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**LOCAL AREA NETWORKS
CONCEPTS AND PRODUCTS**

GG24-3178-01

**International Technical Support Center
Local Area Network Library
Local Area Networks
Concepts and Products**

Document Number GG24-3178-1

April, 1989

International Technical Support Center
Raleigh, North Carolina

Second Edition (April)

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Abstract

This document is designed to provide an introduction to the different types of IBM local area networks (LANs), and a positioning of their product capabilities. It serves as a basis for other LAN documents which provide additional technical information and complements the reference material available with the specific products.

The document is intended for customers, IBM System Engineers and Marketing Representatives working in the LAN environment. In particular, this document looks at the IBM PC Network (Baseband and Broadband) and the IBM Token-Ring Network.

No prior knowledge of local area networks is assumed. However, an awareness of evolving trends in workstation and computer applications will assist the user in understanding the technical capabilities and issues presented.

Related Publications.

Related Publications

- *IBM Token-Ring Network Architecture Reference* SC30-3374
- *SNA Technical Overview* SC30-3073
- *IBM LAN Administrator's Guide* GA27-3748
- *IBM Cabling System Planning and Installation Guide* GA27-3361
- *IBM Cabling System Technical Interface Specification* GA27-3773
- *IBM Token-Ring Network Installation Guide* GA27-3678
- *IBM Token-Ring Network Introduction and Planning Guide* GA27-3677
- *IBM Token-Ring Network Telephone Twisted-Pair Media Guide* GA27-3714
- *IBM Token-Ring Network Telephone Twisted-Pair Media Guide EMEA version* GA27-3733
- *IBM Token-Ring Network Optical Fiber Cable Options* GA27-3747
- *IBM Token-Ring Network Problem Determination Guide* SX27-3710
- *IBM PC Network Baseband Planning Guide* S68X-2269
- *IBM PC Network Baseband Adapter Installation Instructions* - Packaged with adapter
- *IBM PC Network Baseband Adapter/A Installation Instructions* - Packaged with adapter
- *IBM PC Network Baseband Extender Technical Reference* S68X-2266
- *IBM PC Network Broadband Planning Guide* S68X-2268
- *IBM PC Network Hardware Maintenance and Service* S68X-2240
- *IBM PC Network Adapter II - Frequency 1 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapter II - Frequency 2 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapter II - Frequency 3 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapter III/A - Frequency 1 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapter III/A - Frequency 2 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapter III/A - Frequency 3 Installation Instructions* - Packaged with adapter
- *IBM PC Network Adapters Technical Reference* - Packaged with adapter
- *IBM PC Network Adapter II - Frequency 2 Technical Reference* SC30-3490
- *IBM PC Network Adapter II - Frequency 3 Technical Reference* SC30-3491

- *IBM PC Network Adapter III/A - Frequency 2 Technical Reference* SC30-3492
- *IBM PC Network Adapter III/A - Frequency 3 Technical Reference* SC30-3493
- *IBM Token-Ring Network Starter Kit Guide, Version 1.1* SK2T-0303
- *IBM RT PC Technical Reference Token-Ring Adapter* SK2T-0291
- *IBM Token-Ring Network Adapter/A Installation and Testing Instructions* GA27-3784 - Packaged with adapter
- *IBM Token-Ring Network PC Adapter Guide to Operations* - Packaged with adapter
- *IBM Token-Ring Network 16/4 Adapter Guide to Operations* - Packaged with adapter
- *IBM Token-Ring Network 16/4 Adapter/A Installation and Testing Instructions* - Packaged with adapter
- *IBM 8220 Customer Setup Instructions* GA27-3817 - Packaged with 8220 Optical Fiber Converter
- *IBM Token-Ring Network Trace and Performance Program User's Guide* - Packaged with program product
- *IBM Token-Ring Network Remote Program Load User's Guide* GA27-3763 - Packaged with the Remote Program Load feature
- *IBM Local Area Network Host Information* GC30-3479
- *IBM Local Area Network Technical Reference* SC30-3383
- *IBM Local Area Network Support Program User's Guide, Version 1.1* - Packaged with program product
- *IBM Token-Ring Network NETBIOS Program User's Guide* - Packaged with program product
- *IBM Token-Ring Network PC Adapter Support Program for the 3270-PC* - Packaged with program product
- *IBM PC Network Bridge Program User's Guide, Version 1.1* SC30-3402-1 - Packaged with program product
- *IBM PC Network Bridge Program User's Guide, Version 2.0* SC30-3402-2 - Packaged with program product
- *IBM Token-Ring Network Manager User's Guide, Version 1.1* LY30-5595-1 - Packaged with program product
- *IBM LAN Manager User's Guide, Version 1.0* LY30-5595-2 - Packaged with program product
- *IBM LAN Manager User's Guide, Version 2.0* LY30-5595-3 - Packaged with program product
- *IBM LAN Manager Entry User's Guide, Version 1.0* - Packaged with program product
- *IBM PC 3270 Emulation LAN Management Program User's Guide, Version 1.0* SC30-3456 - Packaged with program product
- *IBM PC 3270 Emulation Memory Management Enhancement* Packaged with Product P/N 8575345

- *IBM Remote NETBIOS Access Facility Program User's Guide, Version 1.0* SK2T-0314
- *IBM Remote NETBIOS Access Facility Program Installation and Configuration Guide, Version 2.1* SK2T-0323
- *IBM Asynchronous Communications Server Program User's Guide, Version 1.0* SC30-3464
- *IBM LAN Asynchronous Connection Server Program Installation and Configuration Guide, Version 1.0* SC30-3509 - Packaged with program product
- *IBM 8232 LAN Channel Station Installation and Testing* GA27-3796
- *IBM 8232 LAN Channel Station Operator's Guide* GA27-3785
- *IBM 8232 LAN Channel Station Safety Notices* GA27-3833
- *IBM LAN Channel Support Program User's Guide* SC30-3458
- *IBM Token-Ring Network Manager and NetView/PC Planning and Installation* GG24-3128
- *IBM Token-Ring Network Bridges and Management* GG24-3062
- *NetView/PC Primer* GG24-3115
- *IBM 3725 Network Control Program Token-Ring Interface Planning and Implementation* GG24-3110
- *An Introduction To Programming For APPC/PC* GG24-3034
- *IBM Enhanced Connectivity Facilities SRPI Guide* GG24-3086
- *Connectivity In 1986* GG24-3079
- *IBM Local Area Networks In An Office Systems Environment* GG24-3071
- *IEEE 802.3 Local Area Network Considerations* GG22-9422

ITSC Publication Structure - LANs

The rapid evolution of Local Area Network products has resulted in the availability of a wide variety of documents, including the reference materials available with each product and additional technical planning and support material available from various development and support groups.

To assist users to locate appropriate, up-to-date information the International Technical Support Center is structuring its local area network documentation into a library of publications.

Each publication is produced to address some technical requirements of a specific audience as described in the abstract and preface of the document. Because the ITSC publications are intended to complement, but not replace reference material available with the products themselves, each document also provides a bibliography of related publications.

The International Technical Support Center publications related to local area networks have been planned with the following structure in mind to simplify the problem of locating up-to-date information.

1. Overview manuals which provide tutorial information and cross product conceptual and planning information.
2. Installation manuals which complement product reference material by describing the experiences of the ITSC in installing particular products within a total system. These documents do not address all installation parameters or options as do the product reference materials, but are intended to highlight those aspects of installation which have the greatest impact on successful use of the product, including the relationship between a specific product and other network or system products.
3. Network design and management manuals which describe trade offs and considerations for managing or planning local area networks.

The current library contains the following publications :

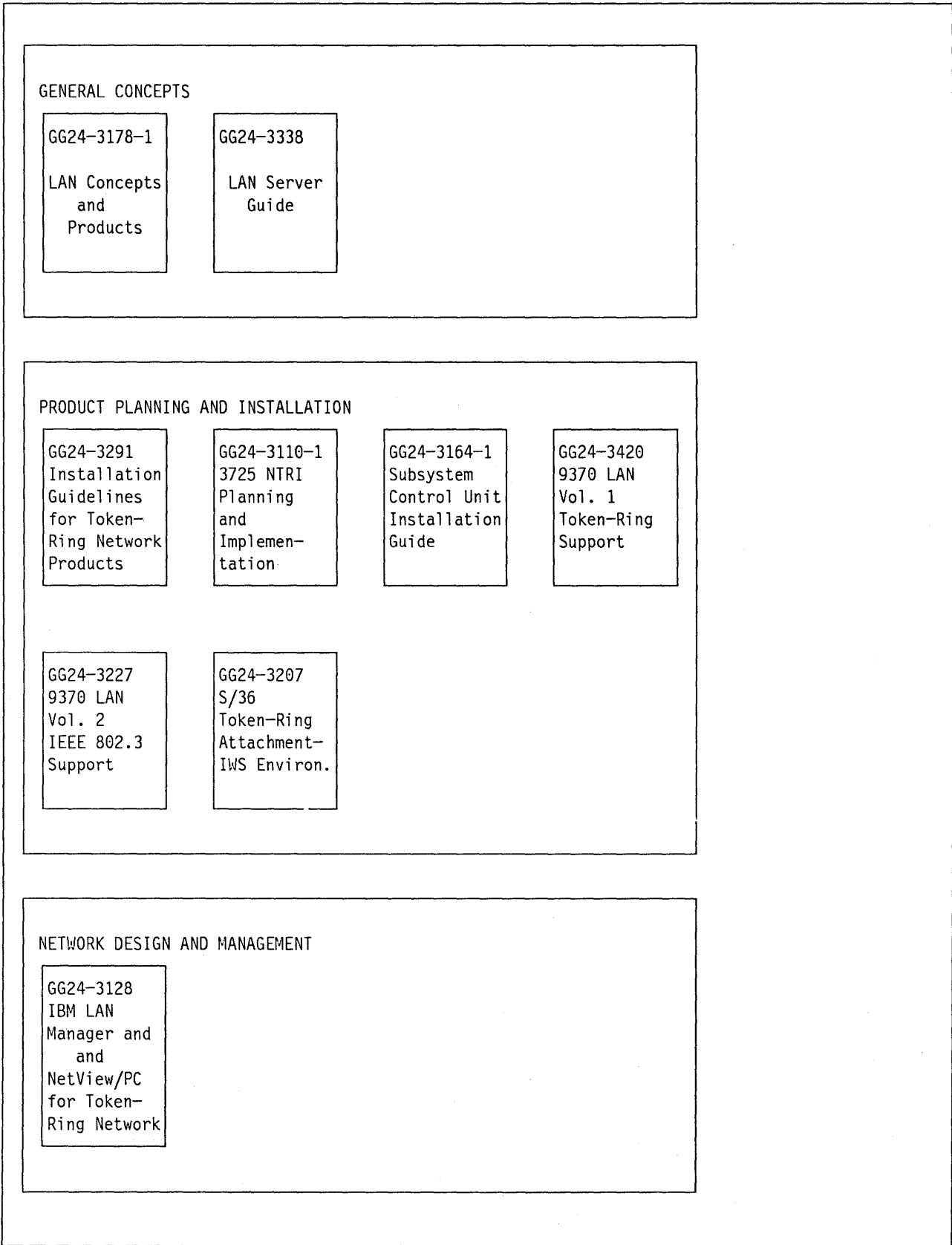


Figure 1. Existing Bulletins in ITSC LAN Bulletin Library.

Acknowledgments

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The advisor for this project was:

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This publication is the result of a residency conducted at the International Technical Support Center, Raleigh.

Thanks to the following people for the invaluable advice and guidance provided in the production of this document:

Joan Cavin
International Technical Support Center, Raleigh

Guillermo Diaz
International Technical Support Center, Raleigh

CSYS PSYS

(304 pages)

Preface

Document Purpose and Scope

The purpose of this document is to provide a better understanding of different local area network (LAN) architectures and the LAN products and solutions marketed by IBM. The document contains:

- LAN Architectures
- IBM PC Network Baseband
- IBM PC Network (Broadband)
- IBM Token-Ring Network
- LAN bridges
- LAN Network Management.

Audience

This document is intended for persons requiring a basic understanding of LANs and IBM LAN solutions for planning and support purposes:

- Customers:
 - DP management
 - Network planning staff
 - Network installation staff
 - Network operations
- IBM
 - Account system engineers
 - Network specialist system engineers
 - Sales representatives.

Document Organization

The document is organized as follows:

- *Chapter 1 Introduction*

Chapter 1 provides a definition of a local area network (LAN) and examines the differences between a LAN and a Private Automatic Branch Exchange (PABX). Major steps in planning for a LAN are identified.

- *Chapter 2 LAN Technology*

Chapter 2 provides a technological overview of physical LAN attachment options, medium access protocols and LAN interconnection.

- *Chapter 3 LAN Architectures and Standards*

Chapter 3 describes the ISO/OSI model, and the IEEE 802 standards for local area networks.

- *Chapter 4 Structured Wiring*

Chapter 4 describes the IBM Cabling System and its utilization in wiring an IBM Token-Ring Network.

- *Chapter 5 IBM Local Area Network Solutions*

Chapter 5 describes the IBM PC Network Baseband, the IBM PC Network (Broadband), the IBM Token-Ring Network, and IBM support for industrial LANs and FDDI. It also describes the programming interfaces available in current IBM LAN offerings.

- *Chapter 6 LAN Interconnection*

Chapter 6 describes different protocols for LAN bridges and various IBM products to interconnect LANs. Multi-segment topologies alternatives are briefly examined.

- *Chapter 7 Device Connectivity*

Chapter 7 describes various gateways and provides an analysis of device connectivity for the IBM PC Networks and the IBM Token-Ring Network.

- *Chapter 8 LAN Connectivity Applications*

Chapter 8 describes products providing local LAN server functions and System/370 host mainframe interactive (MFI) sessions for LAN-attached workstations and various LAN server products.

- *Chapter 9 LAN Management and Recovery*

Chapter 9 describes various network management products for LANs, and identifies the relationship of IBM LAN management products to IBM's total network management strategy.

- *Chapter 10 LAN Positioning*

Chapter 10 provides positioning considerations for major IBM LAN products.

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1. Introduction

Technological advances in computing support the trend towards decreasing hardware cost and increasing computing capability and capacity. This has meant an increased use of personal computers and workstations in the workplace. Many organizations have realized that they can improve the flow and availability of information by interconnecting these devices in a local area network (LAN). Savings can also be realized if some resources such as printers and secondary storage are shared.

A local area network (LAN) provides the interconnection of computer equipment or data communications devices in a local area (over distances typically less than 10 Km).

The following characteristics differentiate a local area network (LAN) from a Wide Area Network (WAN):

- LAN-connected devices are usually separated by shorter distances (typically less than 10 kilometers).
- Higher speed data transmission is usually employed in a LAN (1 - 100 million bits per second (Mbps)).
- In many cases, the LAN cabling system is owned by the organization rather than a common carrier.

Local area networks are usually used to connect equipment within a building or a group of buildings such as a university campus or factory site. Within a building or on private property, an organization may have greater freedom to decide what type of wiring system to use.

The bandwidth for transmission is not a constraint in most local area network implementations. This means that the network can be shared by a variety of devices, including:

- Computers
- Terminals or intelligent workstations
- Peripheral devices (such as printers)
- Telephones
- Sensors
- Video equipment.

Not all networks are capable of handling all devices. For instance, in some countries, telecommunications authorities restrict the integration of their telephone equipment into a privately owned LAN.

Another difference between a wide area network and a local area network is that each station on the LAN must have sufficient intelligence to support sophisticated communications protocols and the ability to sense the status of the network media. Much of this intelligence is usually implemented in microcode on the adapters of devices attaching to the LAN. Consequently, in

this document, the term LAN station represents that portion of a LAN-attaching device which implements the LAN-specific protocols.

This manual will take a look at the IEEE standards for local area networks, and how they fit into the ISO Open Systems Interconnection (OSI) Reference Model. IBM local area networks will be discussed with regard to their implementation of the IEEE standards, connectivity, and network management.

1.1 A Comparison of LANs and PABXs

A PABX (Private Automatic Branch Exchange)¹ is a local telephone exchange on the customer's premises. The PABX has evolved from the days of the manually operated telephone exchange to become an electronic automatic exchange. Early PABXs only provided switching for voice circuits, but with the introduction of computer technology, the modern digital PABX² is capable of switching both voice and data.

Telephone (voice-grade) twisted pair (TTP) wiring is generally used to connect a telephone into a PABX. This wiring scheme requires one twisted pair wire per phone. This provides a 64 thousand bits per second (64 Kbps) line from your phone to a port on the PABX. 64 Kbps is generally considered to be the minimum for quality voice transmission because of the sampling process by which voice is converted into a digital signal for transmission. To digitize speech, samples of the sound waves are captured in small samples which are then encoded into digital pulses. This process is called Pulse Code Modulation (PCM). If speeds less than 64 Kbps are used, the number of samples that can be taken decreases and hence the speech quality decreases.

As indicated above, a single twisted pair wire is required between the PABX and each phone to support voice transmission. To support data transmission in addition to voice, an additional twisted pair and a second port may be required. This is because the load imposed by high volume data traffic such as file transfers or printing would consume too much of the capacity of a single 64 Kbps link and thus disrupt voice connections. For full-duplex data transmission (that is, two-way simultaneous transmission), two twisted pairs are usually required. To avoid potential problems with the requirement for these additional twisted pairs, some PABX manufacturers use higher data rates (such as 256 Kbps) for each TTP link, 128 Kbps for voice, and 128 Kbps for full-duplex data transmission. These rates generally provide 64 Kbps to the user, but use the additional capacity for signalling and controlling. ROLMlink uses 4 x 64 Kbps, 2 x 64 Kbps for voice and data and 2 x 64 Kbps for signalling and controlling.

Most PABX systems have a bus architecture which is used to route or switch the different speech channels. The bus has a much higher data rate than the individual links (up to 500Mbps). This bus can also be used to switch data transmissions. A PABX usually uses time division multiplexing (TDM) to place data on the bus, where it is switched to the appropriate line group, protocol converter, or trunk. The control and timing unit provides control and timing

¹ Also known as a PBX (Private Branch Exchange) in some countries.

² ROLM (registered trademark of the International Business Machines Corporation) refers to its digital PBX as a Computerized Branch Exchange (CBX).

functions for the line and trunk groups, protocol converters, and the service unit. The service unit provides busy and dial tones, and other special functions (such as ring back). See Figure 2 on page 3.

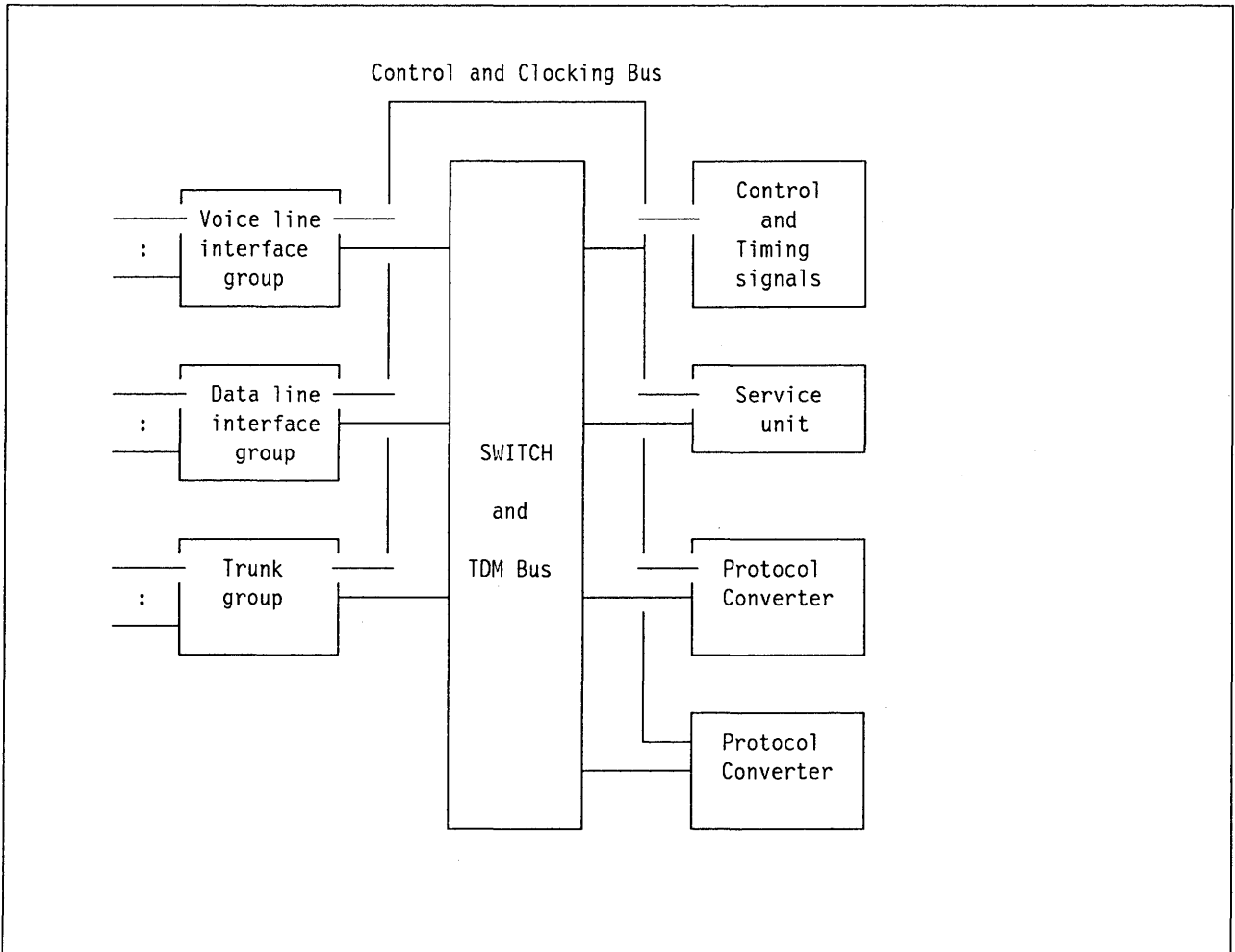


Figure 2. PABX Architecture

A PABX uses circuit switching to provide end-to-end physical and logical connections, rather than the form of packet switching used in a LAN. Because circuit switching is used to connect two devices, the user can communicate with only one device at a time; but once the connection is made, any protocol can be sent through the PABX. The switching (or connection setup) between two addresses is controlled by the user at the user's terminal. Thus to use a file server the user must initiate (dial up) the connection.

A LAN differs from a PABX in that devices attached to the LAN share the transmission media and communicate with other devices using a specialized protocol. They are designed for high-speed data transfer, and attached users can have multiple concurrent sessions with other users and servers.

To send a message to multiple destinations (for example, a broadcast message) in a PABX environment requires as many connections and messages to be executed as there are destinations. In a LAN environment, with an addressing structure which permits receipt of the message by all the destination devices, only one message needs to be sent. Also note that in the

PABX environment, all the destination addresses must be known or pre-defined to establish the connection to carry out this transmission. Most LAN protocols provide for general "broadcast" addresses or "group" addresses that eliminate this requirement.

Today's PABX architectures have some limitations when used to switch large volumes of data or to support devices (such as servers) requiring multiple concurrent connections. However, for users who need to support a variety of protocols with limited or moderate traffic volumes between local or remote resources, a PABX may provide a cost-effective solution. The PABX is also a good solution for supporting the data communications requirements of casual user applications with short connection times.

For environments with higher volumes of data transmission and with a greater need for resource sharing between intelligent devices, a LAN usually provides greater connection flexibility and performance capability in a more cost-effective manner than a PABX.

1.2 LAN Capabilities

One of the main capabilities of a local area network is resource sharing, such as data and expensive peripherals. This ability to share resources can mean a decrease in cost of an individual workstation, since not every workstation may need its own printer or hard disk. A LAN may also provide better reliability and availability than a centrally controlled network. The failure of a workstation does not affect other users on the LAN unless the failure point is a server. A workstation on a LAN usually has more flexibility and function than a fixed function terminal connected to a host system. For example, the LAN user can frequently work as a stand-alone workstation, share resources on the LAN, or be in session with systems external to the LAN. Because the LAN attachments must have some degree of intelligence to support the LAN protocols, they may also provide management or problem determination support through those protocols.

1.3 Planning for a LAN

In planning for a local area network consider the following:

- The organization's objectives.
- End-user requirements.
- Number and location of workstations.
- Requirements for special functions or capabilities such as backup.
- Security.
- Network management.

Objectives for providing the LAN: The LAN planner must know what problems are to be resolved and what expectations have been identified as reasons for installing the LAN.

End-user requirements: The planner must determine which functions end users require from their workstations, and from LAN-provided servers. If an office system is required, what exactly does the end user want from the system? Is it local word processing, or is access to other office systems required via some sort of gateway or server? If the end users need to access a host system, how is it to be done and how many users require this function?

The person planning the LAN will need to look at the number and location of users that require these types of function so that gateways and servers can be planned.

The *number of workstations* and their *location* needs to be considered so that the topology of the LAN can be worked out. It is important to do this to provide sufficient capacity for performance, and adequate availability and recovery capabilities.

The number of users wanting to share the same file(s) and printers needs to be considered. Some files may need to be kept on multiple file servers to distribute the load and ensure acceptable response times.

For performance and security reasons, it may be beneficial to have users divided into work groups or location groups, each on their own LAN with bridges or gateways³ between the LANs. If gateways to other systems are needed, the number of users and the type of usage should be looked at to determine the amount of traffic flow through the gateway, and hence the number and capacity of gateways required. LAN interconnection is described in more detail in "Physical Layer and MAC Sublayer" on page 57.

Special functions: The need for the following types of functions should be identified:

- Access to public switched networks.
- Access to external data bases.
- Application-to-application communication.
- The ability to store files and use printers on a system external to the LAN. See Chapter 8, section 8.1.3 Enhanced Connectivity Facility.

Security: The need for security can affect the topology and type of LAN used. One form of security is to use a number of small LANs (divided by workgroup) and to limit the connectivity between the LANs using gateways. Another consideration is the choice of protocol and media on which the LAN is based. For example, in a LAN using a carrier sense multiple access / collision detection (CSMA/CD) protocol like the IEEE 802.3 standard, signals are broadcast simultaneously to all stations on the LAN. This may present security problems if device implementations do not ensure uniqueness of addresses, and acceptance of only those frames addressed to the device.

³ Bridges or gateways are specialized stations interconnecting two or more separate LANs or systems.

Unless care is taken to ensure that duplicate addresses do not exist, it is possible for messages to be received by multiple stations. In an IEEE 802.5 Token-Ring LAN, the signal is passed serially from one station to another around the ring, but is received only by stations with matching destination addresses. The adapter initialization process prescribed by the IEEE standards ensures that duplicate addresses do not coexist on a ring.

Network management: As the size and complexity of the local area network grows, the need for network management and supporting tools becomes more important. Network management implies more than problem determination. It also includes system and change management.

While fast resolution of problems is important, the ability to fix potential problems before they occur is even more desirable. This involves monitoring the network and looking at utilizations of servers, bridges, and gateways. Systems and change management to support planning of application and network configuration changes is important in all networks, and particularly, large networks.

Consideration should be given to the degree of network management required. LAN designs and supporting tools should be selected to achieve this.

2. LAN Technology

A primary consideration in selecting communications technology for a LAN is the speed of data transmission required and the need to support other types of transmission (such as video) on the same medium.

A second important consideration is the selection of an access protocol to support the traffic distribution and management control requirements of the LAN-attached devices. An access protocol defines how the devices share the media and support basic configuration and recovery functions.

LAN interconnection is an increasingly important aspect of LAN design. As LANs grow with respect to numbers of attached devices and requirements for increased application connectivity, methods for providing backbone configurations and access to external systems may impact selection of different LAN solutions and technologies. While interconnection can be achieved in different ways, bridge stations are usually the most attractive and best performing approach. However, systems called routers and gateways might also be considered as alternative solutions. These different network interconnection techniques will be introduced in section "Physical Layer and MAC Sublayer" on page 57.

End-to-end connectivity within interconnected LANs implies the availability of routes between any two end stations. In communications environments evolving as quickly and continuously as LANs, the ability to establish these routes dynamically is preferable to approaches requiring pre-definition and maintenance of large tables and directories. Two important approaches to bridging will be discussed: source routing and transparent bridging.

2.1 Physical LAN Attachment

The purpose of physical LAN attachment is to provide an interface between the transmission medium and the LAN station's access protocol to the transmission medium. It provides mechanical, electrical, functional and procedural specifications for implementing a LAN.

The mechanical definition specifies the type of connectors to be used. The electrical definition, if applicable, states what voltages are to be used, while the functional definition defines the meaning of the voltages on the different pins. Finally the procedural definition states the sequence of events to be followed to transmit and receive data, including the encoding scheme specifying how digital data is to be represented by electrical or optical pulses.

Many different types of media can be used for the physical layer. For example, telephone twisted pair, coax cable, shielded copper cable and fiber optics are the main types used for LANs. Different transmission techniques may be applied to each of these media types. They are generally categorized as baseband or broadband transmission techniques.

2.1.1 Media Types

2.1.1.1 Coaxial Cable

Coaxial (coax) cable has low attenuation characteristics and can drive signals at high data rates for relatively long distances. Coax is an unbalanced cable (the two conductors have a different impedance to ground) with the shield being used as one of the conductors. This structure (a central core with a shield around it) does not generate as much RF noise as unshielded twisted pair cable does when used with high data rates.

Coax cable can be used for both baseband and broadband transmission.

2.1.1.2 Telephone Twisted Pair Cable

Telephone twisted pair (unshielded, voice-grade twisted pair) cable can be used for data transmission when data signal strength is filtered, and distances are restricted. It is used by many PABX manufacturers to carry voice and data.

Unshielded telephone twisted pair cable tends to suffer from high attenuation (loss of signal strength due to inherent media characteristics) and is very susceptible to noise if located near strong electromagnetic fields (power cables, etc.). A result of attenuation is a reduction in the driving distance⁴, number of attachments and bandwidth potential of the LAN using this medium. When used for high rates of data transmission (for example, 1Mbps or higher), it will radiate radio frequency (RF) emissions. Filters can be used to reduce this. However, filters increase loss in signal strength and add to the cost of the cabling and attachments. TTP wire also suffers from crosstalk⁵ between adjacent twisted pairs. Voice Grade Twisted Pair wiring is generally undesirable for data transmission in excess of 4Mbps.

The IBM Token-Ring Network allows the use of TTP wire in 4 Mbps segments of the LAN.

2.1.1.3 Data-Grade Media (DGM), Shielded Twisted Pair Cable

This type of cable has one or more twisted pairs within a shield. The shielding reduces its susceptibility to low levels of noise and its own generation of radio frequency interference, thus making it more suitable for data transmission. Shielded data grade cable can be used with data rates in excess of 20 Mbps over most distances encountered within buildings.

The cable can be constructed with two twisted pairs within a shield, while maintaining a low level of crosstalk⁵ due to the shielding and the way in which the pairs are twisted around each other. In addition to providing two data paths, the twisting and shielding of DGM cable provides greater immunity to external interference than coaxial cables which use the shield as one of the conductors. Data grade twisted pair cable is a balanced medium better suited to the differential encoding schemes used by some LANs.

⁴ Driving distance refers to the distance a signal can propagate in a specific medium without requiring regeneration.

⁵ Crosstalk refers to a signal in one cable generating a parasite signal in an adjacent cable.

While this type of cable can be used for baseband and broadband transmission, it is primarily used for baseband.

The IBM Token-Ring Network uses DGM Twisted Pair media for both 4 and 16 Mbps LAN segments ⁶.

2.1.1.4 Fiber Optic Cable

Fiber optic cable presents an attractive solution for high speed transmission rates used in backbone local area networks. The cable is relatively immune to the types of electrical noise and grounding trouble that can plague metallic conductors in some environments. Thus, it is also an ideal medium for outdoor connections or for factories or locations in which cabling has to run near higher voltage wiring. Fiber optic cable also has extremely high data transfer capability (hundreds of megabits per second, terabits per second) with very little signal attenuation (signal loss due to the medium). Because of the high data rates and the distances that fiber optic cables can carry a signal without regeneration, its use in telephone networks, channel extenders on mainframe computers, and backbone LANs is rapidly increasing.

In comparison with transmission of electrical signals on copper media, it is difficult to tap an optical signal from a fiber optic cable without the inherent optical signal loss being detected. Therefore fiber optic cable has potential for greater security than metallic conductors.

Fiber optic cable is normally used for baseband transmission.

IBM includes fiber optic cable as part of the IBM Cabling System, referred to as "Type 5 cable". Other fiber optic cables may also be used.

2.1.2 Network Topologies

Numerous topologies are used for local area networks. This section briefly discusses four different topologies. The term *topology* refers to the way in which network devices are interconnected. For example, if every station is directly connected to every other station, this is called mesh topology. Figure 3 on page 10 shows the four network topologies to be described plus two variations of popular LAN topologies.

⁶ LAN segment refers to a single physical local area network running its own independent MAC protocol.

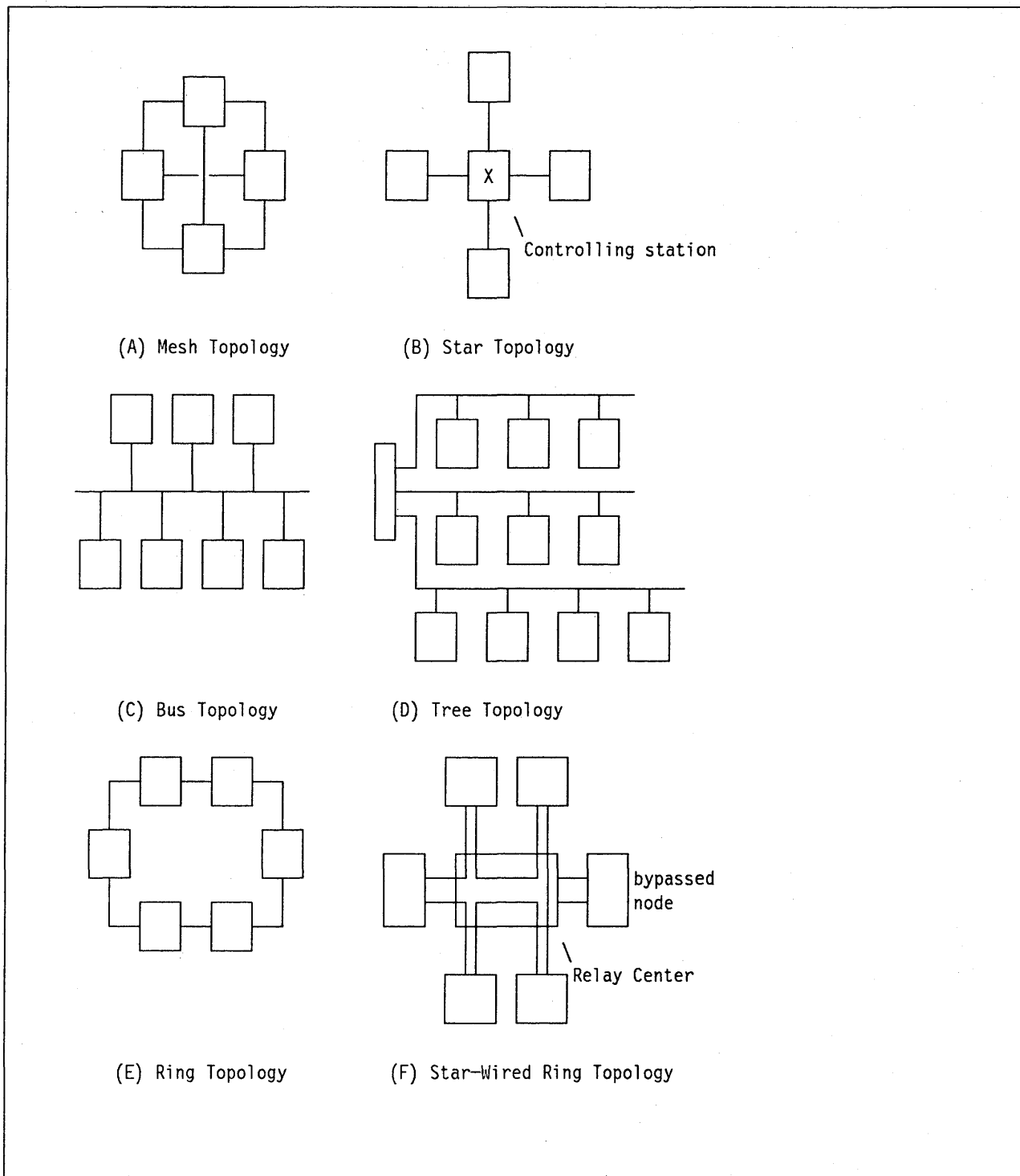


Figure 3. LAN Topologies

2.1.2.1 Mesh Topology

Part A of Figure 3 shows a *mesh topology* network of four nodes. This topology involves some wiring overhead since every network station is directly connected to all the other stations. It also means that each station has to have $(N-1)$ I/O ports, where N is the number of stations in the network.

However, mesh network topology has excellent fault tolerance, since, when a link fails, message traffic can be routed through an intermediate node.

2.1.2.2 Star Topology

In a network that has a *star topology*, each station is connected to a central controlling point (also called switch) via point-to-point lines. Part B of Figure 3 shows a star topology network, with the central controlling node indicated by the "X". A PABX is a good example of this type of network.

For connection-oriented data transmission to another network station, the sending station must send a connection request to the central switch. The switch will then set up the connection. Once the connection is established, the two stations can transfer information.

The structure of a star network is very simple, but, to overcome the disadvantage of having a single point of failure, the central switch must use very reliable components and usually provides some form of redundancy.

2.1.2.3 Bus and Tree Topology

The *bus topology* is very common for local area networks. Part C of Figure 3 depicts a bus topology network. Network stations are attached to a transmission medium, called a bus. When a station transmits a frame or segment of information on the bus, transmission occurs in both directions so that the frame is received by all other stations attached to the bus. Frames are said to be *broadcast* on the medium.

A popular protocol used with this LAN topology is the carrier sense multiple access with collision detection (CSMA/CD) protocol, which will be discussed under *LAN Medium Access Protocols*.

Unlike a multipoint line, in which a control point polls the other devices, there is no controlling station on a broadcast bus topology LAN. Control functions are distributed to all stations on the LAN. Each station must also be capable of detecting faults.

The *tree topology* is a variation of the bus topology. A CSMA/CD protocol can be applied to both topologies, and in both cases transmitted frames are broadcast to all stations active on the shared medium. As with the bus topology, there is no controlling station on the LAN. Part D of Figure 3 illustrates a tree topology network.

2.1.2.4 Ring Topologies

In a network that has a *ring topology*, each station is attached to its adjacent station by point-to-point links, thus forming a physical ring. Each station's adapter regenerates the signal as it retransmits a data packet that is circulating on the ring. A popular protocol used with ring topology is token passing, in which access to the medium is controlled by possession of a circulating token. Different token passing access protocols are defined for ring topology LANs, although token passing is also applicable to a bus local area network. Part E of Figure 3 illustrates a ring topology network.

The major disadvantage of a physical ring topology is its sensitivity to single link failure. If one connection between two stations fails or a bypass for a particular inactive station is malfunctioning, the ring traffic is down.

A variation of a ring topology to avoid this problem is the *star-wired ring topology*, also referred to as *radial hierarchical wiring*.

Although the cable layout resembles a regular star topology, physically and logically the network stations form a ring. Each station is connected to a relay center with transmit and receive paths. The transmit path of one station is connected inside the relay center to the receive path of the next active station, thus bypassing inactive devices as illustrated in Part F of Figure 3. The connecting cable between a ring station and the relay center is called a *lobe*.

The relay center can be implemented as a *passive wiring concentrator*, in which case the relay mechanisms are powered by the ring stations.

The relay center can also be implemented as a *ring wiring concentrator* containing active, powered components that materially increase the ring's error recovery ability, including automatic wrapping to a backup path and some degree of error message processing.

The previous discussion on different LAN topologies applies to a single *LAN segment*. A LAN segment consists of a single common medium and all the LAN devices connected to this medium. LAN segments can be combined to form larger local area networks or to interconnect different types of LAN segments into one network. LAN segment interconnection can be achieved through bridges, routers or gateways. LAN segments can only be combined in a single network using bridges or routers if they share a common communications layer (logical link control sublayer for bridges, network layer for routers). Gateways interconnect network segments which may use a totally different communications architecture. The different network interconnection techniques are discussed in greater detail in "Network Interconnection Techniques" on page 46.

Using a LAN segment as an elementary building block permits design of interconnected multi-segment local area network with a wide range of possible topologies. Again, each of these topologies has its advantages and disadvantages. They are discussed in "Bridged LAN Configurations" on page 149.

Figure 4 on page 13 introduces various concepts related to multi-segment networks.

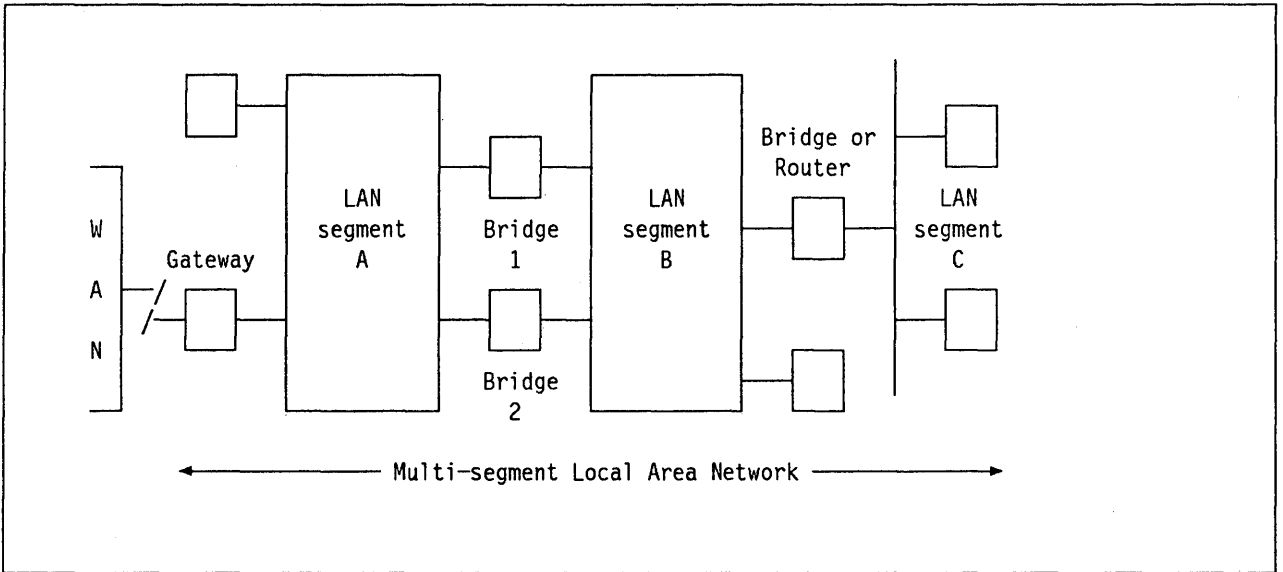


Figure 4. Multi-Segment LAN Example

2.1.3 Transmission Techniques

2.1.3.1 Baseband Transmission

Baseband transmission involves putting a signal directly on the transmission medium without modulating a carrier signal. At any point in time, the information occupies the entire bandwidth available on the medium. Sharing of the medium can be achieved by allocating time slices to different applications. This technique is known as *time division multiplexing* (TDM). It is a quite simple technique and together with the fact that no modulating/demodulating devices are required, Baseband is a relatively inexpensive transmission technology.

Baseband-transmitted signals must be regenerated periodically when transmitting signals over long distances or through multiple connection points. This is due to cable attenuation (losses in signal strength caused by the physical and electrical characteristics of the medium) and losses associated with connectors and/or attachments.

The IBM Token-Ring Network uses baseband transmission, operating at a speed of 4 or 16 Megabits per second (4 Mbps or 16 Mbps), and the IBM PC Network Baseband uses baseband transmission at 2 Mbps.

2.1.3.2 Broadband Transmission

Broadband transmission involves use of techniques to allow generation of signals over multiple channels. In most cases, broadband transmission is based upon use of radio frequency modems in the same way as radio and television signals are transmitted. Resource sharing is accomplished by dividing the medium into logical channels using *frequency division multiplexing*. Any individual channel could use time division multiplexing to provide further sharing.

Since broadband transmission uses multi-channel "CATV-like" technology, it is ideally suited to transmit voice and video. Hence, the broadband approach offers the greatest potential to support voice, video, and data on a single cabling system today. For this reason broadband transmission is quite popular in manufacturing plants.

Transmission of video signals requires only a single channel, because it is transmit only. Data communication involves both transmit and receive. Therefore two channels are required. In order to minimize interference between the transmit and receive channels, significantly separated frequency ranges should be used. Within a transmit/receive channel pair, this characteristic is indicated as the frequency offset, with the forward (higher) frequency range separated from the return (lower) frequency range by a set of frequencies referred to as the guard band. Within each range a sub-range of 6 Mhz defines one channel of a channel pair, where the pair is composed of a return channel below the offset, and a forward channel which corresponds to the lower channel frequency plus the offset. See Figure 5 on page 15.

2.2 LAN Medium Access Protocols

2.2.1 Basic CSMA/CD Concepts

The access to the medium on a LAN controlled by a *carrier sense multiple access with collision detection* (CSMA/CD) access protocol is based on contention between competing stations. The access is said to be *probabilistic* rather than deterministic. CSMA/CD is appropriate for use only with bus or tree topologies because of the collision detection mechanism. In order to detect signal collisions, all stations on the LAN must be able to sense the presence of a carrier on the medium. This does not happen with a ring topology in which a signal is passed serially from one station to the next.

Three main topology/transmission technique combinations are used for CSMA/CD LANs: baseband bus (the most popular), baseband bus with star-wired device controllers, and broadband tree. In each case, station attachment is passive. The signal is neither regenerated nor amplified by the LAN stations. This limits the maximum non-repeated station-to-station distance (typically 500 meters on a baseband bus). In addition, distance between attaching stations must be a minimum of 2.5 meters to minimize the effect of signal reflections in the taps (that is to avoid reflections adding up in phase).

Before transmitting data, a station first listens to the medium to find out whether the medium is idle or whether another station is already transmitting data. If the network is quiet, the station may start its own transmission. The protocol provides multiple access, that is the access mechanism applies to all LAN stations concurrently. Therefore it is possible that two stations could start to transmit at about the same time. Due to propagation delays (media delay, delays at taps and/or repeaters), a station may determine that the medium is idle and start to transmit, while at the other end of the bus a station has already started transmission. Two (or more) stations concurrently broadcasting data on a common medium inevitably cause a collision. The collision is detected as the station listens to the medium while it is transmitting (*collision detection*). This process is called *listen while talk*. Both stations stop transmission and try again later.

The critical part of the CSMA/CD protocol is the recovery process after a collision has occurred. It is this aspect of the CSMA/CD medium access protocol which causes response time and throughput to be probabilistic.

In general, collision recovery proceeds as follows:

1. As soon as a station detects a collision, it stops transmitting data immediately and sends a jamming signal. Since the first condition to make any recovery possible is to stop all additional traffic, the jamming signal informs all active stations about the collision.
2. After being informed about the collision, each station wishing to transmit data must wait a random amount of time before initiating the whole process again, starting with carrier sensing etc.

Three CSMA/CD variations provide increasing degrees of sophistication and optimization:

- *Non-persistent rules*

1. If the medium is idle, transmit.
2. If the medium is busy, wait a random amount of time and repeat step 1.

This method is very simple but inefficient, especially with high utilization of the medium because the opportunity to transmit during a brief idle period may be missed.

- *1-persistent rules*

1. If the medium is idle, transmit.
2. If the medium is busy, continue to listen until the medium is idle, then transmit immediately.
3. If there is a collision, wait a random amount of time and repeat step 1.

If two or more stations are waiting to transmit, a collision will always occur when the medium becomes available. However, since each station will wait a random amount of time after a collision and before retransmitting, things will sort themselves out from there. However the delays created by the non-persistent rules for normal busy media will be avoided.

Within existing CSMA/CD implementations, this method is the most popular.

- *P-persistent rules*

The p-persistent protocol tries to eliminate the collision that happens with the 1-persistent protocol when the medium is busy and more than one station is waiting to transmit. The rules are:

1. If the medium is idle, transmit with a probability of p . Hence there is a probability of $q = (1-p)$ that the station will wait for the next time slot.
2. If the medium is busy, continue to listen until the medium is idle, then repeat step 1.
3. If there is a collision, wait one time slot and repeat step 1.

The main problem with this approach is choosing a value for p . P must be kept low to avoid instability, but this increases the wait probability (q). This approach tends to be unstable with highly utilized media.

The 1-persistent protocol wastes less time after a collision than the non-persistent protocol. The random backoff after a collision reduces the chances of two stations contending for the medium again. Under high traffic conditions, the 1-persistent rules are more like to run into collision and thus create instability. However when $p=1$, $q=0$... hence there is no wait probability. Thus under normal or low traffic conditions the 1-persistent protocol can provide better throughput.

In conclusion, CSMA/CD or contention protocols in general perform best when medium utilization is low. High utilization increases the number of collisions and collision retransmissions, further adding to the utilization. Sensitivity to increased traffic load is one of the major drawbacks of CSMA/CD protocols.

2.2.1.1 Frame Format

Figure 6 shows the frame format used for data transmission on a CSMA/CD LAN according to the international standard specification issued by the IEEE 802.3. See "LAN Architectures and Standards" on page 51page=yes.. Note that this format is slightly different from that used by "Ethernet" adapters.

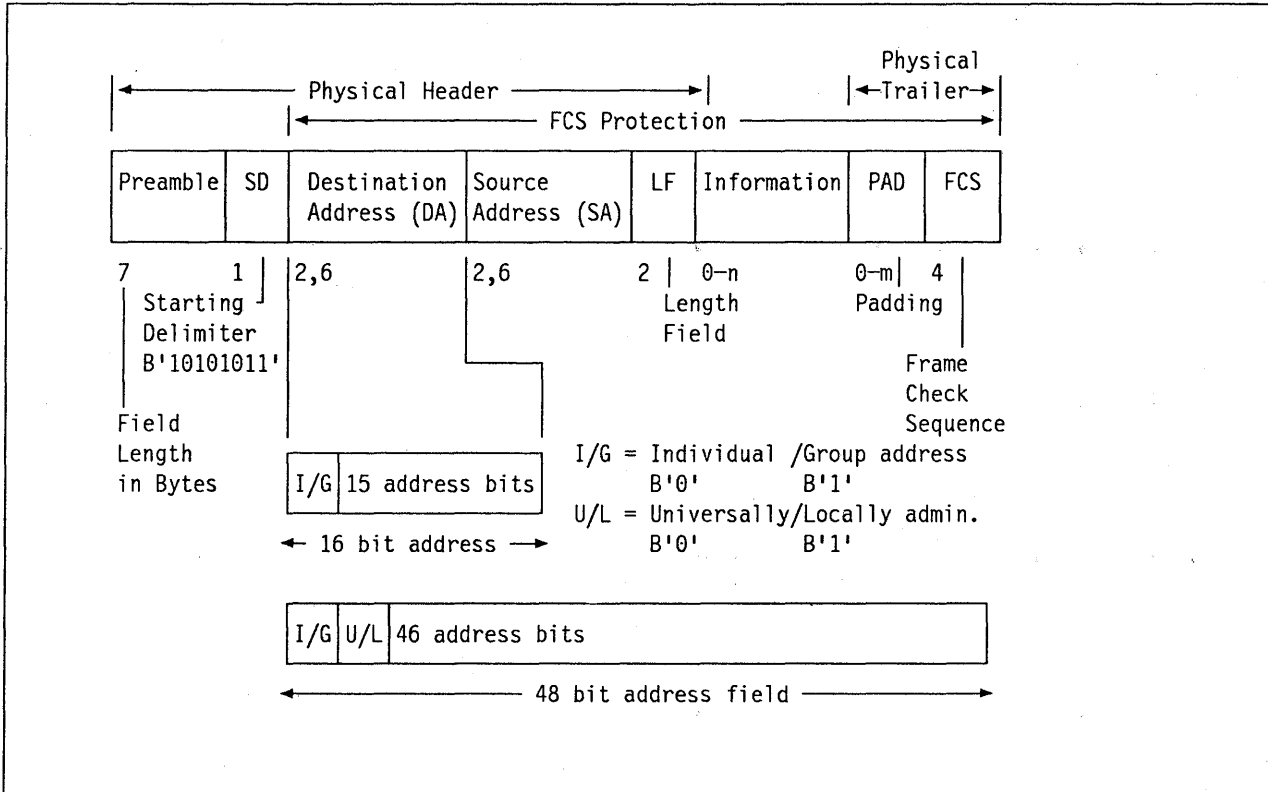


Figure 6. IEEE 802.3 MAC Frame Format

- Preamble- 7 padding bytes, allow the physical layer signalling (PLS) circuitry to synchronize with the receive frame timing circuitry.
- SA, DA - 16-bit or 48-bit medium access control (MAC) address fields according to the IEEE and ISO standards. A vendor is free to choose either of them but all stations on a given LAN must use the same addressing structure. Most current LAN implementations use 48-bit addressing, but some early LANs use 16-bit address fields.
- LF - length field, indicating the actual length of the information field.
- Information field - may contain a LLC protocol data unit (LPDU).
- Padding - may contain padding characters if the minimum frame length requirement is not met (512 bits).
- FCS - the result (32 bits) of a cyclic redundancy check algorithm (specific polynomial executed against the contents of DA, SA, LF, information and pad fields).
- An invalid frame is not passed to the next higher protocol layer (the LLC sublayer), but is discarded by MAC level processing for any of the following reasons:
 - The frame does not contain an integral number of bytes.

- The content of frame length field is inconsistent with the actual frame length.
- The FCS value calculated upon by the destination station does not match the FCS value contained within the frame.

2.2.1.2 Additional CSMA/CD Considerations

- Cabling considerations

With CSMA/CD baseband bus topology, 50 ohm impedance coax wire is recommended to reduce the capacitance caused by the taps. Almost all other communications cables use an impedance of at least 75 ohms. Frequently the long term implications of a particular cable type may be overlooked during initial design and installation. If a CSMA/CD LAN using 50 ohm cable over time provides insufficient capacity for the required data traffic, rewiring will usually be required and may turn out to be a very costly operation.

- Probability of collisions

The probability of a collision occurring is proportional to the number of stations, the number of transmissions per time interval, the length of the LAN, the LAN utilization and the size and number of the collision windows involved. A *collision window* is the time during which a collision may occur. Its maximum value is the time required by a signal to travel between the two outmost stations on a CSMA/CD LAN. On a 10 Mbps CSMA/CD baseband LAN the collision window size equals the one-way propagation delay (sum of all transmission delays) between the contending stations. While the size of collision windows may be decreased by reducing the frame size used by adapters, it is not recommended since it will also increase the number of windows and the overhead caused by frame headers and trailers.

Baseband collision detection is usually accomplished by measuring the signal strength on the bus. Therefore the signal between the two outmost stations must be considerably stronger than normal noise levels. Consequently, on a CSMA/CD baseband LAN, signal repeaters are generally required every 500 meters. This has a positive consequence for the recovery of relatively large frames. On the average, only about 512 bits would have been transmitted when the collision is detected. This stops the frame transmission and initiates the recovery process.

Slot time is the minimum transmission time required by a station to ensure it can hear all possible collisions and is equal to twice the maximum collision window size. This implies a minimum frame size on a 10 Mbps CSMA/CD baseband LAN of 512 bits. The frame header and trailer parts require 208 bits, which leaves a 304-bit data field in a minimum length frame. In shorter frames such as most control frames and short messages, padding characters must be appended to the data field (refer to the frame format). An increase in transmission speed increases the minimum frame size.

Early CSMA/CD LANs had relatively few attachments such as processors and terminal servers (controllers which served multiple fixed function devices). With the advent of the intelligent programmable workstation, the desire to attach such devices directly to the LAN may significantly increase the number of attachments and alter traffic characteristics. Any associated

increase in collision probability should be considered in designing a LAN which will use intelligent workstations.

- Collision resolution

As mentioned before, the first station to detect a collision immediately transmits a *jamming signal* to notify all listening stations that a collision has occurred. In response to this signal, each station enters a *binary exponential backoff algorithm*, causing each station to wait for a random amount of time before attempting to transmit again. If a station's subsequent attempt results in another collision, its backoff delay is doubled. This process may be repeated up to 16 times, after which the station, if still unsuccessful, reports a transmission error. There is no guaranteed delivery at the CSMA/CD MAC level. If traffic levels are high, the more retries a station requires, the worse its chances to succeed may be when attempting again.

- Basic performance

CSMA/CD protocols optimize throughput and response time under conditions of relatively low (less than 40%) bandwidth utilization.

Test measurements indicate that typical user data frames contain about 1000 bits. Using this frame size to simulate the performance of a 10 Mbps CSMA/CD LAN with 100 active LAN devices results in a maximum throughput of about 3.6 Mbps because of the sensitivity of the protocol to load.

Increasing the transmission speed on a CSMA/CD LAN does not significantly improve throughput since the minimum frame length increases proportionally. It may also imply a requirement for more expensive media and additional repeaters since signal attenuation is proportional to the square of the transmission speed.

- LAN growth

In response to growth requirements, one might attempt to increase the maximum allowable distance. However, this also implies increased slot time, minimum frame length and larger collision windows for any given load.

When such architectural constraints create a problem, they may be addressed by bridging separate CSMA/CD LANs together to form an interconnected CSMA/CD LAN as discussed earlier.

- CSMA/CD interconnection considerations

When attempting to project future load growth, it may be risky to underestimate capacity requirements. Recent explosive growth in communications bandwidth requirements is likely to continue in LAN environments. Such applications as image and file servers will quickly use the spare capacity now available.

More detailed analysis of future load growth will show the increasing importance of *LAN interconnection* and higher capacity *backbone LANs*.

A potential problem for any LAN bridge is *frame loss*. Generally, frame loss can occur because of high loads on the LAN or at the bridge level (for example, a bridge running out of queuing capacity).

Excessive frame loss in a CSMA/CD bridge (resulting from collisions) is a much more significant problem. CSMA/CD LANs have no priority

mechanism at the MAC level, and bridge adapters (for example, to backbone LAN segments) by nature tend to experience the highest loads, and will be the most likely ones to be involved in collision recovery. A bridge may also be subject to peak load situations on both sides of the bridge, further decreasing the probability of successful frame transmission across the bridge.

The probability of successful end-to-end data transmission is obtained by multiplying the probabilities associated with each bridge in the path together. This may lead to unacceptable situations if the load increases in one or more LAN segments. Unfortunately backbone LANs, only accessible via bridges, may be the most likely ones to experience high traffic loads. Thus care should be taken during design to ensure that such backbones have relatively few attachments (that is, bridges).

A backbone LAN sometimes needs to offer a transmission speed exceeding the speed of the lower level LANs that are interconnected. As explained before, 10 Mbps is a practical limit for CSMA/CD LANs. Backbone LANs based upon other medium access protocols may offer a more attractive solution, despite the need for installation of different cabling for the backbone.

A common routing technique used in CSMA/CD bridges is based on tables. Tables are dynamically built at the bridge level containing station addresses identified on both sides of the bridge. These tables may become quite large in an expanding LAN environment, and may consume considerable buffer space and processing capacity for table lookup and maintenance. This must be considered when configuring such bridges. In CSMA/CD LANs parallel active bridges to support heavier traffic would cause duplicate frames and collisions and thus are prohibited. One bridge routing algorithm, called spanning tree, does not allow duplicate frames and provides mechanisms to ensure that parallel bridges or routes are not concurrently active. Bridge routing techniques are discussed in "Bridging" on page 155.

2.2.2 Basic Token Passing Ring Concepts

A Token-Ring Network consists of the *attaching medium* and *ring stations* (devices able to attach to the ring and to use the link access protocols).

A token-ring network uses one of several twisted pair media specifications, each having its own price/performance ratio, and all suitable to carry most other data communications signals. A token-ring network may also use optical fiber media.

A single ring token-ring LAN installation is illustrated in Figure 7 on page 23.

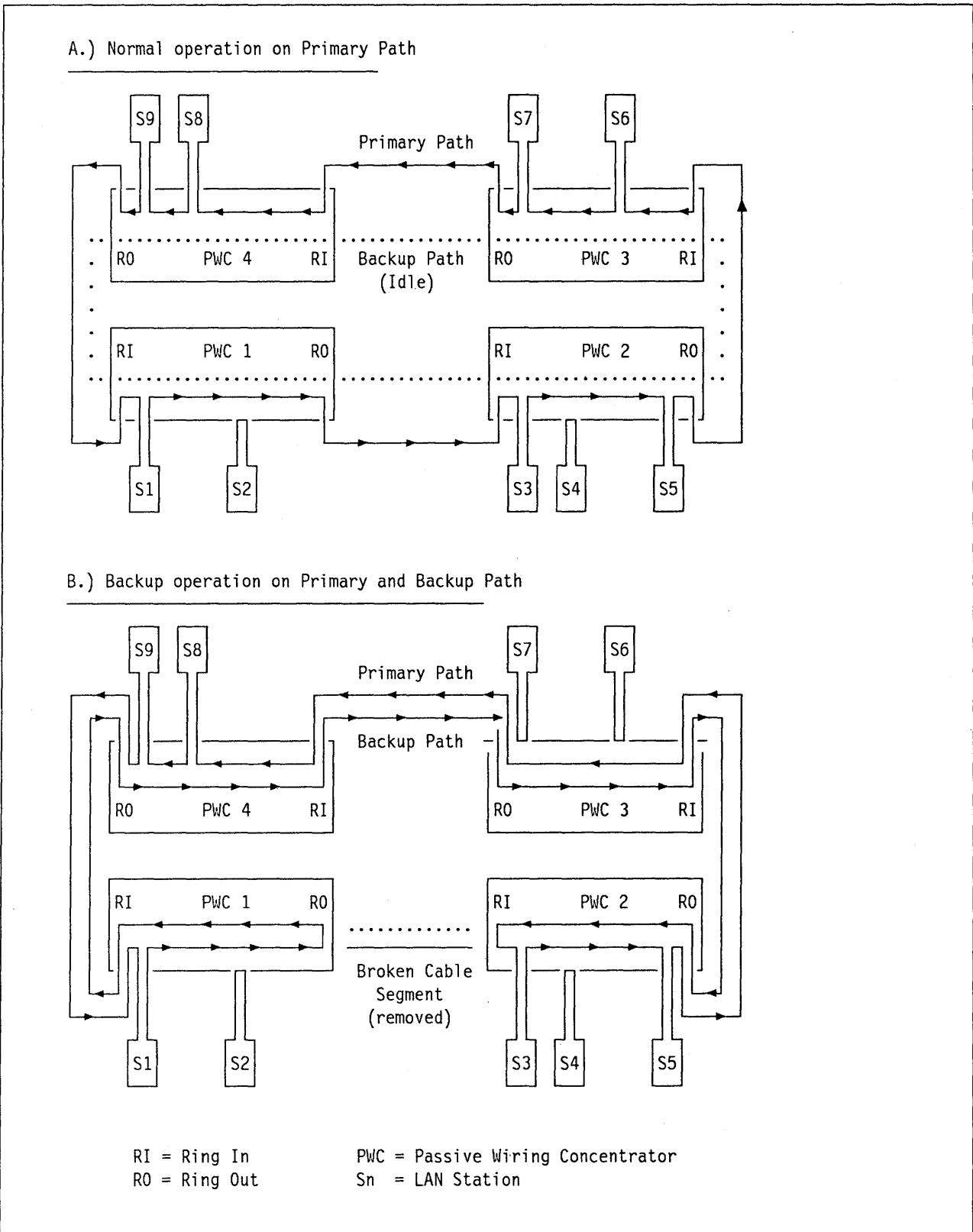


Figure 7. Token Passing Ring Data Paths

This figure shows four *passive wiring concentrators* and nine physically attached nodes. The power from the attached nodes when transmitted to the concentrator activates relays in the concentrator to allow the station to send

signals across the LAN to other stations. In Part A of Figure 7 two adapters (nodes S2 and S4) have not powered their respective PWC relays and therefore their lobe wires are internally bypassed. In Part B of Figure 7 four adapters (nodes S2, S4, S6 and S7) are not actively inserted into the ring (their lobe wires are internally bypassed) and the primary path is wrapped to the backup path in PWCs 1 and 2.

When a cable segment between PWCs fails, manual removal from the appropriate ring-in and ring-out connectors causes automatic wrapping of the primary path to the backup path. How such a permanent wire fault is reported for LAN management is explained in the discussion of beaconing later on in this section.

A ring station transfers data to the ring, in a data transmission unit called a *frame*. Frames are sent sequentially from one station to the next station physically active on the ring. This station is called the *downstream neighbor*. Each ring station repeats the frame. While doing so it performs error checking on the bit stream and it will copy the data if its own address is identified as a destination station in the frame. Upon return of the frame to the originating station, the latter will remove the data from the ring.

In a token passing protocol, a ring station can only transfer data to the ring while it is holding a *token*. The token is a specific bit sequence (24 bits) circulating around the ring at a rated speed (4 Mbps or 16 Mbps in current implementations, 100 Mbps according to the Fiber Distributed Data Interface specification; see "Fiber Distributed Data Interface Concepts" on page 44). Because of the high transmission speed with respect to the total ring length, a short ring might contain only a few bits at any point in time. Only one token may exist on a ring at any given point in time. Therefore, a delay equivalent to the time for a token to circulate the ring is required to ensure that no overrun occurs which would result in a station receiving a token that it is transmitting and thinking that a second token exists on the ring. For a 24-bit token this means a minimum 24-bit delay. In addition to this delay an additional elastic buffer is introduced to support the token protocols and speed.

In order to establish communication between any two ring stations, *addressing* mechanisms are needed. At the same time the integrity of the transmitted frames between ring stations must be preserved. Therefore data checking capabilities are required at the *medium access control* level of a ring station.

2.2.2.1 MAC Addressing

Any ring station is identified by a unique *individual address*. This address can be *Universally Administered*, assigned by the IEEE organization (see "LAN Architectures and Standards" on page 51). Because it is set in read-only memory (ROM) on a token-ring adapter card, the universally administered address is also called a *burned-in address*.

A ring station's individual address can also be *locally administered*, that is set at adapter-open time and typically defined by a network administrator.

A number of destination ring stations can be identified by a *group MAC address*.

A token-ring LAN also provides a special case of locally administered group addresses called *functional addresses*. Each (bit-significant) functional address

represents a well-identified server function within the access protocol. Of 31 possible functional addresses, 14 have been defined while the remaining ones are reserved for future use or may be user-defined as listed in Figure 8 on page 25.

Active Monitor	X'C000 0000 0001'
Ring Parameter Server	X'C000 0000 0002'
Network Server Heartbeat	X'C000 0000 0004'
Ring Error Monitor	X'C000 0000 0008'
Configuration Report Server	X'C000 0000 0010'
Synchronous Bandwidth Mgr.	X'C000 0000 0020'
Locate - Directory Server	X'C000 0000 0040'
NETBIOS	X'C000 0000 0080'
Bridge	X'C000 0000 0100'
IMPL Server	X'C000 0000 0200'
Ring Authorization Server	X'C000 0000 0400'
LAN Gateway	X'C000 0000 0800'
ring wiring concentrator	X'C000 0000 1000'
LAN Manager	X'C000 0000 2000'
User-defined	X'C000 0000 8000' through X'C000 4000 0000'

Figure 8. Functional Addresses

The most relevant protocol server functions will be described in greater detail in the bridge and LAN management sections (see "IBM LAN Bridges" on page 163 and "IBM LAN Manager" on page 268).

In addition two special destination address values have been defined. The *all-stations broadcast* group address X'FFFFFFFF' identifies all ring stations as destination stations. A frame carrying the individual *null address* X'000000000000' as its destination MAC address is not addressed to any ring station, therefore it can only be sent but not received.

IEEE allows vendors to implement either 16-bit or 48-bit MAC addresses. The actual address field formats are shown in the picture Figure 9.

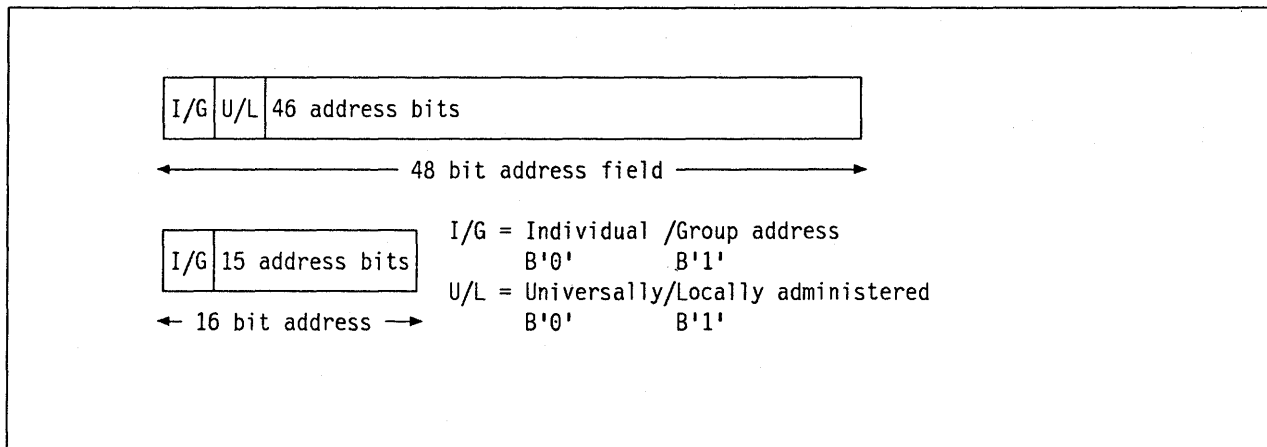


Figure 9. IEEE LANs - MAC Address Format

For the IBM LAN implementations, 48-bit addressing has been selected. The implementation format ⁷ is shown in Figure 10.

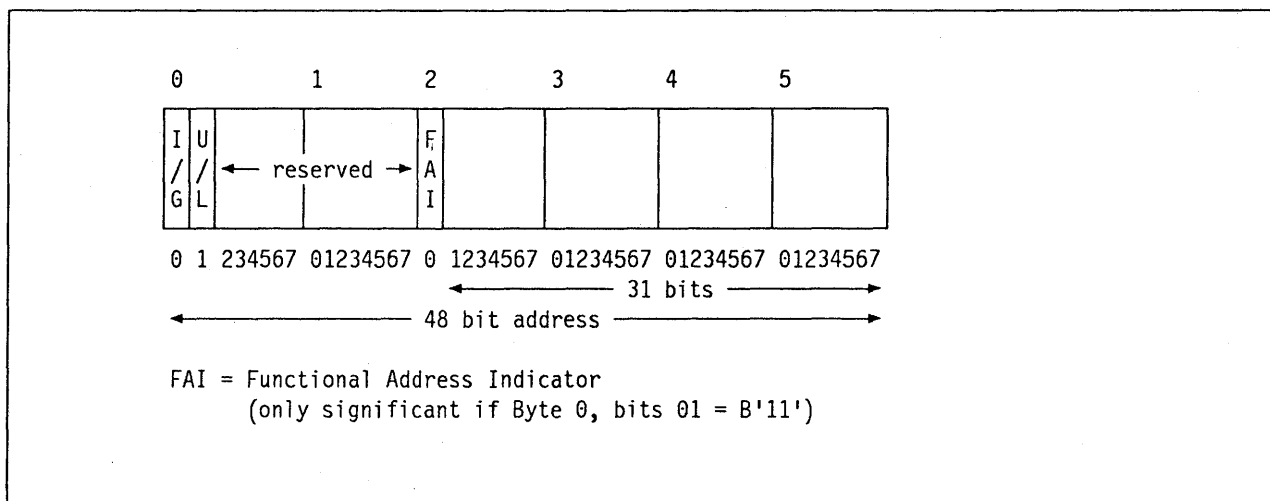


Figure 10. IBM Token-Ring Network - MAC Address Format

- The reserved bits are set to B'0' for locally administered addresses.
- Functional address indicator = B'0' indicates a functional address if I/G = B'1' (indicating a group address).
- For individual locally administered addresses, FAI must be B'0' by convention. This is an addressing anomaly.

These rules yield valid address ranges as described in Figure 11 on page 27.

⁷ The universal/local address field (Byte 0, Bit 1) in a source address is used to indicate the presence of routing information; see "IBM LAN Bridges" on page 163.

	I/G	U/L	FAI	Definition/Range
Individual, Universally Adm.	0	0	0/1	Mfg_Code,Serial_Number (IEEE assigned)
Individual, Locally Admin.	0	1	0	X'4000 0000 0000' - X'4000 7FFF FFFF'
Group Address	1	1	1	X'C000 8000 0000' - X'C000 FFFF FFFF'
Functional Address	1	1	0	X'C000 0000 0001' - X'C000 0000 2000' (bit-sensitive)

Functional Addresses are listed in Figure 8 on page 25.

Figure 11. Valid Address Ranges

One exception exists for 37xx Communications Controllers attached to the IBM Token-Ring Network. Due to an early VTAM/NCP⁸ restriction, locally administered address values X'7FFF FFFF' in bytes 2 - 5 may be considered invalid. Therefore, the individual locally administered address range

X'4000 0000 0000' - X'4000 7999 9999' is valid

for any IBM Token-Ring Network adapter⁹.

2.2.2.2 Data Transmission

The transmission technique used in token passing ring LANs is *baseband transmission*.

In a token-ring LAN, high-order bytes/bits are transmitted first, that is byte 0 is transmitted before byte 1 and high-order bit 0 within a byte (of 8 bits) is transmitted first. This transmission order can be different for other types of LAN segments using a different access protocol, for example, CSMA/CD. Opposite transmission order may be a diagnostic consideration when evaluating trace information from LAN segments of different nature because of the possible need to reorder the bits. The ability to reorder the bits without significant performance degradation, may also be a functional requirement of bridge products being considered for LAN segment interconnection.

⁸ NCP is a registered trademark of the International Business Machines Corporation

⁹ In fact, any adapter will accept X'4000 7dhd hdhd' where d=X'0'-X'9' and f=X'0'-X'F' as valid local addresses. However some software products, such as PC 3270 Emulation Program Version 3, reject non-decimal digits in the address specification.

Figure 12 on page 28 shows the format of the information to be transmitted on a token passing ring.

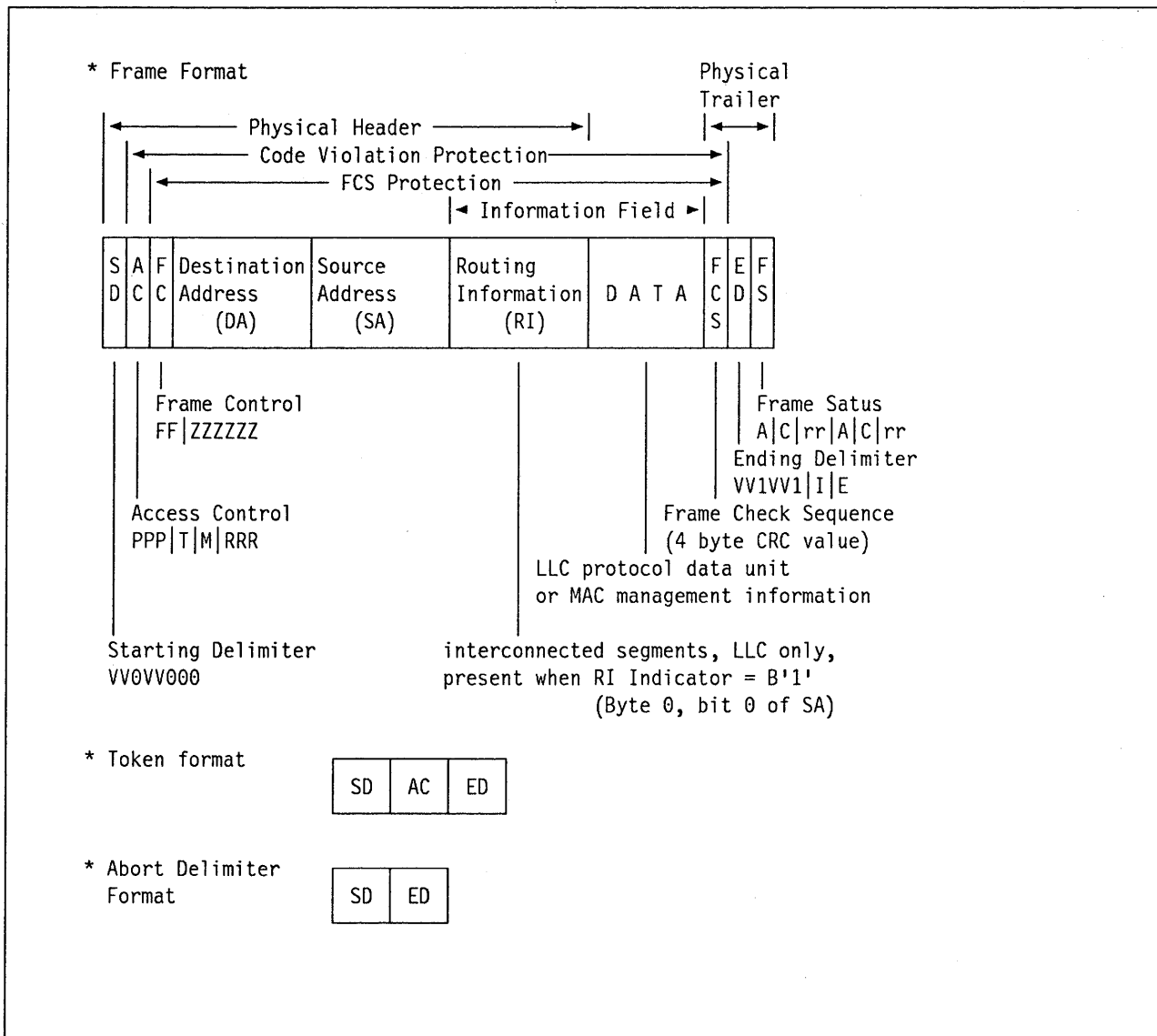


Figure 12. IEEE 802.5 MAC Frame and Token Format

Explanations for abbreviations used in the above figure include:

- SD - starting delimiter consisting of eight bits "VV0VV0 00" and
- ED - ending delimiter consisting of eight bits "VV1VV1 I E" where:
 - VV1VV1 refers to a '1' bit code violation (J) followed by a '0' bit violation (K). This is a function of the differential Manchester encoding scheme used in the Token-Ring Network. Refer to *IBM Token-Ring Network Architecture Reference* for a description of the use of Differential Manchester code violations to define starting and ending delimiters.
 - I is an intermediate bit, B'0' which indicates a single-frame or the last frame of a multiple-frame transmission using a single token.
 - E is an error-detected bit. B'1' indicates existence of a code violation between the starting and ending delimiters, a non-integral number of bytes in the frame or a cyclic redundancy check (CRC) error.

- AC - access control consisting of eight bits "PPP T M RRR" where:
 - PPP are priority bits (low B'000' to high B'111'). A ring station can use a token at a priority less than or equal to the ring station's allowed access priority.
 - RRR are reservation bits (low B'000' to high B'111') which allow a station with high access priority to request that a subsequent token be issued at the required priority.
 - T is the token bit (B'0' = token, B'1' = frame)
 - M is a monitor bit used to prevent continuously circulating frames or non-zero priority tokens. Refer to the functions of the active monitor in the discussion of "Token Monitoring" on page 32 for more details.
- FC - frame control consisting of eight bits "FF ZZZZZZ" where:
 - FF are Frame Type bits (B'00' = MAC frame, B'01' = LLC frame).
 - ZZZZZZ are Control bits (MAC buffering information or 000YYY where YYY indicates the intended LLC sublayer message priority).
- FS - frame status is an eight-bit field "A C rr A C rr" where:
 - A is an address recognized bit (B'1' indicates that a valid station has recognized the destination address)
 - C is a frame copied bit
 - rr are reserved bits

These bits are duplicated within the field because they not covered by the frame check sequence protection.
- Any originating ring station can abort a frame that is being transmitted at any time by transmitting an *abort delimiter*.

The information field in the MAC frame format has been split up into an optional routing information field and data. See "Source Routing" on page 158. In an LLC frame, the data field will contain a *logical link control protocol data unit* (LPDU, see "LLC Protocol Data Unit" on page 75).

When the frame control field indicates a MAC frame (because bits 0 and 1 of the field are equal to B'00') the data field contains specific MAC control information. It consists of a major vector length (LL), a major vector identifier (MVID) and zero or more subvectors as shown in Figure 13 on page 30. The command field within the MVID contains bit values (called code points) that uniquely identify the type of MAC frame.

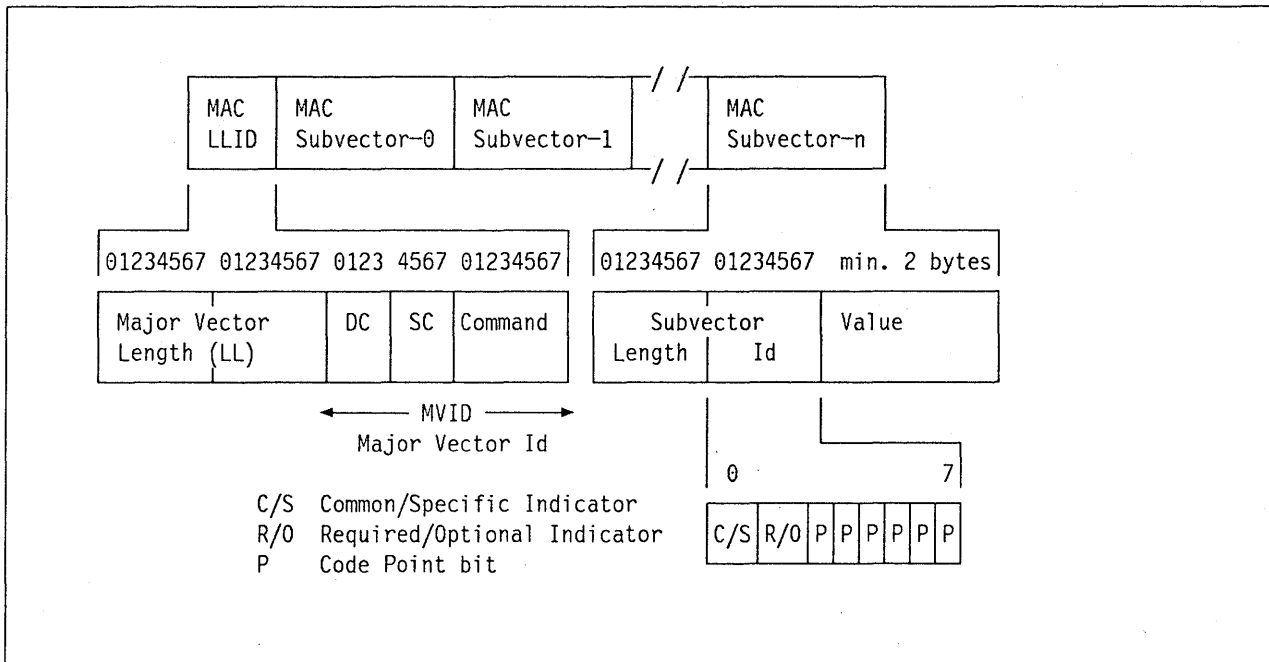


Figure 13. Token Passing Ring MAC Frame - Data Field Format

Examples of MVID code points are X'05' to indicate an Active Monitor Present MAC frame, X'02' for a Beacon MAC frame, etc.. Unique MVID values for 28 different MAC frames have been defined. A complete description can be found in the *IBM Token-Ring Network Architecture Reference*. Subvectors provide additional information depending on the specific major vector identifier.

MAC Frames are processed according to destination and source function classes, including:

- Ring station

The functions necessary for connecting to the LAN and for operating with the token-ring protocols. A ring station is an instance of a MAC sublayer in a node attached to a ring.
- DLC_LAN_MGR

The manager function of the data link control component activates and deactivates ring stations and link stations on command from the physical device. It also manages information transfer between data link control and the physical device.
- Configuration report server (CRS)

The CRS function resides on each ring in a multi-segment environment in which configuration is being monitored. This function receives notifications about station insertion and removal, and notifications about active monitor failures.
- Ring parameter server (RPS)

The RPS function resides on every ring in a multi-segment environment on which operational parameters are centrally managed. It may provide operational values to attaching stations upon request. For example, a ring station may request such parameters as ring number upon insertion into the ring.

- Ring error monitor

The REM server function is present on rings for which errors are to be monitored or analyzed. It collects error information from LAN stations attached to the local ring, analyzes soft error reports and may forward error reports to a LAN manager.

- IMPL server

The IMPL server function and its IMPL functional address are involved during the power-on process of a LAN station equipped with the remote program load feature. Such a station will insert into the ring to find a control program server on the ring from which to download its control program and complete its initialization processes.

- Configuration report server authorized

This is similar to the CRS function but refers to authorization for the LAN manager to perform specific functions.

2.2.2.3 The Token Passing Ring Protocol

To transmit data on the LAN medium, a ring station captures a *token*, and sets the token bit in the access control field to identify that the data being transmitted is a frame. To this header the transmitting station appends destination and source MAC addresses, data, a newly calculated frame check sequence field, and the ending delimiter and frame status fields.

Any subsequent station will receive and retransmit the frame while performing a CRC check. Such a station is said to be in *normal repeat mode*.

In general, a ring station in normal repeat mode checks the data in the tokens and frames it receives and sets the error-detected, address recognized or frame copied bits in a frame (bits E, A, or C) as appropriate while repeating the signal. A destination station will copy the data (*Frame Copying*) and pass the frame on. While processing the frame trailer, the destination station marks the A and C bits. Upon return to the originating ring station, the frame is removed from the ring and the A and C bits in the frame trailer's FS field are checked to see if the frame was recognized and read by the destination station or a bridge. When the frame header is received by the originating station the originating ring station must release a new token, possibly at different priority level, for another ring station to capture and proceed with data transmission. The priority reservation bits in the access control field of the returned frame together with stored priority levels in the originating station determine the priority of the new token. See the description of **access priority** later in this section for details.

This protocol is called a *single token* protocol, since only one token can circulate on the ring at any time.

2.2.2.4 Early Token Release

If an originating station releases a new token only when the frame header has circulated around the ring back to the source and the frame transmission time is shorter than the ring transmit time, then the originating station must generate idles until a header is received.

Token passing ring LAN protocols define the length of a token to be 24 bits and the shortest possible MAC frame to be 200 bits long. On a 4 Mbps token-ring

LAN where the length of 1 bit is roughly 50 meters, a complete token is 1,200 meters long while the shortest frame length would be 10,000 meters. Therefore at 4 Mbps, the percentage of potential bandwidth which remains idle can be extremely small (that is high bandwidth utilization can be maintained at higher traffic levels.)

If, however, we consider a 16 Mbps token-ring LAN, 1 bit being 12.5 meters long, a complete token and the shortest possible MAC frame become four times smaller (300 and 2,500 meters respectively). Now we may wish to optimize the utilization of the medium by reducing the idle time required by waiting for a header. Obviously when moving to even higher transmission speeds, for example, a 100 Mbps FDDI LAN the token passing protocol must be adjusted to achieve better utilization of the potential bandwidth.

The architecture provides an option called *early token release*. With this option a transmitting station will release the token after completing its transmission. In the IEEE 802.5 specifications, this release occurs following the transmission of the frame trailer, but before receipt of the header of the transmitted frame, thereby eliminating the idle time between transmission of the frame trailer and release of a new token. When such early release has occurred, an adapter indicator is set to prevent the adapter from releasing another token upon return of the frame header. This allows multiple frames, but still only one token to coexist on the LAN.

The early token release option may be enabled on a *16 Mbps IBM Token-Ring Network*.

2.2.2.5 Token Monitoring

Token passing protocols provide relatively greater control and management at the medium access control (MAC) level than that provided by CSMA/CD protocols. The token passing ring protocol concepts, described in the following sections, are implemented in the adapters themselves. They contribute to the availability, performance and manageability of a token-ring LAN.

At any point in time, one station and only one performs an *active monitor* function. Any ring station can act as the active monitor. Only one however, will have this function enabled.

Active monitor tasks support monitoring of the token and other ring management functions such as:

- Detection and recovery of a lost token or frame, including initiation of a token when a ring is started.
- Detection and recovery of a circulating priority token or frame.
- Detection and recovery of multiple tokens on the ring.
- Detection and recovery of multiple active monitors.
- Timing control to ensure accurate transmission regardless of the ring length.

All other ring stations are said to be *standby monitors*, prepared to take over the active monitor function should it fail.

The following description summarizes how the active monitor performs its ring management tasks:

- In every transmitted token or frame, the *monitor bit* (M) in the access control field is initially set to B'0'. As the active monitor repeats a frame or non-zero priority token, the M-bit is set to B'1'. If the M-bit had already been set to B'1', the active monitor assumes that the frame or token has already circled the ring once and that the originating station has not been able to remove the frame or priority token. The active monitor will purge the ring and generate a new token.
- To ensure that a complete (24-bit) token can be transmitted before the token returns to the originating ring station, the active monitor introduces a 24-bit ring delay.
- The active monitor periodically broadcasts an *Active Monitor Present* MAC frame. This forces each station on its ring to acquire the address of its *nearest active upstream neighbor* (NAUN) and to initiate a number of control timers within each station. This information is used when isolating errors on a ring and to determine the ring configuration.
- Loss of a token or frame is detected by expiration of an *any-token timer* whose time-out value exceeds the time required for the longest possible frame to circle the ring. The active monitor restarts this timer each time it transmits a starting delimiter. Upon expiration of this timer, the active monitor assumes a lost token or frame, purges the ring and originates a new token. The any-token timer value is defined as the sum of the physical trailer transmission delay plus the delay to transmit the longest frame. The IEEE 802.5 name for this timer is *Valid_Transmission_Timer*.

2.2.2.6 Ring Purge

To purge the ring, the active monitor broadcasts a *Ring Purge* MAC frame (indicated by X'04' in the frame control field) before originating a new token. Return of the Ring Purge MAC frame indicates proper signal propagation around the ring. The Ring Purge frame resets the ring stations to normal repeat mode, canceling or restarting all the appropriate timers. The active monitor starts a Ring-Purge Timer when sending the purge frame. This timer will expire if the frame can't circulate and the monitor will enter a recovery process called *Claim Token*.

2.2.2.7 Neighbor Notification

The *neighbor notification process* begins when the active monitor transmits an Active Monitor Present MAC frame to all stations on the ring (single ring broadcast). The first ring station that receives the Active Monitor Present MAC frame copies it (if possible) and sets the address-recognized (A) and frame-copied (C) bits to B'1'. It then saves the source address from the copied frame as its NAUN address (the address of the active monitor) and starts a timer called the Notification-Response timer.

All other active stations on the ring repeat, but do not otherwise process the Active Monitor Present MAC frame because the frame's A and C bits have already been set.

When the Notification-Response timer of the first station downstream from the active monitor expires, it broadcasts a Standby Monitor Present MAC Frame.

The next ring station downstream copies its NAUN address from the source address field of the Standby Monitor Present frame, sets the A and C bits to

B'1', and starts its own Notification-Response timer. When this timer expires, this station in turn transmits its Standby Monitor Present MAC frame.

In this way, Neighbor Notification proceeds around the ring, with each ring station receiving and transmitting Standby Monitor Present MAC frames until the active monitor copies its NAUN address from a Standby Monitor Present MAC frame. The active monitor then sets the Neighbor-Notification Complete flag to B'1', indicating that the process has been successfully completed.

Neighbor-Notification thus enables a ring station to learn its NAUN address, and to provide its address to its downstream neighbor.

2.2.2.8 Standby Monitor

Any ring station that is not performing the active monitor function acts as a *Standby Monitor*. Its purpose is to detect a failing active monitor and disruptions on the ring.

Each time a token or frame is repeated, a standby monitor restarts its *Good-token timer* (Any-token timer) to verify the presence of an active monitor.

A second timer, the *Receive-Notification Timer*, is restarted by a standby monitor each time it copies an *Active Monitor Present* MAC frame.

If any of these two timers expires, the standby monitor station will initiate the token-claiming process.

2.2.2.9 The Token-Claiming Process

This process, also called the Monitor-Contention Process, is the procedure by which ring stations elect a new active monitor. This process is started upon any of the following conditions by:

- The active monitor detecting
 - loss of signal
 - the Active Monitor Present MAC frame doesn't return (Receive-Notification Timer expires)
 - failure of Ring-Purge MAC frames to return completely (Ring Purge Timer expires)
- A standby monitor detecting
 - loss of signal
 - absence of active monitor's token management functions (good_token timer expires)
 - missing Neighbor_Notification process (Receive_Notification_Timer expires)
- A ring station attaches to the ring and does not detect an active monitor (for example, when it is the first station on the ring).

The ring station detecting one of these conditions enters Claim-Token-Transmit mode by broadcasting a *Claim Token* MAC frame and repeating it at a defined

interval. Each participating ring station¹⁰ compares the address in the Claim Token MAC frame's source address field to its own.

- If the source address is greater than the ring station's address, the station enters Claim Token Repeat operating mode.
- If the source address is less than the ring station's address, the station transmits its own Claim Token MAC frames.
- If the source address is the same as the ring station's address, it continues broadcasting until it has received three of its own Claim Token MAC frames. This indicates that the ring is viable and the station has won token-claiming.

The station then adds the token delay to the ring, purges the ring, starts its active monitor timers, and releases a new token. It is now the new active monitor.

2.2.2.10 Ring Station Insertion

This process is executed by any ring station when entering the ring. It is also known as the five-phase insertion process:

- Phase 0: Lobe testing.

A series of Lobe Media Test MAC frames is sent on the lobe wire to the multi-station access unit. The signal is wrapped at the entry into the multistation access unit causing the frames to return to the station. Then the receive logic is tested. If the tests are successful, a five volt DC voltage (also called *phantom current*) is sent to open the relay and attach to the ring.

- Phase 1: Monitor check.

The attaching station starts its Insert timer, and watches for an Active_Monitor_Present, Standby_Monitor_Present or Ring Purge MAC frame before this timer expires. If the timer expires, token-claiming is initiated. When "first station on ring", the attaching station will become the active monitor.

- Phase 2: Duplicate Address check.

The station sends a Duplicate Address Test MAC Frame (destination address = source address = station's unique address). If a duplicate address is found (A-bit = B'1'), the station detaches from the ring.

- Phase 3: Participation in Neighbor_Notification

The station learns its nearest active upstream neighbor (NAUN) and reports its own address to its nearest active downstream neighbor.

- Phase 4: Request Initialization

A Request Initialization MAC frame is sent to the ring parameter server, if present (if not, default values will be used). The ring parameter server responds with a Initialize_Ring_Station MAC frame. Parameters which can

¹⁰ Every ring station contains an option that indicates whether it will participate in token claiming. However, if the ring station detects the condition, it has to initiate the process.

be set are physical location, soft error report timer value, ring number and ring authorization level. In this way the last three parameters may be set to the same values for all stations on the ring.

2.2.2.11 Hard-Error Detection and Reporting

A *hard error* is a permanent fault that stops normal traffic on the ring. It is usually detected first at the receive side of the ring station downstream from the fault. A change in ring configuration is required to bypass such a fault and to restore normal operation. Reconfiguration may be the result of automatic recovery or, if this process fails to bypass the error, it may require manual intervention.

When a ring station detects a hard error, it starts transmitting at a specified time interval *Beacon* MAC frames until its input signal is restored or until it removes itself from the ring. The detecting station also starts a Beacon timer. All other stations enter *Beacon_Repeat* mode when they receive a Beacon MAC frame.

A beacon frame identifies the address of the nearest active upstream neighbor of the beaconing station as well as error type information.

When the beaconing station's NAUN has copied a number of these beacon frames, the NAUN will go offline and perform microcode and lobe tests. If the tests are successful, the station reattaches to the ring immediately. If the tests fail, the station stays offline.

When the beacon timer expires in the detecting (beaconing) station, and normal traffic has not been restored, the station assumes that its NAUN went offline, found no errors and came back online. It will now go through the same process as its NAUN. If the tests fail, the beaconing station remains detached. If successful, the station reattaches immediately. In the latter case, normal traffic may not have been restored during automatic recovery. Network management will be informed (ref. "IBM LAN Manager" on page 268) and manual intervention will be required. While reporting a permanent hard error, a set of adapter addresses is provided to identify the faulty part of the ring as a small *fault domain*.

2.2.2.12 Soft-Error Detection and Reporting

Intermittent faults that temporarily disrupt normal operation of the ring are called *soft errors*. They are usually tolerated by error recovery procedures but they may impair normal ring operation if excessive or non-random.

The most critical soft errors are monitored in each ring station by means of a set of counters. Every two seconds the values of the soft error counters are sent as a Soft Error Report MAC frame to the Ring Error Monitor functional address (typically residing in a bridge or LAN manager station), where the values for each counter are accumulated. If a soft error counter exceeds a predefined threshold, a LAN Manager will be informed through its link with the LAN reporting mechanism. The LAN Manager may reconfigure the ring to bypass a faulty node, if the fault can be located.

Soft errors are said to be *isolating* if a fault domain can be specified. If not, they are called *non-isolating* soft errors.

2.2.2.13 Access Priority

The following discussion applies both to 4 Mbps and 16 Mbps token-ring LANs and is an integral part of the token passing ring protocol. This access priority architecture is not applicable to the FDDI protocol where access priority is based upon timers rather than the contents of an access control field.

As stated earlier, access priority in a token or frame is indicated the first three bits (PPP) of the access control field (AC). Any reservation of a priority level is indicated in the last three bits (RRR) of the AC field by a station requiring higher transmission priority.

A ring station wishing to transmit a frame at a given priority can use any available token with a priority level equal to or less than the priority of the frame to be transmitted. If such a matching token is not available, the ring station may reserve a token of the required priority in a passing token or frame according to the following rules:

- If the passing token or frame already contains a priority reservation higher than the desired one, the ring station must leave the RRR bits unchanged.
- If the RRR bits have not yet been set (RRR = B'000'), or indicate a lower priority than the desired one, the ring station will set the reservation bits to its required priority.

Upon removal of a frame by its originating station, the reservation bits in the header are checked. If they show a non-zero value, the station must release a non-zero priority token. The actual priority of the new token is based on the priority used by the ring station for the recently transmitted frame, the reservation received upon return of the frame and any stored priority.

A ring station originating a token of higher priority enters *priority-hold state*, (also called a *stacking station* in the IEEE 802.5 token passing ring standards).

Figure 14 on page 38 lists the priority definitions as provided by the IBM Token-Ring Network architecture.

This protocol option however, impacts the priority handling mechanism, since a new token may be transmitted by the originating station before it is able to verify the access control field in its returned frame.

If the frame header was already received, the token will be issued according to the priority and reservation requested for in the AC field of the frame and the resulting priority levels stored in the station.

If the frame header has not yet been completely received by the originating station, the token will be released with the same priority and reserved priority as the transmitted frame.

B'000'	Normal User Priority MAC frames that need no token Response type MAC frames
B'001'	Normal User Priority
B'010'	Normal User Priority
B'011'	Normal User Priority MAC Frames that need token
B'100'	Bridge
B'101'	reserved for IBM
B'110'	reserved for IBM
B'111'	Specialized Station Management

Figure 14. Token Passing Ring Protocol - Priority Allocation Table

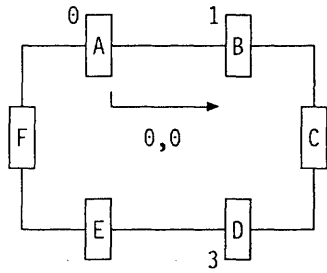
To prevent a high-priority station from monopolizing the LAN medium and to make sure the priority eventually can come down again, the protocol provides *fairness* within each priority level. Figure 15 on page 39 shows how fairness within a priority is maintained.

2.2.2.14 Additional Token Passing Ring Considerations.

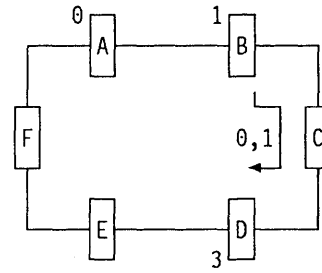
Using an average frame size of 1000 bits to simulate the performance of a 4 Mbps Token passing ring LAN with 100 active LAN devices results in a maximum throughput of about 3.6 Mbps. The token passing ring protocol appears to be particularly stable and even most efficient under high load conditions.

The impact of increased transmission speeds, increased numbers of attached stations, or increased transmission distances on a token passing LAN is significantly less than similar changes on a CSMA/CD LAN. Because each station regenerates the signal, increased distances are easier to support, while transmission speed is primarily limited by the choice of media. The use of bridges to provide additional device capacity and / or distance is an attractive growth option because the absence of collisions simplifies the processing requirements of bridges and maintains the deterministic characteristics of the protocols.

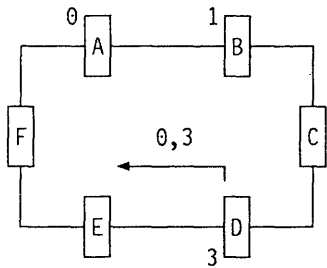
In a token passing ring, fairness in the access protocol and high priority utilization by the bridge helps avoid frame loss. Even when a frame is rejected due to bridge congestion, successful recovery is simplified by the protocol.



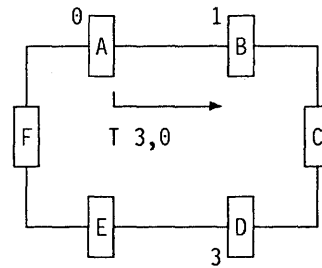
- 1) Station A generates a frame with $P,R = 0,0$ using a non-priority token.



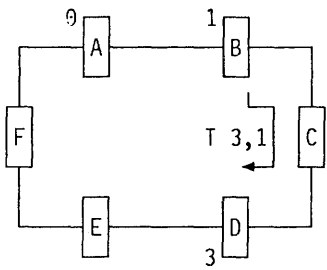
- 2) Station B reserves a priority of 1 ($P,R = 0,1$) in the frame



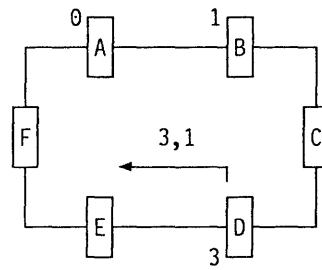
- 3) Station D reserves a higher priority of 3, overriding B's reservation ($P,R=0,3$).



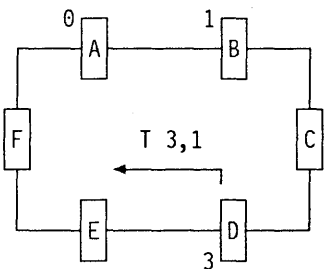
- 4) Station A removes its frame and generates a token at $P,R = 3,0$. A enters Priority-Hold state.



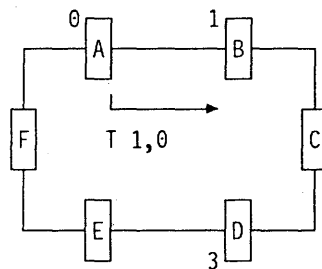
- 5) Station B repeats priority token making a new reservation ($P,R = 3,1$).



- 6) Station D transmits its priority frame with $P,R = 3,1$.



- 7) Station D removes its frame upon return and generates a token at the priority just used ($P,R = 3,1$). Station A is still in Priority-Hold state awaiting a token of the priority



- 8) Station A originates a token at priority level 1 (as reserved) with $P,R = 1,0$ and stays in Priority-Hold state to take the priority ultimately down to level 0.

Figure 15. Token-Passing Ring protocol - Access Priority, No Early Token-Release

2.2.3 Basic Token Passing Bus Concepts

The *token passing bus medium access protocol* is differentiated from the token passing ring protocol mainly by topology requirements and by a timer-based token management approach.

In a bus topology there is no physical sequence between stations. To be able to pass the token from one station to its successor station in a logical ring fashion, specific medium access function must be provided to initiate and maintain the logical ring sequence allowing non-disruptive station insertion or removal.

Instead of relying on a token monitor function as in the token-passing ring access protocol, token management is distributed among all stations involved in token passing based on specific timer values and a continuous measurement of the traffic load on the bus.

Some stations which do not require the ability to transmit frames are said to be *non-token holding* stations. They can only receive frames and are bypassed by the access protocol at token passing time. These stations are only allowed to respond to requests for acknowledgement.

As in any token passing protocol, a station is only allowed to transmit data while it holds the token. Possession of a token can therefore be described as the right to transmit.

In a token passing bus, the appearance of a logical sequence between stations is provided by a concept of predecessor and successor stations. Each station on the medium capable of participating in token holding establishes the identity of its *logical* predecessor and *logical* successor station (independent of physical arrangement on the medium) on the basis of the descending numerical order of MAC addresses of each station. Thus the logical sequence of the stations in Figure 16 on page 40 would be A - C - D - B.

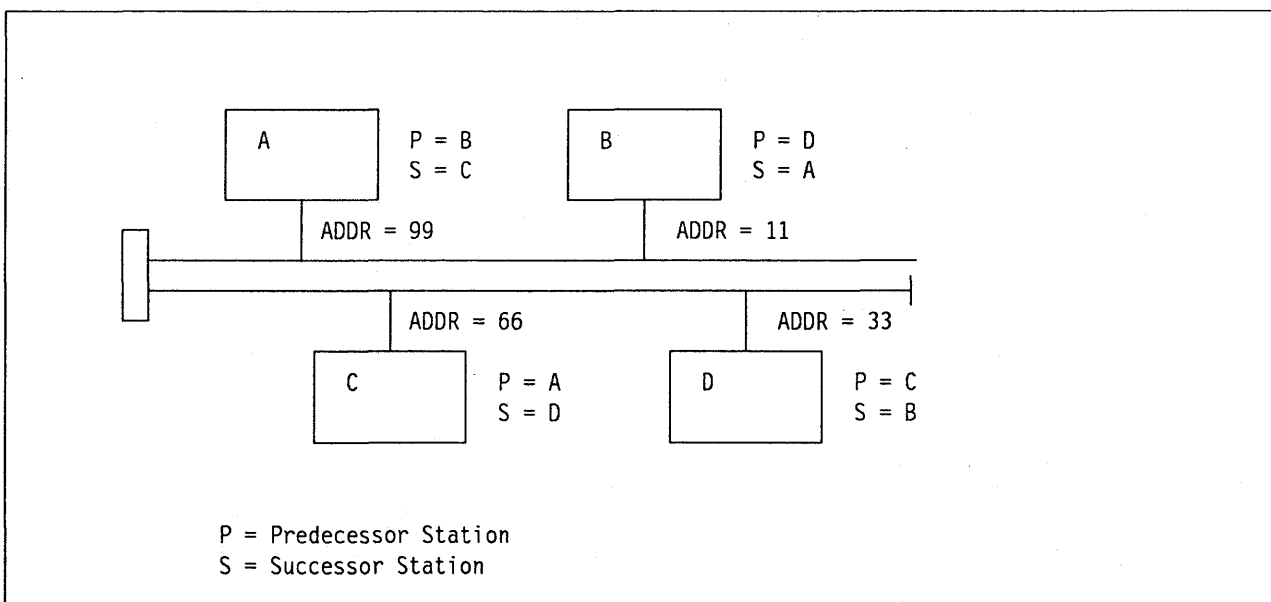


Figure 16. Token Bus Logical Sequence of Stations

The token is normally passed from station to its successor station using a short *token pass frame*. If a station fails to pick up the token, the sending station uses

a sequence of increasingly comprehensive recovery procedures to find a successor station.

2.2.3.1 Frame Format

Figure 17 on page 41 shows the frame format as transmitted on a token passing bus, including the format of a token frame. Note the absence of access control and frame status fields as present in a token passing ring MAC frame.

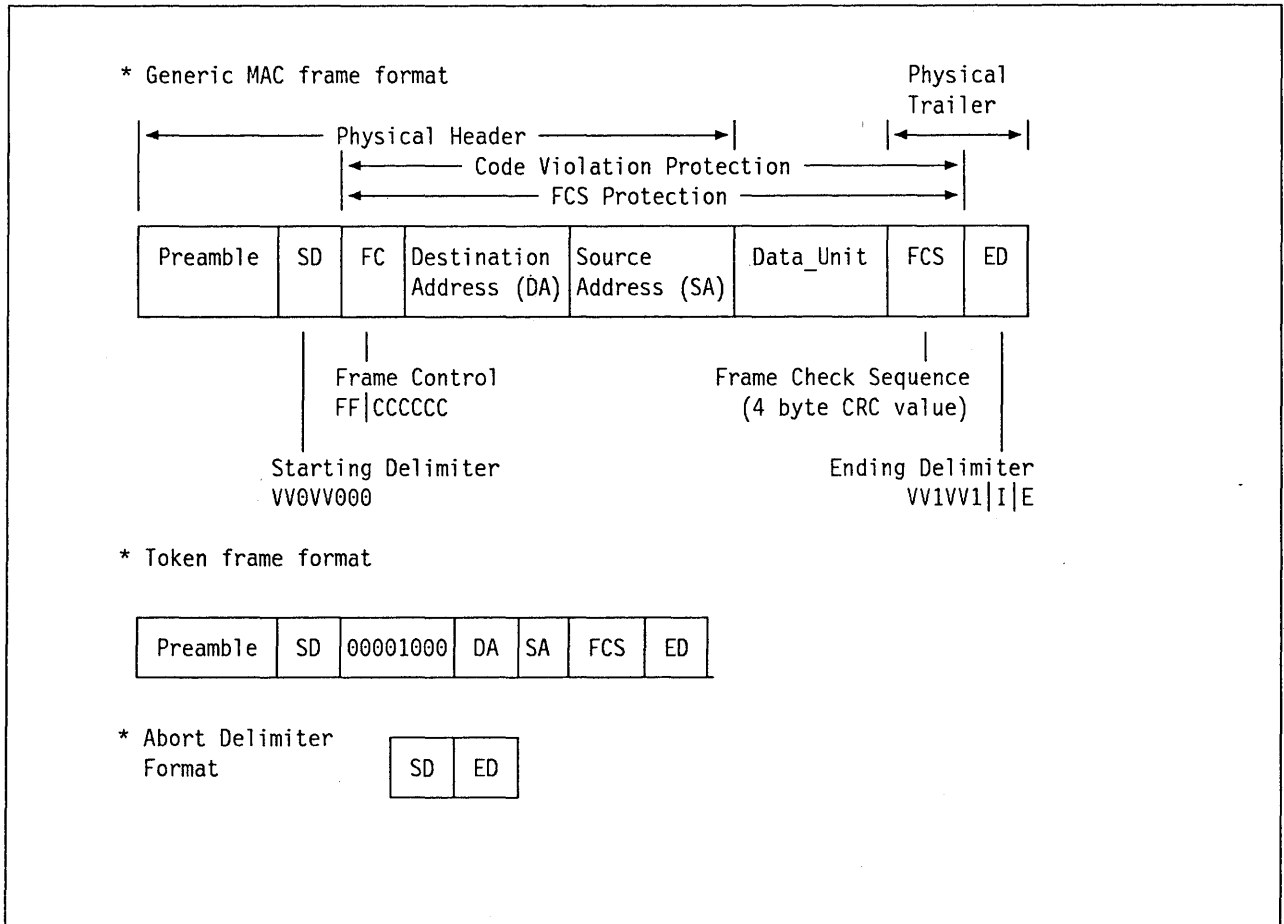


Figure 17. IEEE 802.4 MAC Frame Format

- Preamble - a number of padding bytes used in broadband transmission by the receiver to acquire signal level and phase lock using a known pattern. It also guarantees a minimum End Delimiter (ED) to Start Delimiter (SD) time period to allow processing of the frame previously received.
- SD, ED - see token passing ring frame format
- FC - FF = B'00' - MAC control frame, CCCCC = frame type
 - B'000000' = Claim Token
 - B'000001' = Solicit_Successor_1
 - B'000010' = Solicit_Successor_2
 - B'000011' = Who_Follows
 - B'000100' = Resolve_Contention
 - B'001000' = Token

- B'001100' = Set_Successor
 - FC - FF = B'01' - LLC_data frame, B'10' = Station_Management frame, B'11' = reserved.
- CCCCCC = MMMPPP, PPP = LLC sublayer message priority and MMM = MAC action:
- B'000' = Request_With_No_Response
 - B'001' = Request_With_Response
 - B'010' = Response
- SA, DA - 48-bit MAC address fields, see Figure 9 on page 26.
 - Token frame format - a token is transmitted as a specific MAC control frame with DA = unique MAC address of the successor station and a null data_unit.

When a frame is received by a station, it is checked for transmission errors. Invalid frames are not passed to the LLC sublayer. A MAC frame is invalid if any of the following conditions occurs:

- The frame does not contain an integral number of bytes.
- The result of the cyclic redundancy check upon arrival does not match the contents of the FCS field.

2.2.3.2 The Token Passing Bus Protocol

The major token passing bus MAC functions cover:

- Ring initialization (Claim Token MAC frame)
- Station addition (Solicit_Successor frame)
- Station removal (Set_Successor frame)
- Recovery and management, including:
 - Bus idle conditions
 - Token passing failures
 - Duplicate token
 - Detection of a station with a faulty receiver
 - Duplicate addresses.

When the network is first powered up, or after a catastrophic error, the logical ring needs to be initialized. This process is triggered by the *bus_idle timer* expiring in a LAN station. The detecting station sends a *Claim Token* MAC control frame.

As described above, each participating station knows the address of its *predecessor*, the station that transmitted the token to it and its *successor*, the station to which the token should be sent next.

After a station has completed transmitting data frames and has completed other logical ring maintenance functions, the station passes the token to its successor by sending it a token MAC control frame. Any failure in reaching a successor station triggers a staged recovery mechanism, using other MAC control frames

(*set_solicitor_1* and *set_solicitor_2*). If the token holder does not receive a valid token after sending the token the first time, it repeats the token pass operation. If the successor doesn't transmit after a second token frame, the sender assumes that its successor has failed and sends a *Who_Follows* MAC control frame containing its successor's address in the data field. The station detecting a match between its predecessor and the address in the *Who_Follows* frame data field will respond by sending its address in a *Set Successor* MAC control frame. In this way, the token holding station establishes a new successor excluding the failing station from the logical ring.

Stations are added to the logical ring through a controlled contention process using *response windows*, a specific interval of time common to all stations, and based on numerical address comparisons. The actual procedure is referred to as the *Solicit_Successor procedure*.

This procedure however raises a concern with respect to excessive delay experienced by a station before gaining access to the LAN when many stations attempt to insert into the logical ring and perform the solicit successor procedure. The time a station has to wait between successive passes of the token is called the *token rotation time*. To avoid an excessive TRT, every station measures the rotation time of the token. If the time exceeds a predefined value set by station management, the station will defer initiation of the solicit successor procedure, and verify at the next appearance of the token whether it is now rotating fast enough to perform the procedure.

A station can remove itself from the logical ring simply by not responding anymore to the token passed to it. Ring station sequence recovery procedures will adjust the successor and predecessor information in the predecessor and successor stations respectively.

A more efficient way of leaving the logical ring is to have the exiting station send a *Set Successor* MAC control frame to its predecessor, containing the address of its successor.

2.2.3.3 Access Priority

The token passing bus protocol provides an optional 8-level priority mechanism by which higher layer data frames, LLC sublayer or higher level protocols, are assigned to eight different *service classes* according to their desired transmission priority. Service classes range from 0 (low) to 7 (high).

At the access method level, there are four *access classes*, corresponding to four request queues to store pending priority frames. Access classes are 0 (lowest), 2, 4 and 6 (highest priority).

Token bus MAC maps the service class requested by the LLC sublayer into a MAC access class (service classes 0 and 1 into access class 0, service classes 2 and 3 into access class 2, etc.).

The purpose of this priority mechanism is to allocate bandwidth to the higher priority frames and to send lower priority frames only when there is sufficient bandwidth left. To prevent any station from monopolizing the medium with access class 6 frames, a station can only send class 6 frames for a maximum time defined by station management. When this time expires a station must release the token even if it has additional class 6 frames ready to transmit.

Similarly, each access class is assigned a *target token rotation time*. For each access class a station measures the time it takes the token to circulate the logical ring. If the token returns to a station in less than the target token rotation time, the station can transmit more frames of that access class until expiration of the TTRT. If the token takes more than the TTRT for a specific access class, no frames of this priority class can be sent at this pass of the token. The actual algorithm consists of loading the residual value of a token rotation timer into a *token_holding timer*. If an access class's queue is empty or if the token_holding timer expires, the station begins to serve the next lower access class. When the lowest priority class is serviced the station performs any required logical ring maintenance operation and releases the token for its successor station.

2.2.4 Fiber Distributed Data Interface Concepts

An FDDI LAN is a counter-rotating ring, involving a double fiber connection between adjacent nodes. In this way a dual fiber optic logical ring is achieved in which stations are be connected to both the primary and the alternate paths (Class A stations). FDDI also defines a class of stations (Class B) which are connected only to the Primary Path.

This is unlike a token passing ring in which the ring stations are physically connected to the Primary Path only and use of the alternate path is caused by wrapping the signal at a wiring concentrator or repeater to recover from errors. Refer to "Basic Token Passing Ring Concepts" on page 22.

An FDDI Ring may be represented as in Figure 18.

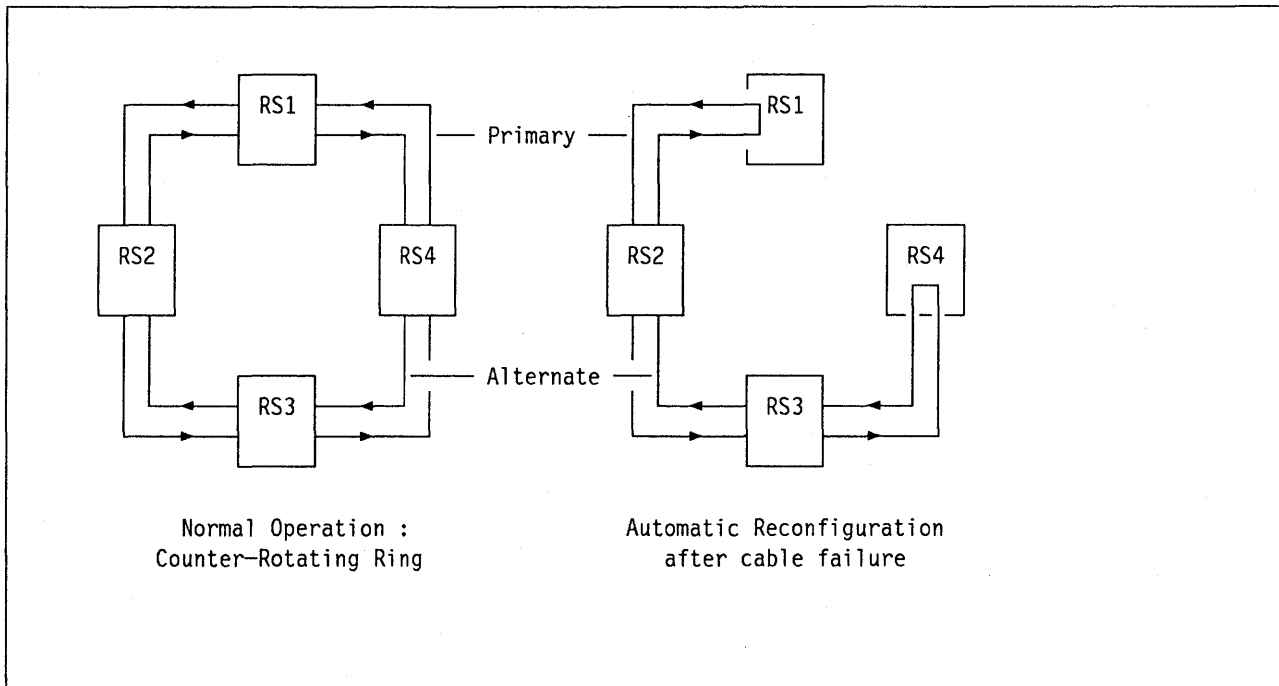


Figure 18. FDDI Physical Installation

2.2.4.1 The Fiber Distributed Data Interface Access Protocol

The access protocol maintained on a FDDI LAN is called the *FDDI timed token access protocol*. This token passing protocol contains features of both the token passing ring and the token passing bus standard protocols with some adjustments to reflect the higher effective transmission speed of 100 Mbps and requirements for real-time applications.

Medium access in FDDI is controlled by *timers* in each station. As in the token-ring network with early token release, an FDDI station appends the token to the end of its transmission. If an increasing number of stations use the appended token to insert their own frames before releasing the token, it will take more time for the token to get around the ring. To minimize the impact of this delay on real-time applications, each station measures the time between successive appearances of the token. An increasing *token rotation time* indicates higher traffic load on the LAN, in which case the available bandwidth may be restricted to higher priority traffic.

Therefore, FDDI applications are divided into two classes. Applications are said to require *synchronous service* if they require access to the ring within a specified time period. FDDI synchronous service provides both guaranteed *bandwidth* and *response time*.

Asynchronous service applies to those applications which need to be serviced only when the load on the ring drops below a predefined level. In FDDI, asynchronous service is available whenever sufficient time is available. In general, with this type of service there is no guarantee for bandwidth or response time. One subclass of asynchronous service, called *restricted asynchronous service* provides some bandwidth and response time guarantees once asynchronous service transmission has been initiated.

Synchronous service implies that each station is allocated part of the total bandwidth of the ring for this purpose. To be able to offer asynchronous service on a FDDI LAN, the total bandwidth cannot be allocated to synchronous service.

The FDDI timed token access protocol establishes the rules for the length of time that a station holds the token and therefore is authorized to transmit data, and provides synchronous and asynchronous service operation. Medium access in FDDI is controlled by timers and counters residing in each ring station.

Every time a ring station receives the token, it may transmit synchronous data for a time allocated to synchronous service operation. If the token rotates around the ring in a time less than the *operational token rotation time* value, determined during the ring initialization process, there is bandwidth left for the station to transmit asynchronous frames. Otherwise asynchronous traffic will be delayed until the traffic load in the FDDI LAN drops sufficiently.

If time is left for asynchronous traffic, all the asynchronous bandwidth available on the ring may be allocated to applications requiring restricted asynchronous service. This type of service provides some guarantee for bandwidth and response time once restricted service has started (that is, after any synchronous traffic and dependent on the total amount of restricted asynchronous traffic). Restricted asynchronous service is provided by the concept of a *restricted token* which can only be captured by any station having restricted frames to transmit.

2.2.4.2 FDDI frame format.

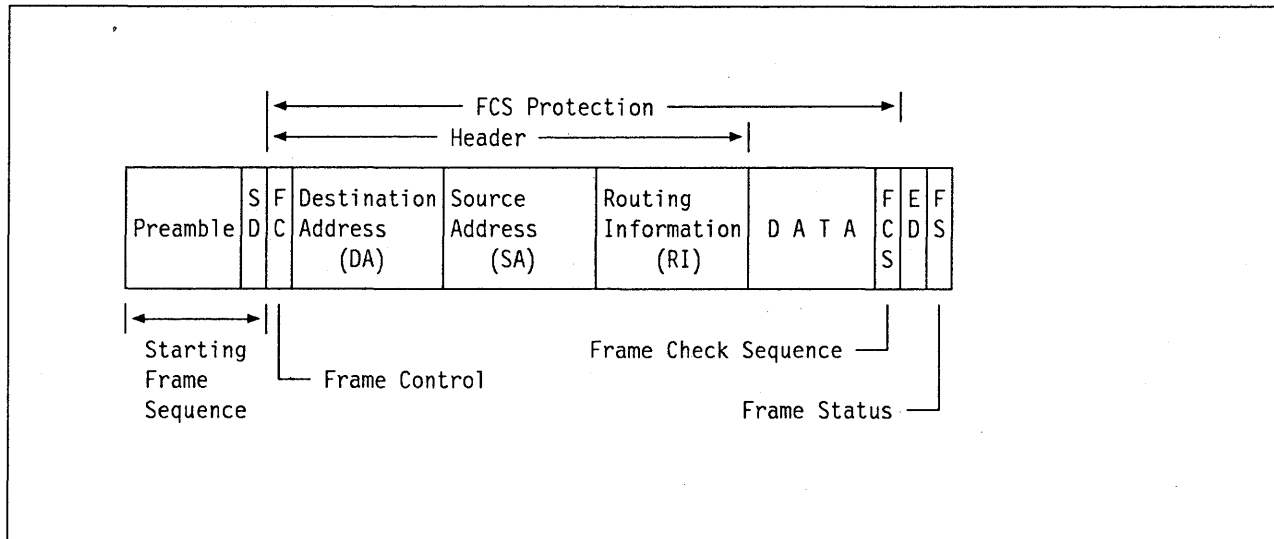


Figure 19. Fiber Distributed Data Interface - Frame Format

The frame format used in an FDDI LAN is very similar to the frame format used in a token-ring network. The primary differences include the use of a preamble to support fiber transmission, and the use of 4bit/5bit encoding to support higher transmission speeds.

- The preamble is at least 64 bits long.
- Starting delimiter and frame control fields each have 8 bits
- MAC addresses are 48-bit addresses, with the same format as in the IEEE MAC standards.
- The frame check sequence is the 32-bit result of a CRC check.
- There is a 4-bit ending delimiter
- The frame status field contains at least 12 bits.

2.3 LAN Interconnection

Different segments of a LAN may be interconnected to form a single logical network.

2.3.1 Network Interconnection Techniques

Techniques for interconnection may be classified into three categories as shown in Figure 20 on page 47.

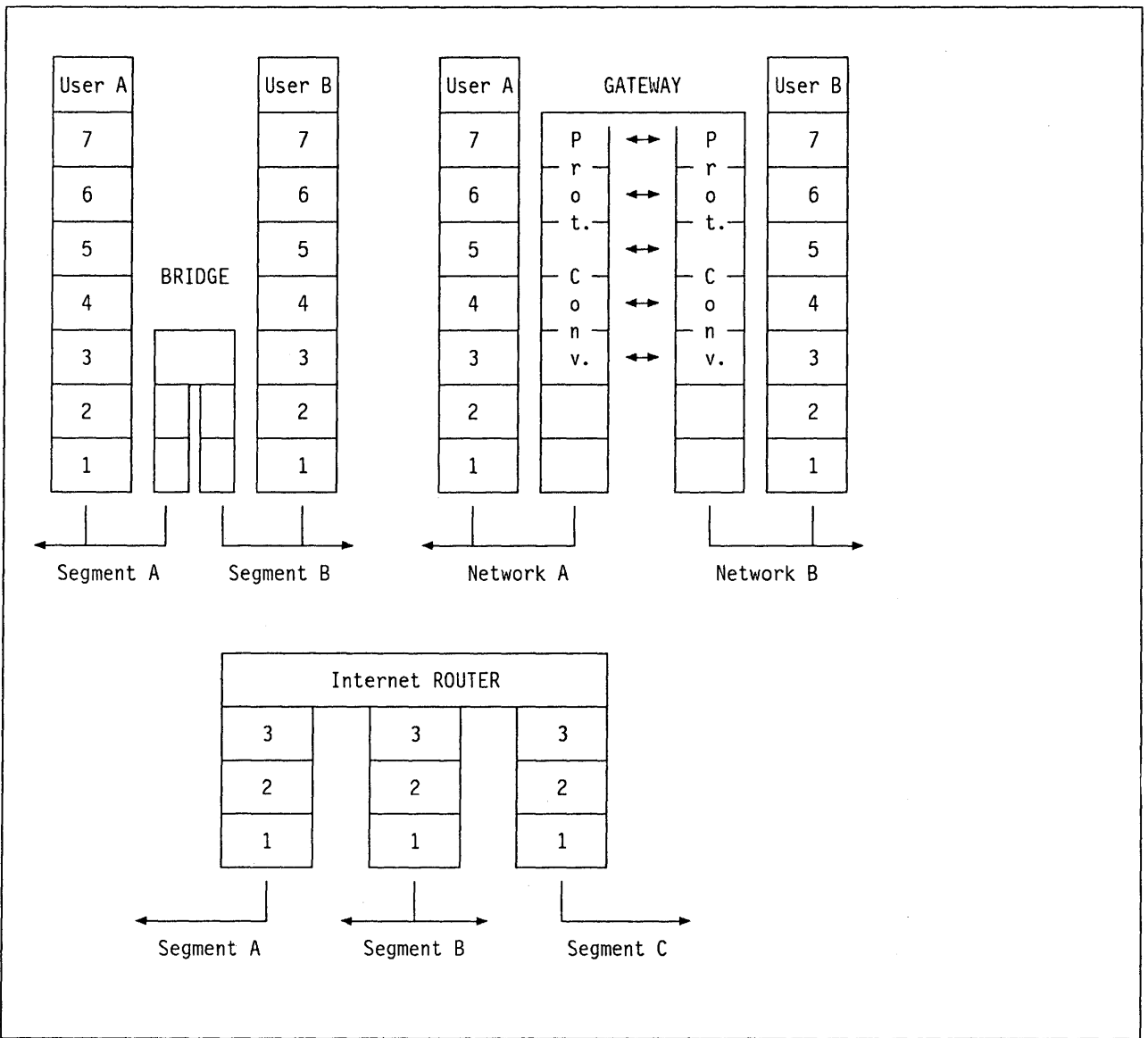


Figure 20. Network Interconnection Techniques (Based upon OSI Reference Model Layers 1 - 7)

The numbered boxes refer to the seven layers of the OSI Reference Model, summarized in "LAN and Communications Standards" on page 51.

Optimal performance can be achieved by interconnecting at the lowest possible level, starting from levels 1 and 2, and supporting the same protocol for the network segments to be interconnected.

At a particular interconnection either two or more segments may be interconnected.

Apart from expanding the logical network, interconnection may be considered for such other important reasons as improving the availability or for providing autonomous network management entities.

- Bridges link segments together at the medium access control (MAC) level, forwarding frames on the basis of routing or broadcast information in the frame. Applications providing the necessary routing information must use

LLC level commands to establish the route to be used. The LAN segments bridged together must share the same logical link control sublayer. Refer to "Logical Link Control Sublayer" on page 70. In general, all stations in a bridged local area network must use the same length MAC address (either all stations use 16-bit addresses or all stations use 48-bit addresses, see Figure 9 on page 26). It is desirable for each specific MAC address to be unique throughout the bridged LAN to permit unambiguous station addressing.

Bridging may provide dynamic routing, transparent to the higher level protocols. Above the DLC layer, bridged LAN segments appear as one single logical LAN. However, the LAN segments may have dissimilar medium access protocols.

Because of the low level at which interconnection is established, bridging is likely to be an optimal solution for connecting LAN segments.

The IBM Token-Ring Network Bridge Program is an example of a bridge implementation which connects *two* ring segments at each bridge. It uses an architecture called source routing in which the route to be followed is carried within each frame.

Another bridge architecture, called transparent bridging, allows interconnection of *two or more* ring segments within each bridge and uses tables within the bridge to determine when and over which port to forward frames.

- A router offers segment interconnection at the network layer. The routing service provided by this approach however is not transparent and must be explicitly called if access to remote network segments across the router is required.

Various router products interconnect more than two network segments. These segments must all share a common Network Layer protocol, such as Internet ¹¹.

- Gateway interconnection uses quite a different approach. A gateway is a system which supports more than one architecture or network addressing scheme to permit connectivity and interoperability between the devices in the attached environments.

Gateway products support mapping of addresses from one network to another, and may also provide transformation of data between the environments to support end-to-end application connectivity. Depending upon the amount of processing involved, and the number of environments supported by a gateway, a gateway will usually provide less throughput than an equivalently priced bridge or router. However, it may be the most cost-effective way to interconnect totally different networks.

¹¹ Internet (IP) is a non-proprietary protocol which operates at the level of the OSI Network Layer and is part of TCP/IP. TCP/IP is a set of protocols and specifications of the US Department of Defense that originated with the ARPANET and Defense Data Networks (DDN). It has since become a widely used set of protocols for multi-vendor connectivity, and has been defined by the Department of Defense as the basis from which they plan to migrate to OSI network protocols.

2.3.2 LAN Bridges

A single logical LAN image at the logical link control level implies bridging mechanisms designed and implemented at the MAC level. It also implies that data can be transmitted from any station to any other station, regardless of the LAN segment to which each station is attached. A frame flows through a bridged local area network from an originating station to a destination station by following a defined *route*. Any information about the route a frame has to follow is called *routing information*.

Today, there are two main MAC bridging architectures and protocols, *transparent bridging* and *source routing*. Routing information may be included in the frame when it is originated by the source station. This requires the source station to acquire the routing information through a search process. The related architecture and protocols are provided by *source routing*.

An alternate solution is to maintain the routing information in tables at the level of the participating bridges. In this case, routing information is generated and updated by the bridges communicating with each other according to specific protocols. The architecture and protocols involved with this approach are referred to as *transparent bridging*.

In "LAN Standards" on page 56, transparent bridging and source routing are positioned with respect to LAN standards. Chapter "Bridging" on page 155 provides further description of bridge architectures and related protocols.

Logic for route resolution may include techniques to provide only a single route between any two end stations, thereby minimizing redundant frame traffic. Such a technique is referred to as a *spanning tree* algorithm. Both source routing and transparent bridging include a spanning tree algorithm. Figure 70 on page 157 shows a spanning tree example using Transparent Bridging.

One route resolution technique used by source routing is called *single-route broadcast route determination* (see "Source Routing" on page 158). This technique includes a spanning tree algorithm referred to as *single-route broadcast path maintenance* which is implemented in the IBM Token-Ring Network Bridge Program V2.0, the IBM Token-Ring Network Bridge Program V2.1 and the IBM PC Network Bridge Program (see "IBM LAN Bridges" on page 163).

In general each individual LAN, referred to as a *LAN segment*, has its own independent MAC level protocol. A bridged local area network, created by either of the above-mentioned MAC bridge protocols, supports communication between stations attached to separate LAN segments as if they were attached to a single LAN. MAC bridges are said to provide a *single logical LAN view*.

3. LAN Architectures and Standards

In the previous chapter, "LAN Technology" on page 7, various technological approaches were described for both physical LAN attachment considerations and medium access methods. Some alternative approaches to LAN interconnection were also introduced.

The 802 Project of the Institute of Electrical and Electronics Engineers (IEEE) has produced a set of standards for LAN architectures, giving vendors guidance for producing LAN products and users a choice of standardized local area networks with a certain degree of interconnectivity. The IEEE LAN standards align with the bottom two layers of the International Standards Organization's (ISO) model for Open Systems Interconnection, referred to as the *OSI Reference Model*.

3.1 LAN and Communications Standards

The International Standards Organization (ISO) developed the seven-layer OSI Reference Model to provide a standard reference for intercommunication between computer systems through a network using common protocols.

The ISO Reference Model, depicted in Figure 22 on page 55, became an international standard in 1983. Each layer addresses a well-defined section of the total architecture. The Layers of the OSI Reference Model are, from top to bottom:

- Application Layer

The application layer gives the user access to all the lower OSI functions. The purpose of this layer is to support semantic exchanges between applications existing in "open" systems.

- Presentation Layer

The presentation layer is concerned with the representation of user or system data. This includes necessary conversions (for example, printer control characters) and code translation (for example, ASCII to or from EBCDIC).

- Session Layer

The session layer provides mechanisms for organizing and structuring interaction between applications and/or devices.

- Transport Layer

The transport layer provides transparent and reliable end-to-end data transfer, relying on lower layer functions for handling the peculiarities of the actual transfer medium.

- Network Layer

The network layer provides the means to establish connections between networks. The standard also includes procedures for the operational control of inter-network communications and for the routing of information through multiple networks.

- Data Link Layer

The data link layer provides the functions and protocols to transfer data between network entities and to detect (and possibly correct) errors that may occur in the physical layer.

- Physical Layer

The physical layer is responsible for physically transmitting the data over the communications link. It provides the mechanical, electrical, functional and procedural standards to access the physical medium.

This layered approach was selected as a basis for the OSI Reference Model to provide flexibility and open-ended capability through defined interfaces. The interfaces permit some layers to be changed while leaving other layers unchanged. In principle, as long as standard interfaces to the adjacent layers are adhered to, an implementation can still work. For example, a system implementation could use either HDLC or local area network protocols as the data link layer. Similarly, a particular layer such as the presentation layer, can be implemented as a null layer for the time being. This means the layer is functionally empty, providing only the mandatory interfaces between the upper and lower layers (application and session layers respectively). The Manufacturing Automation Protocols (MAP 2.1) "IEEE 802.4, ISO 8802-4" on page 59) exemplify implementation with a null layer.

3.1.1 IEEE 802 and OSI

In February 1980, The Institute of Electrical and Electronic Engineers' (IEEE) Computer Society established "Project 802" to draft standards for local area networks. In keeping with the OSI approach, IEEE Project 802 created a reference model with two layers (which correspond to the data link and physical layers of the OSI model). In the IEEE model, however, the data link layer is further divided into two sublayers: the *logical link control* (LLC) sublayer, and the *medium access control* (MAC) sublayer.

Details on these sublayers can be found in "LAN Standards" on page 56.

Due to the variety of technically sound approaches proposed for local area networks, IEEE Project 802 decided to draft standards for the most probable implementations:

- CSMA/CD (Contention Bus)
- Token passing bus
- Token passing ring.

The commonly used names for these standards are derived from the project's initial designation "802". Hence, we have:

- IEEE 802.1 - Higher Level Interface Standard
- IEEE 802.2 - logical link control standard
- IEEE 802.3 - CSMA/CD Standard
- IEEE 802.4 - Token passing bus standard
- IEEE 802.5 - Token passing ring standard.

The IEEE 802.1 Higher-Level Interface subcommittee is currently finalizing the draft IEEE 802.1 standard, also presented to the ISO as an ISO draft proposal. This draft includes the following subjects:

- IEEE 802.1 Part A which describes the relationship of the IEEE 802 work to the ISO Open Systems Interconnection Basic Reference Model.
- IEEE 802.1 Part B which specifies an architecture and protocol for the management of IEEE 802 LANs.
- IEEE 802.1 Part C which specifies the MAC service offered by all IEEE 802 LANs.
- IEEE 802.1 Part D which specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.

Figure 21 on page 53 depicts the relationship between the two lower layers of the OSI model and their associated IEEE 802.x standards.

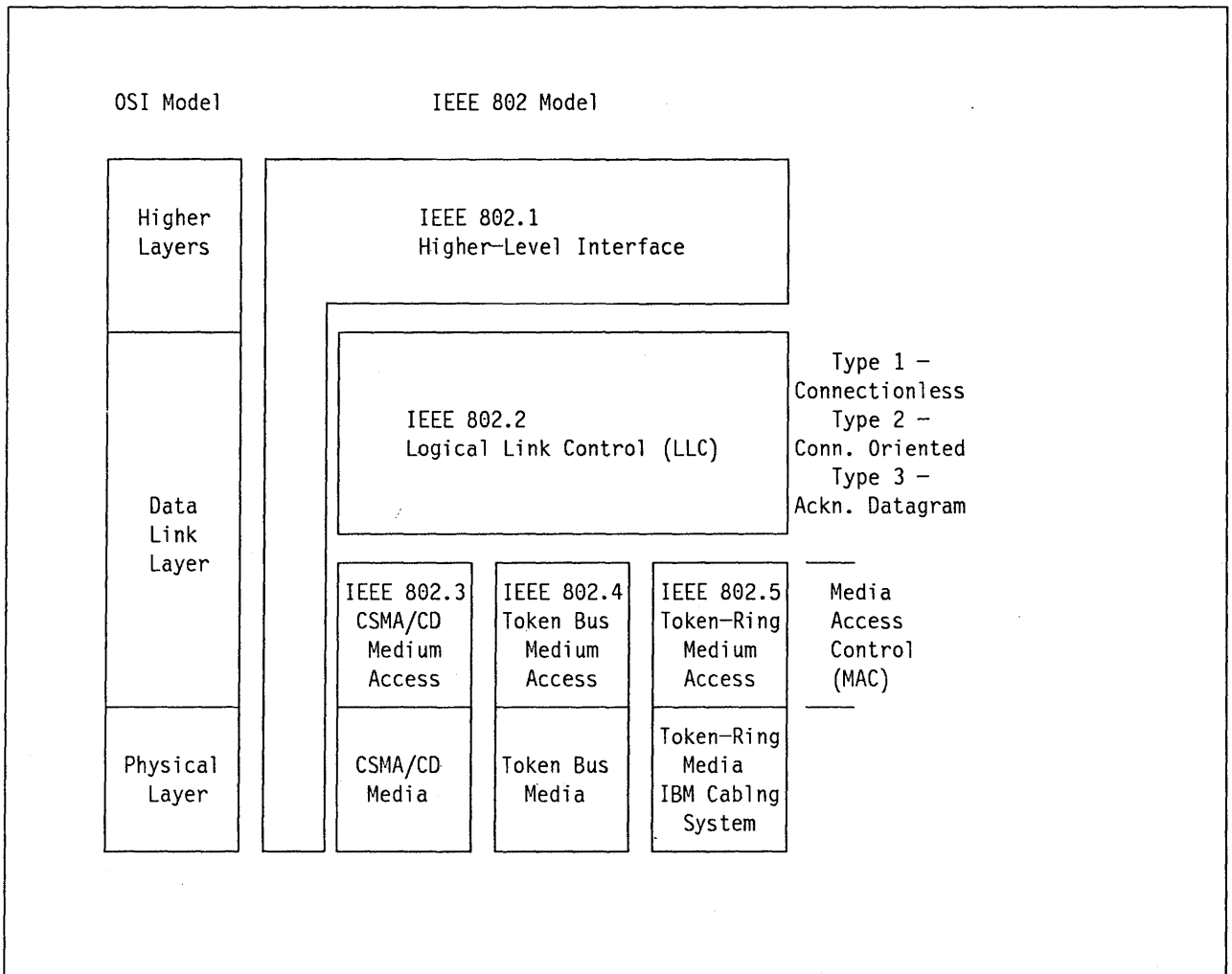


Figure 21. IEEE 802 Model Compared to the OSI Model

The International Standards Organization has since adopted the IEEE 802 standards as part of the OSI Reference Model, and has given them the following ISO numbers:

- IEEE 802.1 Currently an OSI Draft Proposal, DP 8802-1
- IEEE 802.2 Currently an OSI International Standard, IS 8802-2
- IEEE 802.3 Currently an OSI International Standard, IS 8802-3

- IEEE 802.4 Currently an OSI International Standard, IS 8802-4
- IEEE 802.5 Currently an OSI International Standard, IS 8802-5.

3.1.2 OSI and SNA Models

IBM System Network Architecture (SNA) is a proprietary layered architecture which, although defined earlier than the OSI Reference Model, is based upon a seven-layer structure. SNA was announced as IBM's networking architecture in 1974, and the first products implementing the SNA protocols became available in the mid 1970's. Since then, SNA has continued to grow and evolve. Part of this evolution has included IBM's support of standard communications interfaces through continued publication and update of SNA specifications, and through development of enhancements to SNA closely coordinated with emerging international standards. In this way IBM developed the IBM Token-Ring Network as an enhancement to SNA while participating actively in the development of the IEEE 802.5 and 802.2 standards.

Figure 22 on page 55 shows a comparison of the OSI model to the SNA model.

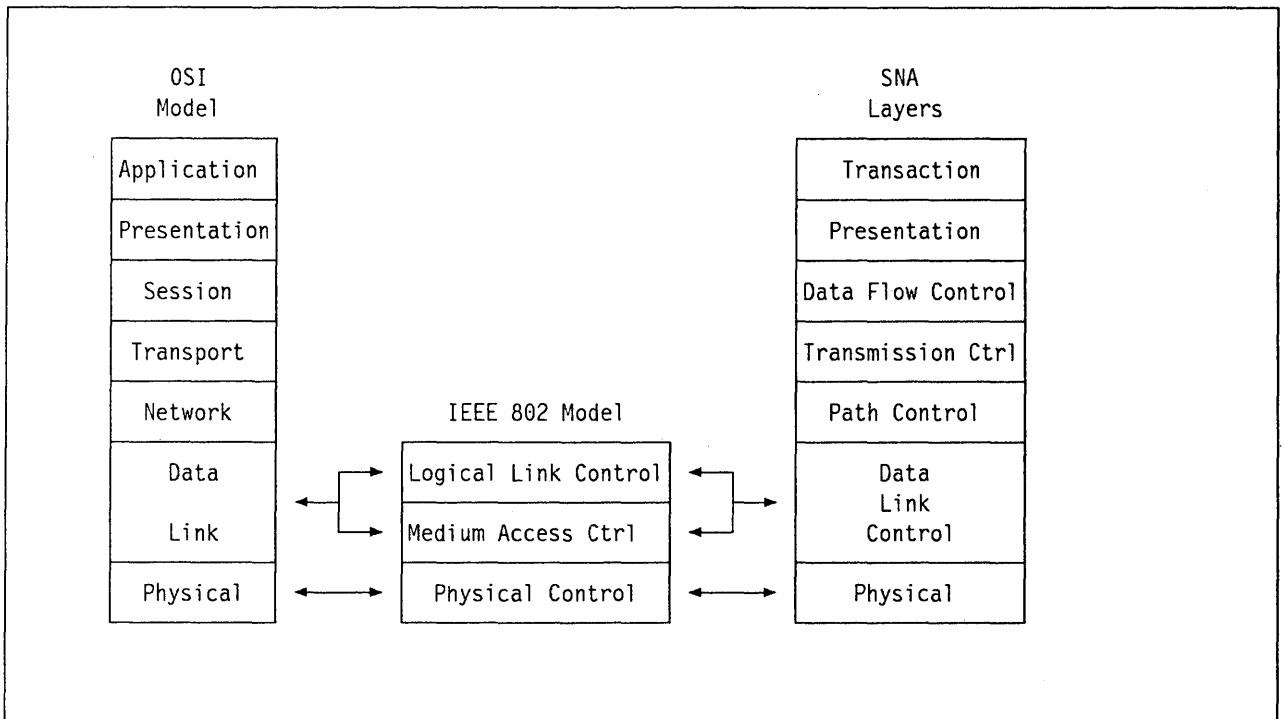


Figure 22. OSI Reference Model, IEEE 802 Local Area Network Model, and SNA Model

Although there is general correspondence between the OSI and the SNA layers, the detailed protocols and services vary. The SNA layers (from the top down) are:

- Transaction services

The transaction services layer provides application services to the end-user of an SNA network. These services are also used by IBM Office Architectures: Document Interchange Architecture (DIA) for document distribution between office systems, and SNA Distribution Services (SNADS) for asynchronous data distribution between distributed applications and office systems.

The transaction services layer also provides configuration, session and management services to control network operation.

- Presentation services

The presentation services layer is concerned with the representation of application, end-user, and system data. The services provided include 3270 data stream support and intelligent printer data stream support.

The presentation services layer also defines protocols for program-to-program communication, and controls conversation-level communication between transaction programs.

- Data flow control

The data flow control layer provides flow control services for logical unit to logical unit (LU-LU) sessions. It does this by assigning sequence numbers, correlating requests and responses, enforcing session request and

response mode protocols and coordinating session send and receive modes.

- Transmission control

The transmission control layer provides basic control of the transmission resources in the network, verifying received sequence numbers, and managing session level pacing. Boundary function support for peripheral nodes is provided by transmission control, and data encryption can also be supported by this layer's services.

- Path control

The path control layer provides protocols to route message units through an SNA network, and to interconnected SNA networks (via System Network Interconnect - SNI).

- Data link control

The data link control layer provides protocols for transferring message units across the physical link between two nodes, and also provides link-level flow control and error recovery. The data link control layer supports SDLC, System/370 data channel, X.25 and IEEE 802.2 and 802.5 protocols.

- Physical control

The physical control layer provides a physical interface for any transmission medium attached to it. This layer defines the signaling characteristics needed to establish, maintain, and terminate physical connections for supported attachments.

3.2 LAN Standards

The data link layer provides the protocols used to physically transmit data on a communications link. These protocols must be able to detect when a transmission has been corrupted by errors and to retransmit the data.

The IEEE 802 project divided the data link layer into two sublayers, the *medium access control* (MAC) layer and the *logical link control* (LLC) layer. These sublayers are discussed in the following sections.

As previously mentioned, the IEEE 802.1 subcommittee work has not yet been completed, especially in the areas of the management and interconnection of IEEE 802 LANs. Individual MAC standards, for example, IEEE 802.5 token passing ring, may include MAC bridge standards in addition to the MAC bridging architecture and protocol proposed as part of IEEE 802.1. Any MAC bridge standard additional to 802.1 however will have mechanisms which allow it to interoperate with the IEEE 802.1 MAC Bridging approach at the MAC sublayer.

The basic architecture behind the token passing ring bridge protocol is *source routing*, while IEEE 802.1 bridging provides a *transparent bridging* approach.

3.2.1 Physical Layer and MAC Sublayer

The medium access control (MAC) sublayer contains mechanisms to control transmissions on the LAN so that two or more stations don't try to transmit data at the same time, logic to control whether a station on the LAN is in transmit, repeat, or receive state, and addressing schemes to control the routing of data on the LAN. It also provides some or all of the following functions:

- MAC addressing. A MAC address is the physical address of the station (that is, device adapter) on the LAN, a pre-defined group address which is recognized by adapters of devices belonging to the group, a broadcast address which is recognized by all adapters on the LAN or a null address for frames which should not be received by any station on the LAN. The MAC address is used to identify the physical destination and source of anything transmitted on the LAN.
- Frame copying. This is the "receipt", that is, copying of a frame into the buffers of an attached adapter which recognizes its own address in the destination address field of a frame.
- Frame type recognition. This is the identification of the type (for example, system or user) and format of a frame of data.
- Frame control. This function ensures that frames can be processed accurately by providing frame check sequence numbers and starting or ending frame delimiters.
- Priority management. This function allows preferential access to the medium while maintaining fairness with respect to all participating stations.
- LAN management. A collection of protocols has been defined to support monitoring of a LAN and the ability to handle error conditions at the access control level.

Some access protocols do not provide priority management or frame control functions, but rely on higher layer services to provide these functions.

3.2.1.1 IEEE 802.3, ISO IS 8802-3

The IEEE 802.3 standard describes the access method and the physical layer specifications for a contention bus LAN. The standard specifies a 1-persistent carrier sense multiple access with collision detection (CSMA/CD) access protocol, using baseband transmission on a single channel pair at 10Mbps. Binary data is transmitted as signal elements on a common shielded 50 Ohm coax cable using the Manchester code scheme. Baseband bus is the most popular IEEE 802.3 topology, although a star-wired baseband bus and broadband tree are also part of the standard.

The maximum allowable non-repeated distance between stations is a 500-meter segment. One or more segments may attach to a particular segment using repeaters. However the maximum number of segments in any end-to-end path is five, that is, a maximum of four repeaters in any path. Within any path, no more than three segments may have stations attached to them, while the maximum number of attachments to one segment is 100.

For the total LAN, 1024 attachments are allowed, with a total end-to-end distance between stations not exceeding 2.5 kilometers.

The standard also describes the *transceiver unit*, used to couple the Data Terminal Equipment (DTE) to the medium. The transceiver unit components together with the associated medium attachment taps cause signal reflections and standing waves (second and third harmonic distortion) due to bridging impedances whenever a transmission occurs. The unusual 50 Ohm coaxial cable was selected to limit the capacitance caused by the taps. Because of these reflections and standing waves, the placement of transceivers along the cable and the lengths of the cables themselves must be controlled to ensure that transmissions are not disrupted. For example, if the standing waves set up by one station's transmission were strong enough, they could be mistaken by that transmitting station for another transmitting station; that is, the transmitting station would erroneously detect a collision. Station attachment to the common bus must be separated by multiples of 2.5 meters to prevent reflections caused by the taps from adding up in phase.

3.2.1.2 Service Primitives

The basic service primitives used in this standard are:

- Medium access data request (MA_DATA.request)

This primitive is generated whenever the LLC sublayer has data to be transmitted to another station(s) on the LAN. The MAC sublayer formats it in a MAC frame and transmits it.

- Medium access data confirm (MA_DATA.confirm)

This primitive is generated by the MAC sublayer in response to a "MA_DATA.request" from the local LLC sublayer. A status parameter is used to indicate the outcome of the associated MA_DATA.request.

- Medium access data indicate (MA_DATA.indicate)

This primitive is sent to indicate that a valid frame arrived at the local MAC layer. The frame was transmitted without errors and was correctly addressed.

The CSMA/CD medium access protocol was described in "Basic CSMA/CD Concepts" on page 16. Figure 6 on page 18 shows the eight-field structure of the 802.3 standard MAC frame.

3.2.1.3 Summary

The IEEE 802.3 standard is a contention-based protocol. For low traffic volumes and relatively short messages, an IEEE 802.3 LAN can provide the best response time. However, because of the instability introduced by collision recovery during periods of high utilization, response times and performance cannot be predicted reliably. At the MAC level, the IEEE 802.3 protocol cannot guarantee access to the medium. These performance considerations make IEEE 802.3 protocol LANs less desirable than other protocols for backbone LANs.

All stations have equal rights to transmit on an idle bus. In low-traffic situations, this minimizes the need to handle priority requests. However, with heavier traffic, the lack of priority support within the protocol may be a problem for some applications.

Special considerations may be required for applications or data with security requirements, because IEEE 802.3 stations broadcast their frames

simultaneously to all other LAN stations on the network which therefore can receive and copy any transmitted data.

Network management is not defined within the IEEE 802.3 standard. It is under consideration as part of the IEEE 802.1 sub-project (see "IEEE 802 and OSI" on page 52).

3.2.1.4 IEEE 802.4, ISO 8802-4

The IEEE 802.4 standard describes the token passing bus access protocol and its physical layer specifications. In this type of LAN, stations on the network are physically connected to a bus, but access to the bus is controlled as if it were a logical ring. Each station keeps track of the addresses of its logical neighbors (that is, those which immediately precede and follow it in a logical sequence). The physical connection sequence on the bus is independent from the order of the logical ring.

A token is used to control access to the bus. Once a station has control of a token, it has complete control of the bus for a defined period of time (the token_holding time). In addition to transmitting one or more frames, the controlling station can poll other stations and receive responses or acknowledgements during this time period. When it wishes to relinquish control of the bus or when the token_holding timer expires, the station passes the token on to its successor station.

The IEEE 802.4 standard defines broadband transmission on shielded coax cable at data rates of 1, 5 or 10 Mbps. It provides a choice of different modulation techniques and cable types. There are three standard topologies, each involving different modulation techniques and cable types used for the trunk and drops. The three topologies have the following characteristics:

- Omni-directional bus at 1 Mbps, using Manchester encoding.
- Omni-directional bus at 5 or 10 Mbps.
- Directional bus with active head-end repeater at 1, 5 or 10 Mbps.

The token passing bus medium access protocol was described earlier in "Basic Token Passing Bus Concepts" on page 40.

In summary, one or more stations on the bus must perform the following functions:

- **Ring initialization**, performed when the network is first powered up and after a catastrophic error.
- **Station addition**, optionally performed when a station holding the token accepts the insertion of a new successor station (that is, a new station with an address that is between that of the station holding the token and its current successor station).
- **Station removal**, achieved by sending a new successor identification to its predecessor, or by just disconnecting from the LAN. In the latter case, recovery mechanisms will establish the proper new logical ring configuration.
- **Recovery and Management**, including recovery from the following types of failures:
 - Bus idle (lack of activity on the bus).

- Token passing failure (lack of valid frame transmission).
- Duplicate token (detected by the token-holding station).
- Detection of a station with a faulty receiver.
- Duplicate MAC addresses.

Figure 17 on page 41 shows the generic 802.4 standard MAC frame format as well as the IEEE 802.4 token format which is transmitted as a special frame.

3.2.1.5 IBM and IEEE 802.4 - ISO IS 8802-4

In 1984, IBM issued a statement of direction stating IBM's intention to implement the Manufacturing Automation Protocol (MAP) standard based upon approval of the MAP Version 3 specifications. IBM also refers to MAP as the *industrial LAN*, which is part of the IBM *Computer-Integrated Manufacturing* (CIM) product offerings. The ultimate goal of CIM is integration of all processes involved in a manufacturing environment. Integration is based on controlling the information flow for which MAP as a full seven-layer communications architecture will provide networking and applications support. The ISO 8802-4 standard provides the two lowest layers of this seven-layer architecture.

3.2.1.6 Manufacturing Automation Protocol

Work on a MAP standard started in 1980 as a task force within the General Motors Corporation. Gradually other manufacturers, including IBM, began to participate in the definition of the protocols and the implementation of products.

The following milestones have occurred in the development of the MAP standard:

- MAP 1.0 was released in April 1984 as the result of the General Motors task force.
- Based upon the participation of additional companies in the standardization process, MAP 2.1 was issued in March 1985 as a set of interim specifications to allow early product development and experience.
- In December 1985, MAP 2.1 was updated to correct some mistakes in the earlier release.
- MAP 2.2 was released in March 1987, with the addition of carrierband network specifications.
- The ultimate standard, referred to as MAP 3.0, was released as a draft in April 1987. Final release is targeted for late 1988.

Figure 23 on page 61 shows the relationship between the seven-layer OSI Reference Model and MAP 2.1.

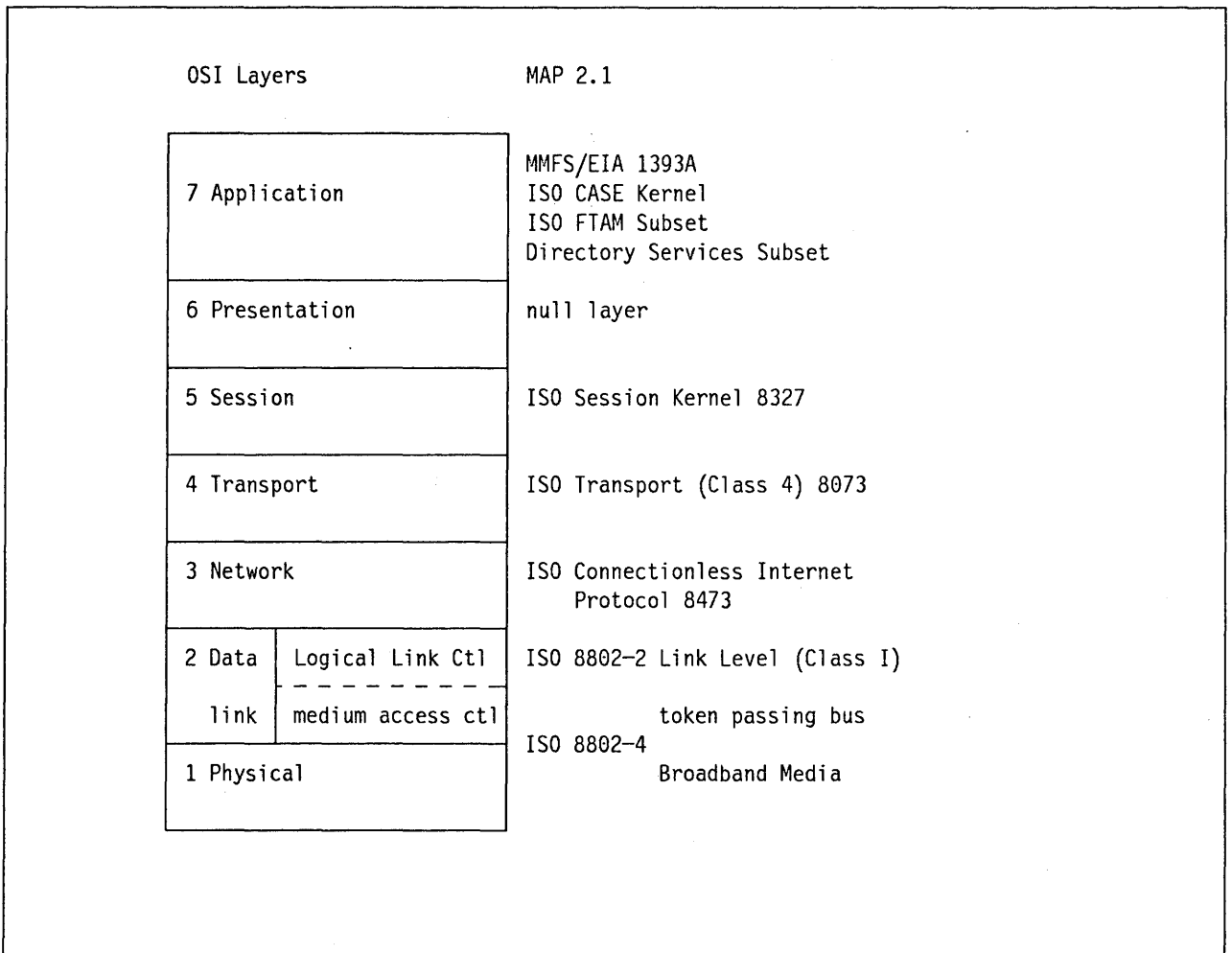


Figure 23. MAP 2.1 and the OSI Reference Model

MAP 2.1 specifications have been subject to two main criticisms:

1. When multi-channel capability is not required, the full broadband implementation is excessively expensive and not required. Therefore some potential users and vendors preferred a carrierband LAN implementation.
2. The processing of a full seven-layer implementation of the architecture may require too much processing time for smaller systems in time-critical applications. Initially, this critique was addressed by two different approaches, *MAP/Enhanced Performance Architecture* (MAP/EPA) and *MiniMAP* (see Figure 24 on page 62).

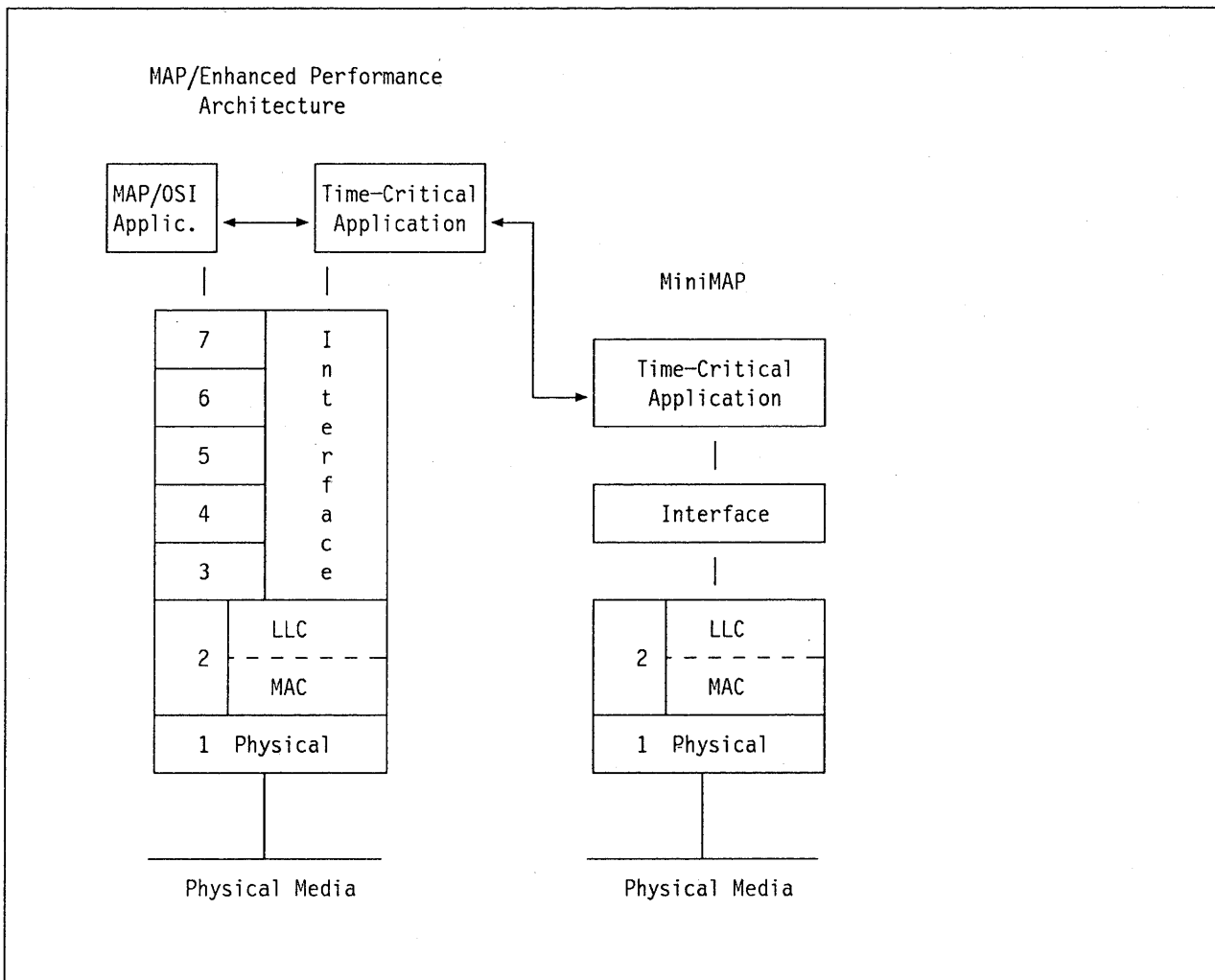


Figure 24. MAP/EPA and MiniMAP

MAP Version 3 enhances MAP 2.1 by:

- Imbedding the MAP/EPA and MiniMAP approaches into the standard to meet the time-dependent requirements of the process industry.
- Replacing MMFS by the Manufacturing Messaging Specifications (MMS).
- Including OSI presentation layer 6 support.
- Extending layer 4 class 4 service dealing with error detection and recovery.

With respect to network interconnection, the MAP approach is to provide a full, seven-layer MAP 3.0 backbone configuration at the plant floor interconnected with other carrierband MAP LANs and other standard LANs such as as IEEE 802.3 and IEEE 802.5. This approach addresses the objective to integrate technical design, office and business applications, computer-aided production management and manufacturing with the communications requirements of the individual production cells as shown in a sample configuration in Figure 25 on page 63.

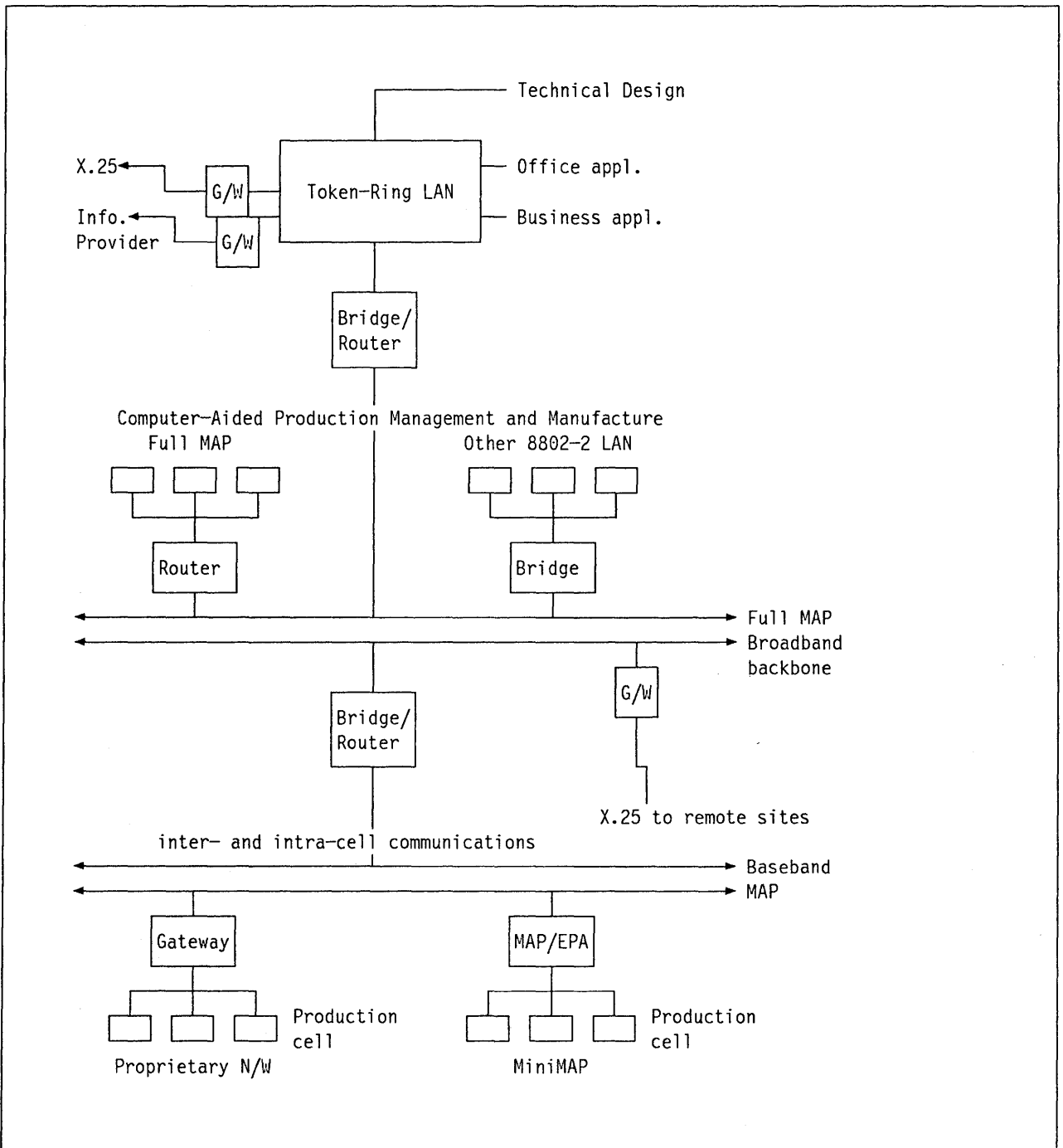


Figure 25. MAP Integrated Network Configuration

An important concern which appeared during the evolution of the Manufacturing Automation Protocol is associated with migration from MAP 2.1 local area networks to a MAP 3.0 environment. This may be difficult because of the nature of the changes. Additional information is provided in "The 8232 LAN Channel Station and Industrial LAN" on page 122.

3.2.1.7 Summary

The token passing bus access method is predominately used for industrial LANs. It uses a logical ring on a physical bus, and has a number of transmission techniques and data rates to choose from.

The protocol optionally provides eight priority service classes to higher level data frames, handled at the MAC level by four access classes based upon the current traffic load on the bus.

With respect to a full seven-layer architecture for the manufacturing environment, application implementation is very limited because of the immaturity of the standards, but will likely increase as the standards are finalized.

3.2.1.8 IEEE 802.5, ISO IS 8802-5

The IEEE 802.5 standard describes the token passing ring medium access protocol and its physical attachments.

In a token passing ring network the stations on the LAN are physically connected to a wiring concentrator usually in a star-wired ring topology. Logically, stations are connected in a pure ring topology. Each station has driver/transmitter as well as receiver circuitry (see Figure 26).

Differential Manchester code is used to convert binary data into signal elements, which are transmitted at 1 or 4 Mbps IEEE standard speeds. An update to the standards to support 16 Mbps is currently in the process of review and approval. The standard does not prescribe the type of cabling to be used. In IBM's Token-Ring Network implementation, shielded twisted pair cabling is recommended.

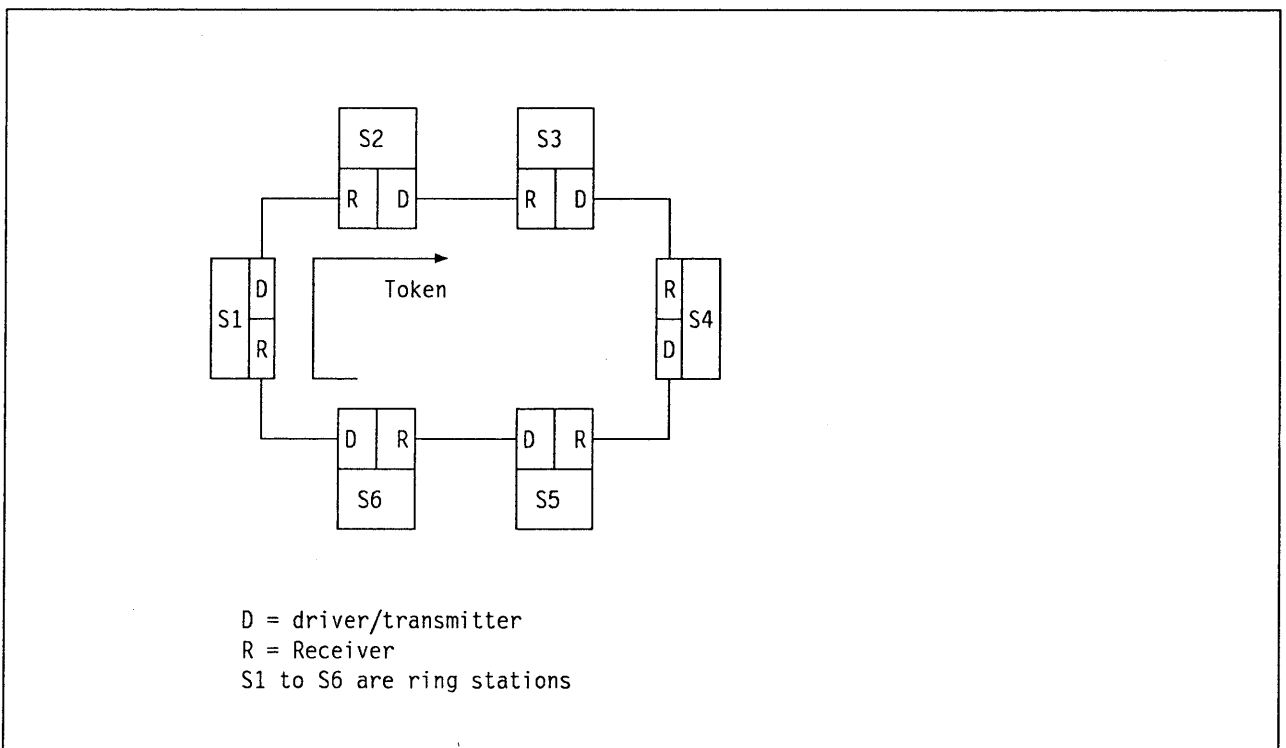


Figure 26. Sample Ring Configuration

Access to the ring is controlled by a circulating token. A station with data to transmit waits for a free token to arrive. When a token arrives, the station changes the token into a frame, appends data to it and transmits the frame. If the destination station is active, it will copy the frame and set the "frame copied" and "address recognized" bits, providing MAC level acknowledgement to the transmitting station. The sending station must strip the frame from the ring and release a new token onto the ring.

An option in the architecture allows the sending station to release a token immediately after transmitting the frame trailer, whether or not the frame header information has already returned. This is called *early_token release* and tends to reduce the amount of idle time in higher speed token passing rings running at, for example, 16 Mbps.

The token passing protocol provides an extensive set of inherent fault isolation and error recovery function, for implementation in every attaching device. The adapter network management functions include:

- Power-on and ring insertion diagnostics.
- Lobe-insertion testing and online lobe fault detection.
- Signal loss detection, beacon support for automatic test and removal.
- Active and standby monitor functions.
- Ring transmission errors detection and reporting.
- Failing components isolation for automatic or manual recovery.

The token passing ring medium access protocol was described earlier in greater detail (see "Basic Token Passing Ring Concepts" on page 22).

In summary, the token passing ring protocol is based on the following cornerstones:

- *Active Monitor*
 - Ensures proper ring delay.
 - Triggers Neighbor_Notification.
 - Monitors token and frame transmission.
 - Detects lost tokens and frames.
 - Purges circulating tokens or frames from the ring.
 - Performs auto-removal in case of multiple Active Monitors.
- *Standby Monitor* (any other ring station)
Detects failures in the active monitor and disruptions on the ring.
- *Token_claiming process*
By which a new active monitor is elected when the current active monitor fails. This process may be initiated by the current active monitor or by a standby monitor.

Figure 12 on page 28 shows the format of a 802.5 standard MAC frame as well as the token format and the format of the abort delimiter.

The architecture describes 28 different MAC control frames, each identified by a unique Major Vector Identifier (MVID). The main ones have been described in "Basic Token Passing Ring Concepts" on page 22 and are referred to as:

- Active Monitor Present MAC frame.
- Ring Purge MAC frame.
- Standby Monitor Present MAC frame.
- Claim Token MAC frame.
- Lobe Media Test MAC frame.
- Duplicate Address Test MAC frame.

- Request Initialization MAC frame.
- Beacon MAC frame.
- Soft Error Report MAC frame.

3.2.1.9 Summary

The token passing protocol provides for efficient use of the media under both light and heavy traffic loads. It guarantees fair access to all participating stations. This fairness is enhanced by an eight-level priority mechanism, based on priority reservations made in a passing token or frame. A key benefit of the token passing ring protocol is its ability to handle increased traffic loads or peaks, making it an ideal protocol for larger and/or more heavily used LANs (including backbone rings). This also makes it a good base LAN for connection to even higher bandwidth LANs such as FDDI.

3.2.1.10 Fiber Distributed Data Interface

The *American National Standards Institute* (ANSI) standards working group X3T9.5 has formulated a draft proposal for an international standard called *Fiber Distributed Data Interface* (FDDI).

FDDI is an optical fiber-based LAN, operating at a nominal rate of 100 Mbps. Physically an FDDI LAN consists of two rings, a primary and an alternate ring. Signalling over both rings is independent, each operating at 100 Mbps. Optical pulses are transmitted in opposite directions, as was shown in Figure 18 on page 44, providing redundancy and recoverability. A proposed extension to the specifications would simultaneously use the capacity available in both fibers to achieve a nominal speed of 200 Mbps. This however impacts automatic recovery on the alternate path as supported on the 100 Mbps FDDI LAN.

In fact, light pulses are transmitted over each fiber at a nominal rate of 125 Mbps. This is because FDDI does not use the binary encoding transmitted bit-by-bit as in Manchester or Differential Manchester Code schemes, but four bits at a time plus one error detection bit to form a transmission unit, called a *symbol*, of five bits. This is referred to as 4B/5B encoding.

A LAN station may be attached to both primary and alternate rings, in which case it is called a Class A station. If however it is only attached to the primary ring, it is called a Class B station. Stations attach to an FDDI LAN via hubs or wiring concentrators which are connected to both primary and alternate rings (Class A). In this way these ring wiring concentrators support star-wired rings or branched-tree topologies.

Although a separate MAC protocol, FDDI supports the IEEE 802.2 logical link control interface supported by the various IEEE 802 MAC standards as a means to simplify connectivity through adherence to standards where appropriate. This should considerably simplify bridging between an FDDI LAN and other LANs supporting the same IEEE 802.2 LLC standard.

The FDDI medium access control protocol was introduced in "Fiber Distributed Data Interface Concepts" on page 44. In the FDDI specifications, the Physical Layer has been split up into two protocols:

- *Physical sublayer - PHY* and
- *Physical Media Dependent sublayer - PMD*.

The FDDI MAC, PHY and PMD sublayers interface with a Station Management protocol, as shown in Figure 27 on page 69. Station management relies on identification of both the *nearest active upstream neighbor* (NAUN) and the *nearest active downstream neighbor* (NADN).

The FDDI MAC frame format in Figure 19 on page 46 suggests how this protocol has borrowed both from the token passing ring and the token passing bus MAC protocols. As in the token passing bus MAC frame, the first field is a preamble and there is no access control field since priority management is not based on reservation bits but on a timed token. As in the token passing ring MAC frame format, the FDDI format contains a frame status field following the ending delimiter, and provides for optional routing information following the destination and source addresses.

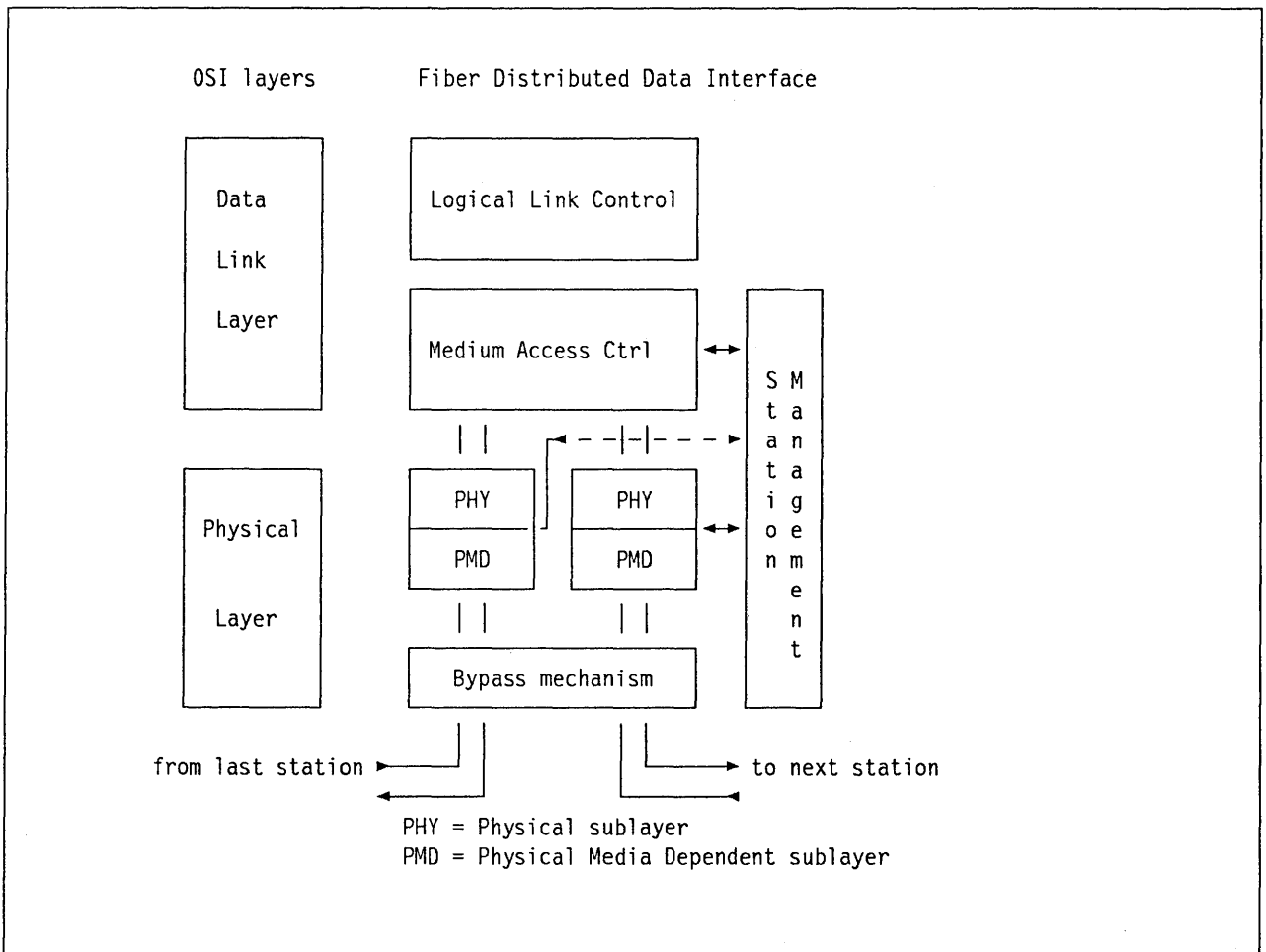


Figure 27. FDDI Dual-Attachment Station

3.2.1.11 Summary

The Fiber Distributed Data Interface protocol is the emerging international LAN standard for very high-speed LAN applications. In order to take full advantage of the capacity offered by the fiber optical medium, FDDI has adopted and optimized existing deterministic access protocol concepts. At the same time, the protocol includes processes to meet the requirements of time-critical applications.

Because of the very high capacity, FDDI is likely to become a prime candidate for backbone LAN applications. In addition FDDI has the required capacity to cope with the fast growing bandwidth requirements for an extended period of time, and makes new application areas such as image transmission more feasible.

3.2.2 Logical Link Control Sublayer

The IEEE 802.2 standard describes the top sublayer of the data link layer. It is common to all the MAC sublayers layers defined by the IEEE. See Figure 21 on page 53. This means higher layer protocols are shielded from the peculiarities of the physical medium as well as from the specific medium access protocol being used. Obviously, limitations such as throughput characteristics and number of attachments, inherent in each of the lower level standard protocols, apply equally to higher layer protocols.

Local area networks (as well as wide area networks) need the function of a DLC layer to optimize the capacity, accuracy, and availability of the physical medium.

The function of a network layer, to route data through the network and set up a connection between two end points, is also needed in a LAN. Basic LAN routing, error control, and flow control is defined as part of the LLC sublayer while the network layer may be a null layer.

In summary, logical link control provides a consistent view of a LAN to the upper layers regardless of the media and protocols being used and may support all required end-to-end connectivity services.

The interface to the upper layers is provided through *LLC service access points* (LSAP), just as service access points are the architected interfaces between any two adjacent layers in the OSI Reference Model Figure 22 on page 55. A station can have more than one SAP associated with it for a specific layer, just as a station may have more than one session active via one SAP. Any link level connection of one station to another is known as a *link*, while at each end of a link, associated control support is referred to as a *link station*. In the remainder of this section, a LLC service access point will be referred to as a SAP.

For example, a LAN station may have a 802.2 LLC level session through SAP X'04' with SAP X'08' in a Token-Ring attached 3174-01L, and concurrently be in session with a file server in another LAN station through SAP X'F0'. Logical link control provides the capability to manage these independent sessions.

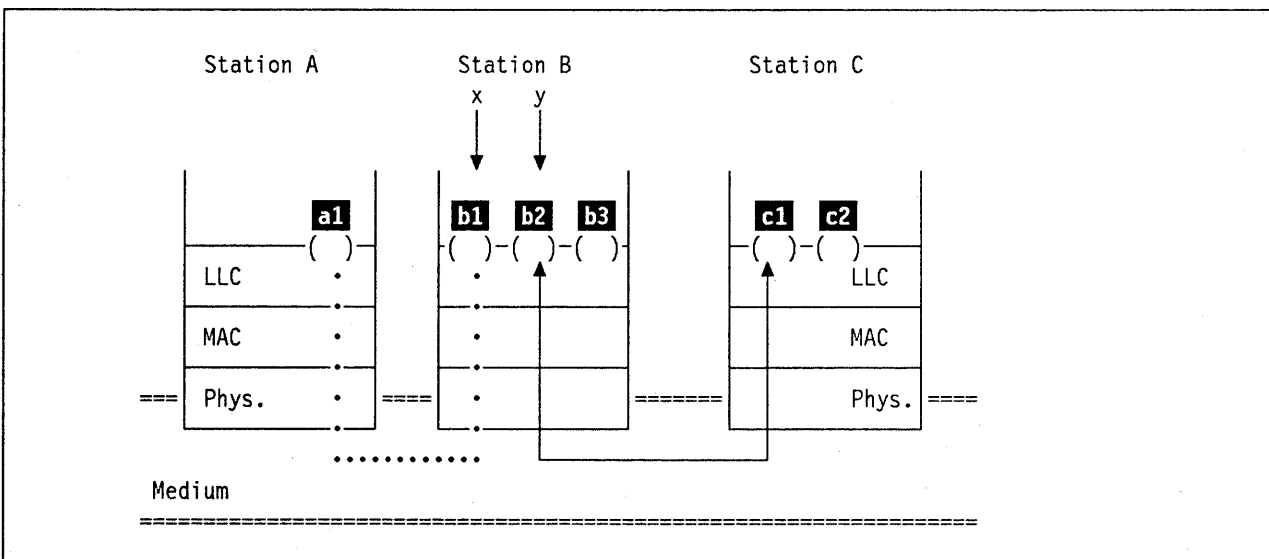


Figure 28. SAPs and LLC Connections

In Figure 28, application x is using SAP **b1** to communicate with a resource in station A. Assume that this resource is a printer. A connection is set up between SAP **b1** and **a1**. Once this connection is established, output can be sent to the printer. At the same time, application y, using SAP **b2**, can have a connection with a resource in station C using SAP **c1**. The use of service access points allows the applications and upper layer protocols to concurrently access the adapter(s) and media of the LAN.

Another way to describe an LLC SAP is to define it as an architected code point between DLC and the upper layers identifying an application to the LLC sublayer. The IEEE standard defines a number of SAP addresses, while the IBM Token-Ring Network Architecture uses a number of user-reserved SAP addresses to interface with IBM proprietary protocols. A list of architected SAP addresses is provided in Figure 29 on page 72. The standard format of destination and source SAP addresses within a logical link control protocol data unit (LPDU) is described in "LLC Protocol Data Unit" on page 75.

SAP I/G	HEX	Definition	Description	Origin
0000000 0	X'00'	Null SAP	Connectionless Service related to MAC SAP	IEEE
0000001 0	X'02'	LLC Sublayer Management	IEEE standardized Network Management	IEEE
bbbb001 0	X'x2'	Network Mgt Function	IEEE standardized Network Management	IEEE
0000001 1	X'03'	LLC Sublayer Group SAP	IEEE standardized Network Management	IEEE
0000011 0	X'06'	D.O.D. Internet	reserved for D.O.D. Internet protocol	IEEE
bbbb011 0	X'x6'	National Stds Bodies	reserved for National Standards Bodies	IEEE
1111111 0	X'FE'	ISO Network Layer SAP	reserved for use by the ISO Network Layer	IEEE
1111111 1	X'FF'	Global SAP	addresses all active Destination SAPs	IEEE
bbbb can be anything except B'0000' (x = X'1' - X'F')				
0000010 0	X'04'	SNA Path Control SAP	default workst. user (also X'08', X'0C')	IBM
0000010 1	X'05'	Path Control Group SAP	addresses all SNA SAP's	IBM
1000000 0	X'80'	reserved SAP addr range	for non-standard, non-architected protocols	user
1001110 0	X'9C'			
1111000 0	X'F0'	NETBIOS SAP	NETBIOS emulation	IBM
1111010 0	X'F4'	LAN Mgmt Indiv. SAP	LAN Mgmt. functions at LLC level	IBM
1111010 1	X'F5'	LAN Mgmt Group SAP	LAN Mgmt. functions at LLC level	IBM
1111100 0	X'F8'	IMPL	default for initial micro-program load	IBM
1111110 0	X'FC'	Discovery	used in dynamic LAN address discovery	IBM

Figure 29. Architected LLC Service Access Points

Figure 30 on page 73 illustrates how SAPs might be implemented in a station to provide logical interface points for different higher-layer protocols (including SNA path control), to acquire data link control services.

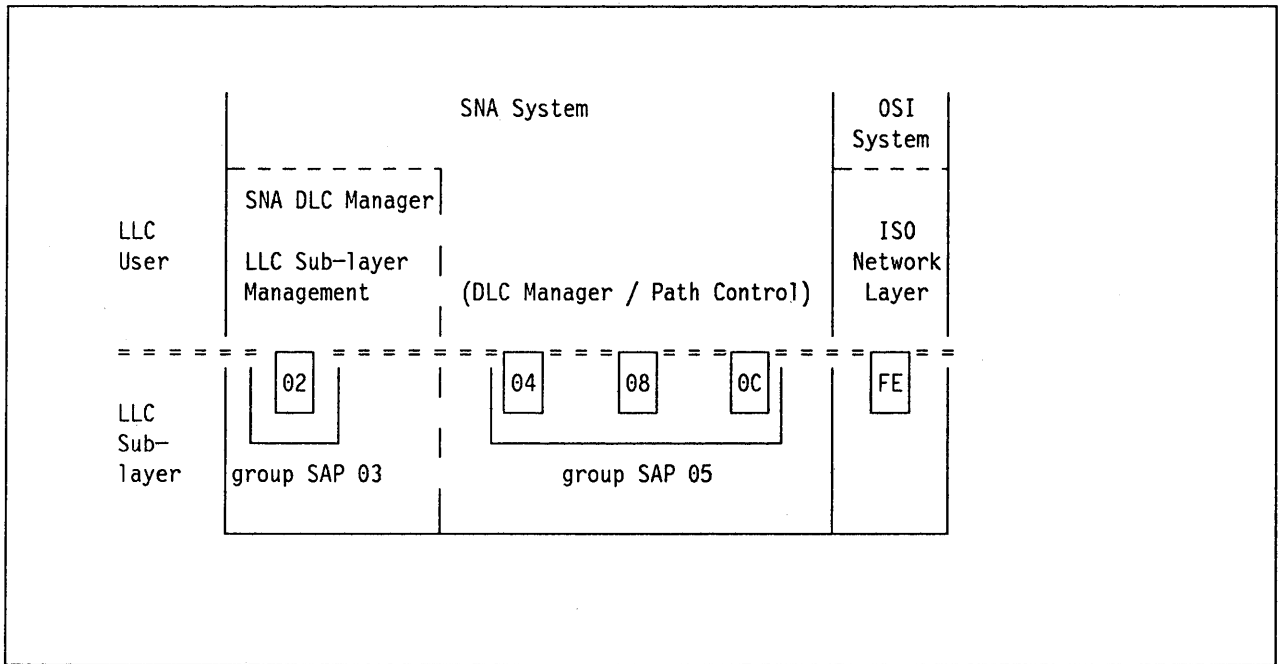


Figure 30. LLC Service Access Points and SNA

3.2.2.1 IEEE 802.2, ISO 8802-2

To satisfy the broad range of potential applications, IEEE 802.2 logical link control defines different types of operation. These types of operation, each representing a number of link-level services, are combined in several *service classes*.

- **Type 1, Connectionless Operation**

The Connectionless services are also referred to as *user datagram* mode of operation. In this mode, there is no Data Link Connection establishment between the SAPs of the end stations before actual information frame transmission starts. At the LLC level there is no guaranteed delivery of frames to the destination station. There is no correlation between frames in a particular data transmission, and the sender does not expect an LLC-level acknowledgement. In this mode of operation, higher layer services must provide recovery and frame sequencing.

- **Type 2, Connection-Oriented Operation**

Prior to data exchange, a data link connection must be established, for which a LLC Type 2 control block has been defined. These control blocks together with the associated delivery and error recovery services are called *link stations*.

The line protocol which is maintained on an established link between end stations is *HDLC Asynchronous Balanced Mode Extended*. In this way reliable end-to-end service for high traffic rates is provided.

Essentially, the LLC Type 2 services may be summarized as:

- Sequence numbering of data frames at the data link layer.
- Error detection and basic recovery.
- Flow control.

This also includes an LLC-level acknowledgement, for which a *window size* of up to 127 outstanding frames may be sent before expecting acknowledgement from the destination station.

- **Type 3, Acknowledged Connectionless Operation**

This third mode of operation has been proposed as an enhancement to the international standard.

In this mode, there is no connection establishment prior to data exchange, as in datagram operation. But link-level acknowledgement, consistent with the window size in use, is expected by the sending station.

Type 3 operation seems particularly appropriate for LANs which experience traffic patterns with unpredictable bursts in message rates, such as a LAN with file servers or backbone traffic.

Currently two classes of LLC operation are defined within the IEEE 802.2 Standard based upon the above Type 1, Type 2, and Type 3 services:

- Class I - data link connectionless services only
- Class II - data link connection oriented and connectionless services

3.2.2.2 LLC Protocol Data Unit

Figure 31 on page 75 shows the format of a logical link control protocol data unit (LPDU) and the code bits for identifying each of the LLC services for both connectionless and connection-oriented modes of operation.

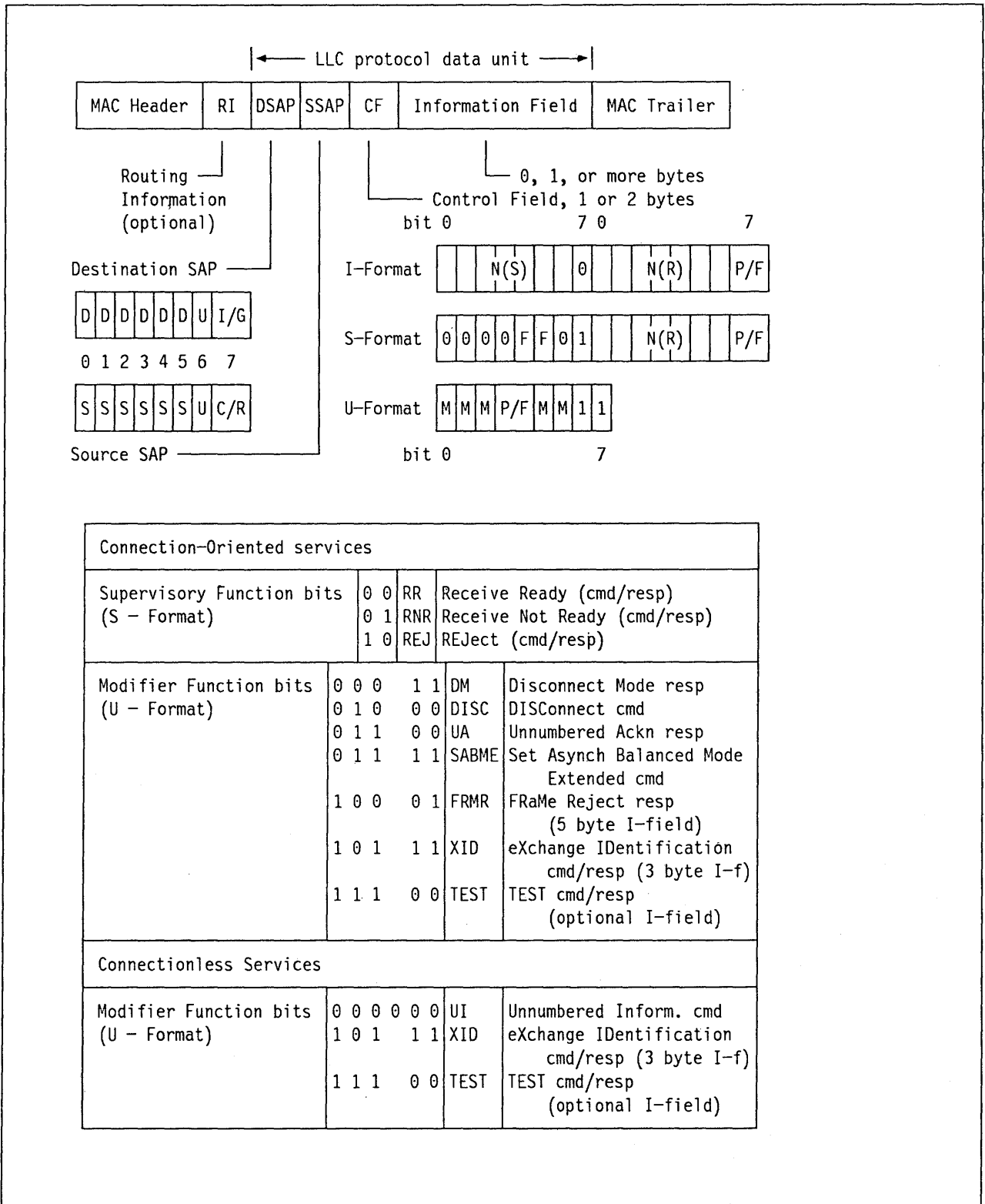


Figure 31. IEEE 802.2 LLC Protocol Data Unit Format

Each LPDU consists of a destination and source SAP address field, a control field and an information field of zero or more bytes. The following table lists the abbreviations used in this figure:

- D = Destination SAP bits.
- S = Source SAP bits.
- U = User-defined address bit (B'1' if IEEE defined).
- I/G = Individual (B'0') or group (B'1') SAP address.
- C/R = Command (B'0') or response (B'1') LPDU.
- N(S) = Transmitter send sequence number.
- N(R) = Transmitter receive sequence number.
- P/F = Poll/final bit.
- F = Supervisory function bit.
- M = Modifier function bit.

DSAP Field: The destination service access point (DSAP) address field identifies one or more service access points for which the information is intended.

This eight-bit field contains one bit to identify whether the address is an individual or a group address, and seven address bits. Two group addresses have specific IEEE standard definitions:

- Global address.

If the DSAP field contains B'11111111', it is a global address (the frame is addressed to all SAPs).

- Null address.

If the DSAP field contains B'00000000', it is a null SAP address, applicable only to connectionless operation. It supports response to a TEST or XID command in those situations where no SAP has yet been activated in the remote node.

SSAP Field: The source service access point (SSAP) address field identifies the service access point which sent the frame.

This eight-bit field contains a bit to identify whether the frame is a command or a response, and seven address bits. The command/response bit is not considered as part of the source SAP address in a received frame.

The low-order bit in the seven address bits of both DSAP and SSAP indicate an IEEE defined SAP address when set to B'1'.

Control Field: The control field is a one- or two-byte field used to designate command and response functions. It contains sequence numbers when required. The control field is very similar to the HDLC control field. Its contents for different LLC services are outlined in Figure 31 on page 75.

Information Field: The information field contains zero or more bytes of information, depending on the particular LLC service contained in the control field.

A LLC PDU is invalid under the following conditions:

- It is identified by the physical layer or MAC sublayer as being invalid.
- The frame is not an integral number of bytes in length.
- It does not contain properly formatted address fields.
- The frame contains mandatory fields that are out of order.
- The frame length is less than three bytes for a one-byte control field, or less than four bytes for a two-byte control field.

Invalid protocol data units are ignored.

3.3 LAN Standards Summary

IBM participates in several standards organizations to promote the adoption of functional, efficient communications. IBM has provided many submissions in the area of LAN standardization, and has taken steps to ensure that IBM LAN products support or closely follow these standards. IBM is also a participant in the Manufacturing Automation Protocol (MAP) project.

Of the IEEE standards described in this chapter, IEEE 802.1 is still in draft status. Network management is one of the key elements being evaluated for inclusion in this layer. Consequently the 802.1 layer is depicted as an "L" shape in Figure 21 on page 53. The other very important issue drafted within the 802.1 subcommittee is LAN interconnection. IBM bridge products will interoperate with the Transparent Bridging protocol as defined by the IEEE 802.1 standard.

IBM has developed a variety of CSMA/CD products aligned with the IEEE 802.3 standard and conforming to IEEE 802.2 logical link control (ISO 8802-2 Draft International Standard). While implementing CSMA/CD protocols in a consistent manner, the IBM PC Network (Broadband) and IBM PC Network Baseband differ from the IEEE 802.3 standard in terms of the media and transmission speeds utilized.

The IBM Token-Ring Network fully conforms to (and enhances) the IEEE 802.5 and 802.2 standards. IBM has participated in and supported the following enhancements to the IEEE 802.5 specifications:

- 16 Mbps as a standardized transmission speed
- Early token release as an option
- Source routing bridge protocols.

These proposals are in the process of being approved for inclusion in the international standard.

The IBM ES/9370¹² processor and the IBM 8232 LAN Channel Station support both IEEE 802.3 and IEEE 802.5 LAN attachments as well as IEEE 802.2 on top of each of those MAC interfaces. The 9370 Token-Ring Subsystem provides a 4 Mbps attachment as well as a selectable 16 or 4 Mbps attachment to the IBM Token-Ring Network.

Similarly, the AS/400¹² series provides IEEE 802.5 support at 4 Mbps with a statement of direction to offer a selectable 16/4 Mbps token-ring attachment.

¹² The ES/9370 and the AS/400 are trademarks of the International Business Machines

4. Structured Wiring

Standard wiring between telephone plugs in an office area and (automated) patch panels has been a common practice for some time. This has not generally been true for data communications where workstations have been connected from their particular locations to control units in other locations by pulling dedicated coaxial or twinaxial cables. The choice of cable type for data communications has also been rather restrictive with respect to the variety of devices that may be attached to a particular type of cable. In an unstructured wiring environment, every relocation or change in type of a device may require considerable planning and installation effort due to these factors.

The emergence of intelligent workstations has led to significant changes in application connectivity: from the traditional hierarchical host-workstation connectivity to a mixture of hierarchical and peer-to-peer connectivity such as that between intelligent workstations used as LAN requesters and servers.

For these reasons, a structured and consistent wiring approach to address the cabling requirements for a large number of different devices and their attachments has become important to many organizations.

4.1.1 Star-Wired Environments

The basic idea of structured wiring is to pre-wire work areas with high-quality cables running to central locations, called *Wiring Closets* where every permanent wire ends at a *Distribution Panel*. The overall purpose is to simplify moves, changes and reconfigurations.

Any change in the location or characteristic of a workstation would usually require only a different connection via jumpers at the distribution panel. More substantial changes in the topology of the attachments would usually be accomplished by adding components in the wiring closet to support the new wiring or attachment requirements, or by pulling additional wire (such as fiber cable) through the shorter and more accessible runs between the wiring closets. Thus the use of a star-wired approach minimizes the costs of maintenance by ensuring that the areas subject to the greatest change are the areas that are the most accessible and least expensive to change from an equipment and labor standpoint. The same structuring also provides simpler problem determination and recovery procedures, since the connection points are clustered in the wiring closets where they are more readily identified and where backup ports can be accessed.

4.1.2 Other Wiring Environments

Other requirements, such as very small networks or the need for broadband transmission (to support both CATV and data transmission) may lead to different wiring approaches from the star-wired approach identified above.

IBM PC Network implementations provide cabling kits or accessories to address either of these requirements.

The IBM PC Network (Broadband) LAN is a 2 Mbps CSMA/CD driven local area network, offered with IBM-supplied cabling kits, referred to as *short, medium and long distance kits*. The cable type used is CATV cable. The wiring is

dedicated for use in the PC Network (Broadband) and is not used for other devices or transmission. With custom wiring using more sophisticated transmitters, the other CATV cable channels may be used for other purposes such as closed-circuit TV. For more details, see "IBM PC Network (Broadband)" on page 110.

IBM PC Network Baseband is a low-cost 2 Mbps CSMA/CD driven local area network, using twisted pair wire to connect its LAN stations into one or more daisy-chains. A PC Network Baseband adapter cable may be obtained to take advantage of the IBM Cabling System in wiring this LAN. "IBM PC Network Baseband" on page 116 provides more details on this LAN offering.

4.2 IBM Cabling System

The IBM Cabling System provides specifications for components and their use in structured pre-wiring of buildings. The components include cables, connectors, wall faceplates, and wiring closet distribution panels.

While IBM helped design specifications for the cabling system, manufacturing, distribution, installation, and maintenance is done by third parties.

The IBM Cabling System provides the elements of a common wiring system capable of supporting most existing and future IBM workstation equipment, in addition to several host processors. Today, the IBM Cabling System consolidates coax, twinax and telephone twisted pair wire transmission support into a multi-purpose quality twisted pair wire (data grade shielded twisted pair). The wiring specifications also permit cost-effective use of fiber cables for backbone wiring. In addition to providing bandwidth for future traffic requirements, the use of fiber backbone cables enables an establishment to install wiring with the potential to support possible FDDI LAN requirements.

The cabling system components are designed to support a concept of structured wiring minimizing the impact of replacement or relocation of equipment. It may be used to pre-wire buildings for all equipment, or to provide additional cable runs for new equipment in existing buildings. While the Cabling System provides specifications for several different types of cable (some of which also support voice transmission), other types may also be supported by the cabling system components subject to attenuation and signalling characteristics. Figure 32 on page 81 illustrates the eight cable types defined within the IBM Cabling System and described in IBM cable planning reference manuals.

Cable	Conductor	Pairs	Shielding	Outdoor	Use
Type 1	Solid Copper	Two AWG 22 Twisted	Braided or Corrugated	Yes (1)	Main Paths Work Area to Wiring Closet
Type 2	Solid Copper	Two AWG 22 Twisted + Four TTP (AWG 22)	Braided No	No	Work Area to Wiring Closet
Type 3 Specs	Solid Copper	Four TTP (AWG 26)	No	No	Work Area to Wiring Closet
Type 5	Fiber Optics	Two Fiber 100/140	No	Yes	Main Paths (inter Bldg)
Type 5J	Fiber Optics	Two Fiber 50/125	No	Yes	Main Paths (up to 500m)
Type 6	Stranded Copper	Two AWG 26 Twisted	Braided	No	Work Area and Wiring Closet
Type 8	Solid Copper	Two AWG 26 Parallel	Braided (each pair)	No No	Work Area Under carpet
Type 9	Solid Copper	Two AWG 26	Braided	No	Main Paths (plenum)

Note 1. Plain, Plenum and Outdoor versions
TTP = Telephone Twisted Pair
AWG = American Wire Gauge

- Type 1 - Shield around two twisted pair of No. 22 AWG solid copper wire.
- Type 2 - Same as the Type 1 cable with the addition of four twisted pair No. 22 AWG telephone conductors.
- Type 3 - telephone twisted pair specification, No. 22 or No. 24 AWG solid copper wire.
- Type 5/5J - Two optical fiber conductors, 100/140 and 50/125 (fiber core/cladding size in microns), other sizes may also be used (for example, 62.5/125 micron).
- Type 6 - Shield around two twisted pair of No. 26 AWG solid copper wire used for patch cables.
- Type 8 - Undercarpet cable, two pair No. 26 AWG solid copper wire, with shielding.
- Type 9 - Two No. 26 AWG solid copper wire, offered as a lower cost alternative to type 1 plenum ¹⁴ cable.

Figure 32. Cable Types

There are many advantages to structured wiring systems incorporating general-purpose cable and components:

- Minimal additional cost of adding a new terminal. The provision of cable and wall outlets at each workplace makes it possible to "plug in" the new equipment.
- Easier and less disruptive movement of equipment. With a wiring closet structure, most changes are made in the wiring closet, minimizing the need to pull or relay new cable. Where changes are required, they can usually be confined to the more accessible wiring closets and shorter cable runs between the wiring closets.
- Simpler problem determination and maintenance. The knowledge of which cable is installed and where helps to minimize cost and time spent associated with maintenance or problem determination.

A key element in problem determination at this level is proper documentation of the cabling system installation, see *Using the IBM Cabling System with Communication Products*. Also refer to recommendations for labelling schemes, worksheets and charts to document the installation in the *IBM Cabling System Planning and Installation Guide*.

¹⁴ Plenum refers to space in the ceiling of a building floor which often is used to run cable ducts. In such cases, local regulations may require the installation of plenum cable which has a teflon coating instead of regular PVC.

The fiber cabling accessories, attachments, and planning guidelines supplied by IBM support the most popular multimode optical fiber specifications, including 50/125 micron, 62.5/125 micron, 85/125micron, and 100/140 micron cables. Because the FDDI LAN specifies 62.5/125 micron optical fiber, many customers may wish to use 62.5/125 micron multimode optical fiber cable in their token-ring network installations. Alternatively, they could use the 50/125 micron specification for those countries where 62.5/125 micron is not commonly used or available. 85/125 or 100/140 micron optical fiber cable are supported, but are not recommended for new installations by customers considering use of FDDI for future applications.

5. IBM Local Area Network Solutions

IBM provides three local area network implementations:

- IBM Token-Ring Network
- IBM PC Network (Broadband)
- IBM PC Network Baseband.

IBM has also announced the following statement of direction regarding LANs based upon the Manufacturing Automation Protocols:

IBM will implement MAP 3.0, which includes the IEEE 802.4 LAN standard and the IEEE 802.2 LLC Class I services, as its strategic LAN offering in the manufacturing area.

In the interim, IBM offers products which implement MAP 2.1 specifications and provide MAP 3.0 compatible application interfaces to minimize migration problems.

5.1 IBM Token-Ring Network

The IBM Token-Ring Network uses baseband transmission at either 4 Mbps or 16 Mbps implementing the IEEE 802.5 standard MAC protocols and the IEEE 802.2 Class II standard LLC protocols. At 16 Mbps, the IBM Token-Ring Network implements the early token release option.

Devices operating at 4 Mbps and others operating at 16 Mbps cannot be intermixed on the same LAN segment. Any attempt to insert a device into the ring at the wrong data rate will cause the ring to fail for several seconds due to the recovery process.

The IBM Token-Ring Network uses a star-wired logical ring topology. Devices on the network are physically attached to passive wiring concentrators, called *multistation access units* (MSAU). The multistation access unit is used as a point to control physical access to the ring, and to provide a method to bypass faulty or inactive devices. Use of a multistation access unit avoids the following problems inherent in a physical ring topology:

- **Reliability**

Failure of a ring station may disrupt the ring due to the loss of signal regeneration. Without a station bypass mechanism, the failure of a single station could stop all ring traffic, affecting all other ring devices. A cable fault between adjacent LAN stations in a physical ring topology can also stop normal operation of the LAN.

- **Serviceability**

Changing the configuration of the network (or even adding a new LAN station) could be disruptive if a controlled insertion process is not implemented.

Using a wiring concentrator can alleviate or remove these problems. For example, having a wiring concentrator that bypasses any inactive station means that when a station fails or a cabling fault occurs in an attaching cable, the ring is not disrupted. Stations can be added or removed from the ring while it is running without affecting other users in the network.

In the IBM Token-Ring Network, this passive wiring concentrator is called the *IBM 8228 Multistation Access Unit (MSAU)*.

5.1.1 IBM Token-Ring Network Components

5.1.1.1 Cabling Components

The IBM Token-Ring Network is designed to make use of a structured wiring system, like the IBM Cabling System mainly because of its star-wired ring topology. Maximum flexibility may be obtained when a building is wired with conveniently located wiring closets containing wiring patch panels and token-ring multistation access units (8228 MSAUs). The IBM 8228 Multistation Access Unit implements the relay center or passive wiring concentrator concept introduced in "LAN Technology" on page 7.

The IBM Token-Ring Local Area Network can be used with all the cable types referred to in Figure 32 on page 81 when installed in conformance with the planning and installation specifications of the IBM Cabling System as described in the *IBM Token-Ring Network Introduction and Planning Guide*. Type 1 or 2 cables should be used for lobes (the connection from the wall outlet to the workstation). Cable types 1, 2 and 5 can be used for the links between the multistation access units.

In an IBM Token-Ring Network operating at 4 Mbps, Type 3 telephone twisted pair cable can be used to connect device attachment locations to multistation access units in a wiring closet provided the Type 3 Cable Specifications for distance and number of station attachments are met, and the cable is not subject to electrical noise. Type 3 TTP wire cannot be mixed with data grade media twisted pair wire within a single physical ring and cannot be used to wire a 16 Mbps token-ring LAN segment.

Figure 33 on page 87 provides a schematic diagram of IBM Token-Ring Network stations connected via IBM Cabling System wiring and attachments. The first part shows the use of data grade media twisted pair; the second illustrates installation requirements when using voice grade (telephone) twisted pair wire.

- A maximum of thirty IBM 8228 Multistation Access Units is supported on a single ring running at 4 Mbps.
- The maximum number of concurrently active devices on a single 4 Mbps ring is dependent upon the type of cable used in wiring the ring, and must include the number of repeaters used (if any) in this count:
 - Type 1 or Type 2 cable - Maximum 260 stations
 - Type 9 cable - Maximum 175 stations
 - Type 8 cable - Maximum 130 stations
 - Type 6 cable - Maximum 96 stations
 - Type 3 cable - Maximum 72 stations.

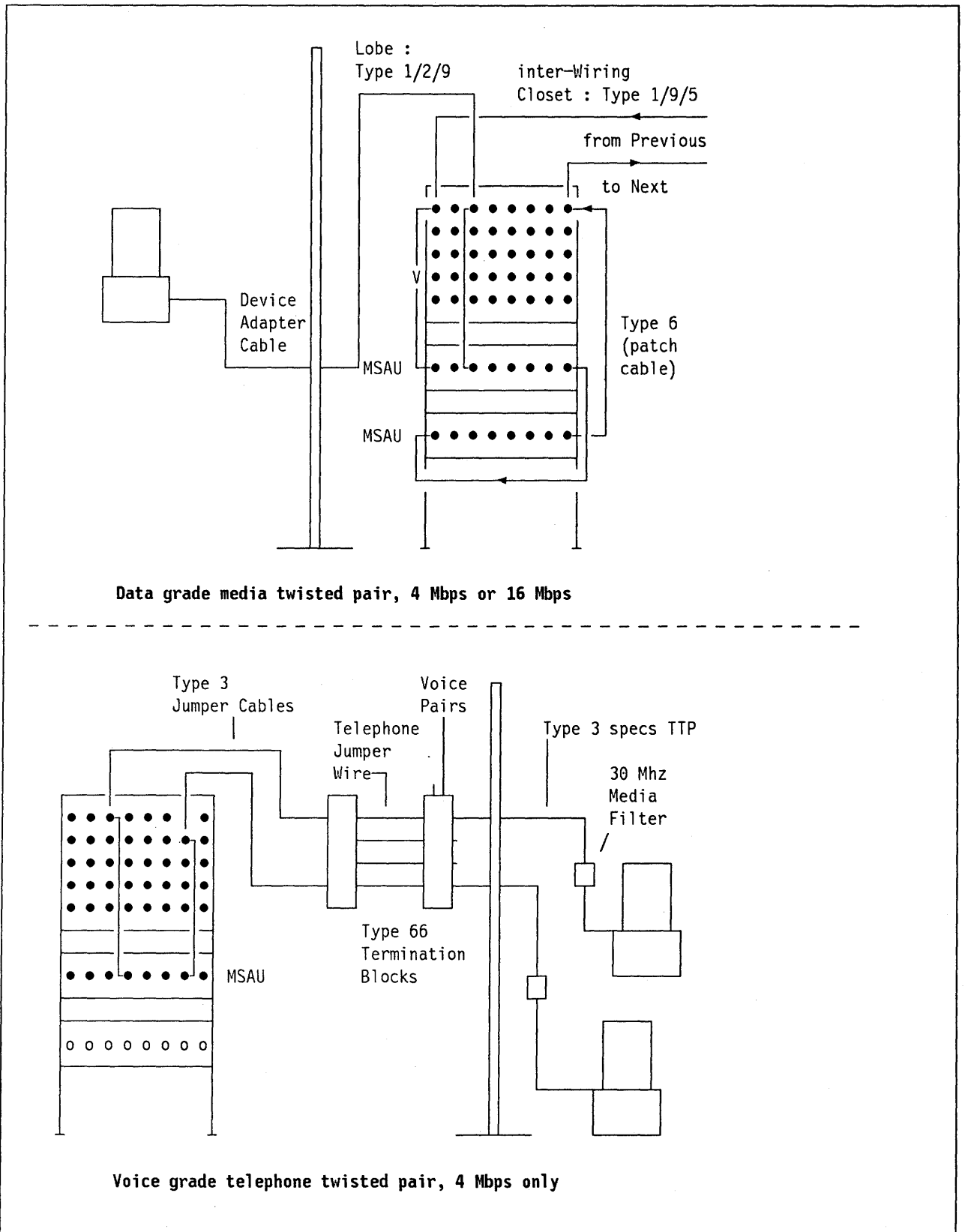


Figure 33. IBM Cabling System in the IBM Token-Ring Network

The differences in the numbers of attachments is a function of the attenuation and signalling differences in the various cable types.

Not more than 136 devices should be attached to a ring operating at 16 Mbps, using a maximum of 17 multistation access units.

- When telephone twisted pair wire is being used a media filter must be installed between the station adapter card and the telephone jack in the wall.

Two type 66 termination blocks are recommended to provide isolation between the data and voice pairs of the telephone wire. Between a data termination block and the distribution panel a Type 3 jumper cable is used.

The telephone twisted pair wiring option may not be available in all countries due to PTT restrictions.

- For further information, refer to the following documentation:
 - *IBM Cabling System Planning and Installation Guide*
 - *IBM Token-Ring Network Installation Guide*
 - *IBM Token-Ring Network Introduction and Planning Guide*
 - *IBM Token-Ring Network Telephone Twisted-Pair Media Guide*
 - *IBM Token-Ring Network Telephone Twisted-Pair Media Guide, European version.*

In addition to the specifications for numbers of attachments identified above, rules are also provided for maximum distances between stations which drive signals, and wiring closets (that is, maximum lobe distances) and between wiring closets.

The number of stations attached to a token-ring LAN may be increased indefinitely by using token-ring bridges. For instance 4 Mbps ring segments may be interconnected with 16 Mbps segments via token-ring bridges; or voice grade (telephone) twisted pair wired Ring segments may be interconnected with ring segments for which data grade media twisted pair wire has been used.

IBM Token-Ring Network bridges are discussed in "LAN Segments Interconnection" on page 149.

5.1.1.2 IBM 8228 Multistation Access Unit

The IBM 8228 Multistation Access Unit supports up to eight LAN stations via device attachment ports and the interconnection of multiple 8228 access units via ring-in, ring-out ports. The 8228 is a passive wiring concentrator that can bypass attached devices by reacting to the presence (or absence) of a signal from the device attachments. Each of the eight device attachment ports includes relay mechanism which is powered by a phantom current¹⁵ from the attaching adapter.

In "Basic Token Passing Ring Concepts" on page 22, a sample wiring scheme involving four multistation access units (referred to as passive wiring concentrators) was described together with an illustration, in Figure 7 on page 23, of a few active or inserted devices as well as several bypassed lobes.

¹⁵ A 5 Volts DC voltage is sent by the attaching adapter over the lobe wire to power the relay. It is called a phantom current because it is transparent to the actual AC data signal.

The backup scenario shows how the backup path is used to recover the ring traffic following a cable break between the ring-out position of one multistation access unit and the ring-in position of the subsequent multistation access unit. This recovery requires manual intervention to remove each end of the cable segment from the ring-in or ring-out ports, unless a pair of 8220 Optical Fiber Converters has been installed with the capability to isolate the broken segment (see "Cabling Components" on page 86).

5.1.1.3 Device Attachment Cards

Any device attachment hardware component, for any IBM token-ring attachable device, is complemented by a software and/or microcode component. The combined components implement the IEEE 802.5 and IEEE 802.2 LAN standards and optionally, additional LAN management function. Whether all of the LLC level code is supplied in the software component or as microcode on a particular token-ring adapter card depends on the type of attaching device.

5.1.1.4 Repeaters and Converters

The distance travelled by a token before regeneration of the signal is limited by the attenuation characteristics of the medium. The adapters of active token-ring devices provide regeneration whether or not the device has data of its own to send. In some cases the signal must be maintained over longer stretches of cable where stations cannot be placed. In these cases a special device called a *repeater* may be used to provide the regeneration.

Only copper wire without repeaters may be used in a *lobe*, that is the wire between the LAN station in the office and a multistation access unit port in the wiring closet.

When longer distances are encountered between wiring closets (*inter-wiring closet connections*), active repeaters or converters may be applied. They are used to amplify and re-synchronize the signal, thus extending the maximum distance allowed between multistation access units in remote and wiring closets.

The distance by which a repeater extends the transmitted signal is measured from the repeater to the next signal driving point. This could be another repeater (as they can be connected in series) or a ring station.

IBM offers three repeaters/converters to provide signal regeneration over copper or fiber cables between wiring closets.

A major consideration in locating repeaters or converters is the distance the signal must be driven in the event cable on the main path fails or is removed, since the backup path, which is usually considerably longer than the main path, will then be used.

For copper wiring between wiring closets, 8218 Copper Repeaters may be installed to provide the necessary signal regeneration. For several reasons a fiber cable may be used between wiring closets, for which a pair of 8219 Optical Fiber Repeaters or 8220 Optical Fiber Converters is required to convert electrical signals to/from light pulses.

A pair of IBM 8220 Fiber Converters actively participates in the token passing protocol, thereby supporting automatic monitoring of both paths and automatic recovery from some types of error. The other repeater devices, the IBM 8218

Copper Repeater and the IBM 8219 Fiber Repeater, are simpler components of the physical cabling and do not implement MAC layer functions.

Repeaters and converters contribute to accumulated phase jitter¹⁶ since they amplify and regenerate the signal as any LAN station does. Therefore, repeaters and converters must be included when considering the maximum number of devices supported for any given cable type on a single ring.

5.1.1.5 IBM 8218 Copper Repeater

Figure 34 represents a Copper Repeater (8218). It is an active component used to cover longer copper-wired distances between wiring closets.

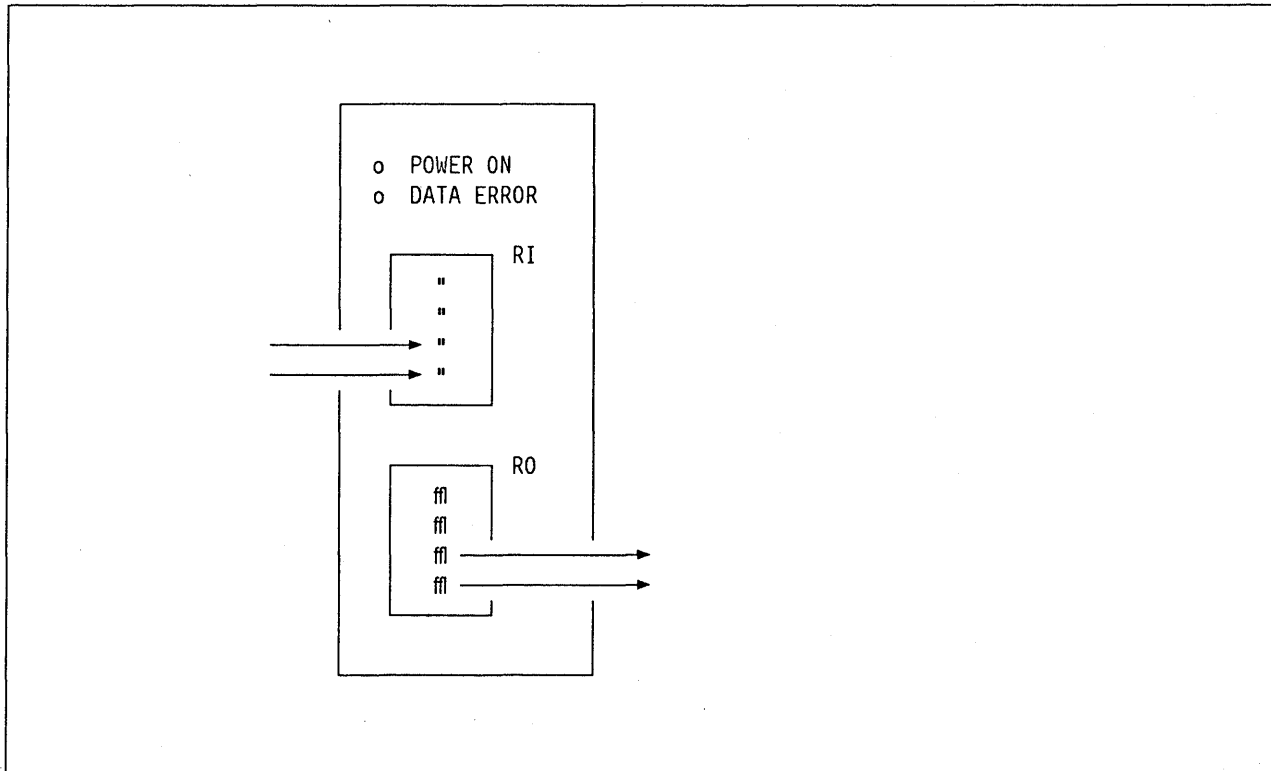


Figure 34. The 8218 Copper Repeater

The IBM 8218 Copper Repeater operates only at 4 Mbps. When used with Type 1 cable, the maximum distance between two Wiring Closets can be increased to 770 meters. With Type 9 cable, the maximum distance is about 500 meters.

Intermediate 8228 Multistation Access Units are allowed between pairs of 8218 Copper Repeaters. The actual placement of 8218s depends upon the result of design guidelines, documented in *IBM Token-Ring Network Introduction and Planning Guide*. This manual also contains the rules and tables required to plan and verify a physical token-ring installation based on IBM Cabling System components.

¹⁶ Every time a signal is amplified and regenerated, a small amount of additional phase distortion is introduced. This accumulated effect of phase distortion is referred to as phase jitter.

In the 8218, only the main path entering the ring in (RI) connector is amplified and retimed. Therefore 8218s must be installed in multiple pairs (minimum four 8218s) to provide signal symmetry and recovery capability via the backup path.

A sample illustration of 8218 Copper Repeaters without intermediate 8228 Multistation Access Units, Figure 35 on page 91, shows why two pairs of 8218s are required to maintain full backup path capability.

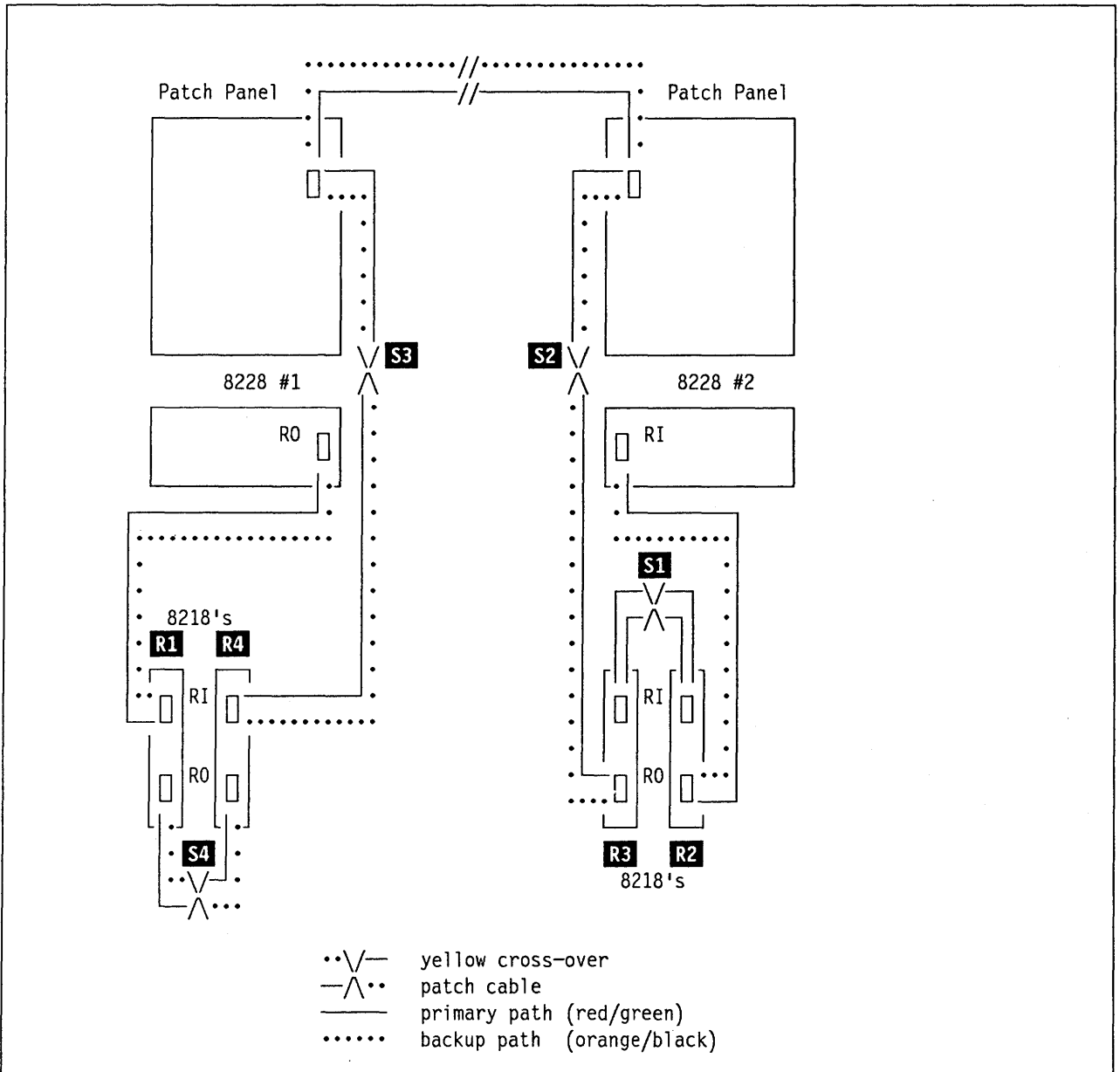


Figure 35. 8218 Copper Repeater Installation

For convenience, the 8218 Copper Repeaters have been identified (from left to right) as: R1, R4, R3, R2. Cross-over patch cables have been numbered S1, S2, S3, S4 (from right to left).

The primary path leaving the multistation access unit ring-out on the left side is normally amplified by R1. Repeater R2 is required at the other end for signal symmetry.

To provide proper amplification of the backup path signal by R3, a cross-over patch cable (S1) is used to swap the ring in and ring out wire pairs entering R2 (only the primary pair (red/green) entering the 8218 Ring-In would normally be amplified). In this way, the signal on the backup path will be amplified by Repeater R3.

Before the signal travels back between the wiring closets, the primary and backup signals must be restored (on the red/green and orange/black pairs respectively) by cross-over patch cable S2.

The amplification of the backup signal by R3 requires another repeater (R4) at the other end. At the ring In of R4 the backup signal must arrive on the red/green pair. Therefore cross-over cable S3 is required.

Finally, after leaving R4, the backup signal is put back on the orange/black pair by cross-over cable S4.

5.1.1.6 IBM 8219 Optical Fiber Repeater

The IBM 8219 Optical Fiber Repeater extends the effective drive distance between wiring closets up to two kilometers using Type 5 cable (containing two 100/140 micron optical fibers). Each IBM 8219 provides a standard 4-wire data connector for the incoming or outgoing copper cable and two optical connectors (marked "receive" and "transmit") for the optical fiber connections as illustrated in Figure 36.

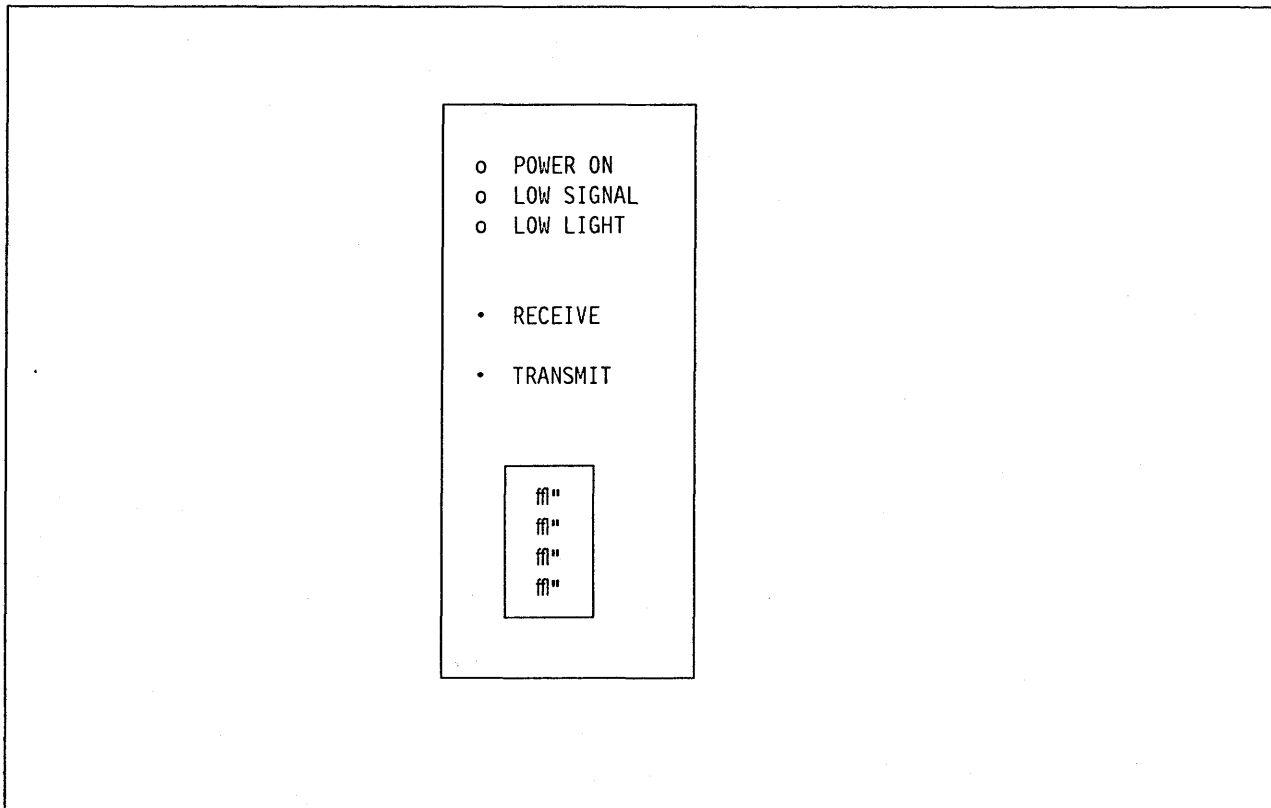


Figure 36. 8219 Optical Fiber Repeater

Other fiber sizes supported are 50/125, 62.5/125 and 85/125. Like the IBM 8218 Copper Repeater, the 8219 operates only at 4 Mbps.

An important advantage of installing fiber cable between wiring closets is that the optical signal is virtually immune from outside interference. Optical media should be considered for outdoor connections or where cabling must pass through electrically noisy areas.

Use of fiber may also be a consideration to simplify coexistence with and/or migration to FDDI LANs in installations with foreseeable high bandwidth requirements.

For more information on the use and installation of fiber optic cabling with current IBM products, refer to *IBM Token-Ring Network - Optical Fiber Cable Options*

Only the signal carried in the primary path (the red/green wire pair in the data connector) is transmitted via the transmit connector of one 8219 and received at the receive connector of the other 8219. The optical signal entering the receive connector is converted back to electrical pulses on the backup copper wire pair (orange/black).

These considerations are illustrated in the 8219 Fiber Repeater installation in Figure 37 on page 94.

Because they use only copper connectors, intermediate 8228 Multistation Access Units cannot be positioned between paired 8219 Optical Fiber Repeaters.

This diagram also shows that only one pair of 8219 Fiber Repeaters is required to provide a connection between wiring closets with full backup capabilities. Note that only one yellow cross-over patch cable is required compared to the four cables required by the 8218 example described earlier.

When the primary signal enters the left 8219 on the red/green copper pair, it will be transmitted as an optical signal on the black fiber. On the right side, the black fiber is connected to the receive connector of the second 8219 where the signal is converted and sent out on the orange/black copper pair. Therefore, after leaving the right 8219, a cross-over cable is applied to put the primary signal back on the red/green copper pair.

In backup situations, the signal will be wrapped at the two 8228 access units. Consequently the cross-over cable will swap the backup signal to the red/green copper wire pair as it leaves the ring-in of the right multistation access unit. Since the backup signal enters the right 8219 on the red/green pair, it will be transmitted as an optical signal on the orange fiber. On the left side, the orange fiber enters the receive connector of the 8219. The optical light pulses will be converted back to electrical signals and sent out on the orange/black copper pair. This direction is correct for the backup signal as it enters the ring-out of the left multistation access unit.

5.1.1.7 IBM 8220 Optical Fiber Converter

The 8220 Optical Fiber Converter operates in a token passing ring to extend the distance between multistation access units in separate wiring closets up to two kilometers when operating at either 16 Mbps or at 4 Mbps.

The 8220 Optical Fiber Converter, unlike the 8218 Copper Repeater or 8219 Optical Fiber Repeater, participates in the token passing ring protocols,

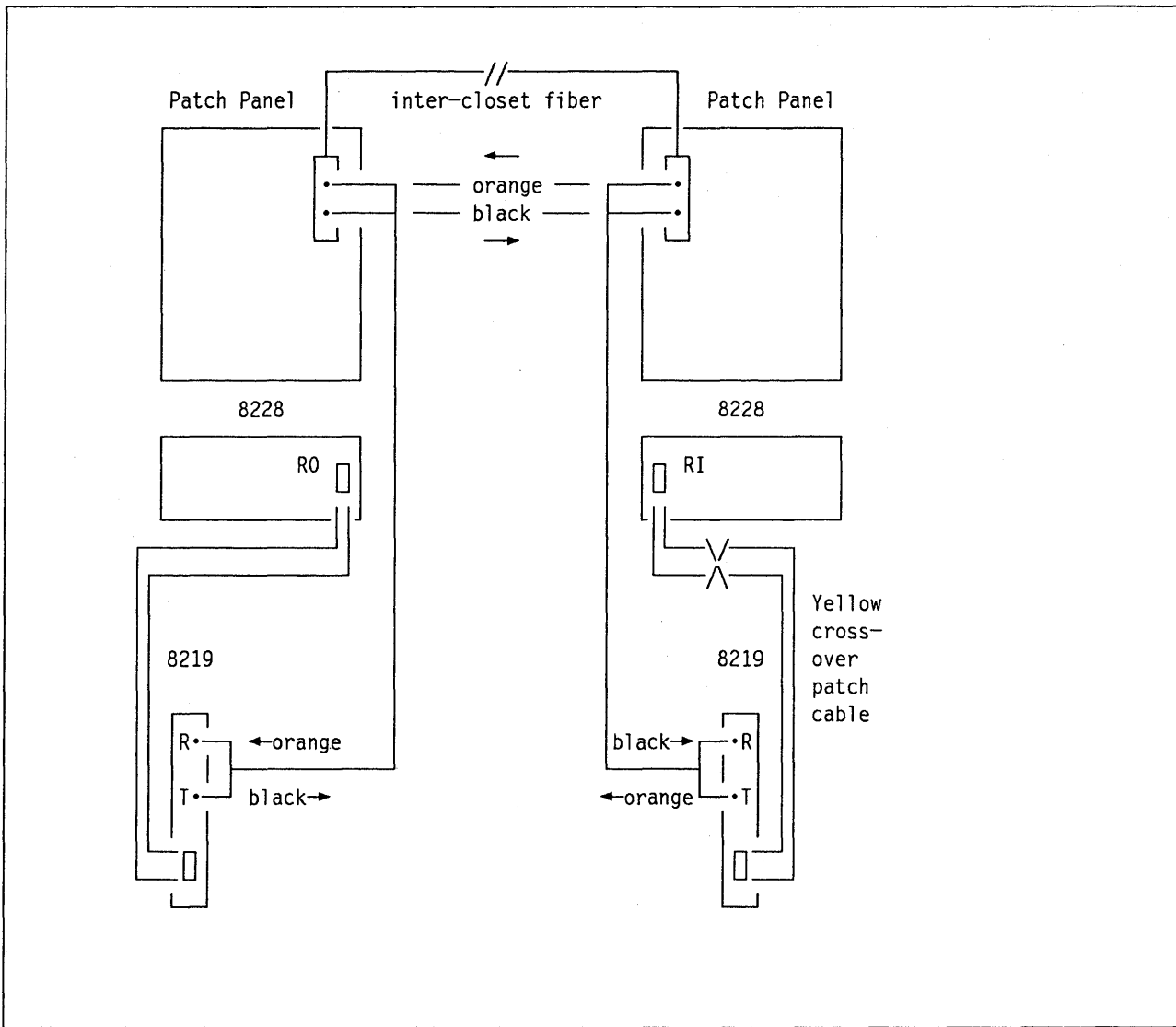


Figure 37. 8219 Optical Fiber Repeater installation

enabling it to provide error detection and automatic recovery functions in some circumstances. As this implies, each 8220 Optical Fiber Converter has a unique individual MAC address to support this capability.

The 8220 Fiber Optical Repeater has one token-ring media data connector to connect the 8220 to the ring in or ring out position of an 8228 Multistation Access Unit, two optical connectors (marked "receive" and "transmit") as shown in Figure 38 on page 95 to connect to the fiber cables.

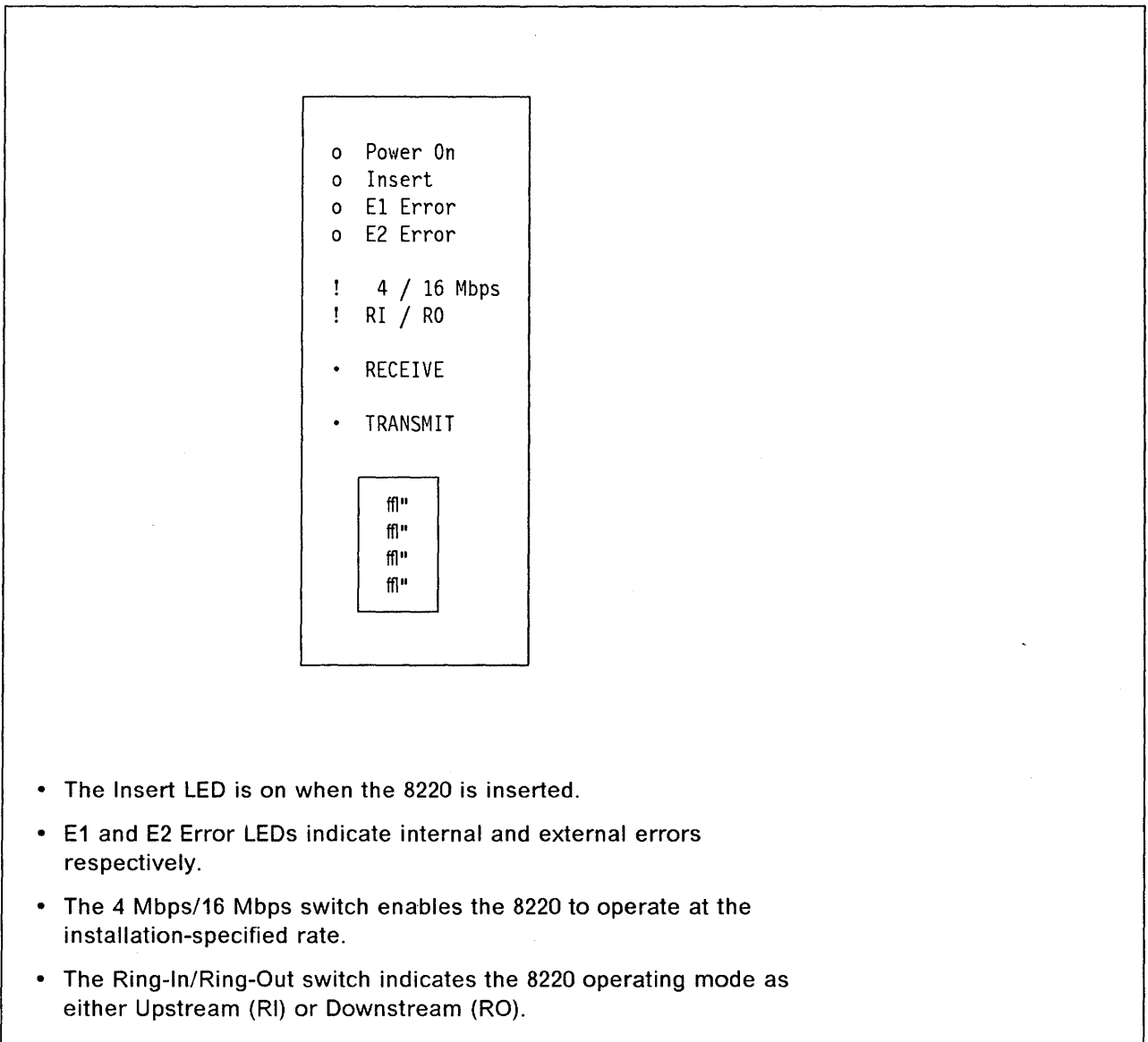


Figure 38. 8220 Optical Fiber Converter

Apart from offering two operational data rates, **4 Mbps** and **16 Mbps**, the 8220 Optical Fiber Converter also has two operational states, **wrap** state and **inserted** state.

- In "wrap" state, the 8220 is not operational. It is physically and logically *not-inserted* into the ring. Due to internal wrapping, a fiber-connected pair of 8220 Optical Fiber Converters form a "closed ring", allowing self-test diagnostics to execute automatically. IBM 8220 Fiber Converters can be removed from and reinserted into a ring like other token-ring stations.
- In "inserted" state, the 8220 is physically and logically *inserted* in both the main and backup paths of the ring, transmitting additional 8220 unique frames as well as *IEEE 802.5 MAC protocol* (non-early-token-release) frames.

The 8220 Optical Fiber Converter can, by means of the RI/RO switch, be set into either of the following operational modes: **Upstream** (Ring-In) or **Downstream** (Ring-Out).

A pair of IBM 8220 Optical Fiber Converters connected as shown in diagram Figure 39 on page 96 is called a **8220 Fiber Optical Converter Subsystem**. Both converters are referred to as *partners* within the 8220 Subsystem protocols.

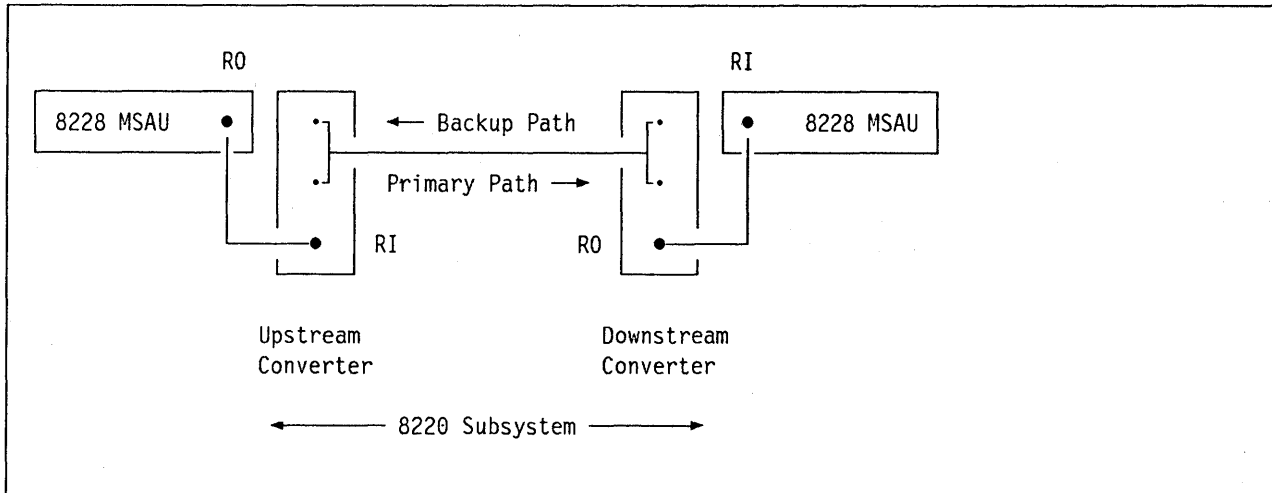


Figure 39. 8220 Optical Fiber Converter Subsystem

In this diagram:

- The upstream (left) converter is connected to the ring-out position of an 8228 Multistation Access Unit. Logically, the upstream converter participates in the ring traffic carried in the main path.
Inversely, the downstream converter is connected to the ring-in position of the next 8228 Multistation Access Unit. Logically, the downstream converter participates in the ring traffic carried in the backup path.
- The upstream converter provides the control function within the 8220 subsystem; the downstream converter follows the control function provided by the upstream converter.
- If a loss of power or failure occurs within the scope of the 8220 subsystem, the 8220 pair will automatically de-insert from the ring and wrap the main ring to the backup ring at each end of the subsystem, thus maintaining the operation of the ring. This is shown schematically in Figure 40 on page 97. As soon as the optical fiber cable is repaired, the 8220 subsystem will return to normal operation.
- An 8220 Optical Fiber Converter can be defined as a *critical resource* to the LAN Manager.
- The Downstream 8220 continuously monitors the condition of the backup ring so that a potential failure in the backup ring can be identified and corrected by operations personnel before the ring is needed for backup operation.

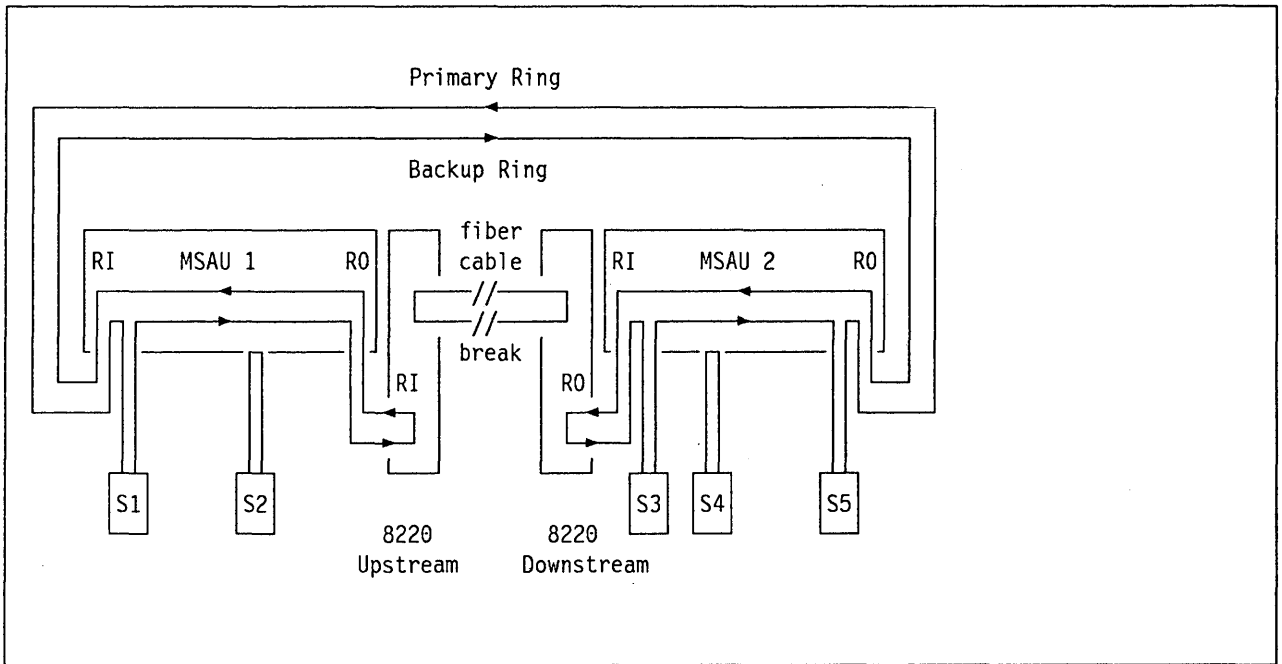


Figure 40. 8220 Subsystem - Automatic Wrap to Backup Ring

For additional installation considerations and the use of cross-over patch cables, refer to the 8219 installation shown in Figure 37 on page 94.

5.1.1.8 Summary

The IBM Cabling System offers cable types and components to implement general purpose structured wiring for data communications. It also allows, within specified limitations, use of existing telephone twisted pair wire for transmission of digital data.

The structured wiring approach implemented by the IBM Cabling System very well suits the cabling requirements of the IBM Token-Ring Network, both at 4 Mbps and 16 Mbps data rates. Unshielded telephone twisted pair wire is only applicable to 4 Mbps token-ring cabling. Between multistation access units in distant wiring closets, optical fiber cable may be installed.

Of the three repeaters/converters offered to extend the distance between separate wiring closets, the 8220 Optical Fiber Converter may frequently provide the most desirable solution. It is the only repeater/converter device supporting both 4 Mbps and 16 Mbps data rates between wiring closets, and is currently the only device that implements automatic recovery for cable failures between wiring closets (since it actively participates in the IEEE 802.5 MAC protocols).

5.1.2 IBM Token-Ring Network Devices

5.1.2.1 Workstations

The original IBM Token-Ring Network Adapter, announced in 1985 and often referred to as Token-Ring Adapter I, has now been withdrawn from marketing.

IBM Personal Computers and the IBM Personal System/2 Model 30, subsequently referred to as Family 1 workstations, can be attached to the IBM Token-Ring Network through the *IBM Token-Ring Network Adapter II* at a data

rate of 4 Mbps. The *IBM 16/4 Token-Ring Network Adapter* offers a 16 Mbps / 4 Mbps switchable token-ring attachment for the same Family 1 devices.

All other IBM Personal System/2 models, equipped with the Micro Channel bus and subsequently referred to as Family 2 workstations, can be attached to the IBM Token-Ring Network through the *IBM Token-Ring Network Adapter/A* at a data rate of 4 Mbps or through the *IBM 16/4 Token-Ring Network Adapter/A* to either a 16 Mbps or 4 Mbps token-ring LAN.

When attached to a 16 Mbps token-ring LAN using the proper Family 1 or Family 2 adapter card, the IEEE 802.5 protocol implementation provides the early token release option.

Enhanced token-ring adapters are available for both Family 1 and Family 2 PCs and PS/2's¹⁷ to support the IBM Token-Ring Network Trace and Performance Program, respectively the *IBM Token-Ring Network Trace and Performance Adapter* and the *IBM Token-Ring Network Trace and Performance Adapter /A* (both operating only at 4 Mbps). The IBM Token-Ring Network Trace and Performance facilities are discussed in "IBM Token-Ring Network Trace and Performance Facilities" on page 293.

The RT/PC provides also a 4 Mbps attachment to an IEEE 802.5 LAN. Software support for the RT/PC is provided by AIX, a Unix-based operating system supporting both TCP/IP and SNA as higher layer protocols in local and wide area networks.

Bridge support for IBM Token-Ring (and PC/Network) LANs is provided by PC/DOS-based software programs for both 4 and 16 Mbps ring interconnection.

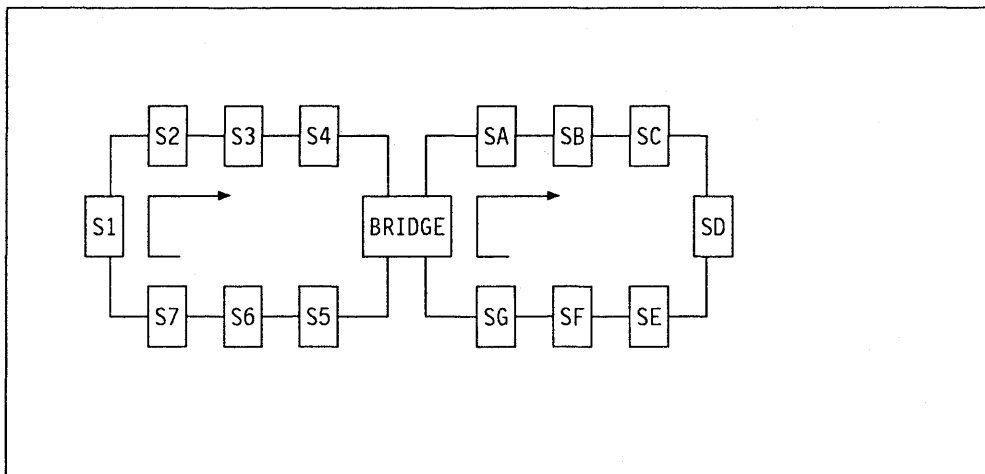


Figure 41. Token-Ring Interconnection via a Token-Ring Network Bridge

The hardware component of a Token-Ring Bridge is a dedicated PC or PS/2 with two appropriate token-ring adapter cards installed. The software component is the IBM Token-Ring Network Bridge Program Version 2.0 or 2.1. To support high traffic rates, IBM recommends that a PC/AT or Personal

¹⁷ PC and PS/2 are registered trademarks of the International Business Machines Corporation.

System/2 be used for bridges. Token-ring bridge products are explained in greater detail in "IBM Token-Ring Network Bridges" on page 165.

5.1.2.2 Adapter Support Interface for Token-Ring Attached Workstations

The adapter support interface between the workstation's processor and any token-ring adapter card is included in the *IBM LAN Support Program*. More details on the other functions of this product are provided in "IBM LAN Support Program" on page 126. One significant function with respect to adapter support however is to provide access to memory locations on a token-ring adapter card from which the workstation processor can retrieve received information or to which it must place data for transmission. These memory locations reside in an area of the adapter card called *Shared RAM*.

All currently offered 4 Mbps IBM Token-Ring Network adapters have a Shared RAM of 16 Kbytes. The 16/4 Mbps switchable adapters have a Shared RAM of 64 KB which can be divided into four 16 KB pages. All or part of these memory pages may be used by system software. A technique called *RAM Paging*, supported by the IBM LAN Support Program, permits use of the entire 16 or 64 KB shared RAM memory while requiring only 16 KB in the PC or PS/2 memory.

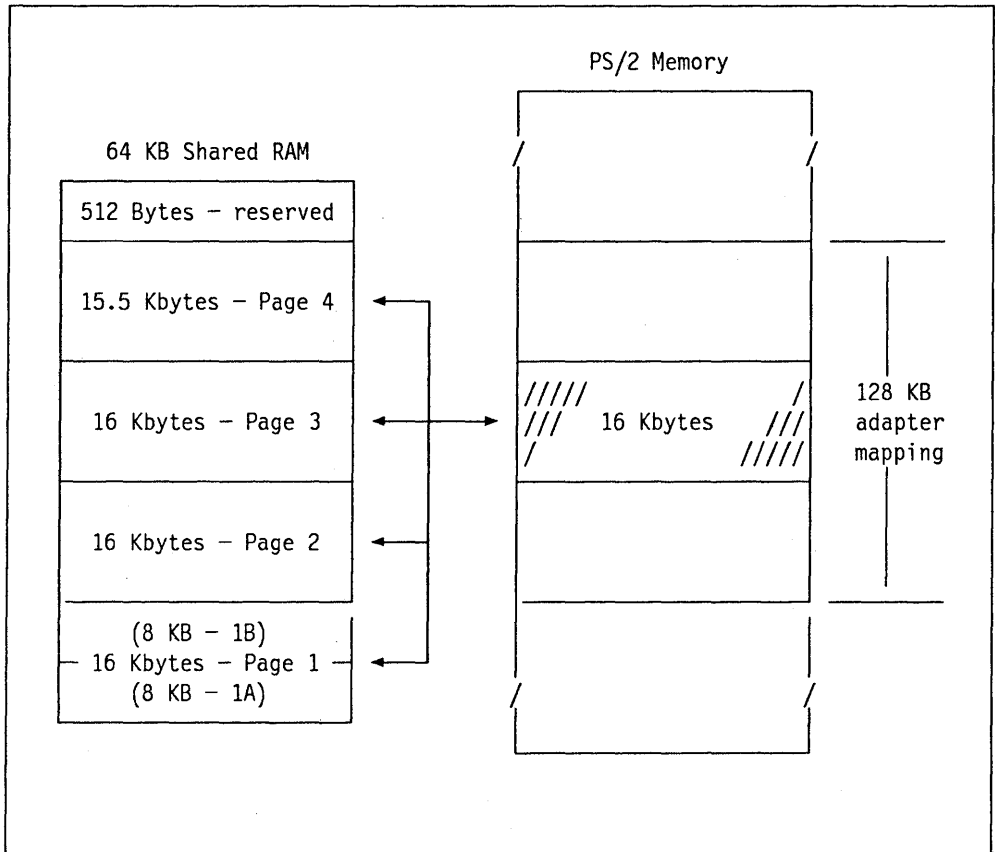


Figure 42. RAM Paging

In general, a larger shared RAM size allows larger frames to be transmitted, (up to a maximum 4 KB frame size on a 4 Mbps token-ring adapter with 16 KB shared RAM versus 16 KB maximum frame size on a 16/4 Mbps token-ring adapter with 64 KB shared RAM). Use of larger frame sizes provides the potential for improved ring utilization. Larger shared RAM memory size also

enables support for more (up to 254) link stations (see "Logical Link Control Sublayer" on page 70).

Figure 43 on page 100 shows the default shared RAM utilization as implemented by the IBM LAN Support Program for a 16 KB Shared RAM size.

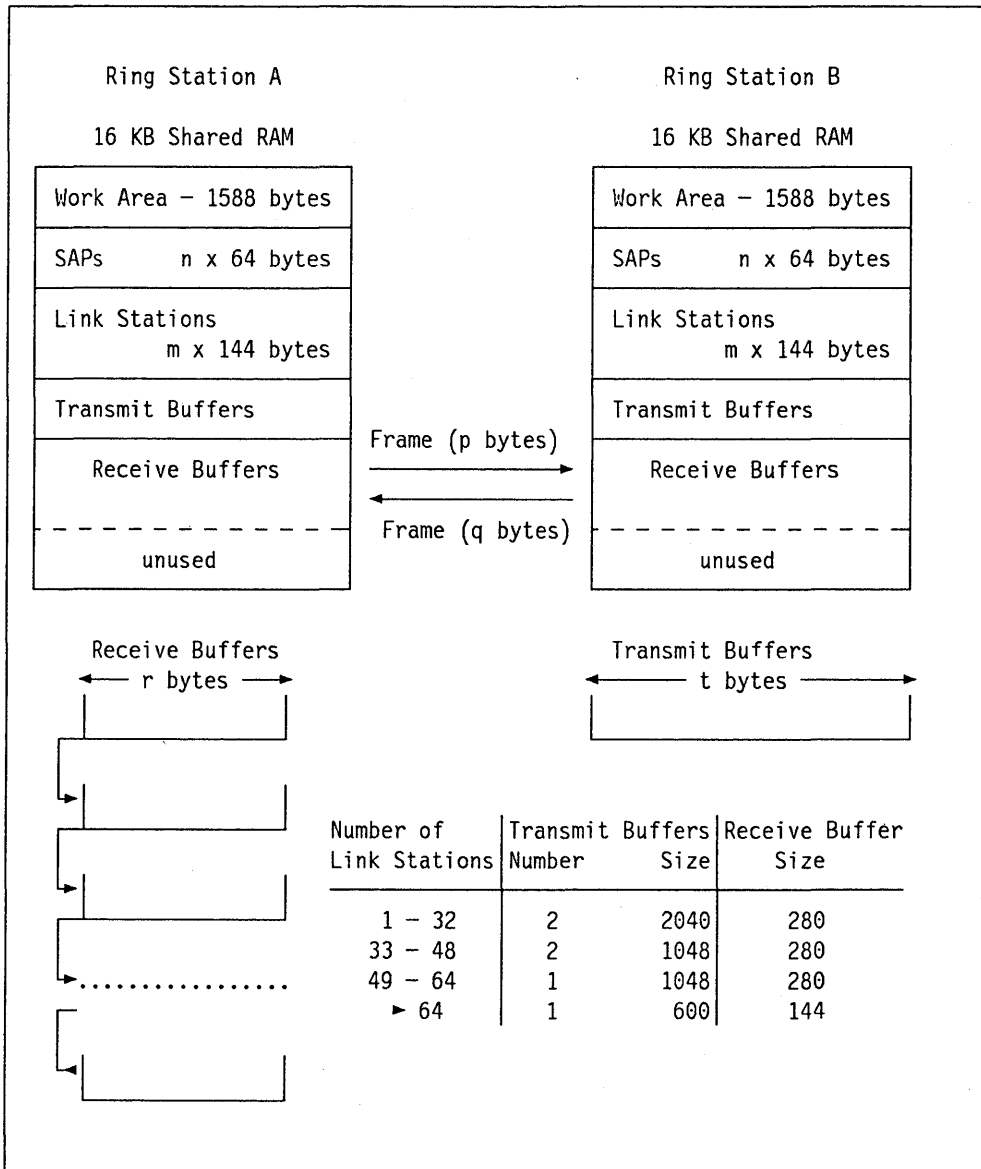


Figure 43. Shared RAM Utilization

The maximum frame length is determined as the smallest of either the transmission buffer size or half the number of receive buffers times the receive buffer size. The number of receive buffers is a function of the number of SAPs and the number of link stations. A realistic maximum number of link stations is 64 for a token-ring adapter with 16KB RAM.

Larger frame sizes can be obtained by reducing the number of required SAPs and link stations. Default parameters supplied by the IBM LAN Support Program should be evaluated with respect to the LAN applications used by the workstation to ensure that neither too few or too many link stations, SAPs, sessions, and outstanding commands are defined.

Receive Buffers are chained to accommodate at least twice the transmit frame size. This prevents overrun for incoming frames received faster than can be handled by the receiving adapter and processor.

Currently IBM Token-Ring Network adapters can be equipped with a *Remote Initial Program Load (RIPL)* feature, consisting of a pluggable EPROM. This feature allows a token-ring attached device to obtain a bootstrap program from a remote LAN RIPL server at power-on time, rather than supplying its own startup code. For additional information, see "IBM PC LAN Program V1.2" on page 235.

5.1.2.3 3174 Token-Ring Attachment Options

Various models of the *3174 Subsystem Control Units* connect to the IBM Token-Ring Network at 4 Mbps via a generic token-ring Interface card called the *Type 3 - 4 Mbps Communication Adapter*. The same models can also be equipped with the *Type 3A Dual Speed (16/4) Communication Adapter*, and customized for operation at either 16 Mbps or 4 Mbps.

These adapters are announced for IBM 3174 Models 01L (*local gateway*), 01R, 02R, 51R and 52R (*remote gateways*) as well as for Models 03R and 53R (*DSPU, PU connected downstream from the LAN gateway*).

The 3174 gateways can be IMLed alternatively as DSPUs. This feature is called *alternate host attachment* to enable an installation to plan for backup host gateway connections. Connectivity considerations are described in "Host Gateways" on page 191.

Microcode support is provided for both adapters by Configuration Support A for the base function and by Configuration Support S for the gateway function. The support also includes the ring error monitor server function, which implements a subset of the ring problem determination support for LAN management operations.

Dependent upon configuration, token-ring information frames up to 4105 Bytes for receive frames and up to 2057 or 4105 Bytes for receive frames are supported as shown in Figure 44 on page 102.

Function	Supported Models	Feature #	I-frame size Transmit Receive (up to)		Config. Support
Gateways	01L, 01R, 02R 51R, 52R	3026	4105	4105	S Re1 5
Type 3A Adapters	03R, 53R	3030	2057	4105	A Re1 5
Alternate Host Att	01L 01R, 02R 51R, 52R	3044	2057	4105	A Re1 5

Figure 44. 3174 Configuration and Supported Frame Sizes

At 16 Mbps, early token release is supported to optimize ring utilization.

For gateway 3174's (Models 1L, 1R and 2R), the Token-Ring Network 3270 gateway optional feature (#3025) includes the "Type 3 - 4 Mbps Communication Adapter" as well as the Token-Ring Attachment cable and the 3174 Configuration Support-S Release 5.

Similarly, the Token-Ring Network 3270 gateway optional feature (#3026) includes the "Type 3A Dual Speed (16/4) Communication Adapter" as well as the Token-Ring Attachment cable and the 3174 Configuration Support-S Release 5

5.1.2.4 37xx Token-Ring Subsystems

3725, 3720, and 3745 Communication Controllers also connect to the IBM Token-Ring Network to provide S/370 host gateway support.

3720 The Token-Ring Subsystem (TRSS) of a 3720 is based on a **Token-Ring Multiplexer (TRM)** and **Token-Ring Interface Couplers (TIC)**. The combination of TRM and TICs is called a **Token-Ring Adapter (TRA)**. The TRSS is only supported on 3720 Models 11 and 12; it provides one TRA located in the base board and has one TRM and up to two TICs operating at 4 Mbps.

3725 On a 3725, the TRSS requires a special **Line Attachment Base Type C (LAB-C)**. A LAB-C includes a Scanner for regular communication lines (up to sixteen LICs) and a TRM with up to four TICs (TRM + TICs = TRA). One TRA can be installed in the 3725 base frame, one or two TRAs may be installed in the 3726 expansion frame with a grand total of two TRAs for the entire

communications controller. As in a 3720, all 3725 TICs operate at 4 Mbps.

3745 The TRSS of a 3745 consists of up to four TRAs where each TRA is made of a TRM and up to two TICs. This provides a maximum of eight TICs. The TRA can be installed in Line Adapter positions 1,2 and 5,6 in the 3745 Base Frame Adapter Board.

For a 3745, either 4 Mbps TICs (*TIC 1*) or switchable 16/4 Mbps TICs (*TIC 2*) are announced. (TIC 2 adapters will become generally available at the end of 1989.) A mixture of TIC 1 and TIC 2 adapters may be installed in the same 3745 Communication Controller, for a maximum of eight TICs.

TICs available for 372x Controllers are now referred to as TIC 1 adapters as opposed to the TIC 2 adapters announced for the 3745. Both TIC interfaces implement the IEEE 802.5 standard. The TIC 2 interface also supports the early token release at 16 Mbps.

IEEE 802.2 connection-oriented services are supplied by a NCP (Network Control Program) generation option called **NCP Token-Ring Interconnection (NTRI)**.

In the case of a 3745, NTRI also permits definition of the LAN data rate (4 or 16 Mbps) for a TIC 2 port, and selection of early token release if 16 Mbps has been selected.

For a TIC 2 adapter, the range of values and default values for transmitted frame sizes (MAXTSL parameter in the BUILD macro) has been changed. The minimum value is 265 bytes and the default value is 2012 bytes. When operating at 4 Mbps, a MAXTSL of 4060 is allowed, while for 16 Mbps operation, MAXTSL can be increased to a maximum of 15,964 bytes.

Each TRA operates under control of NTRI. Each physical connection to the token-ring network appears to VTAM as a full-duplex, non-switched, point-to-point line. Each PU of a terminal connected to NTRI appears to VTAM as a PU on a half-duplex, switched, point-to-point line. NCP to NCP Token-Ring communication is also supported, where each NCP appears to the other and to VTAM as a PU Type 4 on a single leased link.

More information on 37xx - token-ring network connectivity is provided in section "Host Gateways" on page 191.

5.1.2.5 9370 Token-Ring Subsystem

All 9370 local or wide area network integrated communications support is supported by four different communications subsystems. One of these is the IBM 9370 Token-Ring Subsystem, controlled by the IBM Token-Ring Network Subsystem Controller. This subsystem supports connection of 9370 applications over an IBM Token-Ring Network¹⁸.

¹⁸ The IEEE 802.3/Ethernet LAN Subsystem supports connection of 9370 applications over an IEEE 802.3 or Ethernet local area network.

A Token-Ring Network Subsystem Controller consists of *either*

the 9370 Communications Processor Card (feature #6130) and the Token-Ring Adapter card (4 Mbps, feature #6034), *or*

the 9370 Communications Processor Card (feature #6130) and the 16/4 Mbps Token-Ring Adapter card (feature #6134),

and the required adapter software which is provided by the microcoded 9370 Token-Ring Subsystem Support Program.

One 9370 Communications Processor Card supports only one Token-Ring Adapter card, however different Communication Subsystem Controllers may be installed in a single 9370, with a maximum¹⁹ of:

- two in the 9373 (Model 20),
- two in the 9373 (Model 30) or up to 15 with 9370 I/O Expansion Units (feature #5030),
- four in the 9375 (Model 40, 50 & 60) or up to 15 with 9370 I/O Expansion Units (feature #5030),
- twelve in the 9377 (Model 80 & 90) or up to 15 with 9370 I/O Expansion Units (feature #5030).

The 9370 Token-Ring Subsystem complies with the IEEE 802.2 LLC and IEEE 802.5 MAC standards for local area networks.

The initial 9370 Token-Ring Adapter operates at 4 Mbps. The selectable data rate 16/4 Mbps 9370 Token-Ring Adapter is scheduled for availability in second quarter, 1989.

The 9370 Token-Ring Adapter hardware and microcode interface appears to host software as three different channel address groups, each group representing four contiguous channel addresses which together are used to schedule and control data transmission through the adapter. This interface allows up to three different subsystems using the same or different higher-layer protocols (above the Data Link layer) to use the same 9370 Token-Ring Subsystem (adapter) concurrently. The following higher layer protocols are currently supported by the 9370 Token-Ring Subsystem:

VTAM PU5 to PU5 (9370 to 9370 across the LAN), PU5 to PU4 (9370 to NCP), and PU5 to PU2 (9370 to workstation) are supported by both VM and VSE. VTAM to VTAM (PU5 to PU5) and VTAM to NCP (PU5 to PU4) connections have a leased-line appearance, while 9370 to workstation connections have a switched line/device appearance.

TSAF Transparent Services Access Facility is a no-charge feature of VM/SP. It includes support for communication between 9370 members of a TSAF collection over the token-ring. There is no workstation support.

¹⁹ In actual configurations, the maximum number of LAN adapters depends upon the number of other attachments, performance considerations, and the number of available slots.

TCP/IP The VM TCP/IP Program Offering supports TCP/IP protocols for 9370-9370 communication as well as 9370-workstation communication over the token-ring LAN. VM TCP/IP includes a feature providing TCP/IP on PCs and PS/2's. TCP/IP is also supported by AIX running in the RT/PC (trademark of the International Business Machines Corporation).

The 9370 Token-Ring Subsystem supports the Ring Error Monitor server function, enabling management of the ring to which the 9370 is connected from either the 9370 Service Processor or a NetView console.

5.1.2.6 AS/400

All models of the AS/400 can be equipped with an integrated IBM Token-Ring Network adapter.²⁰

AS/400 token-ring attachment hardware is dependent upon whether the processor is a low-end or a high-end model:

Low-End AS/400 models B10 and B20 can be equipped with a maximum of one IBM Token-Ring Network adapter, feature #6160.

High-End AS/400 models B30, B40, B50 and B60 can be equipped with one or two IBM Token-Ring Network Subsystems, feature #6240. The Subsystem consists of a Multi-line Communications Controller and a Token-Ring Network adapter.

All AS/400 Token-Ring Network adapters operate at a nominal data rate of 4 Mbps. There is however, a statement of direction, indicating IBM's intent to supply a switchable 16 /4 Mbps Token-Ring attachment for the AS/400.

The base operating system, OS/400 (trademark of the International Business Machines Corporation) contains the adapter support interface.

AS/400 Token-Ring support implements both the IEEE 802.5 and IEEE 802.2 standards. The support provides for a maximum of 256 concurrently active Logical Link Stations per line, that is per adapter.

Above the DLC layer, only SNA sessions are supported (PU Types 4, 5 and 2.0 and Node Type 2.1). This implies that only LLC service access points (LSAPs) in the range X'04' to X'9C' and multiples of X'04' are accepted, as these SAPs are reserved to interface between the LLC sublayer and SNA path control (ref. "Logical Link Control Sublayer" on page 70).

In the line description of a Token-Ring attachment, up to 16 different source SAPs may be specified for this token-ring connection, as well as the number of link stations to support. The same line description allows the user to specify a maximum size SNA path information unit that can be transmitted or received.

²⁰ They do not require a PC/AT to act as a gateway to the Token-Ring LAN as did the predecessor S/36 (trademark of the International Business Machines Corporation). One S/36 model, the 5363, may also be equipped with an integrated token-ring adapter.

The value is from a minimum of 265 bytes to a maximum of 1994 bytes, (the default value), affects the size frame handled by the adapter.

The AS/400 Token-Ring attachment implements the Ring Error Monitor server function to permit management of the ring to which the system is attached. A line description parameter permits specification of the amount of filtering desired on error frames to permit exception error handling. In addition, the token-ring support contains a Token-Ring Network manager supporting a passive LAN management function. Token-ring error messages are sent to the system console and can be forwarded as alerts to a central NetView network management location. More network management information is provided in "LAN Management and Recovery" on page 253.

5.1.2.7 Series/1 Token-Ring attachment

All models of the IBM Series/1 4956 can be attached to a 16/4 Mbps IBM Token-Ring Network through the IBM Series/1 Token-Ring Attachment Card (feature code 2200) and Cable (feature code 2201).

As depicted in Figure 45 on page 107, this attachment card contains a micro-processor executing the IEEE 802.5 MAC and IEEE 802.2 LLC protocols, both residing in resident microcode.

A second microprocessor, acts as an intelligent interface between the Token-Ring and the Series/1 Bus. It executes the EDX Token-Ring Interface Program (5719-EAC) to provide the required interface between the token-ring attachment hardware and the Series/1 system software (EDX = Event Driven Executive).

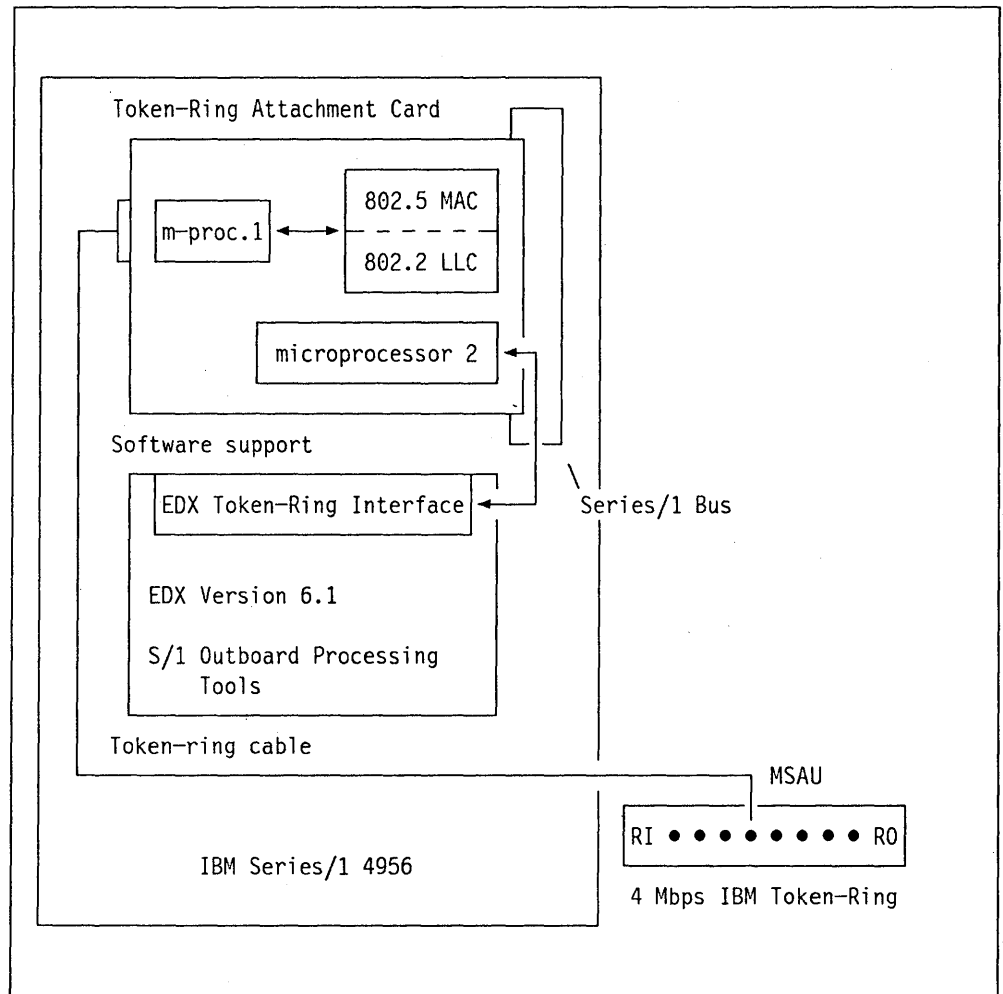


Figure 45. Series/1 Token-Ring Attachment

The EDX Token-Ring Interface Program (5719-EAC) requires the following prerequisite software:

- Event Driven Executive Version 6.1 (EDX V6.1)
- Series/1 Outboard Processing Tools

Each Series/1 Token-Ring Attachment card requires one slot in the Series/1 system unit or in the I/O expansion unit. The number of Token-Ring Attachment cards supported in a single Series/1 system may be limited by power supply limitations.

Additional information is published in *IBM Series/1 Token-Ring Attachment Card Feature Description Manual*, which is shipped with the product but may also be ordered separately.

5.1.2.8 8232 LAN Channel station

The IBM 8232 LAN Channel Station allows IBM Token-Ring Network stations to communicate with **non-SNA** hosts via a System/370 sub-channel.

Two models of the 8232 LAN Channel Station are offered, both controlled by the same 8232 LAN Channel Support Program:

- 8232-001** This model contains one IBM 7532/266 Industrial PC/AT supporting up to two LAN adapters and one System/370 channel adapter.
- 8232-002** This model contains two IBM 7532/266 Industrial PC/ATs supporting up to four LAN adapters, as well as two System/370 channel adapters which can be attached to the same or different host systems.

The 8232 LAN Channel Station attaches to the block multiplexer channel of the IBM 4361, 4381, 308x, 3090 ES/3090 and 9370²¹ mainframes.

To support the IBM Token-Ring Network environment, the 8232 may be equipped with one or more IBM Token-Ring Network Adapter II cards (up to four on Model 002).

The workstations on the Token-Ring LAN may be equipped with any IBM Token-Ring Network adapter, operating at 4 Mbps.

Two different non-SNA environments are supported for token-ring LAN stations:

- **Transmission Control Protocol/Internet Protocol** To support TCP/IP, the 8232 LAN Channel Station requires IBM PC/DOS 3.3 or higher, the IBM LAN Support Program (to support any IBM LAN adapter installed in the 8232) and the IBM 8232 LAN Channel Support Program as described in Figure 46. This table also summarizes the software requirements for workstations and IBM hosts:

²¹ 4361, 4381, 3081, 3084 3090 ES/3090, and 9370 are trademarks of the International Business Machines Corporation.

8232 : IBM 8232 LAN Channel Support Program (5601-232)	
IBM non-SNA Host	LAN Station
IBM TCP/IP for VM (5798-FAL) or IBM TCP/IP for MVS (5685-061)	IBM TCP/IP for PS/2 (5871-AAA)
IBM AIX/370 (5713-AFL) includes TCP/IP protocol	AIX PS/2 TCP/IP (5713-AEW) AIX PS/2 Workstation Host Interface Program (5713-AER) IBM AIX access for DOS users (P/N 11F8252 + 5871-AAA) IBM X Windows Access for DOS users (P/N 11F8253 + 5871-AAA) AIX RT/PC, includes TCP/IP protocol (5501-061)

Figure 46. 8232 - Software Requirements for TCP/IP Support

• **IBM VM Pass-Through Network**

IBM VM/Pass-Through PVME, supporting non-SNA program-to-program communication between intelligent workstations and a VM Host system, is available to 4 Mbps IBM Token-Ring Network stations through the 8232 LAN Channel Station. In this way large VM servers can be made accessible to LAN stations.

Again, the 8232 LAN Channel Station requires IBM PC/DOS 3.3 or higher and IBM LAN Support Program (as for any other IBM LAN adapter installed in the 8232). In addition, the 8232, LAN stations and VM non-SNA hosts need the software listed in Figure 47.

8232 : IBM VM/Pass-Through PC Connect Facility - 8232 Comms Pgm 1.0 (5799-PGB)	
IBM non-SNA Host	LAN Station
IBM VM/Pass-Through Facility Rel.4 + IUCV (5748-RC1) or IBM VM/Pass-Through PC Connect Facility 1.0 (5799-CRJ)	IBM VM/Pass-Through PC Connect Facility - PC Comms Program 1.0 (5799-PFZ)

Figure 47. 8232 - Software Requirements for VM Pass-Through Support

5.2 IBM PC Network (Broadband)

The IBM PC Network (Broadband) is a local area network for the IBM PC family and the IBM PS/2 family. The network uses broadband transmission at 2Mbps on CATV cable, and CSMA/CD for the medium access method. Although it supports CSMA/CD protocols and the IEEE 802.2 protocols, the IBM PC Network (Broadband) does not conform to the IEEE 802.3 LAN standard mainly due to differences in the speeds and broadband signalling characteristics.

5.2.1 IBM PC Network (Broadband) Components

The IBM PC Network (Broadband) consists of a set of IBM products that allow the interconnection of IBM PCs to form a local area network in a tree topology.

The IBM PC Network (Broadband) components are:

- IBM PC Network Adapter cards
- IBM PC Network Translator Unit and Splitter or other commercial translators used with customer cabling
- IBM PC Network (Broadband) cabling components:
 - IBM Base Expander
 - IBM Short Distance Kit
 - IBM Medium Distance Kit
 - IBM Long Distance Kit
- Adapter Support software (the IBM LAN Support Program).

Figure 48 on page 111 shows the structure of the IBM PC Network (Broadband) local area network. Using IBM components the network can support up to 72 Personal Computers or Personal Systems, at a distance of up to 305 meters (1000 ft.) from the translator unit.

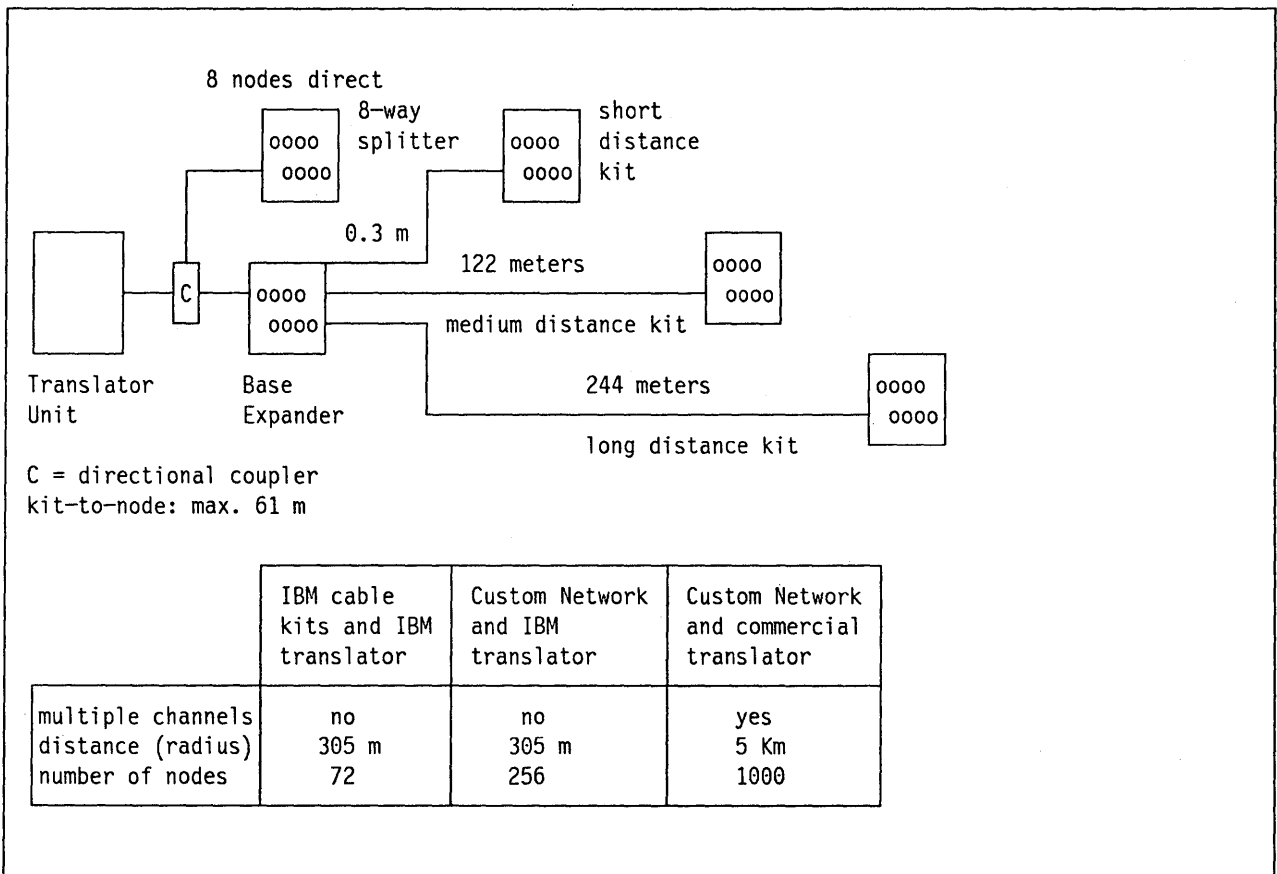


Figure 48. IBM PC Network (Broadband) Components

The number of PCs that can be attached to the network, and the distance that they can be from the translator unit can be increased by using non-IBM equipment. For example, using the IBM translator and non-IBM expander(s) and cabling, 256 PCs can be supported. Using a third-party translator, up to 1000 workstations may be attached while the network radius may be increased to about 5 kilometers.

5.2.1.1 PC Network (Broadband) Adapters

PCs or PS/2's are attached to the network through a PC Network (Broadband) Adapter card. Several adapters are available: the original IBM PC Network Adapter and a number of second generation adapters including the IBM PC Network Adapter II for Family 1 devices, the IBM PC Network Adapter II/A for Family 2 devices, and PC Network Adapters for both families of devices operating at different transmit and receive channels (Frequency 2 and Frequency 3 adapters).

IBM PC Network Adapter

The original PC Network adapter fits only Family 1 devices. It uses Radio Frequency (RF) channels T13 and J from the mid-split channel range (offering 17 channel pairs, with a 168.25 MHz offset). Card-mounted Intel 82586 and 80188 processors provide the CSMA/CD support as well as support for a higher level protocol, *NETBIOS*, in ROM on the adapter.

IBM PC Network Adapter II

This second generation adapter for Family 1 devices uses the same RF channels T13 and J as the original PC Network adapter. The adapter uses an Intel 82588 LAN controller chip to provide framing and media access functions, but does not provide any higher-layer protocol in ROM.

IBM PC Network Adapter II/A

This adapter is equivalent to the PC Network Adapter II but is designed for Family 2 devices with smaller card forms and Micro Channel support.

IBM PC Network Adapter II, II/A Frequency 2

These adapters for Family 1 and Family 2 devices respectively offer the same features as the IBM PC Network Adapters II and II/A, except that they transmit and receive on different channels frequencies. Frequency 2 Adapters use RF channels 2' and O from the high-split broadband range (30 channel pairs with a 192.25 MHz offset). High-split is commonly used in a manufacturing environment, where these adapters can coexist (not communicate) with other devices attached to the same broadband medium, for example, MAP 2.1 adapters.

IBM PC Network Adapter II, II/A Frequency 3

Again these adapters are functionally equivalent to the other second generation (II) PC Network adapters, except that these adapters operate on high-split RF channels 3' and P.

Figure 49 on page 113 lists the part numbers of all current PC Network (Broadband) adapters.

IBM PC Network (Broadband) Adapters (AFE)	Part Number / Feat. Code	04/1989 Part No.
IBM PC Network Adapter	6450213 / 0213	N/A
IBM PC Network Adapter II	1501220 / 1220	25F8279
IBM PC Network Adapter II - Frequency 2	96X5645 / 5645	25F8282
IBM PC Network Adapter II - Frequency 3	96X5646 / 5646	25F8285
IBM PC Network Adapter II/A	1501222 / 1222	25F8278
IBM PC Network Adapter II/A - Frequency 2	96X5647 / 5647	25F8281
IBM PC Network Adapter II/A - Frequency 3	96X5648 / 5648	25F8284

IBM PC Network (Broadband) Adapters (EMEA)	Part Number / Feat. Code	04/1989 Part No.
IBM PC Network Adapter	6450213 / 0213	N/A
IBM PC Network Adapter II	1501220 / 1220	
IBM PC Network Adapter II - Frequency 2	96X5645 / 5645	
IBM PC Network Adapter II - Frequency 3	96X5646 / 5646	
IBM PC Network Adapter II/A	1501222 / 1222	25F8280
IBM PC Network Adapter II/A - Frequency 2	96X5647 / 5647	25F8283
IBM PC Network Adapter II/A - Frequency 3	96X5648 / 5648	25F8286

Figure 49. IBM PC Network (Broadband) Adapters

There is no communications path between PC Network (Broadband) adapters operating on different channel pairs, even if they are attached to the same common medium. All adapters operating on the same transmit and receive channels form one LAN segment, physically and logically separated from adapters operating at a different channel pair. Connectivity can only be provided through LAN segment interconnection such as the PC Network Bridge Program, see "IBM PC Network Bridge" on page 174 for more details.

All second generation PC Network Adapters require the *IBM LAN Support Program* to provide the adapter support interface and make the LAN protocols accessible to applications. The original IBM PC Network Adapter, having NETBIOS in Read Only Memory (ROM) on the adapter card, contains its own interface and gives access to the LAN for application programs through NETBIOS. However, not all NETBIOS commands are supported and no other application interfaces are supported. The IEEE 802.2 LLC interface or other higher layer protocols (for example, SNA protocols) are not available unless the IBM LAN Support Program is used to bypass the ROM NETBIOS, and provide the same interfaces as for the second generation adapters. A more detailed discussion about LAN Support Program and coexistence considerations is presented in "IBM LAN Support Program" on page 126.

5.2.1.2 IBM Translator Unit and Splitter

The IBM PC Network (Broadband) Translator Unit provides broadband frequency translation for a passive IBM PC Network (Broadband). One translator is required for each network. The IBM Translator Unit provides only single channel frequency shift between modulated signals transmitted at a 50.75 MHz center frequency and a receive channel with a 219 MHz center frequency. Only this mid-split channel pair is recognized by the IBM Translator Unit. All other signals are ignored. Third party translators are required to operate a PC Network (Broadband) LAN at the high-split frequencies used by the PC Network (Broadband) Frequency 2 or 3 adapters.

The IBM PC Network Translator Unit is packaged together with a directional coupler and an 8-way splitter, supporting direct connection for eight nodes up to 61 meters (200 feet) from the splitter. See Figure 48 on page 111 for an illustration of the components. The translator supports a single channel-pair, data-only network of 256 nodes if custom cabling is used rather than the pre-cut cabling kits. The nodes (PC or PS/2 workstations) can be up to 305 meters (1000 feet) away from the translator unit. Replacement of the IBM Translator Unit by a more sophisticated device is required if broadband multiple channel capability is desired. In this case however, the calibration and tuning by a CATV specialist should be planned for both initial installation and on-going maintenance.

The directional coupler also has a port for attaching an IBM PC Network (Broadband) Base Expander.

5.2.1.3 IBM PC Network (Broadband) Base Expander

The Base Expander allows for the attachment of up to eight additional cabling kits. Three different kits are available: the IBM short distance kit, medium distance kit, and long distance kit.

Workstations cannot be connected directly to the base expander unit. They must be connected via one of the cabling kits. By using the base expander and the cabling kits an additional 64 PCs (up to a maximum of 72 workstations) can be attached to the network.

5.2.1.4 Cabling Kits

Because of the sensitivity of the transmitters and receivers in Radio Frequency broadband transmission to cables that are either very short or very long, the use of pre-defined cable lengths minimizes and in most cases eliminates the effort and cost of recalibrating the frequencies.

- The IBM PC Network (Broadband) Short Distance Kit connects directly to the base expander and allows up to eight nodes to be connected. Cables are available with lengths up to 61 meters (200 feet) to connect a PC or PS/2 to a splitter.
- The IBM PC Network (Broadband) Medium Distance Kit allows for the attachment of a splitter at 122 meters (400 feet) from the base expander. Hence, the maximum distance a node can be away from the translator is 183 meters (600 feet).
- The IBM PC Network (Broadband) Long Distance Kit consists of a cable that is 244 meters (800 feet) in length and a splitter. PCs or PS/2's attached to the splitter can be up to 305 meters (1000 feet) away from the translator unit.

5.2.2 IBM PC Network (Broadband) Interfaces

5.2.2.1 IBM PC Network Medium Access Control

The IBM PC Network Adapter implements a CSMA/CD protocol like that of the IEEE 802.3 standard, although it does not provide an IEEE 802.3 interface. Apart from transmission speed, technique, and network topology used, the second generation PC Network Adapters (II) are similar to the IEEE 802.3 standard with respect to the CSMA/CD protocol and support for the IEEE 802.2 standard interface. Therefore the way stations access the medium, the MAC frame structure, and the interface provided by the adapters conform to the description of CSMA/CD LANs provided in "Basic CSMA/CD Concepts" on page 16.

5.2.2.2 IEEE 802.2 Logical Link Control Support

For the second generation adapter cards, the IEEE 802.2 layer support and interface is provided by the IBM LAN Support Program V1.10. The IBM LAN Support Program V1.10 optionally provides the same support and interfaces for the IBM PC Network Adapter as it bypasses and replaces the NETBIOS ROM with its own software modules.

The IBM LAN Support Program V1.10 optionally provides a session level NETBIOS interface, running on top of the IEEE 802.2 LLC module. See "IBM LAN Support Program" on page 126 for more information.

5.2.2.3 Higher Layer Protocol support

NETBIOS is a proprietary higher-layer protocol providing session connection support on top of the IEEE 802.2 interface through service access point value X'F0.

SNA service access points provide the required interfaces between the PC Network (Broadband) LAN and SNA path control via service access point value X'04 or multiple of X'04.

The 8232 LAN Channel Station provides the same connectivity to IBM PC Network attached workstations as to IBM Token-Ring Network attached workstations, with one exception. A non-SNA IBM host, running AIX/370, is not accessible from a PC Network device and this environment is not supported. The 8232 LAN Channel station may be equipped with any Family 1, second generation PC Network adapters (Frequency 1, 2 or 3).

5.3 IBM PC Network Baseband

The IBM PC Network Baseband is designed to be a low-cost local area network for IBM PCs and PS/2's. The network uses baseband transmission at 2 Mbps. The medium access protocol is, as for IBM PC Network Broadband, CSMA/CD.

The network consists of one to ten daisy-chain segments. Each segment may connect up to eight workstations. If the IBM PC Network Baseband consists of eight or fewer workstations, the topology can be a linear daisy-chain as illustrated in Figure 50 with a maximum segment length of 61 meters (200 feet).

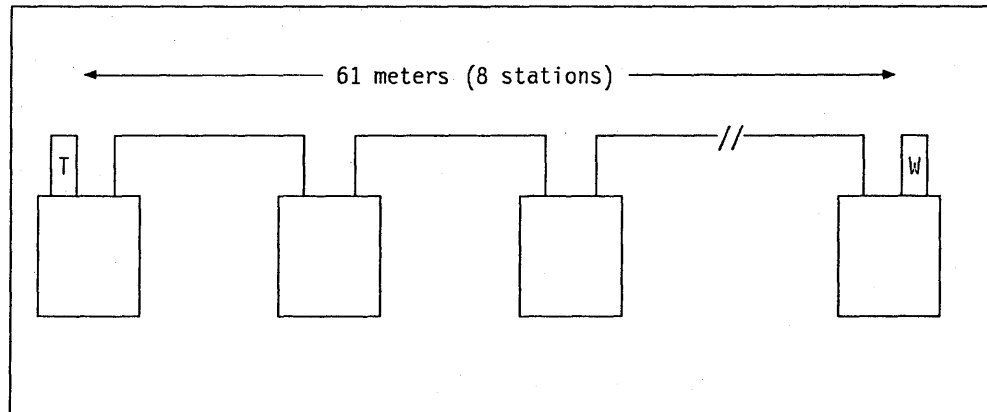


Figure 50. IBM PC Network Baseband - Single Segment Daisy-Chain

There is a Wrap plug at one end of the chain while the other end is terminated with a Terminator plug.

If more than eight workstations are required in the network the IBM 5173 PC Network Baseband Extender must be used. With the PC Network Baseband Extender, up to 80 workstations can be attached to the network in a multiple daisy-chain configuration, illustrated in Figure 51.

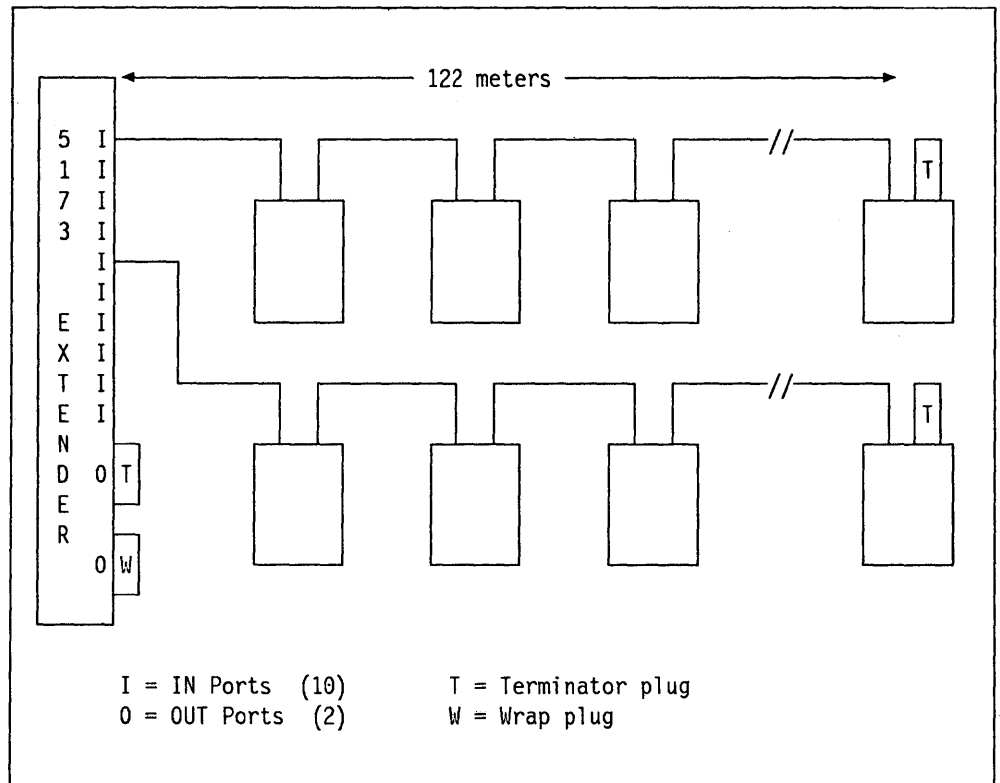


Figure 51. IBM PC Network Baseband - Multiple Daisy-Chain Segments

5.3.1 PC Network Baseband Components

5.3.1.1 IBM PC Network Baseband Adapters

Two adapters are available for the IBM PC Network Baseband: the IBM PC Network Baseband Adapter for the Family 1 workstations, and the IBM PC Network Baseband Adapter/A for Family 2 PS/2's. Instead of a Radio Frequency modem as on IBM PC Network (Broadband) adapters, they use a transceiver on the adapter.

The adapters together with the IBM LAN Support Program provide CSMA/CD medium access control, the IEEE 802.2 LLC protocol and an open interface to the logical link control services. Because the data rate (2 Mbps), topology and electrical characteristics deviate from a Standard IEEE 802.3 CSMA/CD LAN using Twisted Pair media, the IBM PC Network Baseband does not fully conform to the International Standard.

The adapter cards allow up to eight LAN stations to be daisy-chained together, with an overall length of up to 61 meters (200 feet). The length of the chain is dependent on the number of workstations in the chain. For example if there are only two workstations in the network (the minimum number) the distance between the two workstations can be up to 91.4 m (300 feet). Any distance between two workstations in a chain is allowed as long as the total distance between the first and last node does not exceed the recommended maxima listed below:

Number of Nodes	Maximum Distances
2	91.4 m (300 ft)
3	83.8 m (275 ft)
4	76.0 m (250 ft)
5	68.5 m (225 ft)
6	68.5 m (225 ft)
7	61.0 m (200 ft)
8	61.0 m (200 ft)

Figure 52. Length of a Single Segment Daisy-Chain

In any chain like the example illustrated in Figure 50 on page 116, the workstation at one end must have a terminator plug and the station at the other end must have a wrap plug.

The adapter card ROM contains self-test diagnostics that are run when the adapter is powered on. These diagnostics help a user to identify adapter failures without a diagnostic diskette or problem determination manuals.

5.3.1.2 IBM 5173 PC Network Baseband Extender

The IBM 5173 PC Network Baseband Extender is used to expand the IBM PC Network Baseband from eight to eighty nodes. The PC Network Baseband Extender has ten ports, each able to support a chain of maximum eight LAN stations. Each chain attached to the PC Network Baseband Extender has a maximum length of 121.92 m (400 ft). This distance is measured from the extender to the last workstation in the chain.

The IBM 5173 PC Network Baseband Extender is designed for continuous, unattended operation, therefore it does not have an On/Off switch. There are also no option switches or jumpers. The PC Network Baseband Extender has one indicator light which is illuminated when the power is on. The indicator can either be red or green, depending on whether an error was detected by the self-test circuitry. The self-test function is initiated by depressing a button on the front panel.

The PC Network Baseband Extender contains a 12 watt universal power supply. It has ten "IN" ports on the front panel for connecting chains of PCs to the extender, and two "OUT" ports as shown in Figure 51 on page 117. A wrap plug must be inserted in one of the OUT ports and a terminator plug in the other. These two ports are identical. Either plug can be connected to either port. A terminator plug must also be inserted into the adapter card of the last workstation of each chain attached to the extender.

Cabling is not supplied with the extender, nor with the PC Network Baseband Adapter cards, but must be ordered separately.

5.3.1.3 PC Network Baseband Cabling and Accessories

The IBM PC Network Baseband uses twisted pair wiring for interconnecting workstations. Three adapter cables are offered to provide connector compatibility with different types of building wiring. Each cable connects to the workstation adapter with a modular telephone jack (J11). The other end provides either another modular jack or a different connector type to support daisy chaining of workstations, or connection wall jacks or sockets.

The IBM PC Network Baseband Adapter Cable (1501229) is shielded twisted pair cable with modular telephone connectors at each end. It is designed to serially connect the IBM PC Network Baseband Adapter or the IBM PC Network Baseband Adapter/A to other workstations in a daisy-chain fashion, or to connect a workstation to the IBM 5173 PC Network Baseband Extender.

The IBM PC Network Baseband General Purpose Cable (1501228) is a shielded twisted pair cable connecting an IBM PC Network Baseband Adapter or IBM PC Network Baseband Adapter/A to a non-modular telephone socket. It has the modular connector on one end while the other end is made for the older screw terminal blocks.

The IBM Cabling System PC Network Baseband Cable (150227) is a shielded twisted pair cable connecting the IBM PC Network Baseband Adapter, IBM PC Network Baseband Adapter/A, or the IBM 5173 PC Network Baseband Extender (with a modular telephone connector) to the data connector wall jack or data connector distribution panel when using the IBM Cabling System.

Each baseband cable is 7.6 m (25 ft) in length. Several of these cables can be joined together to obtain cable lengths greater than 7.6 meters, or users can make their own cables to the lengths they require. With care to prevent electromagnetic interference, unshielded twisted pair wire, meeting the IBM Cabling System Type 3 specifications, may also be applied.

The IBM PC Network Baseband Extender Rack Mount Kit (1501226) attaches to the IBM 5173 PC Network Baseband Extender to allow it to be rack mounted in a standard 19 inch rack.

5.3.2 PC Network Baseband Interfaces

5.3.2.1 Medium Access Control support

The IBM PC Network Baseband Adapter and IBM PC Network Baseband Adapter/A, combined with the adapter support software of the IBM LAN Support Program, implement CSMA/CD access method protocols functional equivalent to the IEEE 802.3. (Refer to "Basic CSMA/CD Concepts" on page 16 for details on the protocol, and to "IBM LAN Support Program" on page 126 for additional information on LAN Support Program.)

5.3.2.2 IEEE 802.2 LLC and Higher Layer Support

The IEEE 802.2 layer is provided by the IBM LAN Support Program V1.10. This program includes the IEEE 802.2 interface, and optionally provides NETBIOS for higher-layer support. The IEEE 802.2 Interface is also required for Advanced Program-to-Program Communication (APPC). See section "IBM LAN Support Program" on page 126 for more details..

5.4 IBM and Industrial LAN

As explained earlier in "IEEE 802.4, ISO 8802-4" on page 59, the IEEE 802.4 Token-passing bus standard provides the physical layer and MAC sublayer architecture and protocols for a seven-layer Manufacturing Automation Protocol communications network for the manufacturing environment. As described, IBM has stated its intent to provide industrial LAN implementations based upon the final MAP 3.0 specification.

5.4.1 Series/1 and Industrial LAN

The Series/1 in an industrial LAN environment can act as either a communication server or an application server.

5.4.1.1 Communication Server

The Communications Server runs on the Realtime Programming System/Communications Manager (RPS/CM) operating system. Some of the server functions provided are:

- Availability of the Series/1 as a directory server for the network
- Network management agent support
- Host control - that is control of communications with a host system
- Terminal control - that is control of communications with downstream terminals
- Attachment possibilities for System/370 processors.

With a System/370 processor attached to the Series/1, files can be transferred to and from the System/370 using the FTAM (File Transfer, Access and Management) program. Messaging is also supported using the MMFS (Manufacturing Message Format Standard) support. This provides a way for user-written messaging applications to build and decode standard messages.

Both FTAM and MMFS are MAP 2.1 Application Layer services (see Figure 23 on page 61). MMFS is superseded in MAP 3.0 by the Manufacturing Messaging Specifications (MMS).

The Network Management Agent provides information about the activities in the local MAP Communications Server system to the network manager.

Host control allows a host system, such as TSO, IMS, or CICS to communicate with remote 327x terminals, or applications that simulate 327x terminals on a MAP network. The MAP network is transparent to the host systems.

Terminal control allows users of 327x terminals to communicate with remote host systems across a MAP network.

5.4.1.2 Application Server

The Application Server uses the Series/1 Event Driven Executive/Communications Facility (EDX/CF) operating system. The application server is used to control intelligent devices and provides the following functions:

- Network Management Agent services

- A subset of directory services
- MMFS support
- FTAM subset

Figure 53 shows an industrial LAN with two Series/1 attachments to the bus using a network interface unit (not shown in the figure).

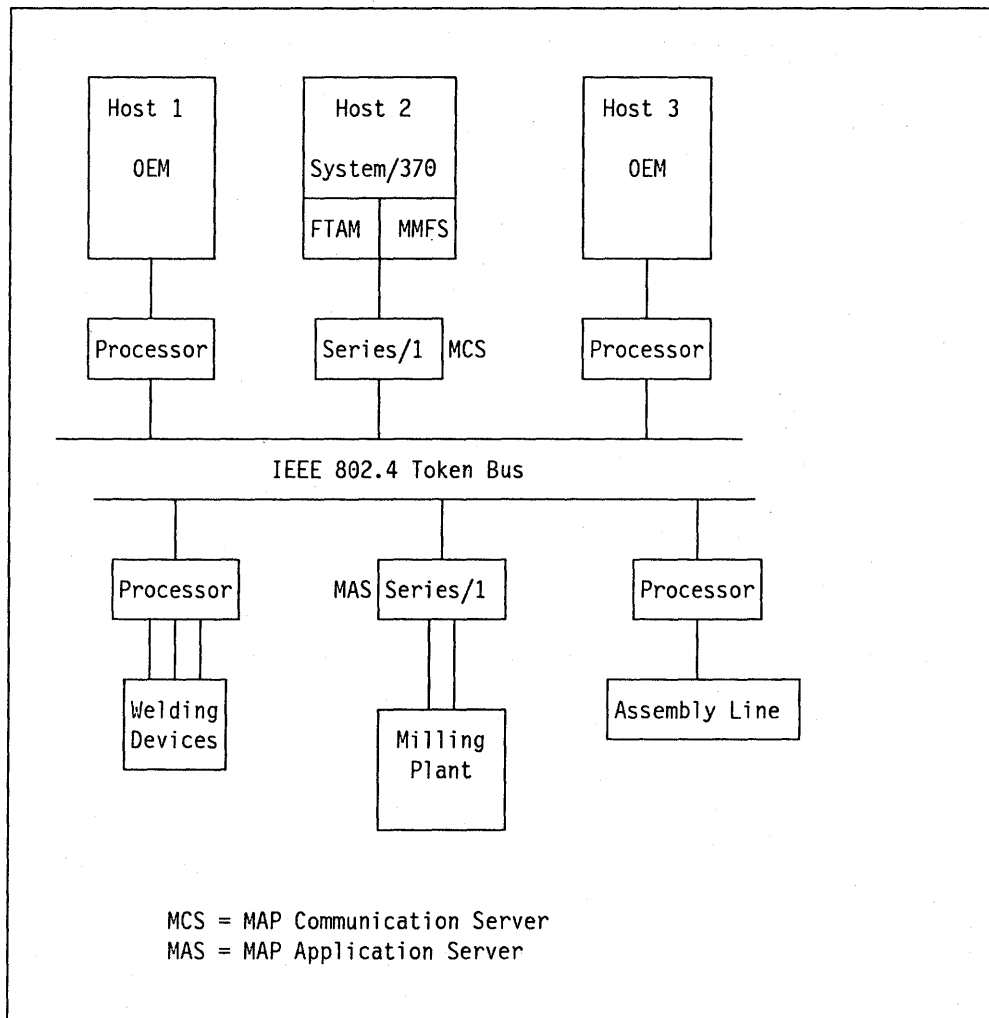


Figure 53. Industrial LAN - Series/1 Servers

5.4.2 The 8232 LAN Channel Station and Industrial LAN

As explained earlier when introducing the 8232 LAN Channel Station support for the IBM Token-Ring Network, the 8232 LAN Channel Station may be attached to a System/370 Channel ("IBM Token-Ring Network" on page 85).

At the LAN attachment side of the 8232, industrial LAN adapters may be installed. The supported adapters are the INI MP-500 Interface Adapters ²²

implementing MAP 2.1. Because these adapters require both LAN adapter slots in the 8232 PC, only one IEEE 802.4 LAN attachment is supported by an IBM 8232 Model 001, and a maximum of two IEEE 802.4 LAN attachments or one IEEE 802.4 attachment and two IEEE 802.3 or IEEE 802.4 attachments are supported by and IBM 8232 Model 002.

The software requirements are summarized in Figure 54, for both the 8232 LAN Channel Station and the IBM System/370 host

8232: IBM MAP LAN Channel Station Support Program (5798-FBF) + IBM PC/DOS Support for Token-Bus Adapter (5590-TBI)	
IBM non-SNA Host	LAN Station
IBM MAP 2.1 Protocol - VM Support (5798-FBG)	software support for INI MP-500 MAP Interface Adapter (INI 94X4235)

Figure 54. 8232 - Software Requirements for MAP 2.1 Support

5.4.3 Migration to MAP 3.0

Migration from MAP 2.1 to MAP 3.0 implies both software application as well as hardware changes and consequently will require considerable planning.

To minimize the effort for software migration, MAP 2.1 application programming interfaces (API) in the current VM support on System/370 mainframes have been designed to be consistent with the MAP 3.0 specifications.

The MMS API Release 2 and the CASE API Release 1 meet the MAP 3.0 Private Communications User API specifications where applicable. Use of these APIs will result in fewer programming changes when migrating to MAP 3.0.

The hardware however will require "significant upgrades", including in most cases replacement of the MAP components. Moreover, future MAP 3.0 products for workstations are likely to be developed for Family 2 devices, while current INI MAP 2.1 adapters support only the Family 1 bus design.

²² Industrial Networking Inc. (INI) is a joint venture between Ungermann-Bass and General Electric, providing communications products for the manufacturing environment, today mainly MAP 2.1 implementations.

5.4.4 MAP - SNA Gateway

Communication between a MAP environment and an SNA network can be provided only by a gateway function since both networks cover a full seven-layer communications architecture.

5.5 IBM and FDDI

The advent of agreement from the ANSI/ISO Standards bodies for the emerging Fiber Distributed Data Interface (FDDI) technology suggests the potential for future incorporation of this technology into many LAN solutions. Some prototype FDDI networks do, in fact exist today, but the standards, particularly for the Station Management protocols are not yet firm enough to ensure that such networks will be compatible with future FDDI products. In view of the cost of FDDI technology, the ability to make cost-effective decisions about which devices to put on an FDDI ring to optimize connectivity and performance will be important to many installations. Inherent similarities between token-ring networks and FDDI networks make potential coexistence and interoperability between the two very practical. In addition, the ability to use 16 Mbps token-ring LANs may help installations who need to design LANs which satisfy the throughput requirements of attaching devices in accordance with the capacity and costs of those devices.

In the interim, until standard FDDI attachments become practical, token-ring installations can be implemented with fiber wiring between the wiring closets, thereby reducing future migration and or conversion costs. For such installations, 62.5 micron fiber which is recommended by the FDDI standards and which is also supported by the IBM Token-Ring Network repeaters and converters would be a practical cable choice for both current and future operation.

5.6 IBM LAN Support Program

Generally speaking, LAN applications may be developed at different levels within the communications architecture, either through standard interfaces or through proprietary communications protocol interfaces.

Some interfaces, although conforming to published standards are system interfaces accessible only by a low-level programming language such as IBM PC/DOS Macro Assembler, while other interfaces are described as high-level Application Programming Language Interfaces (APIs) supported in a high-level programming language such as C, COBOL, or Pascal. Use of system interfaces is often limited to systems programming development, where high-level APIs are more appropriate for general purpose application implementation. Selection of interfaces to use must take into consideration the degree of product sensitivity of the API and the susceptibility of the resulting development to subsequent changes in the supporting environment. In general, users are encouraged to use higher-level APIs such as those provided by the emerging System Application Architecture.

In a PC/DOS environment, the IBM LAN Support Program V1.10 provides system level interfaces for all current IBM LAN adapters operating in Family 1 or Family 2 devices. In an OS/2 EE environment, the equivalent support for Family 2 device adapters only, is provided by the OS/2 EE Communications Manager.

- IBM Token-Ring Network Adapter (withdrawn from marketing)
- IBM Token-Ring Network Adapter II
- IBM Token-Ring Network Adapter /A
- IBM Token-Ring Network Trace and Performance Adapter
- IBM Token-Ring Network Trace and Performance Adapter /A
- IBM 16/4 Token-Ring Network Adapter
- IBM 16/4 Token-Ring Network Adapter /A
- IBM PC Network Adapter (withdrawn from marketing)
- IBM PC Network Adapter II
- IBM PC Network Adapter II/A
- IBM PC Network Adapter II Frequency 2
- IBM PC Network Adapter II/A Frequency 2
- IBM PC Network Adapter II Frequency 3
- IBM PC Network Adapter II/A Frequency 3
- IBM PC Network Baseband Adapter
- IBM PC Network Baseband Adapter /A.

The IBM LAN Support Program V1.10 implements IEEE 802.2 logical link control layer services and protocols, supporting the standard logical link control Class II open interface. Optionally, IBM LAN Support Program V1.10 provides a NETBIOS higher-layer interface for the IBM Token-Ring Network, IBM PC Network (Broadband) and IBM PC Network Baseband. Application programs can be written against the IEEE 802.2 or NETBIOS interfaces. In addition, a number of other higher-layer protocols and interfaces may operate on top of the open LLC interface, including IBM's strategic LU 6.2 protocol for program-to-program communication. Such additional higher layer protocols may be provided through separate products which use IBM LAN Support Program V1.10, for example, APPC/PC for LU 6.2 communications.

NETBIOS is a proprietary but widely implemented higher-level protocol LAN interface for workstation applications. Various applications are available which use the NETBIOS interface to communicate across the LAN, for example the IBM PC LAN Program 1.3 and IBM PC 3270 Emulation Program Version 3 (Gateway and Network Station configurations).

All the function supplied by the IBM LAN Support Program V1.10 is included in the OS/2 Extended Edition 1.1 (trademark of the International Business Machines Corporation) Communications Manager. In addition, the LU 6.2 implementation included in OS/2 Extended Edition Communications Manager has a much more convenient programming language interface as well as high-level language support (IBM C/2 Compiler and IBM Pascal/2 Compiler). The programming interface included in the PC/DOS APPC/PC is limited to IBM PC/DOS Macro Assembler.

Figure 55 shows the base programming interfaces on IBM LANs as introduced above.

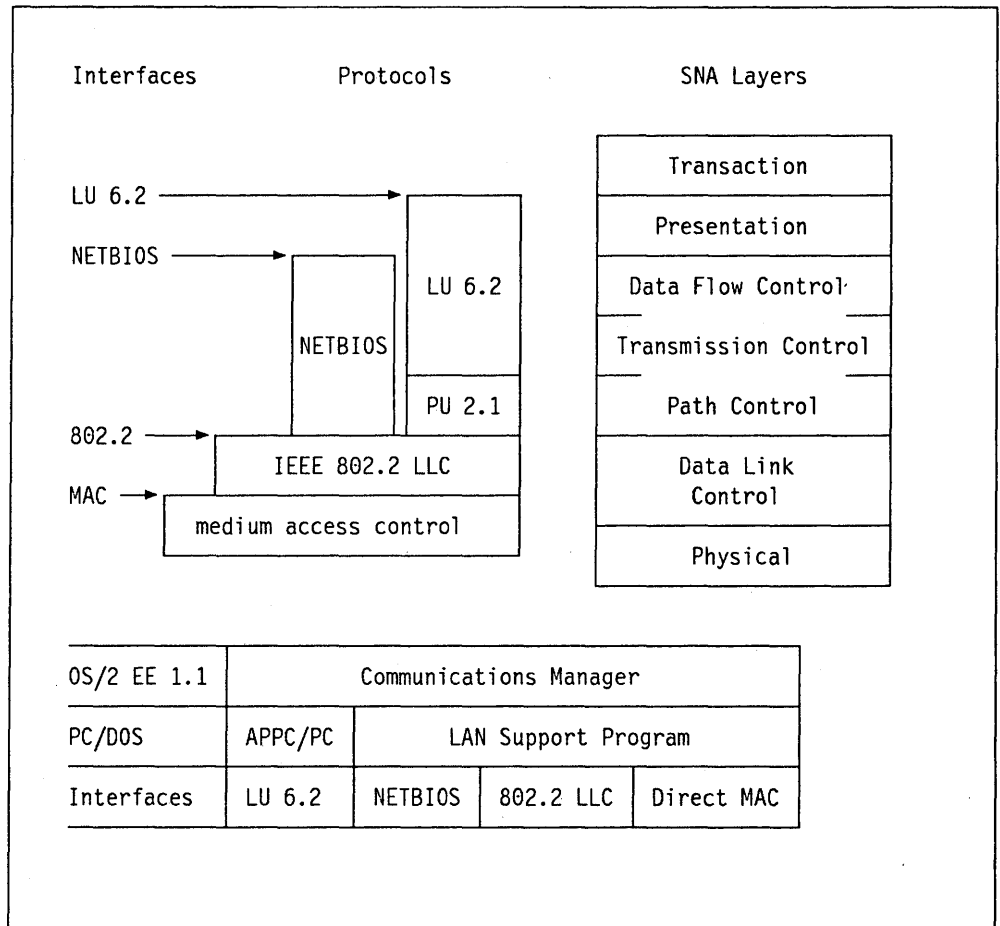


Figure 55. IBM LANs - Base Programming Interfaces

The adapter support program, as provided by the IBM LAN Support Program V1.10 or as included in the LAN Communications Manager of OS/2 Extended Edition 1.1, provides a system application programming interface to the adapter.

With the use of an adapter support program, a local area network system application program assembles a control block containing a command and

related information for the adapter. Control is passed to the adapter support program and the application awaits the results. In other words, the application program passes command control blocks (CCBs) to the adapter support program to interface with the adapter.

Command control blocks are used at the level of the IEEE 802.2 interface and the direct (medium access control) interface.

With the advent of the OS/2 Extended Edition 1.1 LAN Communications Manager, two additional, slightly different command control block structures have been added to the original CCB as it existed in the IBM LAN Support Program. One new CCB is associated with OS/2 1.1's dynamic link routine interface, the other one with its device driver interface.

Applications coded at the MAC level (through the direct interface) are confined to the local ring and will not be able to communicate across bridges.

Additional APIs are offered with various LAN applications, for example, the PC 3270 Emulation API, the Server/Requester Programming Interface (SRPI), the 3270 Workstation Program HLLAPI or OS/2's Common Services Interface (CSI). Such APIs will be introduced as appropriate when discussing various connectivity products in "Device Connectivity" on page 181.

5.6.1 Base Programming Interfaces

5.6.1.1 Open IEEE 802.2 LLC Interface

An overview of the IEEE 802.2 logical link control sublayer was described in "Logical Link Control Sublayer" on page 70, including the concept of LLC service access points to interface between data link control and higher layer protocol services.

Both connectionless or datagram services as well as connection-oriented services are included in the standard. The IBM LAN Support Program V1.10 supports both, as Class II operation. The format of the LLC protocol data unit (LPDU) and a list of the service commands/responses is included in "LLC Protocol Data Unit" on page 75.

5.6.1.2 NETBIOS Interface

Network Basic Input Output System (NETBIOS) is a well-accepted proprietary higher-level LAN protocol, providing a session-level programming interface.

NETBIOS supports a layered communications architecture as shown in Figure 56 on page 129. Names rather than network addresses are used by Netbios applications for session support. Netbios support provides services to locate and associate these names with MAC network addresses.

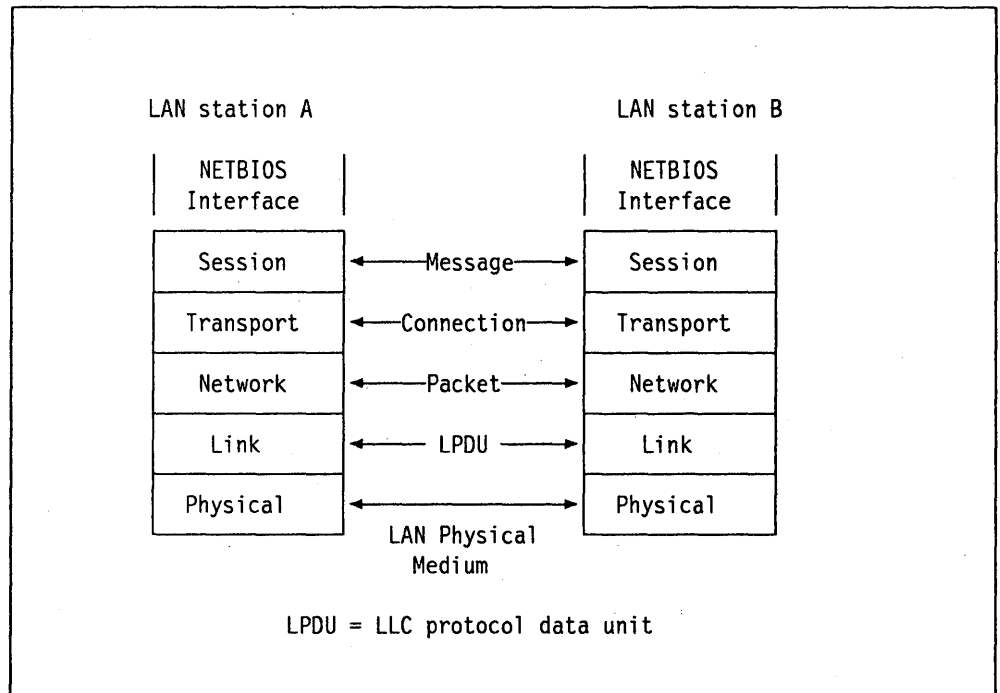


Figure 56. NETBIOS Layer Support

- **Link Layer**

At the Link layer, NETBIOS uses "connectionless" (user datagram) services. This means there is no control at this level for sequenced message delivery or recovery. This level is responsible for the assembly of bits into data units and the delivery of these data units to the physical media for transmission. CRC checking is also performed.

- **Network Layer**

The Network layer is implemented as a "null" layer.

- **Transport Layer**

At this level, point-to-point connections are created supporting data transmission and acknowledgements. Any required flow control or pacing is handled at this level.

- **Session Layer**

Through the session layer, NETBIOS establishes "name" pairs. A name is an identifier for a logical entity in which all session-level communication activity is centered.

The **NETBIOS Interface** provides an application programming interface offering commands for session control, name support, datagram support, and debugging facilities. A overview of the NETBIOS interface and functions is provided later of this section. For additional detail and programming support, users should refer to the *IBM Local Area Network Technical Reference*.

NETBIOS Implementations: Two different versions of NETBIOS, including different error codes and transmission sizes, currently exist and are incompatible from the standpoint of interoperability. NETBIOS was originally provided in microcode on the IBM PC Network Adapter in Read Only Memory (ROM). Subsequently a superset of the original NETBIOS was implemented in the IBM LAN Support Program V1.10, providing equivalent function and application interfaces for all IBM LAN-attached workstations under control of PC/DOS.

When, on a IBM PC Network (Broadband), some stations are equipped with the IBM PC Network Adapter while others are equipped with second generation PC Network adapters, a Netbios coexistence problem arises which must be solved to allow communication among all PC Network (Broadband) stations. Two solutions may be considered, each with different consequences. They will be presented in section "LAN Support Program Structure" on page 136.

Figure 55 on page 127 shows the NETBIOS module as it is implemented by the IBM LAN Support Program V1.10. This module interfaces to IEEE 802.2, using datagram services via the X'F0' LLC service access point (see "IEEE 802.2, ISO 8802-2" on page 74). NETBIOS provides services supporting (non-SNA) peer-to-peer communications.

The NETBIOS Interface: The NETBIOS function within each workstation maintains a table of names that this node and its session partners are known by on the network. Communications between Netbios applications is based upon resource names. These names are provided to NETBIOS by the application program. A name can be a unique or a group name. NETBIOS provides services to ensure uniqueness of names. If name is in the NETBIOS Name Table, a session can be established from this named resource with another named resource. NETBIOS maintains up to 254 selectable names plus one permanent node name (10 bytes of binary zeros followed by the adapter's burned-in address).

NETBIOS is operated from an application program through a control block, called the *network control block* (NCB).

The NETBIOS Interface provides the following services:

General Control Services. which include:

- **Reset**

In the LAN Support Program implementation, this command aborts all sessions, clears both the session and name tables and resets the NETBIOS status. In OS/2 Extended Edition 1.1, this command aborts all sessions for that application program process, clears both the session and name tables and resets the NETBIOS status.

- **Status**

This command requests the status of either a local or remote NETBIOS resource for transfer to the user's program area.

- **Cancel**

This command requests that a command associated with a given network control block (NCB) be cancelled.

- **LAN status alert**

This command is used by application programs that wish to be notified of temporary LAN error conditions that last for over one minute.

- **Unlink**

This command is provided only for NETBIOS compatibility. In the PC Network it drops a session for Remote Program Load. Where the command is issued to an adapter that does not support Remote Program Load, the command will be treated by the NETBIOS program as a "no-operation".

Name Support Services. which allow a program to manage user-assigned names or identifiers by use of the following commands:

- **Add Name**

To add a new name (up to 16 characters) to the memory resident name table.

- **Add Group Name**

A "Group Name" is a mechanism for allowing more than one station to share the same resource name. This enables resources to be defined for functions that may exist in multiple workstations in a distributed application environment.

- **Delete Name**

To remove a name from the name table.

- **Find Name**

To determine whether a given name is registered on a network adapter.

Session Support Services. A "session" is a logical connection between two named resources supporting peer-to-peer communications. When a session has been established with another named resource, information can be exchanged over the session between the two resources. This reliable data transfer is provided by the *session* layer. A program may refer to multiple names and therefore sustain multiple sessions between itself and other stations on the LAN.

Command services available to the user to manage the sessions include:

- **Call**

This command opens a session with another named resource which has an outstanding Listen command.

- **Listen**

This command enables a session to be established between the named resource which issues the Listen and any named resource on the LAN which issues a Call.

- **Hang Up**

This command closes a session between two named resources.

- **Send**

This command is used to transmit data between two session partners. The maximum *message* size is 64 Kbytes. To maintain data integrity, the session is closed if a Send command fails.

- **Chain Send**

A Chain Send is equivalent to the Send command, but the message is made up of two concatenated buffers (maximum 64 Kbytes in total).

- **Send No Acknowledgement** Like the Send command this command provides a send facility, but without requiring a NETBIOS level data acknowledgement.

- **Chain Send No Acknowledgement**

This command is equivalent to the Send No Acknowledgement command, but the message is made up of two concatenated buffers (maximum 64 Kbytes in total).

- **Receive**

This command receives data sent over a specified session or over any open session.

- **Receive Any**

This command receives data sent from any session partner.

- **Session Status**

This command will return the status of one or all sessions for a given Name.

Datagram Support Services provide a connectionless data transmission service. That is, when individual unrelated messages (called datagrams) are to be sent, it is not always necessary to establish a session between the network stations. Messages are just transmitted to a named station or a group of stations on the LAN. No error recovery or sequencing is performed and a station does not have to acknowledge receiving a frame. Datagram Support Services can be contrasted with the "connection-oriented" services offered by the Session Support Services commands. Data transfer using datagram support goes directly to the *data link* layer.

- **Send Datagram**

Allows an application program to send a datagram to a specific name or group name.

- **Send Broadcast Datagram**

Allows an application program to send a datagram to any station which has a Receive Broadcast Datagram command outstanding.

- **Receive Datagram**

A station must use this command to receive datagrams from any name on the network that issues a Send Datagram.

- **Receive Broadcast Datagram**

A station must use this command to receive datagrams from any name on the network that issues a Send Broadcast Datagram.

Debugging Support Services

- **Trace**

In the IBM LAN Support Program V1.10 and OS/2 EE 1.1 implementations of NETBIOS this command has been added to activate and de-activate a trace of all the network control blocks (NCBs) issued to NETBIOS by the application program and some of the command control Blocks (CCBs) issued by NETBIOS.

5.6.1.3 LU 6.2 Interface

APPC (Advanced Program to Program Communication) defines a set of communication services that enable transaction programs to cooperatively execute distributed transactions. APPC function is implemented in an SNA protocol called LU Type 6.2. APPC Transaction Programs (TP), that is application programs using the APPC interface, use the LU 6.2 protocols to communicate with each other as peers.

Communication between two APPC programs is known as a "conversation". A conversation flows on an underlying session between two LUs. When parallel sessions are supported between the LUs, multiple conversations can run concurrently between two transaction programs. Parallel sessions are only supported for LUs associated with Type 2.1 node devices.

Products that implement LU 6.2 provide APPC services in different ways. The precise definition of these services is independent of any particular product, and constitutes part of the architectural definition of LU 6.2. The services are invoked by defined verbs, parameters, and return codes. A "verb" corresponds to a request by a transaction program for some specific service from the LU. As long as a transaction only requests APPC functions supported by both systems (peers), a programmer can use the APPC verb syntax to develop a distributed application independent of the system it will run on.

There are two categories of LU 6.2 conversation verbs, *Basic* and *Mapped*. Basic conversation verbs provide a lower-level interface to the LU. These verbs have greater privileges and are appropriate for system-oriented transaction programs that perform services for other transaction programs. Mapped conversation verbs are intended for user-written transaction programs. They provide an interface suitable for high level languages. Conversations are called basic or mapped conversations depending on the verbs being used.

APPC is IBM's strategic architecture for distributed transaction processing, and has been implemented in the following products. These products all support APPC mapped conversations:

- CICS/VS
- AS/400
- S/38
- System/36
- Series/1
- PCs, PS/2's (APPC/PC, OS/2 EE).

The System Application Architecture (SAA) Common Programming Interface for Communications is a published application programming interface that invokes the services of APPC and LU 6.2 from high-level languages in various SAA environments. As SAA implementations evolve, it is intended that the defined programming interfaces enable users to develop SAA conforming applications that can exist in different SAA product environments with greater product transparency to both programmers and users. Although the Common Programming Interface for Communications is not yet implemented in all the target environments, users can develop APPC applications consistent with the published interface to minimize ongoing application changes.

2

5.6.1.4 APPC/PC

APPC/PC, available in a PC/DOS environment, provides Type 2.1 node and/or PU 2.0 and LU 6.2 function to allow transaction programs to be written for IBM workstations to communicate with other APPC systems. These systems could be any of those listed above; the communication could take place over a LAN or an SDLC link.

LAN workstations attached to the IBM PC Network (Baseband and Broadband) or IBM Token-Ring Network can communicate with each other, with an AS/400, System/36 (5363) or System/370 directly attached to the LAN. If the LAN is remote to the host system, or is attached to the LAN using a gateway to communicate, the APPC transaction program must reside in the gateway, or a relay program must be written to run in the gateway.

This relay program is needed because APPC/PC does not have the ability to examine an incoming connection request and re-route it to another APPC application (see Figure 57).

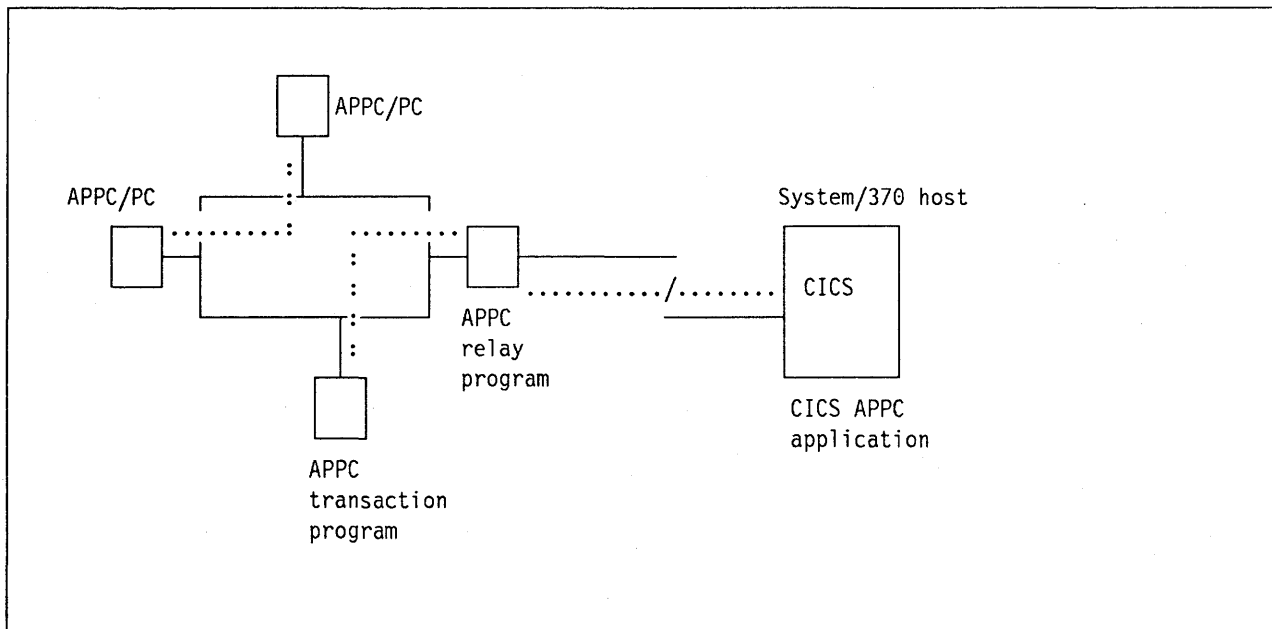


Figure 57. APPC/PC Connections

Through its application programming interface, APPC/PC provides support for both mapped and basic conversations.

Parallel sessions are supported when communicating with the following systems:

- AS/400
- System/36
- S/38
- Series/1
- Another APPC/PC.

Software Requirements: APPC/PC requires the IBM LAN Support Program V1.10 to provide the IEEE 802.2 LLC protocol and interface.

5.6.1.5 OS/2 Extended Edition LU 6.2 Support

APPC support of the OS/2 EE Communications Manager includes not only the base functions of the LU 6.2 protocol, but also provides additional features.

In this environment, a user does not have to issue control verbs like Attach_PU or Attach_LU, as is required when using APPC/PC under PC/DOS. The Application Subsystem shipped with Communications Manager uses the configuration file to perform the establishment of the SNA node and all the links with the other nodes. It also manages activation and deactivation of conversations by means of the automatic start of transaction programs (TPs).

The major features of APPC support under OS/2 Extended Edition are:

- Connectivity via SDLC and IBM LAN adapters
- Acting as either a peer-to-peer (Type 2.1) or boundary function node (PU 2.0)
- Link sharing with 3270 emulation LUs (LU 2.0)
- Support of multiple LUs
- Implicit partner LU support
- Support of parallel sessions
- Automatic session activation
- Remotely initiated TPs
- Multiple access by different TPs
- Use of locally known names (for example, LU aliases)
- Communication and System Management (C&SM) support
- Sending of alerts to the network resource specified in the configuration file
- Link congestion control
- Programming languages support:
 - Macro Assembler
 - Pascal
 - C language.

5.6.2 LAN Support Program Structure

LAN Support Program modules are called DXMnnMOD.SYS where (nn = A0,C0,C1,T0,...), which will be installed as device drivers (that is, extensions of the PC/DOS environment) under IBM PC/DOS 3.3 or 4.0

If two LAN adapters are installed in one LAN station, only one copy of each required device driver needs to be loaded.

The A0 module, also called the interrupt arbitrator, is common for any IBM LAN adapter. It provides the appropriate adapter support interface.

The A0 module allows one optional parameter, the language for load-time error messages:

- 01 - US English (default)
- 44 - UK English
- 33 - French
- 49 - German
- 39 - Italian
- 34 - Spanish
- 46 - Swedish.

The LAN Support Program also contains:

- DXMAID.EXE: the LAN Support Program Installation Aid.
- DXMINFO.DOC: the LAN Support Program Online Documentation.
- TIMERINT.SYS: a device driver to replace obsolete ROM timer interrupt code on old PCs (a BIOSDATE.EXE is provided to determine the requirement for this driver).

The installation aid will place the required device driver commands and default parameters in the CONFIG.SYS file according to the type of LAN adapter and the answers supplied while running the Installation Aid.

5.6.2.1 IBM Token-Ring Network and LAN Support Program

The IBM LAN Support Program V1.10 supports the new 16/4 Mbps IBM Token-Ring Network adapters.

Support for the 64K bytes of RAM, including implementation of RAM paging is provided. RAM Paging enables use of the entire 64 Kbytes shared RAM on the adapter while only requiring 16 Kbytes in the PC Memory. This limits the risk of address range conflicts with other installed adapters, for example, a second LAN adapter.

Both the data rate and the required shared RAM size are specified at adapter installation time via hardware switch settings on the Family 1 adapter, or a software adapter configuration file update for a Family 2 adapter.

The structure of the IBM LAN Support Program V1.10 modules when supporting IBM Token-Ring Network adapters for token-ring attached workstations is shown in Figure 58 on page 137:

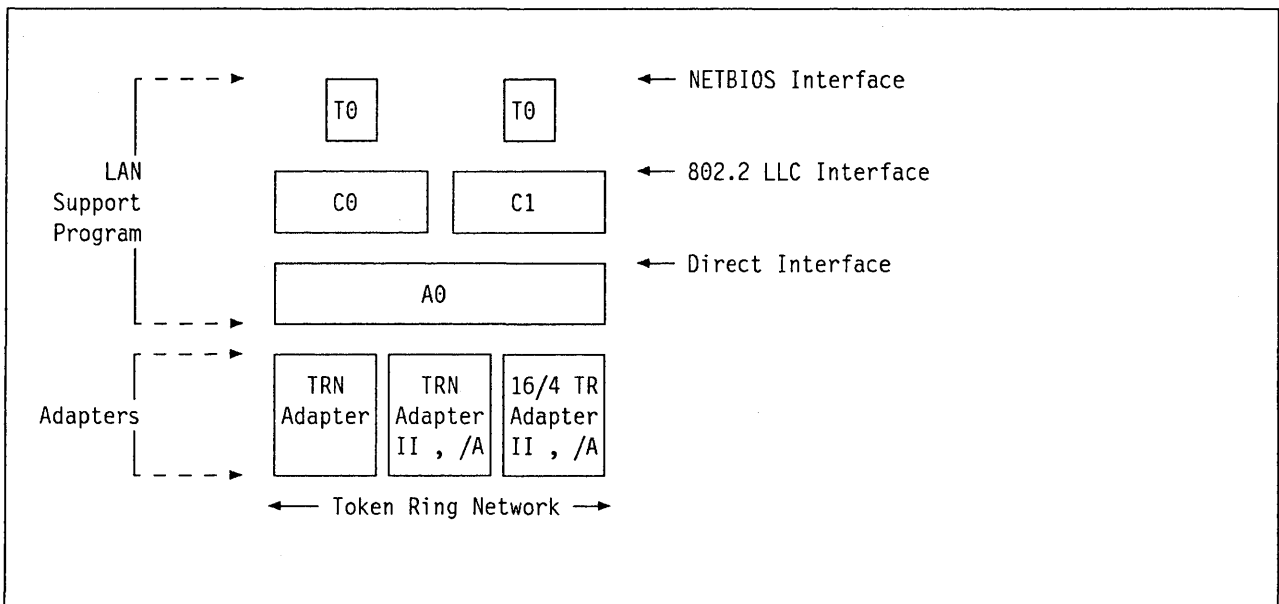


Figure 58. LAN Support Program and IBM Token-Ring Network

IBM LAN Support Program will provide the following device driver commands:

```
DEVICE = \path\DXMA0MOD.SYS
```

```
DEVICE = -path-DXMCnMOD.SYS
```

```
local-addr-0, RAM-0, etr-0, local-addr-1, RAM-1, etr_1
```

```
DEVICE = \path\DXMT0MOD.SYS p1 = n1 p2 = n2 ... / q1 = m1 q2 = m2 ...
```

The C0 module supports IEEE 802.2 Class II operation and provides the appropriate interface, replacing the obsolete TOKREUI.COM program formerly used on the IBM Token-Ring Network.

The C1 module supports IEEE 802.2 Class II operation and provides the appropriate interface for token-ring attached 3270-PCs and LAN stations running 3270 Workstation Program. This module replaces the obsolete TOKR3270.COM program.

When operating at 16 Mbps, use of the early token release option of the token passing ring MAC protocol is indicated by a parameter for the DXMCnMOD.SYS module in the CONFIG.SYS data set.

Both Cn modules support positional parameters to specify operational values for the primary adapter (0) and an alternate adapter (1) if present:

- Local addr: locally administered address.
- RAM: mapping address for shared RAM (ignored for Family 2 Token-Ring adapters).
- ETR: early token release, 0 to use (default) or 1 to disable early token release (ignored if operating at 4 Mbps).

The T0 module, which provides the common NETBIOS protocol and interface uses the LLC Interface provided by the Cn module through a specific NETBIOS service access point (SAP X'F0'). This module replaces the (now obsolete) NETBEUI.COM program on IBM Token-Ring Networks.

The NETBIOS module parameters will not be discussed in detail in this document, as they are related to installation parameters of specific Netbios applications such as the IBM PC LAN Program and the IBM PC 3270 Emulation Program (Gateway and Network Station configurations). Refer to DXMINFO.DOC, the LAN Support Program Online Documentation file, and to the Raleigh ITSC publication *Installation Guidelines for IBM Token-Ring Network Products*.

5.6.2.2 IBM PC Network (Broadband, Baseband) and LAN Support Program

The structure of the IBM LAN Support Program V1.10 modules when supporting IBM PC Network (Broadband) or IBM PC Network Baseband is shown in Figure 59.

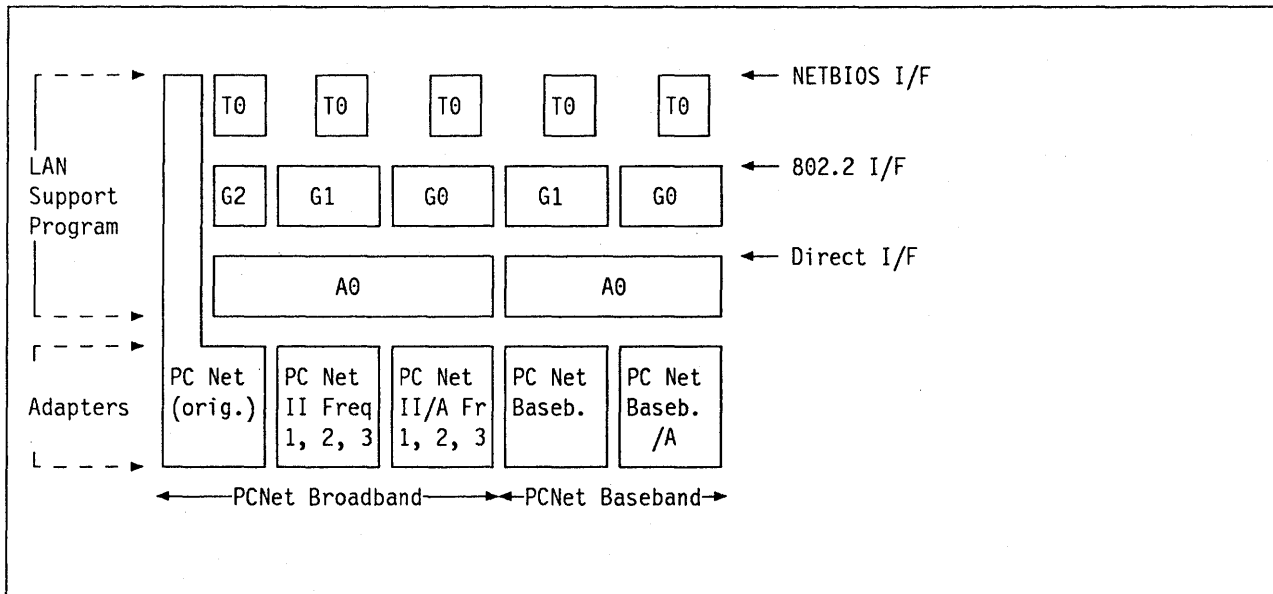


Figure 59. LAN Support Program and IBM PC Network

IBM LAN Support Program will provide the following device driver commands:

DEVICE = \path\DXMA0MOD.SYS

DEVICE = -path-DXMGnMOD.SYS local-addr-0,wrk-0,local-addr-1,wrk-1

DEVICE = \path\DXMT0MOD.SYS p1 = n1 p2 = n2 ... / q1 = m1 q2 = m2 ...

The Gn modules (n = 0, 1, 2; 31, 34, 38 Kbytes resp.) provide the same IEEE 802.2 LLC interface on PC Network adapters as the Cn modules provide on token-ring adapters. The G1 module is required to run Workstation Program on a LAN Station (or to operate the obsolete 3270-PC on a PC Network). The G2 module will bypass the ROM NETBIOS on an original PC Network Adapter.

The Gn PC Network Device Drivers allow a maximum internal work area of 64 Kbytes per adapter. The amount of work space actually required depends on the requirements of the application program with respect to the number of concurrent NETBIOS sessions. The default work space is 8 Kbytes for each PC Network Adapter and is valid for up to fifteen sessions. Between fifteen and twenty-three sessions, a work space of 12 Kbytes is needed, while 16 Kbytes will be used if twenty-four to thirty-two sessions are used concurrently. The WRK parameter of DXMGnMOD.SYS defines the desired internal work area size (in Kbytes).

A common NETBIOS Interface device driver T0 (24 Kbytes), is accessed by the LLC Interface of the Gm module through a specific NETBIOS service access point (SAP X'F0').

5.6.2.3 PC Network (Broadband) Coexistence

Since the Netbios support residing in ROM on the original PC Network (Broadband) adapters is incompatible with the Netbios support required for the later PC Network (Broadband) II and II/A adapters, (module DXMT0MOD.SYS), two alternatives exist to address requirements for the devices to interoperate on a PC Network (Broadband).

The DXMG2MOD.SYS module of the IBM LAN Support Program V1.10 bypasses the ROM Netbios on the original PC Network (Broadband) adapter. It enables these adapters to use the IEEE 802.2 LLC interface to access other higher-level protocols such as APPC or the enhanced Netbios provided by the IBM LAN Support Program V1.10 This alternative requires processor memory for the additional LAN Support Program device drivers.

The *PC Network Protocol Driver* program on a PC Network (Broadband) Adapter II or II/A provides a Netbios level which is compatible with the ROM Netbios on an original PC Network Adapter.

This solution does not provide an open LLC interface and degrades the Netbios performance possible with the IBM LAN Support Program V1.10 Therefore it should only be considered if there are severe memory limitations on the PCs containing the original PC Network Adapters which would prevent them from using the IBM LAN Support Program V1.10.

5.6.2.4 IBM LAN Support Program Structure -Summary

Whenever a workstation contains two LAN adapters, only one copy of each common LAN Support Program module is required.

IBM LAN Support Program requires DOS 3.3 or 4.0. Figure 60 on page 140 shows how the LU 6.2 interface is made available through the IBM LAN Support Program V1.10 combined with the APPC/PC program.

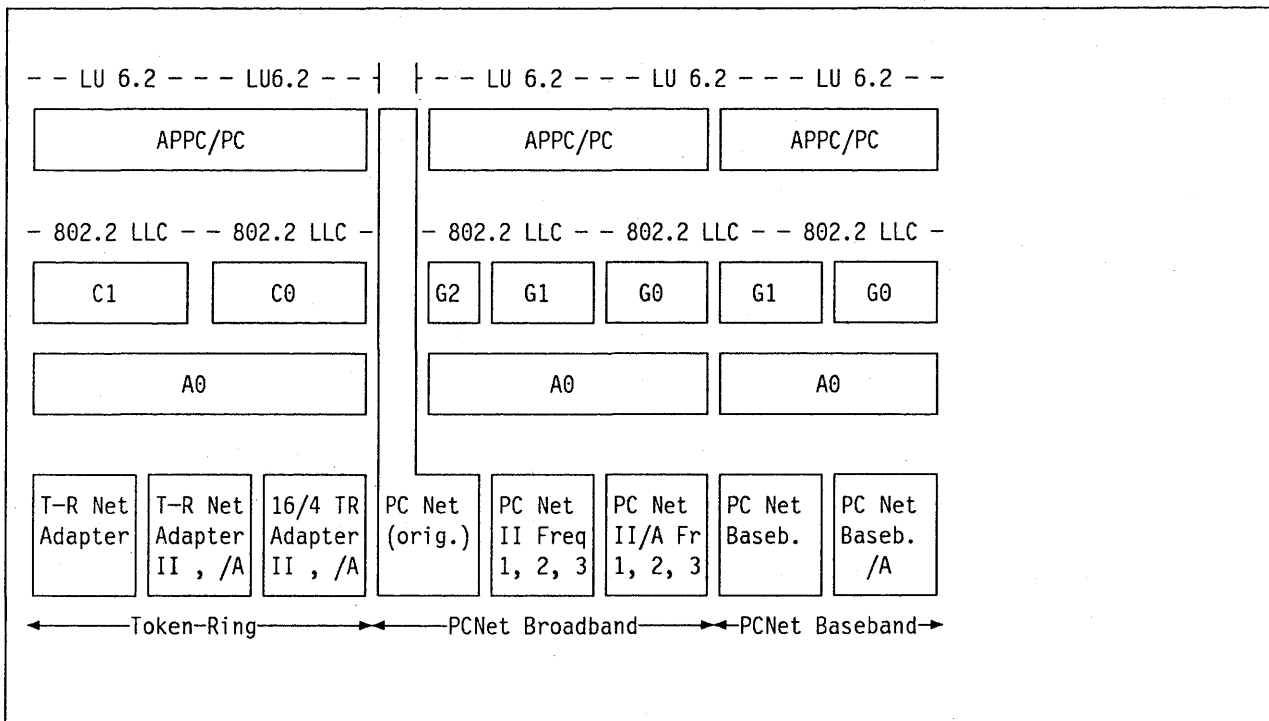


Figure 60. LAN Support Program and APPC/PC

APPC/PC based applications may be run on any IBM LAN. LU 6.2 support is accessed by the appropriate IBM LAN Support Program V1.10 LLC module through an SNA service access point (X'04', X'08', ...).

APPC/PC is a separate product and can be also be run over an SDLC link.

5.6.3 OS/2 Extended Edition 1.1 LAN Support Structure

Figure 61 on page 141 shows the Communications Manager interfaces, including those for PC Network (Broadband), PC Network Baseband and the IBM Token-Ring Network.

These LAN interfaces are very similar to the interfaces provided by IBM LAN Support Program V1.10. Most of the commands are identical and the structure of the commands is very similar.

As mentioned before, specific command control blocks (CCBs) are used to pass commands to the adapter support for OS/2 Extended Edition Communications Manager LAN support.

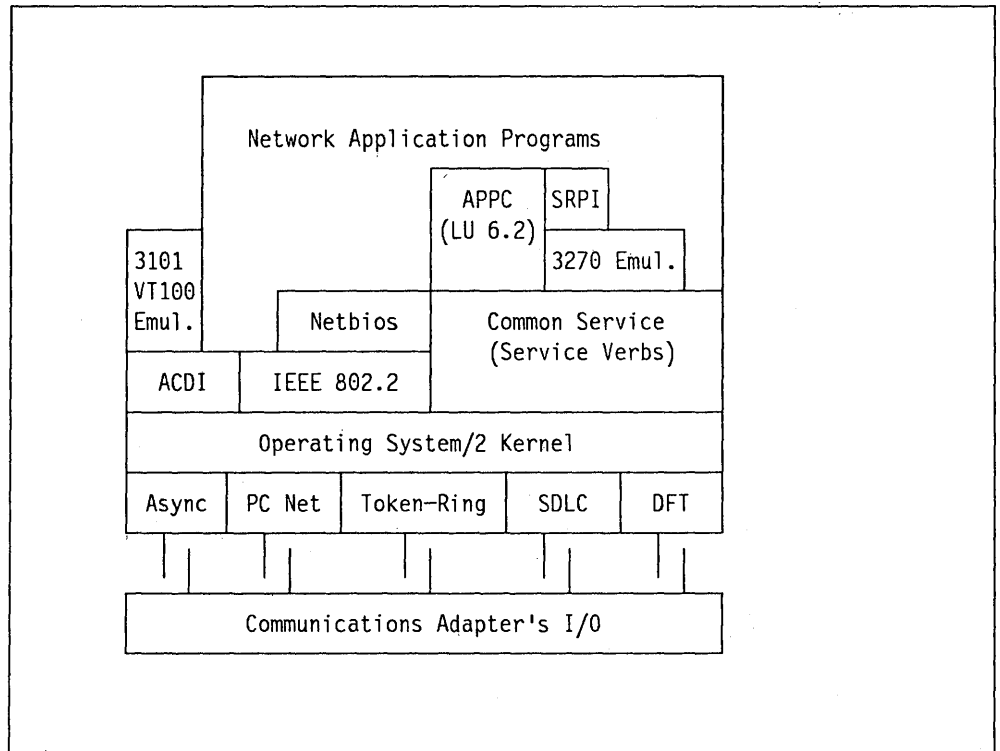


Figure 61. OS/2 Extended Edition 1.1 - Communications Manager Interfaces

One operational consideration is that, whereas in the PC/DOS environment the adapter support and programming interfaces are separate product(s) which must be loaded after loading the operating system, in OS/2 Extended Edition 1.1 the adapter support program is an integral part of the operating system.

As in the IBM LAN Support Program V1.10, the Netbios implementation in the Communications Manager of Operating System/2 Extended Edition V1.1 (trademark of the International Business Machines Corporation) runs on top of the IEEE 802.2 interface. It is used primarily to communicate between PC LAN Program requesters and servers or between Operating System/2 Extended Edition V1.1 requesters and the OS/2 LAN Server. It is also available to network-specific applications.

The Netbios commands provided by the Communications Manager of Operating System/2 Extended Edition V1.1 are identical to the ones described earlier for IBM LAN Support Program V1.10 (see "NETBIOS Interface" on page 128).

In an Operating System/2 Extended Edition V1.1 environment, IBM local area networks may be accessed indirectly through OS/2 dynamic link routines or directly via device driver calls. Two sublayer interfaces are available, IEEE 802.2 logical link control and IEEE 802.5 medium access control (on IBM Token-Ring Network only).

The 802.2 LLC interface supports both connectionless and connection-oriented services. A multi-thread programming interface provides support for multiple application users. It handles control blocks passed from Netbios, from APPC and from user applications concurrently.

LAN support installation and configuration: Operating System/2 Extended Edition V1.1 uses configuration panels to define installation parameters for workstations attached IBM Token-Ring Network adapters and PC Network adapters. These panels are presented to the user depending upon the workstation configuration data.

Figure 62 on page 143 illustrates the profile panels for a token-ring adapter and Figure 63 on page 144 shows the profile panels for a PC Network adapter.

LAN IEEE 802.2 Profile for Token-Ring (1 of 2)

Adapter number and version : n - /A

Adapter shared memory :
Use Universally administered address : Yes
Adapter address :
Functional address :
Group address :

Maximum number SAPs : 2
Maximum link stations : 8
Maximum number group SAPs : 0
Maximum members per group SAP : 0
Maximum number of users : 2

Transmit buffer size : 1048 bytes
Number of transmit buffers : 2
Receive buffer size : 280 bytes
Minimum receive buffers : 10

System key (hex character) :

Esc=Cancel F1=Help F8=Forward

LAN IEEE 802.2 Profile for Token-Ring (2 of 2)

Adapter number and version : n - /A

Adapter "Open" options
Wrap interface : No
Hard error default : No
Soft error default : Yes
Pass adapter MAC frames default : No
Pass attention MAC frames default : No
Monitor contention default : No
Pass beacon frames default : No

Group 1 Response Timer : 50 x 40 ms.
Group 1 Acknowledgement Timer : 50 x 40 ms.
Group 1 Inactivity Timer : 255 x 40 ms.
Group 2 Response Timer : 50 x 40 ms.
Group 2 Acknowledgement Timer : 50 x 40 ms.
Group 2 Inactivity Timer : 255 x 40 ms.

Common LAN adapters queue size : 400 elements
Number Global Descriptor Table Selectors : 50
Attended mode of initialization : No

Esc=Cancel F1=Help F7=Backward

Figure 62. OS/2 EE 1.1 - IEEE 802.2 Profile for Token-Ring

LAN IEEE 802.2 Profile for PC Networks (1 of 2)

Adapter number : n

Use Universally administered address : Yes

Adapter address :

Functional address :

Group address :

Maximum number SAPs : 2

Maximum link stations : 8

Maximum number group SAPs : 0

Maximum members per group SAP : 0

Maximum number of users : 2

Transmit buffer size : 1048 bytes

Number of transmit buffers : 2

Receive buffer size : 280 bytes

Minimum receive buffers : 10

Adapter workarea size : 16K

Esc=Cancel F1=Help F8=Forward

LAN IEEE 802.2 Profile for PC Networks (2 of 2)

Adapter number : n

Group 1 Response Timer : 50 x 40 ms.

Group 1 Acknowledgement Timer : 50 x 40 ms.

Group 1 Inactivity Timer : 255 x 40 ms.

Group 2 Response Timer : 50 x 40 ms.

Group 2 Acknowledgement Timer : 50 x 40 ms.

Group 2 Inactivity Timer : 255 x 40 ms.

Common LAN adapters queue size : 400 elements

Number Global Descriptor Table Selectors : 50

Attended mode of initialization : No

Esc=Cancel F1=Help F7=Backward

Figure 63. OS/2 EE 1.1 - IEEE 802.2 Profile for PC Networks

Relevant parameters not described earlier are explained below:

Adapter number and version An integer indicating whether the adapter is primary (0) or secondary (1) and the adapter type.

- Adapter shared memory** The shared RAM location in the workstation's memory.
- Group address** The group address is not used by the LAN data link control. It needs only to be changed for other applications requiring a group SAP address.
- Maximum number SAPs** LAN data link control requires one dedicated service access point per adapter. Additional application using SAPs must be considered in addition to this SAP.
- Maximum link stations** The total number of link stations required by all LAN applications concurrently using the LAN adapter. Some applications may share SAP and link stations.
- Maximum number group SAPs** Group SAPs are not used by LAN data link control. This number needs to be changed only for other applications requiring a Group SAP address.
- Maximum members per group SAP** Group SAPs are not used by LAN data link control. This number needs to be changed only for other applications requiring a Group SAP address.
- Maximum number of users** LAN data link control is considered as one user of each active adapter. Other users/applications need to be added.
- Transmit buffer size** This value must indicate the largest transmit buffer size used by any application using the LAN adapter.
- Number of transmit buffers** Due to limited shared RAM memory and the size of an SNA RU or non-SNA messages, one or two is considered optimal. There should be several receive buffers for each transmit buffer. There is some performance advantage in overlapped processing and I/O on the adapter for which two transmit buffers are required.
- Receive buffer size** Ideally this value should be large enough to contain the average size data frame received on the network. The default value may have to be increased, depending on LAN application and data traffic characteristics.
- Minimum receive buffers** A minimum of two receive buffers is required to open the adapter. The remaining shared RAM memory, after all other storage requirements have been met, will be used for receive buffers.
- System key (hex character)** Specification of a key permits protection of adapter resources (for example, protection from conflict with other adapters)
- Response Timer** This timer is maintained by the sending adapter whenever an I-format LPDU frame is sent with the "Final" bit set (see "LLC Protocol Data Unit" on page 75). If this timer expires before a response is received, the sending stations solicits remote link station status. Therefore this value should be set greater than the total maximum frame delays within the sending station, the network and the destination station.
- Acknowledgement Timer** This timer is started by a link station whenever an I-format LPDU frame is received into workstation memory, and stopped when an acknowledgement is sent either with an outgoing frame or when the number of I-format LPDUs received before

sending acknowledgement (window size) is reached. If the timer expires, the link station should send an acknowledgement as soon as possible. The timer value should be shorter than the response timer to ensure that the remote link can receive the delayed acknowledgement before the response timer expires.

Inactivity Timer This timer runs whenever the response timer is not running. Expiration of this timer suggests that the link station may be lost. It should be set five to ten times greater than the response timer.

Adapter workarea size The PC Network work area is used to maintain SAPs and link stations. The default value is 16 Kbytes.

5.6.4 OS/2 EE 1.1 LAN Support versus IBM LAN Support Program V1.10

Figure 64 on page 147 compares IEEE 802.2 command support provided by Operating System/2 Extended Edition V1.1 Communications Manager with the IBM LAN Support Program V1.10 under IBM PC/DOS 3.3 or 4.0.

In Operating System/2 Extended Edition V1.1 the Command Control Block (CCB) is changed by increasing the number of fields from seven to thirteen with a corresponding increase in CCB size from sixteen to twenty-six bytes. However, compatible offsets have been maintained for existing fields.

The invocation of IEEE 802.2 services has changed as well. Instead of Interrupt 5C, CALL LANCMDS (call to a dynamic link routine) is used. Data structures should be aligned on even byte boundaries to avoid migration problems.

Commands	LAN Support Program	Operating System/2 Extended Edition
Common Commands		
BUFFER.FREE	X	X
BUFFER.GET	X	X
READ		X
READ.CANCEL		X
RECEIVE	X	X
RECEIVE.CANCEL	X	X
RECEIVE.MODIFY	X	X
TRANSMIT	X	X
DIRECT Interface Commands		
DIR.CLOSE.ADAPTER	X	X
DIR.CLOSE.DIRECT		X
DIR.DEFINE.MIF.ENVIRONMENT	X	
DIR.IMPL.ENABLE	X	
DIR.INITIALIZE	X	X
DIR.INTERRUPT	X	X
DIR.MODIFY.OPEN.PARM	X	
DIR.OPEN.ADAPTER	X	X
DIR.OPEN.DIRECT		X
DIR.READ.LOG	X	X
DIR.RSTORE.OPEN.PARM	X	
DIR.SET.EXCEPTION.FLAG		X
DIR.SET.FUNCTIONAL.ADDRESS	X	X
DIR.SET.GROUP.ADDRESS	X	X
DIR.SET.USER.APPENDAGE	X	
DIR.STATUS	X	X
DIR.TIMER.CANCEL	X	X
DIR.TIMER.CANCEL.GROUP	X	X
DIR.TIMER.SET	X	X
DLC Commands		
DLC.CLOSE.SAP	X	X
DLC.CLOSE.STATION	X	X
DLC.CONNECT.STATION	X	X
DLC.FLOW.CONTROL	X	X
DLC.MODIFY	X	X
DLC.OPEN.SAP	X	X
DLC.OPEN.STATION	X	X
DLC.REALLOCATE.STATIONS	X	X
DLC.RESET	X	X
DLC.SET.THRESHOLD		X
DLC.STATISTICS	X	X

Figure 64. OS/2 EE 1.1 and LAN Support Program 802.2 Commands

5.7 IBM LAN Offerings Summary

The IBM Token-Ring Network is IBM's strategic LAN offering for the campus and office environment. It offers extensive, continuously evolving device attachment capability, including workstations, communications devices and mid-range systems.

The 16 Mbps data rate capability, with announced support by large number of attaching devices, stresses the importance of the IBM Token-Ring Network as a viable backbone LAN in addition to high speed LAN functions. The topology, protocol, and performance characteristics that make the 16 Mbps Token-Ring Network desirable as a backbone LAN today, also offer the potential for ultimate coexistence and operation as cost-effective intermediate or supporting rings in future FDDI backbone LANs.

Connectivity improvements to the IBM PC Network (Broadband) resulting from the ability to bridge to Token-Ring Networks and to attach workstations to multichannel networks using industry standard high-split channel distribution frequencies make PC Network (Broadband) solutions more attractive in environments requiring broadband multipurpose cable (such as concurrent video and data) and broadband manufacturing LANs for which MAP 3.0 support is not yet available or required.

The IBM PC Network Baseband is a low-cost LAN for installations with limited requirements for system/device connectivity. Its attachment capabilities are restricted to interconnection of personal workstations. Attached workstations use the LAN Support Program to obtain support equivalent to that provided to IBM Token-Ring Network and PC Network (Broadband) workstations. This includes use of the IEEE 802.2 LLC interface and access to both Netbios and APPC/PC (LU 6.2). The IBM PC Network Baseband is not intended for larger LANs with requirements for more sophisticated LAN features such as host gateways, LAN Interconnection or integrated LAN Management.

The Communications Manager of OS/2 Extended Edition V1.1 provides enhanced LU 6.2 and multi-tasking support in addition to all the function provided by the IBM LAN Support Program V1.10 and APPC/PC in PC/DOS systems.

6. LAN Segments Interconnection

LAN Interconnection may be considered for various reasons. A prime reason of course is to expand the networking capability by:

- Increasing the geographic area covered by the total LAN.
- Increasing the number of attached devices or wiring closets above that supported on a single LAN segment.
- Providing connectivity between stations attached to different LAN segments so that segment differences (due to use of different MAC protocols, speeds or frequencies) are transparent to higher layer protocols.
- Increasing the bandwidth available to stations on a single segment by splitting a LAN segment into one or more bridged LAN segments. In this way fewer stations have to share the same common medium and access protocol mechanisms.

Even when LAN stations use the same MAC protocol, there may be other physical constraints preventing a station from joining a particular LAN segment. In the case of the IBM Token-Ring, Bridge interconnection is required when:

- The maximum number of stations attached to a single physical ring for a given type of media has been reached (see "Cabling Components" on page 86).
- Some stations are attached via unshielded telephone twisted pair wire while all others are attached to data grade media twisted pair wire. Shielded and unshielded wiring cannot be mixed in a single physical ring.

Two IBM PC Network (Broadband) segments using different channel frequency pairs to transmit and receive information (see "IBM PC Network (Broadband)" on page 110). may use a bridge to provide connectivity between devices attached to the individual segments.

LAN interconnection provides autonomous network management entities ("LAN Management and Recovery" on page 253), and may reduce installation and maintenance required in fast growing LAN environments. Network availability may be further improved by providing alternate connectivity paths across bridges.

6.1 Bridged LAN Configurations

Many factors should be considered when configuring a LAN consisting of a number of interconnected LAN segments, each with its own (perhaps different) MAC protocol.

This section introduces different topology considerations for interconnected LAN segments. Topologies associated with protocols for various single segment LAN (segment) were described in "Network Topologies" on page 9.

Bridged LAN topology can be influenced by any of the following:

- The number of workstations physically supported by a particular type of LAN or cabling.

- Requirements to balance or alleviate heavy traffic associated with particular applications over one or more interconnected LAN segments.
- Requirements for a geographical approach to interconnecting LAN segments by associating segments with specific areas within a building or campus layout.
- Desire to concentrate communications by connecting users with related information needs within LAN segments, known as affinity groups.
- Requirements for performance, reliability and/or availability which may be addressed through use of parallel bridges ²³ or parallel routes ²⁴, providing both increased capacity and backup paths.
- Requirements to separate some LAN stations from others for security purposes by using bridges to provide controllable connectivity paths between secure segments and other stations.
- Requirements to access special function devices such as host gateways or LAN servers which may be best satisfied through use of a backbone topology.

It is evident that there is no "best solution" for every network. However, general guidelines can be given based on the strengths and weaknesses of general topologies, and possible performance expectations.

6.1.1.1 General Guidelines

When the number of workstations is small (typically a network of fewer than 40 workstations) the distribution of workstations within the network will be determined mainly by physical considerations. The existence of departmental groups or affinity groups will also be an important factor in selecting a particular physical layout, as will the number and location of servers.

However, when the number of workstations grows, other factors (such as increased traffic load versus capacity, availability, performance, management and network expandability), increase in importance.

In the remainder of this design section, we will primarily consider bridges interconnecting two token-ring LAN segments, although other segment topologies and MAC protocols could equally apply except where noted.

²³ Parallel bridges are bridges interconnect the same two LAN segments.

²⁴ Parallel routes define end-to-end paths for the same source and destination LAN segments.

- **Server LAN Configuration**

If two work groups or departments share similar files or printers, but are attached to separate rings for other reasons, a server ring can be used to reduce the costs of providing such resources as letter quality printers or large disk storage.

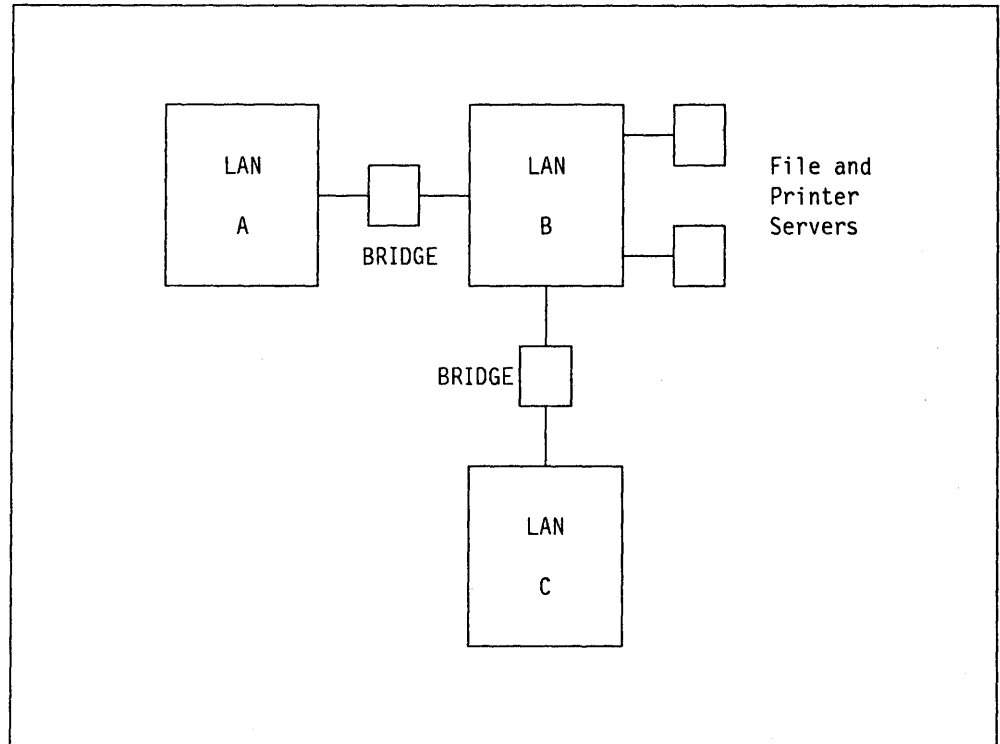


Figure 65. Server LAN Configuration. LAN A and LAN C are two separate departments with little inter-communication. They share servers attached to LAN B.

- **Fully-Interconnected and Loop Configurations**

A fully-interconnected configuration (mesh) provides alternate paths from each LAN segment to another. Should a bridge or path fail, traffic can be routed through an alternate path, thereby increasing availability of the server segment.

This solution tends to become impractical as the number of LAN segments grows. For n LANs, one would require $n(n-1)/2$ bridges. Therefore, a loop configuration as shown in Figure 66 on page 152 can be an acceptable compromise between availability versus cost and complexity ²⁵.

²⁵ A loop configuration with three LAN segments is also fully-interconnected.

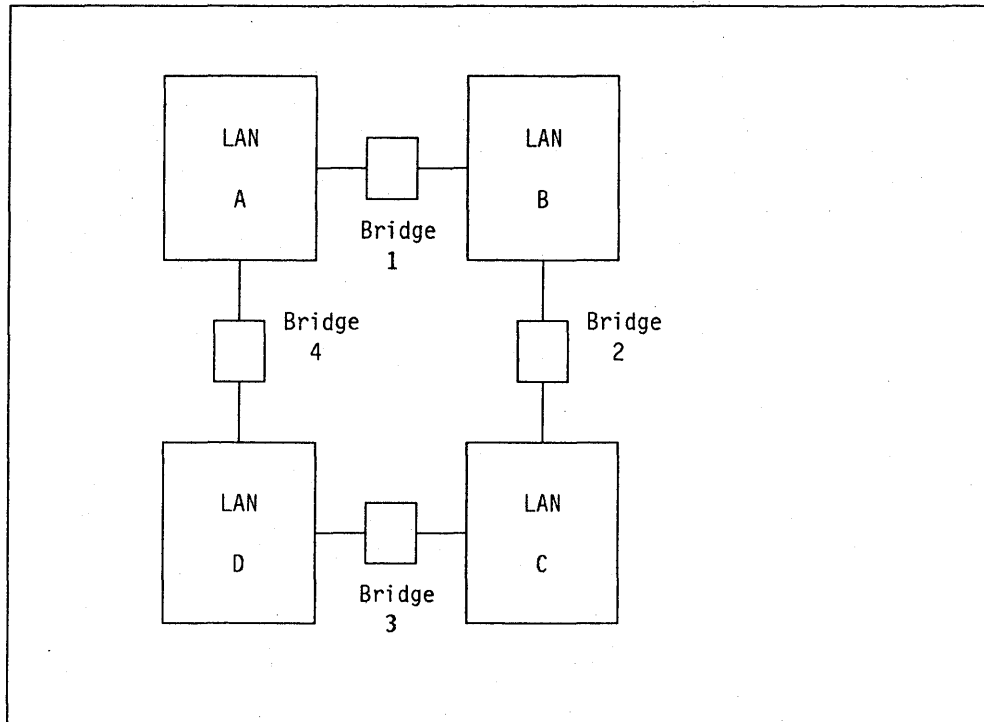


Figure 66. Loop Configuration with Four LANs

- **Parallel Bridge Configuration**

Parallel bridges can address the problems of heavy traffic flows through particular bridges and/or high availability requirements. While the failure of one bridge would impact connectivity between LAN segments over that bridge, sessions could be recovered via the parallel bridge.

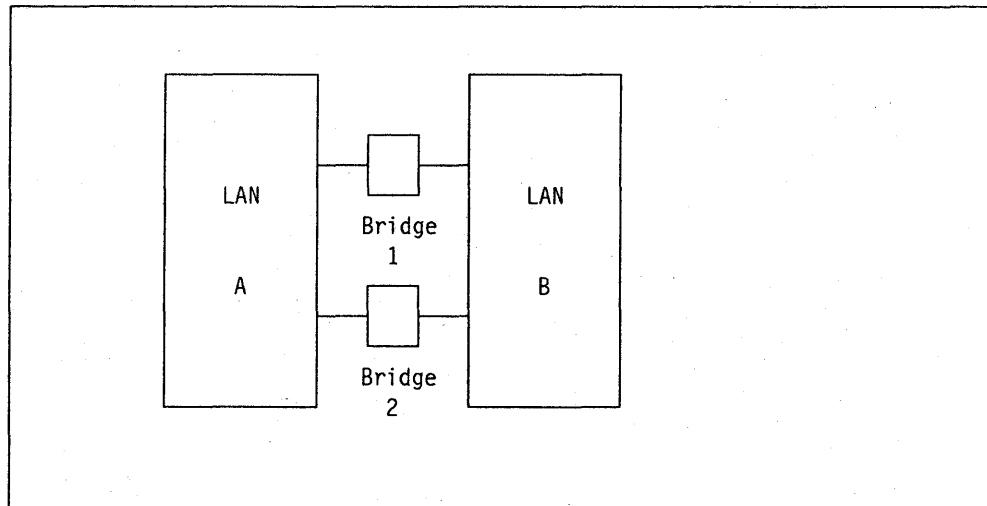


Figure 67. Parallel Configuration

- **Backbone LAN Configuration**

If growth is an important factor, a backbone LAN configuration can provide the necessary flexibility. It also offers common server and gateway access to a potentially very large number of LAN stations.

In a backbone configuration a number of LAN segments, sometimes referred to as departmental LANs, are all connected to the same backbone LAN as shown in Figure 68 on page 153. This implies that between any two LAN stations attached to departmental LANs, there is always a communications path that includes relatively few bridges, whatever the size of the bridged LAN.

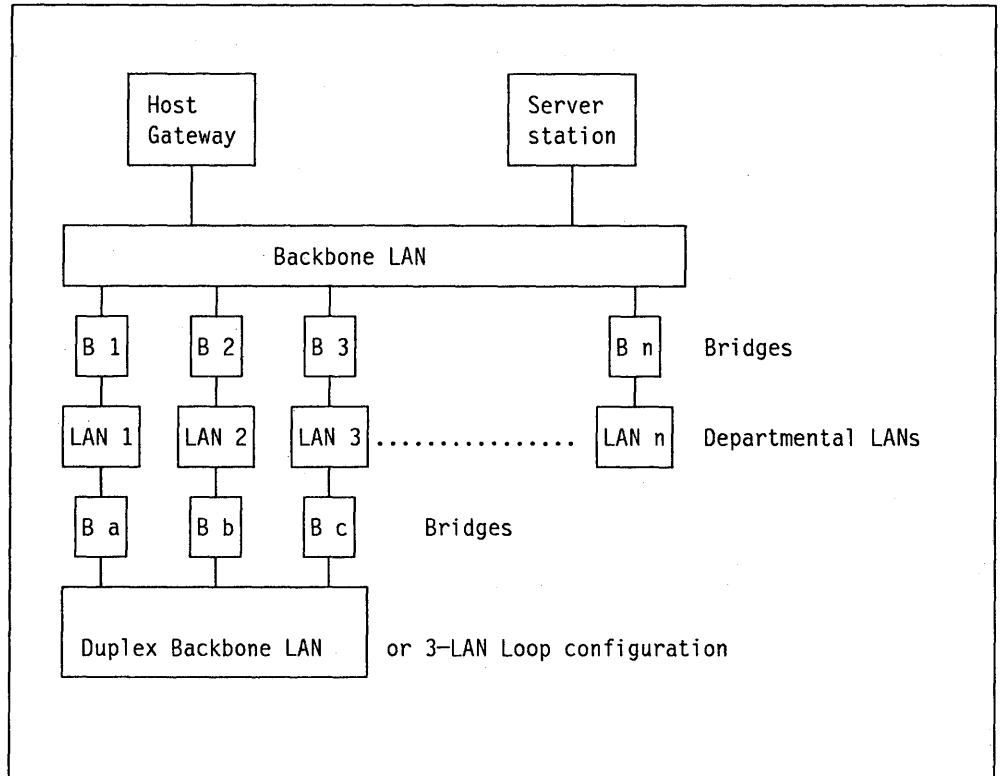


Figure 68. Backbone LAN Configuration

Because of the potentially high concentration of traffic on the common backbone LAN, a LAN segment with stable performance characteristics and possible higher bandwidth than the individual segments may be required. As explained in "Basic CSMA/CD Concepts" on page 16 and "Basic Token Passing Ring Concepts" on page 22, a 4 or 16 Mbps token-ring network may be a more desirable choice for a backbone LAN segment than a CSMA/CD LAN segment.

As an example, the backbone LAN in Figure 68 could be a 16 Mbps IBM Token-Ring Network, interconnecting a mixture of IBM PC Network (Broadband) LANs and 4 Mbps IBM Token-Ring Networks.

Because of high availability, backup and/or capacity considerations, one might consider implementing a duplex backbone, as a mirror image of the first one.

6.1.1.2 Additional Design Considerations for Bridged LANs

When designing a bridged LAN, one cannot ignore the bridge protocol implemented in the bridge products themselves. Special attention may have to be paid to specific bridge parameters.

The bridging technique discussed in "Transparent Bridging" on page 155, does not allow concurrently active parallel bridges or parallel routes.

When using a source routing bridge protocol as presented in "Source Routing" on page 158, one may want to consider a bridge parameter called *single route broadcast* or *hop count*, to prevent flooding of the bridged network with control frames during route resolution.

When selecting a particular configuration, the bridge performance itself should be considered in addition to the above factors.

Bridge processing within a bridged local area network adds some degree of overhead to the overall network throughput. The amount of bridge overhead depends on several factors, some of which are listed below:

- *Frame size*: as the size of the frame increases, the bridge throughput increases. Thus the largest possible frame size should be used, subject to the constraints of applications, memory or buffer management.
- *Bridge Hop Delay*: this is the elapsed time between the end of the receive stage for a frame entering the bridge, and the end of the transmit process for the same frame leaving the bridge through another port. This time is seldom more than a few milliseconds, increasing as the frame size and LAN traffic loads increase, but potentially more important when the interconnected MAC protocols are different or run at different speeds.

End-user perception of application delay may or may not be affected by bridge delays. As a general guideline, with slower applications, such as those involving disk access or host access, bridge delays will not normally be perceived. Other, faster applications such as program loads or memory-to-memory copies, may be impacted when the frames must cross one or more heavily used bridges.

The following factors minimize the impact of the above delays:

- Frames flowing through a bridge may be given a higher traffic priority than normal LAN station frames, thus reducing the probability of bridge congestion due to token-wait time.
- Route selection (based upon source routing) where more than one path is possible, is based upon the fastest rather than the shortest path.

In normal workload conditions, bridge processing does not constitute a bottleneck in a bridged LAN environment.

The IBM bridge products provide performance monitoring information to assist in monitoring traffic flow and bridge performance. See "IBM LAN Bridges" on page 163.

6.2 Bridging

As introduced earlier ("LAN Interconnection" on page 46), two different bridging architectures and protocols have to be considered.

IBM included in its Token-Ring Architecture, see *IBM Token-Ring Network Architecture Reference* a bridge architecture called *source routing*, and developed products implementing this approach. This approach has now been included in the IEEE 802.5 Standard.

In parallel, the IEEE 802.1 subcommittee was working on a MAC bridge architecture called *transparent bridging*, which currently has the status of a Draft IEEE Standard. As a requirement of the IEEE 802 committees, source routing must be capable of interoperating with transparent bridging at the MAC level.

6.2.1 Transparent Bridging

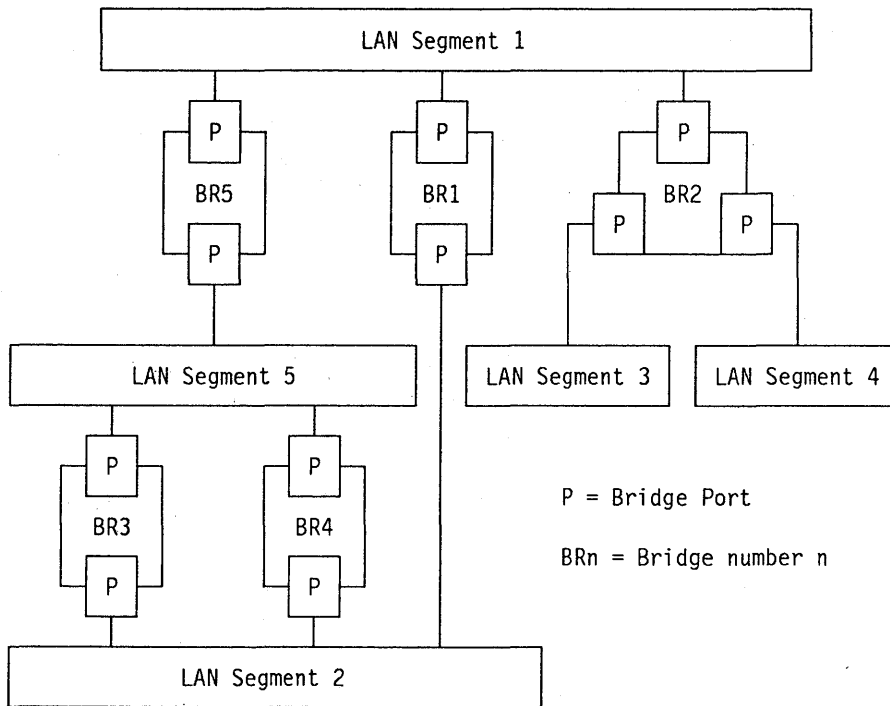
This section describes the transparent bridging protocol and its associated spanning tree algorithm as drafted by the IEEE 802.1 subcommittee.

In this bridge architecture, there is a clear distinction between the actual, physical bridged LAN topology and the simply connected active topology, which reflects use of a spanning tree algorithm. Figure 69 on page 156 shows the physical configuration of a sample bridged LAN as well as a possible active topology.

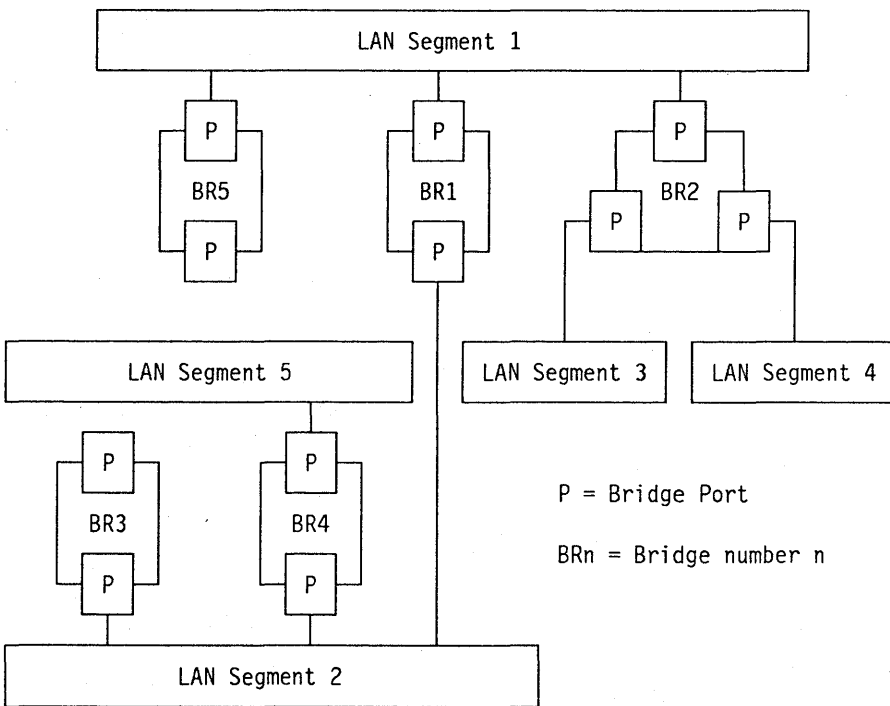
In an active topology, frames are forwarded through those bridge ports which are said to be in *forwarding* state. Other bridge ports do not forward frames and are held in *blocking* state. Bridges only connect LAN segments to which they have attached ports in forwarding state. A port in blocking state may be put in forwarding state, that is become part of the active topology, if bridge components fail, are removed or are added.

In an active topology, one bridge is known as the *root bridge*. Each LAN Segment has a bridge port connected to it, called the *designated port*, which forwards frames from that segment to the root (bridge). The bridge to which the designated port for a particular LAN Segment belongs is called the *designated bridge*. The root bridge is implicitly the designated bridge for all the LAN segments to which it is connected. At any particular bridge, the root port and the designated ports, if any, are the ports in forwarding state.

As an example, bridge 1 in the active topology sample presented in Figure 69 on page 156 has been selected as the root bridge. Therefore it is the designated bridge for LAN segments 1 and 2. Bridge 2 is the designated bridge for LAN segments 3 and 4, while bridge 4 is the designated bridge for LAN segment 5. This structure can be represented as a logical tree topology, called a *spanning tree*, as shown in Figure 70 on page 157.



Bridged LAN - Physical Topology



Bridged LAN - Active Topology

Figure 69. Bridged LAN - Physical and Active Topologies.

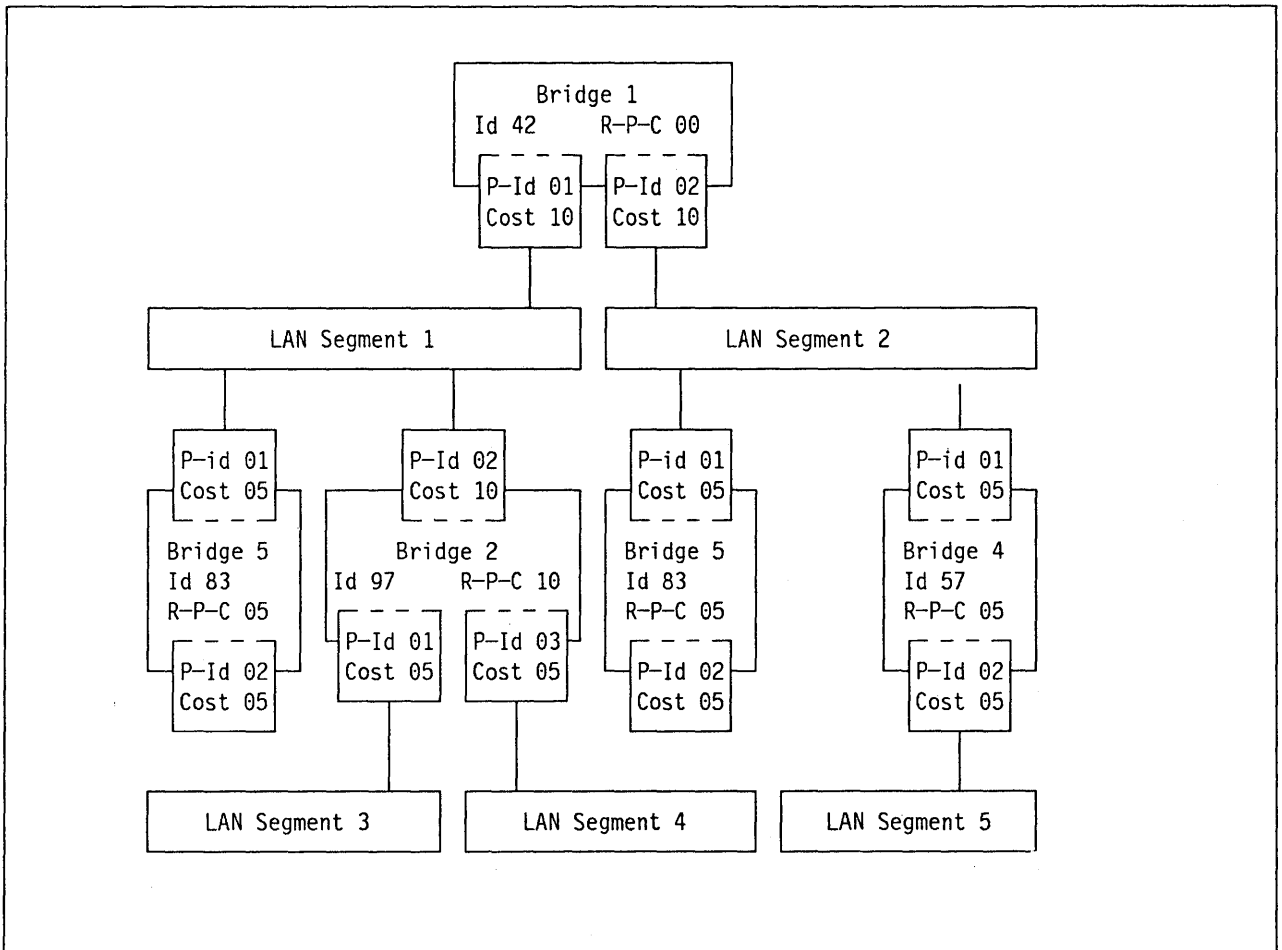


Figure 70. Spanning Tree Sample

Abbreviations in this figure have the following meanings:

- Bridge:
 - Id = Bridge identifier (unique throughout bridged LAN)
 - R-P-C = Root path cost (least-cost path between root and bridge port)
- Port:
 - P-Id = Port identifier (associated with each bridge port)
 - Cost = Path Cost (default value is related to the type of the attached LAN segment)

The active topology is described in a *filtering database*, containing static and dynamic entries. *Static entries* are entered under explicit management control and contain MAC addresses for which filtering is specified as well as a port map that specifies the state (forwarding or blocking) of each port. The following parameters are examples of static entries which, amongst others, determine the active topology:

- Unique bridge identifiers
- The path cost for each bridge port
- The port identifier associated with each bridge port.

Dynamic entries result from a learning process through communication with other bridges or LAN stations to take into account physical LAN configuration changes. Dynamic entries also change whenever the active topology changes (such as the result of updated path cost values). A dynamic entry contains a MAC address for which filtering is specified and a port number to which frames with the specified destination address are to be forwarded.

The filtering database may be initialized with static entries from a permanent database.

Bridges exchange *bridge protocol data units* (BPDUs) to propagate topology information, thereby enabling computation of the active topology and resulting spanning tree. A frame containing a BPDU has a "functional address" as its MAC destination address. This forces all active bridges connected to the same LAN segment as the sending bridge to copy the BPDU information. The information carried in the BPDU supports selection of the designated port for the LAN segment (the one with the lowest root path cost). At the same time, it allows any bridge to select from its designated ports the one which is the closest (that is, lowest cost) to the root as its *root port*. The root bridge is the bridge with the highest priority bridge identifier.

Thus selection of the active topology of a bridged LAN can be managed by setting proper values for bridge identifier (priority component), for path cost and for port identifier for each bridge port.

Because of propagation delays involved in communicating control information, a sharp transition from one active topology to another one is not possible. Therefore wait times are provided by the protocol as well as intermediate port states. Consequently, apart from being in disabled, blocking or forwarding state, a port can be in listening or learning state. A port in blocking state must enter listening state, followed by learning state before entering into forwarding state (that is before actually participating in frame relay).

A very important implication of transparent Bridging with its particular spanning tree algorithm, is that one cannot have concurrently active parallel bridges (interconnecting the same two LAN segments) or even concurrently active parallel paths (interconnecting the same source and destination LAN segments).

6.2.2 Source Routing

Source routing refers to the route-resolution architecture and protocols as implemented in the IBM bridge products, and as described in the *IBM Token-Ring Network Architecture Reference*.

A route through a multi-segment LAN can be described as a sequence of *segment numbers* and *bridge numbers*. A segment number - bridge number combination is called a *route designator*.

Therefore, before looking at the route-resolution mechanisms used in source routing, Figure 71 on page 159 shows how *routing information* is carried within a token-passing ring frame, and how route designators are entered in the RI field.

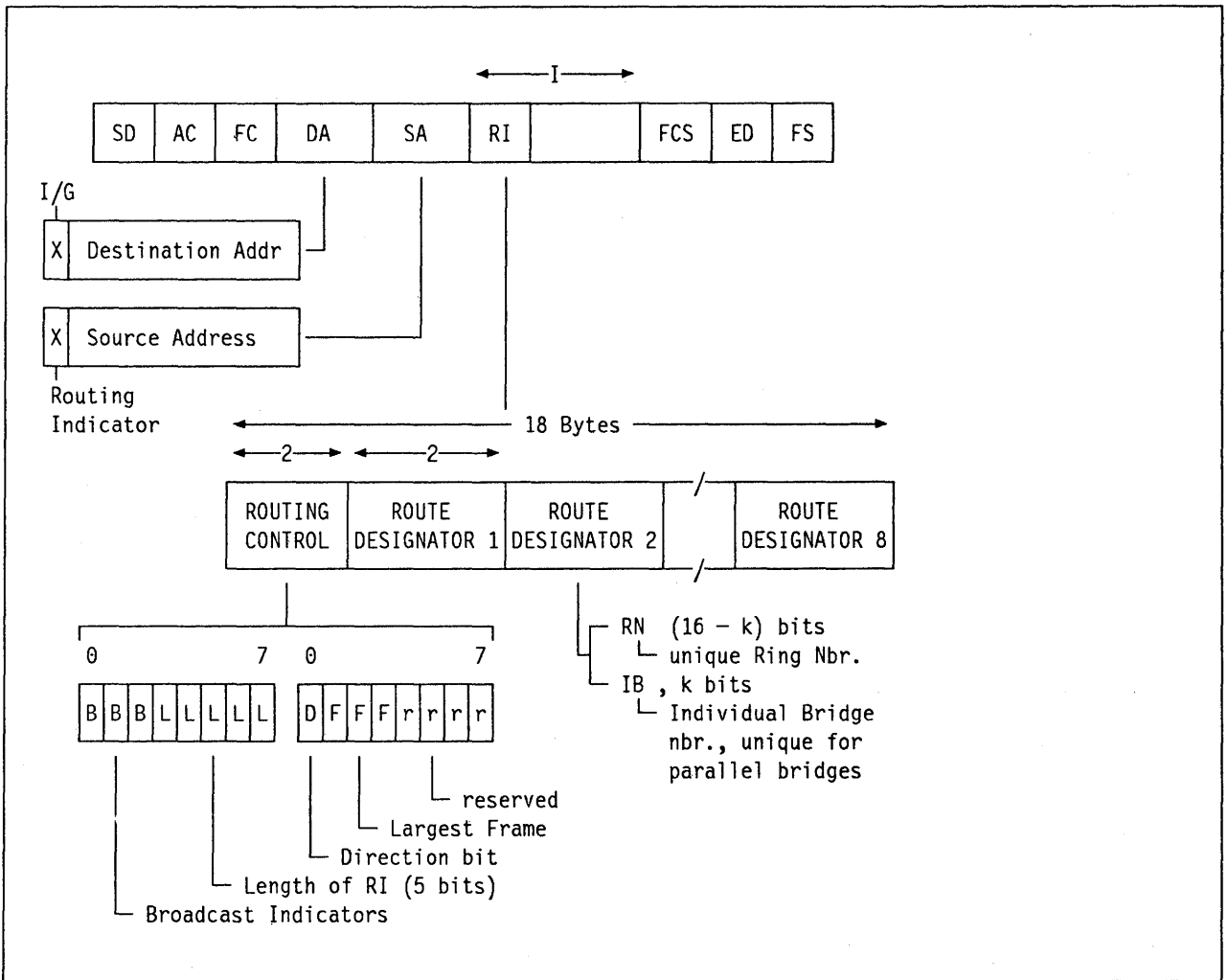


Figure 71. Token Passing Ring Frame - Routing Information Field

Figure 72 on page 160 lists the control bit settings involved in source routing.

Largest Frame	size (bytes)	comments
B'000'	516	I-field, min. for LLC Type 1 operation
B'001'	1500	largest frame size supported in ISO 8802-3 LANs
B'010'	2052	suitable for 24 x 80 full screen data xfer
B'011'	4472	largest frame size supported in FDDI draft and in ISO 8802-5 LANs with T(Token_Holding) = 9ms
B'100'	8191	largest frame size supported in ISO 8802-4 LANs
B'101'		reserved
B'110'		reserved
B'111'		used in all-routes broadcast frames
Broadcast	designator	comments
B'0XX'	Non-broadcast	used in all-routes broadcast frames
B'10X'	All-routes Broadcast	frame transmitted along every route in the network to the destination station
B'11X'	Single-route Broadcast	only designated bridges will relay the frame from one segment to the other
Route Designator	length (bits)	comments
Ring-Number Individual-Bridge-Nr.	16-k k	k is the same for all bridges in one multi-ring LAN, typically k = 4 (Bridge V1)

Figure 72. Routing Information Field - Code Bits

Source routing is started at session connect time by the DLC_LAN_MGR (data link control LAN manager) component of a station taking actions to *resolve the route*

Route resolution is usually a two-stage process, whereby first the destination station is searched on the *local LAN segment*. If the destination cannot be located on the local segment, the destination will be searched on remote segments connected via bridges.

- On-segment route determination: the source station sends a TEST or an IEEE 802.2 XID command LLC protocol data unit (LPDU) to the address of the destination without any routing information. The destination, if present, responds with a TEST or XID response LPDU. If no response LPDU is returned within a specific amount of time, the destination address is not on the local LAN segment, and the second stage of the route discovery is initiated.
- Off-segment route determination: the source station immediately retransmits the TEST or XID LPDU, indicating however the presence of routing information by setting byte 0, bit 0 of the source address field to 1 and appending an initial 2-byte RI field after the SA (see Figure 71 on page 159). At this point the architecture provides a choice between two

main dynamic route discovery processes: *all-routes broadcast route determination* and *single-route broadcast route determination*.

6.2.2.1 All-Routes Broadcast Route Determination

In a TEST or XID command LPDU, broadcast to all rings by the source station, the first two bits of the RI field are set to B'10'. This triggers all bridges to copy the LPDU frame and while forwarding it, to complete the RI field with additional route designator information.

The destination station receives as many command LPDUs as there are available routes, while any received frame contains in its routing information field the precise route which has been followed. Any received command LPDU will be returned as a response LPDU, setting the first RI-bit to B'0' (non-broadcast) and another routing control bit, the direction bit, to B'1'. This forces any response frame to flow back to the source station via the route as built in the LPDU of the command received.

The source station selects the *preferred route* from all returned response LPDUs, and subsequent transmissions to the destination station follow the preferred route. The destination learns the preferred route from the first non-broadcast frame received from the partner source station. The preferred route information between two stations remains valid for the duration of the DLC session between both.

6.2.2.2 Single-Route Broadcast Route Determination

A value of B'11' in the first two bits of the RI field, marks the TEST or XID command LPDU as a single-route broadcast frame. Depending on the setting of the single-route broadcast bridge parameter (see "IBM LAN Bridges" on page 163), the bridge will decide whether or not to copy and forward the bridge (leaving the RI-field unchanged).

In this way, each LAN segment may communicate only one copy of the TEST or XID command LPDU and the destination station will receive only one command LPDU.

The TEST or XID command LPDU is then returned as a response LPDU with the first two RI-bits indicating all-routes broadcast. Again multiple response LPDUs may be received by a source station, but in this case routing information has been collected in the response flow rather than the command flow.

As in the first procedure, the source station selects the *preferred route* from all returned response LPDUs.

Single route broadcast at the bridge level may be set on or off at bridge initialization time by a (controlling) LAN Manager. If all bridges in a LAN are configured for automatic single-route path maintenance the active topology will be dynamically maintained by the bridges. Alternatively, the single-route broadcast specification may be defined as a manual setting. If so defined and the path becomes unavailable for any reason, the LAN Manager must take appropriate action to (manually) define an alternate path.

The dynamic single-route broadcast path maintenance option uses a spanning tree algorithm to maintain the status of each participating bridge. Section "IBM Token-Ring Network Bridges" on page 165 explains how this option is made

available in the IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 and IBM PC Network Bridge Program products.

6.2.3 Split Bridge

A *remote bridge*, also called a split bridge, is a bridge which interconnects LAN segments using a telecommunication link for the transmission of frames between bridge ports, as conceptually shown Figure 73.

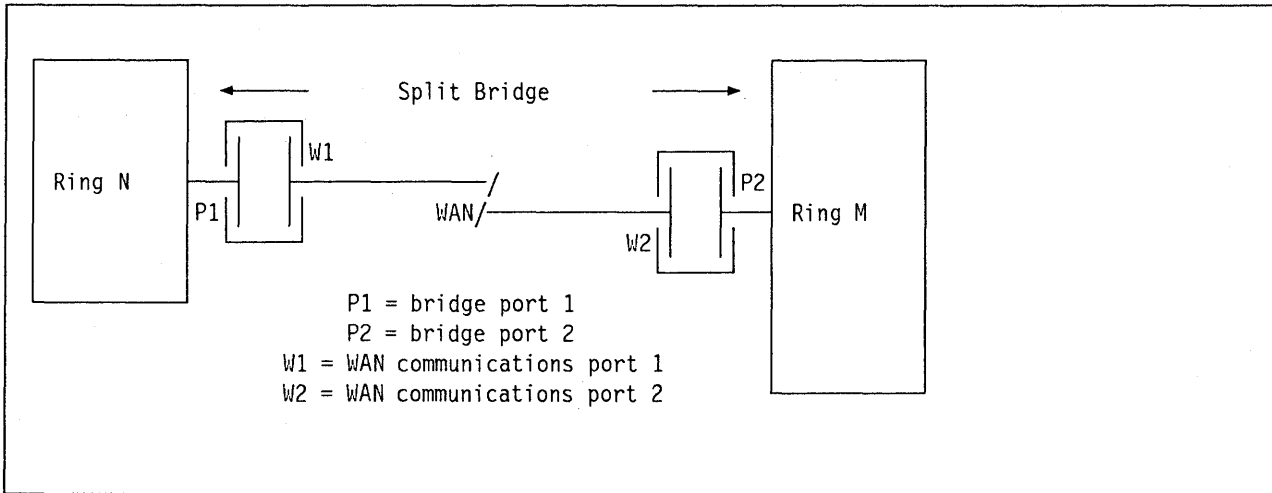


Figure 73. Remote Bridge Concept

Physically, a remote bridge consists of two halves at each side of the communications link. Instead of regular frame forwarding from one LAN adapter to the other one as in a normal Bridge, in a remote bridge a frame is copied in one station from the LAN adapter to the communications adapter (adding source routing information as required). This communications adapter sends the frame across the communications link to the peer communications adapter in the other bridge half, where the LLC frame is copied to the second LAN adapter and transmitted on its LAN segment.

Functionally, a remote bridge provides logical link control level end-to-end connectivity between LAN stations on either side of the bridge, supporting any higher layer protocol carried over the LLC link. In contrast, a typical remote gateway solution as offered by a remote System/370 host gateway device (see "Device Connectivity" on page 181) supports only its own higher-level protocols, for example, LU1, LU2 and LU6.2, between a LAN station and a System/370 mainframe.

IBM provides remote bridge support in the IBM Token-Ring Network Bridge Program V2.1 product. This implementation is described in greater detail in "IBM Token-Ring Network Bridges" on page 165.

6.3 IBM LAN Bridges

IBM local area network bridges are implemented in dedicated workstations attached to two different LAN segments. A bridge workstation contains two LAN adapters, (appropriate for the type of attached LAN segment, and a bridge program running in the workstation's memory.

Since a bridge workstation is entirely dedicated to the bridging function, the different IBM Bridge Programs operate in a single-task IBM PC/DOS 3.3 or 4.0 environment.

Each IBM bridge program supports source routing as described in "Source Routing" on page 158. Since the routing information field can only contain up to eight route designators, end stations in a multi-segment environment communicate over a maximum of seven bridges.

Communication across any IBM bridge is transparent to applications written to the IEEE 802.2 logical link control interface using source routing.

The original bridge program, the IBM Token-Ring Network Bridge Program Version 1.0, is no longer marketed. This product supported interconnection of two 4 Mbps token-ring segments. It was succeeded by *IBM Token-Ring Network Bridge Program V1.1*, which also supports two 4 Mbps token-ring segments. In addition, IBM Token-Ring Network Bridge Program V1.1 can communicate with up to four LAN Managers implemented by IBM LAN Manager V1.0. Network management aspects will be covered in greater detail in "PC/DOS - LAN Manager V1.0" on page 268.

The most recent IBM Token-Ring Network Bridge Programs are the IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 and IBM PC Network Bridge Program.

When all bridges in the network are running either IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 or IBM PC Network Bridge Program and configured appropriately, they will communicate with each other to automatically configure the network single-route broadcast path. Refer to the single route broadcast route determination algorithm in section "Source Routing" on page 158 for an introductory discussion of this route-resolution technique.

IBM Token-Ring Network Bridge Program V2.0

The IBM Token-Ring Network Bridge Program V2.0 interconnects token-ring segments operating at either 4 Mbps or 16 Mbps. IBM Token-Ring Network Bridge Program V2.0 communicates with up to four LAN managers implemented by IBM LAN Manager V2.0.

IBM Token-Ring Network Bridge Program V2.1

The IBM Token-Ring Network Bridge Program V2.1, also referred to as *remote bridge*, or *remote bridge*, includes all the functions and capabilities of IBM Token-Ring Network Bridge Program V2.0. In addition, IBM Token-Ring Network Bridge Program V2.1 provides bridging functions between remote token-ring segments (4 Mbps or 16 Mbps) over a leased teleprocessing (TP) line operating at speeds from 9.6 Kbps to 1.344 MBps. In this case, a LAN

workstation at each end of the TP link will implement one half of the Split Bridge.

When operating as a remote bridge, IBM Token-Ring Network Bridge Program V2.1 provides the capability of filtering frames to be forwarded by the bridge. Via a programming interface, a user program can determine which frames are allowed to pass through the split bridge. This feature is particularly useful to limit bridge traffic when a relatively slow TP line is used between the bridge halves (for example, 9.6 Kbps or 19.2 Kbps).

IBM PC Network Bridge Program.

A more general LAN segment interconnection solution is offered by IBM PC Network Bridge Program. A bridge running the IBM PC Network Bridge Program supports interconnection between any two of the following LAN segments:

- 4 Mbps IBM Token-Ring Network segment
- PC Network (Broadband) operating on channel pair T13 - J
- PC Network (Broadband) operating on channel pair 2' - O (Frequency 2)
- PC Network (Broadband) operating on channel pair 3' - P (Frequency 3)

The PC Network segments, operating on different channel pairs, may or may not share the same broadband medium.

In this way, PC Network (Broadband) attached devices may have access to host gateway devices attached to token-ring segments of the network.

IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 and IBM PC Network Bridge Program are all capable of communicating with IBM LAN Manager V2.0, providing consistent network management for the entire multi-segment LAN.

Before looking at the specific IBM bridge product implementations, Figure 74 shows the major components and their interfaces for a "normal" bridge between two LAN segments.

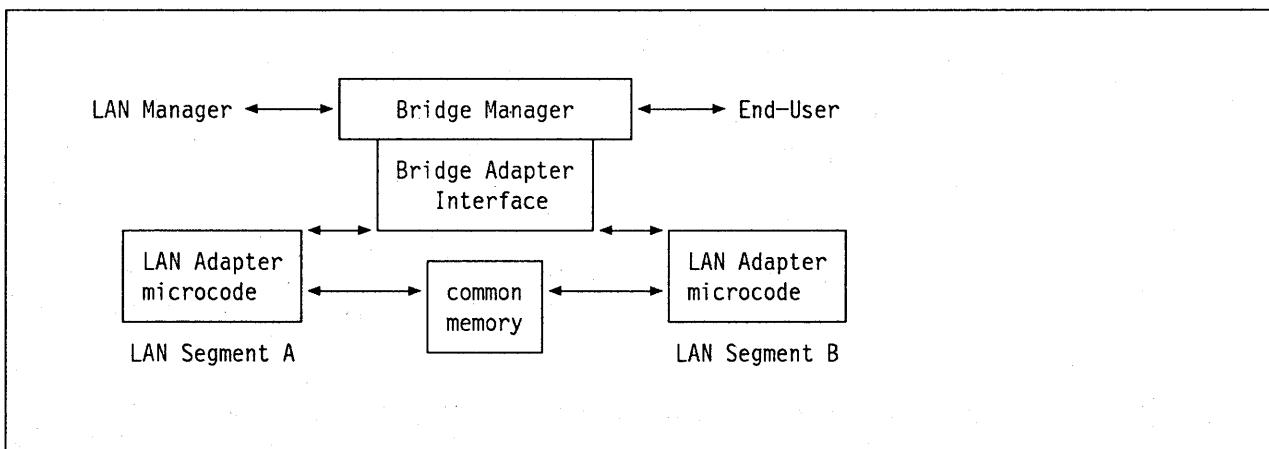


Figure 74. LAN Bridge Structure

Similarly, Figure 75 on page 165 illustrates the major components and their interrelationship for a remote bridge.

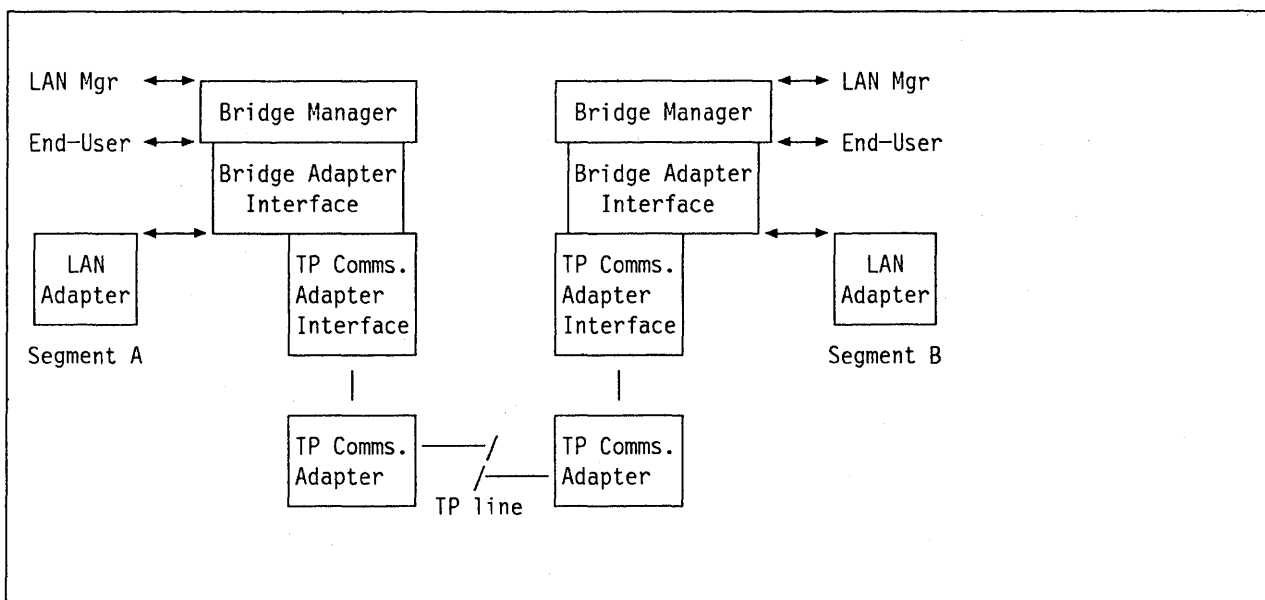


Figure 75. Split Bridge Structure

6.3.1 IBM Token-Ring Network Bridges

6.3.1.1 IBM Token-Ring Network Bridge Program V1.1

The prime function of IBM Token-Ring Network Bridge Program V1.1 is to interconnect 4 Mbps IBM Token-Ring Network segments at the MAC level. Ring stations initiate source routing protocols to resolve the route to a destination station on a separate ring segment. Although still supported, IBM Token-Ring Network Bridge Program V1.1 has been superseded by IBM Token-Ring Network Bridge Program V2.0.

In addition, IBM Token-Ring Network Bridge Program V1.1, via a component called the LAN reporting mechanism, is capable of establishing a reporting link with up to four IBM LAN Manager V1.0s. Each reporting link is an IEEE 802.0 logical link control Type 2 (connection-oriented) link, dedicated to transport network management information in either direction.

LAN management functions and products are discussed in a separate Chapter "LAN Management and Recovery" on page 253. Some LAN management commands change the way in which a LAN segment operates. When a bridge has a reporting link with several IBM LAN Managers to control the same LAN segment, those commands must be reserved to one LAN Manager only to avoid conflicts. This LAN Manager is called the *controlling LAN Manager* for a given bridge. All other (up to three) LAN Managers to which this bridge reports are called *observing LAN Managers*.

The link between a bridge and its controlling LAN Manager is reporting link 0, also referred to as authorization level 0. Once a reporting link 0 is established, IBM Token-Ring Network Bridge Program V1.1 will reject subsequent attempts by other IBM LAN Managers to establish a reporting link 0, thereby avoiding duplicate controlling LAN Managers.

Observing LAN Managers have reporting links 1, 2 or 3 with a given bridge. Reporting links are always initiated by the LAN Manager station, either at LAN Manager initialization or during LAN Manager operation by the network operator through a Link Bridge command. The operator may also decide to unlink a reporting link. Establishing a reporting link requires the operator to provide a link password.

The IBM Token-Ring Network Bridge Program V1.1 may receive requests from IBM LAN Manager V1.0, and send back appropriate responses over a reporting link after executing a given request on an attached ring segment.

In addition, the IBM Token-Ring Network Bridge Program V1.1 may receive commands, reserved to the controlling IBM LAN Manager V1.0, over reporting link 0. For IBM Token-Ring Network Bridge Program V1.1, these commands are:

- Set single-route broadcast in a bridge.
- Remove station on a ring segment.
- Set soft error logging options for a ring segment.
- Perform a path test.

The communication between IBM LAN Manager V1.0's and IBM Token-Ring Network Bridge Program V1.1 is shown in Figure 76 on page 167.

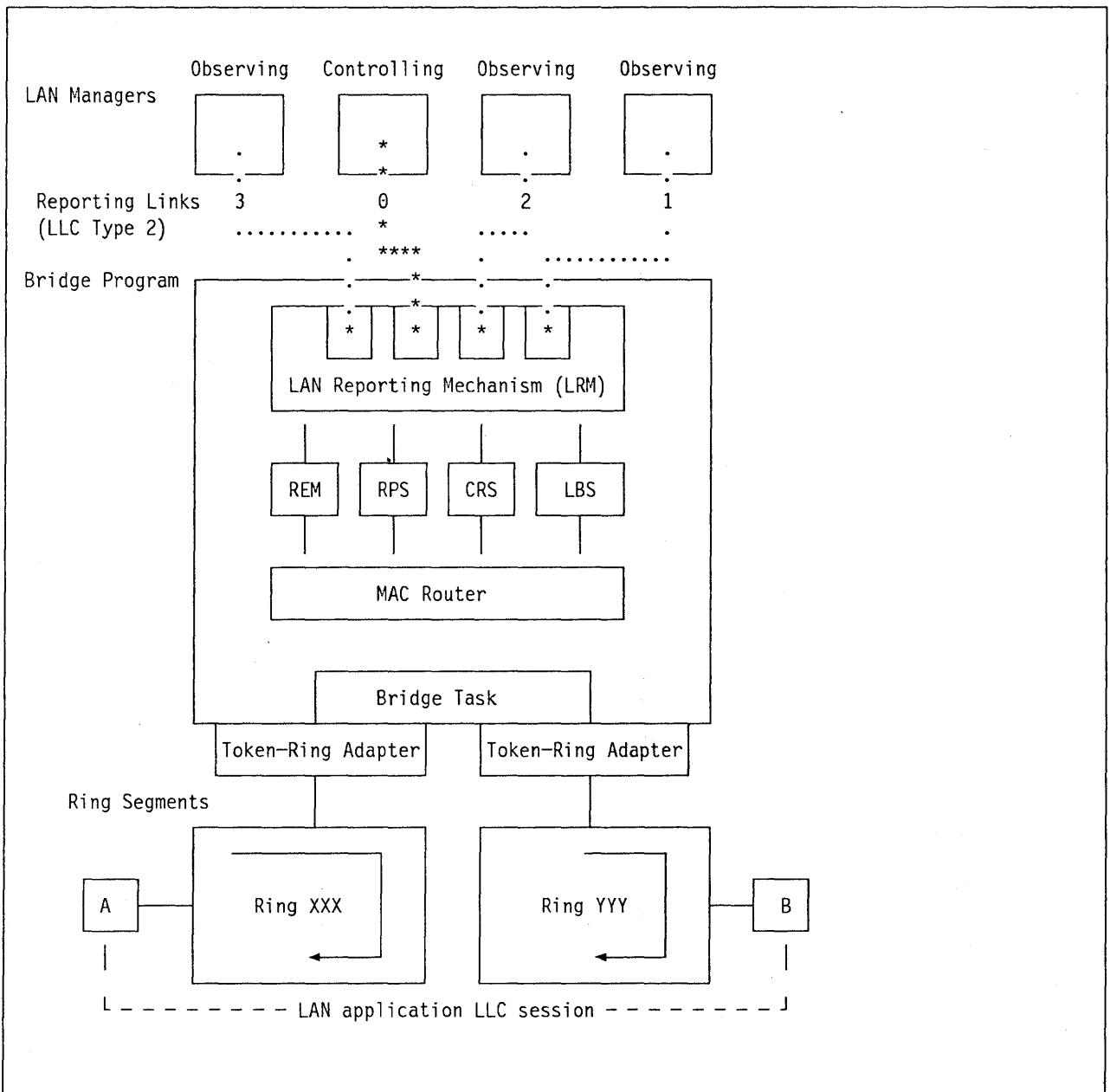


Figure 76. IBM Token-Ring Network Bridge Program V1.1 - IBM LAN Manager V1.0 Communication

This figure summarizes both the application flow between end stations (carrying data and higher-level-protocol header information), and network management data flow. The latter consists of LLC Type 2 sessions between LAN Manager and the LAN reporting mechanism which directs a LAN Manager request/command to the appropriate server function in the Bridge. On the ring segments side, LAN Manager requests/commands are translated into the appropriate MAC frames for execution on one of the two attached ring segments. Responses provided by the appropriate server function are directed to the LAN reporting mechanism which packages them into an LLC frame addressed to the originating LAN Manager.

Various server functions are also illustrated. Some of these, associated with network management, are optional, while the LAN Bridge Server is always present.

LAN Bridge Server

The bridge processing by the LBS function consists of:

- Reading and validating bridge parameters from a configuration file at bridge initialization time and whenever a controlling LAN Manager modifies bridge parameters.
- Performing the bridge self-test during bridge initialization or upon request from an operator through the bridge user interface. This test includes detection of duplicate parallel paths and invalid network configurations (that is inconsistent ring numbering).
- Maintaining a set of performance counters for each adapter, including counters for the number of frames discarded, not received or not forwarded for any other reason, and for the number of frames and bytes forwarded (both for broadcast and non-broadcast frames). On request, the accumulated values may be reported to LAN Manager.
- Accumulating path trace information for frames carrying a system path trace bit set on in the routing information control field. Path trace report frames may be sent to the controlling LAN Manager.

The different bridge server functions which may be enabled optionally on each of the bridge token-ring adapters are also shown in Figure 76 on page 167.

Ring Error Monitor

The REM server function in the bridge compiles error statistics from received Soft_Error_Report MAC frames and selectively generates reports for LAN Manager, depending on the *soft error reporting mode* (normal/intensive) set by LAN Manager.

Ring Parameter Server

In addition to supplying the ring number to stations in response to Request_Init_Parameters MAC frames received by RPS during ring insertion, the RPS function also notifies LAN Manager when a given station has entered the LAN segment. A specific bridge protocol assures that only one RPS function is active on each ring segment.

Configuration Report Server

The CRS function forwards configuration notifications to LAN Manager. Upon receipt of a MAC level configuration notification, it transmits the received information via the LAN reporting mechanism to LAN Manager. From LAN Manager, CRS accepts such commands as Query Adapter, Remove Adapter and Set Station Parameters for execution on a bridge-attached LAN segment.

IBM Token-Ring Network Bridge Program V1.1 Implementation: The software component consists of IBM PC/DOS 3.3 or 4.0 and IBM Token-Ring Network Bridge Program V1.1 (5871-AAA). The IBM Token-Ring Network Bridge Program V1.1 includes the direct and logical link control device driver modules. IBM Token-Ring Network Bridge Program V1.1 also comes with a menu-driven bridge configuration utility, supporting specification of user-modifiable bridge parameters.

IBM Token-Ring Network Bridge Program V1.1 requires a dedicated PC AT, Industrial Computer 7531 or 7532, or any PS/2 model with 256 Kbytes of memory. It attaches to two 4 Mbps Token-Ring Network segments using two IBM Token-Ring Network Adapters II for Family 1 devices or two IBM Token-Ring Network Adapters /A for Family 2 devices. One adapter must be primary, the other alternate and the interrupt levels must be set to 2 and 3 respectively.

Bridge Installation: The IBM Token-Ring Network Bridge Program V1.1 diskette contains the following files:

- ECCMAIN.EXE (the main Bridge Program)
- ECCFEA2.EXE (the Ring Error Monitor Error Analysis Program)
- ECCCNFG.EXE (the Configuration Utility program)
- ECCPARMS.BIN (the default and initial bridge Parameters)
- ECHELP.SCN (the help information file).

Installation begin with completion of the Bridge Planning Chart to determine the bridge parameters. Using this information, the ECCCNFG program is then executed to set the bridge parameters. The main bridge program, ECCMAIN, should be included in the AUTOEXEC.BAT file to allow automatic (re)start of the bridge.

IBM Token-Ring Network Bridge Program V1.1 is shipped with the *IBM Token-Ring Network Bridge Program V1.1 User's Guide*

6.3.1.2 IBM Token-Ring Network Bridge Program V2.0

The IBM Token-Ring Network Bridge Program V2.0 provides interconnection of IBM Token-Ring Network segments operating at either 4 Mbps or 16 Mbps.

In addition to all the network management support provided by IBM Token-Ring Network Bridge Program V1.1 it supports dynamic single-route path route maintenance. IBM Token-Ring Network Bridge Program V2.0 interfaces with up to four LAN Managers running IBM LAN Manager V2.0. The network management information sent to IBM LAN Manager V2.0 can include:

- Soft error reports and beaconing notification.
- Bridge status and performance data.
- Ring configuration reports.

A major extension to the source routing mechanism is provided by the automatic configuration and maintenance capability of the single-route broadcast path.

Figure 77 on page 170 shows the general bridge structure of IBM Token-Ring Network Bridge Program V2.0 and its interfaces with the IBM Token-Ring Network Adapters. Like its predecessor, IBM Token-Ring Network Bridge Program V2.0 includes the adapter handler code and Direct (MAC) and LLC programming interfaces.

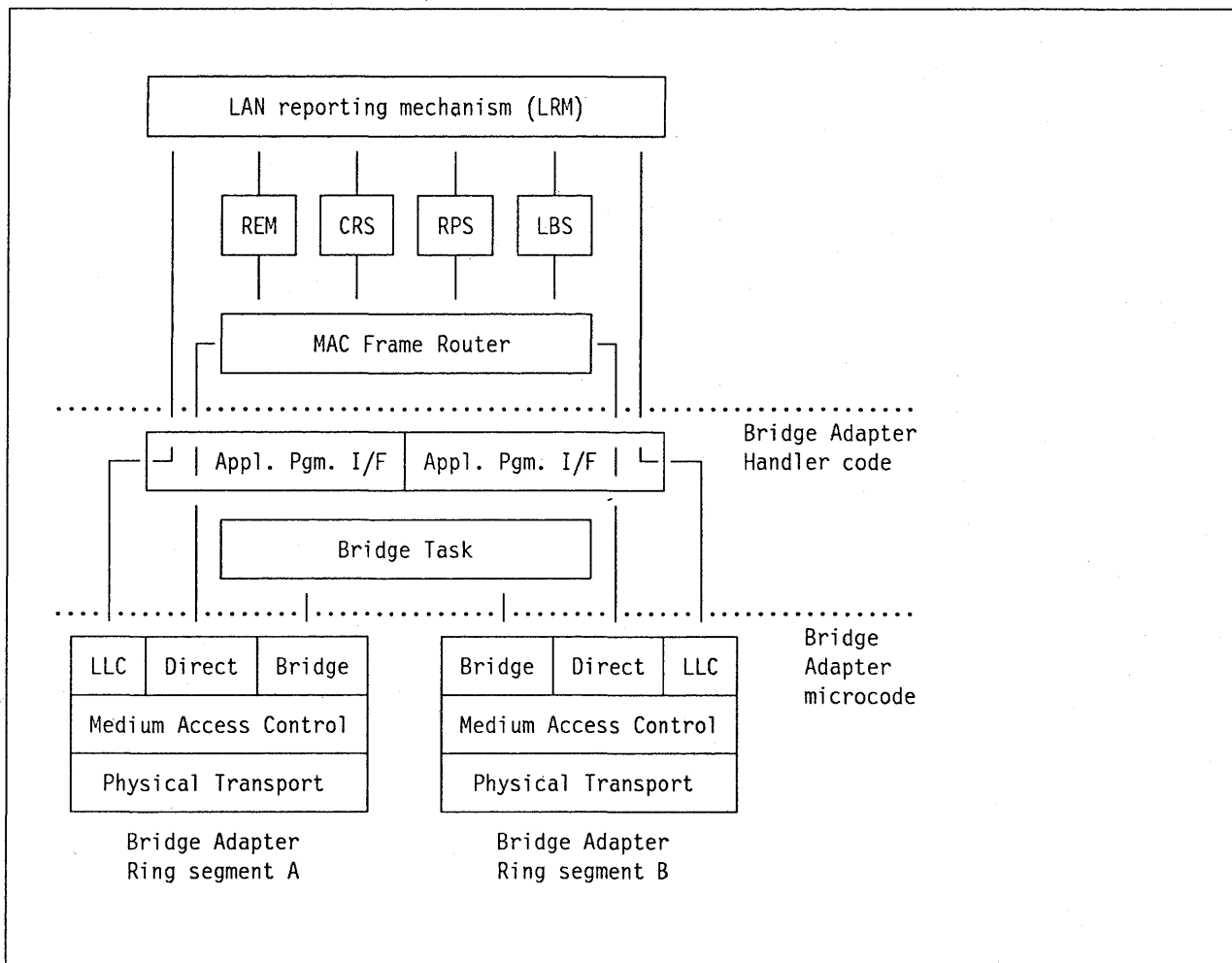


Figure 77. IBM Token-Ring Network Bridge Program V2.0 - General Bridge Structure

Bridge processing by the LAN bridge server function now includes *single-route broadcast path maintenance*. If this spanning tree algorithm is desired, all bridges in the multi-segment LAN must be configured to participate in the dynamic maintenance protocols. During IBM Token-Ring Network Bridge Program V2.0 configuration, the single-route broadcast parameter for each bridge adapter accepts a new value *Auto* for "automatic".

Because IBM Token-Ring Network Bridge Program V1.1 and the earlier (now withdrawn) IBM Token-Ring Network Bridge Program Version 1.0 do not support dynamic maintenance, they must be upgraded to the IBM Token-Ring Network Bridge Program V2.0 to utilize this feature.

Single-Route Broadcast Path Maintenance: The bridge can be configured with the configuration utility or by the IBM LAN Manager V2.0 to communicate with other active bridges to dynamically maintain the network single-route broadcast path.

A bridge, configured to participate in the dynamic maintenance of the network's single-route broadcast path, can be in any of three modes:

Blocking The bridge does not forward single-route broadcast frames and does not participate in the bridge protocols.

Listening The bridge does not forward single-route broadcast frames but participates in the bridge protocols.

Forwarding The bridge forwards single-route broadcast frames and participates in the bridge protocols.

A bridge is in blocking mode during initialization. Once the bridge has opened its adapters and has set the appropriate functional address, it enters listening mode. After participating in the protocols long enough to determine if it should forward single-route broadcast frames, the bridge will either stay in listening mode or enter forwarding mode. Bridges participating in the protocols monitor the single-route broadcast path with inter-bridge communication. All inter-bridge communication is sent as logical link control Type 1 (connectionless) data to the bridge functional address (X'C0000000100'). The inter-bridge communication is periodically initiated by a *heartbeat* frame sent from the *root* bridge. This root bridge is automatically selected through processes specified by the spanning tree algorithm.

The bridges will reconfigure the single-route broadcast path to accommodate network changes caused by a new bridge being activated or an active bridge being shutdown.

It is important to notice that single-route broadcast path maintenance does not affect the way in which a bridge processes all-routes broadcast or non-broadcast frames.

Hardware and Software Requirements: IBM Token-Ring Network Bridge Program V2.0 requires a dedicated IBM Personal System/2 Model 30, 50, 60, 70 or 80, or a PC/AT, or an Industrial Personal Computer 7531 or 7532, with 512 Kbytes of memory and a 720 Kbyte or 1.2 Mbyte 3.5 inch diskette drive.

This device attaches to both ring segments by means of two IBM Token-Ring Network adapters. For Family 1 devices any combination of:

- IBM Token-Ring Network Adapter II
- IBM Token-Ring Network 16/4 Adapter.

For Family 2 devices any combination of:

- IBM Token-Ring Network Adapter/A
- IBM Token-Ring Network 16/4 Adapter/A.

IBM Token-Ring Network Bridge Program V2.0 requires the following software:

- IBM PC/DOS 3.3 or 4.0
- IBM Token-Ring Network Bridge Program V2.0

6.3.1.3 IBM Token-Ring Network Bridge Program V2.1

The IBM Token-Ring Network Bridge Program V2.1 includes the same bridging and network management functions as the IBM Token-Ring Network Bridge Program V2.0. It interconnects IBM Token-Ring Network segments operating at either 4 Mbps or 16 Mbps, supports single-route broadcast path dynamic maintenance and interacts with IBM LAN Manager V2.0 for network management purposes.

In addition, the IBM Token-Ring Network Bridge Program V2.1 can be configured as a *remote bridge*, also called *split bridge*. In this case, frames are

transferred between the two interconnected IBM Token-Ring Network segments via a leased teleprocessing (TP) line operating at speeds ranging from 9.6 Kbps to 1.544 Mbps.

A remote bridge consists of two bridge halves connected by a TP line. Each bridge half requires a token-ring network adapter attached to a LAN segment and a communications adapter attached to the telecommunication network in one of the following ways:

- Via synchronous modems, providing the following interfaces at the indicated speeds:
 - EIA RS-232C/CCITT V.24 at 9.6 Kbps to 19.2 Kbps.
 - CCITT V.35 at 9.6 Kbps to 1.544 Mbps.
 - X.21 bis/CCITT V.24 at 9.6 Kbps to 19.2 Kbps.
 - X.21 bis/CCITT V.35 at 9.6 Kbps to 1.544 Mbps.
 - X.21 (leased only) at 9.6 Kbps to 64 Kbps.
- Via a multiplexor, such as the Integrated Digital Network Exchange (IDNX) Models 20, 40 and 70 through:
 - The USD or HSD communications adapter using CCITT V.35 at 9.6 Kbps to 1.544 Mbps.
 - The QSD communications adapter using EIA RS-232C/CCITT V.24 at 9.6 Kbps to 19.2 Kbps.
 - The QSD communications adapter using CCITT V.35 at 9.6 Kbps to 56 Kbps.

An additional bridge parameter, *Communications Adapter Electrical Interface*, identifies the electrical interface used by the communications adapter to attach to the TP link. Valid options are 1 (RS-232), 2 (RS-422) and 3 (V.35, default value).

The IBM Token-Ring Network Bridge Program V2.1 maintains an internal protocol over the TP line between the two bridge halves.

Communications across a remote bridge, operating with a 1.344 Mbps TP line, is transparent to applications written to the IEEE 802.2 logical link control interface using source routing. However, in general, different restrictions apply with respect to line speed, maximum time delay, frame size, line error rate and number of active concurrent sessions through the bridge. The common rationale behind these different restrictions is to avoid end-to-end session time-out due to excessive delays experienced while crossing the remote bridge.

An important additional feature of IBM Token-Ring Network Bridge Program V2.1, called *frame-forward filtering*, provides a mechanism to limit the traffic across a remote bridge. A bridge parameter, *filtering enabled*, enables invocation of a *filter user appendage* during the frame forwarding decision process. If the filter appendage returns a no forward indicator the frame will be discarded and a specific counter (frame not forwarded, filtered) is incremented. A *filter user appendage* program can be created through a programming interface offered with the IBM Token-Ring Network Bridge Program V2.1. A sample filtering program comes with the product.

Figure 78 on page 173 shows the general bridge structure of IBM Token-Ring Network Bridge Program V2.1 and its interfaces with the IBM Token-Ring Network Adapter and TP communications adapter.

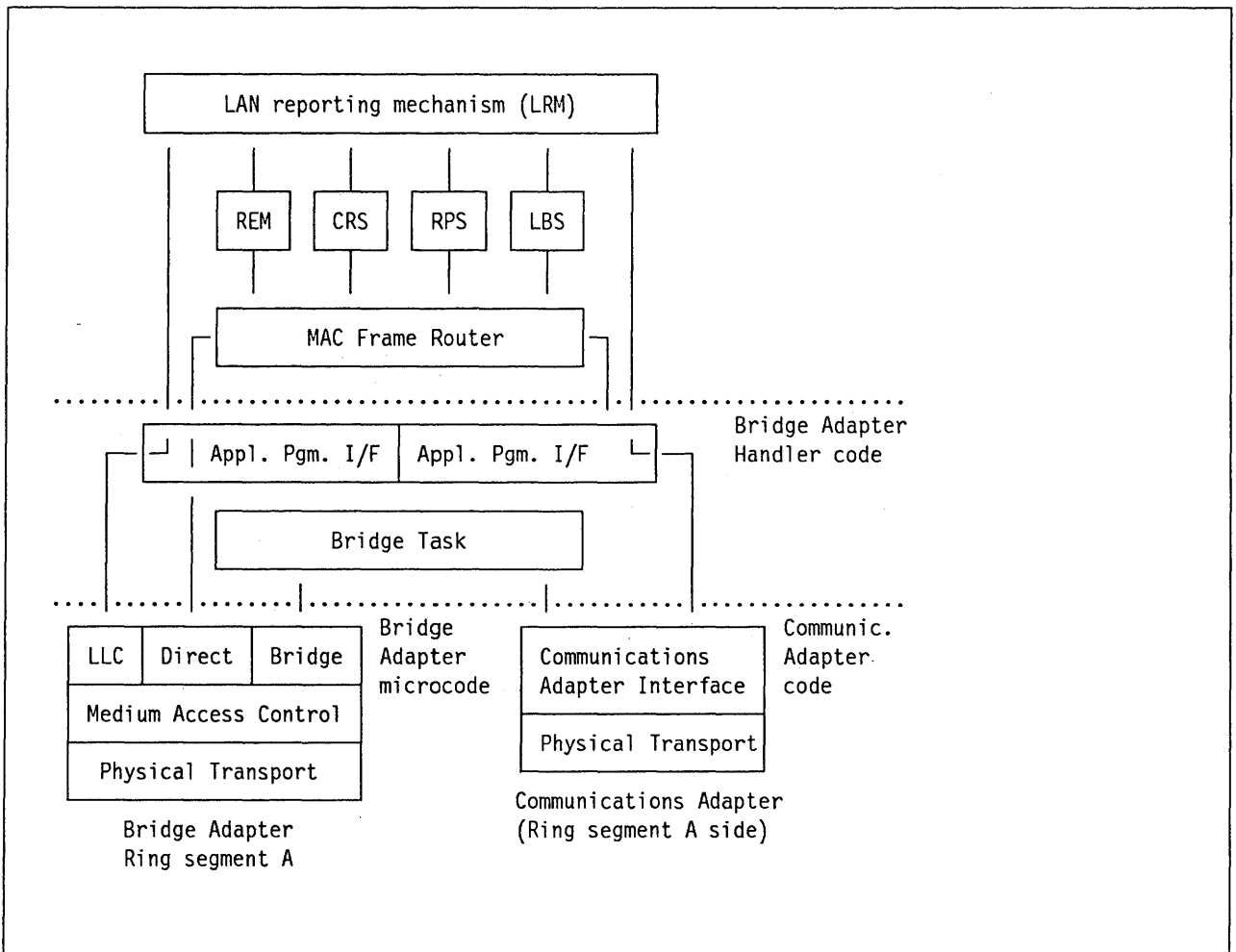


Figure 78. IBM Token-Ring Network Bridge Program V2.1 - General Bridge Structure

Configuration information is passed across the communications link directly during bridge initialization. Both bridge halves verify that the common information matches (for instance bridge number and ring segment number). In addition, when any of the operational bridge parameters is changed by the IBM LAN Manager V2.0, both bridge halves will be updated.

Bridge performance reporting has also been enhanced to reflect split bridge specific information. As mentioned earlier, a special *frame not forwarded, filtered* counter is maintained to report the result of frame filtering by a user exit. In addition, another counter is used to accumulate the number of frames which are not forwarded because a cyclic redundancy check (CRC) error is detected on the TP communications link.

Particularly when the TP link is operated at a relatively low transmission speed, token-ring adapter buffering capacity may sometimes be insufficient to store incoming frames from the ring segment before they can be transmitted to the other bridge half. Therefore, with a split bridge, the *frame not received*

(*adapter congested*) counter may reach its threshold much faster than it would for the same segments and same traffic in a standard bridge configuration.

Hardware Requirements: IBM Token-Ring Network Bridge Program V2.1 requires two dedicated IBM Personal System/2 Model 30, 50, 60, 70 or 80, or a PC/AT, or an Industrial Personal Computer 7531 or 7532, each with 512 Kbytes of memory and a 720 Kbyte or 1.2 Mbyte 3.5 inch diskette drive.

Each device attaches to a ring segment by means of an IBM Token-Ring Network adapter:

- IBM Token-Ring Network Adapter II
- IBM Token-Ring Network Adapter/A
- IBM Token-Ring Network 16/4 Adapter
- IBM Token-Ring Network 16/4 Adapter/A.

In addition, both bridge halves must be equipped with a matching communications adapter to connect to the TP line. A single port on one of the following communications adapters can be used on each split bridge device:

- IBM X.25 Interface Co-processor/2 (for a Family 2 device) with one of the following cable options:
 - Cable option V.24
 - Cable option V.35
 - Cable option X.21.
- IBM Realtime Interface Co-processor with 512 Kbytes (for a Family 1 device) with the supporting features for one of the following interfaces:
 - EIA RS-232C/CCITT V.24
EIA RS-232C/CCITT V.24 Interface Board with RS-232C Modem Attach Interface Cable or RS-232C Direct Attach Interface Cable.
 - CCITT V.35
CCITT V.35 Interface Board and CCITT V.35 Interface Cable.

Software Requirements: For each of the bridge halves IBM Token-Ring Network Bridge Program V2.1 requires:

- IBM PC/DOS 3.3 or 4.0
- IBM Token-Ring Network Bridge Program V2.1
- IBM Realtime Interface Co-processor DOS Support Version 1.0 or higher.

6.3.2 IBM PC Network Bridge

The IBM PC Network Bridge Program provides MAC level interconnection between the following LAN segments:

- Two IBM Token-Ring Network segments operating at 4 Mbps.
- Two IBM PC Network (Broadband) segments.
- An IBM Token-Ring Network segment operating at 4 Mbps or 16 Mbps and an IBM PC Network (Broadband) segment.

Each individual IBM PC Network (Broadband) segment can operate at any of the three supported frequency channel pairs. PC Network (Broadband)

segments may share the same broadband medium (at different frequencies) or have totally separate common media.

Although the IBM PC Network Bridge Program may interconnect two Token-Ring Network segments, its primary purpose is to integrate PC Network (Broadband) segments into a larger (token-ring based) LAN environment, extending the connectivity options for PC Network devices and allowing improved integration of LAN management.

For any type of LAN interconnection, the IBM PC Network Bridge Program uses the concepts of source routing. The bridge function is transparent to applications written to the IEEE 802.2 logical link control interface using source routing, whether the MAC protocol at either side of the bridge is identical or dissimilar. The expected bridge throughput, however, depends on the type of interconnected MAC segments.

The IBM PC Network Bridge Program includes all the network management support provided by IBM Token-Ring Network Bridge Program V2.0 and also supports forwarding of network management data from PC Network (Broadband) segments. Like IBM Token-Ring Network Bridge Program V2.0 and IBM Token-Ring Network Bridge Program V2.1, IBM PC Network Bridge Program interfaces with up to four LAN Managers executing IBM LAN Manager V2.0.

The following IBM Token-Ring Network management information is sent to IBM LAN Manager V2.0:

- Soft error reports and beaconing notification.
- Bridge status and performance data.
- Ring configuration reports.
- Path trace reports.

The following PC Network (Broadband) management information is sent to IBM LAN Manager V2.0:

- Continuous carrier and no carrier notifications.
- Bridge status and performance data.
- Ring configuration reports.
- Path trace reports.
- Topology reports (although the sequence between stations on a CSMA/CD LAN segment is irrelevant).

The IBM PC Network Bridge Program also supports dynamic single-route broadcast paths configuration and maintenance.

Figure 79 on page 176 shows the general structure of IBM PC Network Bridge Program when connecting a PC Network (Broadband) segment and an IBM Token-Ring Network segment. The IBM PC Network Bridge Program includes adapter handlers for both PC Network and the IBM Token-Ring Network, as well as logical link control and bridge protocol software to support PC Network (Broadband) adapters.

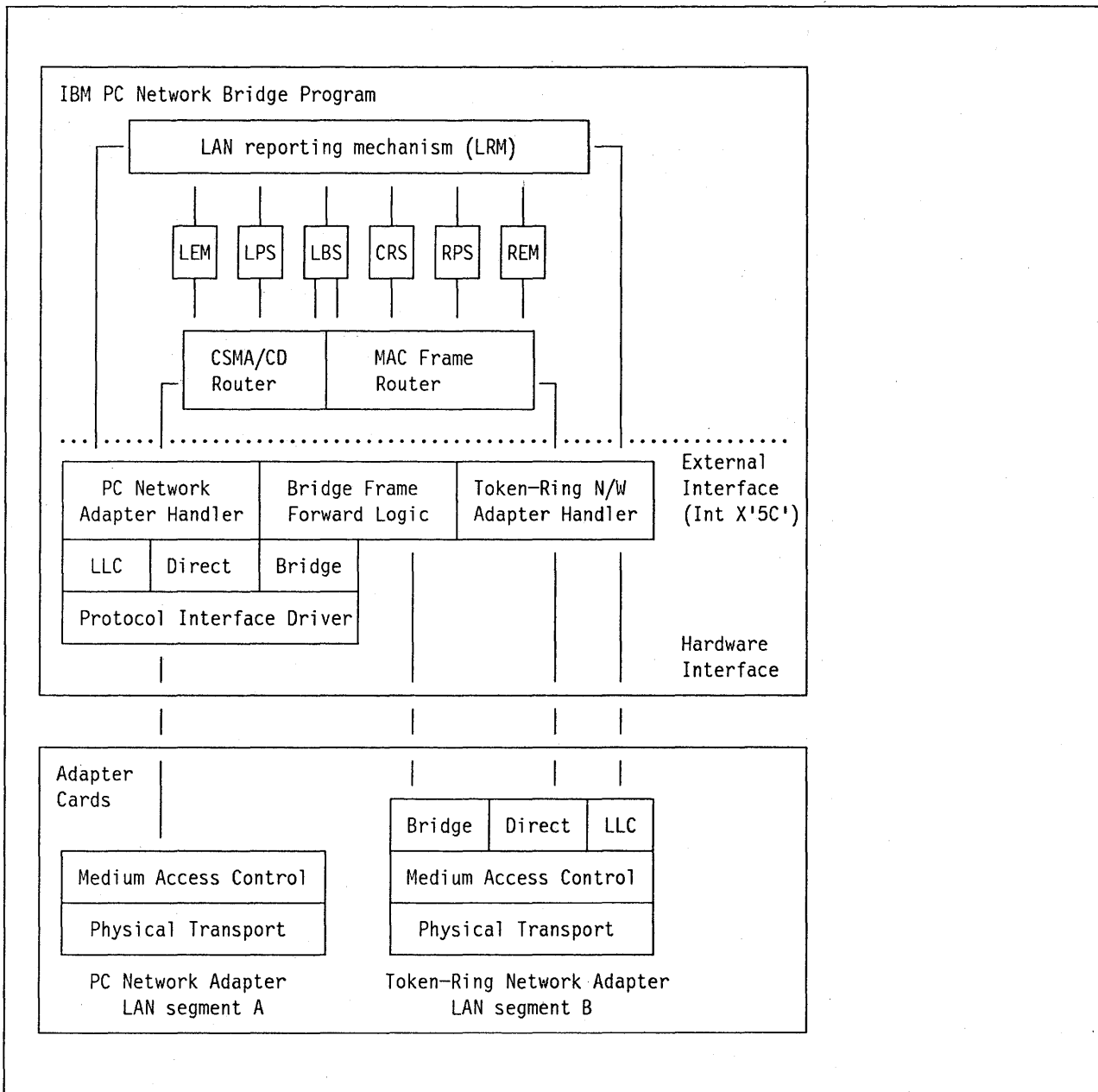


Figure 79. IBM PC Network Bridge Program - General Bridge Structure

The IBM PC Network Bridge Program end-user²⁶ server functions, as opposed to internal system server functions, are referenced explicitly in Figure 80 on page 177. Some servers support only a Token-Ring Network segment, some support only a PC Network (Broadband) segment, and others support both types of network segments.

²⁶ An end user in this context refers to a person at a LAN station, an adapter on the network or a LAN Manager.

IBM PC Network Bridge SERVER	Token-Ring N/W Segment	PC Network Segment
LAN reporting mechanism (LRM)	Yes	Yes
Ring Error Monitor (REM)	Yes	No
LAN Error Monitor (LEM)	No	Yes
Ring Parameter Server (RPS)	Yes	No
LAN Parameter Server (LPS)	No	Yes
Configuration Report Server (CRS)	Yes	n/a
LAN Bridge Server (LBS)	Yes	Yes

Figure 80. IBM PC Network Bridge Program End-User Servers

PC Network stations use LLC protocols for network control functions. Therefore they can communicate directly with a LAN Manager and PC Network (Broadband) segments do not need a CRS server function provided by the bridge.

Bridge processing by the LAN Bridge Server function includes also *single-route broadcast path maintenance*. If this spanning tree algorithm is desired, all bridges in the multi-segment LAN must be configured to participate in the dynamic maintenance protocols.

Hardware and Software Requirements: IBM PC Network Bridge Program requires a dedicated IBM Personal System/2 Model 50, 60, 70 or 80. It requires 384 Kbytes of memory and a 720 Kbyte or 1.2 Mbyte 3.5 inch diskette drive.

Local area network adapters supported are shown in Figure 81 on page 178.

A/E	P/N / FC
IBM Token-Ring Network Adapter /A	69X8138 / 4790
IBM Token-Ring Network 16/4 Adapter/A	16F1133 / 1133
IBM PC Network Adapter II/A	25F8278 /
IBM PC Network Adapter II/A - Frequency 2	25F8281 /
IBM PC Network Adapter II/A - Frequency 3	25F8284 /
(EMEA)	P/N / FC
IBM Token-Ring Network Adapter /A	69X8138 / 4790
IBM Token-Ring Network 16/4 Adapter/A	16F1133 / 1133
IBM PC Network Adapter II/A	25F8280 /
IBM PC Network Adapter II/A - Frequency 2	25F8283 /
IBM PC Network Adapter II/A - Frequency 3	25F8286 /

Figure 81. IBM PC Network Bridge Program - Bridge Supported Adapters

IBM PC Network Bridge Program's only software prerequisite is IBM PC/DOS 3.3 or 4.0. Devices attached to a broadband PC Network segment being bridged by the IBM PC Network Bridge Program require IBM Local Area Network Support Program Version 1.0 with PTF UR22583 or Version 1.1.

6.3.3 IBM Bridge Products Coexistence and Migration

The IBM Token-Ring Network Bridge Program Version 1.0 (P/N 6403831) and the IBM Token-Ring Network Bridge Program V1.1 (P/N 83X7860) can coexist in a multi-segment network with the IBM Token-Ring Network Bridge Program V2.0, the IBM Token-Ring Network Bridge Program V2.1 and the IBM PC Network Bridge Program.

However, to take advantage of the dynamic maintenance capability of the single-route broadcast path, all bridges in the multi-segment network must be running either the IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 or the IBM PC Network Bridge Program, since only those bridge products can be configured for automatic maintenance.

The IBM Token-Ring Network Bridge Program Version 1.0, now withdrawn from marketing, has no functional capability to communicate with a LAN Manager.

The IBM Token-Ring Network Bridge Program V1.1 may communicate with up to four IBM LAN Manager V1.0's. One IBM LAN Manager V1.0 can maintain up to 32 concurrent reporting links with IBM Token-Ring Network Bridge Program V1.1's.

The IBM Token-Ring Network Bridge Program V2.0, IBM Token-Ring Network Bridge Program V2.1 and IBM PC Network Bridge Program all communicate exclusively with IBM LAN Manager V2.0, providing extended network management capabilities as explained in "LAN Management and Recovery" on page 253. One IBM LAN Manager V2.0 can maintain up to 64 concurrent reporting links with any combination of these bridge products.

In summary, to have the full LAN segment interconnection capabilities currently offered by IBM bridge products while maintaining the network management capabilities available with the previous IBM Token-Ring Network Bridge Program V1.1 - IBM LAN Manager V1.0 communications, all bridges and LAN managers must be upgraded concurrently.

The IBM Token-Ring Network Bridge Program 1.0 must be replaced by the IBM Token-Ring Network Bridge Program V2.0. The IBM Token-Ring Network Bridge Program V1.1 may be upgraded at a charge to either the IBM Token-Ring Network Bridge Program V2.0 or IBM Token-Ring Network Bridge Program V2.1. IBM PC Network Bridge Program may provide additional mixed LAN segment interconnection.

The IBM LAN Manager V1.0 may also be upgraded at a charge to IBM LAN Manager V2.0 to make the network management capabilities of the upgraded bridges available.

7. Device Connectivity

Among the three IBM LAN offerings, the IBM Token-Ring Network definitely offers the largest range of System/370 host attachments. An IBM Token-Ring Network can be connected to a System/370 host using the following gateways:

- 3720, 3725, 3745 channel attachment
- 3174 gateway channel attachment
- 9370 channel attachment
- 8232 channel attachment
- PC gateway DFT mode attached to a 3174 or 3274
- PC gateway SDLC attached to a 3720, 3725 or 3745
- PC gateway attached to the 9370 workstation adapter
- PC gateway attached to the 9370 communications adapter

By using a 3270 gateway, LAN workstations can use the IBM PC 3270 Emulation Program or, in most cases, IBM 3270 Workstation Program V1.1 to log on to the host system as a 3270 terminal, execute host-based applications, transfer files, and use host office system. APPC communication can be established between an application on the LAN and a host APPC application. Office applications on the PC can communicate with the host office system. Application considerations will be discussed in "LAN Connectivity Applications" on page 227.

This chapter will focus on the LAN gateway alternatives, not only for the IBM Token-Ring Network, but also IBM PC Network Baseband and IBM PC Network (Broadband). Gateways to departmental systems and asynchronous hosts will be discussed in addition to S/370 host gateway solutions.

7.1 PC Gateways

7.1.1 3270 Emulation

Figure 82 on page 182 gives an overview of the different System/370 host connectivity options, using a PC gateway.

A workstation attached to any IBM LAN, IBM PC Network Baseband, IBM PC Network (Broadband) or IBM Token-Ring Network can be connected to a System/370 host via a workstation, IBM PC or PS/2, which is customized as a PC gateway. LAN workstations first establish a Netbios session with a PC gateway. The PC gateway establishes SNA sessions with the System/370 host for each network station defined to it. It then maps each of its Netbios sessions to the corresponding SNA LU sessions, thereby providing the workstation with a host session.

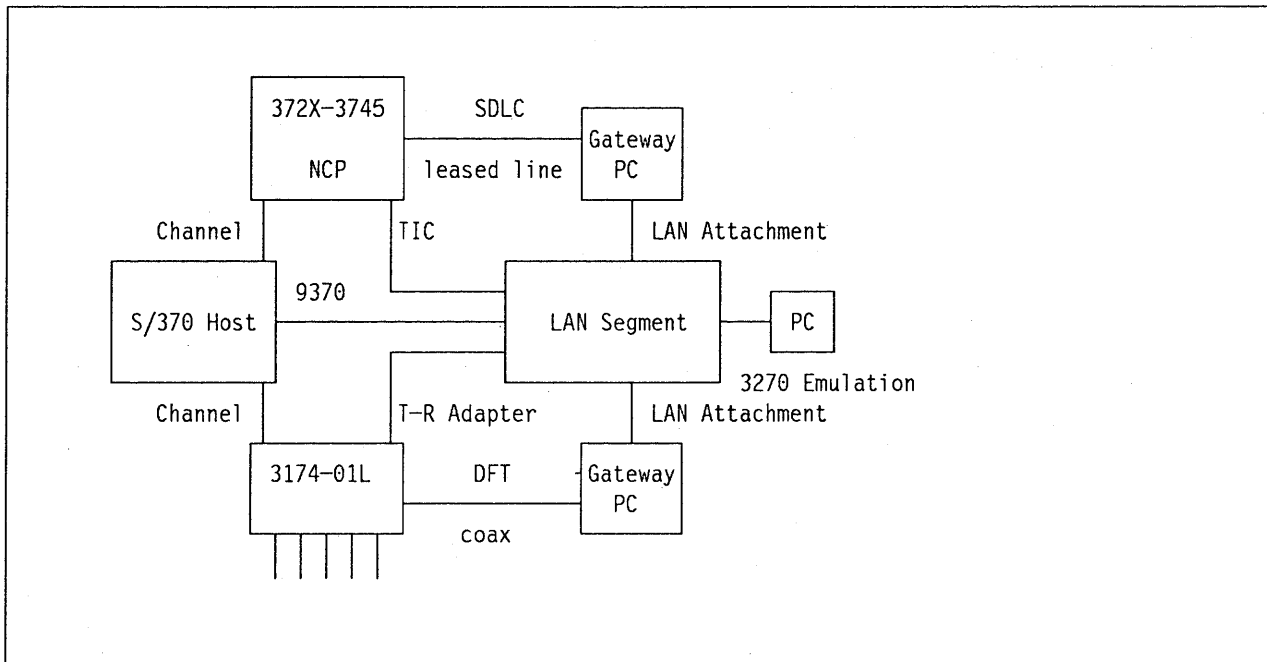


Figure 82. System/370 Connectivity and PC gateways

The only PC application currently able to provide PC gateway function is *IBM PC 3270 Emulation Program* (Version 3), running under IBM PC/DOS 3.3 or 4.0.

The IBM PC 3270 Emulation Program is executed in the PC gateway as well as in any workstation attaching to the System/370 host via the PC gateway. Using the customization feature, the PC gateway is customized as a *gateway station*, and the other stations as *network stations*. The IBM PC 3270 Emulation Program is used to make the LAN devices look like 3270 workstations (LUs) to the host system. Multiple PC gateways can coexist in a given LAN environment to provide the necessary number of host sessions.

A PC gateway may itself have simultaneous 3270 display and/or printer sessions. Depending upon the memory and processing capacity of the gateway, it may also execute an additional PC DOS application as a foreground task. In many cases however, execution of the additional tasks may have an undesirable impact on the performance of the gateway, and the response time of the individual network stations.

IBM has stated its intent to provide an OS/2 EE LAN gateway for both 3170 emulation and APPC (LU6.2).

The PC gateway can communicate with an SNA host using a leased line to an NCP. Up to thirty-two concurrent (display and printer) sessions can be supported. Alternatively, the PC gateway may be coax-attached to a 3174 in DFT (Distributed Function Terminal) mode. In this case, a maximum of five concurrent sessions can be supported.

When the LAN segment shown in Figure 82 is an IBM Token-Ring Network segment, the PC gateway can establish a logical link control session with either NTRI (NCP Token-Ring Interconnection) via a TIC (Token-Ring Interface Coupler), with a 3174 Token-Ring Network 3270 gateway via a 3174 Token-Ring Network Adapter or directly with a 9370 via a 9370 Token-Ring Subsystem. In

these cases, the only communications adapter required by the PC gateway is an appropriate LAN adapter. This connectivity option is only offered with IBM PC 3270 Emulation Program V3.

Note that, with IBM PC Network Bridge Program, the PC gateway may be attached to a PC Network (Broadband) segment, bridged via IBM PC Network Bridge Program to an IBM Token-Ring Network segment.

Section "Host Gateways" on page 191 describes alternate System/370 connectivity solutions using other LAN gateways than PCs or PS/2's. These connectivity options are available with IBM PC 3270 Emulation Program V3 and IBM 3270 Workstation Program V1.1.

7.1.1.1 3174 Control Unit DFT Attachment

A PC gateway can be attached to a 3174 Communication Control Unit by using the 3278/79 Emulation Adapter (if it is a Family 1 device), or by using the 3270 Connection Adapter (if it is a Family 2 device). Both adapters provide coax-attachment to the control unit.

Up to five concurrent sessions can be supported through the PC gateway using the Distributed Function Terminal (DFT) support in the 3174 controller and the IBM PC 3270 Emulation Program. The 3174 can be a remote or channel-attached controller. If more than five concurrent sessions are needed, two or more PC gateways must be attached to the controller.

Non-gateway workstations use the network station configuration of the IBM PC 3270 Emulation Program, while the gateway workstation uses the DFT gateway configuration option.

The IBM PC 3270 Emulation Program uses the Netbios interface to communicate across the local area network between the PC gateway and each of its network stations. As with any Netbios application, the session establishment is based on Netbios names. A network station, identified by a user-defined name, will establish its Netbios session with a PC gateway which contains this name in its gateway table.

7.1.1.2 3270 Emulation Gateway Attachment to a System/370 Host

The gateway workstation must contain an SDLC card or the IBM PS/2 Multi-Protocol Adapter/A to attach to a 3720, 3725 or 3745 Network Control Program via a communications link. The same workstation configuration can be used to connect to the integrated communications adapters of a 4331, 4361 or 9370 Processor.

Non-gateway workstations use the network station configuration of the IBM PC 3270 Emulation Program, while the gateway workstation uses the gateway or gateway/network station configuration. This enables the gateway workstation to look like a remote 3274 to the 3720, 3725 or 3745. It supports up to thirty-two concurrent sessions. When using a PC/AT and the SDLC card, or a Family 2 workstation and the IBM PS/2 Multi-Protocol Adapter/A, transmission speeds of up to 19.2 Kbps can be used. If more than thirty-two concurrent sessions are required, multiple gateway stations will be required. These gateways can be multi-dropped on the same communications line.

7.1.1.3 9370 Workstation Adapter (DFT) Attachment

The 9370 Workstation Adapter is similar to a 3174 control unit. This configuration is limited to five concurrent sessions using the same workstation software configurations as for the 3174 connection. The gateway workstation must use a 3278/3279 Emulation Adapter (Part Number 8665789).

7.1.1.4 AS/400, System/36, System/38 Remote 3270 Support

A workstation emulating a 3274 can be attached to a the AS/400, System/36 or System/38. The gateway workstation must have either an SDLC card or a IBM PS/2 Multi-Protocol Adapter/A card installed, and must use the IBM PC 3270 Emulation Program.

In this mode of operation, workstations on the network can be used as System/36 AS/400, System/36 or System/38 terminals. Because this method of connection involves two terminal emulations (the workstation emulating a 3274 and the AS/400, System/36 or System/38 performing 3270-to-5250 data-stream conversion), it has a higher overhead than alternative connection approaches not based upon a LAN gateway. This mode of operation does not provide virtual disk or printer support on the AS/400, System/36 or System/38, and file transfer is not supported.

7.1.2 System/36 Token-Ring Attachment

The System/36 family of products can be attached to the IBM Token-Ring Network. The 5360 and 5362 System/36s are attached using a dedicated IBM PC/AT. The PC/AT needs an IBM Token-Ring Network Adapter II card, plus the System/36 LAN Attachment Feature and Adapter which connects the PC/AT to the System/36 via a special cable. The System/36 PC (5364) does not require a second PC/AT to be attached to the IBM Token-Ring Network. The only hardware needed is an IBM Token-Ring Network Adapter II card.

The IBM System/36 LAN Communication Program is also required. This program is down-loaded to the System/36 LAN Attachment Feature PC from the System/36.

The System/36 LAN Attachment Feature PC or the System/36 PC can have one or two IBM Token-Ring Network Adapter II's installed. When two adapters are installed, each adapter connects to the same network, or to different IBM Token-Ring Networks. If the adapters are connected to two different IBM Token-Ring Networks, the System/36 LAN Attachment Feature PC does not allow LAN stations attached to one ring to communicate across the System/36 to a station on the other ring. All data addressed to the Token-Ring adapter in a System/36 LAN Attachment Feature PC must be passed to the System/36.

A System/36 attached to the LAN can provide the following functions for workstations attached to the LAN:

- Server function (virtual disks and printers can be defined on the System/36)
- File transfer
- Application machine
- Office system
- Communications gateway.

7.1.3 Non-SNA Communication Gateways

Figure 83 on page 186 illustrates five methods of non-SNA System/370 host connectivity:

1. 9370 Direct attachment.

This attachment supports both IBM Token-Ring Networks and IEEE 802.3 LANs using TCP/IP, TSAF and PVM.

2. 8232 Channel attachment.

The 8232 LAN Channel Station with an appropriate control program provides gateway support for IBM Token-Ring Networks, PC Network (Broadband), and IEEE 802.3 LANs using TCP/IP, PVM and MAP.

3. 3174 Asynchronous ASCII Attachment.

This connectivity option supports ASCII to 3270 protocol conversion, ASCII passthrough to ASCII hosts, and 3270 to ASCII protocol conversion for connectivity with ASCII hosts.

4. Remote-bridge connection.

IBM Token-Ring Network Bridge Program V2.1 is not really a gateway to the host, but can be used as an alternative to a remote gateway, providing transparent bridging for link level protocols to a local ring.

5. IP Router (TCP/IP).

An Internet Protocol Router, a function of TCP/IP protocols, is not really a gateway, but can be used to provide access from a LAN to a remote TCP/IP node.

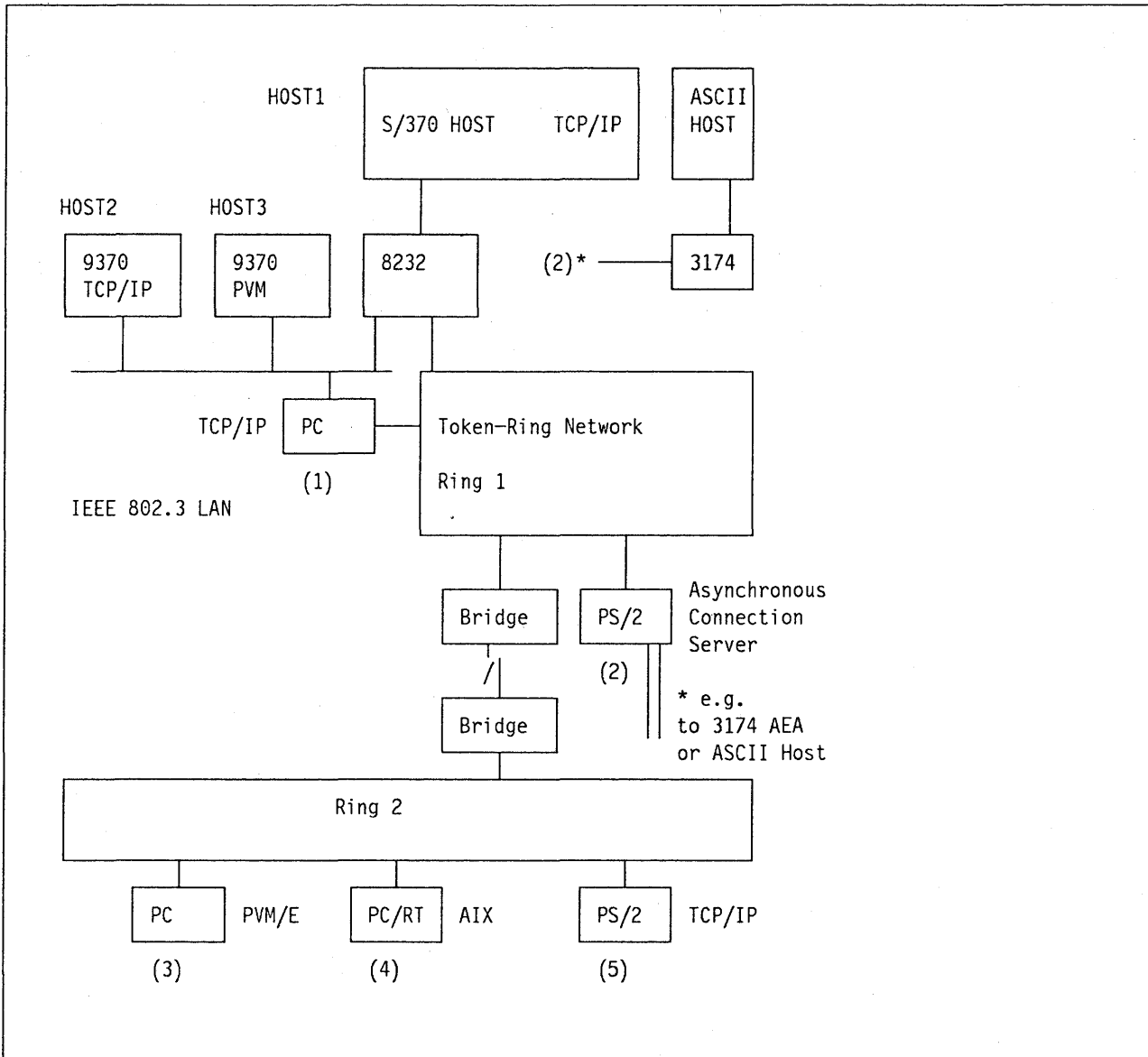


Figure 83. Non-SNA Host Gateways

From a PVM environment, a user at a LAN station may dial into an SNA backbone network to access SNA applications.

A user at a LAN station connected via an IP Router or non-SNA gateway to IBM TCP/IP for VM or IBM TCP/IP for MVS/SP and MVS/XA²⁷ products, can access SNA applications or use the SNA backbone network (LU 0 session) to access a TCP/IP host.

Link-level connectivity may or may not address application level connectivity requirements and functions. For example, keyboard functions for ASCII terminals, data set layouts and message formats or application-to application protocols may not be entirely implemented by a given link-level connectivity scenario.

²⁷ MVS/SP and MVS/XA are trademarks of the International Business Machines Corporation.

TCP/IP and PVM Connectivity via the 8232 LAN Channel Station are discussed separately in sections "8232 Connectivity in a TCP/IP Environment" on page 223 and "8232 Connectivity in a PVM Environment" on page 224 respectively.

7.1.3.1 SNA and Non-SNA 9370 - TSAF Connectivity.

A LAN-attached 9370, running VM/SP Release 5 or Release 6 with the *Transparent Services Access Facility (TSAF)*, is able to communicate with another, similar 9370 over the LAN. In this way, they form a 9370 to 9370 - VM Cluster, providing distributed SQL, Profs Remote Calendar support and other APPC/VM applications to 9370-attached workstations. TSAF can provide such capabilities in a non-SNA environment or can use VM/VTAM Version 3 Release 2 to provide such connection over SNA facilities. This is illustrated in Figure 84.

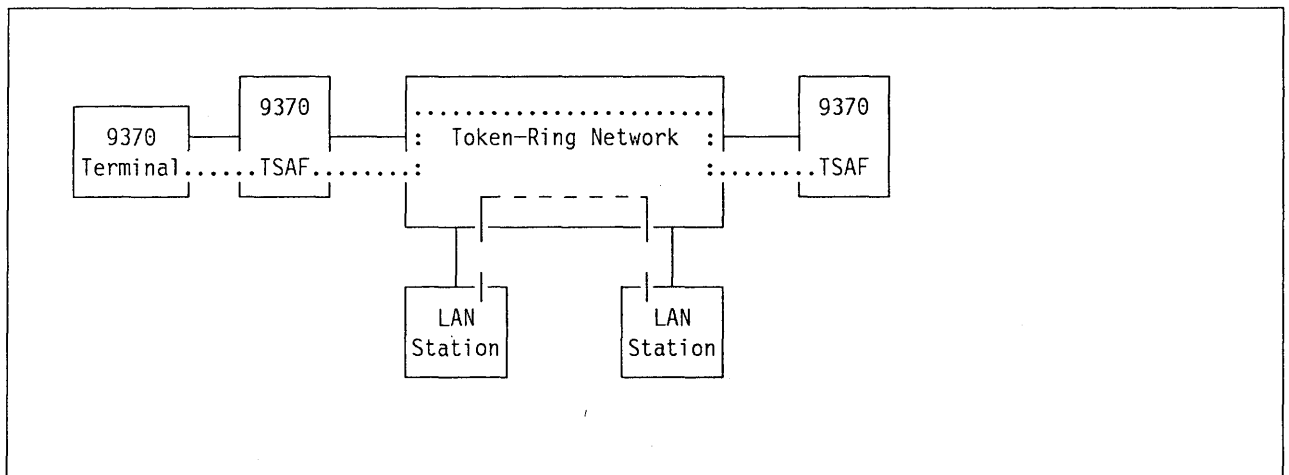


Figure 84. 9370 TSAF to TSAF Communication.

LAN attached workstations cannot communicate with either TSAF 9370 host.

7.1.3.2 Asynchronous Communication PC Gateways

Three approaches are available to provide gateway and asynchronous server capabilities for LAN-attached workstations to access external asynchronous facilities, or for external asynchronous devices to access LAN-attached devices: the IBM Asynchronous Communication Server Program, the IBM Asynchronous Connection Server Program, and the IBM Remote NETBIOS Program.

- **The IBM Asynchronous Communication Server Program**

The IBM Asynchronous Communication Server Program provides an asynchronous ASCII gateway for the IBM PC Network Baseband, the IBM PC Network (Broadband) and the IBM Token-Ring Network. The program uses the PC Asynchronous Communications Adapter card when it is running on a Family 1 device, and the IBM PS/2 Multi-Protocol Adapter/A when the gateway is a Family 2 device.

The Asynchronous Server Program can support up to two adapters on a single PC at transmission speeds up to 19.2 Kbps depending on the type of PC and the number of adapters being used. The PC Gateway does not have to be dedicated.

When a user on the LAN wishes to make a switched connection with an ASCII host or a public switched network, an asynchronous communication

program needs to be executing in the PC. The asynchronous communication program establishes a connection with the IBM Asynchronous Communication Server Program. The user's asynchronous communication program must conform to the Asynchronous Communications Server protocol and use the Netbios interface.

Remote asynchronous workstations can also dial-in to the gateway and connect to a PC application.

Software Requirements

- The asynchronous PC gateway needs the following software:

IBM Asynchronous Communication Server Program

IBM LAN Support Program V1.10

PC DOS 3.3 or higher.

- A LAN workstation that wants to use the asynchronous gateway requires the following software:

An asynchronous communications program (such as terminal emulators, CrossTalk²⁸ or PFS:Access²⁹).

Netbios or IBM LAN Support Program V1.10

PC DOS 3.2 or higher

- **The IBM Asynchronous Connection Server Program**

The IBM Asynchronous Connection Server Program extends the support provided by the IBM Asynchronous Communication Server Program. The Asynchronous Connection Server Program can support up to 32 concurrent sessions, depending on the model of PC being used. The connection server program however requires a dedicated PC with one or more IBM Realtime Interface Co-processor Multiport Adapter cards installed.

The IBM Realtime Interface Co-processor Multiport Adapter card can be installed in a PC/XT-286, PC/AT,³⁰ or a Personal System/2 model 30. The standard IBM Realtime Interface Co-processor Multiport Adapter card comes with four ports, it can be expanded to eight ports. The number of cards that can be installed in the PC depends on its model, as follows:

- 2 in the IBM Personal System/2 Model 30
- 3 in the IBM PC XT-286
- 4 in the IBM PC/AT
- 4 in the IBM Industrial PC/AT

The IBM Asynchronous Connection Server Program can support additional lines on up to two PC Asynchronous Communications Adapter cards, but at least one IBM Realtime Interface Co-processor Multiport Adapter is required.

²⁸ CrossTalk is a trademark and copyright of Software Publishing Corporation.

²⁹ PFS:Access is a trademark and copyright of Digital Communications Associates, Incorporated.

³⁰ PC/XT and PC/AT are registered trademarks of the International Business Machines Corporation.

Up to four IBM Realtime Interface Co-processor Multiport/2 Adapter cards can be installed in a Family 2 device.

LAN users who wish to use the gateway must have an asynchronous communication program executing in their PCs. When using the IBM Asynchronous Connection Server Program, the communication program can use one of two protocols. The Asynchronous Communications Server Protocol, or the Enhanced BIOS (Interrupt 14) Interface.

The Connection Server Program can support both dial in and dial out connections although ports must be defined as one or the other.

A wide variety of connections are possible using this gateway. See Figure 85 on page 190 for more information. Figure 85 shows five different types of connections using the gateway. The first three methods show different ways of connecting to an ASCII host. The host is directly connected to the PC gateway. Note that the LAN can act as a bridge between two gateways.

1. ASCII Host Connection

Connection (1) shows a LAN workstation in session with an ASCII host via the gateway. Connection (2) shows an ASCII terminal attached to the gateway, passing through the network and connecting to an ASCII host. Connection (3) shows a terminal that is accessing the gateway via a public switched network.

2. PC to PC

Connection (4) shows a PC accessing the gateway via a public switched network. It is accessing a PC application in a LAN workstation.

3. PC out

Connection (5) shows a PC passing out through the gateway to access an external information data base.

Software Requirements

- The PC gateway needs the following software:

- IBM Asynchronous Connection Server Program

- IBM LAN Support Program V1.10

- IBM PC/DOS 3.3 or 4.0.

- A LAN workstation that wants to use the asynchronous gateway needs the following software:

- An asynchronous communications program such as a terminal emulator

- IBM LAN Support Program V1.10

- IBM PC/DOS 3.3 or 4.0.

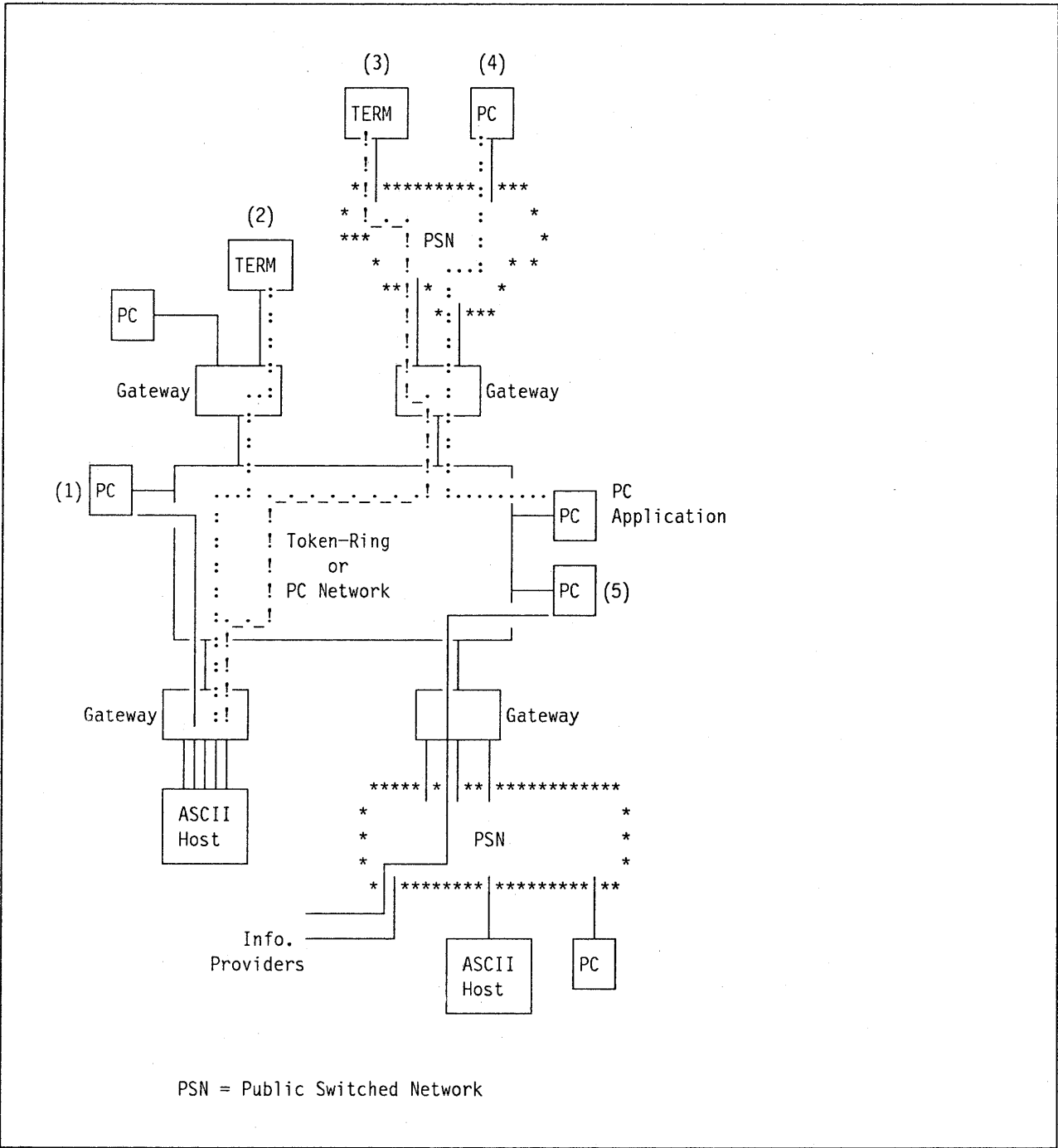


Figure 85. IBM Asynchronous Connection Server Program Connectivity

7.2 Host Gateways

Increasing requirements for host connection are addressed by LAN host gateways. Host connection requirements can be classified under two headers, according to the type of application:

1. Mainframe Interactive applications (MFI)

MFI describes traditional host interactive applications or transactions. A LAN station may use such System/370 host emulation products as IBM PC 3270 Emulation Program and IBM 3270 Workstation Program to access the host system. Additional application capability is provided by Application Programming Interfaces (APIs). Examples are HLLAPI (High-Level Language Application Programming Interface) within IBM PC 3270 Emulation Program and IBM 3270 Workstation Program, and SRPI (Server/Requester Programming Interface) within IBM PC 3270 Emulation Program and Operating System/2 Extended Edition V1.1.

or the strategic APPC (Advanced Program-to-Program Communication, LU 6.2) included in Operating System/2 Extended Edition V1.1 or separately available as APPC/PC. These aspects of MFI applications are covered in section "System/370 Host Main Frame Interactive" on page 227.

2. Distributed Processing applications

Distributed computing is gaining importance as the processing capabilities of personal systems and LAN-attached devices increase. APPC (Advanced Program-to-Program Communication, LU 6.2) included in Operating System/2 Extended Edition V1.1 or separately available as APPC/PC, is a strategic protocol to support distributed applications, including SAA conforming applications. In early and current LAN installations, the major distributed applications are Server applications such as file servers and print servers. An overview of current LAN Server applications is presented in section "LAN Servers" on page 235.

This section describes some LAN connectivity solutions which support the above-mentioned host connection requirements. In general, the host gateways discussed in this section offer better performance and higher capacity than the System/370 PC gateway solutions presented in the previous section and support a wider range of different higher layer communications protocols.

7.2.1.1 SNA System/370 Host Connectivity

Figure 86 on page 192 illustrates three methods of SNA System/370 host connectivity.

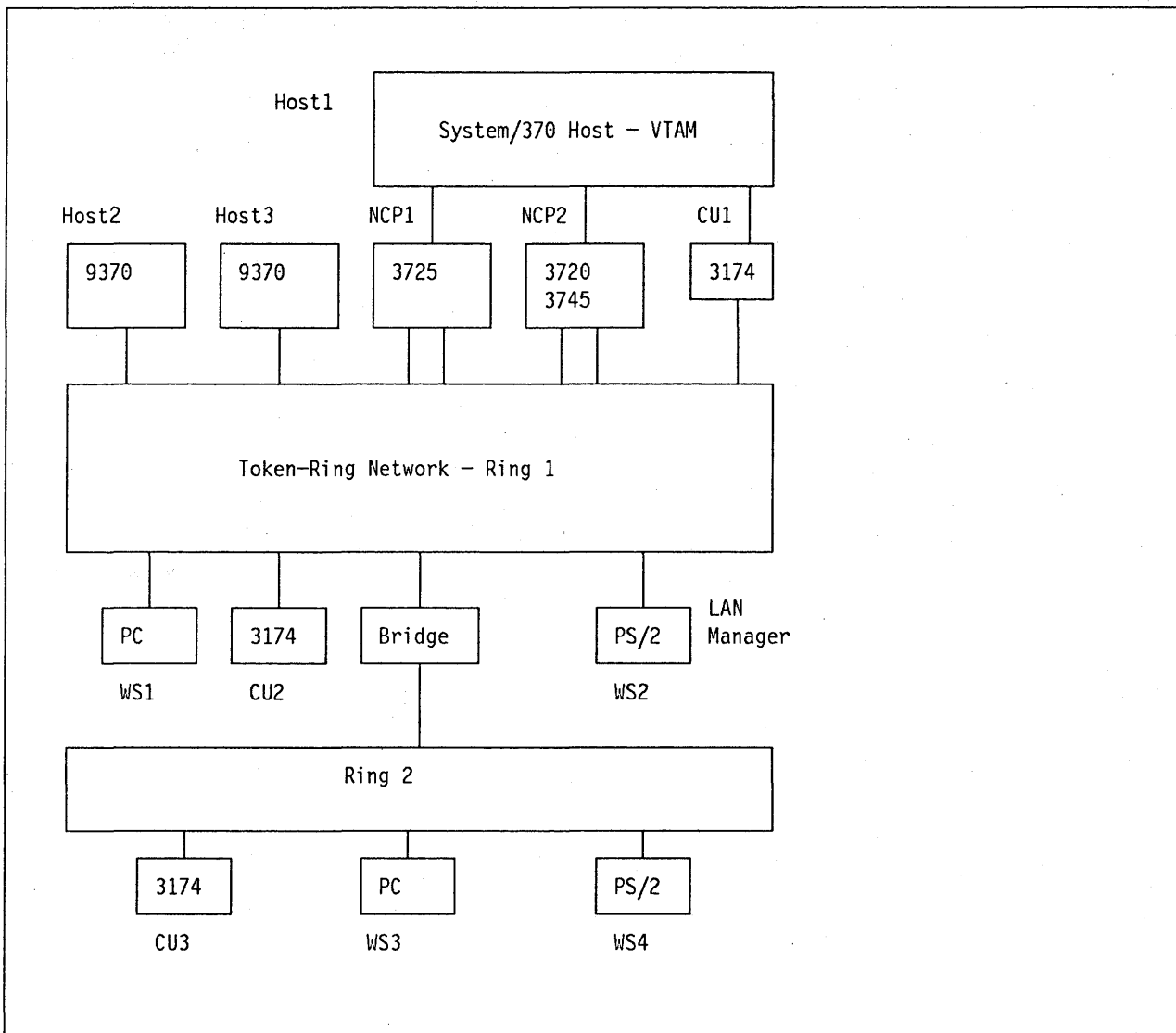


Figure 86. IBM Token-Ring Network - SNA Host Gateways

SNA System/370 host connectivity methods:

- 9370 Direct attachment - handles both boundary network node (BNN) traffic and intermediate network node (INN) traffic through a single adapter. Multiple IBM Token-Ring Adapters may be installed in one 9370, attached to the same or different networks.
- 3720, 3725, 3745 gateway attachment - handles both BNN and INN traffic, but BNN traffic cannot share the same TIC adapter with INN traffic, (that is, at least two Token-Ring Network Interface Couplers are required, except when using the TRA-2 on a 3745). One communications controller may contain multiple adapters, attached to the same or different networks.
- 3174 gateway attachment - supports only BNN traffic, and cannot be equipped with more than one adapter.

In addition, System/370 host PC gateway solutions are possible as described earlier in -- Heading 'CH710' unknown --.

SNA host gateways support INN connectivity as a single link transmission group (TG), whether the gateway function is provided by an NCP or 9370.

- Multiple logical lines may be mapped on a single physical adapter.
- INN logical lines appear as single link, leased line TGs (that is, priority queuing applies).
- Thus, a single adapter may handle traffic for multiple TGs to other NCPs or 9370s (PU Type 4 or 5 partners). Each TG can consist of only one logical line.
- 9370 and NCP host attachments can support INN partners on the same ring or on a ring connected via a bridge.

BNN connectivity support in SNA host gateways:

- All host attachments can support BNN devices on the same ring segment or on a ring segment connected via a bridge.
- All host attachments can support BNN devices on a PC Network (Broadband) segment. connected to an IBM Token-Ring Network segment via IBM PC Network Bridge Program
- All host attachments support both 3270 type traffic and APPC (LU 6.2).
- In a 9370, the adapter supporting INN logical lines can also define additional logical lines for BNN devices. These lines appear as switched point-to-point links.
- In an NCP, the TRA-1 adapter used to define INN logical lines cannot support additional logical lines for BNN devices. A TRA-2 adapter on a 3745 (to be available 12/89) can also define additional logical lines for BNN devices. These logical lines for BNN devices appear as switched point-to-point links.

SNA host gateways and IBM LAN Manager V2.0:

- A workstation using IBM LAN Manager V2.0 can provide LAN management functions concurrent with other applications, as it uses the multi-tasking facilities of Operating System/2 Extended Edition V1.1.
- A LAN Manager implementing IBM LAN Manager V2.0 can route alerts to System/370 "NetView" (trademark of the International Business Machines Corporation) via any of the host attachments. "NetView/PC" (trademark of the International Business Machines Corporation) is not required, but may optionally be used with IBM LAN Manager V1.0.
- A LAN Manager implementing IBM LAN Manager V2.0 can manage multiple IBM Token-Ring Network segments via bridges running IBM Token-Ring Network Bridge Program V2.0 or IBM Token-Ring Network Bridge Program V2.1, and can concurrently manage PC Network (Broadband) LAN segments via bridges running IBM PC Network Bridge Program
- A NetView Release 3 operator can issue commands to the IBM LAN Manager V2.0

More detailed information on LAN management is provided in Chapter "LAN Management and Recovery" on page 253.

7.2.2 3174-01L

The 3174 Model 01L has a Token-Ring gateway feature, described in section "IBM Token-Ring Network Devices" on page 97. The 3174 Model 01L is a channel-attached control unit which provides cost-effective SNA connectivity for small to medium-sized token-ring networks.

Workstations configured as Physical Units (PU) Type 2.0 controllers or other 3174 Model 03R or 53R control units attached to the ring and using the gateway are called Down Stream PUs (DSPUs). These devices appear to VTAM as channel-attached PUs when connected via a 3174-01L. The 3174 can have up to 140 DSPUs defined to it, but the number of concurrent sessions that can be supported by the 3174 depends on the types of devices using the gateway and the volume of traffic they generate.

Figure 87 on page 195 illustrates the physical and logical view of a 3174-01L gateway.

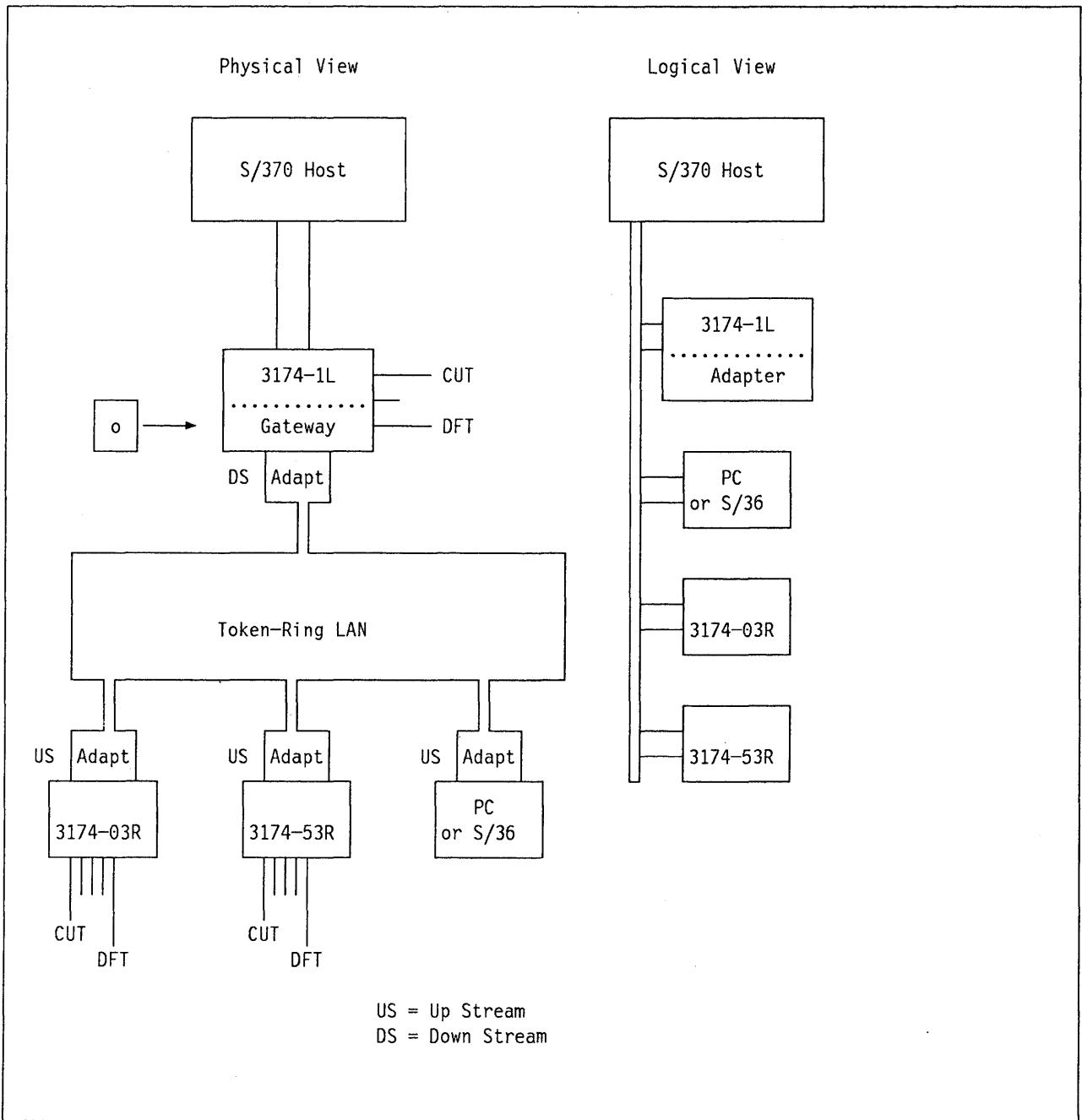


Figure 87. 3174 Gateway - Physical and Logical Views

3174-03R and 3174-53R DSPUs are discussed separately in section "3174-03R and -53R Token-Ring Connectivity" on page 207.

Because the 3174 gateway provides a PU gateway (that is, maps the downstream devices to PU Type 2.0 host definitions), the 3174 supports both 3270 (LU Type 2) sessions and APPC (LU6.2) sessions established between the downstream device and the host. Thus workstations using APPC/PC or the Operating System/2 Extended Edition V1.1 APPC interface may establish LU 6.2 sessions with a host application even though the 3174 does not support such sessions on behalf of its directly connected terminals.

7.2.3 3174-x1R, 3174-x2R

Similarly, remote 3174 Models 01R, 51R, 02R and 52R may provide a remote token-ring gateway capability for small remote LANs via a non-switched SDLC communications link.

In this case, the DSPUs appear to VTAM as multi-dropped PUs. These PUs must be polled as if they were directly attached to the communications link. While the 3174-1R has equivalent capacity to a 3174-01L, delays due to the speed of the communications link and polling overhead significantly reduce the actual throughput possible with a 3174-1R gateway in comparison with a 3174-1L or NCP gateway.

Therefore careful positioning with respect to this host gateway solution is required. In particular, a 3174 remote gateway should not be multi-dropped on a link with other devices, but should use point-to-point connection. A multi-dropped gateway would negatively impact the response time experienced at the DSPUs, as well as the response time of other devices on the link.

Figure 88 on page 197 illustrates the physical and logical view of a 3174-x1R or 3174-x2R gateway.

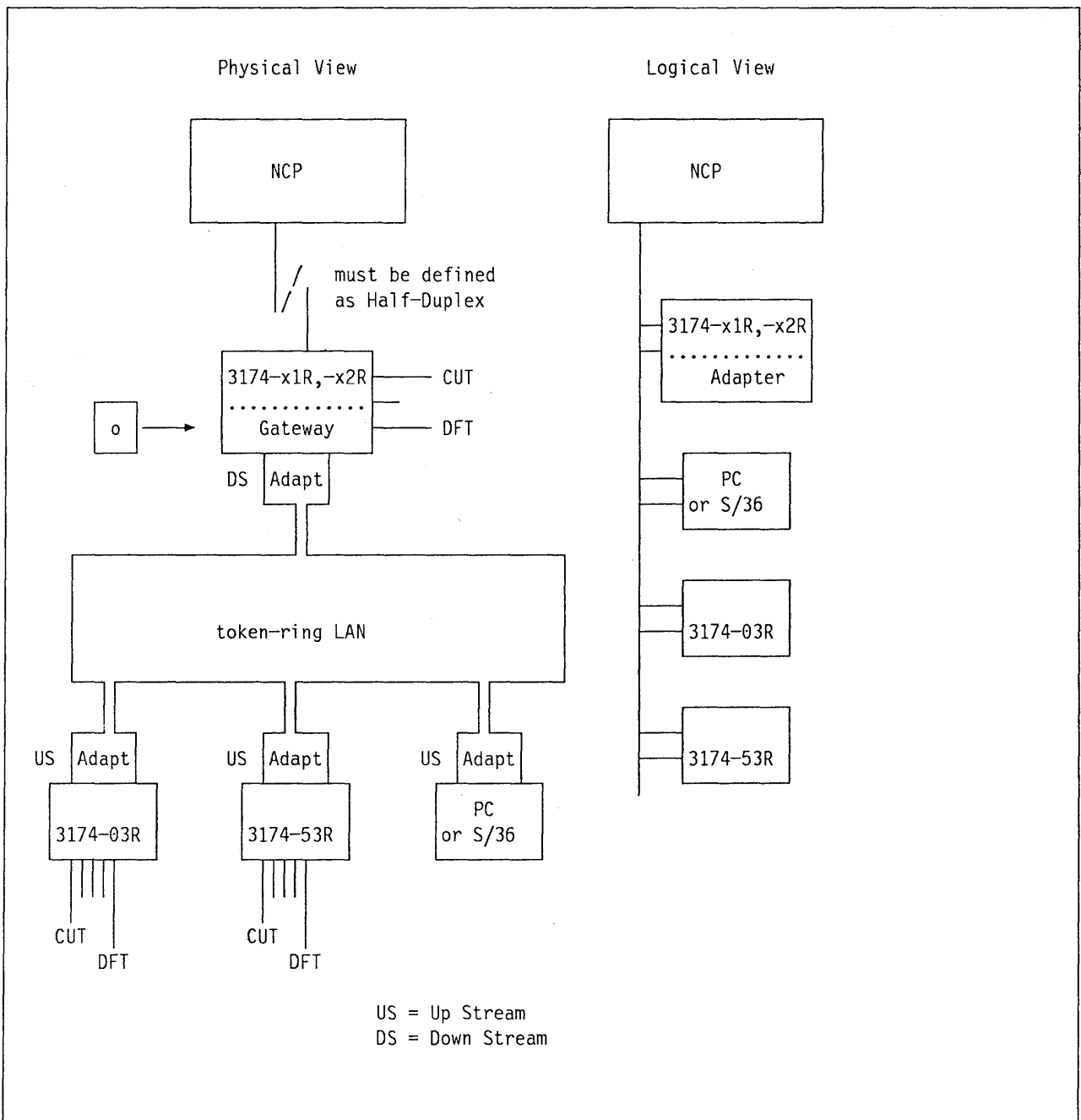


Figure 88. 372X Gateway - Physical and Logical Views

7.2.4 3720, 3725, 3745

The 3720, 3725 and 3745 Communications Controllers can be directly connected to the IBM Token-Ring Network using the Token-Ring Subsystem (TRSS). The Token-Ring Subsystem supports one or more Token-Ring Interface Couplers (TIC). Each TIC provides the hardware and the 802.5 MAC layer support needed for one physical connection of the controller to the IBM Token-Ring Network. The TRSS components are described in "IBM Token-Ring Network Devices" on page 97.

A 3720 can support up to two TICs, a fully configured 3725/3726 or 3745 support each up to eight TICs. These TICs may be attached to the same or to different networks. In any case, NCP requires a different locally administered address for each TIC installed in the same communications controller subsystem.

Support for the TRSS is provided by the NCP through the NCP Token-Ring Interconnection (NTRI). This function of the NCP became available with ACF/NCP Version 4 Release 2.

Figure 89 illustrates a communications controller with an NCP supporting a number of TICs through its NTRI function.

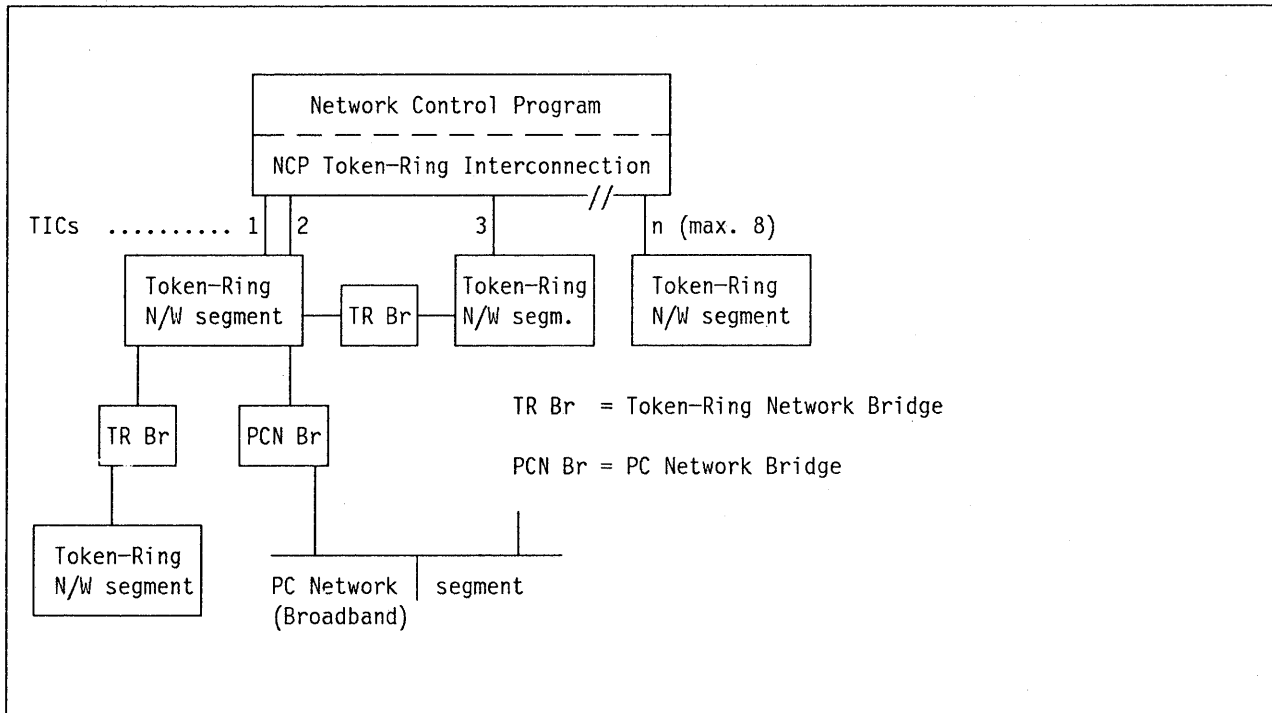


Figure 89. Sample NTRI Configuration

Current NCPs support up to 9999 PUs. However, the limit on the number of sessions that each NCP actually supports is a performance-related rather than an architectural restriction. Traffic and storage requirements for LAN-attached devices as well as other NCP-supported links determine the actual number of attachments that can be supported concurrently.

BNN support within NTRI is provided by NCP Version 4 Release 2 (3725) and NCP Version 5 Release 0 (3720, 3745) or later.

INN support is provided initially in NCP Version 4 Release 3.1 (3725) and NCP Version 5 Release 2.1 (3745).

ACF/SSP Version 3 Release 2 is required to generate ACF/NCP V4 R2 with NTRI BNN support. ACF/SSP Version 3 Release 4.1 is required to generate ACF/NCP V4 R3.1 or V5 R2.1 with NTRI INN support.

ACF/NCP NTRI V4 R2 (or later) is supported by ACF/VTAM V2 R1.0, V2 R2.0, V3 R1.1, V3 R1.2 and V3 R2.

In any case, separate TICs are required for BNN and INN traffic with currently available Token-Ring Adapters (TRA-1). The TRA-2 announced for the 3745 (to be available 12/89) will support both INN and BNN traffic over a single adapter in addition to providing 16/4 Mbps dual speed capability.

Network management support is provided for 372X gateways by NetView Release 2 or 3. This capability is restricted to information recognized by the NCP as a result of 37xx hardware-sensed conditions or NCP-detected session status. Consequently, the 372X gateway cannot provide management support for non-host connected stations such as LAN servers. NetView Release 3 support is recommended as will be explained in Chapter "LAN Management and Recovery" on page 253.

Figure 90 illustrates the NTRI view from VTAM.

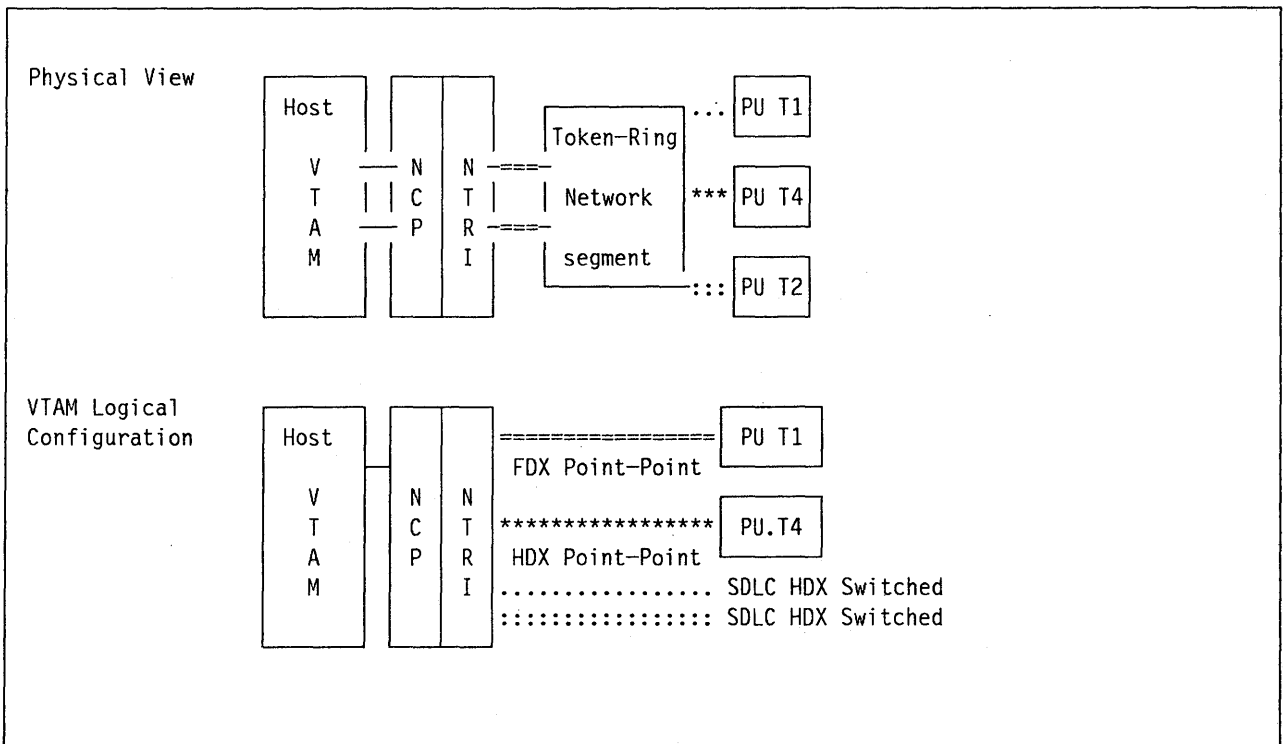


Figure 90. NCP Token-Ring Interconnection and VTAM

When a remote NCP and a local NCP are connected to the same IBM Token-Ring Network, it is important to notice that the remote NCP *cannot* be loaded by the local NCP over the Token-Ring (LAN).

7.2.5 9370

The 9370 can be directly attached to an IBM Token-Ring Network via a *9370 Token-Ring Network Subsystem Controller*, consisting of a 9370 Token-Ring Adapter (4 Mbps or selectable 16/4 Mbps), the appropriate 9370 Communications Processor and the 9370 Token-Ring Subsystem Support Program microcode. These components are described in section "IBM Token-Ring Network Devices" on page 97.

The 9370 Token-Ring Subsystem implements the IEEE 802.5 medium access control and the IEEE 802.2 logical link control LAN standards, and provides a

single attachment to an IBM Token-Ring Network segment. However, one 9370 can be equipped with up to fifteen Token-Ring Subsystems.

In an SNA environment, the 9370 Token-Ring Subsystem is supported by the following software:

- VM ACF/VTAM V3 R1.2 and V3 R2
- VSE ACF/VTAM V3 R2
- MVS and VM ACF/SSP V3 R2.

In addition, the 9370 Token-Ring Subsystem is supported by the NetView release 2 or Release 3.

The 9370 Token-Ring integrated support provides an INN interface for other 9370s (PU Type 5) and for NCPs (PU Type 4).

The 9370 Token-Ring integrated support includes also a BNN interface for downstream PUs (DSPU). Each 9370 Token-Ring Subsystem supports up to 64 PUs. A PU Type 2.0 can be a LAN workstation with or without a printer attached, a 3174-03R or 3174-53R, an AS/400, or a System/36.

On a Token-Ring attached 9370, INN traffic and BNN traffic may share the same 9370 Token-Ring Subsystem, that is adapter.

In summary, the 9370 in an SNA environment provides the following connectivity options:

- 9370 to 9370 (PU Type 5 to PU Type 5)
- 9370 to 37xx NCP (PU Type 5 to PU Type 4)
- 9370 to a 3270 type Station (PU Type 5 to PU Type 2.0).

Figure 91 on page 201 illustrates the VTAM logical view of the 9370 Token-Ring connectivity options.

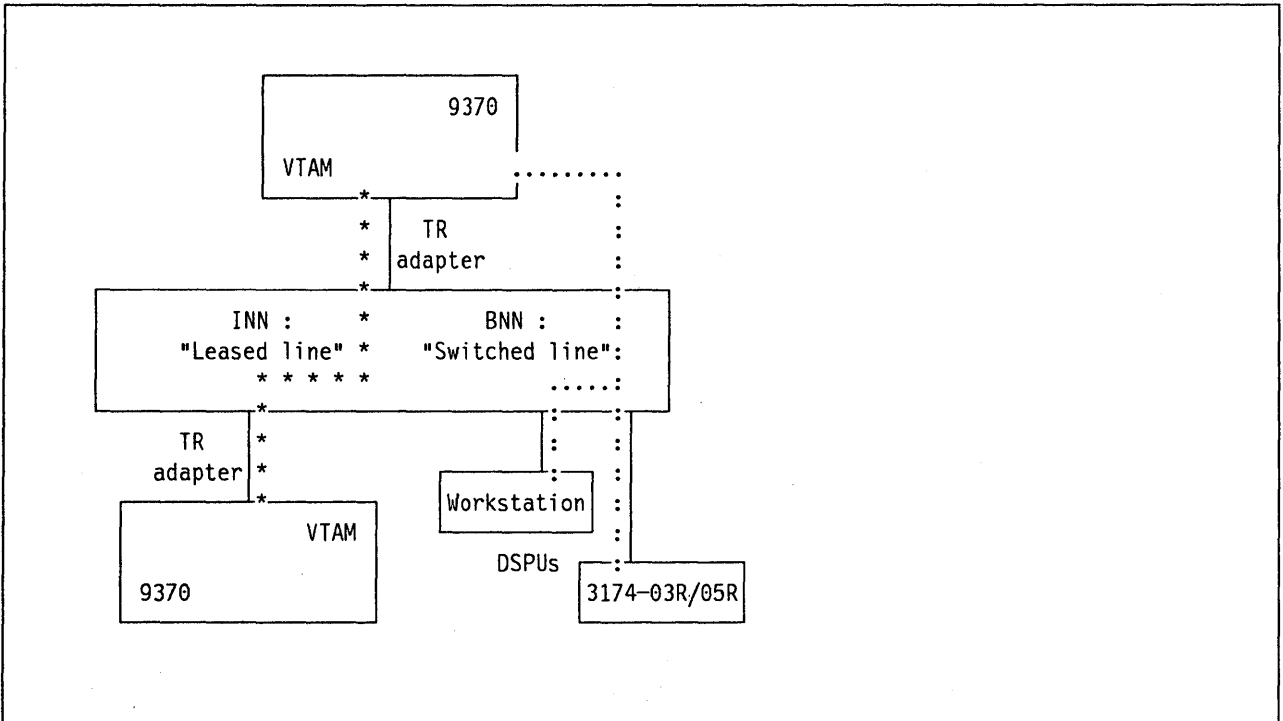


Figure 91. 9370 Token-Ring Subsystem and VTAM

The connection with other 9370's (INN) is viewed by VTAM as a leased line while the connection with a DSPU (BNN) is viewed as a switched line.

An intermediate network node (INN) is defined in a LAN major node. Boundary network nodes (BNN) definitions reside in a LAN major node and in switched major nodes.

7.2.6 Host Gateways - Conclusion

7.2.6.1 Selection Criteria

In order to make an optimal choice between the variety of LAN host gateways, a number of selection criteria are especially important in a LAN environment.

- Functional requirements, for example:
 - Are the required higher layer protocols supported (for example, LU2, LU1 or LU3, LU6.2, TCP/IP, PVM, MAP)?
 - What are the configuration and maintenance implications?
 - How many attachments are supported concurrently?
- Performance expectations, for example:
 - How many MFI transactions per minute are supported for a given average response time?
 - What is the file transfer throughput?
 - What is the relative delay introduced by the host gateway?
- Cost Effectiveness:
 - Consistent criteria should be maintained, for instance the cost per workstation.

- Cost factors related to maintenance, availability etc. must also be included.
- Availability:
 - The availability in a LAN environment is usually more critical than with traditional TP links.
 - Which are the possible backup scenarios?
 - For each backup scenario, does it imply manual intervention or can a backup gateway solution be activated in a fully automated way?

7.2.6.2 Functional Comparison

A functional comparison between the previously discussed SNA host gateways is summarized in Figure 92.

	9370	3720	3725 3745	3174
Local	Y	Y	Y	Y
Remote	Y	Y	Y	Y
BNN traffic	Y	Y	Y	Y
INN traffic	Y	Y	Y	N
No of T-R attachments	2-15 *	2	8	1
VTAM view (BNN)	SDLC Sw Link/PU	SDLC Sw Link/PU	SDLC Sw Link/PU	SDLC ** PU2.0
VTAM view (INN)	SDLC Link/PU	SDLC Link/PU	SDLC Link/PU	-
Max no PUs	64/ADAP	9999	9999	140
Dynam. Def.	Y	Y	Y	N
I0GEN	N	N	N	Y **

* The 9370 can attach multiple Rings depending upon slot availability

** VTAM views Downstream PUs as Local SNA PUs for 3174-01L, and as Multi-dropped SDLC PUs for 3174-x1R or 3174-x2R.

Figure 92. SNA Gateways - Functional Comparison

The 3720, 3725, 3745 and 3174-1L devices attach to a System/370 host on a channel. The 9370, 37XX, 3174-x1R and 3174-x2R can be attached over a remote link to connect a remote LAN.

The 37XX NCPs provide full networking capability with multi-link Transmission Groups (TG) and multiple TGs. The INN capability over an IBM Token-Ring Network however, supports only single link TGs.

The 9370 uses integrated communications adapters to provide single link and single TG capabilities.

All devices use standard Token-Ring cables to attach to a multistation access unit.

Note that a small remote LAN can also be connected via a PC gateway for 3270-type connections.

Alternatively, a small remote LAN can be connected to another LAN via a remote bridge through the IBM Token-Ring Network Bridge Program V2.1.

Because NCP NTRI downstream devices look like switched link attachments, only the maximum number of concurrently active devices must be generated into the NCP. The actual device definitions can be created "dynamically" by adding a switched major node to VTAM, and activating the device.

The 3174-01L performs mapping at the PU level so that attachments look like local VTAM devices. Thus device definition must be provided for the SCP (IOGEN), for VTAM (LOCAL definitions), and for the 3174 (customization). The 3174-x1R or 3174-x2R devices look like multi-dropped SNA PU T2.0 devices.

7.2.6.3 Gateway Positioning

Host Gateway Positioning

- 9370** The 9370 Token-Ring support is applicable to small Token-Ring LANs. Each 9370 Token-Ring Subsystem attaches up to 64 SNA PUs. The 9370 supports multiple Token-Ring Networks and provides local processing capability.
- 3720** The small communications controller provides good network support for small, remote Token-Ring LANs. NCP provides full INN support to the System/370 host. As a communications controller, the 3720 provides access to multiple network resources. It has limited traffic throughput capability in comparison with the larger 3725 or 3745 communication controllers.
- 3725 and 3745** These SNA host gateway solutions provide the best support for large Token-Ring LANs. They also allow automated backup scenarios for high availability.
- When using a NCP for both token-ring LAN and communication link support, relative performance should be evaluated.
- The first TIC added to a 3725 may require installation of a Line Attachment Base - Type C. The 3725 may or may not require the addition of a 3726 to support a Token-Ring Subsystem. These costs, if required should be included for cost comparisons with other gateways.
- 3174-1L** The local 3174 Control Unit provides the best support for small to medium-sized local Token-Ring LANs. Only one Token-Ring adapter is supported. A 3174 host gateway attaches up to 140 PUs and has minimal software requirements. From a throughput point

of view, the local 3174 host gateway features the one of the best local throughput capabilities.

3174-x1R, 3174-x2R capacity of the communication link, plus the overhead of polling of The throughput of this remote host gateway is limited by the capacity of the communication link, plus the overhead of polling of DSPUs. In particular, a point-to-point host link should be provided, rather than a multi-drop link. Whenever possible, the remote 3174 should be connected over a 56 Kbps or 64 Kbps link to the NCP.

Remote NCP Host Gateway versus Remote Bridge: The remote bridge, implemented by the IBM Token-Ring Network Bridge Program V2.1 and described in section "IBM Token-Ring Network Bridges" on page 165, may be considered as an alternative to a remote NCP host gateway, typically a remote 3720.

A functional comparison of these two remote LAN connectivity approaches is presented in Figure 93 on page 205.

Functional Capability	NTRI	Remote Bridge
1) Provide peer-to-peer traffic between LAN devices	Yes - via host & multiple NCPs	Yes - direct link between LANs
2) Multiple Links - for non-disruptive availability	Yes - TG	No - Multiple Bridges, but disruptive
3) Host Gateway	Yes	No
4) Speeds supported	2.4 Kbps - 56 Kbps	9.6 Kbps - 1.544 Mbps
5) Network Definition	NCP Gen plus VTAM definitions	Bridge Installation
6) X.25, Switched Links, or Multi-drop	Yes	No
7) Network Management	NetView - LPDA	LAN Manager + NetView no LPDA
8) Protocol Constraints	SNA (including SNI, TCP/IP, OSI)	LLC (using Source Routing) SNA, TCP/IP, Netbios

Figure 93. Remote NTRI versus Remote Bridge

Some design issues that must be considered when comparing a remote NCP LAN gateway versus a remote bridge are discussed below.

The total connectivity requirement for a given location may be limited to the LAN environment only, or include additional devices, multi-drop links, switched links or X.25 link access.

Another comparison factor is throughput between a System/370 Host and the remote LAN using either of these two connectivity methods. Such traffic characteristics as large frame sizes, or need for flow control may affect throughput, particularly at link speeds below 56 Kbps.

Hardware costs should include such attachment costs as adapters. The NCP NTRI option implies separate TICs for INN and BNN traffic. The remote bridge will require two Personal System/2 devices, each with a TP communications

adapter card as described in the hardware requirements of the IBM Token-Ring Network Bridge Program V2.1. The single leased link and data set costs will be equivalent.

Protocol support in each environment must be matched against actual and future connectivity requirements between the host and the remote LAN stations. Host traffic requirements should be compared with the need for peer-to-peer communications in the total multi-segment local area network.

Additional selection criteria are availability, recoverability and degree of network management provided by each environment.

7.3 3174-03R and -53R Token-Ring Connectivity

The 3174 Models 03R and 53R can be attached directly to an IBM Token-Ring Network as downstream PUs (DSPU). This means that 3270 terminals can now communicate with a System/370 host across the LAN, using one of the gateways described in section "Host Gateways" on page 191.

The 3174-53R is a sixteen-port controller and the 3174-03R is a thirty-two port controller.

7.4 AS/400 LAN Connectivity

An summary of AS/400 LAN connectivity is illustrated by Figure 94 on page 208. It shows three types of connectivity capabilities, each one based on OS/400 Advanced Peer-to-Peer Networking (APPN) support. OS/400 is the operating system of an AS/400 System.

- Path (1) refers to high speed peer-to-peer links between two AS/400 Systems or an AS/400 System and a LAN-attached System/36 (the System/36 LAN gateway is not shown).
- Path (2) presents high speed links between an AS/400 System and a System/370 host gateway.
- Path (3) illustrates the connection between a LAN workstation (PC or PS/2) running the IBM AS/400 PC Support program and the AS/400 System.

The 4 Mbps Token-Ring Network shown may also be a multi-segment local area network, involving PC Network (Broadband) segments or 16 Mbps Token-Ring Network segments. However, some devices, including the AS/400 Systems, shown can only be attached to a 4 Mbps Token-Ring Network segment.

In the future, an AS/400 System may also be equipped with a 16/4 Mbps selectable token-ring network attachment, in accordance with a statement of direction dated November 15, 1988.

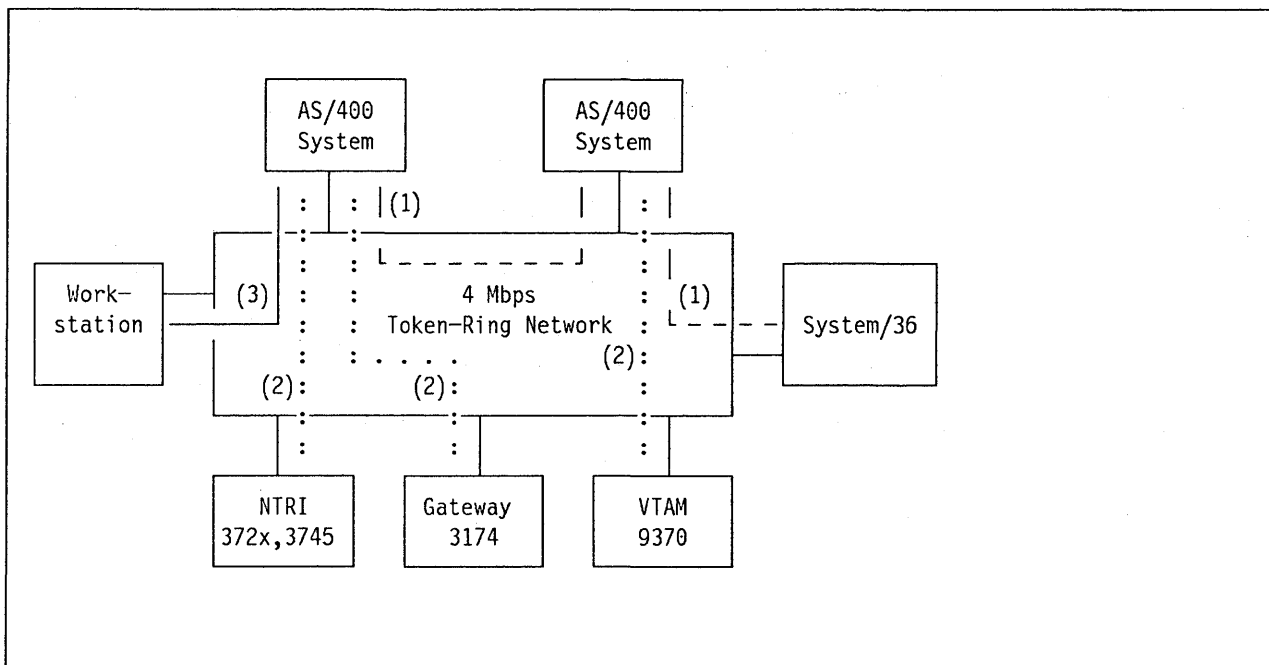


Figure 94. AS/400 Connectivity

High speed peer-to-peer links between two AS/400 Systems or an AS/400 System and a LAN-attached System/36 provide the following functions/services:

- Advanced Peer-to-Peer Networking (APPN)

AS/400 APPN provides a powerful and convenient way to establish and maintain a network of multiple AS/400, System/36 or System/38 systems, PCs and other SNA Node Type 2.1 systems. APPN allows the AS/400 user to install and keep up to date a complex network of interconnected systems without requiring highly skilled systems programmers to generate and maintain the network. Configuration and maintenance of the network is accomplished by the controlling nodes that make up the network. Systems that use DDM, DSPT, SNADS, and APPC can take advantage of APPN networks.

- Advanced Program-to-Program Communications (APPC)

AS/400 APPC allows a program on one system to communicate with a program on a different system so that users can run applications and have access to functions that are not available on the local system to which they are attached. AS/400 APPC/APPN support is based on SNA LU6.2 and PU Type 2.1 and is designed to provide a common session protocol for both document interchange and distributed data processing.

- Display Station Pass-Thru (DSPT)

DSPT allows a user attached to an AS/400 or Sytem/3x to be connected to a remote AS/400 or System/3x, to sign on to that system and execute applications or perform network management functions as if locally connected.

- Distributed Data Management (DDM)

DDM allows application programs on an AS/400 to access files on a remote AS/400, System/3x or CICS/VS system and process those files as if they were on the same AS/400 where the application is running.

- SNA Distribution Services (SNADS)

AS/400 SNADS provides for the exchange of documents, messages, files, and objects with other AS/400, System/3x, Workstations, System/370s and other systems supporting SNADS. SNADS provides the communications support for sending documents etc., to destinations located on the same or other systems in a network.

- File Transfer Support

AS/400 user is able to access the file transfer subroutine that will allow his application programs to exchange data files and/or library members with another AS/400 System or System/36.

High-speed links over a Token-Ring Network between an AS/400 System and a System/370 host gateway provide the following communications support:

- SNA Upline Facility (SNUF)

The SNA Upline Facility provides distributed data processing support to AS/400 users who want to communicate through SNA with a remote System/370 host running either CICS or IMS/VS.

- Distributed Systems Node Executive (DSNX)

AS/400 DSNX provides for the receipt of programs, screen formats, procedures, and data files sent from NetView/DM running in a System/370. AS/400 DSNX also supports redistribution of programs, or data received from a System/370 to another AS/400, System/3x, or workstation.

- Distributed Host Command Facility (DHCF)

DHCF allows an AS/400 to appear as a host system for terminals attached to a System/370. A System/370 user may sign on to an AS/400 and perform network management functions as well as run AS/400 applications as if operating at an AS/400 workstation.

- OS/400 SNA 3270 Device Emulation (3270 DE)

OS/400 SNA device emulation enables an AS/400 user to communicate with application programs on a System/370 host without major changes to the host application program. In this way the AS/400 System can be connected into an existing SNA 3270 network. The AS/400 will appear as a 3274 or 3174 Control Unit with attached display stations and printers.

IBM AS/400 PC Support will be functionally discussed in "AS/400 PC LAN Support" on page 244. Figure 95 on page 210 presents an overview of all communications capabilities between an AS/400 System and a PC or PS/2 running the IBM AS/400 PC Support.

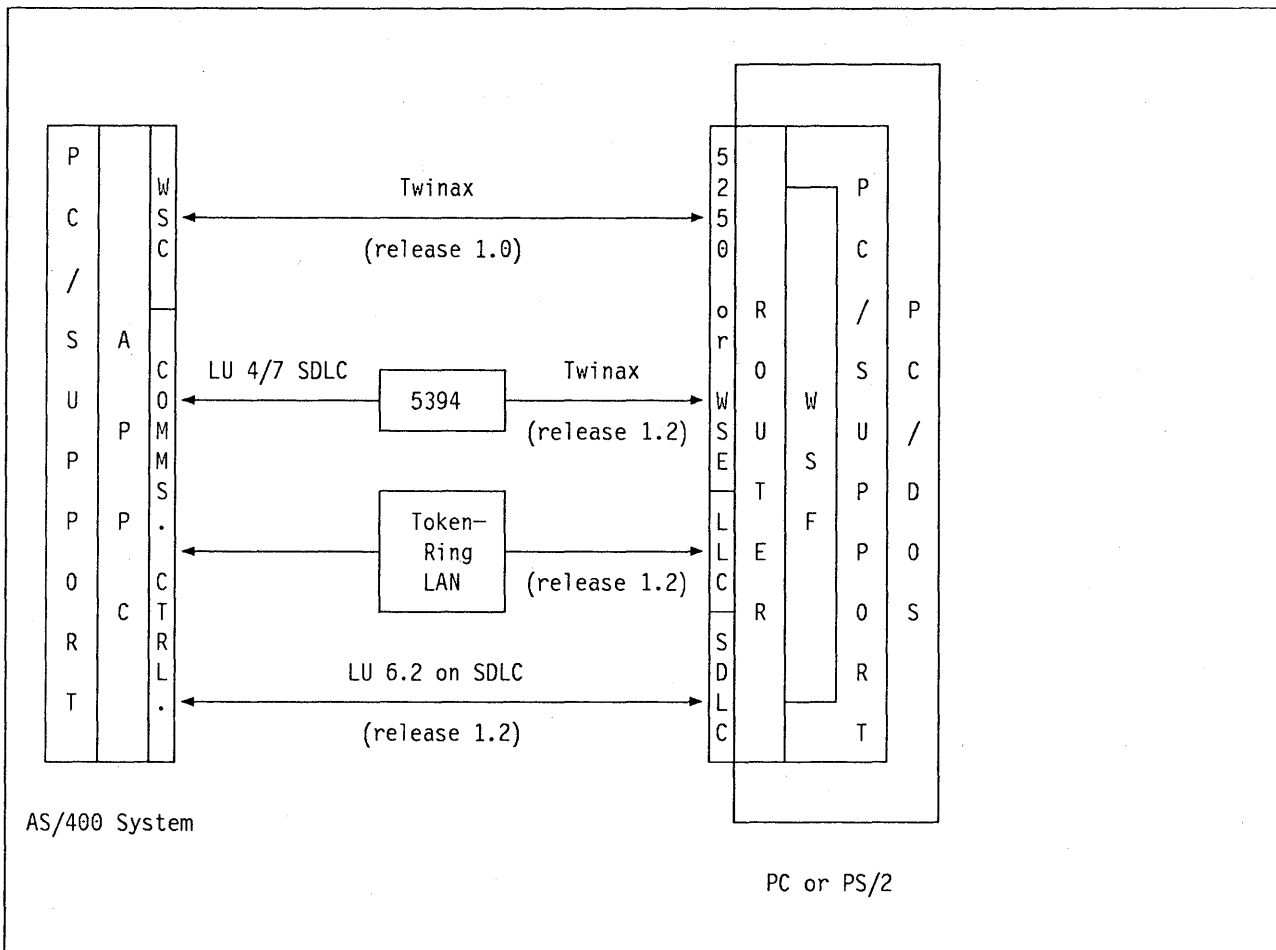


Figure 95. AS/400 PC Support Connectivity

7.5 Series/1 LAN Connectivity

The Series/1 Token-Ring attachment and the hardware and software requirements are presented in "IBM Token-Ring Network" on page 85.

The software interface between the IBM Token-Ring Network attachment hardware components and the EDX V6.1 operating system is provided by the *IBM Series/1 EDX Token-Ring Interface Program (5719-EAC)* program offering.

7.5.1.1 EDX Token-Ring Interface Program

The EDX Token-Ring Interface Program offers two interfaces to:

1. Advanced Program to Program Communication (APPC) interface.
2. Primary System Network Architecture (SNA) interface.

Figure 96 on page 212 illustrates the different connectivity options offered by these interfaces. The reference numbers in the diagram are explained below.

(1) A Series/1 running the EDX Token-Ring Interface Program allows a Series/1 APPC application to communicate over the LAN with:

- Another Series/1 APPC application executing under EDX V6.1.

- A 9370 APPC application running under ACF/VTAM V3.2.
- An AS/400 APPC application executing under OS/400.
- A PC or PS/2 workstation APPC application operating under IBM PC/DOS 3.3 or 4.0 or Operating System/2 Extended Edition V1.1.

(2) The Series/1 Primary SNA interface supports:

- A terminal, connected to a LAN-attached 3174-x3R DSPU to communicate over the LAN with a System/370 host application, using the Series/1 as a passthrough device.
- A LAN attached PC or PS/2 workstation, running IBM 3270 Workstation Program V1.1 under IBM PC/DOS 3.3 or 4.0 or running Operating System/2 Extended Edition V1.1 3270 Terminal Emulation, to communicate over the LAN with a System/370 host application, using the Series/1 as a passthrough device.

(3) A Series/1 running the EDX Token-Ring Interface Program allows a Series/1 primary SNA interface application to communicate over the LAN with:

- Another Series/1 primary SNA interface application.
- A PC or PS/2 workstation running IBM 3270 Workstation Program V1.1 under IBM PC/DOS 3.3 or 4.0 or running Operating System/2 Extended Edition V1.1 3270 Terminal Emulation.

The Series/1 EDX Token-Ring Interface Program provides application programming interfaces which may be used to develop APPC or primary SNA application programs that execute on the Series/1 processor under control of EDX V6.1.

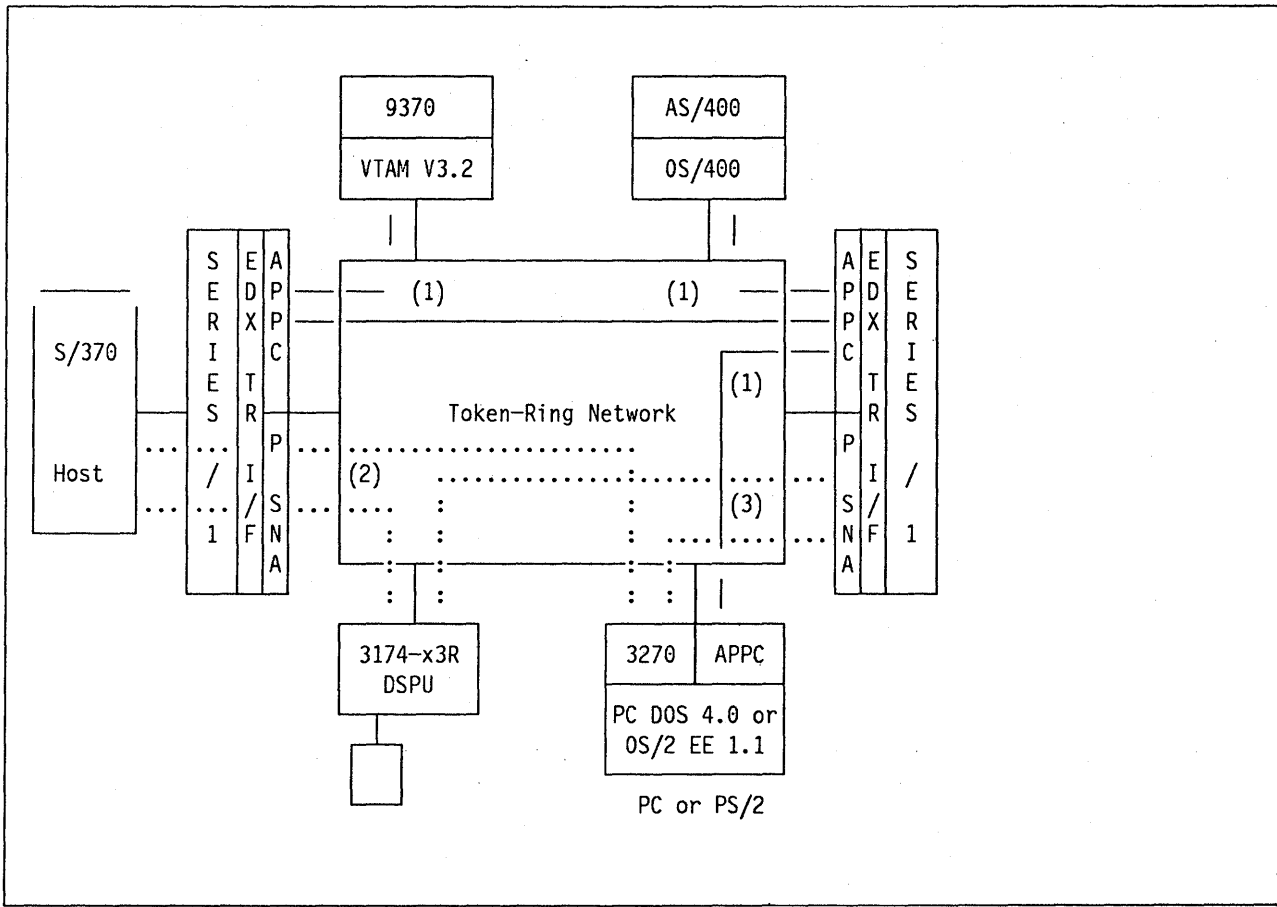


Figure 96. Series/1 EDX Token-Ring Connectivity

7.6 PC-to-PC Communications

Workstations, PCs or PS/2's attached to the LAN can communicate with one another in different ways according to the supporting LAN application programs. A given workstation can be running IBM PC/DOS 3.3 or 4.0 or Operating System/2 Extended Edition V1.1. LAN support for PCs or PS/2's is supplied under both operating environments.

7.6.1 PC LAN Program

If the IBM PC LAN Program is used, intelligent workstations on the LAN can be defined as printer or file servers. Both the server and the workstation need the PC LAN Program. PC LAN Program V1.2 provides basic server/requester function with very limited system administration capabilities. PC LAN Program 1.3 provides Base Services offering equivalent function to that provided by PC LAN Program 1.2, and Extended Services providing additional server/requester environment management. PC LAN 1.3 Extended Services is part of the migration path from PC LAN Program, operating under IBM PC/DOS 3.3 or 4.0, to Operating System/2 Extended Edition V1.1.

7.6.2 APPC

An APPC application running in one PC can communicate with an APPC application in another PC on the LAN via LU 6.2 program-to-program communication protocols.

In a PC/DOS environment, this interface is offered by the APPC/PC program running on top of the IEEE 802.2 LLC Interface provided by the IBM LAN Support Program V1.10.

In an Operating System/2 Extended Edition V1.1 environment, APPC support and the APPC programming interface are an integral part of the Operating System/2 Extended Edition V1.1 Communications Manager.

7.6.3 LAN Office Capabilities

Basic office functions can be provided in a LAN environment between PCs and/or PS/2's executing Personal Services/PC software.

Personal Services/PC offers peer-to-peer communication between LAN workstations, connection from a LAN-attached workstation to a DISOSS/370 office system via a host gateway, and connection from a LAN workstation to a Series/1 used as an office systems server.

7.6.4 OS/2 Extended Edition and OS/2 LAN Server

A flexible server/requester structure, such as that offered by the PC LAN Program in an IBM PC/DOS 3.3 or 4.0 environment, is also provided in an Operating System/2 Extended Edition V1.1 environment. Like the PC LAN Program, multiple, non-dedicated servers may be defined on the LAN. The requester station has a single system image, (that is, the user is not aware of the fact he is accessing remote resources instead of files residing in his own workstation or a locally attached printer).

The product packaging of Operating System/2 Extended Edition V1.1 is significantly different. User stations, now called requesters, require only Operating System/2 Extended Edition V1.1 as the LAN Requester function is an

integral part of the operating system. A Server station requires Operating System/2 Extended Edition V1.1 and an additional software product, called the OS/2 LAN Server program.

The OS/2 LAN Server product environment provides a migration path for IBM PC/DOS 3.3 or 4.0 environment to Operating System/2 Extended Edition V1.1. These products and some migration considerations will be discussed in section "OS/2 EE LAN Server 1.0" on page 240.

7.7 IBM LAN Connectivity

This section summarizes the connectivity options for the three IBM LAN offerings.

7.7.1 IBM PC Network Baseband Connectivity

Figure 97 on page 215 shows the connectivity options for the IBM PC Network Baseband.

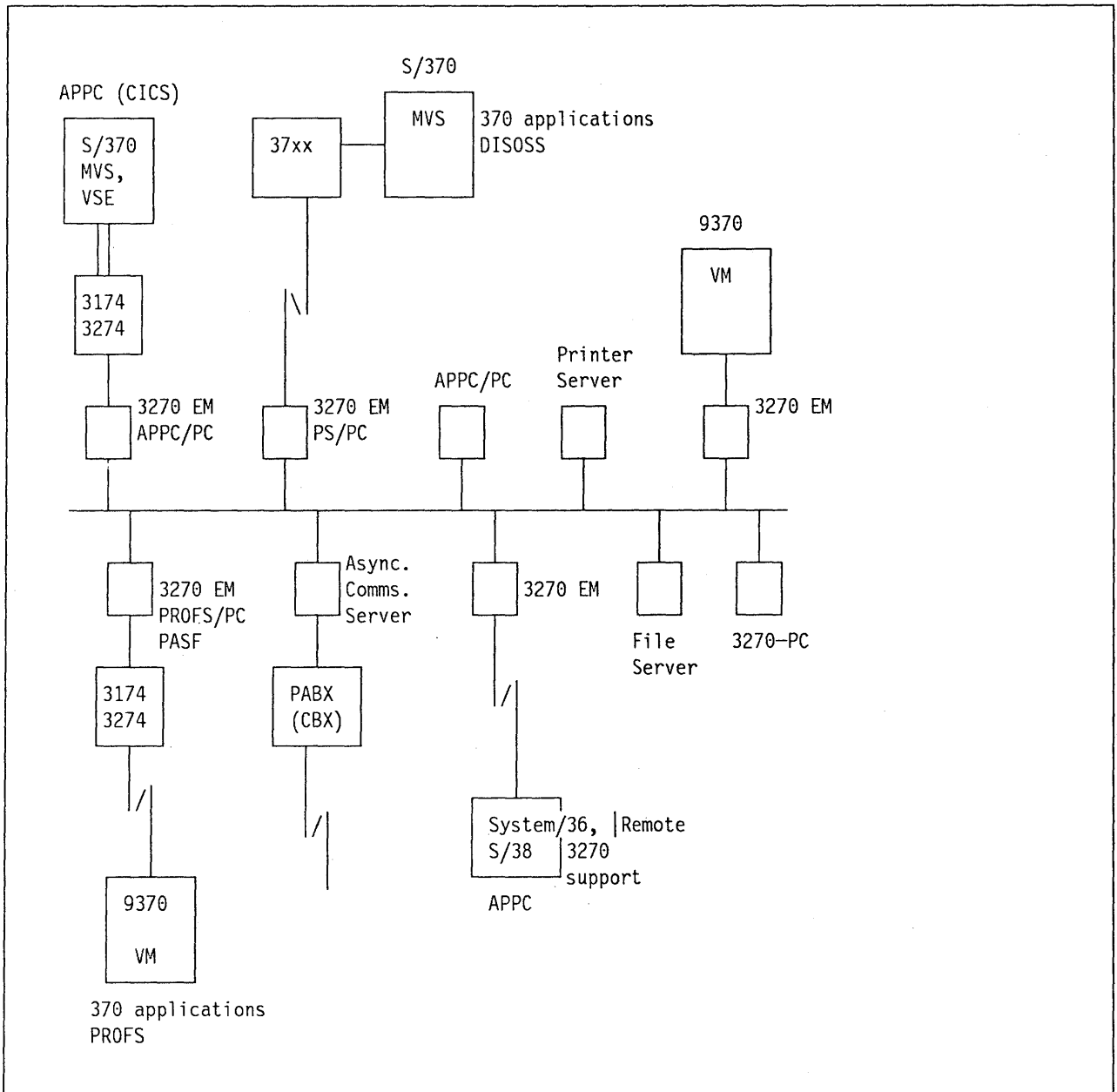


Figure 97. IBM PC Network Baseband Connectivity

7.7.1.1 System/370 Host Attachment

The IBM PC Network Baseband can be connected to a System/370 host system by the following gateway product configurations:

- PC gateway coax-attached to a 3174, or 3274 Terminal Controller.
- PC gateway SDLC attached to a 3720, 3725 or 3745 Communications Controller.
- PC gateway coax-attached to the 9370 Workstation Adapter.
- PC gateway link-attached to the 9370 Teleprocessing Subsystem.

By using a 3270 gateway, PC workstations on the network can use the IBM PC 3270 Emulation Program V3 to logon to the host system as a 3270 terminal, execute host-based applications, transfer files, and use the host office system:

APPC communication can be established between an application on the LAN and a CICS APPC application (see "Base Programming Interfaces" on page 128).

Office applications on the PC can communicate with the host office system (see "Office Support" on page 247).

7.7.1.2 System/36, System/38 Attachment

A PC running the IBM PC 3270 Emulation Program V2 or IBM PC 3270 Emulation Program V3 can be used as a gateway for a remote System/36 or System/38 (see "3270 Emulation" on page 181).

7.7.1.3 Asynchronous Communications Server

Figure 97 shows an asynchronous communications server attached to a PABX. LAN workstations could pass through the PABX to an external information data base, an ASCII host, or a public switched network. (See "Non-SNA Communication Gateways" on page 185.)

7.7.1.4 PC-to-PC Communication

See section "PC-to-PC Communications" on page 213.

7.7.2 IBM PC Network (Broadband) Connectivity

Figure 98 on page 217 shows the device connectivity for the IBM PC Network (Broadband).

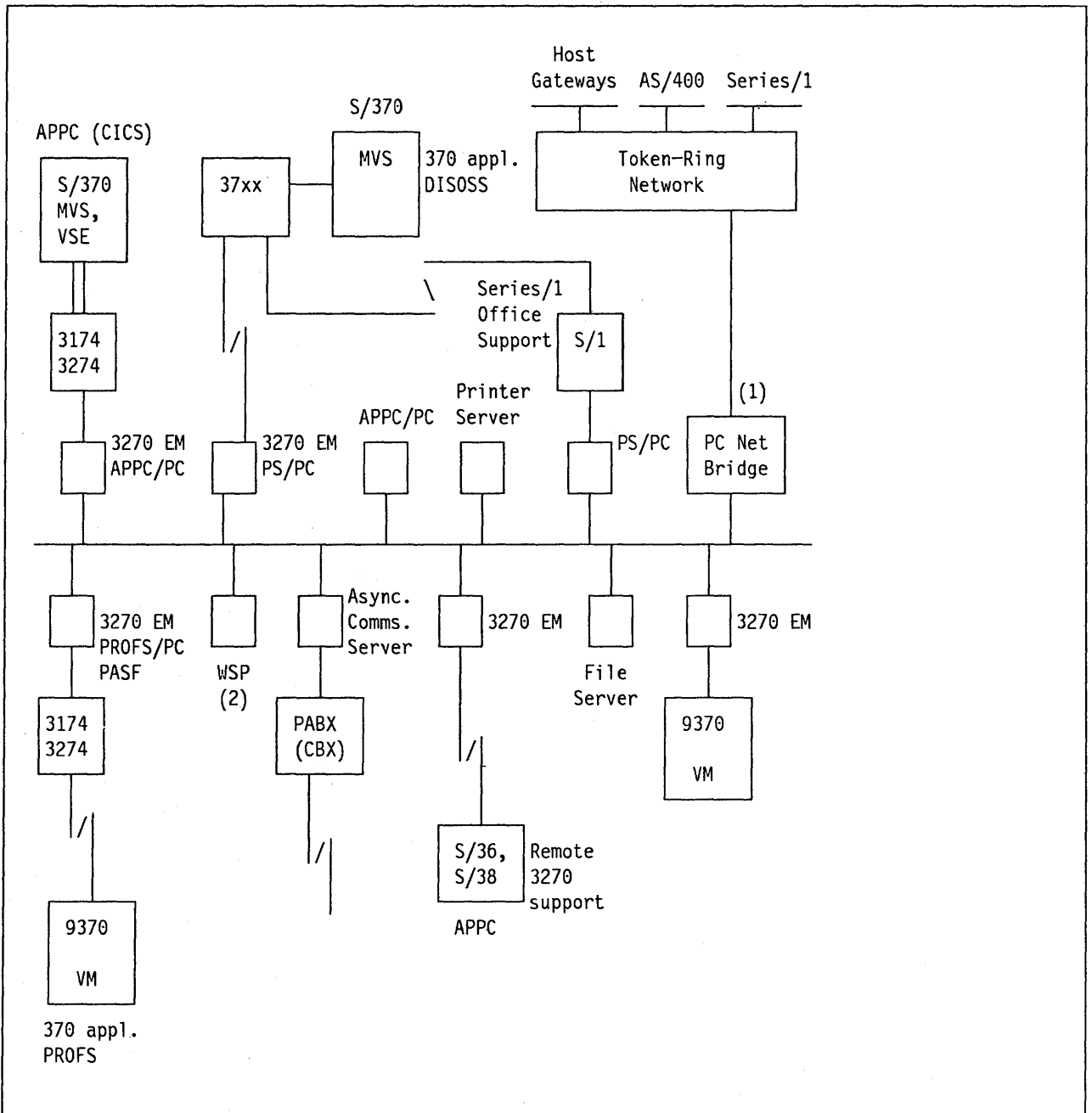


Figure 98. IBM PC Network (Broadband) Connectivity

7.7.2.1 System/370 Host Attachment

The IBM PC Network (Broadband) can be connected to a System/370 host by the following gateway configurations:

- PC gateway attached to a 3174 or 3274 Terminal Controller.
- PC gateway SDLC attached to a 3720, 3725 or 3745 Communications Controller.
- PC gateway attached to the 9370 Workstation Adapter.
- PC gateway attached to the 9370 Teleprocessing Subsystem.

By using a PC 3270 gateway, PC workstations on the network can use the IBM PC 3270 Emulation Program V3 to log on to the host system as a 3270 terminal, execute host-based applications, transfer files, and use the host office system.

APPC communication can be established between an application on the LAN and a CICS APPC application (see "Base Programming Interfaces" on page 128).

Office applications on the PC can communicate with the host office system (see "Office Support" on page 247).

When a PC Network Bridge (1) running IBM PC Network Bridge Program is interconnecting the PC Network (Broadband) segment with an IBM Token-Ring Network, a workstation attached to the PC Network (Broadband) may access a System/370 host through a host gateway device (37xx, 3174, 9370) directly attached to a Token-Ring Network segment (see "Host Gateways" on page 191).

A workstation running IBM 3270 Workstation Program V1.1 (2) may establish its 3270 Emulation Host sessions via the LAN through a Token-Ring Network-attached host gateway (see "3270 Workstation Program" on page 229).

7.7.2.2 AS/400 Connectivity

A workstation running AS/400 PC Support may access a Token-R-attached AS/400 System over the LAN via a IBM PC Network Bridge Program bridge (see "AS/400 LAN Connectivity" on page 207).

7.7.2.3 Series/1 Connectivity

The Series/1 can be used as a communications server to many devices or systems.

A PC/Network-attached workstation may access a Token-Ring-attached Series/1 (running EDX 6.1) via a IBM PC Network Bridge Program bridge. (See "Series/1 LAN Connectivity" on page 210.)

The Series/1 may be attached to a PC Network (Broadband) via a PC gateway. The PC is channel-attached to the Series/1. It needs the IBM Series/1 to PC Channel-Attachment feature and the Series/1-PC Connect Program. The Series/1 requires the S/1 PC Connect Program (5719-CN1).

7.7.2.4 System/36, System/38 Attachment

A PC running the IBM PC 3270 Emulation Program V2 or IBM PC 3270 Emulation Program V3 can be used as a gateway to an SDLC-attached System/36 or System/38 (see "PC Gateways" on page 181).

7.7.2.5 Asynchronous Communications Server

Figure 98 shows asynchronous communication via a workstation attached to a PABX (see "Non-SNA Communication Gateways" on page 185).

7.7.2.6 PC-to-PC Communication

When the PC Network Bridge is installed, LAN-attached workstations running PC LAN Program (1.2 or 1.3), Operating System/2 Extended Edition V1.1 with or without OS/2 LAN Server, Personal Services/PC or APPC applications can communicate as described in section "PC-to-PC Communications" on page 213, independent of the type of the LAN segment to which they are attached (PC Network (Broadband), IBM Token-Ring Network 4 or 16 Mbps).

7.7.3 IBM Token-Ring Network Connectivity

As illustrated in Figure 99 on page 220, the IBM Token-Ring Network supports a wide variety of devices directly connected to the LAN.

7.7.3.1 System/370 Host Attachment

An IBM Token-Ring Network can be connected to a System/370 host using the following gateways:

- Host gateways (see "Host Gateways" on page 191):
 - 3720, 3725, 3745 direct attachment (local or remote)
 - 3174 gateway (local or remote)
 - 9370 direct attachment
- PC gateways (see "3270 Emulation" on page 181):
 - Coax attached to a 3174 or 3274 (DFT mode)
 - SDLC attached to a 3720, 3725 or 3745
 - Attached to the 9370 Workstation Adapter
 - Attached to the 9370 Teleprocessing Subsystem.

Using a PC 3270 gateway, PC workstations on the network can use the IBM PC 3270 Emulation Program V3 to log on to the host system as a 3270 terminal, execute host-based applications, transfer files, and use the host office system.

APPC communication can be established between an application on the LAN and a CICS APPC application (see "Base Programming Interfaces" on page 128).

Office applications on the PC can communicate with the host office system (see "Office Support" on page 247).

Using a host gateway device, directly attached to the Token-Ring Network, a LAN workstation running IBM PC 3270 Emulation Program V3 configured for stand-alone emulation via the Token-Ring, can access a System/370 host system.

Terminals connected to a LAN-attached 3174 DSPU can log on to a System/370 host system via a logical link control session between the DSPU and a host gateway device (see "3174-03R and -53R Token-Ring Connectivity" on page 207). A workstation running IBM 3270 Workstation Program V1.1 may establish its 3270 Emulation host sessions via the LAN through a Token-Ring Network-attached host gateway. (See "3270 Workstation Program" on page 229.)

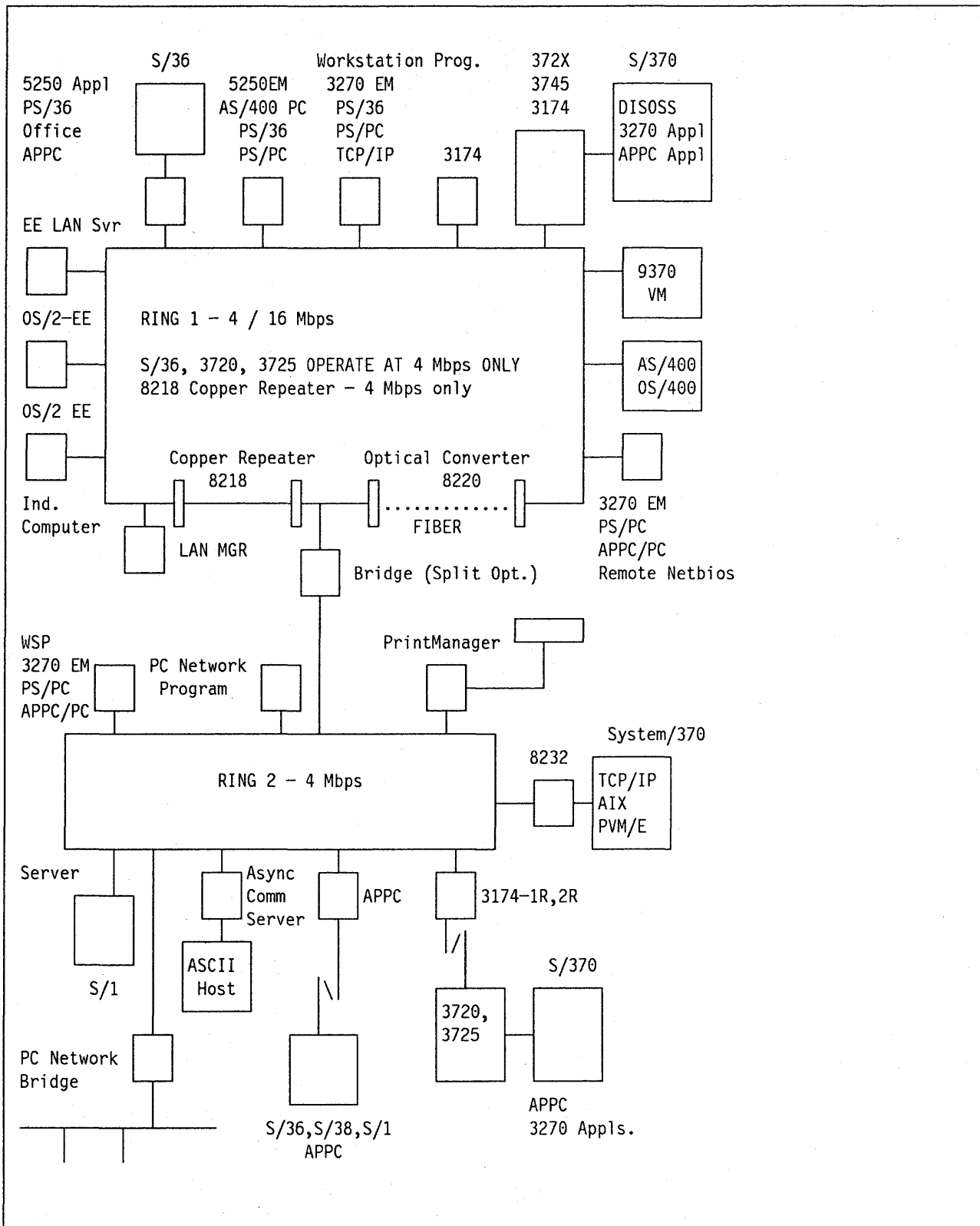


Figure 99. IBM Token-Ring Network Connectivity

7.7.3.2 9370 IBM Token-Ring Adapter

In addition to attaching to the IBM Token-Ring Network as an SNA host gateway, the 9370 Token-Ring Subsystem also supports TCP/IP communication between 9370's over the LAN and with a LAN workstation running PC TCP/IP. In a non-SNA environment, TSAF, as part of VM/SP Release 5, also provides connectivity over the LAN between 9370's (see the *9370 Token-Ring Subsystem* section in chapter "IBM Token-Ring Network" on page 85).

7.7.3.3 3174 03R, 53R Token-Ring Attachment

The 3174 models 03R and 53R can be attached directly to the Token-Ring Network as DSPUs. This connectivity option is described in "3174-03R and -53R Token-Ring Connectivity" on page 207.

7.7.3.4 AS/400 Connectivity

A workstation running AS/400 PC Support may access an IBM Token-Ring attached AS/400 System via the LAN. In addition, an AS/400 system may communicate with another LAN-attached AS/400 or System/36, or with a System/370 host gateway attached to the Token-Ring Network (see "AS/400 LAN Connectivity" on page 207).

7.7.3.5 System/36 Token-Ring Attachment

The physical attachment of a System/36 to an IBM Token-Ring Network is described in "System/36 Token-Ring Attachment" on page 184.

The System/36 attached to the LAN can communicate via the network with System/370 hosts, other System/36s, and PCs attached to the network.

System/370 connectivity can either be 3270 Emulation, remote job entry (RJE), APPC communication with a CICS application, or an office systems connection.

The System/36 can communicate with another System/36 or AS/400 on the LAN, or any S/3x or AS/400 connected in a APPN network. This communication includes display station passthrough, APPC, and Data Distribution Management (DDM).

APPC applications on the System/36 can communicate with APPC applications that reside on PCs attached to the LAN.

A PC running IBM PC 3270 Emulation Program V3 can be used as a gateway to an SDLC-attached System/36 or System/38.

PC workstations can log on in 5250 emulation mode to the System/36 to use System/36 applications such as System/36 Office - Personal Servers/36, or communication subsystems. The Enhanced 5250 Emulation Program is required in the PC, and System/36 PC Support/36 with the workstation feature is required on the System/36. The workstation support feature can support five concurrent terminal sessions, and one printer session.

7.7.3.6 Series/1 Connectivity

A workstation may access applications running under EDX 6.1 in a Token-Ring-attached Series/1 (see "Series/1 LAN Connectivity" on page 210).

The Token-Ring-attached Series/1 supports communication with another Token-Ring-attached Series/1, with a Token-Ring-attached 9370, a 3174 gateway and a Token-Ring-attached AS/400 System.

The Series/1 may also be attached to the LAN via a PC gateway. The PC is channel-attached to the Series/1. It needs the IBM Series/1 to PC Channel-Attachment feature and the Series/1-PC Connect Program. The Series/1 requires the S/1 PC Connect Program (5719-CN1).

7.7.3.7 Asynchronous Communications Server

Figure 99 shows an ASCII host attached to an Asynchronous Communication Server (see "Non-SNA Communication Gateways" on page 185).

7.7.3.8 PC-to-PC Communication

Via bridges, LAN-attached workstations running PC LAN Program (1.2 or 1.3), Operating System/2 Extended Edition V1.1 with or without OS/2 LAN Server, Personal Services/PC or APPC applications can communicate as described in section "PC-to-PC Communications" on page 213, regardless of the type of LAN segment to which they are attached.

7.7.3.9 Bridges and Management

The IBM Token-Ring Network Bridge Program V2.0 and IBM Token-Ring Network Bridge Program V2.1, interconnect IBM Token-Ring Network segments, either as normal bridges, or as remote bridges. The Token-Ring interconnection solutions apply to 4 Mbps IBM Token-Ring Network segments as well as 16 Mbps IBM Token-Ring Network segments. In addition, the IBM PC Network Bridge Program provides the capability to interconnect a 4 Mbps or 16 Mbps Token-Ring segment with a PC Network (Broadband) segment (see section "IBM LAN Bridges" on page 163).

The final user perception of such a complex multi-segment, multi-protocol LAN environment is one of a single LAN, providing connectivity to all other LAN-attached devices, including gateways and mid-range systems.

As explained in "LAN Management and Recovery" on page 253, the entire multi-segment LAN may be managed by a single LAN Manager station running IBM LAN Manager V2.0. This LAN management may or may not be integrated in central site network management.

7.8 IBM 8232 LAN Channel Station Connectivity

The *IBM 8232 LAN Channel Station* and its various control programs, provide connection and data transfer services between LAN devices and non-SNA hosts via a System/370 channel.

The different connectivity options may be divided into three categories according to the supported communications environment:

1. TCP/IP Network
2. VM/Pass-Through PVME
3. MAP 2.1 Network.

Figure 100 shows various 8232 connectivity options.

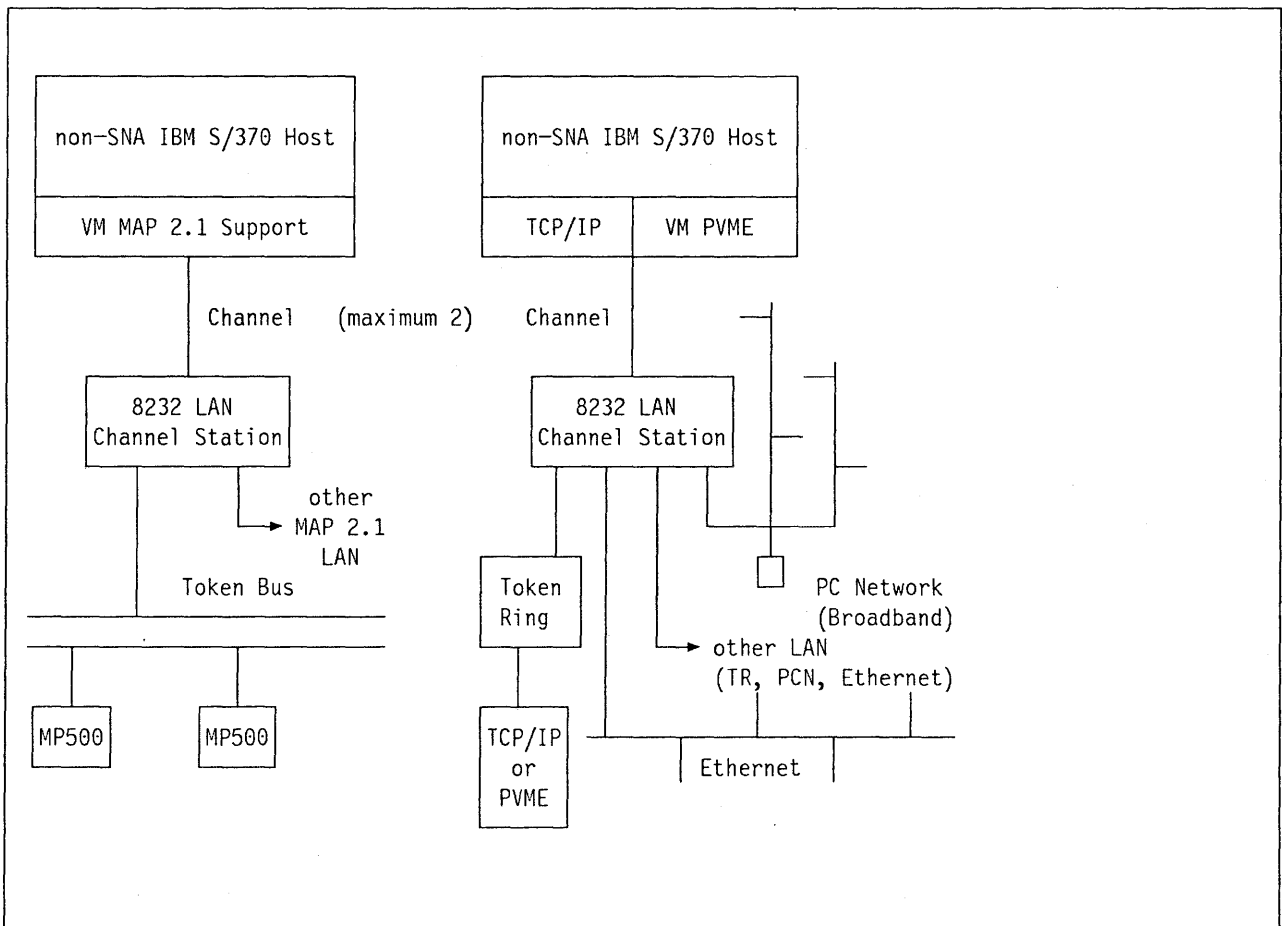


Figure 100. 8232 Connectivity Options

7.8.1 8232 Connectivity in a TCP/IP Environment

The 8232 LAN Channel Station offers non-SNA connectivity in a TCP/IP network for stations attached to IBM Token-Ring Network, IBM PC Network or Ethernet³¹ local area networks.

Hardware and software requirements to support TCP/IP via an 8232 are described in Figure 46 on page 109.

The LAN Support Program in the 8232 LAN Channel Station is only required when IBM Token-Ring Network or IBM PC Network adapters are installed (one to four adapters in total). Support for the Ethernet adapter is included in the control program of the 8232 LAN Channel Station (IBM 8232 LAN Channel Support Program).

The Transmission Control Protocol/Internet Protocol as a non-proprietary protocol set, is widely used to establish a communications network between dissimilar data processing systems.

TCP/IP may be supported in non-SNA mainframes by AIX/370. For host connection the following software may be considered for use in a PC or PS/2 attached to the LAN:

- AIX PS/2 TCP/IP which provides host file transfer, electronic message switching, and access to remote servers.
- AIX PS/2 Workstation Host Interface Program which is supported on PS/2 Models 70 or 80. It supports 3270 datastream host interaction and high-speed host file transfer.

The RT/PC has its own operating system, AIX RT/PC, that includes TCP/IP support for access to host and other Unix-type systems.

7.8.2 8232 Connectivity in a PVM Environment

The 8232 LAN Channel Station offers non-SNA 3270 connectivity via a VM/Pass-Through PVME program offering for stations attached to IBM Token-Ring Network, IBM PC Network or Ethernet local area networks.

Hardware and software requirements to support this offering are described in Figure 47 on page 109. The LAN Support Program in the 8232 LAN Channel Station is only required when IBM Token-Ring Network or IBM PC Network adapters are installed (one to four adapters in total). Support for the Ethernet³¹ adapter is included in the control program of the 8232 LAN Channel Station (IBM VM/Pass-Through PC Connect Facility - 8232 Communications Program 1.0).

The IBM VM/Pass-Through PC Connect Facility enables connection of an IBM (non-SNA) System/370 architecture mainframe to IBM Token-Ring Network, IBM PC Network or Ethernet local area networks as server machines. These servers, as they are implemented in large mainframes, may provide considerable disk, print and computing resources to the LAN stations.

This facility may also provide non-SNA 3270 workstation emulation via IBM VM/Pass-Through from a LAN workstation running IN/PCS.

³¹ Ethernet is a trademark of the Xerox Corporation.

7.8.3 8232 Connectivity in a MAP Environment

MAP 2.1 industrial LAN connection requirements are discussed in “IBM and Industrial LAN” on page 121, where Figure 54 on page 123 summarizes the supporting software requirements.

Only one MAP 2.1 LAN adapter, for example, an INI MP-500 MAP Interface Adapter ³², may be installed in a 8232-001, or a maximum of two in a 8232-002, because each adapter requires two adapter slot positions.

³² Industrial Networking Inc. (INI) is a joint venture between Ungermann-Bass and General Electric, providing communications products for the manufacturing environment, including MAP 2.1 implementations.

8. LAN Connectivity Applications

8.1 System/370 Host Main Frame Interactive

8.1.1 PC 3270 Emulation Program

The IBM PC 3270 Emulation Program software provides 3270 emulation to intelligent workstations, PCs or PS/2's. IBM PC 3270 Emulation Program V3 is discussed in this document, because it is the only version available providing support for both network stations and LAN-attached host gateways (see section "Host Gateways" on page 191).

IBM PC 3270 Emulation Program V3 operates with IBM PC/DOS 3.3 or 4.0 and requires the IBM LAN Support Program V1.10 to support of the workstation's LAN adapter.

8.1.1.1 IBM PC 3270 Emulation Program V3 functional overview

IBM PC 3270 Emulation Program V3 provides LU 2 (display session), LU 1 and LU 3 (printer session) support for a PC or Personal System/2.

Support for 3270 data stream and extended emulation functions (such as file transfer) is the same for all IBM PC 3270 Emulation Program configurations.

The IBM PC 3270 Emulation Program provides a subset of 3270 hardware control functions as for each configuration as follows:

- A PC gateway configuration provides a subset of 3274-51C controller functions (basic PU 2.0 support) for connected network stations (LUs). Up to thirty-two network stations are supported by the gateway function.
- A network station configuration provides support equivalent to 3278-2 or 3279-2 display stations (basic LU 2 support with one session per stations) and/or 3287 emulation (LU 1 or LU 3 - one per station, printer or disk). The display session emulation does not support Programmed Symbols or Vector Graphics data streams. IBM PC 3270 Emulation Program only supports the base 3270 datastream, with the exception of file transfer support. A workstation configured as a network station requires PC gateway station services to access a System/370 host.
- A PC gateway plus network station configuration which combines the capabilities of the gateway and one network station configuration. Up to thirty-two³³ network stations are supported by the gateway function, including the network station with the gateway itself.
- A standalone station configuration which provides PU capabilities for its own network function, enabling it to operate without a gateway station. It does not support additional network stations.

³³ DFT host connection to a 3174 only supports up to 5 network stations.

Depending upon the memory requirements of a given configuration, a concurrent PC DOS application can be executed in the foreground while the 3270 emulation function is active in the background. A "hot key" enables a user to switch from one application to the other. PC DOS is a single-task operating system, using a time-slicing algorithm to share resources between foreground and background programs. When a concurrent PC DOS application is brought into the foreground, the IBM PC 3270 Emulation Program application will be suspended in background. In a gateway configuration, both memory availability and possible impact on network station performance must be considered when planning to run another PC DOS application concurrently.

8.1.1.2 Standalone Configuration

The standalone configuration of IBM PC 3270 Emulation Program V3 supports various communication attachments:

- 3270, 3725 or 3745 via a teleprocessing (TP) line. This requires either a:
 - SDLC Adapter card (Family 1 devices)
 - PS/2 Multi-Protocol Adapter (Family 2 devices).
- 3274 or 3174 via coax (DFT mode). This requires either a:
 - 3278/79 Emulation Adapter (Family 1 devices)
 - 3270 Connection Adapter (Family 2 devices)
- SNA host gateway via a Token-Ring network. This requires one of:
 - An appropriate token-ring adapter depending on the workstation hardware (Family 1 or 2) and token-ring network transmission speed.
 - An appropriate PC Network (Broadband) adapter depending on the workstation when the PC Network (Broadband) segment is interconnected with an IBM Token-Ring Network segment via a PC Network Bridge.
 - The Netbios support and interface module of IBM LAN Support Program V1.10 (DXMT0MOD.SYS) is **not** required since the standalone station uses an IEEE 802.2 logical link control session to communicate with the host gateway.

8.1.1.3 Network Station Configuration

The PC or Personal System/2 may be attached to any IBM LAN. A network station requires a PC gateway on the LAN, with which it will communicate using a Netbios session. The session is established based on a match between the Netbios name configured in the network station and an entry in a gateway station identifying the Netbios names of all the network stations it will support. See section "Base Programming Interfaces" on page 128 for more information on the Netbios protocol and interface.

With this configuration, IBM PC 3270 Emulation Program requires the Netbios module of the IBM LAN Support Program V1.10.

8.1.1.4 Gateway or Gateway with Network Station Configurations.

The gateway configuration provides System/370 host connections for up to:

- 32 sessions if SDLC-attached over a TP line to a Communications Controller.
- 5 sessions if coax-attached in DFT mode to a 3174 Control Unit.
- 32 sessions if communicating over the LAN with an SNA host gateway.

The adapter requirements are similar to those described for the standalone configuration.

The PC or Personal System/2 may be attached to any IBM LAN. The Netbios module of the IBM LAN Support Program V1.10 is required in gateway and network station configured systems and uses a Netbios session via service access point (SAP) X'F4' to communicate between the gateway and network and network station. A gateway or standalone station communicates over the LAN with a SNA host gateway over an IEEE 802.2 LLC link via SAP X'04' (SNA SAP).

The number of PC gateway or standalone stations on a LAN is not restricted, and different host attachments may be defined in individual gateways or standalone stations.

8.1.1.5 Memory Requirements

Figure 101 lists the memory requirements for IBM PC 3270 Emulation Program V3, to support the base configurations and additional functions provided by the product when explicitly requested during configuration. The figures exclude IBM PC/DOS 3.3 or 4.0 and IBM LAN Support Program V1.10 memory requirements.

Base memory requirements	
Standalone	161 Kbytes
Network Station	155 Kbytes
Gateway	195 Kbytes
Gateway † Network Station	223 Kbytes
Additional function	
DFT attachment	5 Kbytes
Alternate task	11 Kbytes
Keyboard remap	2 Kbytes
Printer emulation	11 Kbytes
File transfer	18 Kbytes
PS API Interface	8 Kbytes
ECF SRPI Interface	30 Kbytes

Figure 101. IBM PC 3270 Emulation Program V3 Memory Requirements

8.1.2 3270 Workstation Program

8.1.2.1 Functional Overview

The IBM 3270 Workstation Program provides 3270 function for a PC or PS/2 workstation equivalent to the former 3270-PC workstation control program. In summary, the IBM 3270 Workstation Program provides multi-3270 host session and multi-DOS capabilities in an IBM PC/DOS 3.3 or 4.0 environment:

- Up to four concurrent host sessions, including support for extended datastream and a range of screen sizes.
- Up to six concurrent PC/DOS sessions, providing a multi-tasking appearance of the workstation.
- Up to two Notepad sessions (24 x 80 characters).
- Support of the Extended Memory Addressing Adapter (XMA), providing about 2.25 Mbytes memory under control of the IBM 3270 Workstation Program.
- The IBM 3270 Workstation Program does not support printer emulation; it provides only LU 2 capability.

The IBM 3270 Workstation Program provides a range of workstation control functions, allowing a user to define window parameters for each host or DOS session and to establish screen profiles describing up to ten different working environments. In addition, a IBM 3270 Workstation Program user is provided with a number of powerful tools, including session to session (presentation space to presentation space) copy and keystroke recording. IBM 3270 Workstation Program also contains an application programming interface, called HLLAPI.

8.1.2.2 System/370 Host Communications Support

Host communications support is dependent upon the version of software (IBM 3270 Workstation Program V1.0 or IBM 3270 Workstation Program V1.1).

IBM 3270 Workstation Program V1.0 requires a 3278/79 Emulation Adapter (Family 1) or a 3270 Connection Adapter (Family 2), coax-attached in DFT mode to a 3174 or 3274 Control Unit.

In addition, IBM 3270 Workstation Program V1.1 may establish the 3270 emulation session over the Token-Ring via an SNA host gateway. In this case, an IEEE 802.2 LLC link is established between the LAN-attached workstation and a host gateway using SNA service access points. Concurrently, the workstation may communicating with other LAN Stations through a different service access point.

Note that a workstation running IBM 3270 Workstation Program V1.0 may also be LAN attached, but but the LAN attachment can only serve the PC/DOS sessions. The host sessions require a separate (3270 emulation) communications adapter.

When operating the PC LAN Program (see "IBM PC LAN Program V1.2" on page 235) in a PC DOS session, several restrictions apply with respect to PC LAN Program functions that can be enabled.

The IBM 3270 Workstation Program does not provide a PC gateway capability, nor can it make use of a PC gateway implemented by the IBM PC 3270 Emulation Program to satisfy the 3270 emulation requirements.

Because of the high memory requirements of the IBM 3270 Workstation Program control code and the multi-DOS capability, use of the XMA Adapter is strongly recommended to relieve PC DOS memory constraint.

8.1.3 Enhanced Connectivity Facility

IBM Enhanced Connectivity Facility (ECF) offerings are a set of products that enable programs to be written to access resources located in remote locations. The programs use a simple call/return interface that is independent of any network communication method and does not require knowledge of the location of the resources or the environment.

The interface is called the *Server-Requester Programming Interface (SRPI)*. SRPI is an application interface over which requests and replies are passed using a Connectivity Programming Request Block (CPRB).

Application programs that request services using the SRPI are called "requesters". Requesters build a request in the form of a CPRB and pass it through the SRPI using a standard programming language subroutine call. The request CPRB is received by a PC program called a "router", which directs the request over the communications link to a host system where it is received by a host router.

The host router in turn transfers the request CPRB across the host SRPI to a server application. The server processes the request and sends a reply to the requester in a CPRB via the host SRPI/router to the PC router/SRPI.

The reply is received by the requester as a return from the subroutine call that initiated the request. Figure 102 illustrates the process.

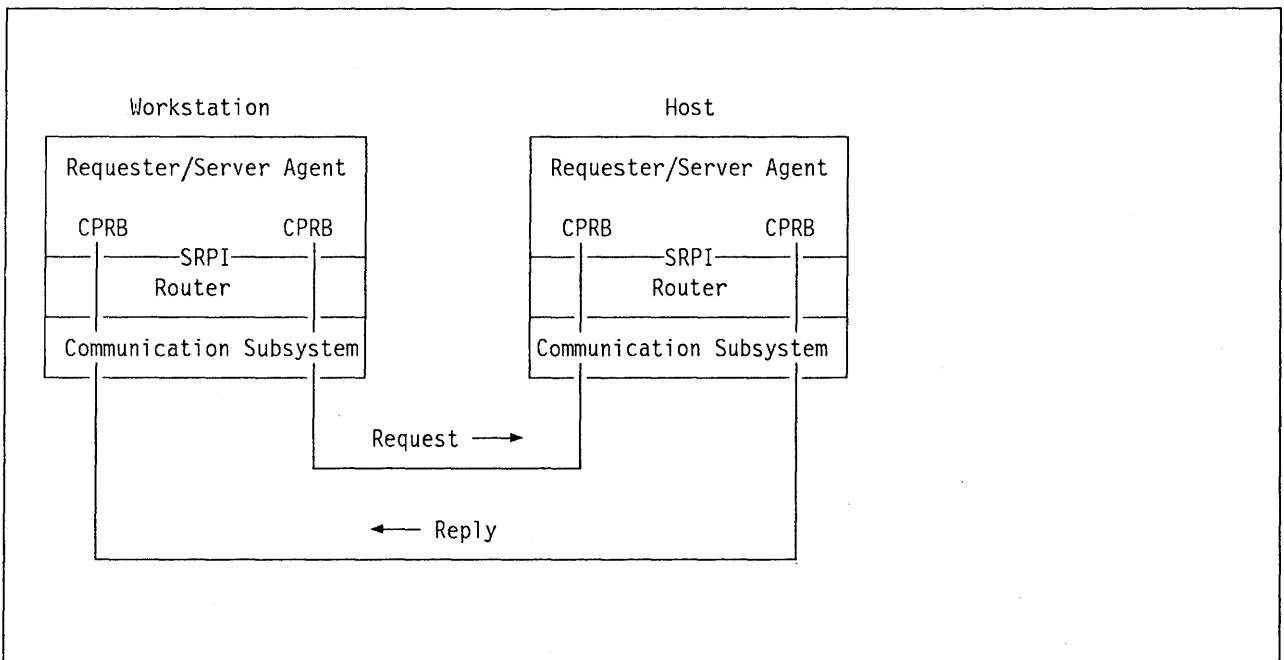


Figure 102. ECF Layers and Interfaces

8.1.3.1 Server-Requester Programming Interface

The SRPI is the programming interface between either the PC requester or host server program and the router. The SRPI provides the following potential capabilities for requesters:

- Simple interface to access servers
- Call/Return Model
- Communication protocol independence.

Two functions are defined as part of the SRPI. They are:

- Send Request

The send request function initiates a request from a PC requester program.

- Send Reply

The send reply function returns a reply from a server program in response to a request from a PC program.

8.1.3.2 IBM Requester/Server Products

IBM currently has two products that implement the requester or server function for System/370 to PC ECF. The products can be used in a LAN or standalone PC environment. They are:

- *IBM TSO/E Requesters-Servers (5665-328)* - This product provides a server agent for MVS/TSO and an Enhanced Connectivity Facility Requesters feature for the IBM PC or PS/2.
- *IBM CMS Requesters-Servers (5665-327)* - This product provides a server agent for VM/CMS and an Enhanced Connectivity Facility Requesters feature for the IBM PC or PS/2.

The router component and server-requester programming interface for the PC is provided by the IBM PC 3270 Emulation Program V3 in an IBM PC/DOS 3.3 or 4.0 environment, and by the Operating System/2 Extended Edition V1.1 Communications Manager in an OS/2 environment. The router component for the host is provided by TSO/E for MVS, and VM/SP for VM.

When the IBM PC requester is used with one of the host servers, the following services are provided. These can be invoked on the PC either by using menus, or by using DOS or OS/2 commands:

- Virtual Disk (VDISK)

A PC user or application can use host disk space as if it were a disk device attached to the PC. Data is stored in PC format without translation.

- Virtual File (VFILE)

Allows the PC user or an application program to access host files as if they were PC files. Any data transformations are done automatically, based on user-supplied file definitions.

- Virtual Print (VPRINT)

A PC user can print output on a host printer as if it were a PC printer. The PC printer data stream is translated to an IBM 1403 or an IBM 3800 Model 1 printer data stream.

- Virtual Copy (VCOPY)

VCOPY provides a powerful means of file transfer between a PC and a host system. During the file copying, data may be transferred without translation (binary), with translation between ASCII and EBCDIC (text), or with specific data transformations as described in a file definition (formatted).

- Host Data Base Services

Data can be extracted from DB2 or SQL/DS data bases through an SQL query (VSQL), or through a DXT extract request (VDXT).

- Run Host Command, Procedure or Program (VHOST)

Enables the PC user or application program to execute programs, commands and procedures on the host system and return line-by-line results to be shown at the PC or stored in a PC file.

8.1.3.3 OS/2 EE SRPI Implementation

The Operating System/2 Extended Edition V1.1 Communications Manager provides the send-request function. It also provides a SRPI profile which, in conjunction with the server name or alias supplied as a parameter of the send-request function, routes the application request to the appropriate host session.

Migration from PC/DOS to OS/2 Extended Edition may require some changes of SRPI applications, due to a different operating system interface to SRPI, and some new or obsolete return codes. The CPRB mapping is unchanged and requires no changes to SRPI applications.

8.1.4 OS/2 EE Communications Manager

The Operating System/2 Extended Edition V1.1 provides OS/2 3270 Terminal Emulation as part of the OS/2 Extended Edition Communications Manager.

This 3270 emulator supports up to five sessions via an SDLC link to an NCP or an IEEE 802.2 LLC link over a Token-Ring Network to a SNA host gateway. In this case, an appropriate SDLC adapter or LAN adapter is required in the workstation.

In addition it offers up to five extra sessions via an appropriate 3270 emulation adapter, coax-attached in DFT mode to a 3174 Control Unit or a 9370 Workstation Controller.

Both environments, emulation via SDLC or Token-Ring network and emulation in DFT mode via a coax-attachment, can operate at the same time, providing up to ten concurrent 3270 emulation sessions.

The OS/2 Communications Manager 3270 Terminal Emulation is illustrated in Figure 103 on page 234.

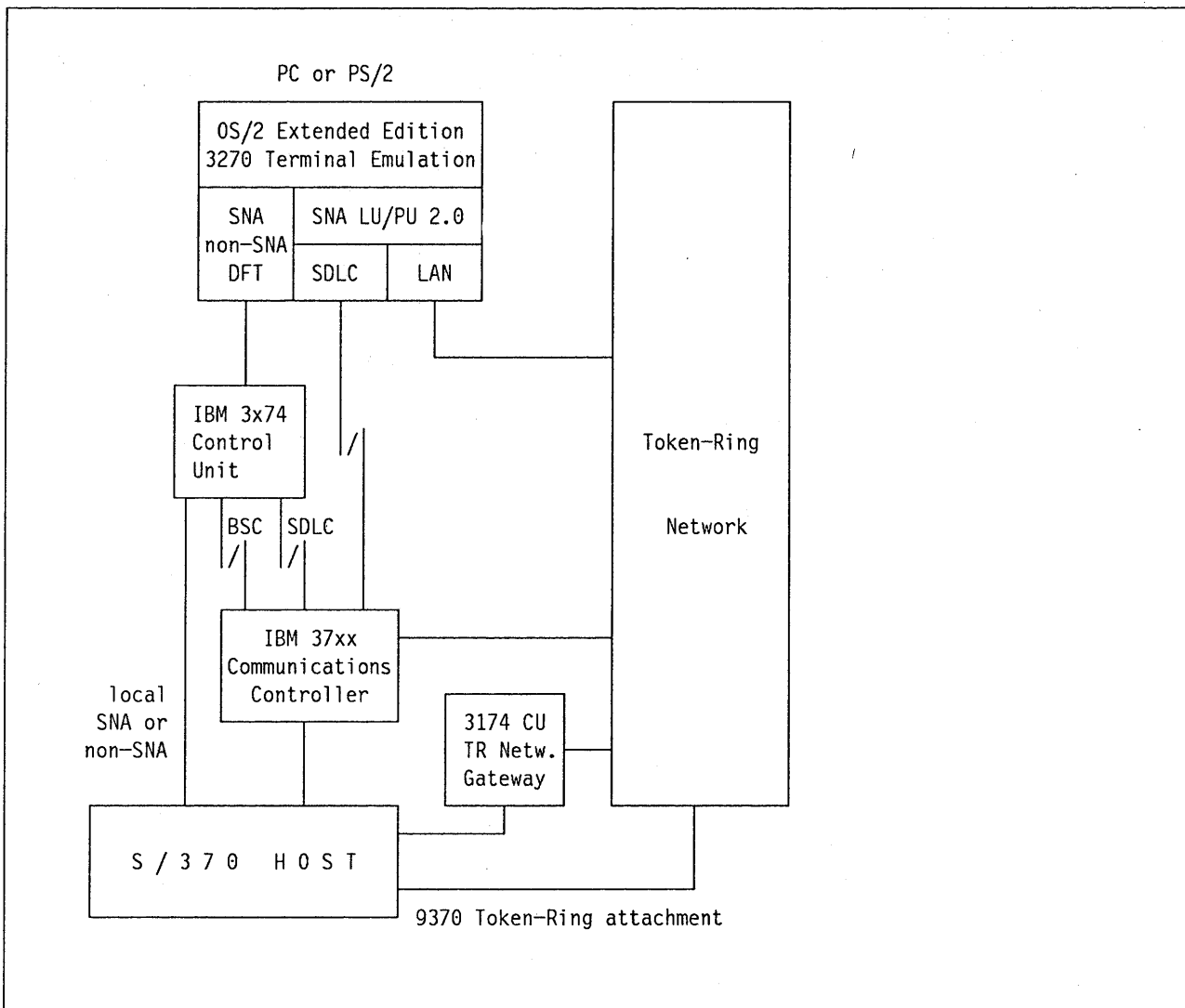


Figure 103. Operating System/2 Extended Edition V1.1 - 3270 Terminal Emulation Connectivity

The Communications Manager 3270 Terminal Emulation emulates the following displays:

- 3178 Model 2
- 3278 Model 2, 3, 4 and 5
- 3279 Model S2A and S2B.

All base data-stream functions are supported, as are the multiple interactive screens, extended attributes (including seven colors and extended highlighting), file transfer and emulator keyboard remapping.

This emulator is fully compatible with OS/2 LAN Server/Requester functions executing as another OS/2 task and sharing the same LAN adapter.

8.2 LAN Servers

8.2.1 IBM PC LAN Program V1.2

The IBM PC LAN Program V1.2 provides resource sharing, server and message functions for the IBM Token-Ring Network, IBM PC Network (Broadband) and IBM PC Network Baseband. The program will run on Family 1 and Family 2 workstations, supporting all currently available LAN adapters.

Sixty-four workstations are supported per server equipped with a Token-Ring Network Adapter, twenty-nine per server equipped with a IBM PC Network Adapter.

8.2.1.1 Modes of Operation

Two primary modes of operation are provided by the IBM PC LAN Program V1.2. The first mode is a *redirector* that intercepts application program calls for disk and printer input/output (I/O). The I/O request is then redirected over the network to an IBM PC containing a server function. Upon receipt, the redirector passes the response to its request back to the application as if it had been satisfied locally.

The second mode is a full-function *server* that receives and responds to network requests for disk and printer I/O. All server mode workstations contain the redirector function; but a workstation defined as a redirector mode station cannot perform as a server. All server requests run in the background, allowing concurrent operation with another application. Attention, however, should be paid to the response time for handling redirected I/O requests. As IBM PC LAN Program V1.2 operates under PC DOS, a single-task operating system, time-slicing is used between the server function in background and another DOS application executing in foreground.

The IBM PC LAN Program V1.2 also provides a *receiver* mode (a redirector with the ability to receive and log messages) and *messenger* mode (a receiver with additional more complex message functions, referred to as advanced message functions, and a full-screen interface).

The message function included in the IBM PC LAN Program V1.2 is designed for ease of use. The user can save a message in a user-specified file, retrieve it, and send the message at a later time. The message saved in the file may be one entered by the user to send to another user, or it could be one received from another user. Messages in the file can be transferred with additional information to another network user.

Network users of the IBM 3270 Workstation Program can access IBM System/370 host applications while using the redirector, receiver or messenger mode of the IBM PC LAN Program V1.2. They can also perform file transfer and redirect files to a LAN file server for storage.

The IBM PC LAN Program V1.2 contains a set of operator functions, consisting of commands and menus, that users may use to manage resource sharing and other functions. These include:

- Configuring the IBM PC LAN Program for each PC's mode of operation.
- Establishing or deleting a workstation name on the network.

- Establishing a file-sharing environment for both server and redirector.
- Managing the server print queue for shared printers.
- Communicating with other LAN workstations.
- Performing data-file transfer operations.

8.2.1.2 Disk Sharing

Disk sharing is implemented in the PC Network program for DOS drives or directories. Part of the sharing function is to allocate a level of access that will be permitted for a resource. For example, you can assign a name to a directory, together with a password and an access level of "read only".

Access to files on a disk drive or directory can be managed on the following levels:

- Read Only
- Write Only
- Read/Write/Create/Delete
- Read/Write
- Write/Create/Delete.

PC DOS file locking may prevent concurrent update of the same file. However, since the notion of a record does not exist in PC DOS, record locking capability, if needed, must be programmed using the IBM PC LAN Program (PC Macro Assembler) programming interface and the PC DOS byte-locking mechanism.

8.2.1.3 Printer Sharing

Printer output can be directed to a printer attached to another system unit on the network. The PC designated to be a print server requires a hard disk for print spooling and can share its printer with multiple remote users.

8.2.1.4 Security

Security and access rights on the network are provided in the form of a password unique to each resource name. An optional password may be required to establish a session with another name.

Control of who has access to a specific resource and the need for a password is managed by the owner of the resource and is strictly an administrative function. For example, each disk that is made available to the network for sharing may be assigned a password and users who wish to access the disk are required to provide the password before using it.

The IBM PC LAN Program V1.2 does not provide central network administration functions or a user logon capability.

8.2.1.5 Positioning for Resource Sharing

The I/O redirection functions of the PC LAN program support the sharing of disks and printers on any IBM LAN environment. The following advantages may be gained from resource sharing.

- Resource Sharing advantages.

- Lower cost per workstation: each workstation does not need to be fully configured, for example, with a printer or hard disk. Only server PCs must have a hard disk installed.
- Multiple users can have access to a single shared resource.
- Centralized control of common data can now be achieved through disk and file sharing.
- Maintenance of disks and data files can be managed at a single station.
- Printers and printer output can be managed from a single station.
- Application transparency: the I/O redirection function is suitable for most PC applications, usually without changes to the program.
- Access control is provided in the form of:
 1. Passwords which can be used to restrict access to resources.
 2. Owner control, as to whether the resource is "read only" or can be updated.

Server functions may be shared in a workstation with other functions or may require a dedicated workstation. Print and file servers may be in the same or separate PCs.

- Print Server advantages:

- The management of different classes of printer output can be controlled from a single location in a work area.
- Paper handling is reduced by allocation of printers for specific printing requirements.
- Multiple printers can be attached to a single server PC.
- The print server can print in a background partition, so that the PC can continue to be used for another task or application.
- Most IBM text and graphic printers are supported.
- Plotters are supported.
- IBM LAN PrintManager complements the print server for 3812, and provides 3820 Page Printer support where high quality and special printing is required.

- File Server advantages:

- Controlled access to common data, such as a master file.
- Control functions that permit applications to specify a level of sharing for each file.
- Concurrent access to data by multiple users with software-enforced integrity at the file level.

8.3 IBM PC LAN Program V1.3

The IBM PC LAN Program V1.3 provides two types of services:

- *Base Services*, mainly for compatibility/migration from IBM PC LAN Program V1.2.
- *Extended Services*, providing improved management and usability as well as a migration path to an Operating System/2 Extended Edition V1.1 environment.

In addition, IBM PC LAN Program V1.3 supports Remote Program Load, that is a requester station (or user station in IBM PC LAN Program V1.2 terminology) may receive its Initial Program Load data from a remote server on the LAN.

IBM PC LAN Program V1.3 also has improved performance in comparison with IBM PC LAN Program V1.2 when executed with the LAN Support Program V1.02 or higher.

8.3.1.1 Extended Services

The IBM PC LAN Program V1.3 Extended Services provides enhanced management over the server/requester LAN environment through administrator services including user, application and workstation administration and enhanced security mechanisms.

Enhanced usability is achieved through additional user services, including an improved menu structure with application selector capability.

IBM PC LAN Program V1.3 Extended Services provides server, receiver and redirector configurations. As compared to IBM PC LAN Program V1.2, IBM PC LAN Program V1.3 uses twice as many Netbios sessions as the equivalent IBM PC LAN Program V1.2 configuration requires.

IBM PC LAN Program V1.3 Extended Services provides a *single systems image* to its users. This is achieved through the concept of a *domain*. A LAN environment may be divided into multiple IBM PC LAN Program V1.3 domains. One system administrator function is associated with each domain.

Administrator Services functions may be executed by the system administrator from any IBM PC LAN Program V1.3 workstation using a particular IBM PC LAN Program V1.3 user name, referred to as the domain controller. This name is also the name or identification of the domain. The domain controller is also the prime server within the domain. The main administrator services functions are:

- Define and manage IBM PC LAN Program V1.3 users, including the definition of user identifications, associated passwords, access rights, etc. This function allows the administrator also to define an application selector menu for each user.
- Define and manage shared printer resources.
- Define and manage applications, accessible by IBM PC LAN Program V1.3 users within the domain when authorized by the system administrator.
- Define and manage file sets required by applications.

These Administrator Services remove the resource definition task from the IBM PC LAN Program user, while providing substantial additional control over the distributed processing environment.

Other Administration Services include:

- Definition and management of machine identifications.
- Definition and management of images, describing an IBM PC LAN Program V1.3 startup profile for each machine that needs to be remotely IPL'd (these machines require appropriate hardware, that is the RIPL feature on an IBM Token-Ring Adapter card).
- Set system date and time.
- Perform system shutdown.
- View and/or print the domain control data base, containing all the above-mentioned definitions.

IBM PC LAN Program V1.3 Extended Services also provides additional or enhanced user facilities:

- Each IBM PC LAN Program V1.3 user may have an individual application selector profile.
- The user's environment may be tailored to reflect specific disk and/or printer selection, content of the application selector menu (within the authorized set of applications assigned by the domain manager) and sign-on password modification.

In addition, any IBM PC LAN Program V1.3 user may view the network status, view the printer status and print queues (even manipulate his own print jobs) and query which users are signed-on.

Users may access a resource shared by a server belonging to another domain than the home domain. Such a resource is called an external resource as opposed to internal resources, made available by servers within the home domain. Sharing and accessing external resources, however, is a function of the IBM PC LAN Program V1.3 base services and is out of the control of system administration services within the domain controller.

IBM PC LAN Program V1.3 provides on-line help facilities and a tutorial facility.

8.3.1.2 Hardware and Software Requirements

The following workstations may be defined as server machines:

- PS/2 Model 50, 60, 70 or 80, or a PC/AT.
- 640 Kbytes of memory with a fixed disk and the appropriate LAN adapter.
- Optionally, the optical disk is supported.

Any PC or PS/2, which may be equipped with a LAN adapter and has a minimum of 512 Kbytes of memory, may be defined as a regular IBM PC LAN Program V1.3 workstation.

All machines have the following software requirements:

- IBM PC/DOS 3.3 or 4.0

- IBM LAN Support Program V1.0 or V1.1 (minimum V1.02 recommended).

IBM PC LAN Program V1.3 can co-exist with IBM PC LAN Program V1.2 in the same LAN environment. Message exchange between IBM PC LAN Program V1.2 and IBM PC LAN Program V1.3 machines is possible. The IBM PC LAN Program V1.2 Permit command is no longer supported by IBM PC LAN Program V1.3.

8.3.2 OS/2 EE LAN Server 1.0

The IBM OS/2 LAN Server builds on the IBM PC LAN Program V1.3 functions, providing them in an Operating System/2 Extended Edition V1.1 LAN environment and taking advantage of OS/2's inherent capabilities.

It provides resource sharing for disks, printers and serially attached devices, plus facilities for defining, controlling and managing access to the LAN resources. The IBM OS/2 LAN Server operates on any IBM LAN.

The IBM OS/2 LAN Server has two components: the requester function, included in the Operating System/2 Extended Edition V1.1, and the server function which is packaged separately as the IBM OS/2 LAN Server product.

The IBM OS/2 LAN Server is designed to be compatible with IBM PC LAN Program V1.3. It offers, however, enhanced and new capabilities, such as:

- High performance non-dedicated servers.
- Advanced security system.
- Print job management.
- Enhanced network user and administrator interfaces.

The workstations operating as either requesters or servers must be 80286 or 80386 based PCs or PS/2's, the PC/XT and PS/2 Models 25 and 30 are not supported.

As with IBM PC LAN Program, the server configuration is a superset of the requester configuration. The concepts of system administrator, domain, domain controller, server, etc. presented in the previous IBM PC LAN Program V1.3 section, remain valid for the IBM OS/2 LAN Server.

8.3.2.1 IBM OS/2 LAN Server Highlights

- Full support of OS/2 protected mode and multi-tasking environment.
- High performance non-dedicated server taking advantage of the large memory support and the protected mode operation of the OS/2 operating system.
- Installation and configuration facilities.
- Network administration facilities, providing full-screen interface viewing and controlling system operation from any workstation.
- Network user full-screen interface.
- Network user command line interface.
- Network startup and shutdown.
- Access control system modelled on RACF for SAA future compatibility.

- Concepts of users and groups of users.
- Sign-on/sign-off.
- Control of access to resources based on user identity.
- Generic resource profiles to simplify administration of access controls and to improve the performance.
- Multiple servers managed as a single logical system.
- Comprehensive facilities for managing the IBM OS/2 LAN Server system.
 - Full remote control and administration of all system facilities from any machine (workstation or server).
 - Network usage and diagnostics.
 - Time scheduled execution of commands at a remote server.
- Facilities for sharing disk directories and files with other users on the network.
- Exploitation of the OS/2 Presentation Manager print spool function, with extensions to support networking functions, such as:
 - Multiple print destinations for a queue.
 - Start or stop times for print queues.
 - Notification of print job completion to users.
 - Print job separator pages.
 - Queue priority.
- Network utilities for network copy and move functions for files.
- Remote device sharing, providing I/O-level access to remote COM and LPT devices (serially attached and printer devices), as if they were local.
- User-to-user messaging facility.
- Remote program execution, enabling authorized users to run programs on a remote server (NET RUN facility).
- Remote IPL of PC DOS workstations.
- Compatibility with IBM PC LAN Program V1.3 requesters.
- Access to IBM OS/2 LAN Server resources by IBM PC LAN Program V1.3 Base Services and Extended Services requesters.

All these functions reinforce the single system image of a functionally enriched distributed processing environment on a local area network.

8.3.2.2 IBM OS/2 LAN Server System Structure

The diagram in Figure 104 on page 242 shows the logical relationship of the IBM OS/2 LAN Server components with the OS/2 operating system.

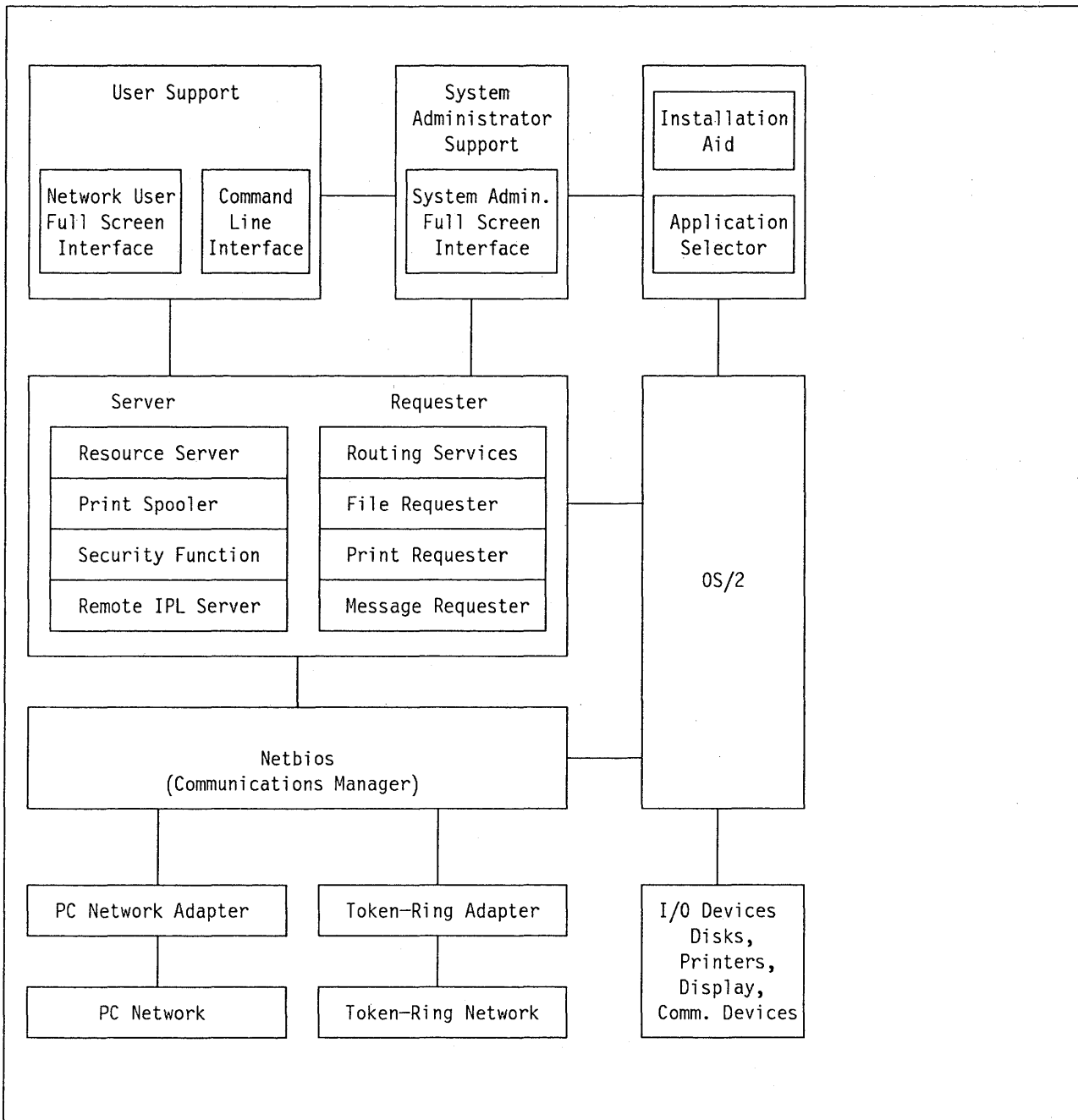


Figure 104. OS/2 EE LAN Server System Components

8.3.2.3 Migration from IBM PC LAN Program V1.3 to Operating System/2 Extended Edition V1.1 and IBM OS/2 LAN Server

Operating System/2 Extended Edition V1.1 requesters cannot access IBM PC LAN Program V1.3 servers. Therefore, IBM PC LAN Program V1.3 servers should be migrated first to IBM OS/2 LAN Server's, allowing access to both IBM PC LAN Program V1.3 and Operating System/2 Extended Edition V1.1 requesters.

Later on, requester workstations may be gradually migrated to the Operating System/2 Extended Edition V1.1 environment.

8.3.3 System/36 PC LAN Support

8.3.3.1 System/36 - PC Support/36

PC Support/36 provides function in both the IBM PC and the System/36 to support file transfer and resource sharing.

Virtual Disk Multiple virtual disks can be defined on the System/36. PCs attached to the LAN can access these disks as if they were local PC drives. Up to eight virtual disks are accessible at one time. They can vary in size from 5 Mbytes to 32 Mbytes.

Virtual Printers PC printer output can be directed to a System/36 printer.

File transfer Data files, library source and procedure members can be transferred between the System/36 and a PC workstation. The PC Support/36 program does all the necessary data translation.

A portion of PC Support/36 is executed in the PC. The product is packaged with a diskette containing a loader program to transfer the required code from the S/36 to the PC on the LAN. To establish a session with a System/36 using PC Support/36, the loader program first initializes the System/36 gateway PC/AT and establishes a connection with the System/36. The code for the IBM PC is then transferred from the System/36 to the PC on the LAN.

Security/Integrity: PC Support/36 utilizes the security and audibility features of the System/36 System Support Program.

8.3.3.2 5250 Terminal Emulation

PC workstations can log on to the System/36 to use System/36 applications, System/36 Office - Personal Servers/36, or communication subsystems. The Enhanced 5250 Emulation Program is required in the PC, and System/36 PC Support/36 with the workstation feature is required on the System/36. The workstation support feature can support five concurrent terminal sessions and one printer session.

8.3.3.3 Systems Connectivity

The System/36 attached to the LAN can communicate via the LAN or wide area network with System/370 hosts, other System/36's, and PCs attached to the network.

System/370 connectivity can either be 3270 Emulation, remote job entry (RJE), APPC communication with a CICS application, or an Office Systems connection.

The System/36 can communicate with other System/36's or AS/400's on the LAN, or any S/3x or AS/400 connected in an APPN network. This communication includes display station pass-through, APPC, and Data Distribution Management (DDM).

APPC applications on the System/36 can communicate with APPC applications residing on PCs attached to the LAN.

8.3.4 AS/400 PC LAN Support

The IBM AS/400 PC Support is an integrated software product that expands the power and the use of a PC or PS/2 by extending system resources and server functions of the AS/400 System to end users and application developers.

IBM AS/400 PC Support can be used for applications such as data transfer, file serving, print serving and office integration. It provides access to the AS/400 System data base, AS/400 controlled printers. In addition IBM AS/400 PC Support provides display station, printer and graphics workstation functions.

As explained previously in "AS/400 LAN Connectivity" on page 207, communications between a workstation and an AS/400 system can use Advanced Program-to-Program Communication/Advanced Peer-to-Peer Networking (APPC/APPN) support.

The PC router, a prerequisite program on the PC for using IBM AS/400 PC Support, is capable of sending and receiving up to 16 Kbytes of data through the workstation controller with no major impact on performance. All IBM AS/400 PC Support functions use a common communication interface. Refer to Figure 95 on page 210 for the relationship between different software components.

The IBM AS/400 PC Support router is designed to communicate primarily with the AS/400 system. In a network with AS/400 System and System/36 together, the PC can get PC Support services from the AS/400 System and the System/36 concurrently, using the PC Support/36 Coexistence PRPQ.

The IBM AS/400 PC Support router controls the communications between one or more AS/400 PC Support functions on the PC and their counterparts on the AS/400.

8.3.4.1 IBM AS/400 PC Support Functional Overview

All existing functions of PC Support/36 and PC Support/38 are available on the AS/400 except virtual disk support (VDISK).

During installation of the IBM AS/400 PC Support on the PC, the following functions are automatically configured:

Shared Folders The shared folders function allows the user to access PC information stored in folders in the AS/400 System (this function replaces VDISK).

Transfer The transfer function allows the user to transfer data between the AS/400 System and the PC.

Update The update function automatically updates the AS/400 PC Support programs on the PC, ensuring that the most appropriate level is installed on the PC.

Optionally, the following functions may be configured during installation:

Message The message function allows the user to send and receive messages from other PCs.

Virtual Printer This function allows the user to use printers attached to the AS/400 System as though they were directly attached to the PC.

Workstation The workstation function allows the user to sign on to the AS/400 System through a display session. Up to five separate sessions are supported, which can be any combination of display, graphic or printer sessions.

Organizer The organizer function allows both PC functions and AS/400 functions to be run from a single AS/400 menu on the PC.

8.3.4.2 5250 Emulation without IBM AS/400 PC Support

Any of the following available IBM options can be used if IBM AS/400 PC Support is not needed:

- Enhanced 5250 Emulation
- Remote 5250 Emulation Version 2.0
- Workstation Emulation Program.

The 5250 Emulation products will be used in the same way as they were on System/3x, but only to perform workstation functions on the AS/400 System. No IBM AS/400 PC Support functions can be invoked from an emulated session.

8.3.5 LAN PrintManager

The Local Area Network PrintManager licensed program (6317-042) provides device management support for attachment of a 3820 Page Printer to an IBM Token-Ring Network or an IBM PC Network.

The LAN PrintManager allows users on a LAN workstation to process 5151 ASCII print or text files created by PC application programs for printing on the 3820 Page Printer. The 3820 attaches to a specified IBM PC LAN Program print server on the LAN which may also be used as a LAN workstation when no PrintManager files are being printed.

8.3.5.1 Functional Description

LAN PrintManager uses the print services support provided with the IBM PC LAN Program. It adds user-specified formatting parameters to a 5152 ASCII print or text file created by a PC application and invokes IBM PC LAN Program print services which transmit the file to the server. The IBM PC LAN Program print services on the server then transmits the file to the LAN PrintManager device driver for printing on the 3820 Page Printer.

A series of hierarchical menus allow the user to specify page format and invoke the system services required for execution. The support parameters provide facilities to:

- Select from 54 IBM-supplied uniformly spaced and mixed-pitch fonts, including representations of the 5152 fonts.
- Select one of four print orientations (0, 90, 180, 270 degrees).
- Select paper size.
- Select either simplex or one of two duplex print modes.
- Specify the paper source as either the paper bin, cassette, or one of two predetermined combinations from both the bin and cassette.
- Set margins.
- Set initial line spacing.

- Specify the number of copies of the entire print file.

Additional supporting services allow the user to:

- Set an error limit threshold.
- Set tabs.
- Define the fonts to be used with each job.

8.3.5.2 Hardware Requirements

The PC serving the 3820 must have an SDLC communications adapter card and communications cable.

- An EIA Interface Cable is required for modem attachment.
- A self-clocking external modem or modem eliminator which supports the EIA RS232C interface and protocol supporting point-to-point, non-switched common carrier service.

Attachment of an IBM 3820 Page Printer to the IBM Token-Ring Network, IBM PC Network (Broadband) or IBM PC Network Baseband requires that the IBM 3820 be attached to a PC or PS/2, operating as an IBM PC LAN Program file/print server.

LAN workstations using the facilities of PrintManager to create and schedule print jobs for the 3820 must have a minimum of 384 Kbytes of memory.

8.3.5.3 Software Requirements

The IBM LAN PrintManager on an IBM Token-Ring Network, IBM PC Network (Broadband) or IBM PC Network Baseband requires:

- IBM PC/DOS 3.3 or 4.0
- IBM LAN Support Program V1.10
- IBM PC LAN Program V1.2 or IBM PC LAN Program V1.3 Base Services.

8.4 Office Support

Several approaches are available to support office functions on a LAN. The office system could be for LAN workstations only, using Personal Services/PC, or a System/370 host-based office system connecting to office products on the LAN. PS/PC is used to connect to DISOSS, and the PROFS feature PROFS PC is used to connect to PROFS in a VM environment.

A third alternative is a System/36 or AS/400-based office system for the IBM Token-Ring Network. The following sections take a look at the functions provided by PS/PC, PROFS PC, and the System/36. The AS/400 solution has been covered separately in "AS/400 PC LAN Support" on page 244, most functions are very similar to the System/36.

8.4.1 Personal Services/PC

Personal Services/PC is an office-oriented mail management system using IBM PCs and/or PS/2's. It provides a comprehensive and easy-to-use set of office systems functions for all users in the office environment. Operating as an application that supports Document Interchange Architecture (DIA) on the PC or PS/2, Personal Services/PC offers a wide range of automated mail functions.

8.4.1.1 PS/PC Functions

The functions include sending and receiving messages, documents, and PC files. Information may be transmitted in one of two basic ways:

1. Through DISOSS/370, where information being sent is stored until it is retrieved by the recipient. Information may be distributed within a single DISOSS/370 system or across multiple DISOSS/370 systems using SNA Distribution Services (SNADS).
2. Peer-to-peer (directly between PCs) with Personal Services/PC.
 - Personal Services/PC sends and receives the following "mail types" using IBM Document Interchange Architecture (DIA):
 - IBM Revisable Form Text Document Content Architecture (RFTDCA) data stream, for interchange with other IBM word processing programs or systems supporting this IBM data stream format.
 - IBM Final Form Text Document Content Architecture (FFTDCA) documents.
 - Personal Computer DOS files.
 - Messages.
 - Notes, which are messages associated with a document or file. (A simple revision capability is provided for notes and messages.)
 - Personal Services/PC provides file cabinet functions, which enable the user to:
 - Work with new mail.
 - Work with the entire contents of the file cabinet, which contains all items that have been sent or received.
 - Selectively review and work with a portion of the file cabinet content.
 - Forward an item, with or without a note.

- Reply to an item.
- View an item, which can be a message, note, final-form-text (FFTDCA) document, or a PC printer file.
- Change information about an item in the file cabinet.
- Delete an item from the file cabinet.
- Print a final-form-text (FFTDCA) document or PC printer file.
- Transform a document from PC printer file format to final-form-text (FFTDCA), or from final-form-text (FFTDCA) to PC printer file format.
- Annotate individual items in the file cabinet with tags of up to eight characters, such as "newmail", "old", or "personal", to assist in categorizing and organizing the content of the file cabinet.
- Nicknames:
 - Users can have a list of up to 100 nicknames to be used in place of user IDs when sending mail. These nicknames expand into full user IDs during the send operation.
 - Nicknames can be referenced in distribution lists.
- Distribution lists:
 - A distribution list is a predefined set of recipients.
 - Up to 50 distribution lists can be defined and maintained.
 - An individual distribution list can contain up to 50 recipients.
 - Distribution lists may be combined during a single send operation.
 - As a distribution list is selected, the user is given the option of deleting entries before completing the send operation.
- Defaults for personal file location, customization, and communications-related information can be entered and stored once and easily modified as required.
- A trace facility, which can be activated and deactivated by the user, is provided. Both PC and host operations can be traced to assist in problem diagnosis and resolution.
- A help facility can be invoked by a single stroke of a function key. "Help in context" provides guidance and assistance with the topics, fields and concepts related to the current screen.

8.4.1.2 PS/PC Operating Environment

PCs, PS/2's attached to a LAN can use PS/PC to provide three different types of office environments:

- PCs on the LAN can be connected to a DISOSS/370 Office System via any of the System/370 gateways described in Chapter 7.
- PS/PC can be used locally on the LAN to provide a office functions between peer workstations.
- PS/PC can be used to communicate with a Series/1 being used as an office systems server, using the IBM Series/1 Office Connect Program.

8.4.2 PROFS PC Support

The PROFS PC Support feature of PROFS Version 2 extends many of the powerful functions of PROFS to the IBM Personal Computer family. Used in conjunction with PROFS V2 at the host, this feature is designed to provide the PC workstation user with many PROFS functions. For most users, a host PROFS session would be initiated only to transfer PROFS mail or other files or to use PROFS or VM functions that are not available at the PC.

PROFS PC uses a set of menus which are designed to be similar and complementary to those on the host PROFS system. A significant number of PROFS functions are supported by this feature including in-basket processing of both notes and documents, viewing and processing of mail, and local printing.

In addition, the PROFS PC Support feature enables the user to easily store and mail PC files and to store groups of files on the host PROFS data base for subsequent retrieval. These files can be DisplayWrite documents, spreadsheets or other application reports. Documents created on DisplayWrite 1, 2, 3 or 4 can be easily exchanged with other PROFS users and PROFS PC users.

PROFS PC users can customize the support feature to their own needs and operating environment and to provide additional function.

The PROFS PC Support feature is a complete replacement of the former PROFS/PC Program Offering, providing additional function and better usability.

8.4.2.1 PROFS PC Functions

PROFS PC Support provides the following functions:

- Distributed PROFS Function
 - Get new and current mail (including notes and documents).
 - The following note processing functions are supported: View, Create, File, Forward, Print, Erase and Reply.
 - Text from PC files can be included into notes, and notes can be stored in PC files.
 - Document Processing functions provided are: View, File, Forward, Print and Erase.
 - Personal PC mail log
- Document Interchange Capabilities
 - PROFS PC has a menu-driven procedure to store PC files into a PROFS data base, and mail them to other PROFS users.
 - Multiple files can be sent to the PROFS host system using one transfer request.
- Communication Flexibility
 - Communications Profile.
 - Additional 3270-PC family members supported.
 - Asynchronous Communications support.
 - Support of other communication adapters through exits.
- Usability Features

- Consolidated Mail functions.
- PC user exits.
- Color support.
- User exits at the PROFS host system supporting document transformations.
- Use of commands to bypass menus.
- Menus can be tailored.
- National Language Support
 - PROFS PC Support provides language support equivalent to the PROFS Version 2 host system.

8.4.2.2 PROFS PC - PC, PS/2 Component

The PROFS PC Support feature is provided on a tape that contains the documentation and code necessary to install and distribute the product. The steps for installation and distribution are as follows:

- Install the feature tape on the host system according to the instructions included with the feature tape.
- Download the PC code to a PC following the instructions included with the feature tape.
- Create the "master" PC diskettes using the utility supplied and the documentation included with the feature tape.
- Distribute copies of the "master" diskettes to the individual users.
- Install the PC code on individual PCs or PS/2's following the installation instructions contained in the manual for the PROFS PC Support feature.

8.4.2.3 PROFS PC - Host Connection

PCs using the PROFS PC support feature can communicate with PROFS using any of the System/370 gateways described in Chapter 7.

8.4.3 System/36 Office

When the System/36 is attached to the IBM Token-Ring Network, PCs on the LAN can have access to System/36 office products. PC Support/36 with the workstation feature is required.

The workstation feature provides support for DisplayWrite/36 and Personal Services/36. Text functions are provided to optimize the performance of text operations when using DisplayWrite/36 via the Token-Ring Network. These functions include the following:

- Word wrap
- Continuous text entry
- Tab entry and control
- Split screen format
- Prompting.

8.4.4 Series/1 Office Connect Program

The Series/1 can be an office systems gateway for the IBM PC Network Baseband, the IBM PC Network (Broadband) and the IBM Token-Ring Network when the IBM Series/1 Office Connect Program is used. The Series/1 Office Connect Program provides document distribution services and document library services through the implementation of Document Interchange and Distribution Architectures.

The Series/1 Office Connect Program provides an office connection for users on the Series/1, and workstations on an attached LAN to the following office systems:

- IBM DISOSS/370
- IBM Personal Services/36
- IBM Personal Services/38
- Other IBM Series/1 Office Connect Systems.

The library facilities provided by the Series/1 Office Connect Program allow a Personal Services/PC 1.2 user to file, search for, retrieve, print or delete documents stored in the Series/1 library. The program also provides the facility for PC DOS files to be exchanged between an IBM PC attached to the Series/1 Office Connect Program, and an IBM PC user attached to any of the above systems, via Personal Services/PC.

8.4.5 PROFS Application Support Facility

8.4.5.1 PASF Functional Overview

PROFS Application Support Facility (PASF) is a PROFS V2 R2.2 feature which allows work with other products such as DW/370, VM/AS Release 5, SQL/DS, and QMF if installed. PASF helps to integrate these products from the user's perspective, and allows them to share information.

The PC interface for PROFS Application Support Facilities is included with the VM host product. It contains the files which must be downloaded to the workstation to support the connection.

The PC/PS user can access PASF via 3270 emulation, but the PC PASF interface allows access to other PC products, such as DW4, Host Data Base View (HDBV), or Personal Decision Series V2, from the PASF PC interface menus, and gives access to most functions shown on the 9370 PASF interface menu.

VM/ISPF is required on the 9370 to provide front-end menus to PROFS and others products, with PASF.

8.4.5.2 PASF Connectivity Example

As an example, a user may be using PROFS Application Support (PASF) on an intelligent workstation (PC or PS/2) connected to the 9370 Workstation Adapter or Token-Ring Subsystem.

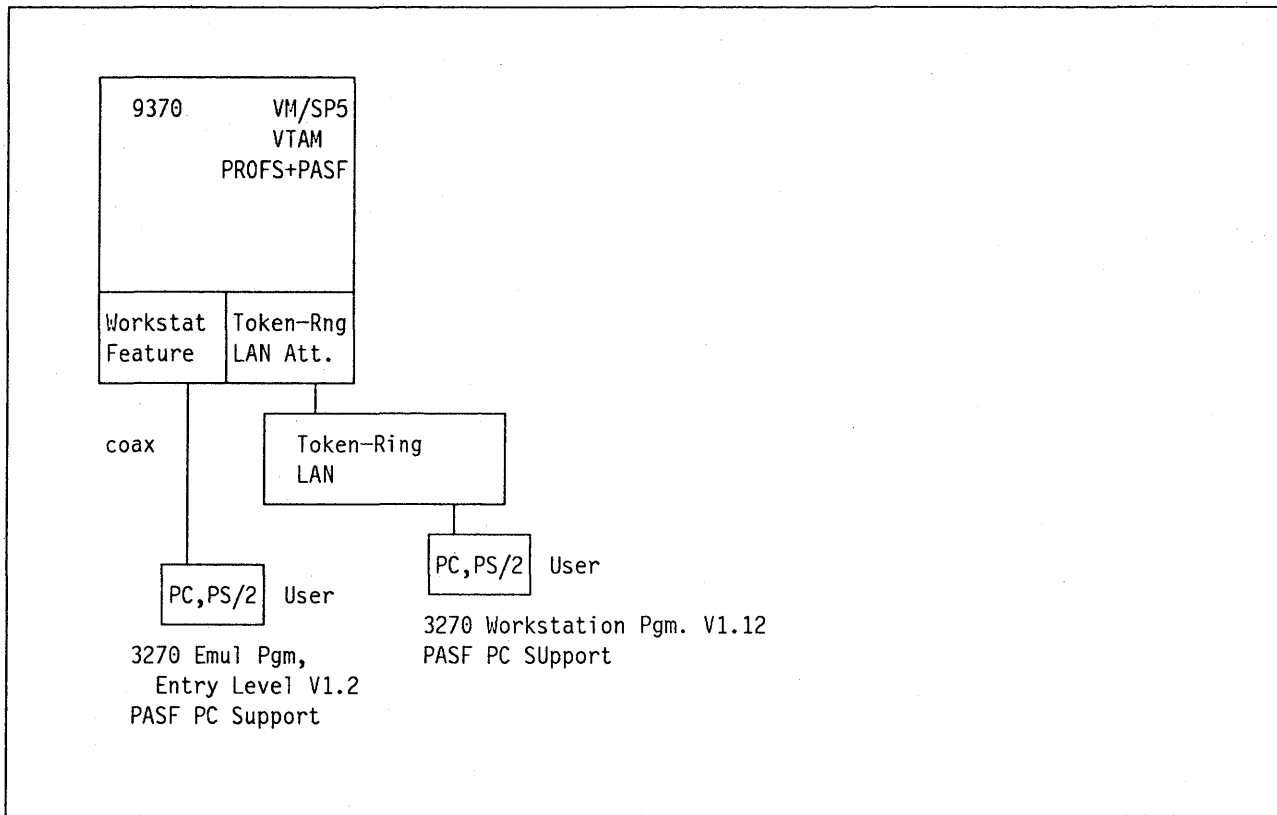


Figure 105. PASF Connectivity with a PC or PS/2

9. LAN Management and Recovery

As local area networks grow in size and function the need to manage and control the LAN becomes increasingly important. Component failures and bottlenecks within the networks can become more difficult to manage. How, for example, do you manage a remote LAN where there is no technical support staff to look after it ?

Some LAN-attached devices are of special importance in the operation of the network, for example, backbone bridges, print servers, large file servers, or such critical cabling components as the 8220 Optical Fiber Converters. Additional management function to monitor these devices may improve availability management. This is known as *critical resource management*.

Network management tools are needed to provide information on the LAN status and performance. These tools should also be capable of providing network management support for remote networks, and provide a means to control them from a central site. In general, central site network management should not only receive LAN level alert information but the network operator should also be able to issue commands to be executed by LAN stations.

For many installations, a frequent question is "how much network management function is required to manage a LAN of any given size, and at what point is additional capability required"? The answers to such questions depend on many factors, such as the importance of high availability to the end-users. A general recommendation is that by the time a LAN has 30 to 40 workstation attached to it, it should have at least one device monitoring the LAN to provide network management services.

When the LAN environment is connected to a larger SNA network with central site management tools available (that is NetView), integration of LAN management into total network management is highly recommended.

This chapter looks at various IBM LAN management products for PC/DOS or OS/2 Extended Edition V1.1 environments. including some which implement limited LAN management capability as well as those providing more comprehensive function. 1.1 environment.

- PC/DOS 3.3 or 4.0
 - IBM PC 3270 Emulation LAN Management Program V1.0
 - IBM LAN Manager V1.0.
- OS/2 Extended Edition 1.1
 - IBM LAN Manager Entry V1.0
 - IBM LAN Manager V2.0.

In addition NetView/PC will be discussed as one approach to communication between either of the two IBM LAN Manager products and NetView in a host system.

These LAN management products cover the network management requirements for LANs ranging in size from a small, single-segment IBM PC Network Baseband to larger, high-function, multi-segment bridged 4 Mbps or 16

Mbps Token-Ring Networks. The latter may include local or remote segments or possible interconnection with IBM PC Network (Broadband) segments.

The last section in this chapter will describe the IBM Token-Ring Network Trace and Performance Facilities. This product, operating on a single IBM Token-Ring Network segment, allows continuous measurement of ring utilization, and supports selective tracing of frames circulating the ring.

9.1 IBM's Total Network Management Strategy

In IBM Network Management Strategy, often referred to as the C&SM (Communications and Systems Management) strategy, network management is conceptually separated from the transport of data through the network, and any network component can implement one or both responsibilities.

Various management disciplines are addressed by the C&SM strategy:

- Problem management
- Operations management
- Performance management
- Configuration management
- Accounting management
- Change management.

These may all be part of the function of a given network component. Whenever a network error is detected, it should be reported. The network manager also needs statistics about use and performance of the network to allow for network planning and accounting. Also the network component should provide information about changes in network topology.

Regardless of the way these functions are implemented, the ultimate goal is to maximize availability and capacity of the network with respect to the network users.

9.1.1.1 Network Management Structure

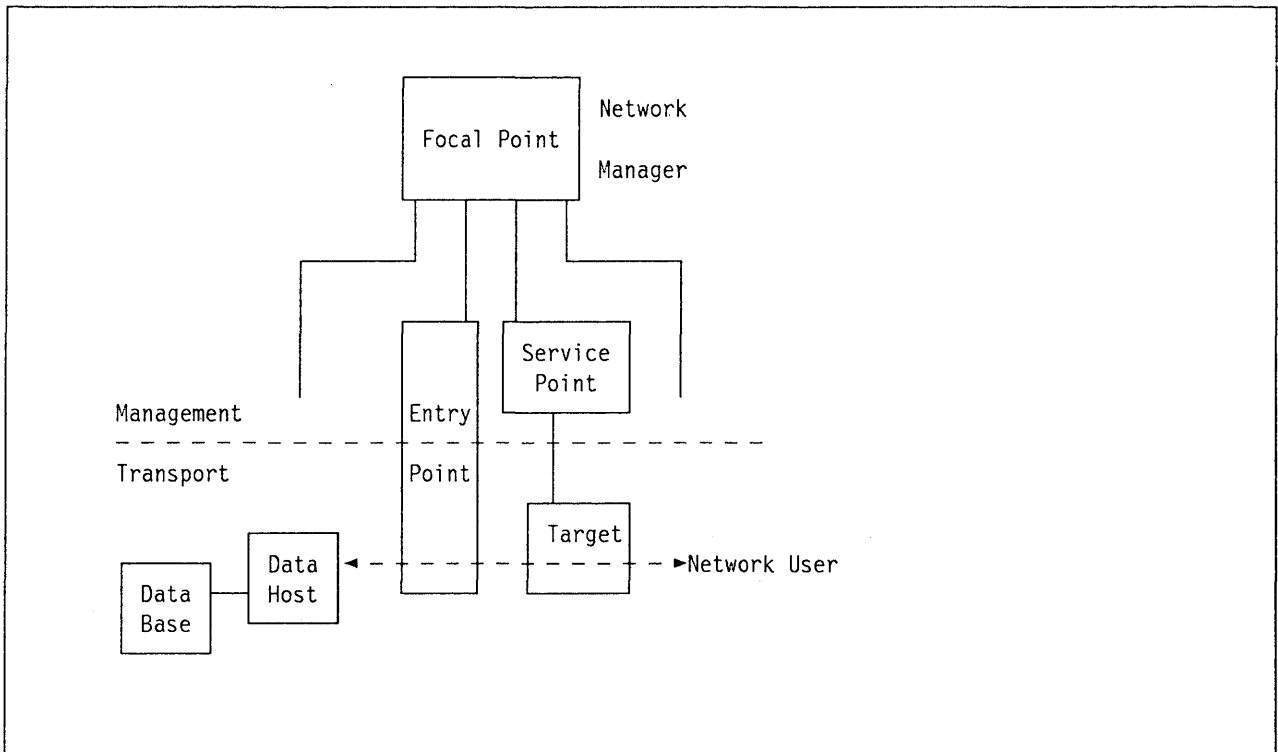


Figure 106. Relationship between Transport and Management Function

Four entities are defined within IBM's Total Network Management Strategy.

- **Focal point**

This entity manages all of the remotely and locally attached network components in its domain from a central location for one or more of the above-mentioned network management disciplines. This centralized management provides a global view of the network required to understand the interrelationships between network components. It also consolidates management resources and expertise.

- **Service Point**

The service point makes a network component visible to the network manager residing at the focal point. It handles the transportation of network management data between a network component, called a target, and the focal point. The service point shields the focal point from specifics of the target, but does not have any transport responsibilities beyond the movement of network management data.

- **Entry Point**

This entity has the responsibilities of a service point with respect to network management as well as regular data transportation responsibilities through the network.

- **Target**

The target is a network component that does not have its own direct access to the network manager. It only provides regular data transport, and relies on a service point for the network management part.

The focal point, service point and entry point are considered to be within the network management system. The target is managed by the network

management system but is not part of it. The four network management entities interact, as shown in above Figure 106.

9.1.1.2 Network Management Interfaces

Within the network management system, the focal point interacts with a service point and with an entry point transporting network data. The communication within the network management system is based on a subset of SNA, called the *Network Management Vector Transport* (NMVT), which describes the communication protocols and the content of the network management data.

Using NMVT protocols, a service/entry point reports outages for itself or any attached component to a focal point in the form of *alerts*. Similarly, the network manager in a focal point uses defined formats and protocols to transmit *commands* to the target.

These alerts and commands are defined independently from the specifics of a target device or subsystem. The formats and protocols between the service point and the target are intentionally undefined; each target may have a different interface. The target's service point must handle the specifics for that target. The target must be capable of indicating outages and responding to commands and it must supply information to the service point allowing the service point to provide the focal point with accounting, planning or performance information. The service point must translate the formats and protocols of the target-service point interface into the NMVT formats and protocols.

Any general-purpose service point must provide a programming interface to handle the particularities of a given target.

9.1.1.3 LAN Management and the Network Management Strategy

Within the Network Management Strategy a LAN subsystem may be considered a target and the management server of the LAN a service point provider.

As with any target, the peculiarities of a particular LAN environment will influence the relationship between the service point and the LAN.

Regardless of the size of the LAN, varying from a few stations to several thousand, the enterprise-wide communication system must have end-to-end network management.

LAN management must provide LAN traffic monitoring capabilities, function to manage the physical attachment of LAN devices and enhancements to global management of distributed applications and resources.

Local LAN management server functions can be integrated with a service point when the LAN is part of a larger wide area network, and thus relocated to a distant focal point. While the LAN subsystem is then controlled by the overall network management system, the local LAN management capability still remains if needed. LAN operation and management can be shared, if desired, between a local operator via a local operator interface and the focal point network manager.

9.2 IBM LANs and Network Management

Although sharing of a common medium is an essential characteristic of a local area network, control of LAN traffic is distributed between the participating devices. Each station implements significant self-management and network-monitoring function. Therefore, in a LAN environment, the first level of network management is provided by the individual LAN stations.

At this point it may be worthwhile to review CSMA/CD and Token-Ring Network protocols, as presented in "LAN Medium Access Protocols" on page 16, with respect to LAN management capabilities inherent in the MAC level protocols.

Protocols for a CSMA/CD based LAN provide limited LAN management function at the MAC level. Collision recovery is the major function provided. To support function such as identification of problem adapters, the IBM CSMA/CD products IBM PC Network (Broadband) and IBM PC Network Baseband, implement network management functions via special LLC frames. These frames are emitted periodically by each station on the LAN. For example, these frames identify the sending station address and contain that station's counts for number of transmitted frames, number of collisions and number of frames rejected due to congestion. This information can be used by a LAN management function to keep track of station activity and to identify potential problems.

Essential management concepts in the token-passing ring include the *active monitor*, the *neighbor notification process* which is the basis for fault domain identification, *beaconing*, a process that deals with hard errors and the *soft error reporting mechanism*. The IBM Token-Ring Network uses also IEEE 802.2 logical link control level network management frames.

Error information generated at the LAN MAC protocol level, can be collected and analyzed for a given LAN segment by a LAN error monitor function (LEM). On an IBM Token-Ring LAN segment this server function is called ring error monitor (REM). In general, the LAN error monitor function can be enabled in most attached LAN devices whenever a network failure or performance degradation is detected.

In addition, other management servers can be installed on a LAN, for example, LAN parameter server (LPS or RPS on a Token-Ring), configuration report server (CRS), LAN bridge server (LBS) and LAN reporting mechanism (LRM). These server functions are discussed in "IBM LAN Bridges" on page 163.

9.2.1.1 LAN Management Products Overview

The LAN management products announced by IBM in 1988 execute in an Operating System/2 Extended Edition V1.1 environment to extend the range of management functions and connectivity options between service point and focal point available.

Figure 107 on page 258 presents an overview of the various IBM LAN management products, their hierarchy within the network management system and the coverage within the LAN subsystem.

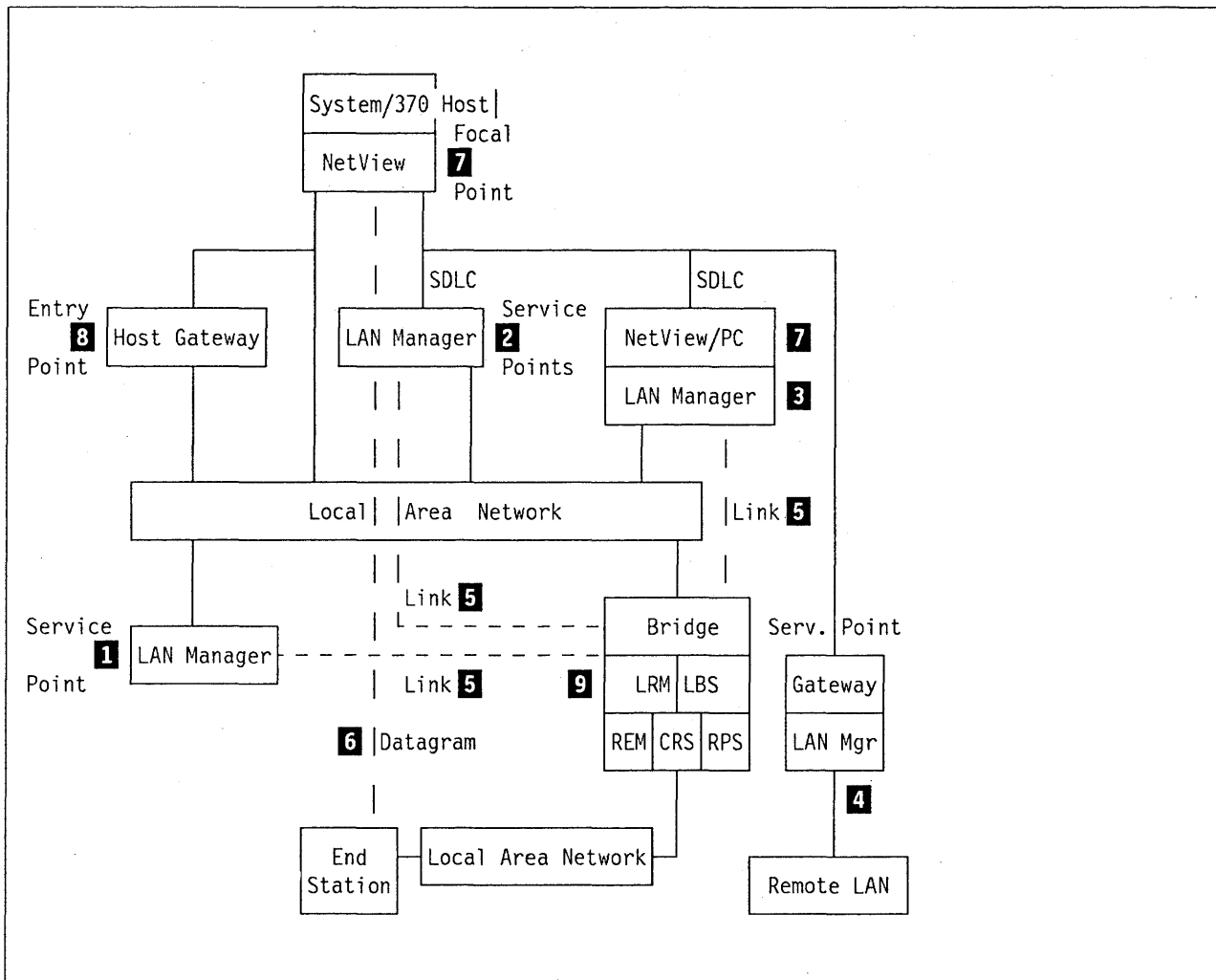


Figure 107. LAN Management Products Hierarchy

The following list explains the reference numbers in Figure 107. Additional details on the products are provided later in this chapter.

1. This LAN Manager refers to **IBM LAN Manager V2.0**, operating in an Operating System/2 Extended Edition V1.1 environment. It is capable of maintaining up to 64 *reporting links*, with bridges. Reporting links are network management LLC links which are implemented by either IBM Token-Ring Network Bridge Program V2.0 or IBM Token-Ring Network Bridge Program V2.1³⁴ or IBM PC Network Bridge Program³⁵.

LAN Manager (as a Service Point), communicates with NetView (as the focal point) via a 3174, 372x or 3745 token-ring gateway or directly via a 9370 Token-Ring attachment if NetView resides in this system. This allows LAN network management to be extended to NetView by using the *service*

³⁴ IBM Token-Ring Network Bridge Program V2.1 is a local or remote bridge between two token-ring segments, (4 or 16 Mbps).

³⁵ IBM PC Network Bridge Program is a local bridge connecting one PC Network (Broadband) segment to another or to a Token-Ring Network segment (4 or 16 Mbps), or connecting two Token-Ring Network segments (4 or 16 Mbps).

point control services of NetView at a System /370 host, including the service point control interface (SPCI) facility. SPCI allows the NetView operator to issue commands to the LAN Manager and receive responses back.

If focal point management of only a single LAN segment is required, the same host connections can be used with IBM LAN Manager Entry V1.0 (also operating under Operating System/2 Extended Edition V1.1).

2. This LAN manager also refers to **IBM LAN Manager V2.0**. If host gateway capabilities are not available to support connection with the focal point, the SDLC communications support included in the Communications Manager of OS/2 EE may be used to support communications between LAN Manager and NetView in the host. Again, IBM LAN Manager V2.0 will support multi-segment LAN management from a focal point and/or from the local LAN Manager station. IBM LAN Manager Entry V1.0 offers only single LAN segment management from a focal point. Nor local LAN management function is provided by IBM LAN Manager Entry V1.0.
3. The third LAN Manager referenced in Figure 107 can be either IBM LAN Manager V1.0 (under IBM PC/DOS 3.3 or 4.0) or IBM LAN Manager V2.0 (under Operating System/2 Extended Edition V1.1) running as a NetView/PC application. In this case NetView/PC provides the Service Point function connected to the NetView focal point in the System/370 Host. Neither of the products offered for single LAN segment management can run as a NetView/PC application.
4. This reference depicts management of small, remote LANs connected to a central host system via a gateway function. The applicable IBM products are IBM PC 3270 Emulation LAN Management Program V1.0 (under IBM PC/DOS 3.3 or 4.0) and IBM LAN Manager Entry V1.0 (under Operating System/2 Extended Edition V1.1).

In addition to management of host-connected sessions the central site network management can also support the remote LAN subnetwork. Usually there will be no local network management expertise in the remote location. Therefore the LAN management solutions proposed in this environment are operated exclusively from the focal point's NetView console. The Service Point function resides in the Gateway.

5. Reference **5** illustrates the dedicated LLC sessions, called reporting links, between IBM LAN Manager V1.0 or IBM LAN Manager V2.0 and one of the bridge products. A bridge is capable of maintaining up to four concurrent links with four different LAN Managers. However, only one link connects to a *controlling* LAN Manager, while the remaining links connect to *observing* LAN Managers for this bridge. A controlling LAN Manager has exclusive authority to perform a number of specific LAN management commands.
6. An important feature offered only by the LAN management products operating under Operating System/2 Extended Edition V1.1 (IBM LAN Manager V2.0 and IBM LAN Manager Entry V1.0) is called *Alert transport service for applications*. This function allows an application running in a LAN station and acting as a reporting entity, to send alerts to NetView at the focal point via the LAN Manager (and across bridges in the case of IBM LAN Manager V2.0). Implementation of this capability uses a particular protocol between a reporting entity and the LAN Manager. This protocol is called *Management Frame Transport Service*. Together with the NMVT alert

transport mechanism between LAN Manager and the focal point, this protocol constitutes the *application alert transport service*.

7. NetView's Service Point Command Services introduced earlier allows LANs (and other systems) to be incorporated into an automated operations strategy, enhancing human operator action with programmed control. NetView provides a number of other interfaces and functions:

- *Hardware Monitor*: shows failures of equipment, operating systems and application software, and providing diagnostic tools.
- *Session Monitor*: supports detection and diagnosis of problems related to SNA sessions and providing SNA session information.
- *Status Monitor*: displays the status of the SNA network and provides a capability to reactivate network resources (lines, PUs, LUs).
- *Command Facility*: allows users to control the SNA and non-SNA portions of the network via commands to VTAM, NCP, the Operating System and NetView/PC.

The NetView-to-NetView/PC interfaces are represented in Figure 118 on page 292.

8. The LAN host gateways, 3174, 372x or 3745 as well as the 9370 token-ring attachment act as entry points within the network management system. They have data transportation responsibilities within the SNA network but may also provide management services to the network.
9. The internal structure of the bridge is described in ("IBM LAN Bridges" on page 163). The bridge component called LAN reporting mechanism is responsible for maintaining logical connections (links) with up to four different LAN Managers. Through this server function, a LAN Manager is also capable of changing bridge parameters.

The next remainder of this chapter describes the IBM LAN management product offerings from the standpoint of the different IBM LANs and provides more detailed descriptions of the capabilities provided by various hardware and software products.

9.2.2 IBM PC Network Baseband

Two LAN management products apply to the IBM PC Network Baseband as shown in Figure 108.

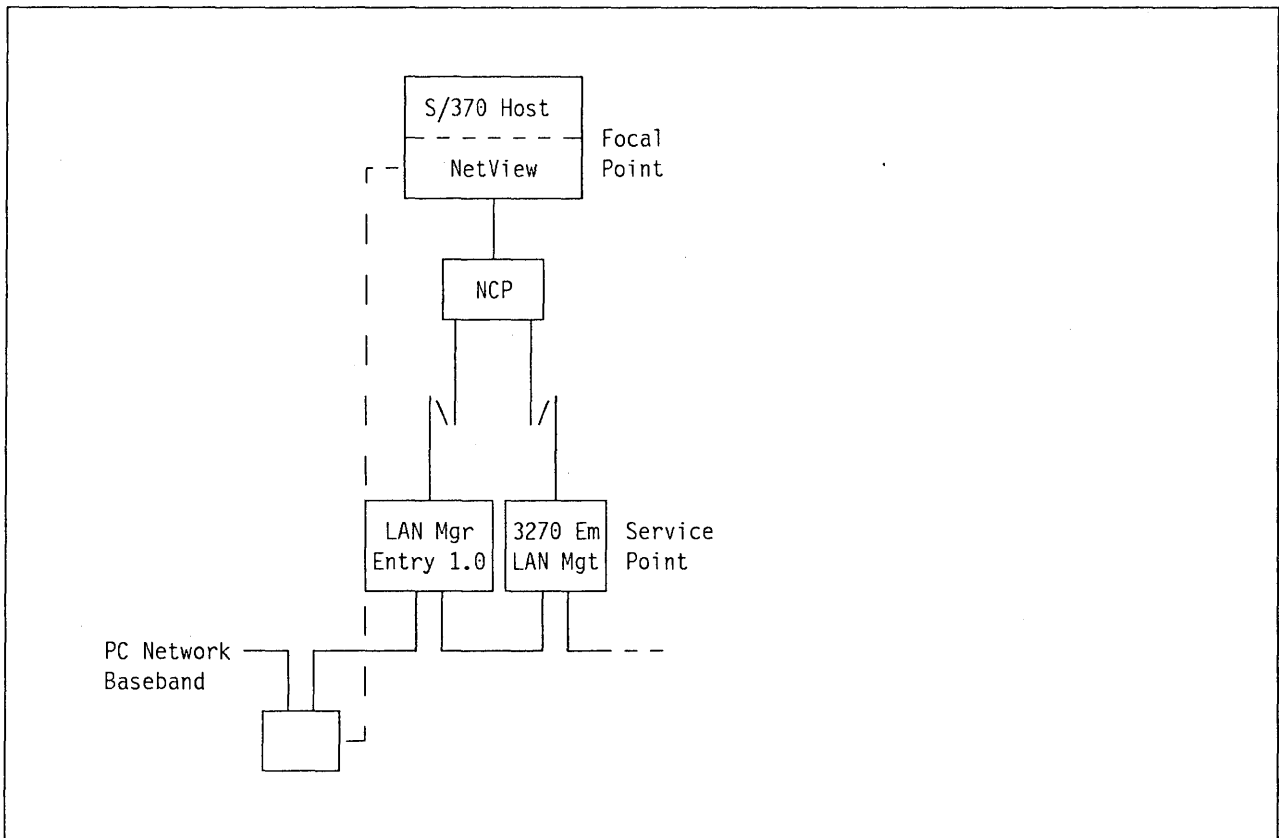


Figure 108. IBM PC Network Baseband - Network Management

- **IBM PC 3270 Emulation LAN Management Program V1.0** runs in a PC 3270 Emulation gateway station. The emulation software operates in a IBM PC/DOS 3.3 or 4.0 environment. IBM PC 3270 Emulation LAN Management Program V1.0 offers host alert forwarding capability using the SSCP - PU session available from the gateway function. No local LAN management operator commands or user interface are available.
- **IBM LAN Manager Entry V1.0** runs in a LAN station under Operating System/2 Extended Edition V1.1. It offers host alert forwarding as well as alert transportation services from LAN applications. The only communications path to NetView in the host system is offered by the integrated SDLC support included in the Communications Manager of OS/2. The same station can be used for other applications concurrently.

9.2.3 IBM PC Network (Broadband)

The LAN management solutions applicable to the IBM PC Network (Broadband) are represented in Figure 109.

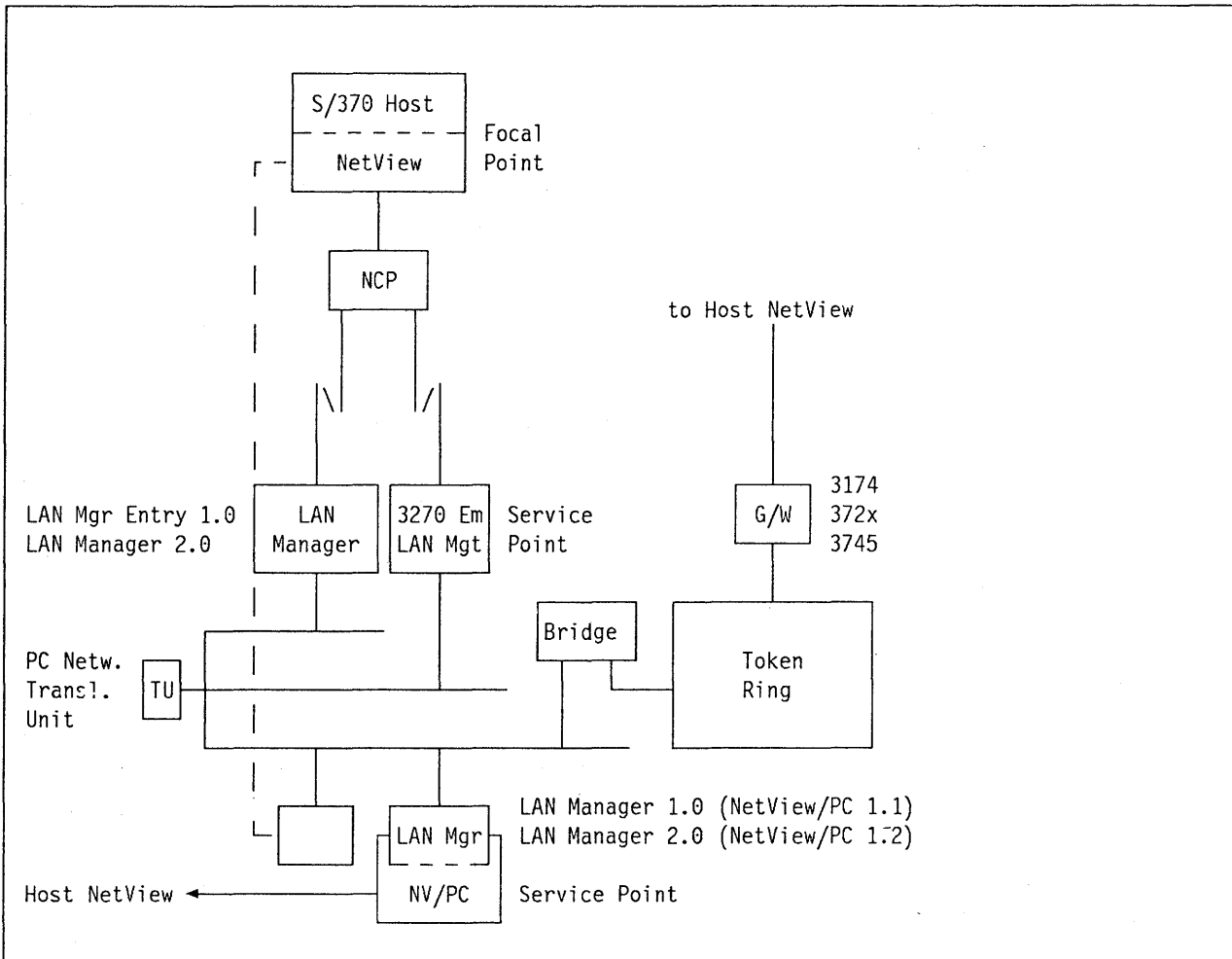


Figure 109. IBM PC Network (Broadband) - Network Management

Prior to the availability of the LAN management capabilities shown in the picture, the *PC Network Analysis Program* provided some management and diagnostic function.

PC Network Analysis Program will monitor a single IBM PC Network (Broadband) segment to provide information on:

- Traffic on the bus.
- Collisions.
- Misalignments.
- CRC errors.
- Adapter resource errors.
- Retransmissions and aborted frames.

This product also provides detailed traffic patterns. PC Network Analysis Program will notify to its operator:

- Adapter thresholds exceeded.
- Network thresholds exceeded.

- Excessive traffic.
- Station absence.
- Name conflicts.

This product may be sufficient for local LAN Management on a small, non-host connected IBM PC Network (Broadband).

For larger, possibly interconnected PC Network (Broadband) environments and/or when the LAN is connected to a host with central site management capabilities, one of the products presented in Figure 109 on page 262 should be considered.

For smaller, non-interconnected PC Networks connected to a NetView host, IBM PC 3270 Emulation LAN Management Program V1.0 applies in a IBM PC/DOS 3.3 or 4.0 environment or IBM LAN Manager Entry V1.0 under Operating System/2 Extended Edition V1.1 just as for the IBM PC Network Baseband.

Larger IBM PC Network (Broadband) LANs require the local LAN management function offered by one of the two LAN Manager products.

If the IBM PC Network (Broadband) is interconnected with other PC Network segments and/or IBM Token-Ring Network segments, only IBM LAN Manager V2.0 under Operating System/2 Extended Edition V1.1 can be used. To communicate with the NetView host, either the OS/2 SDLC support can be used or a host gateway attached to an interconnected Token-Ring segment, or IBM LAN Manager V2.0 can run as an application under NetView/PC 1.2. In the latter case, Remote Console Facility is not available. There is however a statement of direction expressing IBM's intention to provide this feature in the future. The Service Point Command Interface capabilities require NetView Release 3 in the host system.

Neither IBM LAN Manager V2.0 nor IBM LAN Manager Entry V1.0 can use a PC gateway to reach the host system since currently there is no OS/2 Extended Edition LAN gateway capability. There is also a statement of direction committing IBM to supply this capability in the future.

Both LAN management products running under Operating System/2 Extended Edition V1.1 provide the application alert transport services from a LAN station.

For a large, single segment IBM PC Network (Broadband), the necessary local LAN management function can be provided by IBM LAN Manager V1.0 running under PC DOS. The only communications connectivity to a System/370 NetView host is provided by running IBM LAN Manager V1.0 as a NetView/PC 1.1 application. In this environment the Remote Console Facility of Netview/PC is available but it cannot be enabled concurrently with host alert forwarding due to the 640 Kbytes memory limitation of PC DOS. IBM LAN Manager V1.0 does not offer application alert transport services to NetView, and it does not provide SPCI support. This means the NetView operator will receive alert notifications through the host alert forwarding facility, but cannot issue commands to the LAN Manager.

9.2.4 IBM Token-Ring Network

The IBM Token-Ring Network has a very rich MAC architecture, including extensive self-management and network-monitoring components as explained before.

In addition, the IBM Token-Ring Network adapters for Family 1 or Family 2 devices come with a diagnostic tool, the *Ring Diagnostic Program*, which enables the ring error monitor server function and provides a local operator interface for purposes of monitoring a single token-ring segment. Apart from a Ring Test command, the operator cannot actively manage the LAN segment.

Network management function on the IBM Token-Ring Network is not confined to PCs or PS/2's attached to the ring. Devices like the 3174, and the 372x or 3745 can send alerts to NetView for various types of error on the local LAN segment to which these devices are directly attached.

In the network management system, these devices are called entry points because they assume data transport and network management responsibilities.

The LAN Management solutions applicable to the IBM Token-Ring Network are represented in Figure 110.

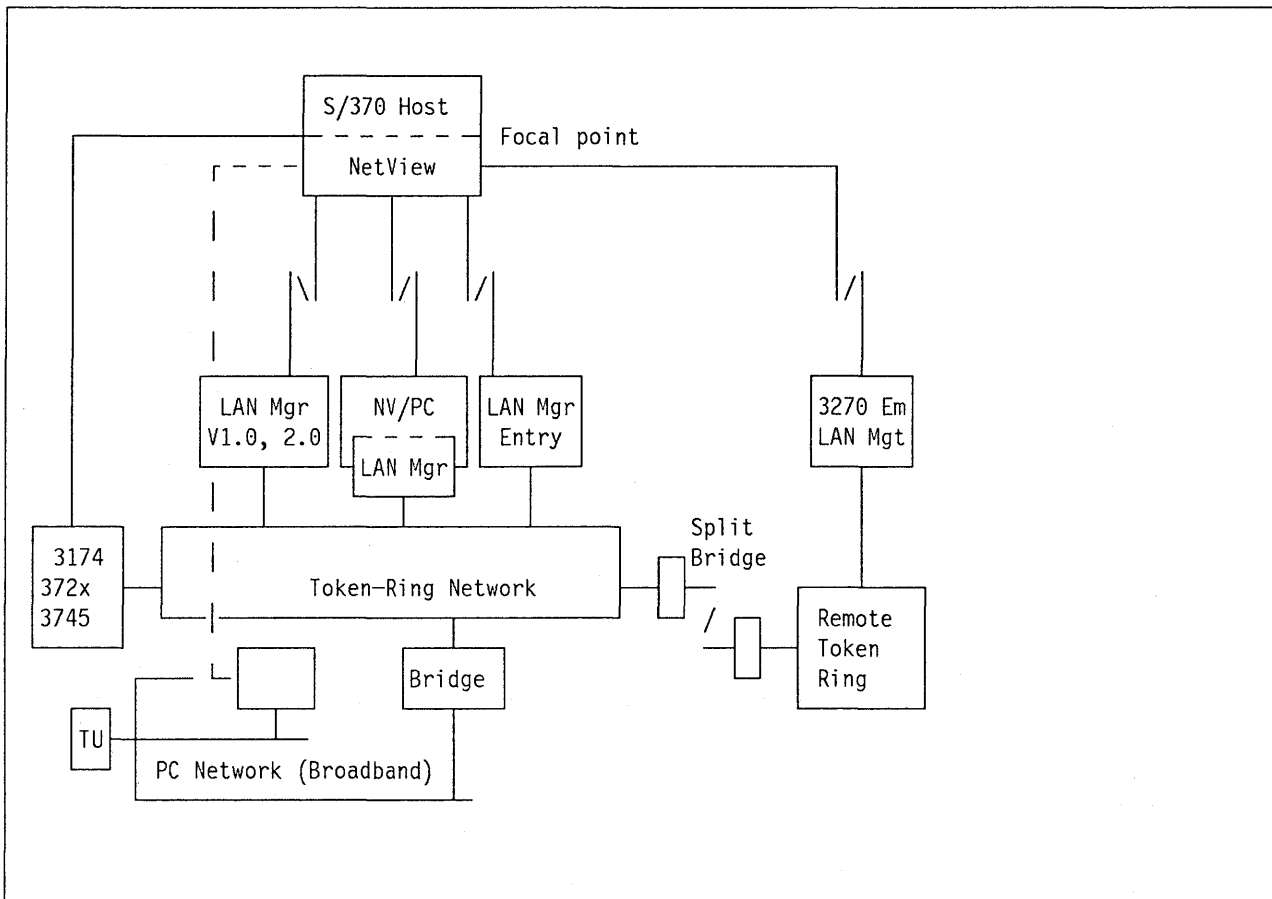


Figure 110. IBM Token-Ring Network - Network Management

The IBM PC 3270 Emulation LAN Management Program V1.0 and IBM LAN Manager Entry V1.0 apply also to monitor small, remote IBM Token-Ring

Networks and send alerts to a NetView host as they did for IBM PC Network (Broadband).

Remote token-ring segments, connected via IBM Token-Ring Network Bridge Program V2.1 (split bridge) to a backbone token-ring segment in the main LAN environment, can also be managed using IBM LAN Manager V2.0 by a local LAN Manager operator or from the NetView Release 3 console.

In general terms, the IBM LAN Manager V2.0 and IBM LAN Manager V1.0 functional capabilities are similar to those discussed in the previous section on IBM PC Network (Broadband). However, IBM LAN Manager V1.0 does not provide critical resource monitoring when operating on the IBM Token-Ring Network and can manage only 4 Mbps token-ring segments, interconnected by IBM Token-Ring Network Bridge Program V1.1.

A number of IBM LAN Manager V1.0 or IBM LAN Manager V2.0 functions are only effective in an IBM Token-Ring Network environment due to the nature of the MAC protocol. Others only have meaning and/or effect depending on the type of LAN segment.

9.2.4.1 3174 Gateway

3174 Gateway Models 01L, 01R, 51R, 02R or 52R with Configuration Support S Release 5 implement a subset of ring problem determination support. They can enable the ring error monitor (REM) server function for the ring to which they are directly connected, initiate beaconing and send network management data over the SSCP-PU session to NetView.

Like other token-ring attached host gateways, a 3174 gateway may provide the communications path for network management data between NetView and either IBM LAN Manager V2.0 or IBM LAN Manager Entry V1.0.

In accordance with the IBM Token-Ring Network Architecture, attached devices constantly monitor the token-ring traffic and their own attachment hardware for any possible problems. When a problem is detected, a frame is sent to the REM by sending an error MAC frame to the REM functional address (X'CO0000000008'). When such a frame arrives at the 3174, it copies the error information and sends it to NetView as a basic Alert. Alerts are created for both hard and soft error categories. These alerts contain error codes for specific LAN events.

The REM function in the 3174 is only a reporting function, commands cannot be sent from NetView to control the LAN via the 3174.

The 3174 gateway is capable of sending the following alerts to NetView:

- Alerts (NMVT 0)
- Link Events NMVTs (NMVT 1)
- Problem Determination Statistics (NMVT 25).

In test mode, from the port 0 screen, menu-driven panels allow users to display the event log, query adapter status, etc.

9.2.4.2 3720 and 3725

The 3720 or 3725 connection to the IBM Token-Ring Network does not implement a REM function. The NTRI monitors its own adapter, (the TIC) and is aware of beaconing conditions on the ring. When it detects a fault with itself or a beaconing condition it sends a generic alert ³⁶ to NetView.

If a device in session with a VTAM application experiences a problem that impacts the session, VTAM will provide additional information about the problem to NetView.

In addition to sending alerts to NetView, NetView also supports an NTRI trace. This enables problem determination to be done at a session level for connections using the NTRI gateway.

9.2.4.3 Token-Ring-Attached 9370

The 9370 may be configured to enable the REM server function at the token-ring attachment level. When an error frame is received, the error information is copied and sent to the Processor Console, where it is formatted and displayed to the console operator. The 9370 Processor Console is an intelligent workstation, attached to the 9370 and running a 9370 Processor Console program.

A LAN alert, when displayed at the processor console, may be translated into a basic alert and sent to NetView running in the 9370. This NetView may be an intermediate focal point and communicate network management data to a central focal point NetView, running in a System/370 host. Through special panels, provided with NetView in the 9370, the basic alert information may be transformed into a generic alert NMVT and sent to the central site NetView.

9.2.4.4 Token-Ring-Attached AS/400

OS/400, the operating system of the AS/400, provides support for network problem management using SNA alerts.

Alerts are created, based on messages that are sent to the local operator, to provide notification of problems with AS/400 hardware resources (devices, controllers, communication lines). Each AS/400 token-ring attachment is described to OS/400 as a communications line. In addition, software errors can be reported.

These local system messages can cause alerts to be created and sent to a focal point.

The AS/400 can be an intermediate problem management focal point, which receives and displays alerts.

When part of a network that has a System/370 Host running NetView, the OS/400 may route generic alerts to NetView.

Figure 111 on page 267 illustrates the OS/400 alert support.

³⁶ In a generic alert, the text that makes up the alert is represented by *code points*. Generic alert code points are used for the alert type, alert description, probable causes, user causes, install causes, failure causes, recommended actions and detail qualifiers.

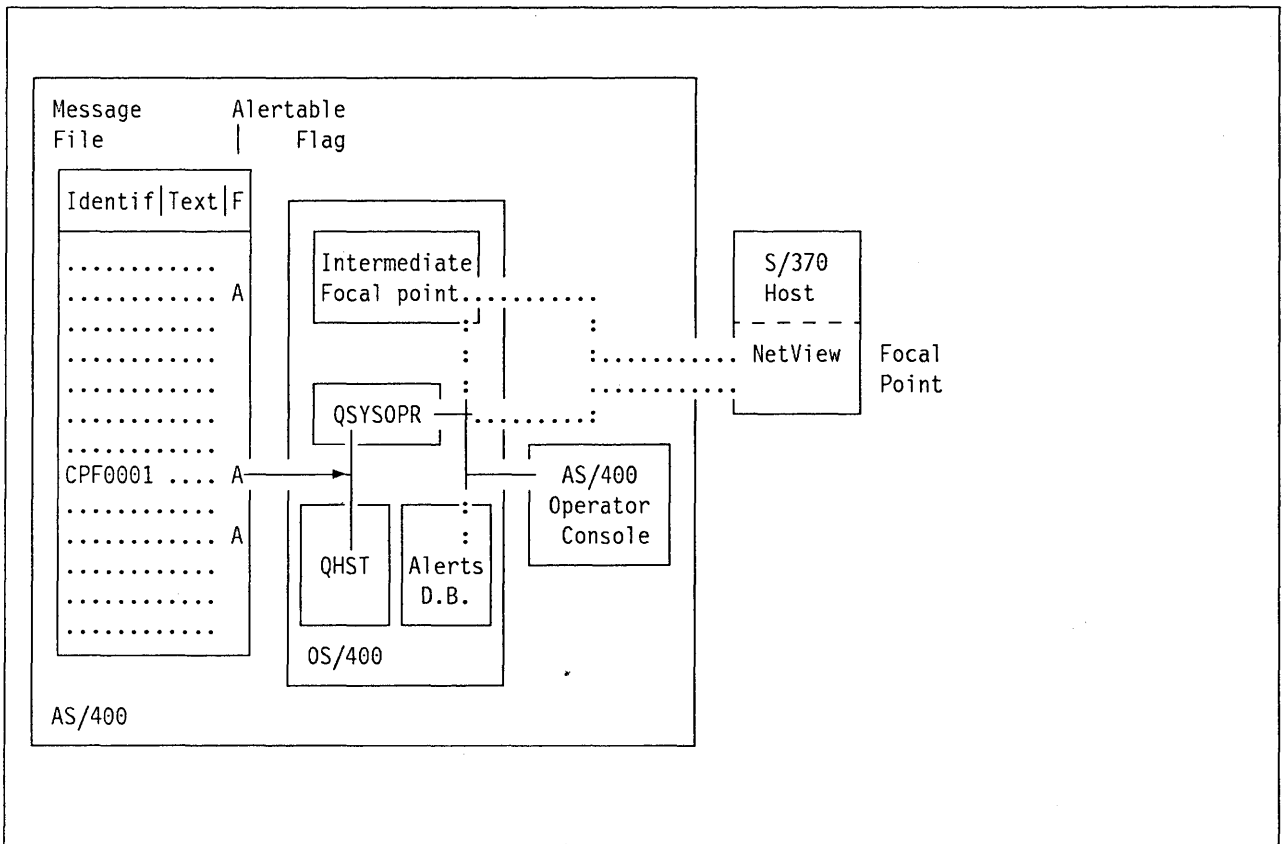


Figure 111. OS/400 Alert Support

Message identifiers or codes and associated message text reside in a message file of an AS/400, containing about 13,000 messages. A flag associated with each message indicates whether or not a message is "alertable", that is whether or not a message causes an alert to be generated when the related problem occurs. A limited subset of OS/400 messages has been defined as alertable. In addition, the local system operator can modify the alertable flag of particular messages.

When a problem occurs, a message is put in system operator message queue (QSYSOPR) and marked in the message history file (QHST). In the event of an alertable message, an alert is generated and sent to the appropriate focal point(s) as a generic alert.

Optionally, the local system operator can choose to log alerts on the AS/400 system in the alert data base. The system operator has commands to retrieve alerts from the alert data base, delete alert entries, etc. He may also generate an alert which has not been signaled by a message.

9.3 IBM LAN Manager

9.3.1 PC/DOS - LAN Manager V1.0

The IBM LAN Manager V1.0 provides LAN level network management functions for the IBM Token-Ring Network and the IBM PC Network (Broadband). The LAN Manager assists the user in performing fault isolation, error recovery, gathering network and station status information, and performing control functions.

The network management functions for the IBM Token-Ring Network include support for multiple rings. Up to 33 rings with a maximum of 260 stations per ring can be supported. To achieve this, the IBM LAN Manager V1.0 is capable of maintaining up to 32 dedicated LLC sessions with bridges running either IBM Token-Ring Network Bridge Program V1.1, IBM Token-Ring Network Bridge Program V2.0 or IBM Token-Ring Network Bridge Program V2.1

The IBM PC Network (Broadband) can connect up to 1000 stations. IBM LAN Manager V1.0, when operating in a device attached to the IBM PC Network (Broadband), cannot establish a session with a IBM PC Network Bridge Program bridge. Therefore, in this LAN environment, IBM LAN Manager V1.0 can only provide network management for the local PC Network segment.

The IBM LAN Manager V1.0 can run as a stand-alone PC/DOS application or as a NetView/PC application. When IBM LAN Manager V1.0 is running as an application of NetView/PC 1.1, it automatically forwards LAN alerts as generic alerts to NetView running in a System/370 host. Alternatively it allows remote LAN management through the Remote Console Facility of NetView/PC 1.1.

Concurrent execution of both host alert forwarding and remote console facility for the IBM LAN Manager V1.0 application, is not possible due to the 640 Kbytes memory constraint in PC/DOS. See "NetView/PC" on page 284 for more information on NetView/PC.

In either mode of operation, IBM LAN Manager V1.0 requires a dedicated PC or PS/2. IBM LAN Manager V1.0 is packaged with an installation program that allows the user to select which local area network the program is going to manage, and the whether the program is running as a PC/DOS application or as a NetView/PC 1.1 application. IBM LAN Manager V1.0 includes all the function of its predecessor, IBM Token-Ring Network Manager V1.1 (now withdrawn).

9.3.1.1 Problem Determination and Recovery

The IBM LAN Manager V1.0 records problems related to adapters and the medium. The operator is notified whenever a hard error occurs, and when soft error thresholds are exceeded. When IBM LAN Manager V1.0 is used on a IBM PC Network (Broadband), it provides the facility to monitor critical stations on the network. The user identifies which stations should be monitored and an alert is generated if one of these stations does not respond. This is a very useful function as it permits the monitoring of gateways and servers.

On either IBM Token-Ring Network or IBM PC Network (Broadband), the IBM LAN Manager V1.0 notifies the operator of a failure condition by issuing an audible alarm and displaying a highlighted indicator on the operator display.

When IBM LAN Manager V1.0 is operating as a NetView/PC 1.1 application, these alerts are forwarded to NetView on the System/370 host. The alerts can be viewed at the LAN Manager or NetView operator console. They include the following information about the problem:

- Error Type:
(permanent, temporary, performance, unknown)
- Alert description
- Device: (The type of device with a problem: an adapter, an application etc.)
- Probable cause
- Recommended actions

9.3.1.2 Event Logging and Report Generation

The IBM LAN Manager V1.0 records network events in a log stored on disk. In addition to alerts, other events can optionally be logged. For example, stations or adapters joining and leaving the network, intensive mode recording data, and LAN status information can be recorded. Intensive mode recording involves logging soft errors as if they were hard errors. This means that a record of the events leading to an alert can be captured. Intensive mode recording only applies to the IBM Token-Ring Network.

Reports can be generated from the information stored in the event log. The reports can be for all adapters or for a specific adapter. A report can be for a time period, or about LAN status, or even for a specific message number. These reports can be displayed and/or printed.

9.3.1.3 Operator Control Functions

By using the IBM LAN Manager V1.0, a systems administrator can find out the status of the network and have some control over devices attached to it. The status of any station currently active on the network can be obtained, and a list of all the active stations can be produced. The administrator can issue a command to remove a LAN adapter from the network.

A connectivity test can be run to verify connectivity between two workstations. This is very valuable in diagnosing connectivity problems, especially in a multi-segment Token-Ring Network environment.

Operator interaction with the IBM LAN Manager V1.0 is simplified through the use of menus and symbolic names for network devices. The symbolic names are used when referring to an adapter or displaying information on it. The names are defined and stored in a symbolic names file on a local drive of the LAN management workstation. Each name is assigned to an adapter address.

Function keys are also used to simplify the operation, and HELP is available on program functions.

9.3.1.4 Managing a Multi-Segment IBM Token-Ring Network

To manage a multi-segment IBM Token-Ring Network with the IBM LAN Manager V1.0 the IBM Token-Ring Network Bridge Program V1.1 is required. With this bridge program the IBM LAN Manager V1.0 can communicate with up to 32 bridges through its LAN reporting mechanism function.

All the function provided for managing a single segment IBM Token-Ring Network applies to every ring segment in a multi-segment network. The bridge sends reports to IBM LAN Manager V1.0 on the ring status. The following types of reports can be sent:

- Beaconing and soft Errors
- Configuration reports
- Path trace information (to allow problem resolution)
- Bridge traffic counters (which aid in monitoring bridge performance and utilization).

The bridge can perform commands on behalf of IBM LAN Manager V1.0. It can query an adapter to determine its status, remove it from the ring, and test the path between two adapters.

Some commands however can only be issued by the *controlling LAN Manager*, that is the LAN Manager which has a reporting link 0 (controlling link) to the bridge. All remaining links, if any, to other LAN Managers must be *observing* links (reporting links 1, 2 and 3). The controlling LAN Manager has exclusive authority to:

- Remove stations through bridges from remote ring segments.
- Set Ring Error Monitor options for remote ring segments.
- Set bridge parameters (including all reporting links).

9.3.1.5 Security and Auditability

Because the IBM LAN Manager V1.0 is a very powerful tool, allowing the user to remove stations from the network, it provides a security feature. The optional security password feature can assist the LAN administrator in preventing unauthorized use of the program. The LAN Manager does not receive or transmit user data itself, hence it does not impact user security.

Information for creating an audit trail of stations and bridges joining and withdrawing from the network can be optionally included in the event log.

9.3.1.6 Hardware Requirements

The following hardware is required when the IBM LAN Manager V1.0 is being used as a stand-alone application (that is, NetView/PC 1.1 is not being used):

- A dedicated IBM PC XT, XT-286, AT, or any member of the IBM Personal System/2 family.
- One of the following LAN adapters:
 - IBM PC Network Adapter II (including Frequency 2 and Frequency 3)
 - IBM PC Network Adapter II/A (including Frequency 2 and Frequency 3)
 - IBM Token-Ring Network Adapter (withdrawn from marketing)
 - IBM Token-Ring Network Adapter II
 - IBM Token-Ring Network Adapter/A.

Note that the IBM PC Network Adapter card is not supported in the dedicated PC for the IBM LAN Manager V1.0, but it can still be used in network PC workstations when using the IBM LAN Support Program V1.10.

- 640 KB of memory
- Monitor
- Printer (optional).

When the IBM LAN Manager V1.0 is running as a NetView/PC 1.1 application and alerts are being forwarded to a NetView host, the following hardware is required:

- A dedicated IBM PC XT, XT-286, AT, or any member of the IBM Personal System/2 family.
- One of the following LAN adapters:
 - IBM PC Network Adapter II (including Frequency 2 and Frequency 3)
 - IBM PC Network Adapter II/A (including Frequency 2 and Frequency 3)
 - IBM Token-Ring Network Adapter (withdrawn from marketing)
 - IBM Token-Ring Network Adapter II
 - IBM Token-Ring Network Adapter/A.
- For Family 1 devices, one or more of the following is required:
 - IBM Realtime Interface Co-Processor Multiport Adapter (128 KB, #6240)
 - + Realtime Interface Co-Processor 512 KB Memory Expansion (#6242)
 - IBM Realtime Interface Co-Processor Multiport Adapter (128 KB, #6050)
 - + Realtime Interface Co-Processor 128 KB Memory Expansion (#6242)
 - IBM Realtime Interface Co-Processor Adapter (512 KB, #6160)

A total of 256 KB of memory is required for asynchronous connection (remote console facility), 512 KB for SDLC connection (alert forwarding).
- For Family 2 devices:
 - IBM Realtime Interface Co-Processor Multiport Adapter /2 (#6263)
 - + 4-Port or 8-Port RS-232-C Interface Board (#6267 or #6265 resp.)
- NetView/PC additional requirements, see section "IBM Token-Ring Network Trace and Performance Facilities" on page 293.
- 640 KB of memory
- Monitor
- Printer (optional, but strongly suggested).

9.3.1.7 Software Requirements

When the IBM LAN Manager V1.0 is being used as a stand-alone station:

- IBM PC/DOS 3.3 or 4.0

When NetView/PC is being used:

- NetView/PC 1.1
- IBM PC/DOS 3.3 or 4.0.

9.3.2 OS/2 EE - LAN Manager V2.0

IBM LAN Manager V2.0 enhances IBM LAN Manager V1.0 both in its stand-alone network management capabilities as well as in its mode of operation as a NetView agent or as a NetView/PC application.

IBM LAN Manager V2.0 can operate in three different environments as shown in Figure 112. Parts of this figure will be identified with the indicated reference numbers throughout this section.

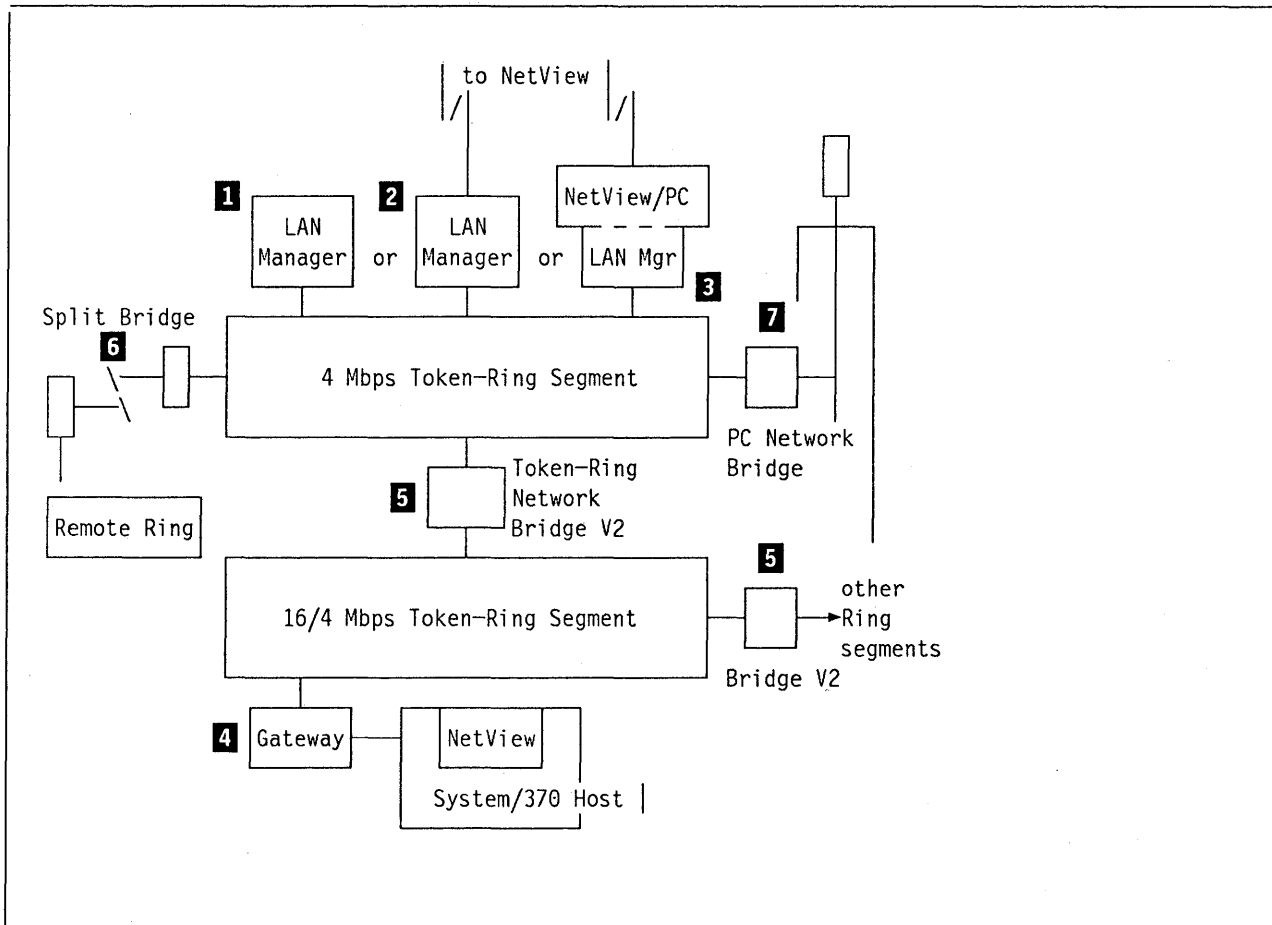


Figure 112. IBM LAN Manager Version 2.0 Overview

- As a stand-alone LAN Manager in non-host based environments **1**.
IBM LAN Manager V2.0 operates under Operating System/2 Extended Edition V1.1, allowing multiple tasks to run in parallel and lifting the 640 Kbytes memory constraint of PC/DOS.
- As a LAN management agent for NetView running in the host.
IBM LAN Manager V2.0 **1** uses the Operating System/2 Extended Edition V1.1 Communications Manager support to access the NetView host using existing LAN gateway devices **4** attached directly to a token-ring segment. In this way, an exclusive communications link to the host for LAN management is not needed. Until the Operating System/2 Extended Edition V1.1 LAN gateway capability becomes available, PC or PS/2 gateways cannot be used for this purpose. This implies that the host gateway device,

for example a 3174-01L or a 3745, can only be attached to an IBM Token-Ring Network segment.

Alternatively, IBM LAN Manager V2.0 **2** may communicate with the host via an SDLC protocol provided by Operating System/2 Extended Edition V1.1 Communication Manager through an SDLC adapter or a PS/2 Multiport adapter.

- As a NetView/PC application **3**.

Whenever NetView/PC is already providing service point functions for other applications or subsystems, IBM LAN Manager V2.0 may execute as another NetView/PC V1.2 application. NetView/PC V1.2 also operates under Operating System/2 Extended Edition V1.1.

NetView Release 3 is recommended in the host system to provide maximum functional capability, mainly with respect to the Service Point Command Facility (SPCF).

IBM LAN Manager V2.0 includes all the function of IBM LAN Manager V1.0. Refer to the previous section for an overview and discussion of IBM LAN Manager V1.0.

The next few paragraphs will provide some more information about the extended network management capabilities offered by IBM LAN Manager V2.0.

9.3.2.1 Mixed LAN Management

IBM LAN Manager V2.0 is capable of maintaining up to 64 LAN management LLC links concurrently with 64 different bridges (LAN reporting mechanism component). These links may be dynamically updated by the network management operator.

The bridges may be implemented by either IBM Token-Ring Network Bridge Program V2.0 **5**, IBM Token-Ring Network Bridge Program V2.1 **6** or IBM PC Network Bridge Program **7**. Bridges running IBM Token-Ring Network Bridge Program V1.1 may coexist on the LAN environment and will operate properly as far as basic bridge protocol is concerned. The LAN segments serviced by IBM Token-Ring Network Bridge Program V1.1 however cannot be managed by IBM LAN Manager V2.0. IBM LAN Manager V1.0 can be used to provide the required LAN management for these segments, until the bridges are migrated to IBM Token-Ring Network Bridge Program V2.0.

In this way, IBM LAN Manager V2.0 offers LAN management of any LAN environment consisting of 16 Mbps or 4 Mbps IBM Token-Ring Network segments, and PC Network (Broadband) segments, as shown in Figure 112 on page 272.

In a mixed multi-segment LAN environment, each LAN segment has a segment identifier (a four-digit number nnnn). The operator interface for ring segments and PC Network (Broadband) segments identifies them by a segment name RINGnnnn, or segment name CBUSnnnn respectively.

9.3.2.2 Service Point Command Interface

Whenever IBM LAN Manager V2.0 is communicating with NetView in the host, the NetView operator is able to issue commands to the LAN Manager and receive responses back from these commands.

The commands are actually entered as pseudo-commands by the operator. Each pseudo-command activates a CLIST, shipped with IBM LAN Manager V2.0 and stored in NetView. The CLIST issues a *Service Point Command Interface* (SPCI) command, carrying the appropriate parameters. The SPCI command is received either directly by IBM LAN Manager V2.0 or by NetView/PC V1.2, depending upon whether IBM LAN Manager V2.0 operates directly as a NetView agent or as a NetView/PC V1.2 application.

The SPCI commands are executed at the LAN Manager level, and responses are returned to NetView for display at the operator console.

IBM LAN Manager V2.0 includes the following eleven commands:

- Query adapter
- Query bridge
- Query network:
- Query topology
- Path test - valid only in a Token-Ring Network environment
- LAN segment test
- Remove adapter
- Link bridge
- Unlink bridge
- Change bridge parameters.

9.3.2.3 Alert Transport Service for Applications

This important new feature of IBM LAN Manager V2.0 allows *applications* to generate and send alerts to a focal point. In this context, the application is referred to as a *reporting entity*.

This capability relies on the *alert transport service* facility, by which a reporting entity uses the services of the LAN Manager to allow a reporting entity to send alerts (such as an application alert) to NetView. Figure 113 on page 275 shows the relationships among the reporting entity, the LAN Manager, the LAN bridges, and the alert focal point. Alert transport service provides a mechanism to transport alerts from a reporting entity to the alert focal point, even though these two components may not have an SNA session established between them.

Alert major vectors will be constructed by the reporting entity and sent to the LAN manager. These pre-built alerts are enveloped by a LAN management formatted frame. The LAN Manager formats and sends the necessary NMVT to the alert focal point in the same way as it formats and sends alert data gathered by LAN bridges in session with the LAN Manager.

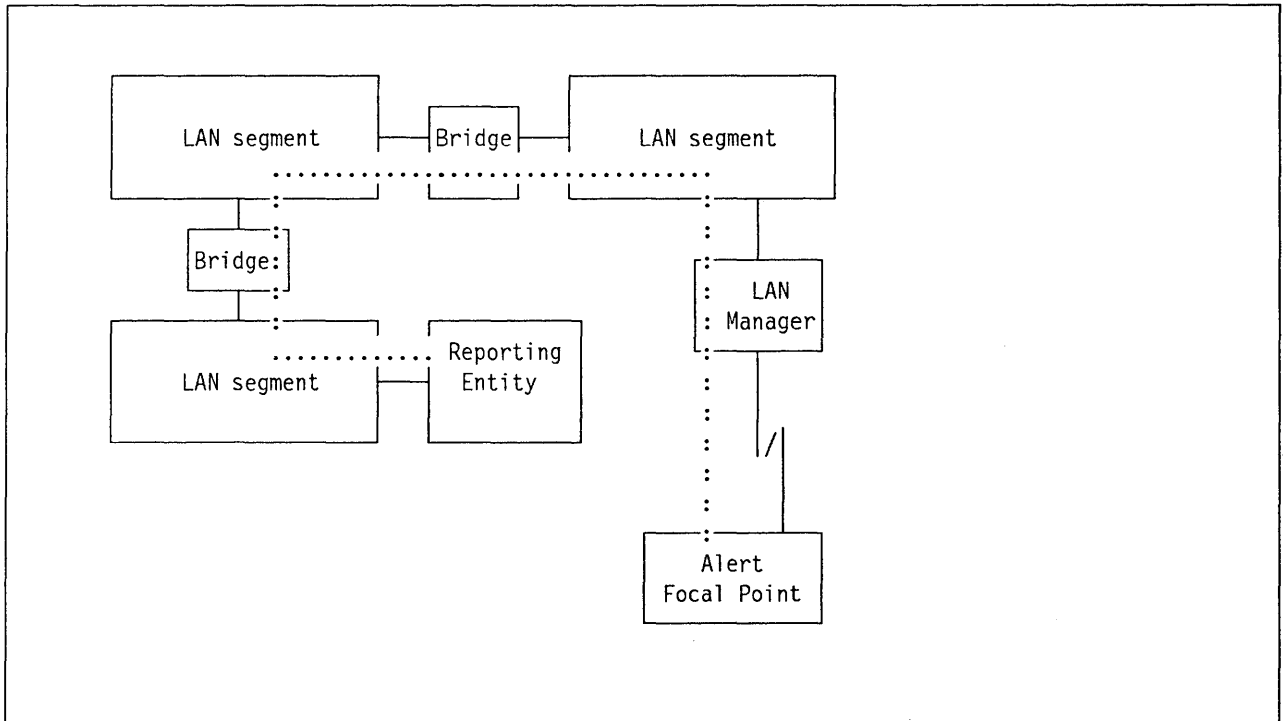


Figure 113. Alert Transport Service

The transport service used for the communication between the reporting entity and the LAN Manager is called *Management Frame Transport Service*. This architecture provides a way for using LLC Type 1 (connectionless) services to allow a LAN station to reliably send management messages to the LAN Manager. It is a requirement to use LLC Type 1 service in order to avoid the necessity of the LAN Manager having connections established with each station in the LAN that might have information to send to it. This is achieved using the following algorithm:

1. A LAN station sends a management frame (from its own MAC address, any SAP) to the LAN Manager (functional address = X'C0000000200', SAP=X'F4'). This frame is sent using limited broadcast and contains a correlator subvector within it.
2. Multiple LAN Managers may receive the message. The controlling LAN Manager returns an acknowledgement to the originating address, reversing the path indicated in the received message frame. This acknowledgement contains a correlator subvector with the same value as the correlator present in the original message.
3. The originating station resends the message multiple times at regular, predetermined time intervals until it receives an acknowledgement or it times out. This insures that, if at all possible, the LAN manager will receive a copy of the message. Due to timing considerations, the LAN Manager may receive multiple copies of the message. The LAN Manager can detect and discard duplicates by examining the correlator value. If the sending station has not re-used correlator values for which it has not received acknowledgements, the LAN Manager can determine the uniqueness of a message by the concatenation of the correlator value, the sending address, and the sending SAP.

9.3.2.4 Critical Resource Monitoring

This IBM LAN Manager V2.0 feature allows the LAN Manager operator to define any workstation, identified by its unique universal or local MAC address, as a critical resource.

IBM LAN Manager V2.0 will monitor this station and send an alert whenever this critical resource is lost from the LAN. This feature is especially useful to monitor such essential resources in an operational LAN environment as print servers or large file servers, gateway devices, backbone bridges or in general any bridge for which no backup route exists. It may also complement the error reporting of an intelligent 8220 Optical Fiber Converter.

9.3.2.5 Multiple LAN Manager Support

Up to four LAN Managers running IBM LAN Manager V2.0 may be in session with the same LAN Bridge. Their relationship with the bridge is set by the network operator, identifying the reporting link to be either *controlling* or *observing*.

Execution of any controlling IBM LAN Manager V2.0 command on a remote LAN segment is performed by the bridge, including commands that change the way in which LAN components operate or the topology of the remote segment (for example the Remove Adapter command).

An observing LAN Manager may not issue a command altering the way in which the remote LAN segments functions. In general, an observing LAN manager is restricted to Query-type commands.

Communication from IBM LAN Manager V2.0 to IBM LAN Manager V2.0 is not supported.

9.3.2.6 Migration and Coexistence

The panels and messages of IBM LAN Manager V2.0 are similar to those used by IBM LAN Manager V1.0. In addition a utility package allows users to migrate the symbolic names file and bridge definition file from IBM LAN Manager V1.0 to IBM LAN Manager V2.0. This Program Upgrade Package is available between December 30, 1988 until September 30, 1989.

With respect to the enhancements discussed in the previous paragraphs, migration to IBM LAN Manager V2.0 is strongly recommended. The only instance in which delayed migration may be desired is when IBM LAN Manager V1.0 execution as a NetView/PC V1.1 application using the Remote Console Facility is required.

When migrating to IBM LAN Manager V2.0, bridges running IBM Token-Ring Bridge Program Version 1.0 or 1.1 should be upgraded simultaneously to IBM Token-Ring Network Bridge Program V2.0 to allow proper multi-segment LAN management.

In a NetView/PC environment, migration to IBM LAN Manager V2.0 implies concurrent migration from NetView/PC V1.1 to NetView/PC V1.2 if use of IBM LAN Manager V2.0's host gateway communications capability is not a sufficient alternative.

IBM LAN Manager V2.0 is supported with NetView Release 2. However, the NetView operator LAN management command functions of IBM LAN Manager V2.0 through SPCI will only be available when running with NetView Release 3.

9.3.2.7 Hardware Requirements

The following hardware requirements apply to the workstation in which IBM LAN Manager V2.0 will be running either stand-alone or via a LAN-attached host gateway to NetView:

- IBM PC XT-286, PC/AT or PS/2 Models 50, 60, 70 and 80.
- 500 Kbytes memory (for IBM LAN Manager V2.0 only).
- One diskette drive and one fixed disk (minimum 20 Mbytes)
- Any currently available IBM Token-Ring Network Adapter or any currently available IBM PC Network (Broadband) Adapter.
- Printer (optional but recommended).

If using the Operating System/2 Extended Edition V1.1 SDLC communications support to establish the NetView session, the following additional hardware is required:

- IBM SDLC Adapter on a Family 1 device.
- IBM PS/2 Multiprotocol Adapter on a Family 2 device.

If running IBM LAN Manager V2.0 as a NetView/PC V1.2 application, the following additional hardware is required:

- Either the appropriate IBM Realtime Interface Co-Processor Adapter or
- The IBM SDLC Adapter on a Family 1 device, or IBM PS/2 Multiprotocol Adapter on a Family 2 device.

9.3.2.8 Software Requirements

IBM LAN Manager V2.0 has the following software requirements:

- Operating System/2 Extended Edition V1.1
- The then-current release of NetView (currently NetView Release 3).
- The then-current release of NetView/PC (if required, currently NetView/PC V1.2).
- The IBM Realtime Interface Co-Processor control program for PS/2 (if applicable, to drive the RTIC adapter).

9.4 Management Products for Small LANs

9.4.1 3270 Emulation LAN Management

The IBM PC 3270 Emulation LAN Management Program V1.0 provides the capability to send alerts and other network management information up to a centralized network management host for small, remote token-ring LANs and PC Networks (Baseband and Broadband).

The IBM PC 3270 Emulation LAN Management Program V1.0 monitors the IBM Token-Ring Network for hard errors, including beaconing conditions, and accumulates soft error data for threshold analysis. On the PC Network it monitors for inoperative bus conditions. The alert conditions are not presented locally at the LAN station as there is no local user interface, but are formatted and sent to NetView as NMVTs (Network Management vector transports). These alerts are sent to NetView using the existing SSCP-PU flow provided by IBM PC 3270 Emulation Program.

The program can only execute in the workstation that is being used as the 3270 gateway. The IBM 3270 Emulation Program continues to provide host gateway function for workstations on the LAN while the IBM PC 3270 Emulation LAN Management Program V1.0 monitors the LAN.

Figure 114 on page 279 shows two remote local area networks using the IBM PC 3270 Emulation LAN Management Program V1.0 for network management.

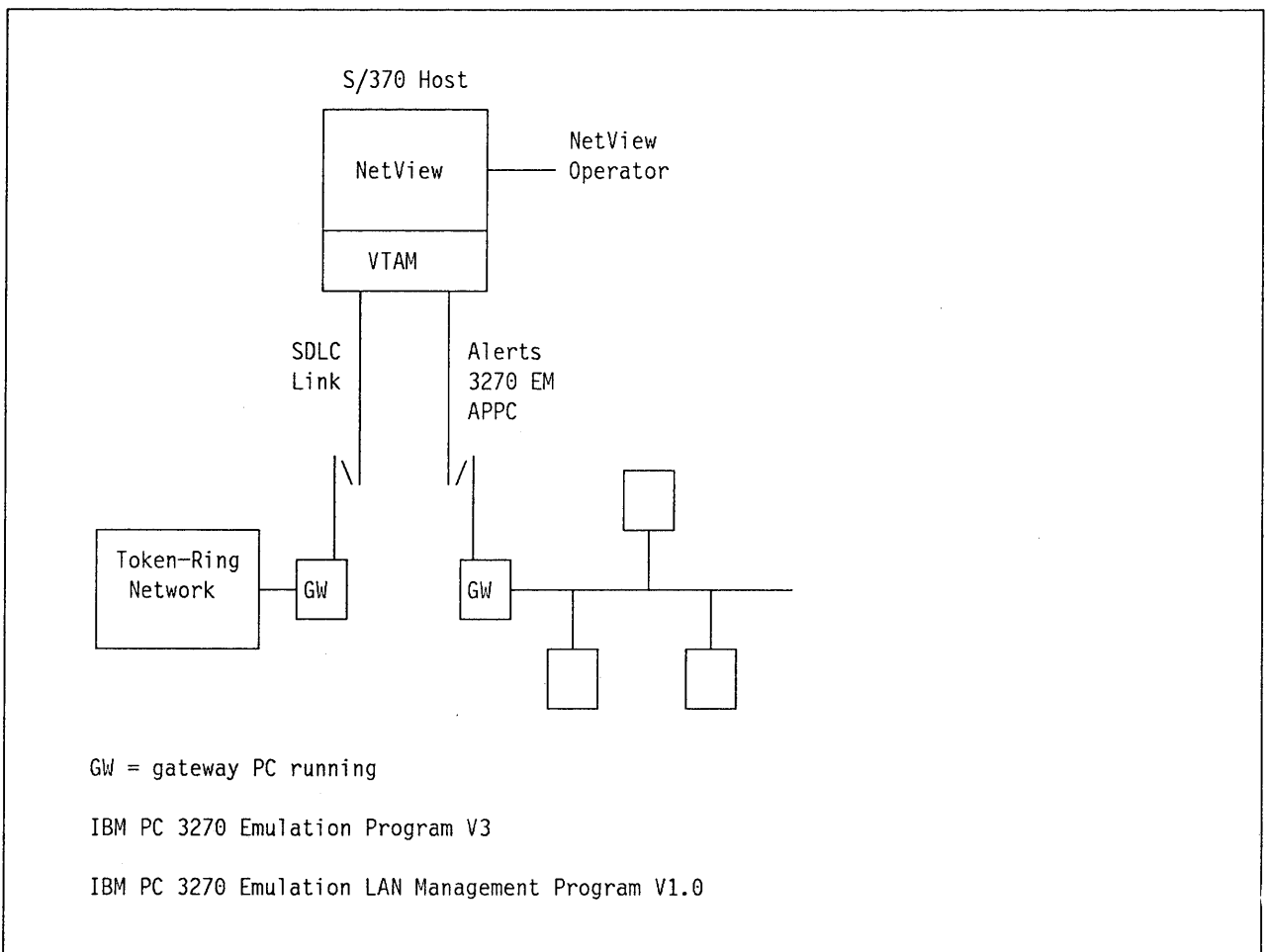


Figure 114. Use of IBM PC 3270 Emulation LAN Management Program V1.0

9.4.1.1 IBM PC 3270 Emulation LAN Management Program V1.0 Structure

The IBM PC 3270 Emulation LAN Management Program V1.0 has two major components (shown in Figure 115 on page 280): The LAN error monitor and the alert generator functions.

- *LAN Error Monitor*

The LAN error monitor is the component that detects error conditions on the LAN and processes them. It receives information on hard and soft errors from the LAN adapter, and passes the processed information to the alert generator.

- *Alert Generator*

The alert generator is responsible for building alerts to be sent to NetView. It constructs an alert from the information captured by the LAN error monitor and uses the PU function of the 3270 Emulation program to send the alert to NetView.

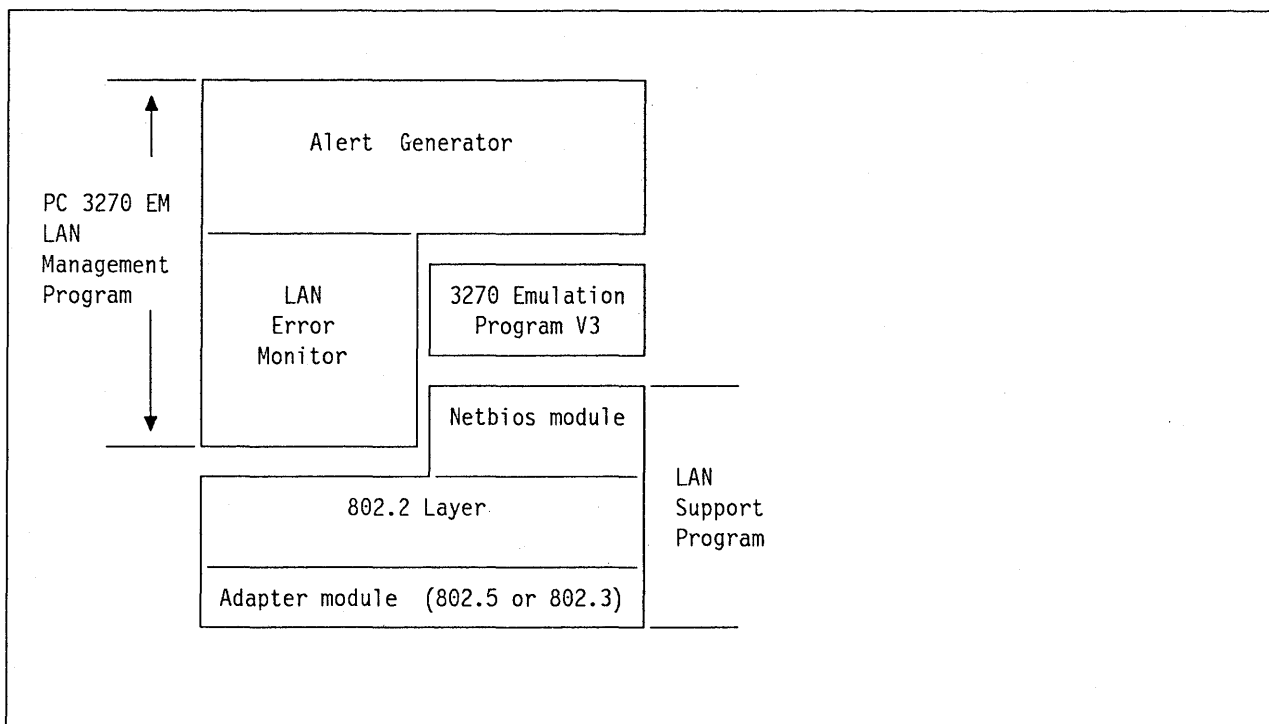


Figure 115. IBM PC 3270 Emulation LAN Management Program V1.0 Structure

9.4.1.2 IBM PC 3270 Emulation LAN Management Program V1.0 Alerts

The generic alerts are sent to NetView for processing can be viewed from any NetView console. They contain information on the type of error (permanent, temporary, unknown), a description of the problem, including the type of device causing the problem (if known), and recommended actions to solve the problem.

The following types of alerts can be sent to NetView by the IBM PC 3270 Emulation LAN Management Program V1.0 in a PC/Network environment:

- A hardware error in a reporting station's CSMA/CD adapter has occurred. The adapter is now inoperative.
- An error was discovered at a reporting adapter's programming interface. The adapter is now inoperative.
- A continuous carrier condition has been detected on a CSMA/CD bus and the source of the condition is the gateway's adapter.
- A continuous carrier condition has been detected on the CSMA/CD bus and the gateway's adapter is not the source.
- The reporting node's adapter received a Remove Adapter command from a LAN Manager, and as a result has left a CSMA/CD LAN.
- A no-carrier condition was detected on a CSMA/CD bus.

The following types of alerts can be sent to NetView by the IBM PC 3270 Emulation LAN Management Program V1.0 in a Token-Ring Network environment:

- Adapter error: local Token-Ring Adapter - a hardware error in the reporting station's adapter has occurred. The adapter is now inoperable.

- Wire fault: Token-Ring lobe - the reporting station's adapter detected a wire-fault condition on the ring.
- Auto remove: Token-Ring lobe - the reporting station's adapter has left the ring as part of the beacon automatic-recovery process. That is, the self-tests completed unsuccessfully.
- Token-Ring remove command received - the reporting station's adapter received a remove adapter command from a LAN Manager, and as a result has left the ring.
- Software program error - an error was discovered at the adapter programming interface. The adapter is now inoperable.
- Token-Ring inoperative - the ring has been beaconing for more than 52 seconds.
- Token-Ring temporary error - the ring was in a beaconing state for less than 52 seconds and then recovered.
- Excessive Token-Ring errors - ring error monitor (REM) has detected excessive soft errors for the ring.
- Software program error - the REM process is in an error state.

9.4.1.3 Hardware Requirements

IBM PC 3270 Emulation LAN Management Program V1.0 can run on the IBM PC XT, XT-286, AT, or any member of the IBM Personal System/2 family, equipped with one of the following LAN adapters:

- IBM PC Network Adapter II (including Frequency 2 and Frequency 3)
- IBM PC Network Adapter II/A (including Frequency 2 and Frequency 3)
- IBM PC Network Baseband Adapter
- IBM PC Network Baseband Adapter/A
- IBM Token-Ring Network Adapter
- IBM Token-Ring Network Adapter II
- IBM Token-Ring Network Adapter/A
- IBM Token-Ring Network 16/4 Adapter (operating at 4 Mbps)
- IBM Token-Ring Network 16/4 Adapter/A (operating at 4 Mbps)

Other non-gateway adapters on the PC Network can use the IBM PC Network Adapter card, but the IBM LAN Support Program V1.10 must be used.

In addition you will need SDLC adapter, or the IBM PS/2 Multi-Protocol Adapter/A depending on the workstation being used for the gateway.

Additional workstation requirements:

- 248 Kbytes of memory for the IBM PC 3270 Emulation Program gateway code.
- 48 Kbytes of memory for the IBM PC 3270 Emulation LAN Management Program V1.0.
- Monitor
- Printer (optional).

9.4.1.4 Software Requirements

- PC Software:

IBM PC 3270 Emulation Program V3.02 or higher

IBM LAN Support Program V1.01 or V1.1 (required for IBM Token-Ring Network 16/4 Adapter and IBM Token-Ring Network 16/4 Adapter/A).

IBM PC/DOS 3.3 or 4.0

- Host Software:

NetView (Release 1, 2 or 3).

9.4.2 OS/2 EE - LAN Manager Entry Version 1.0

Like the IBM PC 3270 Emulation LAN Management Program V1.0, the IBM LAN Manager Entry V1.0 product only provides network management function as a service point in conjunction with a NetView focal point. Its LAN management capabilities are limited to a single IBM Token-Ring Network segment, 4 Mbps or 16 Mbps, or a single IBM PC Network (Broadband or Baseband) segment.

Like the IBM PC 3270 Emulation LAN Management Program V1.0, it does not provide a local operator interface at the LAN segment level. Network management function is available only at the central site network operator console.

IBM LAN Manager Entry V1.0 cannot operate as a NetView/PC application.

Aside from these environmental similarities between the two small LAN management products, IBM LAN Manager Entry V1.0 is much closer to IBM LAN Manager V2.0 in terms of function and implementation.

IBM LAN Manager Entry V1.0 operates as an Operating System/2 Extended Edition V1.1 application with all the benefits explained under "OS/2 EE - LAN Manager V2.0" on page 272.

IBM LAN Manager Entry V1.0 acts as a NetView agent, communicating with NetView using a LAN-attached host gateway device (for example 3174, 372x or 3745) or a dedicated SDLC link relying on Operating System/2 Extended Edition V1.1's SDLC protocol support. The latter is currently the only possible communications environment when operating IBM LAN Manager Entry V1.0 on a IBM PC Network Baseband.

Functionally, IBM LAN Manager Entry V1.0 forwards its own generated alerts to NetView. It also supports the alert transport service for applications in the same way as IBM LAN Manager V2.0.

IBM LAN Manager Entry V1.0 provides a subset of the Service Point Command Interface

(SPCI) support offered by IBM LAN Manager V2.0. As IBM LAN Manager Entry V1.0 supports on single segment network management, only the following six commands are supported:

- Query Adapter Profile
- Query Network Status
- Query Topology

- LAN segment Test
- Remove Adapter
- Reset LAN Manager.

Refer to "OS/2 EE - LAN Manager V2.0" on page 272 for more details. The SPCF commands issued by the NetView operator are processed in the same way as discussed with IBM LAN Manager V2.0.

Critical resource monitoring is supported in the same way as IBM LAN Manager V2.0. However, the resources must be defined as part of the product installation and customization because there is no operator interface to create such definitions during operation.

9.4.2.1 Hardware Requirements

IBM LAN Manager Entry V1.0 can run on the IBM PC XT-286 or PC/AT, or on IBM PS/2 Models 50, 60, 70 and 80, equipped with any of the current IBM Token-Ring Network Adapters (including the 16/4 Mbps adapters), IBM PC Network (Broadband) Adapters or IBM PC Network Baseband Adapters.

Additional hardware requirements:

- An SDLC adapter, or IBM PS/2 Multiprotocol Adapter depending on the workstation being used for the gateway.
- 480 Kbytes of memory (for IBM LAN Manager Entry V1.0 only).
- Monitor
- Printer (optional).

9.4.2.2 Software Requirements

IBM LAN Manager Entry V1.0 requires in the LAN management workstation:

- Operating System/2 Extended Edition V1.1
- IBM LAN Manager Entry V1.0

Host software requirements:

- the then current release of NetView (at the time of publication NetView Release 3).

Earlier NetView releases will not support the SPCF capability for LAN management.

9.5 NetView/PC

NetView/PC is an IBM network management program product that extends network management capabilities beyond the SNA environment, providing integrated management of SNA, non-SNA addressable, voice and non-IBM elements of the information network.

It is a network management tool designed to provide common system services and functions for one or more associated applications running under it, and communicating with it via a supplied application program interface (API). NetView/PC provides monitoring and problem determination services for these applications. It also provides a communication channel for network management information to flow to NetView from these applications, and eventually for commands to flow from NetView to the applications using service point control facilities (SPCF).

IBM LAN Manager V1.0 can run as a stand-alone station in the LAN environment. Alternatively, it can run as a NetView/PC V1.1 application and send alerts to NetView on a System/370 host or use the NetView/PC support to provide a remote LAN Management console. NetView/PC V1.1, like IBM LAN Manager V1.0, operates in a IBM PC/DOS 3.3 or 4.0 environment.

IBM LAN Manager V2.0 can also run as a stand-alone LAN workstation. In addition, it can communicate with a NetView host without NetView/PC services via a LAN gateway or via Operating System/2 Extended Edition V1.1 Communications Manager's SDLC support. Alternatively, it can run as a NetView/PC V1.2 application. When connected to NetView in either way, IBM LAN Manager V2.0 supports LAN commands and alerts locally or from NetView and also provides an application alert transport service. NetView/PC V1.2, like IBM LAN Manager V2.0, operates in an Operating System/2 Extended Edition V1.1 environment.

Customer-written application programs can use the NetView/PC API to take advantage of NetView/PC's network management function to extend network management to non-IBM devices.

NetView/PC V1.2 with IBM LAN Manager V2.0 should be considered whenever LAN management from a central site management location is combined with management of other non-SNA parts of the network. Such use NetView/PC V1.2 can provide efficient and consistent network management support for both the LANs and other network resources. If however no other non-SNA parts of the network have to be managed, it may be preferable to accomplish LAN management integration into focal point network management by using one of the LAN gateway connectivity options.

Users of IBM LAN Manager V1.0 have a migration option to IBM LAN Manager V2.0.

9.5.1 NetView/PC Functions and Structure

The functions of the NetView/PC can be divided into Base System Services and services which are available only if they are separately configured to run with the NetView/PC Base System Services. In NetView/PC, this configuration procedure is referred to as *Grouping*.

The Base System Services are:

- NetView/PC Access Method Services.
- NetView/PC Data Base Manager.
- NetView/PC DOS Partition Support.
- NetView/PC API/CS.
- NetView/PC Console Dialog Manager.
- NetView/PC System Services Manager.
- NetView/PC Help Facility.

Through grouping the operator may define more NetView/PC functions to be initialized:

- NetView/PC Service Point Command Facility
- NetView/PC Host Data Facility
- NetView/PC Host alert facility
- NetView/PC Local alert facility
- NetView/PC Remote Console Facility (RCF)
- IBM LAN Manager V1.0 (NetView/PC V1.1)
- IBM LAN Manager V2.0 (NetView/PC V1.2)

Note that, in the IBM PC/DOS 3.3 or 4.0 environment of NetView/PC V1.1, there is insufficient memory within the 640 Kbytes addressing constraints to perform all of the above additional functions. For example, the host alert facility and the IBM LAN Manager V1.0 can be executed together, or the remote console facility and the IBM LAN Manager V1.0 can be executed together. However, concurrent operation of IBM LAN Manager V1.0 with host alert facility and remote console facility is not possible.

Figure 116 on page 286 shows the structure of NetView/PC V1.1. In the figure, IBM product-unique and vendor applications are included.

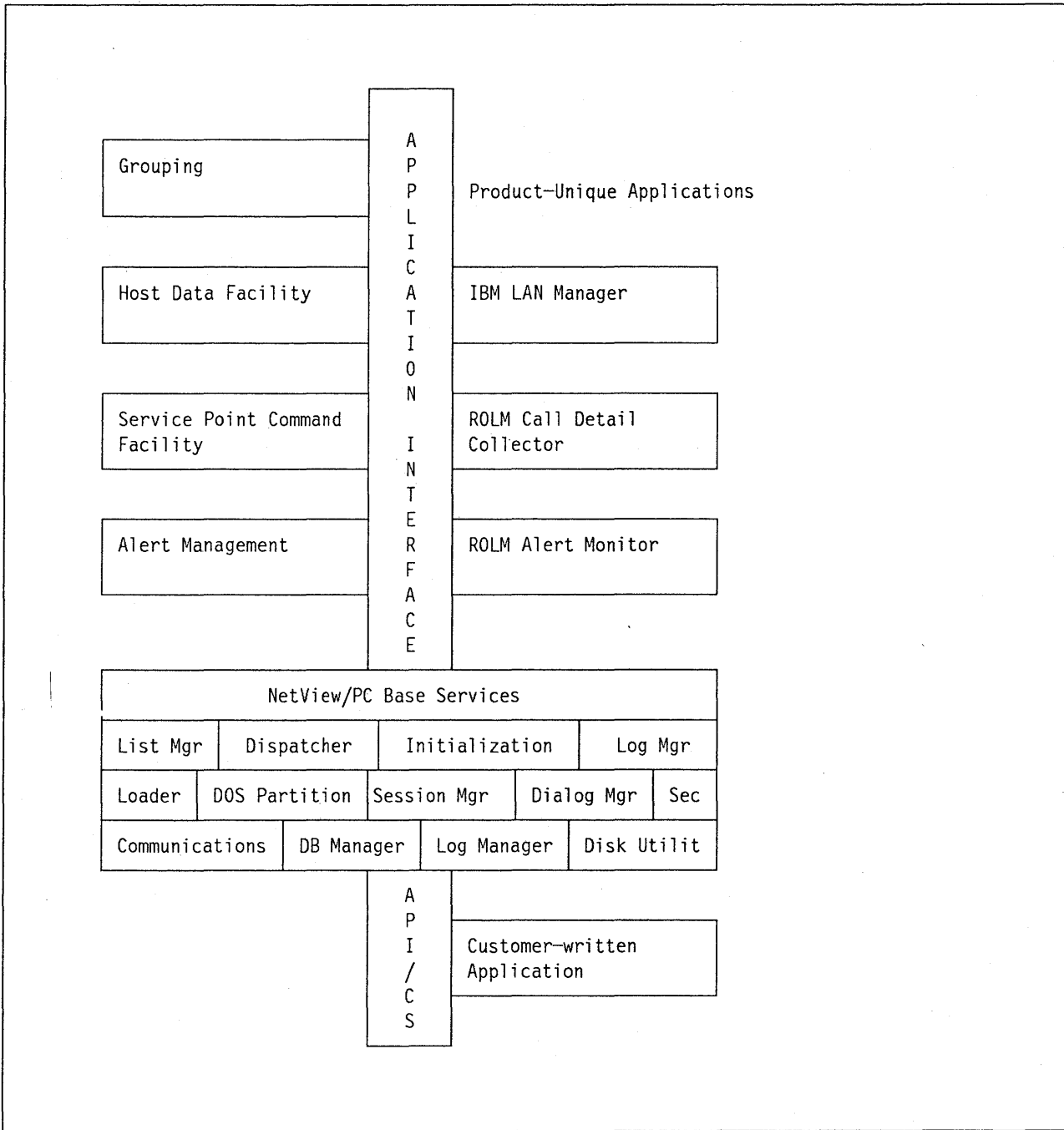


Figure 116. NetView/PC 1.1 Base Functions and the Applications

The subsequent paragraphs discuss some components/features of NetView/PC V1.1. They equally apply to NetView/PC V1.2 unless stated explicitly. However, even in the PC/DOS environment, NetView/PC V1.1 provides a multitasking appearance to the NetView/PC operator.

9.5.1.1 Access Method Services

The Access Method Services Manager (AMS) provides services for the creation and maintenance of files. NetView/PC V1.1 processes can use the AMS to perform functions that are similar to the PC/DOS file function calls.

The services provided are:

- Create/delete/copy/rename a file.
- Get/free disk space.
- Create/delete/change a PC/DOS sub-directory.
- Obtain information about a file.

9.5.1.2 Data Base Manager

The NetView/PC Data Base Manager (DBM) provides support for auxiliary storage devices including disk and diskettes. NetView/PC V1.1 DBM is used to open, read, write and close disk-resident files.

9.5.1.3 Console Dialog Manager

All interactions between the operator and NetView/PC take place using application dialogs. Menus and a "fill-in-the-blanks" approach simplifies operation and reduces operator training time.

Dialog management services support the definition of dialogs and individual panels, and panel maintenance. These services are also available to customer-written applications.

The console dialog manager provides the facility for operators to switch from one application to another without interrupting the execution of previous applications.

9.5.1.4 Operator Services Manager

The NetView/PC Operator Services Manager provides the following functions:

- The ability to display *operator intervention* messages from various NetView/PC tasks.
- Allows the user to selectively define the software components in the NetView/PC environment.
- Definition of operator IDs and passwords to be used when logging onto NetView/PC. Operators without system operator authority are not allowed access to this function.
- Ability to log off from NetView/PC without terminating the operation of NetView/PC.
- With the region manager facility, either the remote console facility or the local alerts facility can be used.
- A NetView/PC help facility.

9.5.1.5 CNM Support

Customer-written applications can monitor non-SNA devices down stream from NetView/PC. When a problem is detected the application can create an alert for the network operator. The CNM support allows NetView/PC's alert manager to receive alerts from a NetView/PC application and to send them to NetView in a System/370 host.

NetView/PC V1.2 in addition allows the NetView Rel.3 operator to issue commands, activating CLISTS stored at NetView. Each CLIST in turn, issues a service point control interface (SPCI) command, containing the appropriate parameters. Through the SPCF interface, NetView/PC V1.2 passes the operator command to IBM LAN Manager V2.0 for execution. IBM LAN Manager V2.0 sends a response back for display at the NetView operator console.

9.5.1.6 Alert Management

NetView/PC supports only network management vector transport (NMVT) formatted generic alerts. This applies to both alerts received by NetView/PC from an application, for example, LAN Manager, and those sent by NetView/PC to NetView.

The alert manager in NetView/PC will display an "AL" at the bottom of the screen and generate an audible alarm to notify the operator that there are alerts waiting. The "AL" is cleared when the operator views the alert(s).

Alerts are stored in an alert file on the workstation's hard disk. They are sent to NetView over a dedicated SDLC link. For both NetView/PC V1.1 and NetView/PC V1.2, the SDLC link may be provided by the appropriate IBM Realtime Interface Co-Processor Multiport adapter. Alternatively, NetView/PC V1.2 supports use of Operating System/2 Extended Edition V1.1 Communications Manager's SDLC support to provide an SDLC link using either an SDLC adapter or a Multiprotocol Adapter.

9.5.1.7 Remote Console Facility

The Remote Console Facility (RCF) of NetView/PC V1.1 enables NetView/PC V1.1 running in a local PC to control a remote PC running NetView/PC V1.1. The two PCs must be connected using an asynchronous communication link.

When in session, the keyboard of the LAN-attached NetView/PC (that is, the remote PC) is locked. All keystrokes from the local operator are passed to the NetView/PC residing in the remote PC. All information displayed on the screen of the remote PC will also be displayed on the screen of the local PC.

The local NetView/PC V1.1 operator could, for example, use the IBM LAN Manager V1.0 running as a NetView/PC V1.1 application in the remote PC to control a remote IBM Token-Ring Network or IBM PC Network (Broadband). If a LAN workstation was causing problems on the LAN, it could be forced off the LAN.

When using the Remote Console Facility, the IBM Realtime Interface Co-processor Multiport Adapter is required in both the local and remote workstations.

Figure 117 on page 289 shows a typical NetView/PC V1.1 configuration for network management on local and remote LANs. Alerts can flow from the local and remote LANs up to a NetView host. Note that the local PC running NetView/PC V1.1 has to be SDLC-attached to the host, and the asynchronous link between the two NetView/PC V1.1 systems can only be used for NetView/PC communication.

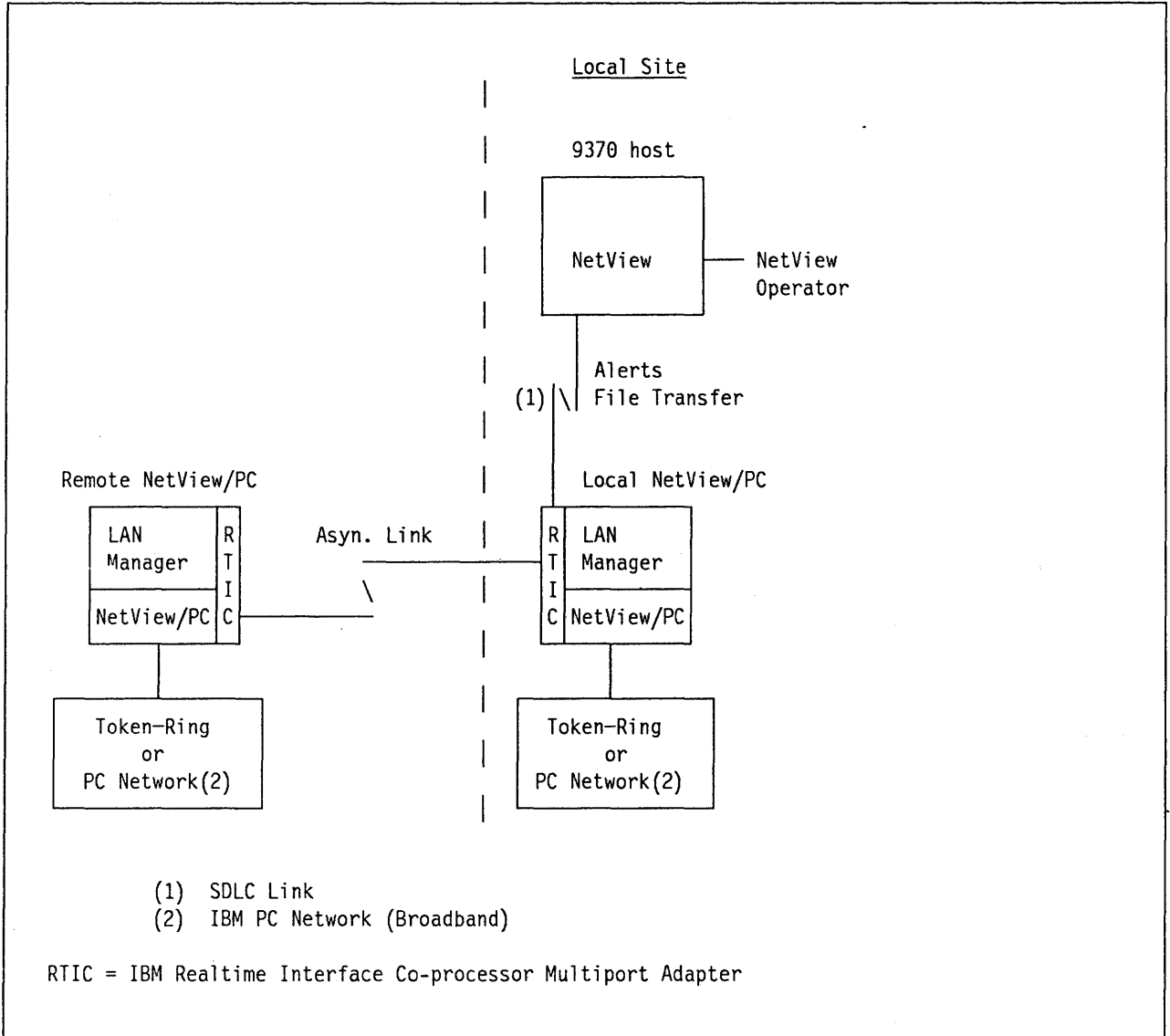


Figure 117. NetView/PC 1.1 Remote Console Facility

Remote console facility is not supported in NetView/PC V1.2. However a statement of direction, issued with the announcement of NetView/PC V1.2, states IBM's intention to provide remote console support in the future.

9.5.2 NetView/PC Hardware Requirements

NetView/PC V1.1 requires the following hardware:

- IBM PC XT, XT-286, AT, IBM PS/2 Model 30.
- 640 KB of memory.
- One 5.25in double-sided diskette drive or a high-capacity diskette drive.
- 10-megabyte (or more) hard disk.
- An IBM Color Display with a IBM Color/Graphics Monitor Adapter, or an IBM Monochrome Display with a Monochrome Display and Printer Adapter.
- Graphics printer or "Proprinter" (registered trademark of the International Business Machines Corporation) (optional)
- IBM Realtime Interface Co-processor Multiport Adapter

This adapter is required to support NetView/PC V1.1's communication facilities.

NetView/PC V1.2 requires the following hardware:

- For configurations using the IBM Realtime Interface Co-processor Multiport Adapter, see the NetView/PC V1.1 requirements.
- For configurations without the IBM Realtime Interface Co-processor Multiport Adapter:
 - IBM PS/2 Multiprotocol adapter (PN 6450348) or
 - IBM SDLC Adapter (PN 1501205 or 1502090).

9.5.3 NetView/PC Software Requirements

NetView/PC V1.1 requires the following software in the IBM PC:

- IBM Realtime Interface Control Program DOS Support (5669-177): A communication software package to control IBM Realtime Interface Co-processor Multiport Adapter.
- IBM PC/DOS 3.3 or 4.0.

NetView/PC V1.1 requires the following software in the host:

- For transmitting alerts and other CNM data:
 - NetView for MVS/XA (5665-362)
 - NetView for MVS System/370 (5665-361)
 - NetView for VM (5664-204).

NetView/PC V1.2 requires the following software in the workstation:

- IBM Realtime Interface Control Program OS/2 Support (5662-281)
This will be optional after a maintenance update scheduled for year-end 1989.
- Operating System/2 Extended Edition V1.1

NetView/PC V1.2 requires the following software in the host:

- For transmitting alerts and other CNM data:

- NetView for MVS/XA (5665-362)
- NetView for MVS System/370 (5665-361)
- NetView for VM (5664-204)
- NetView for VSE (5666-343).
- Additional software may be required when using NetView/PC V1.2 to implement change management, for example CICS/DDM (5665-463), NetView/DM 1.1 and VTAM Protocol Conversion Application at the host, and IBM PC Node Executive (PCNX) at the workstation level.

9.5.4 NetView/PC Summary

NetView/PC is a sophisticated network management tool. It can be used to monitor SNA and non-SNA environments, and report locally or send alerts to a central SNA CNM site.

NetView/PC can be used to integrate LAN management into central site network management at a focal point. It is optional when IBM LAN Manager V2.0 is being used.

The next list summarizes the additional or enhanced functions of NetView/PC V1.2 in comparison with NetView/PC V1.1:

- NetView/PC support on Operating System/2 Extended Edition V1.1, providing memory protection for NetView/PC applications and elimination of the PC/DOS memory addressing constraint (640 Kbytes).
- Generic alerts enhancements, allowing alerts, locally generated by NetView/PC, to be viewed at the NetView/PC workstation itself.
- SPCF has been improved to provide enhanced performance and to support up to 128 different applications concurrently whereas NetView/PC V1.1 could only support one.
- NetView/PC V1.2 can communicate with a NetView host via Operating System/2 Extended Edition V1.1's SDLC support rather than the IBM Realtime Interface Co-processor Multiport Adapter hardware and software support.
- Remote console facility is currently not available under NetView/PC V1.2, but the intent to provide it in the future has been stated.

In conclusion, Figure 118 on page 292 illustrates the major components of both NetView and NetView/PC, and the communications link between the focal point (NetView) and the service point (NetView/PC).

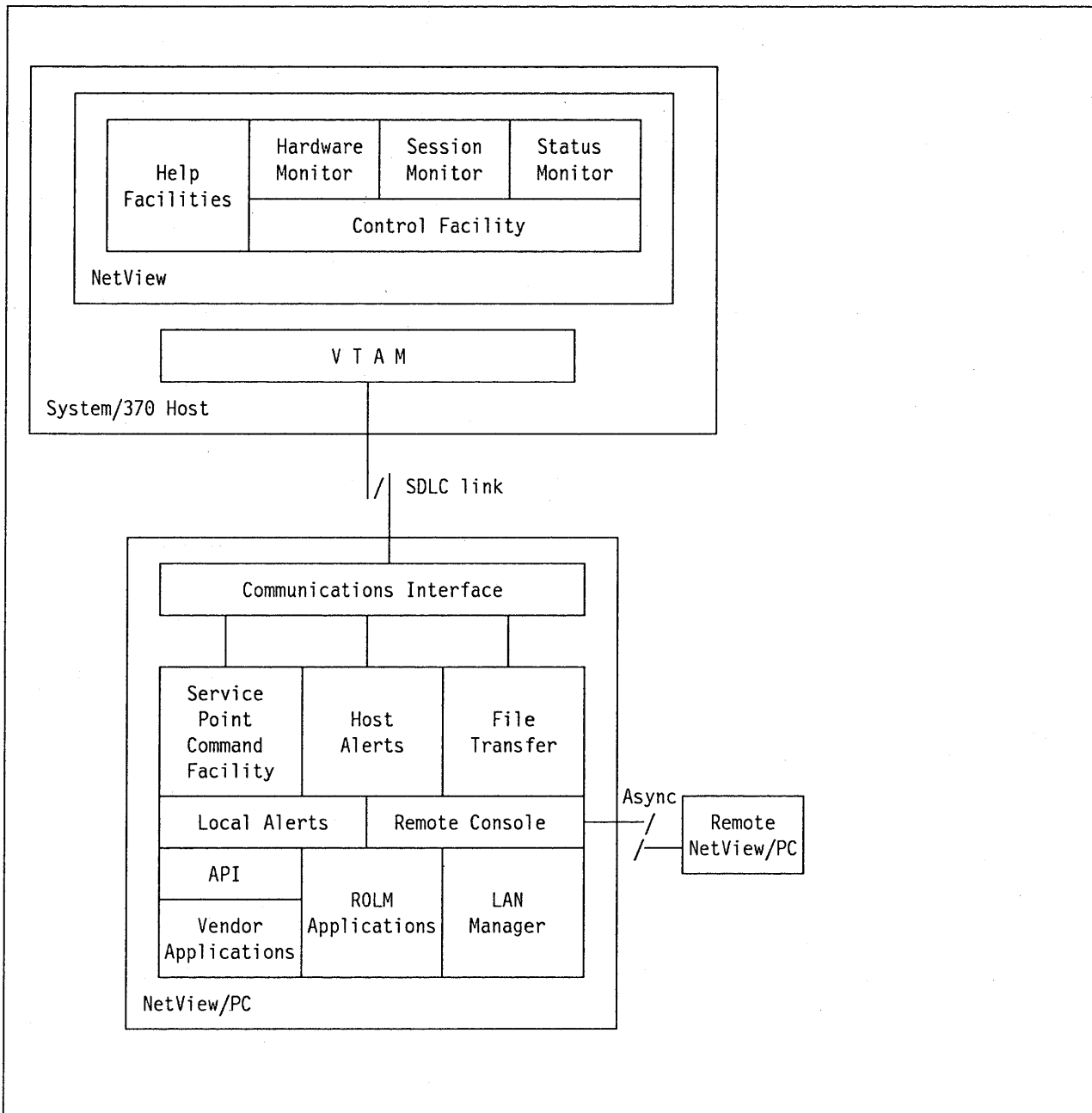


Figure 118. NetView and NetView/PC

9.6 IBM Token-Ring Network Trace and Performance Facilities

9.6.1.1 Product Description

The IBM Token-Ring Network Trace and Performance tool consists of both a hardware and a software component.

Additional capability is required for the IBM Token-Ring Network Adapters II and /A to support the required software functions. The enhanced adapters are known as IBM Token-Ring Network Trace and Performance Adapter II and IBM Token-Ring Network Trace and Performance Adapter II/A (part numbers 96X5773 or 96X5774). Both operate exclusively at 4 Mbps.

When not used with the corresponding software component, one of these adapters will behave like a regular Token-Ring Adapter II or Token-Ring Adapter II/A.

IBM Token-Ring Network Trace and Performance Program (Pgm/N 96X5763) is the corresponding software, providing a ring trace function or a performance monitoring function for the ring to which the trace and performance system is attached.

9.6.1.2 Trace Facility

The trace facility provides the ability to capture and analyze data traffic on the ring to which the tool is connected. The user may specify various filters such as type of frames to be captured (MAC, non-MAC, All), a specific set of destination and/or source addresses, type of LLC service command etc., before starting a ring trace. The trace facility will then write the captured frames to a user-specified file which may be analyzed using the Trace Analysis Facility. This analysis tool provides a summary of all frames indicating for each, the destination and source address fields and the frame function (command) represented by each (with respect to MAC, LLC, SNA or PC/Netbios operation). Each record has a sequence number. The detailed trace analysis report contains detailed information for each frame identified in the summary. In addition to the sequence number, each detail record contains a time stamp and a formatted listing of the frame (or frame header) contents. MAC header and trailer fields, and LLC header and routing fields are interpreted in addition to the hexadecimal display of the information field. The timer resolution is 10 milliseconds. Search parameters can be setup to enable analysis of selected records rather than the complete file.

The special hardware features of the Trace and Performance Adapter are required to enable the trace facility to trace frames not addressed itself. In trace mode, the adapter is opened to observe all frames, but does not participate in neighbor notification protocols.

To address possible security exposures, it is recommended that IBM LAN Manager V2.0 or IBM LAN Manager V1.0 be used in conjunction with the Trace and Performance program. In Trace mode, the adapter is required to send a special frame to the LAN Manager functional address, confirming that it is active and tracing. This feature is supported by IBM LAN Manager V2.0 and IBM LAN Manager V1.0. They can be set to allow or disable the trace facility. If disabled, the LAN Manager will force the trace adapter offline, and the current trace data set will be erased.

9.6.1.3 Performance Facility

The second function of the IBM Token-Ring Trace and Performance Facilities addresses ring performance. The performance facility collects ring traffic statistics in a user-specified file and displays a real time measure of the ring load as a percentage of the 4 Mbps theoretical ring capacity. Recording of data is based upon system defaults or specifications provided by the user. Counters similar to those specified for the 3174 controller are used to collect the data associated with specific frame and byte sequences and the relevant information is written by the performance facility to disk. Activation of the performance monitoring facility inserts the adapter in the ring and participates in regular ring protocol operation but cannot send/receive data through the LLC application interface to/from other applications in the performance monitoring system.

A performance analysis facility is available to display tabular reports of the statistics in various ways: according to frame type (total frames, MAC, LLC) and/or frame length distributions. The performance analysis facility also supports the printing of performance statistics in graphical form.

9.6.1.4 Additional operational considerations

If the token-ring segment being traced is not monitored by a LAN Manager, special care should be taken to secure the trace and performance monitoring station. In trace mode this station is capable of recording all data traffic on the ring to which it is attached. Physical protection of this station as well as encryption of critical data portions may have to be considered.

At any stage during setup of ring data collection or data analysis help is provided to assist the user to specify appropriate filtering or search criteria and to clarify displayed data.

Analysis reports generated through either of the two analysis facilities may be printed or written to disk for further processing.

When neither the trace nor the performance monitoring functions are invoked, the adapter operates as a regular Token-Ring Adapter II or Token-Ring Adapter II/A. On completion of trace or performance monitoring activity, the adapter will also reset to operate as a regular Token-Ring Adapter II or Token-Ring Adapter II/A.

9.6.1.5 Positioning

The previous discussion as well as miscellaneous differences between some LAN Manager functions and Token-Ring Network Trace and Performance facilities clearly points out the different yet complementary approach towards ring management offered by these products.

Whereas LAN Manager is aimed at continuous LAN segment monitoring of a multi-segment environment, preferably integrated into central site network management operations, the Token-Ring Network Trace and Performance facilities provide a specific, in-depth analysis tool for specialized problem determination of traffic on a single ring segment.

Token-Ring Network Trace and Performance facilities are adapted to be used in areas such as protocol verification or to assist in ring design by measuring load conditions on individual rings to obtain information to decide whether or not to split rings or rearrange devices.

The Token-Ring Trace and Performance Facilities prove to be particularly interesting in:

- Token-ring network problem determination
- Application development debugging and/or protocol verification
- Token-ring network design through ring utilization and/or device utilization statistics.

Therefore these facilities should be an integral part of any major IBM Token-Ring Network implementation plan.

9.7 IBM LAN Management Products Summary

The following table summarizes the IBM LAN management products both functionally and with regard to the different IBM LAN offerings. In addition, LAN specific diagnostic tools (Ring Diagnostics and PC Network Analysis Program) and the IBM Token-Ring Trace and Performance Facilities have to be considered.

Local PCNet Baseb	Area PCNet Broad	Netw. Token Ring	multi segm.	LAN size		Oper. System	Commands local I/F	SPCI supp.	Alerts Host Forw.	Appl. Xport	Rem. Cons. Fac.	Gateways to NetView NV/PC appl.	PC Gatew	OS2EE SDLC	3174 37xx
Y	Y	Y 4Mbps	N	small	PC 3270 Emul. LAN Management Program	PC/DOS 3.3 4.0	N	N	Y	N	N	N	Y	N	N
Y (1)	Y (2)	16 & Y 4Mbps	N	small	LAN Manager Entry V1.0	OS/2 EE 1.1	N	Y	Y	Y	N	N	N (9)	Y	Y
N	Y	Y 4Mbps	Y (5)	med.- large	LAN Manager V1.0	PC/DOS 3.3 4.0	Y	N	Y (3)	N	Y (3)	1.1 Y (3)	N	N	N
N	Y (2)	16 & Y 4Mbps	Y (6)	med.- large	LAN Manager V2.0	OS/2 EE 1.1	Y	Y	Y	Y	N (4)	1.2 Y	N (9)	Y	Y
N	N	16/4 Y 4Mbps	N	N/A	9370	N/A	N/A	N	Y (7)	Y	N	N/A	N/A	N/A	Y
N	N	Y 4Mbps	N	N/A	AS/400	N/A	N/A	N	Y	Y	N	N/A	N/A	N/A	Y
N	N	Y 16/4	N	N/A	3174 Gateway RPDS (8)	N/A	N/A	N	Y (7)	Y	N	N/A	N/A	N/A	Y

(1) Only OS/2 EE 1.1 SDLC Gateway capability applies.

(2) Host gateways 3174, 37xx,... only accessible on Token-Ring segment via PC Network Bridge.

(3) Host alert forwarding and remote console facility are mutually exclusive under PC/DOS (640KB limit).

(4) NetView/PC 1.2 includes S.O.D. to provide Remote Console Facility in the future.

(5) Token-Ring segments only (only links with IBM Token-Ring Bridges).

(6) Mixed Token-Ring / PC Net (Broadband) segments via links with PC Network Bridges.

(7) Basic alerts, that is text included in the NHVT instead of code points;
9370 may convert to Generic Alerts.

(8) 3174 implements a subset of Ring Problem Determination Support (including REM server function).

(9) The OS/2 LAN Gateway (S.O.D.) will provide this function.

Figure 119. LAN Management Products - Summary

10. LAN Positioning

10.1 IEEE 802.3, ISO IS 8802-3

The IEEE 802.3, ISO 8802-3 International LAN Standard, also known as the contention bus, specifies the carrier sense multiple access with collision detection (CSMA/CD) protocol to be used for accessing the common media.

This architecture is best suited for relatively stable local area networks with low traffic volumes and a relatively short average frame length.

The CSMA/CD protocol is very sensitive to high traffic loads, and therefore is not really suited in such an environment. As a backbone LAN is likely to concentrate LAN traffic, another LAN approach may be more appropriate.

Several architectural factors may inhibit CSMA/CD based LAN implementation in rapidly expanding LAN environments.

The CSMA/CD contention-based algorithm offers probabilistic media access to the LAN stations which may be more susceptible to overload in environments with large or volatile traffic characteristics.

The "broadcast" signalling employed in the IEEE 802.3 LANs may make fault domain isolation more difficult in larger LANs, and limits automatic recovery options at the medium access control level.

CSMA/CD-based LANs were the first local area network implementations to become generally available in commercial products. Today, there are many CSMA/CD based LAN offerings which makes this LAN approach quite popular and consequently a good candidate for LAN interconnection.

The requirement to support collision recovery and to minimize propagation delays tends to increase the cost of bridges and repeaters CSMA/CD LANs. In many cases CSMA/CD LANs use specialized cabling which cannot be used for other traditional data communications traffic.

Because of the early popularity of Ethernet LANs, many installed LANs use products which are capable of supporting only the Ethernet protocols and not the IEEE 802.3 protocols which evolved from the earlier specifications. This must be taken into consideration in planning for any-to-any connectivity.

IBM implements CSMA/CD in two of its LAN offerings: IBM PC Network Baseband and IBM PC Network (Broadband). These products are similar to, but do not conform to IEEE 802.3, ISO 8802-3 standards.

The IBM PC Network Baseband addresses the small establishment/work group environment, providing a cost-effective solution within the limitations of a single LAN segment approach without interconnection capabilities or sophisticated network management tools.

The IBM PC Network (Broadband) addresses the establishment/campus wide network environment, offering a versatile broadband environment with a variety of OEM attachments. This product is capable of co-existing on a broadband bus in a manufacturing environment.

10.2 IEEE 802.4, ISO IS 8802-4

The IEEE 802.4, ISO 8802-4 LAN standard, also referred to as Industrial LAN, offers the two bottom layers of the Manufacturing Automation Protocol (MAP), a full seven-layer communications application architecture for the manufacturing environment.

This LAN standard is best suited to meet the high broadband multi-channel communications requirements, which typically arise on the plant floor.

At the same time, MAP 3.0 as the emerging version of the seven-layer standard is called, meets another very important requirement. It includes the capability of providing guaranteed bandwidth and offers a fast-path solution for time-critical applications.

A broadband environment with many different channels requires specialized transmitters and may involve a considerable tuning effort. In addition, all components are designed to operate in a very aggressive industrial environment. This implies expensive translator units and adapters, and installation/maintenance costs compared to baseband LAN solutions for an office environment. For these reasons, a MAP LAN should not be considered in a rapidly expanding environment, unless this is the only LAN solution to meet some of the basic communications requirements. In a large, integrated multi-segment LAN environment, MAP segments should not be chosen for the backbones. An industrial LAN does not offer the best solution to meet high availability requirements.

10.3 IEEE 802.5, ISO IS 8802-5

The IEEE 802.5, ISO 8802-5 LAN standard, known as Token-Ring, is implemented by IBM with its IBM Token-Ring Network. This LAN product provides IBM's most versatile, general purpose LAN solution, offering native attachments for a variety of devices, workstations as well as communications devices and mid-range systems. It offers easy expansion capabilities and convenient solutions for topology changes.

For customers with larger, or rapidly growing LANs, the Token-Ring protocols are ideally suited to build a multi-segment hierarchical LAN. Various bridge products offer solutions for backbones with requirements for high-performance interconnection between Token-Ring segments operating at different speeds, for interconnection with IBM PC Network (Broadband) segments, or for interconnection with remote token-ring segments over teleprocessing lines.

The IEEE 802.5, ISO 8802-5 LAN Standard includes extensive network management and auto-recovery capabilities, which, together with products and topologies providing automatic backup offer the best solution for high-availability LANs.

The IEEE 802.5, ISO 8802-5 LAN standard specifies a baseband medium. Thus, solutions such as IBM PC Network (Broadband) may be preferred for broadband LANs, although IBM Token-Ring LAN segments may be interconnected with broadband LAN segments via bridges.

Token-Ring LAN segments, offered with the IBM Token-Ring Network at 4 Mbps and 16 Mbps transmission speeds, provide a basis for coexistence with emerging standards such as FDDI to address the bandwidth requirements of ultra-high speed local area networks. The Token-Ring Network approach is closely aligned with the Fiber Distributed Data Interface (FDDI), an emerging ultra-high speed LAN standard offering 100 Mbps on optical fiber media both in terms of frame format and cabling. These similarities provide the potential for relatively simple and cost-effective migration to and coexistence with future FDDI LANs in many establishments.

Token-ring cabling includes general-purpose copper wiring, which may be used for most traditional data communications traffic, as well as optical fiber cabling between the wiring closets. Cabling requirements for the IBM Token-Ring Network are best satisfied by IBM Cabling System's structured wiring approach, limiting the need for wiring changes and substantially adding to the ease of re-configuration or growth.

Finally, the IBM Token-Ring Network offers important LAN management capabilities for a multi-segment environment, with optional integration into central-site network management through IBM LAN Manager V2.0, various SNA host gateways and the NetView focal point implementation in a System/370 host system.

10.4 LAN Interfaces

The standards organizations specify a standard protocol IEEE 802.2 or ISO 8802-2 which is common to the three LAN standards IEEE 802.3, IEEE 802.4 and IEEE 802.5 as well as FDDI.

This link-level protocol has an open LAN interface, commonly referred to as the LLC interface. IBM supports this interface through the IBM LAN Support Program V1.10 for all workstation attachments to the IBM Token-Ring Network, IBM PC Network (Broadband) and the IBM PC Network Baseband. All other devices with native IBM Token-Ring Network attachments, communications controllers, cluster controllers and mid-range systems, use this interface to communicate over the LAN. IEEE 802.2 LLC is also the common interface across a multi-segment LAN environment, regardless of the various medium access control protocols used by the individual LAN segments.

IBM implementations of the IEEE 802.2 LLC interface provide easy integration of the LAN protocols into IBM System Network Architecture (SNA), and are the basis of communications between LAN devices and IBM System/370 host systems across SNA gateways. It is also the basis for IBM's strategic LU 6.2 protocols for program-to-program communication between LAN stations.

In addition, IBM provides through the IBM LAN Support Program V1.10 a non-standard but widely accepted higher layer interface for LAN-attached workstations, called Netbios. Netbios is used by a variety of popular applications for LAN attached workstations.

List of Abbreviations

<i>ANSI</i>	American National Standards Institute
<i>APPC</i>	Application Program to Program Communication
<i>ASCII</i>	American (National) Standard Code for Information Exchange
<i>AWG</i>	American Wire Gauge
<i>BNN</i>	Boundary Network Node
<i>bps</i>	bits per second
<i>CATV</i>	Community Antenna TeleVision (Cable TV)
<i>CCITT</i>	Comite Consultatif International Telegraphique et Telephonique (International Telegraph and Telephone Consultative Committee)
<i>CF</i>	Control Field
<i>CIM</i>	Computer-Integrated Manufacturing
<i>CPRB</i>	Connectivity Programming Request Block
<i>CSMA/CD</i>	Carrier sense multiple access with collision detection
<i>dB</i>	decibel
<i>DDM</i>	Distributed Data Management
<i>DFT</i>	Distributed Function Terminal
<i>DISC</i>	DISConnect (Command)
<i>DLC</i>	Data Link Control
<i>DSAP</i>	Destination Service Access Point
<i>DSPU</i>	Downstream Physical Unit
<i>DTE</i>	Data Terminal Equipment
<i>EBCDIC</i>	Extended Binary Coded Decimal Interchange Code
<i>FCS</i>	Frame Check Sequence
<i>FDX</i>	Full Duplex
<i>FDDI</i>	Fiber Distributed Data Interface
<i>GW-NCP</i>	Gateway NCP
<i>HDX</i>	Half Duplex
<i>HLLAPI</i>	High Level Language Application Programming Interface
<i>ICS</i>	IBM Cabling System
<i>INN</i>	Intermediate Network Node
<i>IEEE</i>	Institute of Electrical and Electronic Engineers
<i>IMPL</i>	Initial Microprogram Load
<i>IO</i>	Input/Output
<i>ISO</i>	International Standards Organization
<i>IWS</i>	Intelligent Workstation
<i>Kbps</i>	Kilobits per second (Thousands of bits per second)
<i>LAN</i>	Local Area Network
<i>LED</i>	Light Emitting Diode
<i>LLC</i>	Logical Link Control
<i>LPDU</i>	Logical Link Control Protocol Data Unit
<i>LSAP</i>	Logical Link Control Service Access Point
<i>LU</i>	Logical Unit
<i>MAC</i>	Medium Access Control
<i>MAP</i>	Manufacturing Automation Protocol
<i>Mbps</i>	Million bits per second
<i>MFI</i>	MainFrame Interactive
<i>MMS</i>	Manufacturing Messaging Specifications
<i>MVID</i>	Major Vector IDentifier
<i>NADN</i>	Nearest Active Downstream Neighbor
<i>NAUN</i>	Nearest Active Upstream Neighbor
<i>NCP</i>	Network Control Program

<i>NTRI</i>	NCP Token-Ring Interface
<i>OSI</i>	Open Systems Interconnection
<i>PABX</i>	Private Automatic Branch Exchange
<i>PC</i>	Personal Computer
<i>PU</i>	Physical Unit
<i>RAM</i>	Random Access Memory
<i>RF</i>	Radio Frequency
<i>RI</i>	Routing Information
<i>RR</i>	Receive Ready
<i>SABME</i>	Set Asynchronous Balanced Mode Extended (Command)
<i>SAP</i>	Service Access Point
<i>SDLC</i>	Synchronous Data Link Control
<i>SRPI</i>	Server/Requester Programming Interface
<i>SSAP</i>	Source Service Access Point
<i>TCP/IP.</i>	Transmission Control Protocol/Internet Protocol
<i>TIC</i>	Token-Ring Interface Coupler
<i>TRA</i>	Token-Ring Adapter
<i>TRM</i>	Token-Ring Multiplexor
<i>TRSS</i>	Token-Ring SubSystem
<i>TSAF</i>	Transparent Services Access Facility
<i>TTP</i>	Telephone Twisted Pair (Wiring)
<i>UA</i>	Unnumbered Acknowledgement
<i>XID.</i>	Exchange Identification

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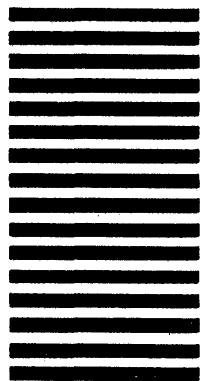
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