initiates outage procedures for SNA sessions that were active on that SDLC link. Since there is no way for an IP network to guarantee the delivery of SDLC information frames before the idle timer expires, session loss across serial tunnels is a real possibility. As the size of the underlying IP network increases and/or the amount of traffic carried by the IP network increases, the SDLC idle timeout problem becomes even more acute.

There are ways around this problem. The NCP gen is quite flexible in the specification of values for the SDLC idle timeout. These timers are adjustable and can be increased to some maximum value that will never happen.

Serial Tunnelling Optimizations

Some of these misgivings about serial tunnelling across IP networks have been addressed by the vendors of multiprotocol routers. Perhaps the greatest win is a feature known as *poll spoofing*, sometimes called "remote polling" or "proxy polling."

Poll Spoofing

As mentioned above, there is an idle timer for each SDLC link in order to determine if the link connection has dropped. For a healthy SDLC link that is not actively transferring data, there are continuous *polls* from the primary SDLC link station and *poll acknowledgments* from the secondary. (These are sometimes referred to as "session keep-alive frames.") SDLC polls and poll acknowledgments are, in reality, two-byte SDLC Receiver Ready (RR) control frames. If these two-byte SDLC frames are encapsulated inside a TCP/IP packet with (at least) a 20-byte TCP header and a 20-byte IP header, this means that continuous 42-byte IP packets would traverse the IP network even when the SNA end stations do not have any data to transmit. As SNA traffic on the TCP/IP network increases, this could impact network performance.

The serial tunnelling products from some multi-protocol router vendors provide poll spoofing. As an example, Cisco's poll spoofing feature is called *proxy polling*. It terminates the SDLC polls at the router port and therefore takes the majority of the nonproductive SDLC traffic off the network. The Cisco router connected to the 3745 communication controller issues poll acknowledgments to the SDLC polls from the communication controller while the router that is connected to the establishment controller issues polls to the 3x74. Therefore, the SDLC session is kept alive at either end of the connection even though there is no traffic traversing the internetwork.

When either side receives actual SDLC data instead of a poll or poll acknowledgment, the routers then perform the encapsulation and route the packet through the network. The data is then presented to the SNA end device as if the data just became available from the partner device. While this technique greatly reduces the amount of internetwork traffic, it does increase the buffering requirements of the routers and makes for a more complicated software design. The mechanism of poll spoofing is shown in Figure 4.

There is a much larger benefit to poll spoofing than reducing the overhead traffic load in the internetwork. The host gen is no longer sensitive to the internetwork delays that could occur in the tunnel. Since the SDLC connection is kept alive at the directly attached router, the SNA end devices never see these internetwork delays.

Notice also in Figure 4 that poll spoofing requires two variants of the SDLC drivers in the routers. There is a secondary link station at the 3745 end of the tunnel and a primary link station at the 3x74 end of the tunnel. In traditional hierarchical SNA networking, this means that the upstream router is configured as a secondary SDLC link station while the downstream router is configured as a primary SDLC link station. This relationship always holds since the communication controller is always the primary link station.

Discovering Link Station Role

However, this rule is broken in APPN networks and will also be broken in SNA subarea networks once communication controllers acquire more peer-to-peer functionality than they have today. SNA peer-oriented communication requires the SDLC link

Serial Tunnelling with Poll Spoofing

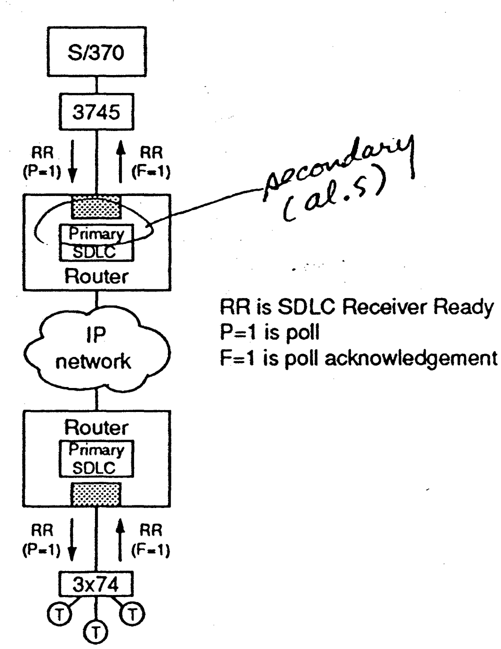

Figure 4

stations to negotiate their respective primary and secondary roles at link start-up time. This means that the router cannot know *a priori* which link station role it must assume in the poll spoofing dialogue with the real SNA device. Some mechanism must be implemented that lets the router determine which link station role it must assume. Cisco calls this process link station role *discovery* and states that it assists in flexible SDLC tunnelling.

Priority Assignment

A feature called *priority assignment,* to be included in Proteon's SDLC tunnelling product in 1992, will reduce the effect on the SNA end user of the nondeterminism of the intervening IP network. Its SDLC relay attempts to provide the same predictable response time by assigning a higher priority to SDLC traffic through the IP network. The feature that Cisco offers in its serial tunnelling product directed at this same goal is load balancing. If the SDLC traffic is being transported across an IP network, the routing protocol on the IP network may be able to do load balancing. This algorithm provides a method to select alternate paths through an IP network in order to obtain a more balanced traffic flow.

Another feature to reduce or eliminate the effects of an IP network is offered by some vendors with their serial tunnelling products. If the nondeterministic properties of an IP network are not acceptable to a particular SNA environment, then an alternate transport mechanism is provided. These serial tunnelling products permit the encapsulation of SDLC traffic inside HDLC information frames for transport across a point-to-point serial network. The encapsulation overhead can be very small—even four bytes—and the nondeterministic properties are reduced or eliminated. This configuration would allow SNA sites to upgrade their existing SNA wide area network services to use multiprotocol routers without the potential of adversely affecting the response time characteristics of the existing network.

Miscellaneous Serial Tunnelling Features

Vendors have included other miscellaneous features in their serial tunnelling products in order to add value to them. Some of the more interesting ones are:

Link Redundancy

Many bridge/routers provide a mechanism to configure multiple links between two routers that implement serial tunnelling. While only one link is used to transfer data between the routers, the routers can automatically switch to a backup path should the active link be lost.

Serial Tunnelling Feature by Vendor

Vendor/ Feature	Cisco Systems Serial Tunnel (STUN)	Wellfleet Sync Pass Thru	CrossComm SDLC Pass Through	Proteon SDLC Relay
Encapsulation Technique	IP or HDLC	HDLC	LLC Type 2	IP
Poll Spoofing	Yes	No	No	No
Redundant links	Yes	No	No	No
Serial products	SDLC, HDLC, any ISO 3309-compliant	SDLC, HDLC	SDLC, HDLC	SDLC
Arbitrary media	Yes	No	No	Yes
Load sharing	Yes	No	No	Yes
Priority assignment	Yes	No	No	Yes

Table 1

Support for non-SDLC Serial Traffic

Cisco, CrossComm, and Wellfleet all offer the serial tunnelling service to HDLC connections (for X.25 traffic) as well as to SDLC. Cisco provides a mechanism to define any ISO 3309-compliant link level protocol for tunnelling.

SDLC Link Station Address Transparency

Vendors try to make their serial tunnelling protocols insensitive to the actual SDLC station addresses. It is therefore possible to tunnel two different SDLC streams from devices with the same SDLC link station address through the network using a single pair of routers.

Table 1 summarizes the serial tunnelling offerings from the multiprotocol vendors who have either released or announced products. This table identifies various serial tunnelling features by vendor.

SDLC Bridging

An alternate to serial tunnelling, SDLC bridging is also a means of integrating SDLC devices into LAN-based internetworks. Unlike tunnelling, which uses SDLC on both host and device sides, SDLC bridges *convert* SNA traffic from SDLC to other data link layers such as the LLC format. This allows SDLC devices to communicate directly with a LAN-attached SNA communication controller, rather than through an SDLC communication controller interface.

Vitalink is the first internetworking vendor to provide SDLC bridging, which it announced in September. Other companies, including Cisco, Netlink, Sync Research, and Wellfleet have also announced this capability, and *SNA Perspective* expects that other internetworking vendors will add it too.

Summary

This article has discussed in detail the technology of SDLC tunnelling by multiprotocol vendors. SDLC tunnelling represents the first stage of products from the multiprotocol vendors to address the needs of SNA interoperability but will definitely not be the last. However, due to the complexity of routing SNA in a native manner, these serial tunnelling products will be around for several years.

While these products represent a rather simple form of SNA interoperability, they are sensitive to the underlying transport network characteristics. Some of those characteristics manifest themselves to SNA end users in ways they might not be accustomed to, such as variable response time and session loss.

Advantages of serial tunnelling are:

- Customers are able to take advantage of advances in multiprotocol router technology while maintaining their SNA networks
- The existence of a serial tunnel under SNA does not significantly affect most host gens
- Serial tunnelling is unaffected by changes in SNA

Disadvantages of serial tunnelling are:

- Without poll spoofing, SNA sessions are sensitive to data link timeouts resulting in loss of session
- If the serial tunnel is across a network with non-deterministic delivery properties, then the SNA end users are subject to variable response times

Some of the more advanced features vendors may offer with their serial tunnelling products are:

- Poll spoofing
- Priority transmission through IP networks
- Transport across any serial medium ■

NCR 56xx Series Communication Processors

NCR's SNA Business Unit (SBU) (formerly NCR Comten) has five different models of communication processors, together with software products for them. NCR has been in the SNA communications business for 20 years and has more than 3,500 communication processors installed.

The company's communication processors use its own NCR Comten Advanced Communications Function/Network Control Program (ACF/NCP) instead of (although it's compatible with) IBM's Network Control Program (NCP). Rather than merely follow in IBM's footsteps, this has allowed NCR to incorporate such innovations in its communication processor as Ethernet, TCP/IP and 1,024-line connectivity.

NCR has been highly focused on integrating open systems with SNA on a single communication processor in support of the trend away from vendor-proprietary architectures and toward open communication. The most recent result has been a second release of its TCP/IP protocol stack. OSI protocols are also under development, to be released when there is sufficient demand.

New Announcements

In October, NCR's SBU announced several new products—5630 communication processor family, Multiple Communications Adapter Module (MCAM), and NCR Comten TCP/IP Release 2.

The new 5630 family is discussed below. The MCAM supports LAN and WAN connectivity to the communication processor. It is an intelligent subsystem, I/O controller platform based on the 486 microprocessor, microchannel architecture, and SCSI technology. TCP/IP Release 2 will support enhanced host applications and network-based functions.

NCR Comten 56xx Models

NCR's Comten communication processors range from the new, low-end processor, the 5630, up to the high-end 5675-B, with three models in between.

The 5630, designed for the same market segment as the IBM 3745 1x0 series, has performance advantages over IBM. The 5630 can support up to 32 full-duplex lines, and direct connection of up to sixteen 16/4 token ring or Ethernet LANs. The customer can also choose up to two channels, two T1 interfaces, or one channel and one T1 interface. The 5630 prices start at $39,000.

The NCR Comten 5675-B supports up to sixteen channels, up to 1,024 full-duplex lines, up to 24 T1/E1 lines, and direct connection of up to 64 16/4 token ring or 48 Ethernet LANs.

One unique advantage of NCR Comten communication processors is that the CPUs for the low-end and intermediate processor models each offer three levels of CPU performance. This means that the LAN throughput on each of these NCR Comten models can be increased by swapping out the CPU on an installed communication processor. Since CPU performance can create a bottleneck when processing data from LANs, if they are being used at a high percentage of their considerable bandwidth, a customer can scale up an existing 56xx processor to the next higher processor. For example, a processor with a level 1 CPU can be upgraded to level 2 (the base CPU for the 5665) performance or to level 3, which is the CPU used in the high end 5675-B model. With IBM, to obtain a communication processor to handle a larger amount of LAN traffic, one would have to select from its high-end 410 or new 310 or 610 models. With the NCR Comten processors, the user does not need to buy a greater amount of connectivity connectivity just to support increased LAN traffic.

TCP/IP and X.25

NCR's TCP/IP enables communications between IBM mainframes and systems from other vendors. It also provides peer-to-peer communications for applications, file transfers, and electronic mail. Further, it offers a TCP/IP LAN gateway to WANs. NCR provides a broad range of host and terminal X.25 packet assemblers/disassemblers (PADs).

Multi-Vendor Networking Facility (MVNF)

Designed to enhance the function of 3270 terminals, MVNF provides end users with access to multiple 3270 host applications concurrently. The applications may reside in a wide variety of 3270 host environments, including SNA, pre-SNA, non-SNA (multivendor), and X.25.

For more information, contact: NCR Network Products Group, 2700 Snelling Avenue North, St. Paul, MN 55113, (612) 638-7391. ■

Amdahl 4745 Series Communication Processor

Amdahl has been in the IBM-compatible communications controller business for eleven years and has an installed base of over 1,200. Amdahl's first communication processor (formally called front-end processor) was the 4705, then the 4725 and, for the past few years, the 4745.

All Amdahl communication processor are IBM Network Control Program (NCP)-compatible, meaning they can run IBM software, while the NCR Comten products only support NCR Comten's NCP emulation software.

The 4745 is plug-compatible with IBM's 3745, except for varying connectivity and hardware features supported. Plug-compatible means that an IBM 3745 can be replaced by an Amdahl 4745 without making any changes to the IBM software, including the NCP or the physical network that connects to the communication processor. This allows for an easy transition from an IBM to an Amdahl product. Amdahl prices its products for a 15 percent cost/performance advantage over IBM.

The 4745 supports:

- Both NCP Versions 4 and 5 (the IBM 3745 does not support NCP Version 4, which runs on the 3725) which eases migration from 3725- to 3745-type architecture.
- Token ring LANs (4 Mbps currently, has committed to supply 16 Mbps).
- 8 Mbyte memory capacity.
- Automatic backup/recovery (Auto ISA) to enable one 4745 to assume the role of another 4745 in the event of a system failure.
- Interfacing with the IBM 37x5 communication controller products

On September 30, 1991, Amdahl began general delivery of three new features:

- A high-speed scanner that supports U.S. and European T1 data connections.
- A high-performance feature that improves CCU and channel adapter performance. Performance was increased through the use of static RAM for the main storage unit, and new LSI technology and bus and tag handling on the channel adapter. Throughput is increased between 30 and 80 percent depending on the networking environment.
- The expanded channel connectivity feature allows connectivity to additional hosts, up to four on the Model 110 and eight on the 210.

The 4745 is available in models 110 and 210. The 4745-110 supports up to four channels, up to 64 lines, one token ring adapter (TRA) with two 4Mbps token ring LAN connections, and up to two high-speed scanners with two active and two backup T1 lines. The 4745-110 can be upgraded to the larger 210 model. The 4745-210 supports up to eight channels, up to 256 lines, up to two TRAs with four 4Mbps token ring LAN connections, and up to four high-speed scanners with four active and four backup T1 lines. Amdahl expects to support NCP Version 6 soon after it is available.

For further information, contact: Amdahl Corporation, 1250 East Arques Avenue, Sunnyvale, CA 94088-3470, (408) 746-6000 ■

U.S. Installed Base
September 1991

IBM	15,081
NCR	1,389
Amdahl	424
Others*	3,397
Total U.S.	20,291

*Others include CCI, IDEA Courier, Lemcom, Nixdorf, AT&T Paradyne, Commex, and Memorex Telex.
Source: Computer Intelligence

Communication Controller Installed Base

Computer Intelligence of La Jolla, California, estimates that about twenty thousand IBM and IBM-compatible communication controllers are installed in the United States. These include some devices that are not, strictly speaking, IBM-compatible communication controllers, but serve a similar front-end processor function. These also include some older hard-wired devices and many before the advent of NCP.

SNA Perspective estimates that the U.S. population of these devices represents about half of the worldwide installed base, which yields a worldwide base of 40,000. The majority of NCR and Amdahl communication controllers are outside the U.S.

(continued from page 1)

Nomenclature

In this article, we will refer to the category of products represented by the IBM 3745 as communication controllers, which includes the older IBM 3705, 3720, and 3725 as well. When we talk about future developments, however, we mean the IBM 3745 and the oft-rumored 3765. IBM used to call this class of product front-end processors (FEPs) before their functionality was enhanced to support generalized routing. The companies that make compatible products, Amdahl and NCR Comten, refer to them as communication processors.

Traditional Data Circuits

Two of the primary functions of a communication controller, as shown in Figure 5, are

- Concentration: "concentrate" lower speed data lines to high-speed data lines
- Connectivity: connect a large number and variety of data circuit types

If the need for data circuit connectivity disappears because of LANs, will the need for communication controllers also disappear? We don't think so.

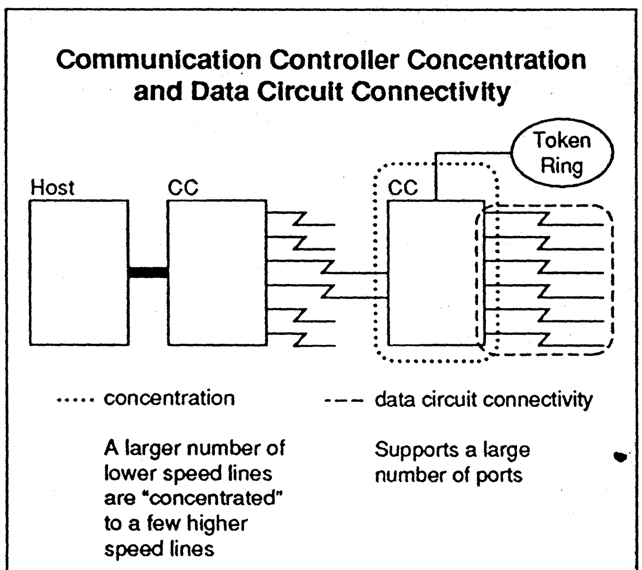

Figure 5

From the Demise of Multipoint...

Because of corporate acceptance of token ring LANs, the traditional nonswitched (leased line) multipoint SDLC data circuits are declining rapidly. Switched, nonswitched, and token ring interfaces are shown in Figure 6. Locations supported by multipoint SDLC data circuits are excellent candidates for conversation to token ring or even Ethernet.

Although SNA is not supported natively on Ethernet, a variety of gateways are available to provide SNA connectivity. If an existing SDLC establishment controller cannot accept a token ring adapter, products are now available that connect the controller to a token ring and enable the SDLC controller to access the host via token ring (see article in this issue on serial tunnelling, with SDLC Bridging on page 7).

This reduction in data circuits does reduce the requirement for data circuit connectivity to communication controllers.

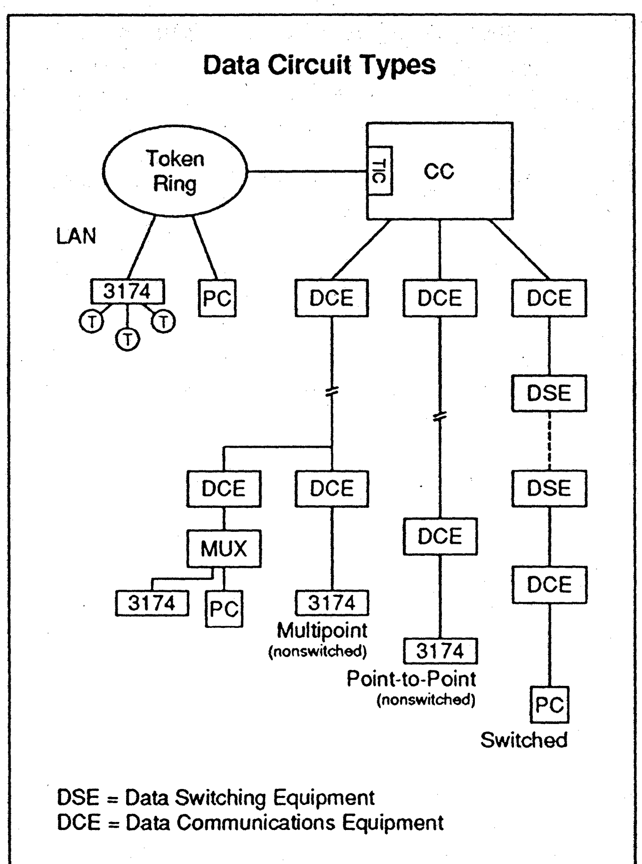

Figure 6

...and Continuance of Point-to-point...

What will continue to exist, although it is unclear to what extent, is nonswitched point-to-point SDLC. The need for this is found in locations with a single establishment controller or workstation beyond the reach of a LAN multistation access unit (MAU). Some SNA gateways are also designed specifically to allow users on a LAN to communicate with an SNA host using either SDLC or token ring. In some cases, particularly if the LAN is Ethernet, point-to-point SDLC is the better choice. (We emphasize point-to-point here because if the connectivity needs require multidrop lines, as described above, a token ring would usually be more advantageous, even if it were to exist in parallel with the Ethernet LAN.)

SDLC would be the more cost-effective choice: an SDLC card versus an MAU with a bridge or router. More importantly, network management is eased with the SDLC solution. Numbers of small SDLC segments are currently more effectively managed than multiple multiprotocol internetworked segments. Further, using SDLC, problems can be managed and corrected using either NetView or VTAM. Currently, only a rudimentary central management facility exists for token ring LANs using NetBIOS. (For more details on LAN management see "Taming the Wild LAN: Systems Management," *SNA Perspective*, February 1991.)

Several companies offer multiprotocol routers that can transmit SDLC, as described in the companion article in this issue. This functionality enables a remote SDLC controller to be connected to a router at the remote site while the router at the local site is connected to a communication controller. This displaces the leased line previously used between the remote SDLC device and the communication controller by using the TCP/IP backbone. Only point-to-point SDLC is currently supported on these products. Several vendors also plan to improve SDLC support by incorporating a serial/token ring gateway—converting the SDLC traffic into LLC frames and passing it to the host using token ring. Rather than being limited to requiring a communication controller to access the host from the LAN, they allow the use of any token ring interface to the host, including a 3172. An apparently logical, albeit large, next step would be for a multiprotocol router to emulate a local 3174 and communicate directly with VTAM via an IBM channel. But channel technology doesn't come easily and *SNA Perspective* expects that these router vendors would develop such capability jointly with companies with existing channel experience, such as Network Systems Corporation and McDATA.

...to the Brighter Future of Switched

Not only will switched SDLC continue to exist, but it, X.25, and dial-up asynchronous will grow to support small offices that do not require a leased line—single proprietorships and the emerging telecommuter segment. The total number of American working at home either full- or part-time increased 22 percent to 33 million in 1990.

Thanks to developments in modem technology and improvements in phone line quality, the days of slow response times and link dropping are over. Now with high-speed dialup modems, users can communicate at data rates up to 38.4 kbps with confidence that the link will remain up because of sophisticated error correction. In addition to public data networks (PDNs) or value-added networks (VANs) based on

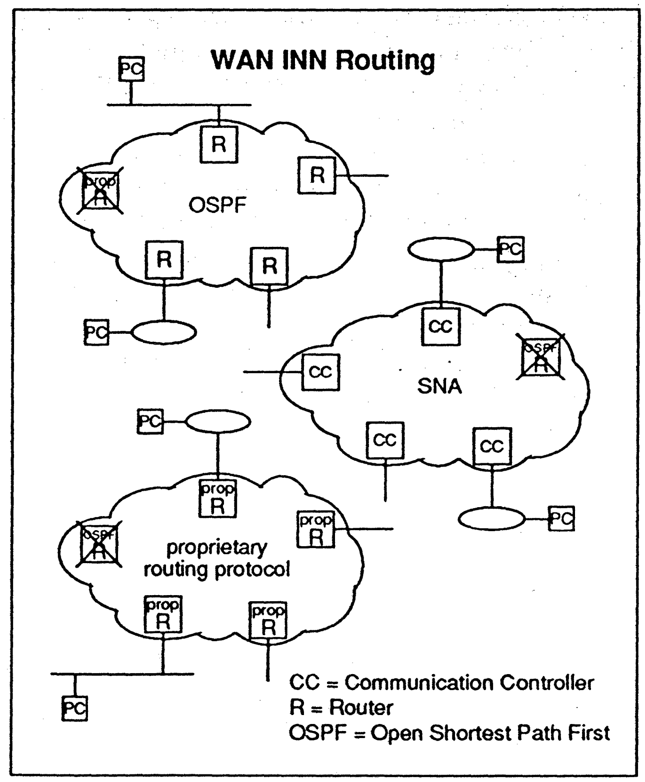

Figure 7

X.25, an SNA PDN, the Information Network, is offered by IBM and is available for networking SNA in native mode over a large geographical area. Figure 7 (page 11) shows how different routing networks, including SNA, can exist within a network "cloud," regardless of the protocols being routed within the cloud. These networks can support a variety of protocols externally, though only those for which they have the capability to map into or envelop in the routing protocols that are used inside the cloud. For example, IBM's communication controllers can now transport OSI (now) and TCP/IP (September 1992) traffic across an SNA backbone.

Remote communication controllers can reduce the cost of remote dial-in. For example, a user may install a remote communication controller in a region with sufficient dial-in traffic from several locations in that region but which is located a significant distance from the data center. Then, using a leased line or WAN from the remote communication controllers back to the data center, dial-up or WAN charges of the individual users can be substantially reduced.

BSC Today

Binary synchronous communications (BSC or bisync) is an outdated technology, superseded when SNA was introduced in 1974. We might expect it would have disappeared, but a surprisingly large amount of IBM-related data communications traffic is still BSC. Our discussions with users indicate that an average of 20 percent of all mainframe communication lines today are BSC. This is backed by findings from Computer Intelligence of La Jolla, California, on the penetration of SNA in the United States. A 1990 report showed that VTAM was used at only 73 percent of all IBM and plug-compatible mainframe sites and also reported that nearly 70 percent of sites still use BSC. The presence of BSC is only slightly lower in Fortune 1000 companies. However, this report covers only the United States; the presence of BSC is significantly lower outside the United States, since most of these mainframe networks postdate the 1974 introduction of SNA.

In most cases, the BSC equipment or BSC emulators were chosen, remain, and are sometimes still chosen today purely for cost reasons, usually in spite of the data center's recommendation of SNA technology. Communication controllers support BSC, but few vendors with multiprotocol products adding SNA support plan to support BSC. BSC equipment or the BSC emulation package would need to be replaced should the communication controller supporting them be replaced by a multiprotocol network. Replacing BSC with SDLC, or especially with token ring products with an associated LAN, would be very undesirable to these users from a cost standpoint.

Other Circuit Types

X.25 and Frame Relay

IBM has long provided extensive X.25 support on its communication controllers. In Europe, due to the proliferation of X.25 by the telephone companies, X.25 is extensively used and is expected to continue to grow significantly in the future. Demand for X.25 connectivity in communication controllers for Europe will remain strong.

In the United States, the use of X.25 has been growing, though it has not become as widespread as it is in Europe. However, this growth is expected to slow and eventually decrease because of frame relay, SMDS, and other new WAN technologies (see "Extended LAN Technologies," *SNA Perspective* March 1991).

Many X.25 vendors have switched development of products from X.25 to frame relay. X.25 is not an efficient backbone technology, with its relatively slow data rates of 56–64 Kbps and antiquated excessive error checking. Frame relay offers as much as a six-to-one cost/performance advantage over X.25. The availability of frame relay networks will have a profound affect on LAN-to-WAN interconnections and on communication controller routing now that NCP 6.0 will support frame relay. X.25 will still be less expensive than these newer protocols for applications, such as terminal-to-host applications, that do not require this higher performance. This use, and links to international sites, will compensate to some extent for the shift in routing traffic to newer WAN technology networks. Like BSC, X.25 will continue to be heavily used for many years.

Token Ring

The communication controller has for some time provided a token ring gateway to the host. Each subsequent release of NCP has offered more support, particularly in the form of additional options and flexibility in the area of backup and recovery from the failure of a token ring interface coupler (TIC) on a communication controller or the associated MAU connection. Advantages of token ring over SDLC include efficiency/speed, reliability, lower cost, IBM commitment, and protocol independence. A token ring LAN can transmit not only NetBIOS and SNA but other protocols such as OSI.

One drawback of the communication controller (and many other routers, for that matter) was its inability to route NetBIOS from one LAN over the SNA backbone to another LAN. This was remedied by a kludge solution, called the IBM LAN to LAN Wide Area Network Program, that runs under OS/2 EE on a PS/2 or PC. NetBIOS can be routed between two LANs (token ring or Ethernet) that are both running this program. The NetBIOS traffic is encapsulated in LU 6.2 and can travel over LAN, SDLC, or X.25. Though this program provides an important functionality, performance is an issue.

Need for Low-End Models

The advantages of remote communication controllers for concentration still apply today, although the data circuit connectivity requirement is less. This creates a market for lower end (and lower cost) models. IBM has addressed this need with the 1x0 model series of the IBM 3745; so has NCR Comten, another communication controller vendor. Companies such as Brixton Systems have also started to get into this market with partial node type 4 support (see the article "Brixton Systems and Node Type 4 Routing Emulation," *SNA Perspective* August 1991).

SNA Perspective believes this trend toward a wider range of communication controller models will continue, with the cost/connectivity differences between the lower and upper end models continuing to increase. Larger, higher performance models with increased connectivity will be used locally as front ends to mainframes, with a reduction in the number of communication controllers used. Consolidation of communication controllers will streamline the network and reduce the amount of time and the expense of maintaining the network.

Smaller, lower cost models will be used as remote concentrators/SNA routers. These will not be like the small models of the past, however. They will have increased LAN connectivity and protocol support, enhanced WAN connectivity, and sufficient performance to process both.

SNA on Internetworks

Internetworking of SNA is catching on. The important questions for users are: how fast and to what extent?

The advantages of interconnecting SNA and other networks include

- Eliminating link redundancy
- Lowered equipment costs
- Transport efficiency
- Peer networking (new devices do not need to be defined in an SNA gen)

See the "Internetworking and SNA" series, *SNA Perspective* December 1990 and January, March, and July 1991. There are a number of factors to consider when comparing multiprotocol internetworking with SNA routing using communication controllers:

- Reliability
- Support
- Bandwidth efficiency

Reliability

A primary concern is reliability. A communication controller (node type 4 or PU 4) is extremely reliable at routing SNA traffic because of its ability to use virtual routes. When considering the use of a multiprotocol internet for SNA traffic, users must determine how reliable the equipment and routing method is, compared to using communication controllers. If it is less reliable, is it reliable enough for the traffic moving over it? The internet protocol (IP), for example, discards a packet if it cannot be routed. (See the accompanying article in this issue for a discussion of how this problem is handled in multiprotocol routers with SNA support.)

Support

Second, what level of support does the vendor provide in the event of hardware and software problems? Is the service good enough to support mission-critical operations? Can this vendor provide for all the user's internetworking needs now and in the future, or will the user need to buy products and support from a number of different vendors?

Efficiency

Another factor is long-term WAN efficiency. There is a significant difference between the amount of bandwidth required for connectionless and connection-oriented protocols.

Connectionless Disadvantage—A connectionless protocol, such as TCP/IP's internet protocol (IP), requires two or more times the bandwidth of SNA, a connection-oriented protocol. Purchasing the extra bandwidth required for IP is expensive, more so in Europe and the Pacific Rim than in the United States. When analyzing the costs of operating a network over five years, approximately 85 percent is the cost of the bandwidth. In spite of the higher initial equipment costs above multiprotocol routers, an SNA com-munication controller backbone network can be significantly less expensive to operate over the life of the equipment.

Connection-Oriented Disadvantage—There are also, of course, disadvantages to a connection-oriented routing protocol. In SNA, in particular, one significant challenge is having to define the entire network in sysgens or NCP gens. One area of possible improvement for SNA traffic is to inter-network at layer 2 (bridging) instead of a higher layer (routing). IBM has been working to make the SNA environment more dynamic and easier to configure, although these advances appear to users to be painfully slow. One major step in this direction will be APPN support on VTAM and NCP, but this is not expected until early 1993 at the earliest and which, in addition, will not address existing subarea networks.

In addition to protocol differences, each different internetworking product transports the same data using the same protocol with varying WAN efficiency. Premium, sophisticated internet equipment will keep WAN expenses to a minimum. *SNA Perspective* cannot overemphasize the importance of product research and evaluation in selecting products for such key elements of a network.

Implementing Internetworking

Network managers and indeed the entire operational staff of an SNA network have a great deal of training and experience in NCP, SDLC, and SNA networking. Before a move is made to internetwork a user's SNA and non-SNA networks, such staff should be trained and gain some experience in internetworking.

SNA Perspective believes the best approach to migrating to internetworks is a stepwise progression. Users would train the required staff and implement a few internetworking connections between LANs running noncritical operations to help them gain

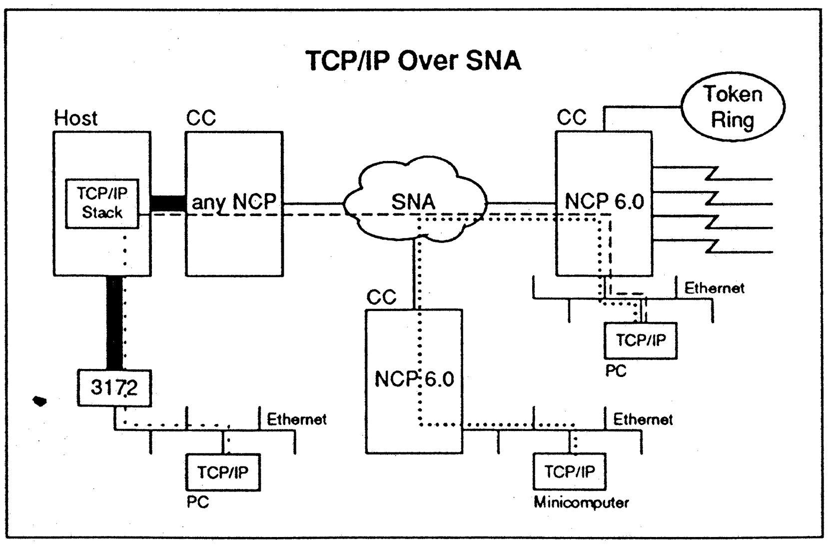

Figure 8

experience. A major challenge will be deciding on the method for network management over the internetwork. It will take years for large users to develop experience and confidence in internetworking before mission-critical operations are converted.

The Future of the Communication Controller

TCP/IP

IBM has been increasing its focus on TCP/IP, stating in June 1991 that it no longer considers TCP/IP to be an interim protocol. (Some recent evidence of this increased focus is its support of an integral Ethernet interface in the 3745 and the ability of NCP to transport TCP/IP across an SNA backbone.) This is good news for IBM customers. It demonstrates that IBM is being more responsive to market demands and eases communication between IBM products and products from other vendors.

NCR Comten's communication processors already support both token ring and Ethernet, as well as TCP/IP (see the sidebar on the recent NCR Comten announcements). Over 20 percent of NCR's communication processors are shipped with TCP/IP support. Amdahl, the other IBM-compatible communication controller supplier, has not announced plans regarding support of TCP/IP on its products (see the sidebar on Amdahl communication processors).

IBM's implementation of TCP/IP is similar to its implementation of X.25 with XI. The IBM 3745 will be a TCP/IP entry point to an SNA network and the TCP/IP traffic will be encapsulated in SNA for routing across the SNA backbone. Even though TCP/IP is a routable protocol, IBM will not implement IP natively on the communication controller, pointing to the inefficiency of routing IP as compared to SNA. See Figure 8 (page 14) on TCP/IP options from a mainframe with a TCP/IP protocol stack.

OSI

OSI was IBM's original plan for providing routable protocol support. However, even its own OSI/CS does not support OSI traffic on SNA. Figure 9 illustrates how IBM's OSI remote programming interface (RPI) can support OSI traffic across an SNA network by encapsulating the output from an OSI application in LU 6.2 packets, sending them to a system with a full OSI stack, which can then send OSI packets out to an OSI (not SNA) network, either through the 3745 or the 3172.

WANs

Now that IBM has decided on frame relay as the 3745's high-speed WAN transport combined with the higher performance communication control unit (CCU) in models 310 and 610, the stage is set for the IBM 3745 to support higher speed interfaces. IBM has indicated that T3, FDDI, and ISDN will be supported on the 3745. See Figure 10 (page 16) for an illustration of the variety of options available from or announced by IBM for WAN communications from the 3745. The *Architect's Corner* column in this issue for a further discussion of the 3745's protocol connectivity.

In addition to frame relay and the higher performance CCU, IBM has announced its intent to support the ESCON channel on the 3745, with a product announcement expected in 1992.

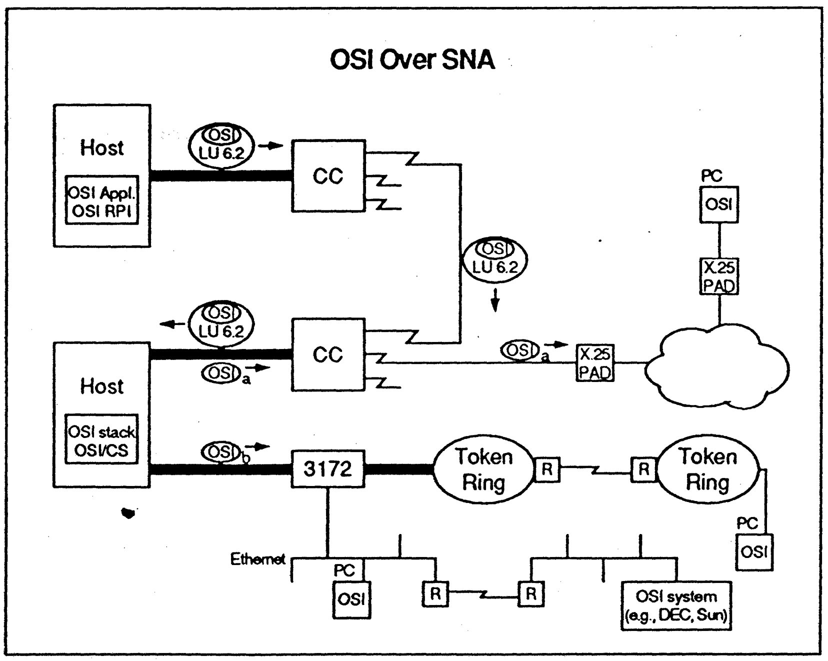

Figure 9

When it sees s sufficient justification, IBM could add other higher speed interfaces such as FDDI and T3 to the 3745. *SNA Perspective* expects FDDI will be the successor to token ring for intermediate network node (INN) connections between communication controllers.

Because of their bandwidth, *SNA Perspective* believes that IBM considers SONET (Synchronous Optical Network) and OC-3 (Optical Carrier-3) as better suited to multiprotocol routing, not just one protocol such as SNA on the IBM 3745, so we do not expect these interfaces to be supported.

IBM continues to state that the 3745 has untapped potential and will be its communication processor platform well into the 1990s. IBM has been concentrating on improving the throughput performance of the 3745 and reducing the cost of switching packets. *SNA Perspective* believes the company will move to enhance NCP performance by introducing more parallel processing and off-loading routine tasks to the LAN and scanner interfaces.

APPC

In its March 1991 announcement of APPN support for MVS and VM, IBM committed to supplying APPN support for VTAM and NCP by March of 1993. IBM has also stated that APPN support for these operating systems will require only VTAM and NCP to be upgraded. CICS, TSO, CMS, application interfaces, LU 2, and 3270 will be unaffected.

SNA Perspective believes that, though this capability is unannounced, either NCP version 6.0 will support APPN by the time it is released in September 1992 or perhaps with NCP version 6.1 in early 1993. Last month's *SNA Perspective* article, "The SNA Subarea Under Siege," addresses the evolution to APPN from subarea networking.

Summary

If SNA was ever simple, those simpler days of SNA networking have passed. Now a plethora of options for networking are available. This is good, but not necessarily easy.

Several factors influence the decision to either stay with communication controllers as routing nodes, integrate them with internetworking routers, or replace them at remote sites in favor of LAN and internetworking schemes. These are:

- staff training and expertise
- hardware life cycles
- cost (taking all factors into account)
- corporate strategy

Looking back at the history of IBM data communications, development has always been evolutionary. IBM attempted, unsuccessfully, to enact a

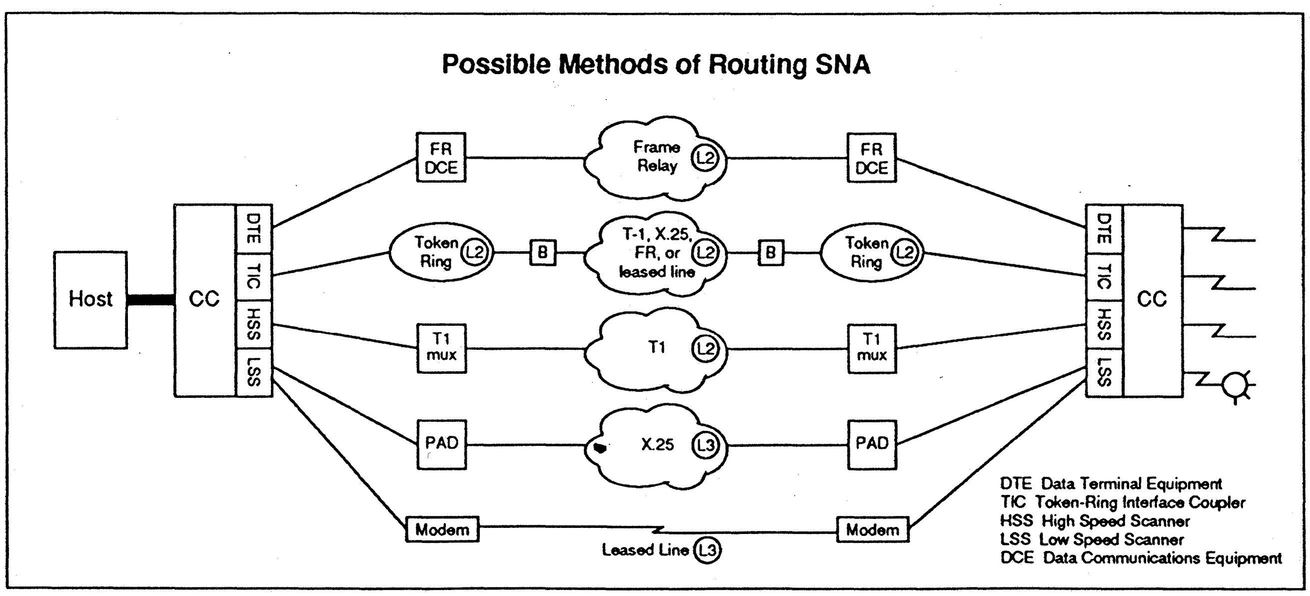

Figure 10

revolution by not supporting BSC after introducing SNA. Future development of SNA will certainly be evolutionary too.

Multiprotocol products, including some from IBM, will gradually displace certain traditional SNA circuits until an appropriate balance is reached. We believe that SDLC will continue to complement token ring as a point-to-point solution.

Communication controller manufacturers will respond to market demands by offering new features that add value to their products. This same passage of time will also give the internetworking equipment vendors the opportunity to enhance their products.

The future of communication controllers in local sites as front ends to mainframes looks strong. However, as a LAN gateway, it is challenged by many products.

These challengers include non-IBM and IBM products, such as the IBM 3172 and future channel-attached IBM RS/6000. Communication controllers at remote sites, a significant 40 percent of the communication controller market, are in the center of the internet millistorm.

There is no doubt that the remote communication controllers and internetworks will coexist—with users being the beneficiaries of open communications to IBM and non-IBM host or peer systems and increased speed and efficiency. To what degree the remote communication controllers coexist will depend on how well they are adapted to the changing market segment and their total cost compared to other internetworking solutions. ■

Routing SNA

SNA is referred to, in the internetworking world, as a nonroutable protocol. This is because SNA does not provide an open interface except on top of layer 2 (for the data link layer) and at the presentation layer (SNA's function management layer) for LU sessions.

The SNA and OSI layers are somewhat, but not precisely, comparable. First, the division of functions between architectural layers is not the same. Second, the extent of functionality in each layer is different. For example, SNA was designed with the assumption of an unreliable underlying physical network and provides an extremely reliable data link layer. In contrast, TCP/IP tolerates a less reliable data link layer, and performs more error detection and correction at layers 3 and 4.

Further, traditional SNA was designed as a hierarchical system to support very large data environments, so SNA routing depends on extensive routing tables and link schedulers. The Network Control Program (NCP) code (which implements the SNA node type 4) in a 37x5 communication controller takes some three million lines of assembler code. In comparison, a Cisco router which supports fifteen different protocols—including OSI, TCP/IP, Novell's IPX, Apollo Domain, AppleTalk 1 and 2, DECnet Phase IV and V, Banyan Vines, 3Com 3+, X.25, DDN X.25, and XNS—contains approximately a quarter million lines of C code. Lines of C code cannot be compared directly to assembler code, an approximate ratio might be five lines of assembler to one line of C. But that still translates into only 1.25 million lines of assembler code for the entire Cisco protocol suite.

Certainly, not all of the NCP code would be necessary to provide basic routing functions on a multiprotocol router, since some of the NCP code is used for front-ending a mainframe and would not be needed in a multiprotocol router that is providing only SNA routing functions. However, it would still be extensive. For example, the Brixton BRX PU4 emulation code, which emulates basic SNA routing, was created in about one-third of a million lines of C, or the equivalent of over 1.5 million lines of assembler code just for SNA routing. ■

Architect's Corner

Front End Developments: IBM's "Edge City" Syndrome

by Dr. John R. Pickens

In an interview on National Public Radio in September, Washington Post staff writer Joel Garreau explores a modern phenomenon brought about by a combination of technology and necessity. His theory is that a revolution in workplace habits has been wrought by technology—personal computers, fax machines, and transportation technology. The city dwellers of the past have moved their workplaces closer to home in sprawling suburban centers, which he terms "edge cities." Effectively, the job has been moved closer to the workforce.

I believe a similar phenomenon is beginning to unfold in the IBM world of mainframes (urban center) and distributed systems, personal computers, and the like, but I won't repeat that here. Rather, I'll focus on recent architectural developments in mainframe access (the transportation network into the urban center), and its potential impact on fostering the networking equivalent of "edge cities."

How Many Roads? Thousands

How many roads lead to the mainframe? If you stop and think about it for a while, I think you'll be surprised.

In the 1960s, 1970s, and early 1980s, virtually all enterprise computing was focused on the mainframe. Access to the computing resource was through dumb terminals or software in personal computers that emulated dumb terminals. It is no coincidence that, in this early period, very few roads led to the mainframe. There was one WAN link type—RS-232. Two WAN link protocols—BSC and then SDLC. Beyond the data link, only one transport protocol—SNA. And a virtual dominance of 3270 establishment controllers utilizing these primitive data highways to carry dumb terminal traffic to the mainframe.

So what has changed?

First, an observation. I never cease to be amazed by the rate of change in LAN/WAN connectivity alternatives. Considering IBM alone, it seems that at just about the point that the industry begins to understand IBM's LAN/WAN/terminal attachment options for mainframes, IBM unveils yet another attachment strategy and set of attachment options. In fact, the picture has gotten sufficiently complex and jumbled that one of my motivations for this article was to try to put it back in order.

So how many roads would you guess lead to the mainframe? Five? Ten? Fifty? Would you believe a thousand?

It is important to note that, as in any public transportation system, there are highways, feeder roads, and back roads to consider in constructing the answer.

Mainframe Highways

How many highways lead to the mainframe? I count ten. The key is determining what to count (see Figure 11, page 19).

- SNA, OSI, and TCP through the 3745
- SNA through the 3174
- SNA, OSI, and TCP through the 3172
- SNA, OSI, and TCP through the RS/6000

I justify counting both the protocol and the hardware on the basis that each protocol family branches out into a separate mesh network of feeder and back-road networks.

Channel-Attached RS/6000?

What is new in this picture is the RS/6000. With IBM's September 1991 announcement cornucopia, an attachment strategy was announced that would allow for channel-attached RS/6000 systems. Why would IBM add yet another front end to the picture? Internetworking coverage.

IBM has publicly discussed its plans for a multiprotocol router based on the RS/6000. When this happens, then direct channel attachment to the mainframe makes sense. Even if it doesn't, a general-purpose minicomputer may not make the best platform for concentrating dumb ASCII terminal and for providing a portal into the world of Unix, AIX, and OSF/DCE computing systems. Another possibility for the RS/6000 would be to take a more active role in OSI-based and SNMP-based network management. Further, because of its applications processing power, the RS/6000 becomes an edge city edifice in its own right.

I'd like to conclude this analysis by looking at the next layer of feeder roads which branch out from the main highways (see Figure 12). How many feeder roads are there, counting once for each protocol family? I count 32.

- From the 3745:

  SDLC (1), X.25 (3), Token-Ring (3), Ethernet (3), T1 (3), Frame Relay (3)

- From the 3174:

  Token ring (1)

- From the 3172:

  Ethernet (3), Token ring (3), FDDI (3)

- From the RS/6000:

  Ethernet (3), Token ring (3)

Fanout Exponentially

How do I get to thousands? Simple. In the next layer of fanout, there are an exponentially increasing set of alternatives for connection: subarea nodes, APPN nodes, bridges, routers, internets...

Note that some of the paths I've counted are not yet shipping, e.g., 3745 Frame Relay. There are other paths that I have not counted, e.g., personal computers with DFT-based coax attachments to 3174 establishment controllers, integrated mainframe token ring and WAN adapters, and X.21 and ISDN network connections.

But the sense of the analysis should be clear. Today, many paths lead to IBM's urban center—the mainframe. By analogy, the transport network is in place for the construction of the next layer in the computing architecture—client/server systems, personal computers, workstations—the edge city. ■

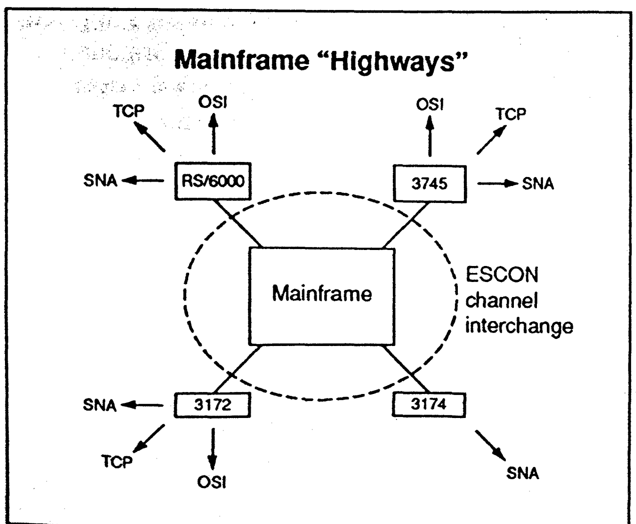

Figure 11

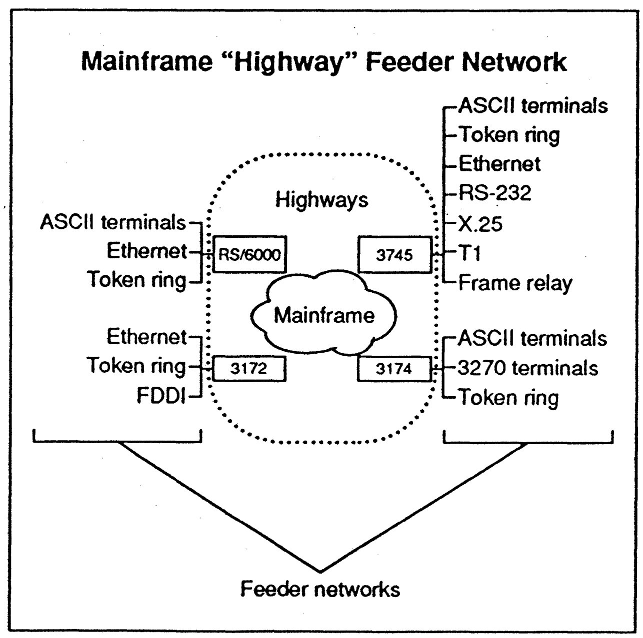

Figure 12

IBM Announcements

The September Avalanche

IBM continued its tradition of a large rollout of announcements in September. *SNA Perspective* found few highly significant products in the September announcements. Rather, IBM used a shotgun approach across mainframes, DASD, networking, management, client/server, and applications development, taking moderate and expected steps in all areas. *SNA Perspective* expects more networking announcements in October.

A Database Framework

IBM unveiled the Information Warehouse, a framework (along the lines of its SAA framework), for access to data in a distributed environment.

Remote-unit-of-work (RUOW) distributed database management functions will be supported between DB/2, SQL/DS, OS/400 database manager, and OS/2 database manager (as client). This support is based on IBM's Distributed Relational Database Architecture (DRDA).

NCP 6.0

The primary new features announced were support for frame relay and Ethernet. Other features include session transmission priority and new virtual route alert notification. This seems on the surface not to warrant a new version but rather only a new release. *SNA Perspective* expects IBM to add features to NCP 6.0 before its release in September 1992.

TCP/IP

TCP/IP was added to NCP, allowing TCP/IP support from Ethernet through the 3745 either across the SNA backbone or into a host with TCP/IP. TCP/IP for OS/2 and DOS were enhanced. The OS/2 product now supports X-Server and X.25 access. TCP/IP for DOS now supports NFS client and can operate under Windows 3.0.

NetView

NetView Version 2 Release 2 includes two new transport implementations of the previously announced LU 6.2 support: Management Services Transport (MS) for conversations of short duration and High Performance Transport (HP) for transfer of bulk systems management data. This new release also includes several automation features.

NetView Version 2 Release 3 will include an enhanced graphic monitor facility, which will manage IBM and non-IBM devices from one OS/2 workstation, and the Resource Object Data Manager, which provides object-oriented services.

Hosts as NetWare Servers

LAN Resource Extension and Services/MVS (LANRES/MVS) and LANRES/VM are mainframe-based server products to support NetWare clients. This product was previously available for VM as an RPQ product.

SystemView Data Model

IBM announced the availability of the data model for SystemView. However, though it is consistent with emerging OSI management standards, it is still incompatible with IBM's AD/Cycle information model in the Respository Manager/MVS. IBM sources say this is being addressed internally, which *SNA Perspective* views as a political battle which has been going on since SystemView's announcement a year ago. ■

 • Subscription rates: U.S. - one year $350, two years $520. International - one year $385, two years $590 • *SNA Perspective* is published monthly by CSI, 2071 Hamilton Avenue, San Jose, CA 95125 • Telephone (408) 371-5790 • Fax (408) 371-5779 • Managing Editor: Louise Herndon Wells • Associate Editors: Vincent Busam, Alan Kucharski, Basil Treppa • Circulation Coordinator: Cheryl Roberts • Contributors: Wayne Clark, Alan Kucharski, Dr. John R. Pickens • Typesetting and illustration: Aaron Lyon at dSIGN • The information and opinions within are based on the best information available, but completeness and accuracy cannot be guaranteed.