Planning Apollo Networks and Internets

Order No. 009916-A01

First Printing: June 1987
Last Printing: May 1990

10 9 8 7 6 5 4 3 2 1

Preface

This manual describes Apollo networking from a network planner's perspective. It covers Apollo network types, topologies, configuration requirements, and specifications. We assume that you're familiar with computers and networks in general, but not necessarily with Apollo networks.

We intend that you use this manual in conjunction with the others listed in the "Related Manuals" section. The manuals listed there provide detailed environmental requirements for nodes and peripherals, specific installation instructions for the Apollo Token Ring Network, and network and internet management information.

We've organized this manual as follows:

Chapter 1	Provides general information about network planning, such as network planning goals and responsibilities.
Chapter 2	Introduces and compares Apollo networking options.
Chapter 3	Describes Apollo Token Ring network cables and accessories.
Chapter 4	Describes how to plan an Apollo Token Ring network layout.
Chapter 5	Describes the basic configuration rules for Apollo Token Ring on shielded twisted pair cable.
Chapter 6	Describes the FDDI network cables and accessories.
Chapter 7	Describes the basic configuration rules for an FDDI network layout.
Chapter 8	Describes IEEE 802.3 network cables and accessories.

Chapter 9	Describes the basic configuration rules to consider when planning an IEEE 802.3 network installation.
Chapter 10	Describes the IEEE 802.5 network cables and accessories as well as the basic configuration rules to consider when planning an IEEE 802.5 network installation.
Chapter 11	Describes the hardware used to connect networks in an internet.
Chapter 12	Contains general internet planning information as well as specific information about Domain and TCP/IP internet topologies.
Appendix A	Provides information about ordering network accessories from the *Instant Apollo* catalog.
Appendix B	Contains information related to the Domain/DFL–100 Fiber Interface Unit.
Appendix C	Contains summary information about the network controllers used to connect Apollo nodes to the networks and internets discussed in this manual.

We also provide network and internet planning checklists and glossary of terms at the back of the book.

Related Manuals

The file **/install/doc/apollo/os.v.***latest software release number***__manuals** lists current titles and revisions for all available manuals.

For example, at SR10.2 refer to **/install/doc/apollo/os.v.10.2__manuals** to check that you are using the correct version of manuals. You may also want to use this file to check that you have ordered all of the manuals that you need.

(If you are using the Aegis environment, you can access the same information through the Help system by typing **help manuals**.)

Refer to the *Apollo Documentation Quick Reference* (002685) and the *Domain Documentation Master Index* (011242) for a complete list of related documents.

For more information on the Apollo Token Ring network protocol, see *Apollo Token Ring Media Access Control Layer and Physical Layer Protocol* (010005).

For environmental requirements for Domain hardware, see *Domain Hardware Site Planning Specifications* (009859).

For coaxial cable installation procedures for an Apollo Token Ring, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* (009860).

For more information on operating the Apollo Token Ring Remote Network Switch, see *Using the Network Topology Control (NTC) Software* (013419-A00). For planning information, see *Planning for the ATR-RNS* (012798-A00).

For more information about the DFL-100, see *Installing and Operating the Domain/DFL-100 Fiber Interface Unit* (008626).

For more information about Domain internets, see *Managing Domain/OS and Routing in an Internet* (005694). Also refer to the specific managing manuals for any other network software products you plan to use in your internet.

For more information about TCP/IP internets, see *Configuring and Managing TCP/IP* (008543).

For more information about HP EtherTwist, see *HP EtherTwist Network Start-Up Guide* (5090-2642), *HP EtherTwist Hub Installation Guide* (5090-2632), and *HP AdvanceNet HPLAN Configuration Guide for IEEE 802.3 and Ethernet Networks* (5090-2607).

For more information about IEEE 802.3 networks, see *ANSI/IEEE Standard 802.3 for Local Area Networks* (FIPS PUB 107).

For more information on IBM Token Ring networks and installation, refer to the following documents:

- *IBM Token-Ring Network Introduction and Planning Guide* (GA27-3677)
- *IBM Cabling System Planning and Installation Guide* (GA27-3361)
- *IBM Token-Ring Network Installation Guide* (GA27-3678)
- *IBM Token-Ring Network Telephone Twisted-Pair Media Guide* (GA27-3714)

For more information about Apollo network and internet controllers, refer to the following documents:

- *Installing the 802.3 Network Controller-AT* (009741)
- *Installing the Apollo Token Ring Controller-AT* (010616)
- *Unpacking and Installing the EtherController-MB* (008265)
- *Unpacking and Installing the Domain/Bridge Controllers* (005697)

For more information on Electronic Industries Association (EIA) Standard RS–449 and RS–422 specifications, contact the EIA Engineering Department, 2001 Eye Street, N.W., Washington, D.C. 20006

For more information on the Digital Cross Connect (DSX) specifications, refer to the *Bell System Technical Reference for High Capacity Terrestrial Digital Service*, publication number 41451, and the *AT&T Compatibility Bulletin #119*.

You can order Apollo documentation by calling **1–800–225–5290**. If you are calling from outside the U.S., you can dial **(508) 256–6600** and ask for **Apollo Direct Channel**.

Does This Manual Support Your Software?

This manual assumes that SR10.0 is the software version you are running unless another version of the software is specifically mentioned. To verify which version of operating system software you are running, type:

bldt

If you are running Domain/IX on a release of the operating system earlier than SR10.0, then type:

/com/bldt

Problems, Questions, and Suggestions

We appreciate comments from the people who use our system. To make it easy for you to communicate with us, we provide the Apollo Product Reporting (APR) system for comments related to hardware, software, and documentation. By using this formal channel, you make it easy for us to respond to your comments.

You can get more information about how to submit an APR by consulting the appropriate Command Reference manual for your environment (Aegis, BSD, or SysV). Refer to the **mkapr** (make apollo product report) shell command description. You can view the same description online by typing:

man mkapr (in the UNIX® shells)

help mkapr (in the Aegis shell)

Alternatively, you may use the Reader's Response Form at the back of this manual to submit comments about the manual.

Documentation Conventions

Unless otherwise noted in the text, this manual uses the following symbolic conventions.

literal values — Bold words or characters in formats and command descriptions represent commands or keywords that you must use literally. Pathnames are also in bold. Bold words in text indicate the first use of a new term.

user–supplied values — Italic words or characters in formats and command descriptions represent values that you must supply.

CTRL/ — The notation CTRL/ followed by the name of a key indicates a control character sequence. Hold down <CTRL> while you press the key.

——— ⊞ ——— This symbol indicates the end of a chapter.

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Chapter 1

Introduction

This chapter provides an overview of Apollo network concepts, configurations, and services. It also provides an overview of network planning goals and responsibilities.

1.1 Overview of Apollo Networks

An Apollo network is a network that contains Apollo workstations, called nodes, using Domain services. Apollo networks are adaptable, multipurpose systems designed to support a variety of computer equipment from different manufacturers, numerous system resources, and several cabling options. They support multiple applications and can grow and change as new applications are introduced and the user population increases.

Domain/OS, the operating system, supports the network and runs on the physical network. Nodes connected to the network can load data from the network into memory just as they would from their own disks. Domain/OS makes the information on all disks available to any node on the network.

Each node in the network requires the use of at least one disk, called a **boot volume**, that contains the operating system and other system software it needs to run. Disked nodes are physically connected to the disk that they use as the boot volume. **Diskless nodes** share the boot volume of some other disked node in the network, called a **network partner**.

To run in the network, a diskless node must have a network partner. The network partner's disk provides all of the necessary operating system and support software for the diskless node. Because a diskless node relies on it partner for system software, it can operate only when the partner node is operating. If the partner node is removed from the network while the diskless node is running, the diskless node will crash. As a network planner, it is important that you take such dependencies into account when setting up the network.

Apollo networks provide full **Domain services** to all Apollo nodes. Domain services, part of our standard software, include the following:

- Transparent information sharing among Apollo nodes.
- Distributed processing, including remote procedure call for Apollo and non-Apollo nodes.
- Network device sharing, allowing multiple protocols, such TCP/IP, to share a single network controller. Thus, you can have an internet that simultaneously uses Domain and TCP/IP protocols.
- Diskless booting and remote paging for Apollo nodes (located on the same network).
- Transparent communication between separate networks (internet).
- Network independent operation of station management commands.
- TCP/IP for communications with non-Apollo systems.

Figure 1-1 shows a simple serial-wired Apollo network. The following are some examples of Domain services that refer to nodes on this network. Both **node_x** and **node_y** are independent workstations with their own disks and Domain/OS operating systems.

- Transparent File Copying — If you are logged in to node_x and you are in a C shell with your current directory as **//node_x/user_x**, you can copy a file to a directory on **node_y** by doing the following:

  ```
  cp file_x  //node_y/user_y/file_x
  ```

  You can set your directory to **//node_y/user_y** and delete the file as follows:

  ```
  cd //node_y/user_y
  rm file_x
  ```

- Transparent Editing — You can edit a file on **node_y** from **node_x** by doing the following at the Display Manager command line (press the EDIT key to get the "Edit file:" prompt) on **node_x**:

  Edit file: //node_y/user_y/file_y

  The file appears in a window on the display at **node_x** and is available for editing.

- Program Execution and Paging Across a Network — You can execute a file (**program_z** on **node_y** in this example) on **node_x** by typing the following command in a C shell on **node_x**:

  //node_y/user_y/program_z

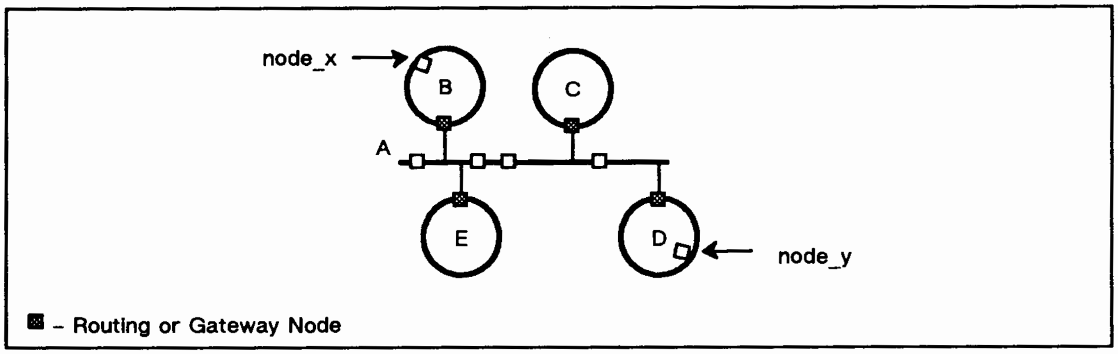


Figure 1-1. Apollo Networks in a Domain Internet

For more information about these services, see the appropriate managing manual (for example, for information on TCP/IP, refer to *Configuring and Managing TCP/IP* or for information on diskless booting in your SysV environment, see *Managing SysV System Software*).

If your site contains non-Apollo systems that do not use TCP/IP protocols, you may be able to use one of our other communications facilities, such as Apollo/Integrated SNA or Apollo/TECHnet to add non-Apollo resources to your Apollo network. Some of the facilities allow you to access information on non-Apollo systems from an Apollo workstation, while others allow you to use Domain services from a non-Apollo system.

As you read this chapter, keep in mind the number of nodes and other devices that you plan to connect in your Apollo network, the applications you intend to run, and the geographic extent of your intended installation. One of the network types and configurations described in this chapter will suit your needs.

1.2 General Information about Network Configurations and Services

An Apollo network provides complete computing resources, Domain services, and transparent access to all Apollo nodes on the network. In addition, an Apollo network provides access to non-Apollo nodes and resources.

The distinguishing characteristic of an Apollo network is Domain services and protocols provided by the Domain/OS operating system. An Apollo network can operate on several different physical network interfaces, such as Apollo Token Ring, IEEE 802.3, or IEEE 802.5, as well as on different physical media, such as coaxial cable, fiber-optic cable, or twisted pair cable.

An Apollo network can be configured as the following:

- A single **Local Area Network (LAN)** — We currently support communications on four types of LANs:

  - The **Apollo Token Ring network**, which is our proprietary high-speed token-passing ring.

  - The **IEEE 802.3 network** (also called an **Ethernet** network), which conforms to the ANSI/IEEE Standard 802.3 for Local Area Networks* and consists of Domain services running on Ethernet.

  - The **IEEE 802.5 network** (also called an **IBM Token Ring** network), which conforms to the ANSI/IEEE Standard 802.5 for Local Area Networks and consists of Domain services running on the IBM Token Ring.

  - The **Apollo FDDI network**, which complies with the emerging standard of the ANSI X3T9.5 committee.

  These LANs combine the power of a distributed computing environment with the flexibility to handle large numbers of nodes in almost any conceivable layout.

- A combination of two or more LANs in an **internet** — An internet allows you to connect independent Apollo or non-Apollo networks in a local area or between widely separated areas (sites in different states, for example).

You can have different combinations of network layers. An Apollo network (meaning Domain services and protocols) can be layered on an Apollo Token Ring using coaxial or shielded twisted pair cable (typically used with an IEEE 802.5 or IBM Token Ring network). An Apollo network can also be layered directly onto an IEEE 802.5 network.

These network configurations are described in more detail in Chapter 2 and in the network-specific chapters included in this manual. Table 1-1 summarizes the network and internet configurations available currently.

* The ANSI/IEEE Standard is FIPS PUB 107.

Table 1-1. Network and Internet Summary

Network Config-uration	Ideal Number of Nodes	Maximum Number of Nodes	Principal Application	Network Management Considerations
Serial-Wired Apollo Token Ring	Several hundred, dependent on your network management capabilities	Several hundred, dependent on your network management capabilities	Connect nodes in a single work group	Inherent features simplify fault identification. DQC-100 allows quick removal or addition of nodes.
Star-Wired Apollo Token Ring	1 to 8 nodes *per loop*	Several hundred, *no limit on number of loops*	Organize modular work groups in one network	Speedy fault isolation with network switches. Remaining loops are unaffected by failure. Need network control area for switch monitoring/operating.
DFL-100 Extended Apollo Token Ring	(See Serial-Wired and Star-Wired Apollo Token Rings above)	(See Serial-Wired and Star-Wired Apollo Token Rings above)	Join nodes in adjacent build-ings	Improves network management and efficiency. Automatic features isolate/recover from fiber-optic link and ring inter-ruptions.
Domain on IEEE 802.3 Network	Dependent on applications/ data traffic load	1024 (practical limit may be lower depending on your applications & data traffic)	Connect Domain nodes to multi-vendor corporate backbone	Fault location/identification requires special equipment.
Domain on IEEE 802.5 Network	Dependent on applications/ data traffic load	260 per ring on Type 1 cable or 72 per ring on unshielded twisted pair cable	Connect Domain nodes to multi-vendor corporate backbone	Speedy fault isolation. MIC plugs allow quick removal and reconfiguration.
Series 10000 FDDI Network	Dependent on applications/ data traffic load	500 dual - attachment stations	Connect Domain nodes to multi-vendor corporate backbone	Apollo dual-attachment ring offers optical by-passing ca-pability.
Internet	Dependent on types of networks in the internet	Dependent on types of networks in the internet	Increase overall flexibility, allow communication between diverse network types	Transparent communication between nodes on different networks. Requires careful resource planning.

1.3 Network Planning Goals and Responsibilities

As a network planner, you cannot expect to anticipate all the uses for such networks, nor can you purchase unlimited amounts of equipment. However, by keeping a few goals and responsibilities in mind, you can plan a network that will adapt to growth and change, serve the needs of users, and meet your budget.

Briefly, the major planning goals include the following:

- Designing in Adaptability — To accommodate growth without requiring major redesign or extensive recabling.
- Ensuring Reliability — To provide consistent, dependable communications service.
- Tailoring the Network for Your Applications — To support multiple applications, machine types, topologies, and resources; and to meet performance (response time) requirements.
- Meeting Costs — To establish the optimum price/performance ratio.

The following sections elaborate on these goals, and provide basic guidelines for implementing them in your Apollo network.

1.3.1 Designing in Adaptability

Contemporary networks must accommodate growth and change. They must allow you to introduce new elements (for example, application technologies, computer systems) without extensive recabling or reprogramming of existing systems. Such networks are often referred to as extensible or *open*.

One effective way to achieve an open network is *modularity*. You should plan your network around modular groups that can accept new elements as *local* resource demands grow and change. In the context of Apollo networks, a module can be an Apollo network that connects to other Apollo networks or other types of networks by using bridges or routers.

A modular network design also adapts easily to changing **configurations**. For example, you may need to partition the network when a failure in a modular group interrupts data flow, or for testing or other purposes. In a modular network, network operation can continue over alternate data paths. Section 12.3.3 on adaptive routing provides specific examples of alternate data paths.

1.3.2 Ensuring Reliability

As networks become larger and more complex, so does the task of isolating failures and restoring network services. To help increase the reliability of your network, follow these recommendations:

- Avoid single points of failure in your design. Design the network so that a single hardware or software problem (such as a cable break or system failure) cannot interrupt overall network communication.

- Use proper cable installation techniques. By observing hardware specifications and following installation instructions closely you can minimize loose or broken connections that can degrade network performance or interrupt operation.

- Distribute resources throughout the network. To avoid competition for resources that can slow data traffic and disrupt service, plan adequate resources in groups where you anticipate heavy use and be prepared to add or subtract resources if needs change.

Figure 1–1 shows a simple internet configuration with four Apollo Token Rings. If users on each network need additional disk storage space for files they are working on, you can place an additional node with a large disk drive on each network. Thus, if users on the local network cannot access the central network, they can still access their files.

1.3.3 Tailoring the Network for Your Applications

Today, it is common for a network to support office automation, accounting, and project management and other business software, as well as engineering and computer–aided manufacturing applications. In addition, the network may contain equipment for wide–area communications.

To avoid underutilized or overutilized network resources, you should become familiar with the applications your network will run. Know what machine types the applications run on and the special configurations required by the applications (for example, performance enhancements or added memory). You might need to create a single network for nodes that run computation–intensive programs. You should also be able to determine the resource and data storage capacity needs of each application, as well as the application traffic patterns.

In Figure 1–1, if a resource such as a CAD/CAM database is to be used by users on all networks, place it on the central network. However, if only users on Network B access this database, then place it on Network B. Chapter 12 provides more information on and examples of internet topologies.

1.3.4 Establishing Price/Performance Goals

Understanding your applications will help you determine your performance requirements. To meet your cost goal, you must choose the most economical configuration that satisfies that requirement and still provides for growth and change.

In planning how to meet performance requirements and keep costs down, examine the benefits of a single open **network architecture**, such as the Apollo network, that supports multiple users and applications. We have discussed how an open network can adapt to growth and support additional users and a range of applications. The alternative, an application-specific network architecture, may achieve the desired performance but does not address the needs of the whole organization. The Apollo network also connects, through internets, to other Hewlett-Packard computers as well as those from other vendors.

For example, you can place several diskless Apollo nodes on an Apollo network, with each node booting off of and using the disk of a disked Apollo node. At a later time, you may upgrade these nodes to disked nodes if your software applications and their data storage needs change.

In general, hardware costs for a given level of performance are shrinking and increased computational power is now available in desktop workstations. Consequently, your initial investment can be small to meet your startup needs, and can grow in small increments at your own pace.

1.3.5 Planning Responsibilities

As a network planner, it is your responsibility to plan your Apollo network by using the information in this manual. We can advise you in special circumstances, and we offer network maintenance services; but unless you plan and install your network correctly, it may never operate efficiently and reliably.

Your responsibilities are to

- Purchase and install suitable network cable and connectors, defined by the appropriate specifications. (See the respective network chapters for descriptions; see Appendixes A and B for ordering information.)

- Ensure that your site meets the environmental and electrical standards required for Apollo nodes and peripherals (see *Domain Hardware Site Planning Specifications*).

- Plan your network for efficiency, reliability, and future growth by using the information in this manual.

As your vendor, we provide

- Hardware specifications and recommendations.
- Planning and installation guidelines and procedures.
- Fast and convenient supply of approved network cable, connectors, switches, and accessories through the *Instant Apollo* catalog.

We have designed this manual to help you meet your planning goals and responsibilities. Please let us know how we can improve it by using the Reader's Response form at the back of the book.

Chapter 2

Apollo Network Configurations

This chapter introduces Apollo network configurations, topologies, transmission media, and connection devices. Refer to the network-specific chapters in this book for cabling and planning information.

2.1 Network Interface Types

Apollo nodes now can support the following five different types of physical network interfaces. The following sections describe the various network configurations.

- Apollo Token Ring
- FDDI (Fiber Distributed Data Interface)
- IEEE 802.3 (Ethernet)
- IEEE 802.5 (IBM Token Ring)
- Serial Line (SLIP)

2.2 The Apollo Token Ring Network

The Apollo Token Ring (ATR) network protocol links each node to the next in a *ring* topology. Access to the network is arbitrated by a **token** — a specific sequence of bits passed from one node on the ring to the next. A ring network is a network in which nodes—computers or other devices on the network—are connected together serially in the configuration of a ring.

The system allows only one token to be on the ring at any given time, and specifies that the token always circulates in the same direction. Possession of the token gives a particular node the exclusive use of the network for the duration of its message transmission. Therefore, a normally operating network never experiences collisions (or contention for the token) that would impair efficiency.

When a node has a message to transmit, it acquires the token, sends the message, and then releases the token back onto the ring. On the average, all the nodes on the network have an equal chance of acquiring the token. The token-passing mechanism results in a very fast network arbitration which allows the ATR to support heavy data loads without significant service degradation.

Additionally, because of the circular data flow, each Apollo node can create a map of the network topology (that is, the node can perform **topology determination**). Also, each node constantly monitors the presence of its **upstream neighbor** (the node immediately preceding it on the ring) and transmits a failure report (this is often called beaconing) if it is unable to detect a coherent signal from its upstream neighbor. All other nodes on the ring can receive this report since they are downstream from the break. With this failure report and a network topology map, it is easy to isolate network failures to the nodes on either side of a break.

In addition to the high data transfer rate and convenient error detection/isolation, the Apollo Token Ring allows you to

- Connect hundreds of nodes in a single network without using external transceivers and/or repeaters.
- Instantly connect or disconnect nodes without disrupting the network (using the Domain/DQC discussed in Section 3.1.2).
- Install cable from a central control point (see Section 2.3.2).

For more information about the Apollo Token Ring network protocol refer to *Apollo Token Ring Media Access Control Layer and Physical Layer Protocols.*

2.3 Apollo Token Ring Network Configurations

This section describes the various configurations to consider when planning an Apollo Token Ring network. The following types of ATR network configurations are discussed:

- Serial-wired ring
- Star-wired ring
- Extended ATR using fiber-optic cable and a Domain Fiber-Optic Link (DFL-100)

2.3.1 The Serial-Wired Ring

The serial-wired ring contains nodes connected in a serial fashion. The serial-wired ring is often illustrated as a circle, as shown in Figure 2-1. It offers easy installation and minimal planning, and is the simplest configuration if your network consists of only a few nodes located in a single area (such as a laboratory or classroom). However, keep in mind that a single failure can disable the entire network. Therefore, if you're planning a network of more than 10 nodes, or where the nodes are more than a short walking distance apart, consider installing a **star-wired** Apollo Token Ring network. A star-wired network (see Section 2.3.2) can help to simplify maintenance and management tasks.

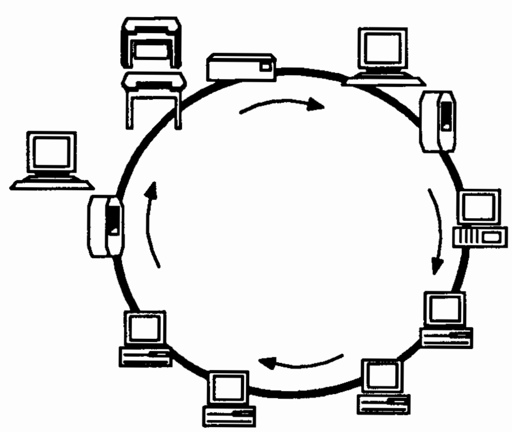


Figure 2-1. Serial-Wired Apollo Token Ring Network

2.3.2 The Star–Wired Ring

As shown in Figure 2–2, a star–wired ATR configuration allows you to create independent node groupings, or **loops**. Cable passes through either a manual or remote **network switch** as it enters and exits each loop.

You can use the Apollo Token Ring Remote Network Switch (ATR–RNS) or a manual network switch to disconnect one or more loops from the rest of the network. Each "switched–out" loop continues to function as a small ring. However, since the switched–out loop is disconnected from the rest of the network, the nodes on the switched–out loop can communicate only with each other. Figure 2–3 shows how data flows in a star–wired ring when one loop is switched out.

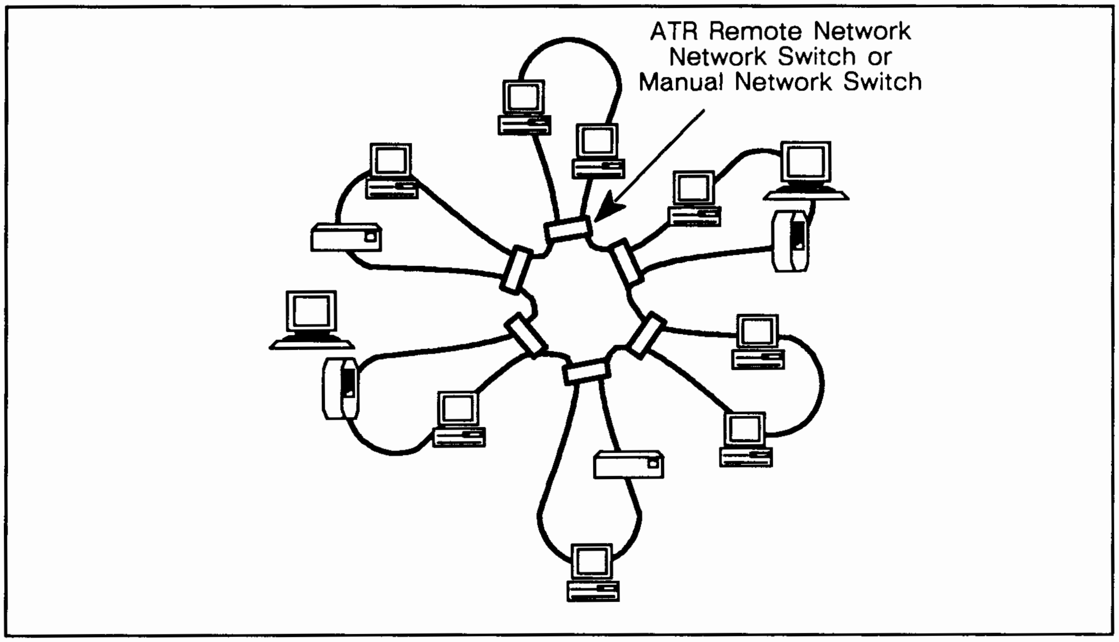


Figure 2–2. Star–Wired Apollo Token Ring Network

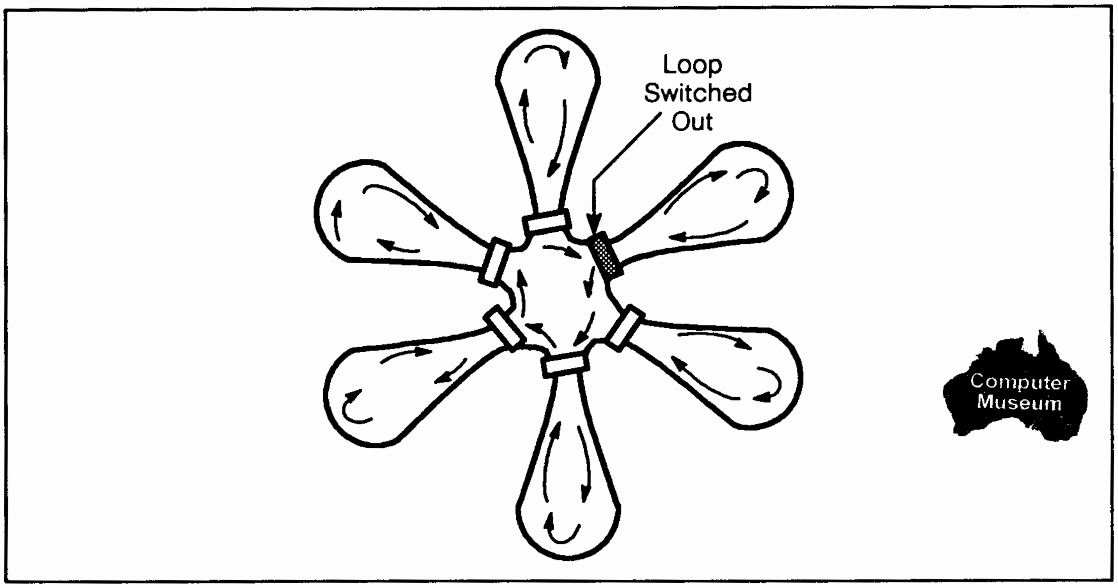


Figure 2-3. Star-Wired Apollo Token Ring Network

To design a ring to cover a larger area such as a multistory building or building complex, you can connect several star-wired configurations as shown in Figure 2-4. Loops 0, 1, 2 and 3 are major loops. Generally, switches controlling major loops are located in a **network control room.** Subloops (indicated by the letters **a** through **o**) run throughout the building and contain nodes. Their controlling switches can be located in the network control room, or distributed throughout the building. You can switch each major loop in and out of the main ring in the same way you switch a subloop in and out. Many ATR installations configure each floor of a building as a major loop and groups of offices as subloops.

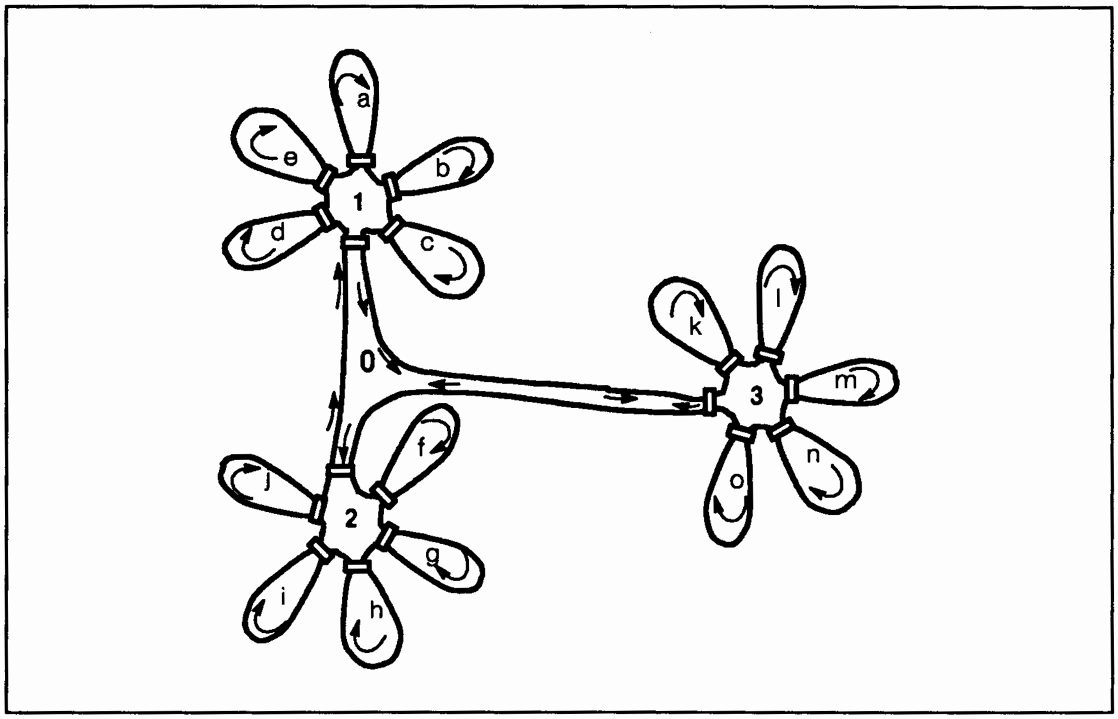


Figure 2–4. Several Connected Star–Wired Configurations

A star–wired network maximizes network availability and extensibility by allowing you to

- Quickly isolate cable faults and node failures to a single loop, and switch that loop out of the network while you keep the rest of the network operating normally.
- Install cable and connectors in a switched–out loop without disturbing data flow in the rest of the network.
- Operate your installation as one large ring or as a combination of independent loops. You use the network switches to create different combinations of loops.
- Protect certain nodes (nodes running tests, for example) from network interruptions by locating the nodes on a single loop.

When you plan a star–wired ring, keep in mind that the network resources (for example, printers, partner nodes, and/or software source files) on a particular loop become unavailable to the rest of the network whenever you switch out that loop. Therefore, you must carefully allocate your resources if you plan to have loops that may be switched out for long periods.

2.3.3 Domain Fiber–Optic Extension for ATR (DFL–100)

You can extend a single Apollo Token Ring network between buildings by using fiber–optic cable and the **Domain Fiber–Optic Link (DFL–100)**. The DFL–100 attaches to the Apollo Token Ring network coaxial cable and provides an interface point for fiber–optic cable.

NOTICE: The DFL–100 extension is a separate product and serves a different purpose than the Apollo FDDI network discussed in Section 2.4.

Fiber–optic cable is strongly recommended for interbuilding communication because it exhibits very low signal loss and is not affected by many environmental conditions that can disturb data flow in coaxial cable. Following are some of the desirable characteristics of fiber–optic cable:

- Low signal loss. This allows a fiber–optic cable link to be up to 3 km (9843 ft) in length.
- Does not conduct electricity, thus fiber–optic cable
  - Is unaffected by electromagnetic interference (produced by lightning and power lines)
  - Isolates any difference in ground potential between buildings
  - Is difficult to monitor electronically, thus promoting network security

Figure 2–5 shows a typical configuration using the DFL–100 and fiber–optic cable.

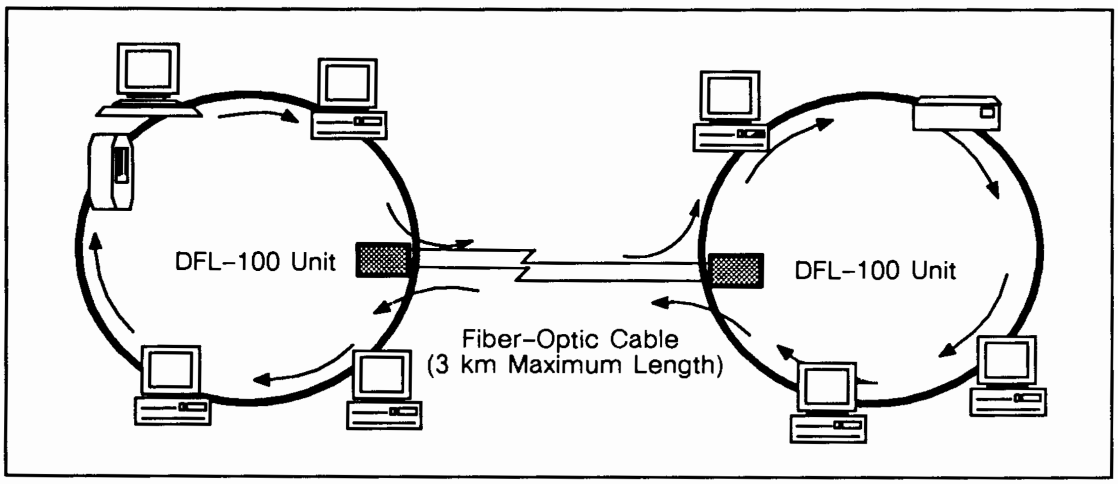


Figure 2–5. Apollo Token Ring Network Extended with Fiber–Optic Cable

Data passing through fiber–optic cable has the same effective through–put as coaxial cable, so you can transmit large amounts of data over the fiber–optic link with minimal delays.

Note that the DFL–100 extends a *single* ring over a distance. Therefore, if you use the DFL–100 to link rings in adjacent buildings, you form a single, larger ring.

Because there is no limit to the number of DFL–100 links in the network, you can use the DFL–100 to form a single ring from many rings. However, we do not recommend that you connect several DFL–100 units back–to–back. There should be an active node (a deactivated or bypassed node is not sufficient) between them. Figure 2–6 shows an example where DFL–100s connect seven previously separate rings into *one* ring that spans seven sites.

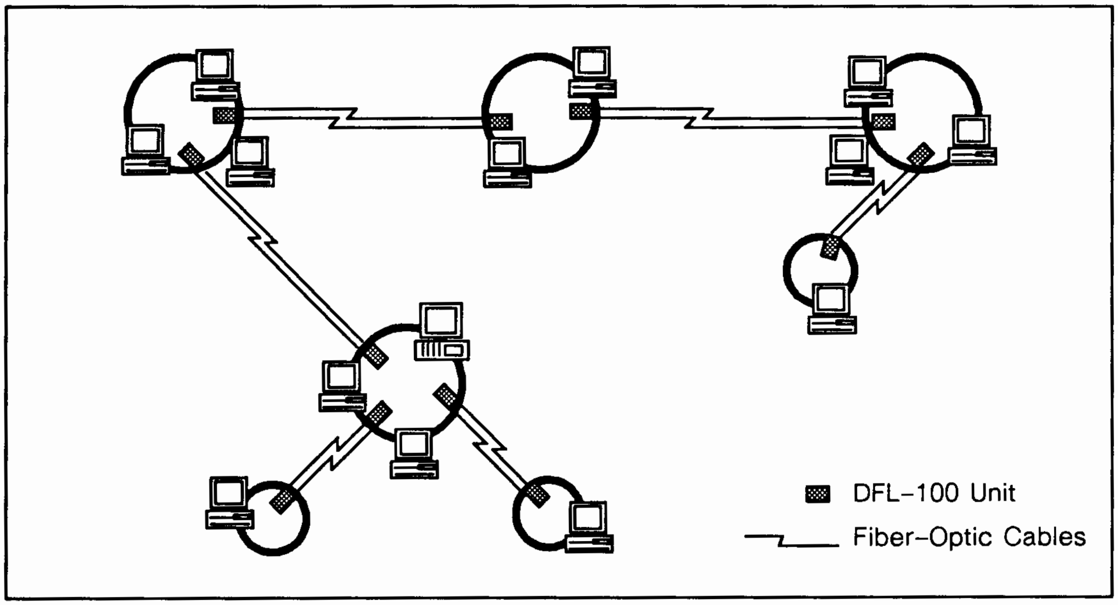


Figure 2–6. DFL–100 Extended Ring Spanning Seven Sites

Additionally, the DFL–100 fiber interface unit has automatic built–in **redundancy** capabilities to improve network reliability and aid network management. The redundancy mechanism operates when you install *two* complete fiber–optic links. The second (redundant) link activates automatically to bypass a failure in the primary link. Figure 2–7 shows a redundant configuration.

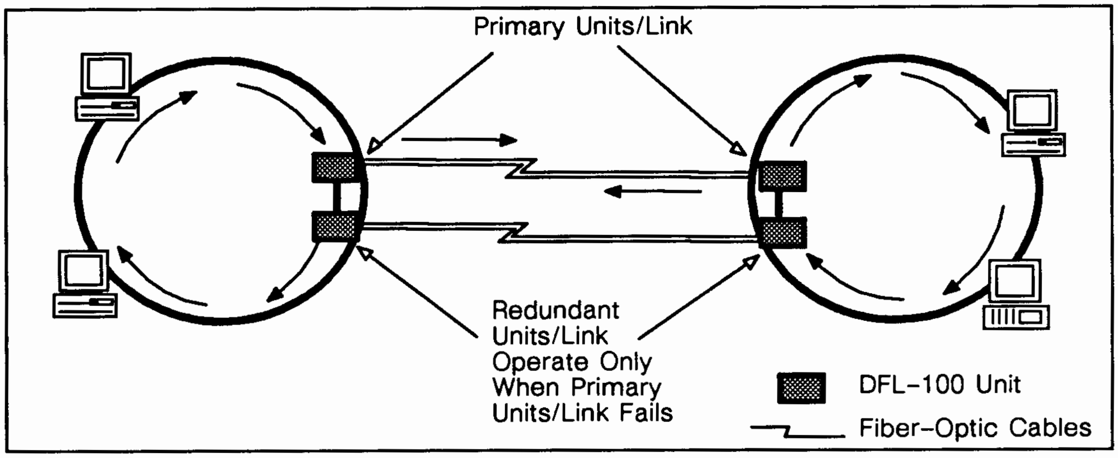


Figure 2-7. Redundant DFL-100 Configuration

Chapters 3 and 4 provide more information about the DFL-100 interface unit and cable layout. For installing and operating instructions for the DFL-100 unit, see *Installing and Operating the Domain/DFL-100 Fiber Interface Unit.*

2.4 FDDI

The **Fiber Distributed Data Interface (FDDI)** is a specification for a high-speed fiber-optic ring network. Data flows around the ring from one node to the next until it reaches its destination. An FDDI node can be either a station or a concentrator (the difference is explained in later sections) in the ring.

NOTICE: The FDDI network is a different type of network from an ATR network with a DFL-100 fiber-optic extension, which is discussed in the previous section.

An FDDI network consists of two fiber-optic rings referred to as the primary and secondary rings. The primary ring alone can be used for data traffic, with the secondary ring available as a standby ring. Or, both rings can be used simultaneously for data traffic, providing a total bandwidth of 200 Mbps. Data on the two rings flows in opposite directions and is referred to as counter-rotating. When a fault occurs on one or both rings, network interfaces on each side of the fault reconfigure the dual rings into one ring, isolating the faulty section. This provides a degree of fault tolerance in the network. See Chapters 6 and 7 for further information on FDDI cabling and network accessories.

NOTICE: This manual assumes that you are planning a dual-ring network consisting of primarily dual attachment stations (DASs). However, this manual does provide information to help plan for future integration of concentrators and single attachment stations (SASs).

An FDDI backbone network is shown in Figure 2–8.

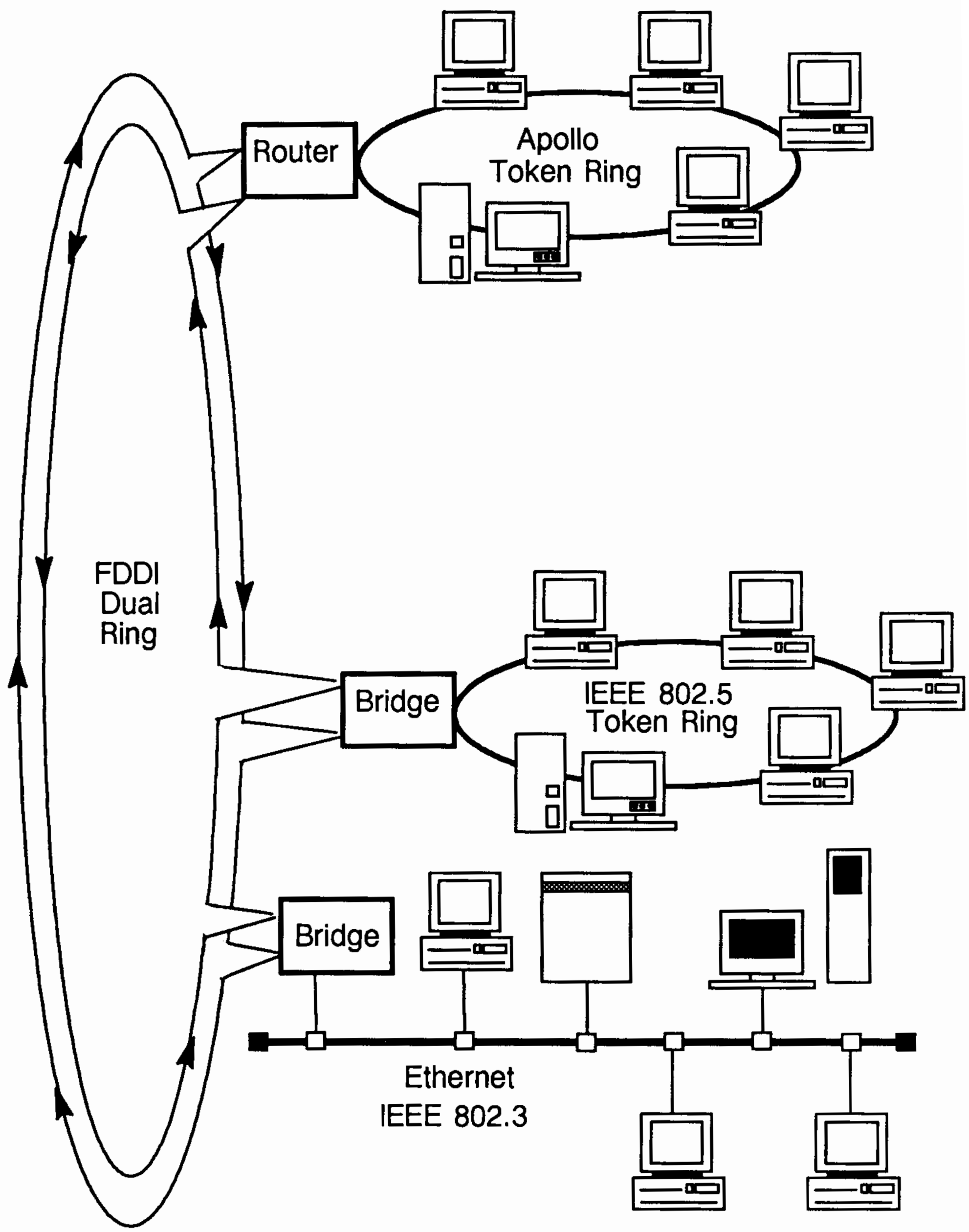


Figure 9–8. An FDDI Backbone Network

2.4.1 Applications for FDDI Networks

FDDI is intended to provide high-speed communications at a reasonable cost. Its principal applications are

- As a backbone network in an internet
- As a back-end network connecting high-speed computers and their peripheral devices (such as storage devices)
- As a front-end network connecting terminals, PCs, and workstations where an application, such as CAD/CAM, requires high-speed transfers of large amounts of data
- Any application where security and/or a high degree of fault tolerance is required

2.4.2 Station Types

There are four types of nodes that can attach to an FDDI network:

- Dual attachment stations (DAS)
- Single attachment stations (SAS)
- Dual attachment concentrators
- Single attachment concentrators

Figure 2-9 shows an FDDI network configuration that includes all of these types of nodes.

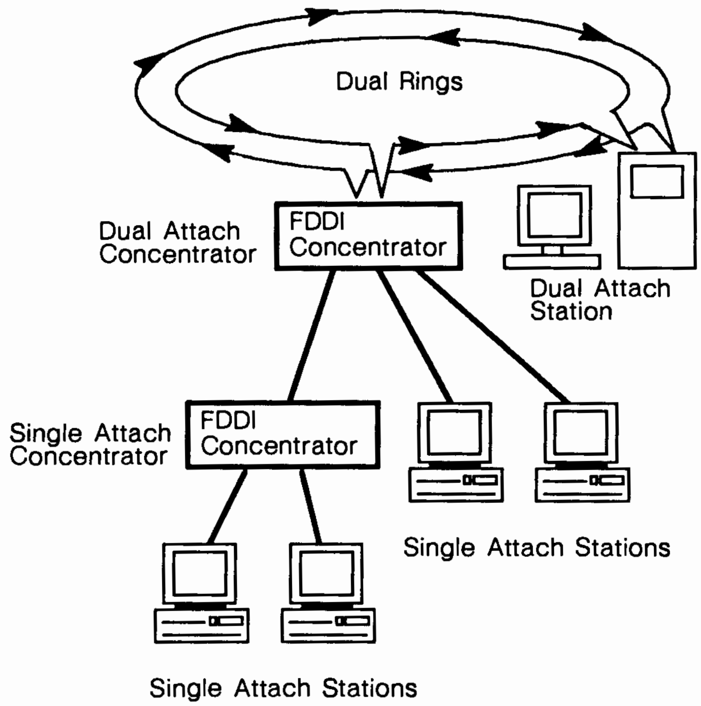


Figure 9-9. FDDI Network Configuration

Figure 2-10 shows each of the first three node types, and illustrates the dual attatchment station (DAS) capacity for ring reconfiguration in the event of a cable fault. Note that the dual ring reconfigures to become one ring. See Chapters 6 and 7 for more detailed information on FDDI.

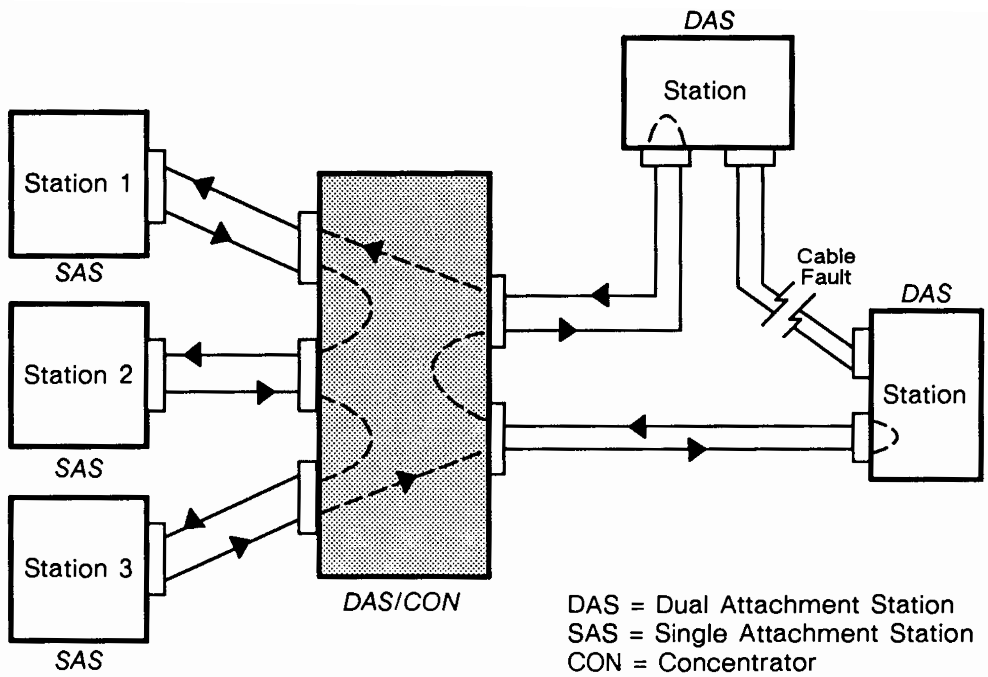


Figure 2–10. FDDI Network with Cable Fault

2.4.3 Dual Attachment Stations

A **dual attachment station (DAS)** connects directly to both rings of the network. This means that it has two distinct **Physical Layer (PHY)** entities. A PHY constitutes the physical connection to the ring and includes the fiber–optic transmitter and receiver. A DAS has the potential to transmit and receive data on either ring, or on both rings simultaneously.

To transmit and receive data or frames on both rings simultaneously, a DAS must have two **Media Access Control (MAC)** entities. The MAC entity implements the token–passing protocol, capturing the token, forming frames, and transmitting them. The MAC also monitors network traffic, and copies frames that are addressed to it.

Two MACs are not required by the FDDI standards. If a DAS has only one MAC, it can operate on only one ring at a time, although it may have the ability to switch back and forth between the primary and secondary rings.

A network address identifies a MAC, rather than a station or a PHY connection. Thus, a station with two MACs has two network addresses, and a station with one MAC has only one address.

A DAS, regardless of the number of MACs, has the ability to reconfigure the dual ring into a merged single ring if it detects a ring failure between it and the next node on a ring.

2.4.4 Single Attachment Stations

A **single attachment station** (SAS) connects to only one of the two network rings. A SAS has one PHY and one MAC. Because a SAS attaches to only one ring, it has no ring-reconfiguration capability. For this reason, single attachment stations must attach to the network through a concentrator. Concentrators are described in the next two sections.

Single attachment stations provide a lower cost alternative to dual attachment stations, but provide less capability and require the presence of a concentrator.

2.4.5 Dual Attachment Concentrators

A **dual attachment concentrator** (DAS/CON) serves as an interface between the dual-ring FDDI network and the single attachment stations and concentrators. An SAS cannot connect directly to the dual ring without compromising the reconfiguration feature of the network; therefore, a DAS/CON is used to connect to the network, and single attachment stations are connected to the concentrator. A DAS/CON, like other dual attachment stations, has the ability to reconfigure the rings when it detects a failure.

2.4.6 Single Attachment Concentrators

A **single attachment concentrator** (SAS/CON) is an SAS that serves as a concentrator.

2.4.7 Token-Passing Protocol

FDDI uses a timed token-passing protocol to transmit data. Stations transmit data as a stream of bits. When a station wants to transmit data, it forms a **frame** (also called a **packet**). Frames begin with a unique bit sequence called a starting delimiter and end with a unique bit sequence called an ending delimiter, so that receiving stations can identify the beginning and end of the frame. In addition to the data to be transmitted, each frame also contains the network address of the destination station, the network address of the originating station, and other information.

A special frame, called a **token**, circles the ring continuously. When a station wants to transmit, it waits for the token to arrive and "captures" it by not retransmitting it to the next station. Once it has the token, the station transmits its data, and issues a new token that is available for other stations to capture and use. The destination station copies the packet from the network, and sets fields in the packet to indicate that it has received and copied the packet. The packet then continues around the ring until it reaches the station that originally sent it; this station then strips the packet from the ring. Packets from several stations may be on the ring simultaneously.

The FDDI protocol is a *timed* token-passing protocol because a station can hold the token only up to a specified amount of time. Therefore, there is a limit on the amount of aysnchronous data that a station can transmit on any given token opportunity. (A station is always allowed to transmit queued synchronous data, up to a previously negotiated synchronous bandwidth allocation, regardless of available token-holding time.) Because a sending station is responsible for issuing a new token after transmitting packets, the station directly downstream from a sending station has the next opportunity to capture the new token. These features of the protocol ensure that the ring's **bandwidth** (its total information carrying capacity, that is, 100 Mbps) is divided more or less equally among stations on the ring.

2.5 IEEE 802.3 Network

The IEEE 802.3 network is a 10 megabits-per-second (Mbps) **bus network** defined by the ANSI/IEEE Standard 802.3 for Local Area Networks.

NOTICE: Although the IEEE 802.3 network is often called an Ethernet network, Ethernet networks do not conform to all of the IEEE 802.3 specifications, as they preceded the standard's publication.

IEEE 802.3 networks use a network access method known as **Carrier Sense Multiple Access with Collision Detection** (CSMA/CD). Each node monitors the network and receives and copies the data packets addressed to it. When a node has data to transmit over the network, it waits for a clear **channel** (when carrier is not detected) and then transmits its data on the network. If two or more nodes send data simultaneously, a **collision** occurs. However, the nodes automatically recover from collisions and retransmit at random time intervals. (If a node experiences a specified number of consecutive collisions, the node reports an error.)

The most significant advantage to using the IEEE 802.3 network is the large number of vendors who design nodes and other devices for attachment to this type of network. Many establishments already have the proper IEEE 802.3 cabling installed. By using an IEEE 802.3 network, you can use your current cabling system to implement full Domain services without the expense of installing new cable.

2.6 IEEE 802.3 Network Configurations

This section describes the various configurations to consider when planning an IEEE 802.3 network.

Currently, we offer this networking option for all Domain workstations and servers with an IBM PC AT compatible bus and for the DN5XX-T and DN10000 workstations and servers configured with a VME bus. These nodes connect to an IEEE 802.3 network through a network controller and network attachment devices that meet the IEEE 802.3 specifications for physical signaling and cabling. The attachment devices are available through the *Instant Apollo* catalog (see Appendix A for ordering information). For information about the network controllers used to connect Domain workstations to an IEEE 802.3 network, refer to Appendix C.

NOTICE: Although data packets generated by Domain nodes on an IEEE 802.3 network are compatible with repeaters and other connection devices that conform to earlier Ethernet standards, you must use the controller that we supply and attachment devices that conform to the IEEE 802.3 standards to attach Domain nodes to the network.

The IEEE 802.3 standard contains specific rules that govern how you configure your network, the physical characteristics of the cables, and the devices used to connect nodes and other devices to the cable. We describe all of these parameters and compatibility between Ethernet and IEEE 802.3 equipment in Chapters 7 and 8.

2.6.1 The Single–Backbone Configuration

In the IEEE 802.3 network, each node taps into a single length of coaxial cable called the bus or **backbone**. Figure 2–11 shows the simplest form of this network using only a single backbone cable.

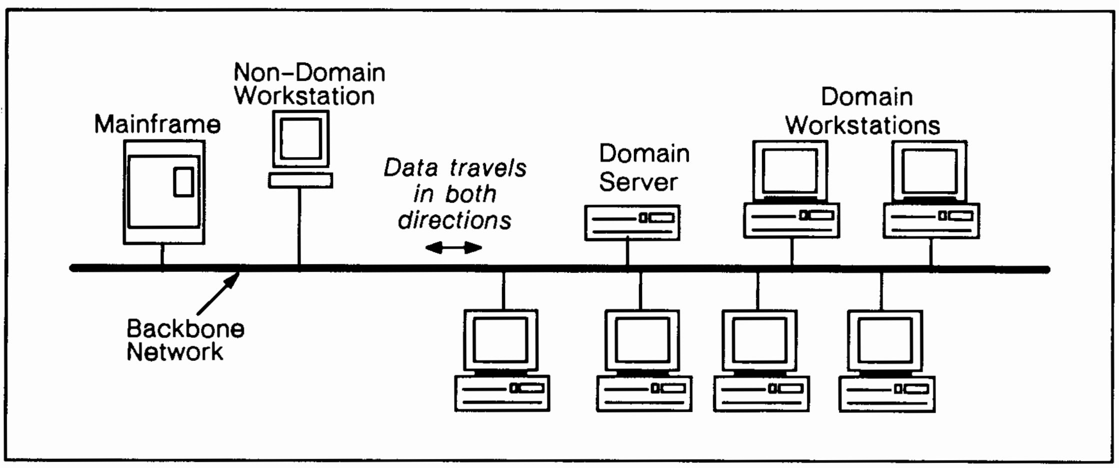


Figure 2–11. Single–Backbone IEEE 802.3 Network

2.6.2 The Cascaded or Fan–Out Configuration

If you are planning a network for a large building or group of buildings, you should consider a **cascaded** configuration for greater flexibility and reliability. Figure 2–12 shows a large IEEE 802.3 installation, in which several backbones are connected with **repeaters** and **multiport transceivers** that are used to add large numbers of nodes to the network. (Refer to Chapters 7 and 8 for more information about IEEE 802.3 network devices.)

2.6.3 HP EtherTwist Configuration

An HP EtherTwist network is a local area network that runs over twisted pair cabling. EtherTwist networks are designed to be compatible with Type 10Base–T, IEEE 802.3, and Ethernet networks. Apollo nodes in an EtherTwist network are connected in a star topology, joined at a central hub. One EtherTwist hub can connect up to 12 nodes. Hubs can be connected to each other using twisted pair cable or backbone cable (ThinLAN coaxial, ThickLAN coaxial, or fiber–optic). For more detailed information on HP EtherTwist, refer to the *HP EtherTwist Network Start–Up Guide* and *HP EtherTwist Hub Installation Guide* manuals.

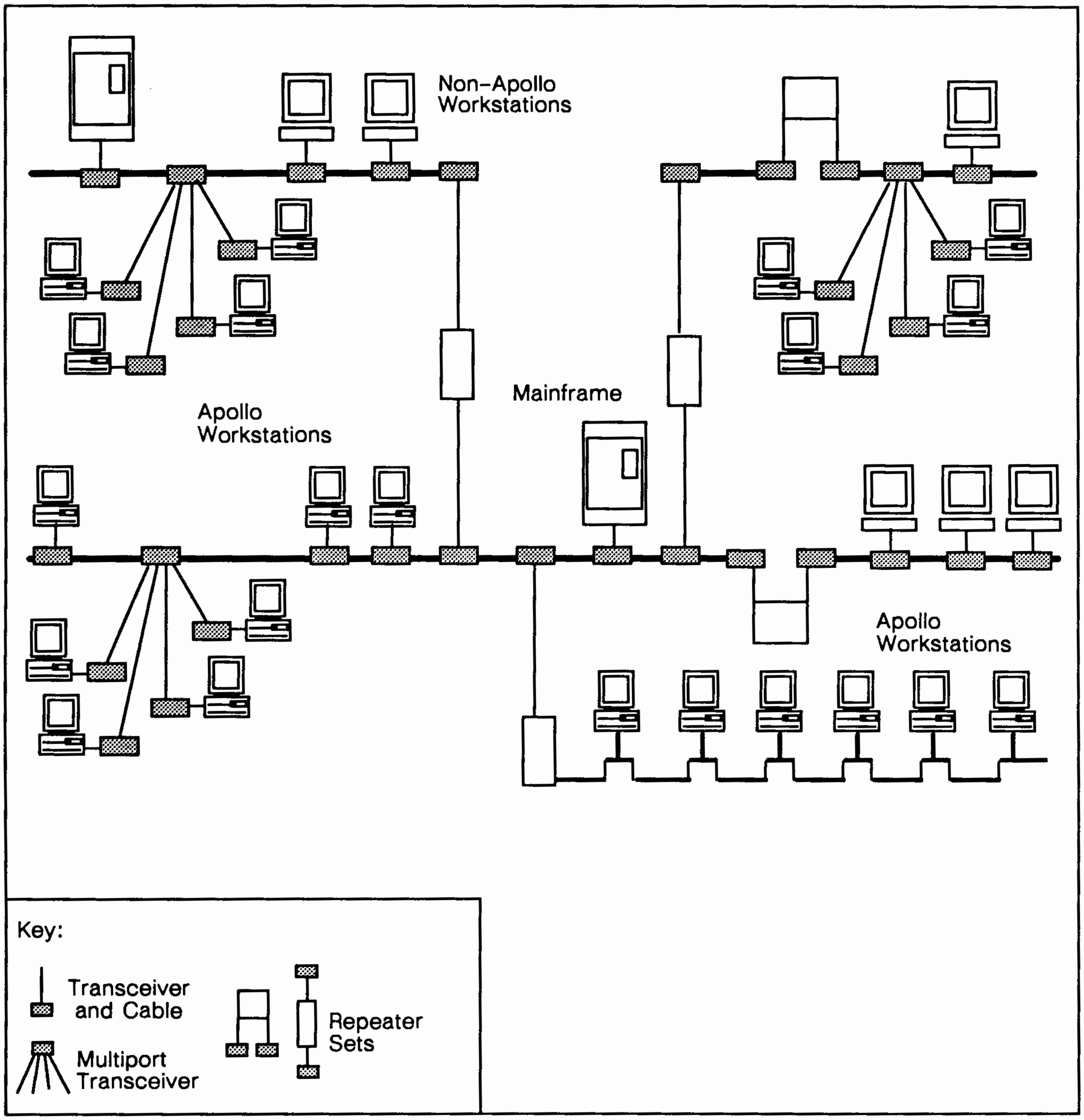


Figure 2-12. Large IEEE 802.3 Network

2.7 The IEEE 802.5 Network

This section briefly describes the IEEE 802.5 Local Area Network (LAN) standard and the Apollo 802.5 product set that supports that standard. We then list the hardware and software requirements for connecting an Apollo node to an IEEE 802.5 network.

The 802.5 LAN standard is one of a family of standards defined by the Institute of Electrical and Electronics Engineers (IEEE) that apply to the physical and data link layers of the International Standards Organization Open Systems Interconnection (OSI) Reference Model.

The 802.5 standard defines a ring network using the token passing access method. Currently, station attachment to the ring medium is defined by the 802.5 standard to consist of a 1–, 4–, or 16–megabit–per–second (Mbps) shielded twisted pair cable. IEEE 802.5 networks often are referred to as IBM Token–Ring Networks, since the standard is based on LAN technologies developed by IBM.

2.7.1 IEEE 802.5 Network Configuration

IEEE 802.5 networks usually are configured as star–wired rings. The loops of the star are created with multistation access units (**MAUs**), which provide access to the network for attaching devices. Figure 2–13 illustrates an IEEE 802.5 star–wired configuration.

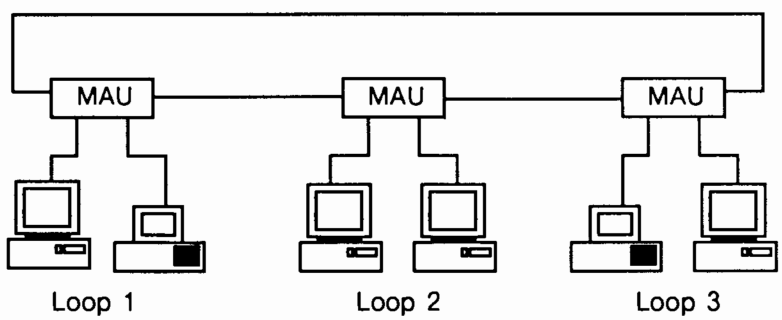


Figure 2–13. IEEE 802.5 Star–Wired Ring Configuration

Typically, MAUs can attach four or eight devices, called **lobes**, to a network. When an attaching device does not need access to the network, it is bypassed within the MAU. When the device again wants access, the MAU connects it to the network. See Chapter 10 for information about the MAUs available from Apollo.

Telephone shielded twisted pair cable is the media required by the IEEE 802.5 standard. The wire must be #22 or #24 AWG (American Wire Gauge) with at least two pairs of solid copper wire in each cable. The wires must have a minimum of two twists per foot. See Chapter 10 for information about the cables available from Apollo.

2.7.2 Domain Services on IEEE 802.5 Networks

When you directly connect Apollo AT compatible bus-based workstations (with the exception of Series 10000 workstations) to IEEE 802.5 networks, you receive all the Domain services, such as diskless booting and Domain routing. You also receive the services of any other network communications protocols you may have installed on the node.

For example, Apollo nodes on an 802.5 network may use Domain routing and protocols to communicate with other Apollo nodes located on the same network, or on interconnected Apollo Token Ring or IEEE 802.3 networks. In addition, Apollo nodes on 802.5 networks that also have TCP/IP installed may communicate with other vendors' equipment using TCP/IP and other Apollo products layered on top of TCP/IP, such as Apollo/TECHnet. Figure 2-14 illustrates the networking capabilities supported by the Apollo 802.5 product set.

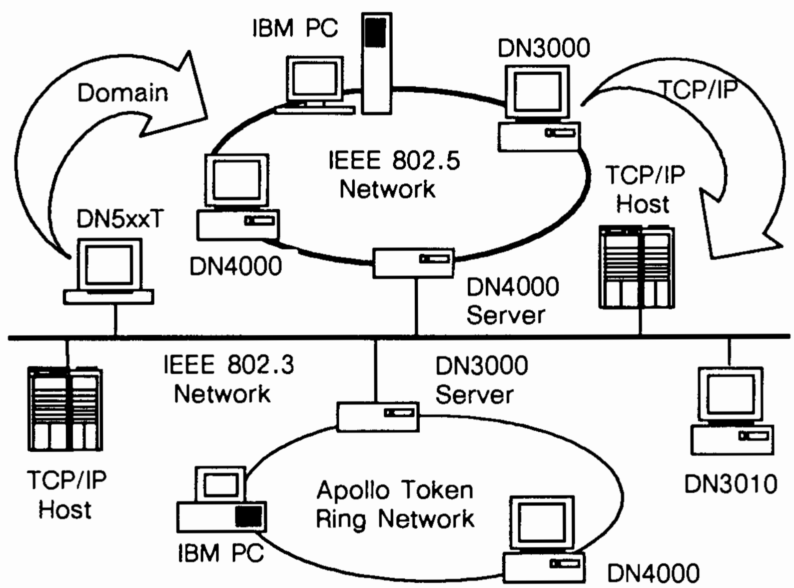


Figure 2-14. Domain 802.5 Networking Capabilities

Apollo nodes on IEEE 802.5 networks now support IBM Token-Ring source routing. Nodes can supply information in the frame routing information field and can perform MAC-level routing.

Packets sent by an Apollo node on an 802.5 network can now be routed by MAC-level bridges to other 802.5 networks. Packets sent by Apollo nodes can also be routed between 802.5 networks by Apollo nodes using Domain routing.

2.7.3 Hardware and Software Requirements

The Apollo hardware products that support 802.5 networks include the 802.5 Network Controller–AT and selected 802.5 cables and accessories. See Chapter 10, "IEEE 802.5 Planning and Cabling Information" for cable and accessory descriptions and ordering information. Software Release 10.1 or later is required for nodes operating on 802.5 networks.

2.8 Internets

An **internet** is a system of two or more connected networks which may or may not be of the same type (for example, Apollo Token Ring and IEEE 802.3 networks). The internet may use one or several communications **protocols** (for example, Domain or TCP/IP).

Although an internet can compromise the speed and efficiency of a single network, it often provides the optimum network performance in multivendor environments or over wide geographic areas.

2.8.1 Internet Protocols

Our network architecture currently includes two internet protocol families as part of standard software:

- Domain — The protocol that supports the full set of Domain services. This protocol was developed at the Apollo Systems Division of Hewlett–Packard. Internets (or portions of an internet) running the Domain protocol are often referred to as **Domain internets**.

- TCP/IP — An industry standard protocol providing multivendor communications. Because of its wide acceptance as an industry standard, the TCP/IP internet is often referred to as simply the **Internet**. However, to distinguish it from the Domain internet we refer to that portion of an internet using TCP/IP protocols as a TCP/IP internet.

Layered on these standard networking protocols are many other communication protocols, such as Remote Procedure Call (RPC), part of our Network Computing Service, and Domain/Access, which provides access to VAX superminis. Additionally, other layered protocols, such as SNA and LU 6.2, which provide access to IBM mainframes and networks, are also available.

All of these protocols can run simultaneously on the same network media (that is, cable), or they can run independently on different parts of the internet. Ask your sales representative for information about our current communications products.

2.8.2 Internet Physical Configurations

There are two types of Apollo internet configurations:

- A simple internet configuration consisting of two networks
- A heterogeneous internet configuration consisting of any of the types of networks that we support

The first type of configuration uses a **point–to–point** link and two Apollo nodes to connect the two networks. The two nodes that connect the two networks to the point–to–point link are called **routing nodes**. Routing nodes perform the function of routing Domain packets between similar networks. This message relaying function, or **routing service**, is part of Domain services.

The second type of internet configuration uses an Apollo node as a direct connection between two or more similar or dissimilar networks. For example, you can use an Apollo node to connect two ATR networks, or one or more ATR networks and an IEEE 802.3 network. In this type of internet configuration, if only Domain protocols are used, the connecting node is called a routing node. If TCP/IP protocols are used, the node is called a **gateway node**. A gateway translates packets from one protocol type to another and routes packets to their destination address. A TCP/IP gateway is a type of gateway that routes TCP/IP packets between hosts that are able to communicate through TCP/IP protocols. These hosts are referred to as **TCP/IP hosts**. Every Apollo node is a TCP/IP host. Only an Apollo node equipped with the proper network controller can function as a TCP/IP gateway.

A single Apollo node, properly equipped, can provide both Domain routing service and gateway service. Thus, you can run TCP/IP or Domain protocols over both of these configurations. Examples of these internet configurations are shown in Figure 2–15 and 2–16.

Figure 2–15 shows a simple internet consisting of two Apollo Token Ring networks connected through a point–to–point link. The point–to–point link can be an IEEE 802.3 **link segment** or a T1 service offered by a telecommunications company.

Figure 2–16 shows an Apollo Token Ring network directly connected to an IEEE 802.3 network by a single Apollo node. In this example, the Apollo node is equipped to provide both Domain routing service and gateway service. Thus, all the Apollo workstations in Figure 2–16 can communicate with each other using Domain protocols, and all of the systems (Apollo and non–Apollo), except for the IBM mainframe, can communicate through TCP/IP protocols. In this example, the Apollo systems communicate with the IBM mainframe through an SNA gateway node using an optional communications product such as Domain/SNA. Note however, that IBM mainframes can also communciate through TCP/IP proctocols when equipped with the proper hardware and sofware.

More detailed information about internet configurations is provided in Chapters 11 and 12.

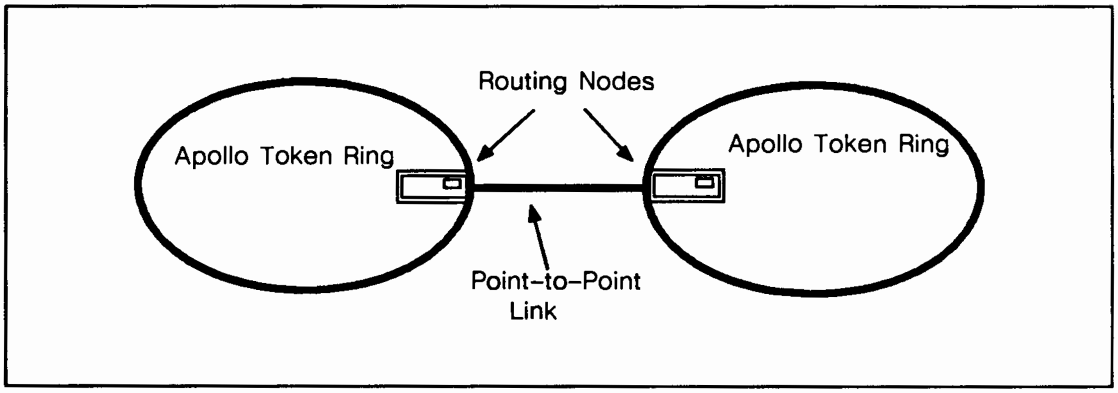


Figure 2-15. Simple Internet

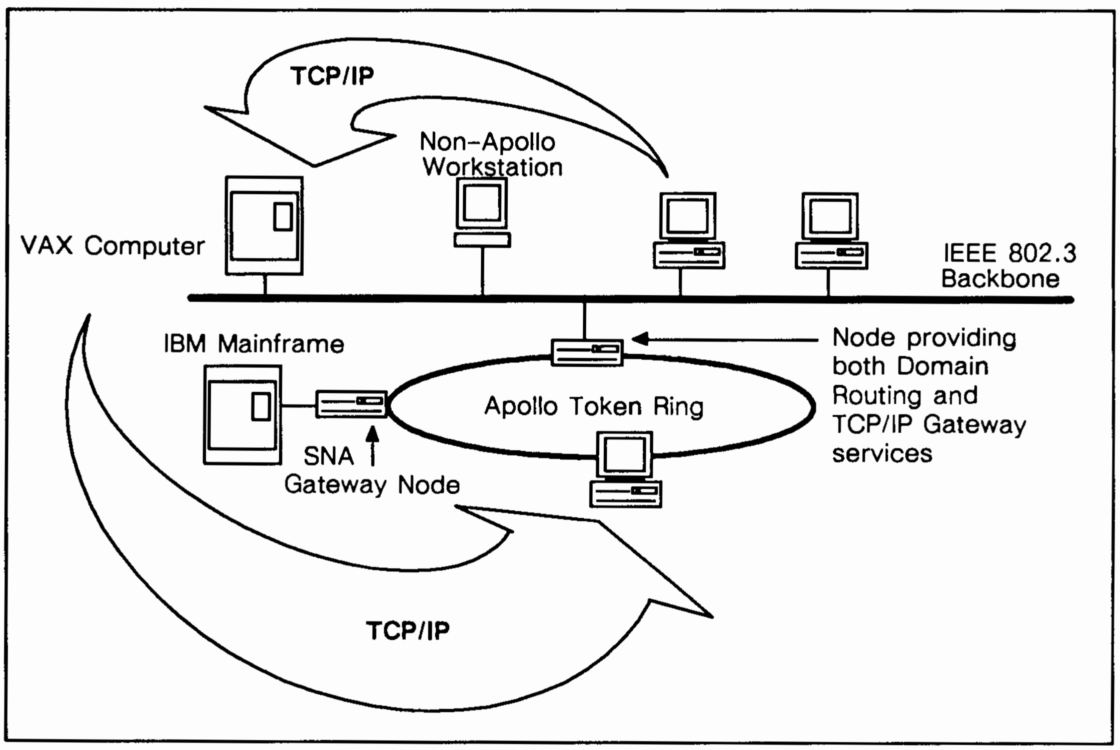


Figure 2-16. Heterogeneous Internet

Following are some of the benefits provided by internets:

- Data travels only in its local network *unless* that data is specifically marked for nodes on other networks. This allows for communication between networks without overloading a single network.

- Two or more networks can be managed as a *single* network, even when your organization has geographically distant sites or is located in several different buildings.

- Internets have the capacity to isolate individual networks from interruptions in other networks.

- Internets provide increased network efficiency and flexibility by allowing you to

  - Group nodes, mass storage devices, and other peripherals that share specialized data in a single network while preserving access to that data by nodes in other networks.

  - Create a single network for nodes that run computation-intensive programs.

  - Prevent access to networks at certain times (for example, during testing).

Note that our internet products are *not* designed to run large, network-intensive programs between nodes on separate networks. Therefore, plan to locate resources such as program compilers on the same network as the nodes that access them. In addition, diskless nodes can only boot from partners located on the *same* network. So, plan to locate partner nodes on the same networks as the diskless nodes they serve.

Creating an internet adds to your individual network management tasks, such as assigning network addresses, starting the internet communication processes, and extending your login protection mechanism to the internet. Once established, however, the advantages of creating smaller interconnected networks may reduce overall management requirements and also enhance performance within each network. For example, an internet can increase performance by reducing token latency (in an ATR network) or by reducing collisions (in an IEEE 802.3 network).

Chapters 11 and 12 provide more information about internet hardware and about designing an internet topology. For more information about internet management tasks, refer to *Managing Domain/OS and Domain Routing in an Internet*.

Chapter 3

Apollo Token Ring Cable and Accessories

This chapter contains descriptions and specifications of the network cables and accessories for an Apollo Token Ring network. Unless otherwise specified, the coaxial cable and most of the accessories described in this chapter are available through the *Instant Apollo* catalog. (Refer to Appendix A for instructions on ordering items from the catalog). Table 3-1 provides a comparison of the three types of LAN cable that can be used in an Apollo network using the attributes typically used in making cabling decisions.

Table 3-1. LAN Backbone Cable Types

ATTRIBUTES	TWISTED PAIR		COAXIAL	FIBER OPTIC
	Unshielded	**Shielded**		
Noise Immunity	Low	Low-Med	Medium	Very high
Bandwidth	Low	Low	Medium	High
Connector Assembly	Easy	Easy	Easy	Difficult
Reliability	Low	Low	Medium	Medium
Maintainability	Medium	Medium	Medium	Medium
Geographical Diameter	Meters	Meters	Kilometers	100 Kilometers
Technology Impact	Low	Low	Medium	High
Apollo Supported	No	Yes	Yes	Yes
Cost	Low	Low	Medium	High

3.1 Coaxial Cable and Accessories

Currently, the recommended medium for an Apollo Token Ring network is a baseband coaxial cable. This cable transfers data at a rate of 12 Mbps, handles and installs easily, and is available at a moderate cost. This section describes our approved coaxial cable and the devices designed for use with the cable.

3.1.1 Cable Description and Specifications

Baseband coaxial cable contains two conductors: the signal conductor, provided by a copper center conductor, and a reference, provided by tinned copper braid. The copper center conductor is surrounded by a dielectric. Aluminum foil surrounds the dielectric, and tinned copper braid surrounds the foil. A plastic (PVC) or TEFLON jacket encases the entire cable. This construction shields the cable against electrical noise. Figure 3–1 shows the composition of Apollo Token Ring coaxial cable.

WARNING: For networks inside buildings, be sure to use TEFLON–jacketed cable where local and national fire laws apply.

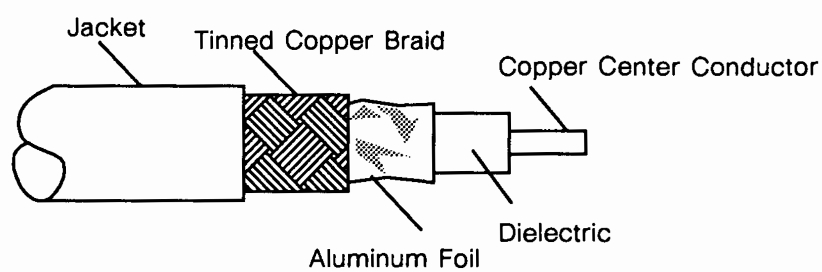


Figure 3–1. Apollo Token Ring Coaxial Cable

You, or a cable service agent that you designate, are responsible for purchasing, installing, and preparing your network cable. Table 3–2 gives our specifications for coaxial cable. Refer to *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* for cable installation procedures.

NOTICE: Although many types of coaxial cable are available for baseband networks, to ensure that your ring operates at optimum speed, efficiency, and reliability you *must* install coaxial cable that meets our specifications.

Because of its vulnerability to electromagnetic interference, such as lightning, we recommend that you use coaxial cable for links *inside* buildings only. To extend an Apollo Token Ring network between buildings, we recommend that you use fiber–optic cable. For more information about fiber–optic cable refer to Section 3.2.

Also, for cable runs between buildings you can use coaxial cable that is rated for exterior installation. However, you *must* install lightning suppression devices on each end of the cable to protect the nodes from electrical surges produced by lightning.

If you connect the cable shielding to the buildings' ground systems, the possible difference in the buildings' ground potentials can cause current to flow on the cable. This **ground loop current** can degrade the signal over an outdoor space and cause network problems. To avoid this problem, Apollo nodes are designed to provide the ground reference point for the network cable. Each node contains a transformer that ac couples the signal and prevents ground loop currents in the cable.

Table 3-2. Apollo Token Ring Coaxial Cable Specifications

Characteristic	Specification	
Electrical Specifications		
Operating Voltage	30 volts RMS, minimum	
Delay	1.3 ns/ft, maximum	
Conductor	18 AWG solid copper	
Conductor Resistance	7.5 ohms/304.8 m (1000 ft), maximum	
Shield Resistance	5.2 ohms/304.8 m (1000 ft), maximum	
Impedance	75 ohms	
Capacitance	17.3 pF/ft	
Velocity of Propagation	78%	
Attenuation	MHz — dB Loss/30.5 m (100 ft) 10 — 0.70 ± 0.10 50 — 1.40 ± 0.10 100 — 2.10 ± 0.10	
Physical Specifications		
	PVC—NEC CL2*	**Plenum Cable NEC CL2P—UL Classified for Plenum use****
Temperature Range	-10 °to 60 °C (14 °to 140 °F)	-60 °to 150 °C (-76 °to 302 °F)
Conductor Diameter	0.00091 to 0.01016 mm (0.036 to 0.040 in - 18 AWG)	0.01016 mm (0.04 in - 18 AWG)
Dielectric	Cellular Foam Polyethylene	NEC CLass 2P Material such as foam TEFLON
Dielectric Outside Diameter	45.7 mm (0.180 in)	45.7 mm (0.180 in)
Shield Tape	Aluminum/Mylar 100 % coverage	Aluminum/Mylar 100% coverage
Shield Braid	Tinned Copper 60% coverage (minimum)	Tinned Copper 60% coverage (minimum)
Minimum Bending Radius	457 mm (1.80 in)	457 mm (1.80 in)
Jacket Outside Diameter	Black PVC 6.86 mm ±0.25 mm (0.27 ±0.01 in)	NEC Class 2P material Outside diameter varies with material. TEFLON-FEP 6.35 mm (.250 in) SOLEF 6.07 (.239 in)

* Use only NEC Class 2 Cable.
**Use only NEC Class 2P, UL Classified cable.

3.1.2 The Domain/DQC Quick Connect System

The Domain/DQC Quick Connect System allows you to instantly connect any Apollo node or server processor to the ring network. The Domain/DQC consists of a special wall unit and plug/cable assembly, and provides a permanent termination point for the network coaxial cable at any node location.

Two types of plug/cable assemblies allow you to connect any Apollo workstation or server processor to the Domain/DQC unit. Figure 3-2 illustrates the plug/cable assemblies and wall unit.

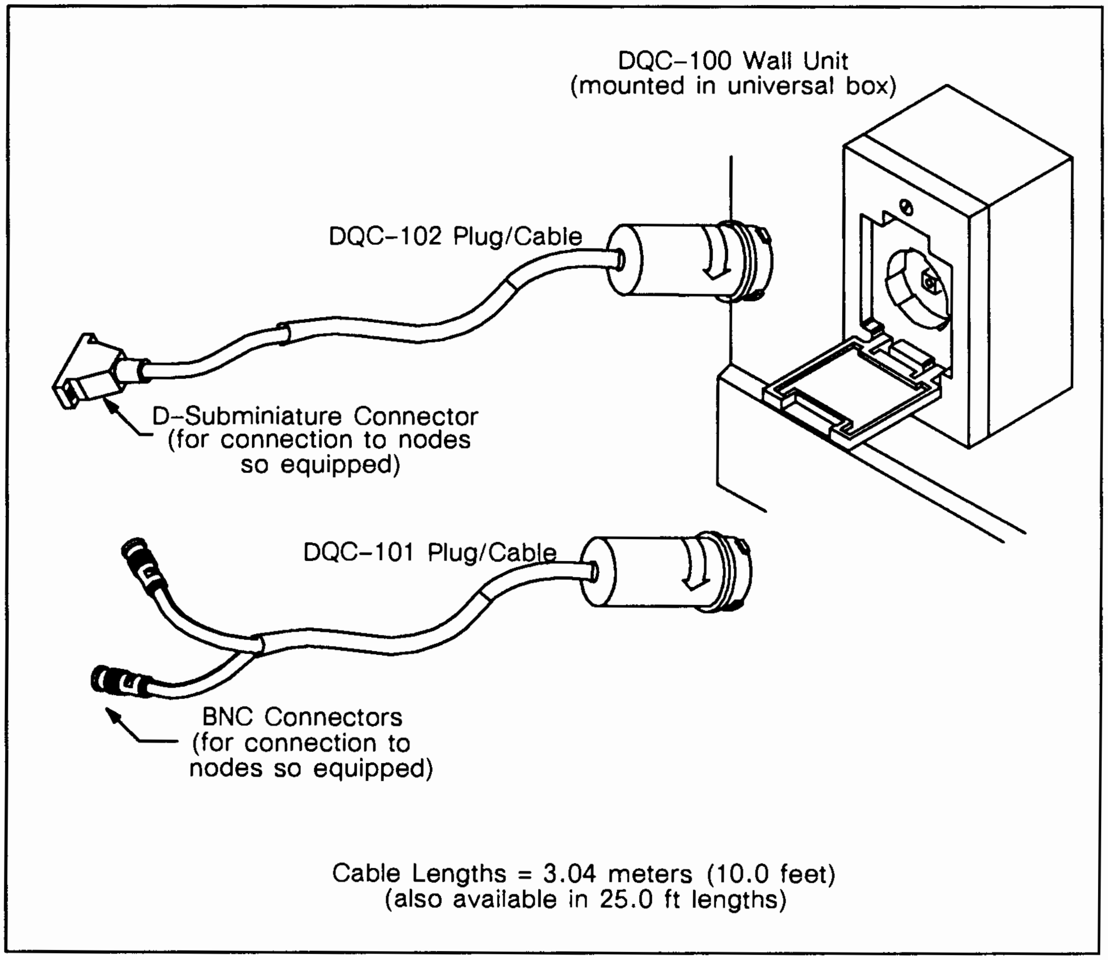


Figure 3-2. The Domain/DQC Quick Connect System

The Domain/DQC arrives with a universal mounting box that allows you to install the unit directly in the wall. However, you can mount the unit in U.S. standard utility boxes and cable raceway systems. Table 3-3 lists the types of U.S. utility boxes suitable for mounting the DQC-100 Wall Unit.

Table 3-3. U.S. Standard Utility Boxes for Mounting the DQC-100

Vendor	**Model Number**	**Metal Raceway**
Out-of-Wall Box		
Wire Mold Co. Hartford, CT 06110	Metal Box #5744	#500 (can house 1 network cable) #700 (can house 2 network cables)
Partial In-Wall Box		
Wire Mold Co. Hartford, CT 06110	800 Series B&C or BA&C Plastic Box	800 series
Standard Electrical Boxes (In Wall)		
2 x 4 x 2 $^1/_8$-inch (network cable not routed through conduit) 4 x 4 x 2 $^1/_8$-inch (network cable routed through conduit)		

The DQC-100 accepts *only* our approved coaxial cables (including TEFLON-insulated cables). If you use other types of coaxial cables with the DQC-100, you risk a poor connection and your network may not perform reliably. (See Table 3-2 for coaxial cable specifications.)

Currently, the Domain/DQC ships with Domain Series 3000 and Series 4000 nodes. Wall units and additional plug/cable assemblies are available through the *Instant Apollo* catalog. For Domain/DQC installation procedures, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network.*

3.1.3 BNC Connectors

You can terminate the network coaxial cable with BNC connectors to attach network switches, the DFL-100 fiber interface units, and certain Apollo nodes. We recommend two types of BNC (bayonet-end) connectors for use in an Apollo Token Ring network: wrench crimp BNC connectors and tool crimp BNC connectors.

Wrench crimp connectors offer over 40 pounds (18.1 kg) of strain relief and can easily be uncoupled when you need to check any part of the connection. Although wrench crimp connectors require soldering, we recommend using this type of connector if you will be pulling the network cable or manipulating it a great deal after you have added connectors.

Tool crimp BNC connectors offer approximately 40 pounds of strain relief and must be cut apart and discarded when you suspect a faulty connection. This type of connector crimps onto the braided shielding and/or jacket and does *not* require soldering. However, connectors may slip off or degrade the shield integrity with frequent bending, pulling, and flexing.

NOTICE: The two types of BNC connectors described here are *only* for use in an Apollo Token Ring network; these connectors are *not* suitable for connecting Apollo nodes to an IEEE 802.3 network. (Refer to Chapter 8 for information about IEEE 802.3 network attachment accessories.)

Figure 3–3 illustrates the two types of BNC connectors.

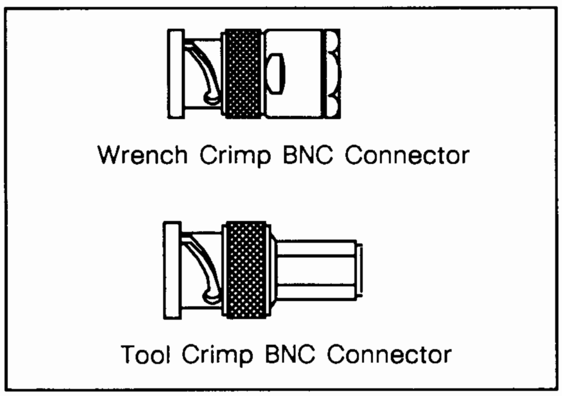


Figure 3–3. BNC Connectors

Both types of BNC connectors attach to PVC– and TEFLON–jacketed Apollo Token Ring coaxial cable. The connectors are available through the *Instant Apollo* catalog. For BNC connector installation procedures, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network*.

NOTICE: Because TEFLON–jacketed cable is inflexible and slippery, follow the instructions for attaching the connectors *precisely*.

For ATR–RNS remote operating information, see *Using the Network Topology Control (NTC) Software* and the *ATR–RNS Release Document*. The release document ships on the media with the NTC software.

3.1.4 The Network Cable Tag

We offer network cable tags to help you identify the direction of data flow in your ring. Fastened to the cables at each node and network switch location, the information that you print on the tag shows whether data is flowing *to* or *from* the node or switch. A filled square on the tag indicates that the data flows to the node or switch; an empty square indicates that the data flows from the node or switch. Additional information on the tag identifies the loops that the cable connects and the length of the connecting cable segment. Figure 3–4 shows a blank cable tag and a completed tag for a cable bringing data *to* a node or switch.

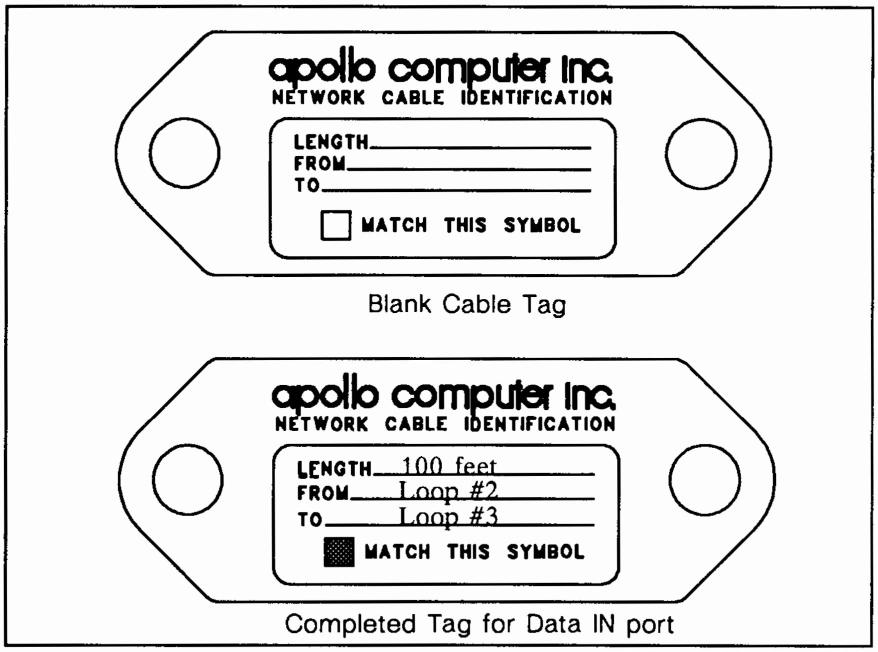


Figure 3–4. Network Cable Tags

You can order cable tags through the *Instant Apollo* catalog (see Appendix A for ordering information). Refer to *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* for more information about how to use the tag.

3.2 Fiber–Optic Cable and Accessories

Fiber–optic cable can be used instead of coaxial cable as a transmission medium over Apollo Token Ring networks. This section describes the fiber–optic cable, the DFL–100 fiber interface unit, and accessories available for use with the Apollo Token Ring network. The DFL–100 extension is a separate product and serves a different purpose than the Apollo FDDI network.

3.2.1 Fiber–Optic Cable Specifications

Fiber–optic cable, used with the DFL–100 product, has many characteristics that make it an excellent transmission medium. Among these characteristics are the following:

- High data rates (over 1 gigabit per second in some applications) and low error rates (one bit error per 10^9 bits)
- Electromagnetic isolation
- Low signal loss (**attenuation**)

Because fiber–optic cable is immune to electromagnetic interference (produced by lightning and power lines, for example), fiber–optic cable effectively isolates differences in ground potential between buildings. Because of its low attenuation, the DFL–100 link can be up to 3 km (9843 ft) in length. (See Table 3–4 and Table 3–5 for complete fiber–optic cable specifications.)

Fiber–optic cable consists of a core of optical fibers, encased in a layer of cladding that is surrounded by buffering, strengthening, and jacketing materials. Figure 3–5 illustrates the composition of fiber–optic cable.

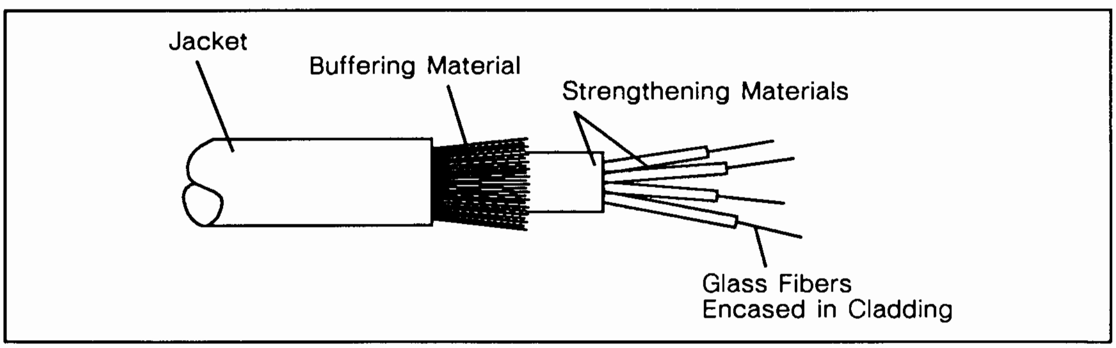


Figure 3–5. Fiber–Optic Cable Cross Section

Like coaxial cable, many types of fiber–optic cables are available. However, you *must* install fiber–optic cable that meets our specifications listed in Table 3–4 and Table 3–5. To order suitable cable and connectors, refer to the vendor information in Appendix B.

We provide general fiber–optic cable installation information in Chapter 4. However, we recommend that a professional fiber–optic cable installer prepare your site and install the cable. (After the cable is laid, your service person can install the DFL–100. The DFL–100 installation manual, *Installing and Operating the DFL–100 Fiber Interface Unit,* is shipped with the DFL–100 unit.)

Table 3-4. 50/125-Micrometer Fiber-Optic Cable Specifications

Characteristic	**Specification**
Optical Core Specifications	
Cable Construction	Loose Buffer Tube, Color Coded
Fiber Type	Graded Index Multimode
Number of Fiber Channels	2 (minimum)
Core Diameter	50 µm, nominal
Glass Cladding (Outer Diameter)	125 µm, nominal
Numerical Aperture	0.20
Attenuation	3.0 dB/km maximum at 850 nm
Bandwidth	160 MHz/km at 850 nm, minimum 200 MHz/km at 1300 nm, minimum
Refractive Core Index	1.466 at 850 nm, peak 1.460 at 1300 nm, peak
Operating Temperature	−10° to +50° C (+14° to +122° F) 2-channel burial installations −40 °to +50° C (−40 °to +122 °F) multichannel aerial or burial installations
Mechanical Specifications	
Strength Member	Kevlar, Fiberglass Epoxy Rods (FGE)
Buffer Tube Braid	Kevlar, 1- and 2-fiber cable only
Inner Jacket	PVC (polyvinyl chloride)
Outer Jacket	PE (polyethylene-solid)
Maximum Fiber Length	3.0 km; maximum single length available is 2.0 km. For 3 km, splice 2 km and 1 km.

Minimum Bending Radius

# Fiber Channels	2	4	6	8	10
Long Term	4 in	5 in	5 in	6 in	8 in
During Installation	6 in	7 in	7 in	8 in	10 in

Maximum Load

# Fiber Channels	2	4	6	8	10
Long Term	30 lb	53 lb	53 lb	53 lb	53 lb
During Installation	750 lb	560 lb	560 lb	650 lb	520 lb

Table 3-5. 62.5/125-Micrometer Fiber-Optic Cable Specifications

Characteristic	**Specification**
Optical Core Specifications	
Cable Construction	Loose Buffer Tube, Color Coded
Fiber Type	Graded Index Multimode
Number of Fiber Channels	2 (minimum)
Core Diameter	62.5 μm, nominal
Glass Cladding (Outer Diameter)	125 μm, nominal
Numerical Aperture	0.27 ±0.01
Attenuation	5.0 dB/km maximum at 850 nm 3.0 dB/km maximum at 1300 nm
Bandwidth	160 MHz/km at 850 nm, minimum 200 MHz/km at 1300 nm, minimum
Refractive Core Index	1.478 at 850 nm, peak 1.472 at 1300 nm, peak
Operating Temperature	−10° to +50° C (+14° to +122° F) 2-channel burial installations −40° to +50° C (−40° to +122° F) multichannel aerial or burial installations
Mechanical Specifications	
Strength Member	Kevlar, Fiberglass Epoxy Rods (FGE)
Buffer Tube Braid	Kevlar, 1- and 2-fiber cable only
Inner Jacket	PVC (polyvinyl chloride)
Outer Jacket	PE (polyethylene-solid)
Maximum Fiber Length	3.0 km; maximum single length available is 2.0 km. For 3 km, splice 2 km and 1 km.

Minimum Bending Radius

# Fiber Channels	2	4	6	8	10
Long Term	4 in	5 in	5 in	6 in	8 in
During Installation	6 in	7 in	7 in	8 in	10 in

Maximum Load

# Fiber Channels	2	4	6	8	10
Long Term	30 lb	53 lb	53 lb	53 lb	53 lb
During Installation	750 lb	560 lb	560 lb	650 lb	520 lb

3.2.2 Fiber–Optic Cable Connectors

We recommend three types of fiber–optic cable connectors for use with our specified fiber–optic cables, as well as connectors suitable for connecting the unit to fiber–optic patch panels (see Chapter 4 for information about patch panels). Table 3–6 lists the cables, connectors, and the purpose of the connectors.

Table 3–6. DFL–100 Fiber–Optic Cable Connectors

Cable	Connector	Purpose
50/125 μm	905 SMA	Connects to DFL–100 unit
50/125 μm	906 SMA	Low attenuation connector for DFL–100 unit or patch panel.
62.5/125 μm	905 SMA	Connects to DFL–100 unit
62.5/125 μm	ST Series	Low attenuation connector for patch panel.

Among the connectors listed in Table 3–6, ST Series Connectors provide the lowest attenuation for connections to fiber–optic cable patch panels. Note that ST connectors do *not* connect to the DFL–100 unit; therefore, cables must be terminated with 905 or 906 SMA connectors on one end *only*.

Tables B–4 and B–5 in Appendix B list preterminated 50/125 cables, connectors for unterminated cables, and cable vendors and part numbers.

3.2.3 The DFL–100 Fiber Interface Unit

The DFL–100 fiber interface unit, shown in Figure 3–6, allows you to extend an Apollo Token Ring through fiber–optic cable. The interface unit converts the electrical signals on the coaxial cable to the optical waves carried on the fiber–optic cable. The unit connects directly to the coaxial cable through BNC connectors and to fiber–optic cable through fiber–optic connectors on its rear panel. Two fiber interface units and two fiber–optic cable **channels** form a complete link. (Refer to Chapter 4 for information about planning the locations of the fiber interface units.)

The DFL–100 fiber interface unit has built–in **bypass** and redundancy capabilities. The bypass mechanism operates to bypass the fiber–optic link in case of a failure. The redundancy mechanism operates when you install two complete fiber–optic links. The second (redundant) link activates *automatically* when there is a failure in the primary link. You can also operate the bypass and redundant mechanisms from a remote location by using a special remote cable and switch.

Refer to Chapter 4 for DFL-100 placement guidelines. For more information about how to operate the fiber-interface unit, including remote operation, see *Installing and Operating the DFL-100 Fiber Interface Unit* (included with the unit). For dimensions and ac power requirements, see *Domain Hardware Site Planning Specifications.*

The DFL-100 unit is available through our standard price list.

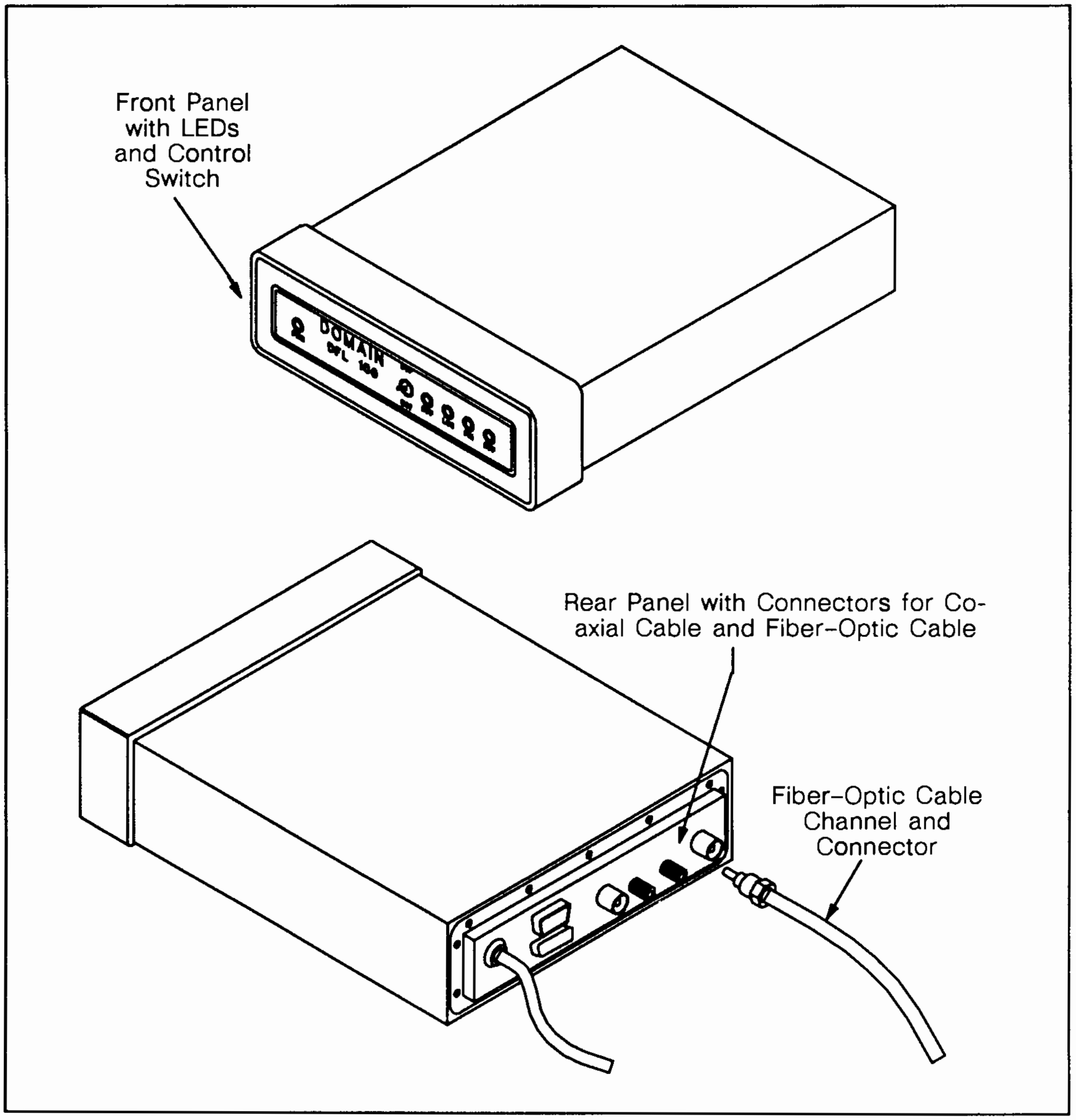


Figure 3-6. The DFL-100 Fiber Interface Unit

Apollo Token Ring Network

3.3 The Manual Network Switch

The manual network switch makes it easy for you to create a star-wired ring configuration by providing a simple method for switching loops in and out of the network. As shown in Figure 3-7, the switch attaches to our coaxial cable with BNC connectors mounted on the switch.

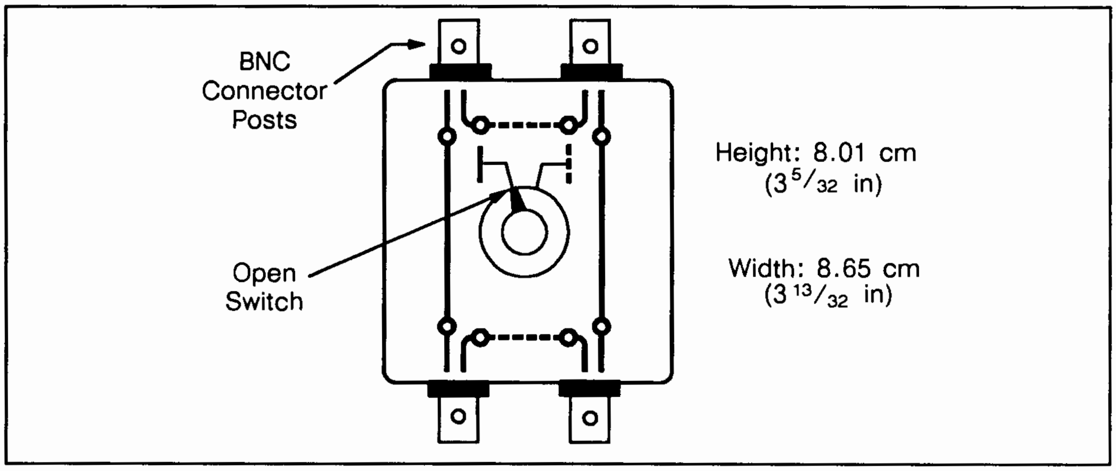


Figure 3-7. The Manual Network Switch

When a loop's network switch is *open* (switched left), data from the previous loop in the network flows into the loop, through the loop, and out to the next loop. When a loop's switch is *closed* (switched right), data from the network bypasses the loop, and data from nodes in the loop stays within the loop. Figure 3-8 illustrates how the switch operates.

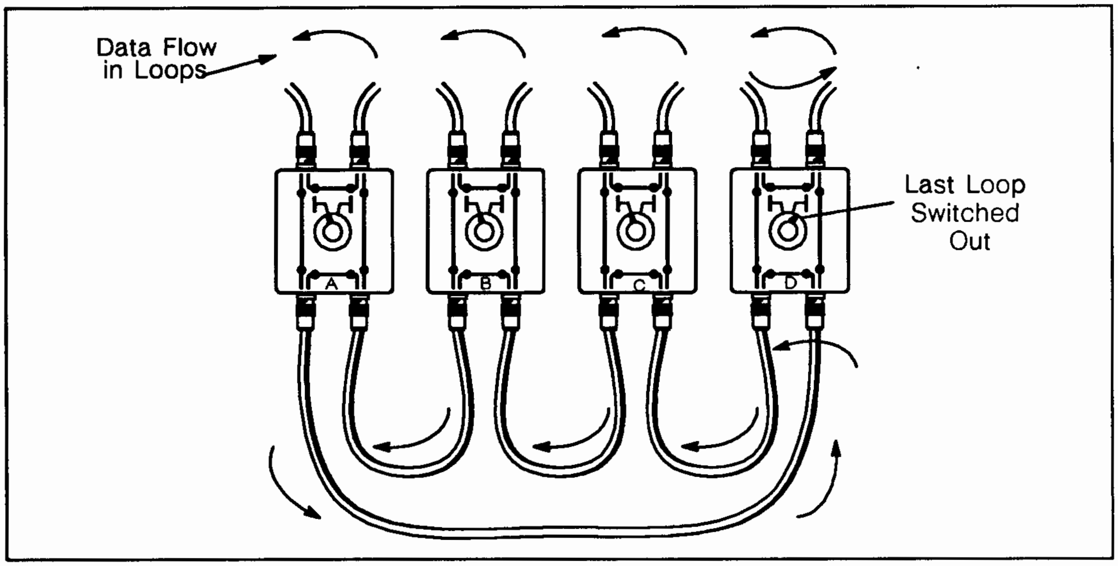


Figure 3-8. Data Flow Through the Network Switch and Several Loops

Network switches are available through the *Instant Apollo* catalog (see Appendix A for ordering information).

NOTICE: We recommend that you use *only* the switches we provide through the catalog. Our switches are impedance matched to ensure a high-quality signal and network reliability.

For network switch installation procedures, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network.*

3.4 The ATR Remote Network Switch

The ATR Remote Network Switch (ATR-RNS) provides a cost-effective method of configuring a large or small **star-wired ATR**. Each ATR-RNS switch unit contains connectors for eight network **loops**. Each loop can be switched into or out of the network by using the front-panel pushbuttons or through a **serial communication** link to an ATR-RNS **control node**. The switch units can be connected through ATR coaxial cables to form a larger network with many more loops.

In addition to supporting a large or small ATR network, each switch unit contains connectors for an optional troubleshooting network, called the **isolation ring**. The isolation ring allows you to switch problem loops out of the **main ring** to a separate cable for isolation and diagnosis.

The ATR-RNS, shown in Figure 3-9, arrives with rack-mounting hardware.

The ATR–RNS switch units can replace or augment single–loop switching facilities in your network. (The **single–loop switch** is also called the network switch or wall switch.)

The following sections describe ATR–RNS features and provide ordering information for the ATR–RNS hardware and software components. For more information on the ATR–RNS, refer to *Planning for the ATR–RNS.*

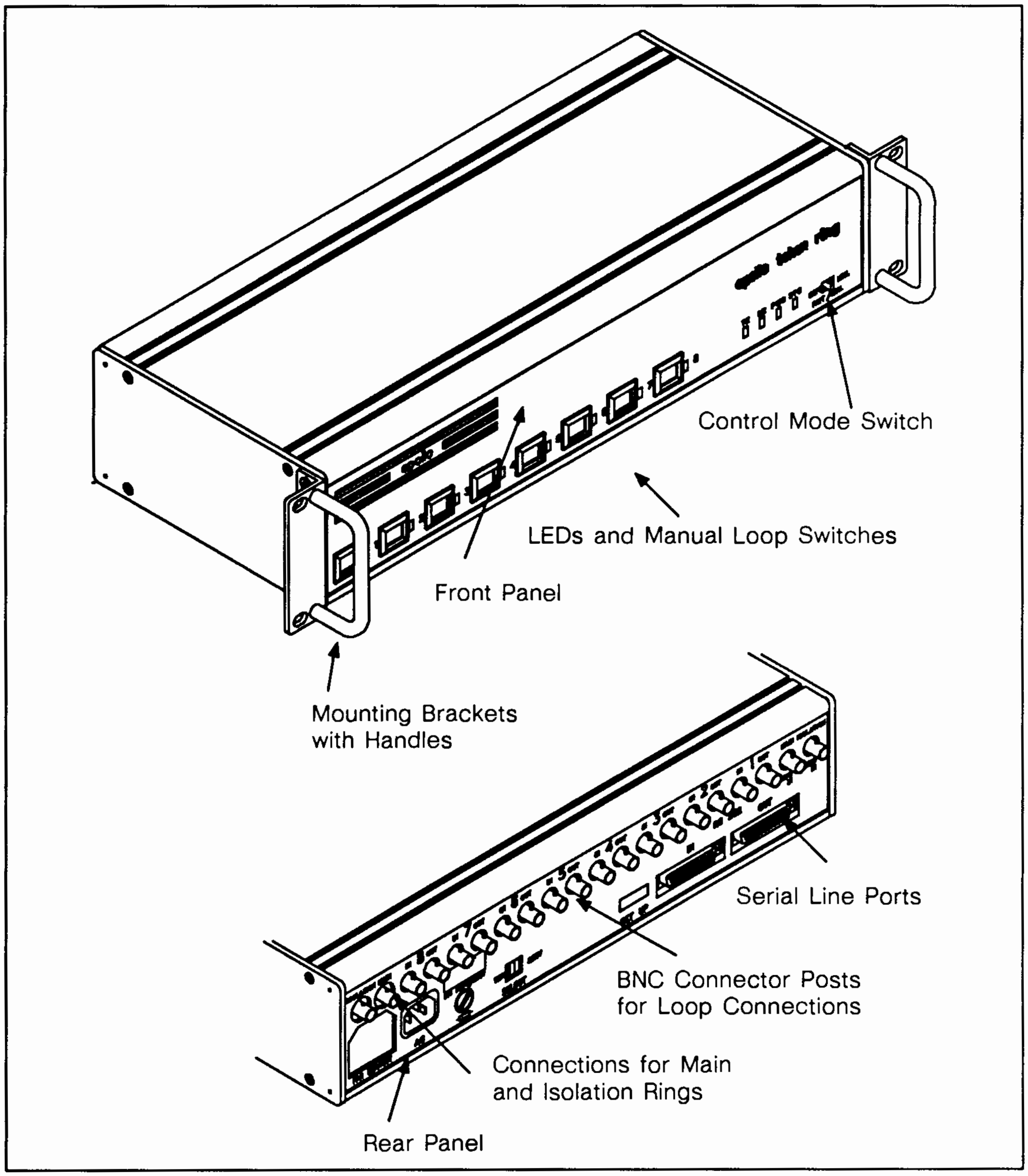


Figure 3–9. ATR–RNS Features

3.4.1 Manual Operation

The ATR–RNS contains front panel pushbuttons to manually switch loops into and out of the network. These controls operate whether or not you are using remote control. To help prevent conflicts between manual and remote switching, a **mode switch** on the front of the switch unit allows you to set control for local (manual) control, remote (serial line) control, or both. For manual operating instructions, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network*.

3.4.2 LED Indicators

The front-panel LEDs indicate the loop configuration at all times, as well as serial line transmit/receive activity, operation errors, and ac power status. For more information about the LEDs, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network*.

3.4.3 Isolation Ring

To aid network troubleshooting, the ATR–RNS has connections for an optional isolation ring. The isolation ring provides a separate ring network for troubleshooting problems in loops. No nodes are connected to the isolation ring cable. If a loop is malfunctioning, the system administrator can switch the failing loop into the isolation ring for troubleshooting, without affecting operation of the main ATR network.

3.4.4 Remote Configuration Control

Each ATR–RNS unit contains a set of socket connectors conforming to the Electronic Industries Association (EIA) Recommended Standard 232 (**RS–232**). These connectors facilitate a serial connection to an ATR–RNS control node. The serial connection typically consists of a twisted pair cable or combination of twisted pair cables and a modem connection linking the control node and ATR–RNS switch units. The ATR–RNS unit contains a switch to set the serial transmission baud rate (bits per second) to 300, 1200, 2400, or 4800.

The ATR–RNS control node can be any Apollo workstation. The workstation's **Serial Input/Output (SIO) port** contains an RS–232 socket connector (**female**) and accepts cables equipped with standard RS–232 pin connectors (**male**). All Apollo workstations have at least one SIO port equipped with an RS–232 female connector.

The ATR–RNS **Network Topology Control (NTC) software** allows a system administrator to switch loops into and out of the network while sitting at the control node. Because communication between the control node and the switch units does *not* depend on a functioning ATR network, switching loops in and out through the serial connection can take place during network failures. Thus, you can quickly switch out problem loops and restore network operation.

The NTC software consists of

- The NTC **application program**, which provides network topology and status information through an interactive graphic user interface

- The NTC **server**, which monitors the ATR–RNS units connected to the serial line, transmits messages from the NTC application to the attached units, and provides information to the NTC application about the status of the attached units

- A serial–line diagnostic utility to verify ATR–RNS operation

The NTC application and server processes communicate through the **Network Computing System**. The control node must contain the SR9.7 or a later version of the Network Computing Kernel (NCK) software. See the *ATR–RNS Release Document* and *Using the Network Topology Control (NTC) Software* for more information about the NTC software and the Network Computing System.

3.4.5 Automatic Failure Recovery

The ATR–RNS unit continuously runs a set of internal diagnostics that monitor the health of all components. When the diagnostics detect an error, the unit automatically resets and checks for the error. If the error does not recur, the unit notifies the operator that an error was detected by flashing the STS (status) LED on the front panel and by sending an error message over the serial line, if present, to the NTC application. During this process, the unit continues to operate normally, and communication on the network is uninterrupted.

If the error recurs, the unit repeats the reset and verify procedure. If the error persists, the unit automatically switches out all its loops. Then the unit notifies the operator that it can no longer proceed reliably by extinguishing the STS LED and sending a message over the serial line, if present, to the NTC application.

During a failure, the ATR–RNS unit also redirects data from the main ring to a bypass circuit, so the rest of the ring continues to operate normally.

Note that the switch unit does *not* detect **unclocked data**, that is, corrupt data. Nodes perform this checking function on the ATR network and transmit a “broken link” error message.

3.4.6 Ordering Information

The ATR–RNS equipment described in this section is available from the *Instant Apollo* catalog. See Appendix A for additional information.

3.4.6.1 ATR–RNS Rack–Mount Unit

The ATR–RNS (model number ATR RNS) comes with mounting hardware for mounting in any EIA standard 19–inch (48.3–cm) rack.

A vertical floor rack and single–unit wall rack (ITR–19RACK–FL, ITR–19RACK–WL) are available through the *Instant Apollo* catalog.

3.4.6.2 Software

The ATR–RNS remote operating software and diagnostic (model number SFW–RNS–ATR) is available as a separate product, so you can upgrade manually operated ATR–RNS switch units to remotely operated units.

3.4.6.3 Cables and Connectors

Network loops connect to the ATR–RNS switch unit through BNC connector posts, located on the switch unit's rear panel. These BNC connector posts are suitable for approved ATR coaxial cables terminated with approved BNC connectors. See *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* for information about approved cables and BNC connectors.

The ATR–RNS serial ports accept standard, 25–pin RS–232 connectors. Preterminated RS–232 cables in various lengths are available through the *Instant Apollo* catalog (see Appendix A for lengths and model numbers).

Each ATR–RNS unit arrives with one 2.9–foot (90–cm) coaxial **jumper cable**. Jumper cables complete the connections for the main and isolation rings on standalone units. To connect multiple units in larger configurations, you need to terminate longer coaxial cable lengths with BNC connectors.

3.4.6.4 Documentation

For ATR–RNS ac power information, see *Domain Hardware Site Planning Specifications* and its updates.

For ATR–RNS installation information, manual operation instructions, and a procedure for replacing single–loop network switches with ATR–RNS units, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network*.

3.5 Apollo Token Ring on Twisted Pair Cable

Apollo Token Ring networks can now run on shielded twisted pair (Type 1) cable using the Apollo Token Ring Type 1 Adapter cable. The Type 1 adapter cable facilitates the use of the 75–ohm Apollo Token Ring (ATR) controller with the 150–ohm IBM shielded twisted pair data wiring system.

You can use one of two different types of Type 1 adapter cables, depending on the network connector on the back of your system unit.

- One cable type (CBL–BALUN–BNC) connects the IBM Type 1 twisted pair cable to the Apollo Token Ring controller by using BNC connectors.

- The second cable type (CBL–BALUN–DSUB) connects the IBM Type 1 twisted pair cable to the Apollo Token Ring controller by using a D–subminiature connector.

We recommend that you use either an Apollo Token Ring manual network switch or an Apollo Token Ring Remote Network Switch to connect networks of coaxial media with the shieleded twisted pair media. The switches are used to facilitate ease of diagnosis and fault isolation. See Chapter 5, "Planning for ATR on Shielded Twisted Pair Cable" for more information.

Chapter 4

Planning an Apollo Token Ring Network Layout

Proper design and layout are essential for an efficiently functioning network. This chapter provides guidelines for planning the cable layout and locating equipment for

- A serial–wired Apollo Token Ring network
- A star–wired Apollo Token Ring network
- A DFL–100 fiber–optic ring extension

Although the information in this chapter will help you with an initial plan, we recommend that you work with a professional cable installer to design the final coaxial and/or fiber–optic cable layout.

For detailed information about coaxial cable routing and terminating procedures, see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network*. Because of the special handling and installation techniques that fiber–optic cable requires, we do *not* provide a similar installation manual for fiber–optic cable. (See Appendix B for vendor information and basic installation guidelines).

If you are planning to connect ATR networks in a Domain or TCP/IP internet, use the guidelines in this chapter along with the internet information in Chapters 2, 11, and 12 to plan your network.

While you plan your network, keep a copy of *Domain Hardware Site Planning Specifications* on hand. Refer to it for environmental requirements, including electrical requirements, service clearance requirements, and equipment dimensions.

4.1 Planning the Apollo Token Ring Cable Layout

This section provides information about planning your coaxial cable layout.

4.1.1 Number of Nodes

You can install hundreds of Apollo nodes in a single Apollo Token Ring network and add or move nodes as your requirements change. We place no limit on the number of nodes you can install in a single ring (though there is a practical limit of 1024 nodes), other than your ability to provide adequate network services and maintain network reliability and performance. (Your network management tasks increase slightly with each new node and each new application.) For optimal reliability, rather than install a single large ring, we recommend that you consider creating a Domain internet of several smaller rings (see Chapters 11 and 12 for more information).

In a star–wired ring, we recommend that you plan for each loop to eventually contain five to eight nodes located physically close to one another; for example, along the same hallway, or on the same floor of a building.

4.1.2 Maximum Distance between Nodes

You can place nodes anywhere on the ring, provided that you observe a maximum cable length of *1 km (3281 ft)* between *active* nodes. This means that two nodes can communicate reliably over 1 km or less connecting cable; if the cable length is over 1km, the signal deteriorates and may cause a transmission error.

For a network planner, this means that you must design your network so that it is unlikely that the failure of one or two nodes can cause the effective cable length between the downstream and upstream active nodes to exceed the maximum length.

NOTICE Apollo nodes transmit and receive data through a set of relays. The nodes are considered *active* when these relays are *connected to the network* and the node is receiving, reclocking, and transmitting data. Normally, the relays are connected when the node is running the operating system. However, the relays are also connected when the node is performing diskless operations (e.g., booting from another node) or running certain diagnostics from the **Mnemonic Debugger (MD)** program. The relays *bypass the network* when the node is powered off, removed from the network with the **netsvc –n** command, or sitting idle in the MD.

When you *logically* disconnect nodes from the network with the **netsvc –n** command but leave the nodes electrically and physically connected, you add to the normal signal attenuation on the cable. Consequently, if you logically bypass several nodes *in sequence*, you may introduce enough attenuation to disrupt communications between the remaining active nodes.

IBM compatible PCs residing on the network using the PCI product are considered "nodes," so they also must obey the distance-between-active-node rule. It is especially important to realize that turning off PCs that are sequentially arranged (that is, not separated by one or more Apollo workstations) could result in violation of the distance rule and therefore failure of the network.

In a star-wired Apollo Token Ring network, plan the distances between the nodes so that you can switch out several consecutive loops without exceeding the 1 km (3281 ft) maximum length. Figure 4-1 illustrates planning node locations in loops.

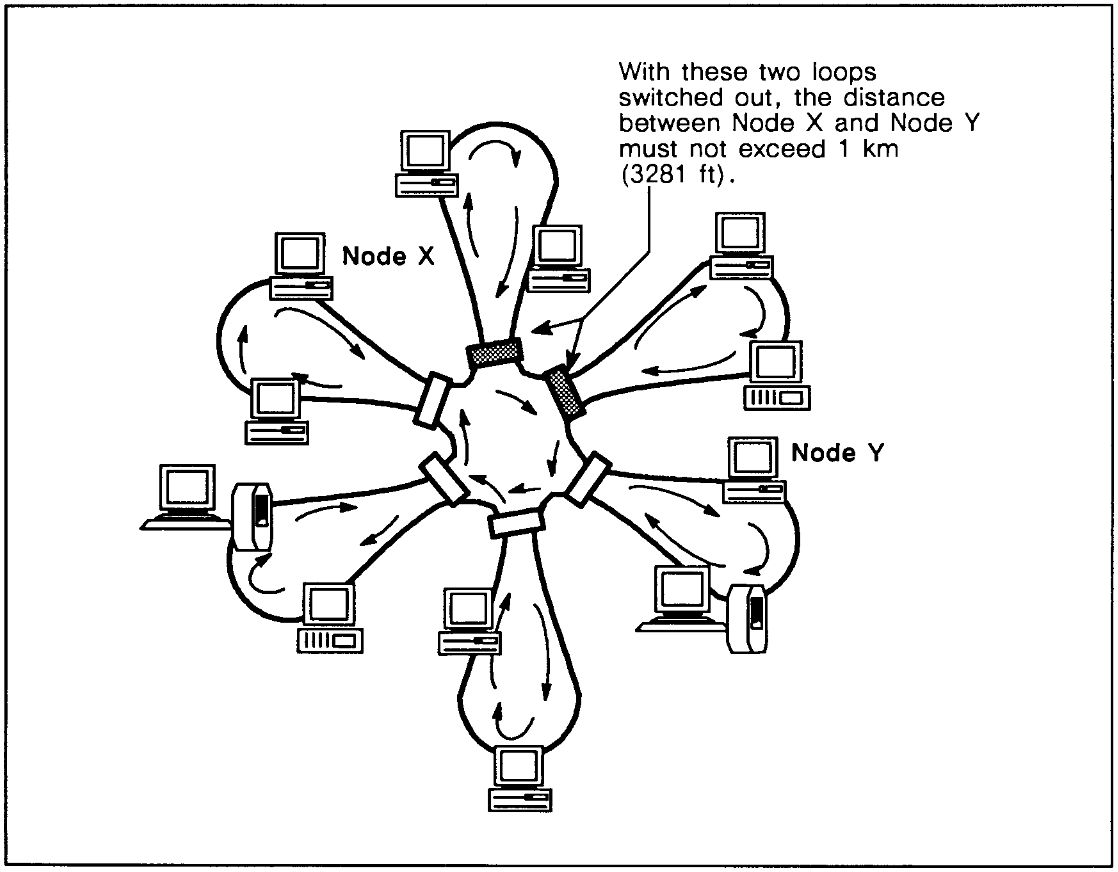


Figure 4-1. Maximum Cable Length in a Star-Wired Apollo Token Ring Network

We recommend that you keep an up-to-date network diagram that *accurately* records node locations and cable lengths. This can help you avoid exceeding the maximum length when switching loops in and out or bypassing too many nodes in a row. (See Section 4.4, "Making a Network Layout Diagram," for more information.)

4.1.3 Planning Diskless Node Locations

Always plan to locate diskless nodes on the same loops as their partner nodes. Otherwise, when you switch out a partner node's loop, the diskless node no longer has access to the operating system and *cannot* continue to operate. In addition, arrange for adequate disk storage in each loop to service the diskless nodes. In many cases, the partner node also provides disk storage for diskless nodes; however, especially large files may require storage space outside the partner node.

We do not limit the number of **diskless nodes** that a single partner node can support. However, the number of diskless nodes a partner node can effectively support depends on several factors, including

- The size of the diskless node's main memory
- The CPU time demanded by the applications that you plan to run on the partner node

A diskless node obtains operating system **bootstrap** services from a partner node. A diskless node **pages** operating system code over the network from its partner node into its own main memory. Diskless nodes with added memory page less frequently and, therefore, perform most efficiently.

Providing bootstrap service and paging consumes the partner node's CPU time and memory. For the best performance, plan to *limit* additional services on the partner node.

4.1.4 Planning the Cable Route

You can route cable above a suspended ceiling, between walls, or under flooring. If your building does not lend itself to this, you can also route cable through raceways or cable troughs.

WARNING: If your building uses the space above the suspended ceiling as a plenum for air exchange instead of employing air intake and return ducts, and your local laws have adopted National Electrical Code (NEC) guideline number 725-B (which addresses fire hazards), you *must* follow the guideline that prohibits routing PVC-insulated cable in airways.

For locales outside North America, check your local electrical codes.

If you route PVC–insulated cable in a plenum, you may install conduit in the plenum and route the cable through the conduit. Or, you may use TEFLON–insulated coaxial cable, which is specially designed for use in plenums. (For information about ordering approved TEFLON–insulated cables, see Appendix A.)

We do *not* recommend laying coaxial cable outdoors. Variations in ground potential of buildings, exposure to electromagnetic interference such as lightning and other environmental conditions, pose hazards to this cable even if it is buried deep under ground in conduit. Instead, to extend your network between buildings, we recommend that you install a DFL–100 fiber optic interface unit or create an internet using a fiber optic link segment or T1 service.

When you plan your cable route, work with an electrical diagram of your building. Use the electrical diagram to ensure that the power required by a group of nodes and peripherals does not exceed the power provided by that ac loop. Also, note the location of all ac power cables, electric conduit, junction boxes, and any equipment or devices that produce electromagnetic fields. Because the proximity of an ac current can interfere with signal transmission on the coaxial cable, coaxial cable *must* be 24 inches away from all of these areas. (For example, *do not* run cable over fluorescent lights, alongside electric wiring, or near motors, fans, or air conditioning.)

As you plan the cable route, keep in mind that data in the ring flows from nodes upstream to nodes downstream. The coaxial cables you lay will connect one node's transmit port to the next node's receive port. You must decide on the direction of data flow in the ring *before* you lay the cable. When the cable installers cut a cable to terminate it, they will label the cable ends according to the direction of data flow that you've established.

4.1.5 Allotting Cable

If you plan to route cable in raceways, measure the distances accurately so that you will end up with enough cable at node locations to make a proper termination.

If you plan to install a Domain/DQC at each node location, allot approximately 30 cm (1 ft) of cable to make the termination. The amount of cable will vary depending on whether you plan to install the Domain/DQC in cable raceways or mount it directly in the wall. (See *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* for installation instructions.) The Domain/DQC cable assembly allows you to place the node within 3 m (10 ft) of the termination point.

If you plan to use BNC connectors at any node location, allot 6 m (20 ft) of cable to make the termination and allow flexibility in placing the node.

For a star–wired ring, allot approximately 0.65 m (2 ft) to connect each network switch to the next. You will also need a length of cable to connect the first and last switches; see *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* for switch dimensions and installation instructions.

4.2 Planning an Extended ATR Using DFL–100 Interface Units

You can extend an ATR network by joining previously separate rings or by substituting fiber–optic cable for a portion of the coaxial cable that would normally make up the ring. If you plan to merge existing rings, you will need to prepare each ring much as you would for a Domain internet (see *Managing Domain/OS and Domain Routing in an Internet* for information about these tasks). To extend an ATR network with fiber–optic cable, you'll need to install a DFL–100 fiber optic interface unit at each end of the fiber–optic cable link segment.

The remainder of this section provides information about planning the fiber–optic cable layout and placing the DFL–100 interface units. You *must* use fiber–optic cable that meets our specifications (see Section 3.2). We provide ordering information for specified cables in Appendix B. Since we do not provide procedures for installing fiber–optic cable, we also list some installation guidelines in Appendix B to help you plan the installation with a professional fiber–optic cable installer.

After the fiber–optic cable is installed, our service person will test the cable with an optical power meter before installing the DFL–100 fiber interface units. For information about how to install and operate the fiber interface unit, see *Installing and Operating the DFL–100 Fiber Interface Unit*.

Note that the Apollo FDDI network uses fiber–optic cable but is different from the DFL–100 product. See Chapters 6 and 7 for more information.

4.2.1 Planning the Fiber–Optic Cable Route

A fiber–optic link can be up to 3 km (9843 ft) in length. Do *not* plan to connect multiple lengths and DFL–100 units in sequence to span a distance greater than 3 km; the DFL–100 unit *cannot* function as a repeater in this manner. Figure 4–2 shows acceptable and unacceptable fiber–optic cable configurations.

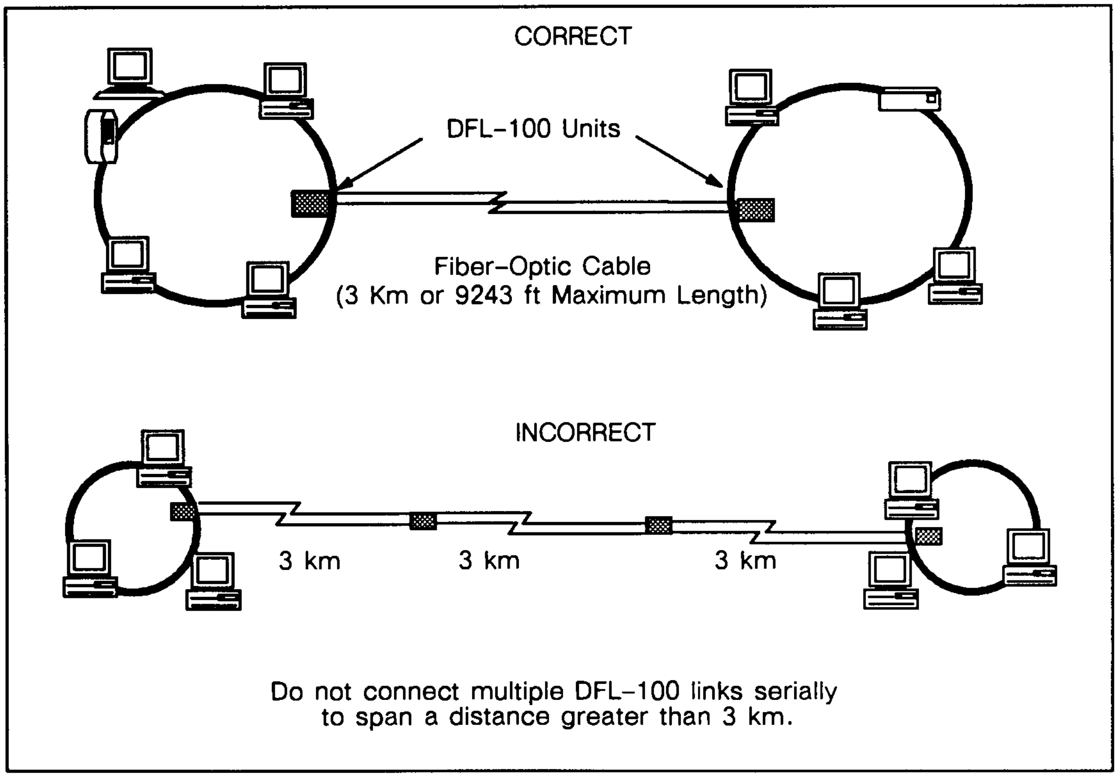


Figure 4-2. Correct and Incorrect DFL-100 Configurations

4.2.1.1 Physical Cable Considerations

Cable manufacturers produce fiber-optic cable pieces with a *maximum length of 2 km (6562 ft)*. If you need to install a length of fiber-optic cable longer than 2 km, you must attach the 2-km length to the additional length. To minimize decibel (signal) loss over the link, we recommend that you splice the cable, rather than install a patch panel with connectors and bushings (see Appendix B).

Our specified cables are heavy-duty cables suitable for *outdoor* installations. However, these cables can be installed in interior locations in conduit, *provided that no local or national (NEC) fire and smoke restrictions apply*. If you plan to route fiber-optic cable indoors, you might consider purchasing a light-duty cable. In this case, you must ensure that the fiber portion of the cable meets our optical core specifications.

NOTICE: Our specified fiber-optic cable is *not* suitable for interior locations where fire and smoke restrictions apply. If you need to route fiber-optic cable in plenum space, you may need to purchase TEFLON-insulated cable and splice it to the outdoor link. Check your local building codes. (See Appendix B for ordering information for TEFLON-insulated fiber-optic cable.)

4.2.1.2 Planning Adequate Cable Channels

Data flows in one direction on each fiber-optic channel. Therefore, plan to install cable that contains at least *two* channels, in order to handle transmissions to and from the DFL-100 interface units. For a redundant configuration (see Section 4.2.4), you will need at least *four* channels.

Consider purchasing fiber-optic cable that contains more channels than you intend to use immediately. Installing the cable can be a major undertaking, especially if you must dig trenches and bury conduit. By purchasing extra channels, you can increase your fiber-optic capacity with little additional labor. The presence of other channels allows you to attach other fiber-optic devices in the future.

4.2.1.3 Signal Attenuation

In certain cases, you may need to calculate the attenuation in your fiber-optic link to ensure its operation. Attenuation results from the light wave's passage through connectors, splices, patch panels, and the cable itself. Plan to calculate attenuation if your DFL-100 link meets any two of the following criteria:

- Spans the maximum distance
- Connects through a patch panel
- Contains more than one splice

Refer to Appendix B for complete information on how to calculate signal attenuation.

4.2.2 Planning the Fiber-Optic Cable Installation

Although the procedures for installing fiber-optic and coaxial cables are similar, you should ensure that your cable installers have received special training in laying fiber-optic cable. Fiber-optic cable installation techniques require considerably more precision than that required to install coaxial cable.

There are several methods of installing fiber-optic cable in outdoor locations (for example, direct burial, pulling through underground duct, and aerial installation using utility poles). Ensure that your installers follow the basic installation guidelines detailed in Appendix B regardless of the installation method they choose.

4.2.3 Planning the Location of the DFL-100 Fiber Interface Units

Plan to locate the fiber interface units near the fiber-optic cable termination point, if possible. You can allow up to 300 m (1000 ft) of coaxial cable between each DFL-100 unit and the adjacent nodes. This cable length is shorter than the maximum allowed between active nodes on the ring because the DFL–100 unit does not contain signal amplification hardware. Figure 4–3 illustrates proper placement of the DFL–100 units.

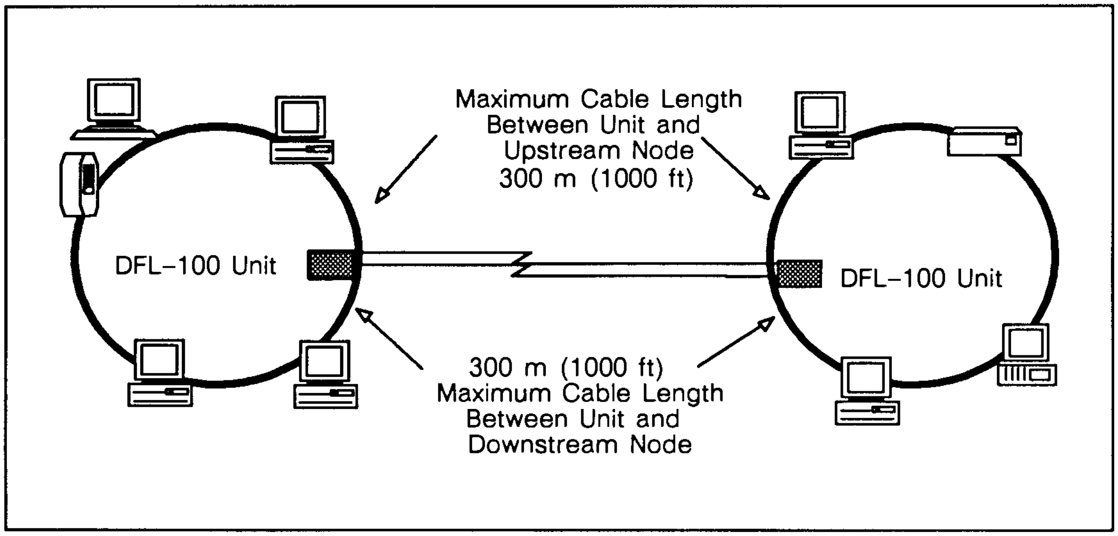


Figure 4–3. Proper Placement of DFL–100 Units

Do *not* plan to install two DFL–100 units in the same ring with no node between them (a back–to–back configuration). The units *must* transmit signals from the fiber-optic cable directly to a node for signal modulating/demodulating and reclocking before the signal can be transmitted to nodes on the ring. Figure 4–4 illustrates an unacceptable back–to–back configuration.

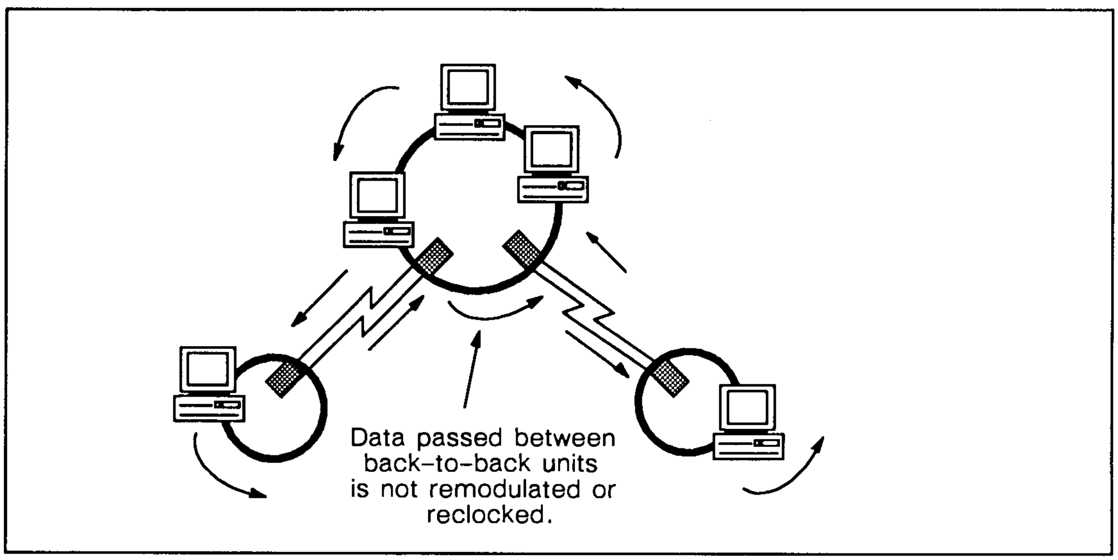


Figure 4–4. An Unacceptable Back–to–Back DFL–100 Configuration

In a star-wired Apollo Token Ring network, plan to locate the fiber interface unit in its own loop. If you locate the unit in a loop with nodes, and you switch out the loop to service the nodes, you will switch out the fiber-optic link. If your configuration includes redundant units, each pair of redundant units should be in the same loop.

4.2.4 Planning a Redundant DFL-100 Configuration

A redundant configuration consists of two *independent* fiber-optic links that are connected by a special redundancy cable. Figure 4-5 shows a redundant DFL-100 configuration.

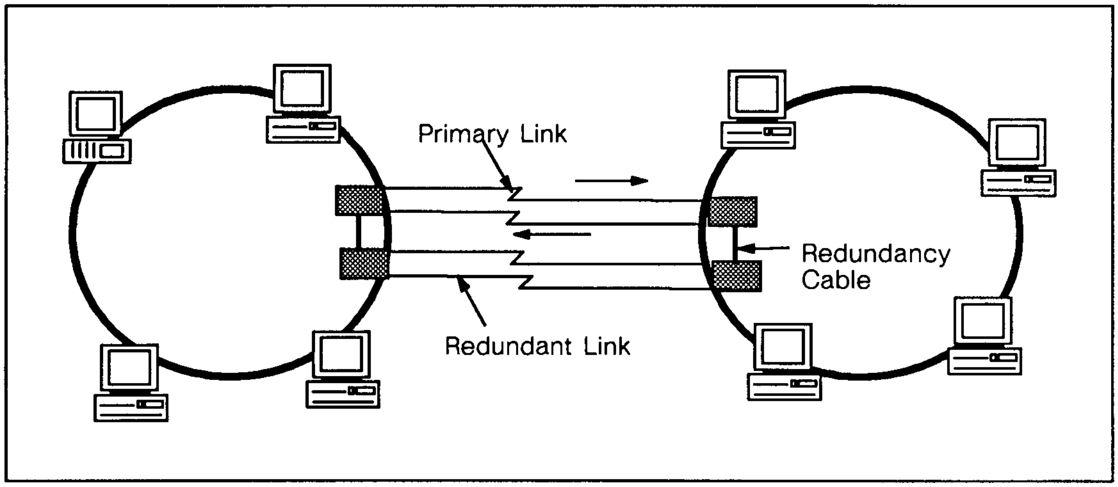


Figure 4-5. A Redundant DFL-100 Configuration

Plan to locate the two links near each other so that you can monitor both of them simultaneously during the primary/secondary switch-over process. The redundancy connecting cable that we supply is 2 m (6.5 ft) long.

You must also prepare a length of network coaxial cable to serve as the ring connection between the redundant units. The coaxial cable need only be long enough to connect the two fiber interface units. (See the BNC connector termination procedures in *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* to prepare the coaxial cable length. See *Installing and Operating the DFL-100 Fiber Interface Unit* for instructions on connecting the coaxial cable to the units.)

NOTICE: In the event of damage to the cable conduit, both the primary and redundant links could be affected. For greater reliability, route the primary and redundant links in *separate* conduits.

Do *not* plan to achieve redundancy or faster throughput by connecting nodes in a triangle configuration, as shown in Figure 4-6. In this configuration, data can only circulate on one channel. No data reaches the units' receive ports, and the units quickly switch into bypass mode. With all units in bypass mode, *no* data is transmitted over the fiber-optic link.

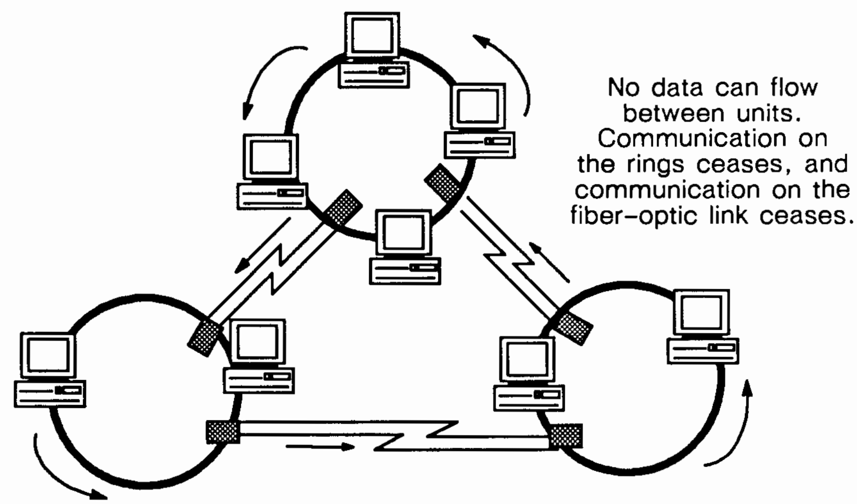


Figure 4-6. An Inoperable Redundant DFL-100 Configuration

4.2.5 Planning for Remotely Controlled DFL-100 Units

The fiber interface unit is equipped with a connector for controlling the unit's bypass and reset features from a remote location. You can install a remote switch assembly in the network control area or in an office and run a connecting cable between the unit and the remote switch. In this manner, your network administrator can operate the unit from a convenient location.

For a remote installation, you must supply a suitable remote power supply, switch, cable, and connector to connect the fiber interface unit and the remote switch. (See *Installing and Operating the DFL-100 Fiber Interface Unit* for device details.) In order to meet FCC/VDE emission requirements, plan to use shielded cable in your remote control switch–and–cable assembly. As our customer, it is your responsibility to ensure that your remote control assembly meets all applicable FCC/VDE emission requirements.

4.3 Planning the Network Control Room for an ATR Network

The network control room/area not only contains network switches for a star–wired ring, it also provides a centralized place for network record keeping and administration. In star–wired rings, the network control room is a valuable aid in network expansion and maintenance because you can switch many loops in or out from one switching location. In small networks, you should plan for a network control area to contain at least a network diagram and a log book. Including a network control room in your network plan will simplify the process of adding new nodes to your network in the future.

Plan a network control room near the center of your network. At a minimum, the control room should contain the following:

- A copy of the network diagram (See Section 4.4, "Making an ATR Network Layout Diagram")
- A node to run network management/troubleshooting software
- A log book to record network problems and service calls
- A list of system administrators and service personnel and their phone numbers
- Network switches (for a star-wired ring only)

The control room node should be on its own loop to aid in network troubleshooting. If you are planning a fiber-optic ring extension, you may be able to locate the DFL-100 interface units, or remote switches for the units, in control rooms. With a star-wired ring, plan for your system administrator to monitor the network and the switches to ensure that the network functions smoothly with a minimum of unnecessary interruptions. For network security, consider limiting access to this room by installing a locking door and giving keys to authorized personnel only.

4.4 Making an ATR Network Layout Diagram

This section contains guidelines for creating a layout diagram for an ATR network. It also includes a sample layout diagram. Use this information to create your own network diagrams. Not only is such a plan necessary for laying cable at the site, but network debugging is extremely difficult without proper network documentation.

Plan to post a layout diagram in the network control room, or where your system administrator and service personnel can easily consult it. A network diagram should show the following:

- The cable allotted at each node location. (See Section 4.1.5, "Allotting the Cable," for more information.)
- The cable lengths between each node. This will help you determine the combinations of nodes you can remove or power down without exceeding the maximum cable length between active nodes. Use a key, such as 5 mm = 1 m or 0.25 in = 1 ft, to calculate the cable lengths.
- Locations of future node sites. Plan your network to include any location that may contain a node in the future.
- Direction of data flow in each loop. This information aids troubleshooting by identifying upstream and downstream nodes.

- Loop numbers. Number the loops starting at the network control room according to the direction of data flow. (Data will flow from Loop 1 to Loop 2 and so on.) In addition to numbering, you can trace each loop in a different color.

- Office, room, and work area numbers. You will use them to identify equipment locations.

- Office sizes. You use these to plan for adequate clearance for nodes and peripherals.

When your nodes arrive, plan to add the node models, names, and IDs to this diagram. You should also plan to note the locations of nodes that contain key directories and files on the diagram. *Plan to keep this document up to date as you add and move nodes and equipment.* Updating the diagram should be one of your system administrator's regularly scheduled tasks.

If you plan to install a fiber-optic ring extension, note the locations of each DFL-100 fiber interface unit, the building entry points of the fiber-optic cable, and the fiber-optic cable layout. In addition, indicate the fiber-optic cable installation type (e.g. burial, aerial).

If you plan to create an internet, note the locations of routing and gateway nodes and the layout of the transmission media that will connect the networks. If you plan to use T1 service to connect rings, you may not be able to indicate the media layout, but you should indicate the locations of T1 interface devices.

Figure 4-7 shows a sample cable layout diagram for a star-wired ring. Node locations, loops, network switches, and cable lengths between nodes are all noted. Future node locations are also included, marked with an "x."

The diagram helps you determine the cable lengths between active nodes so that you do not exceed the 1 km (3281 ft) maximum. In Figure 4-7, the cable lengths represent an average office layout. (The longest length is 100 m — approximately 328 ft.) Even if all but the first and last nodes in the network (the nodes at locations A-1 and E-2) were switched out, you would not exceed the 1 km length. However, if you plan to connect nodes at opposite ends of a large building with one long cable run, you may exceed the limit if several nodes are removed from the network.

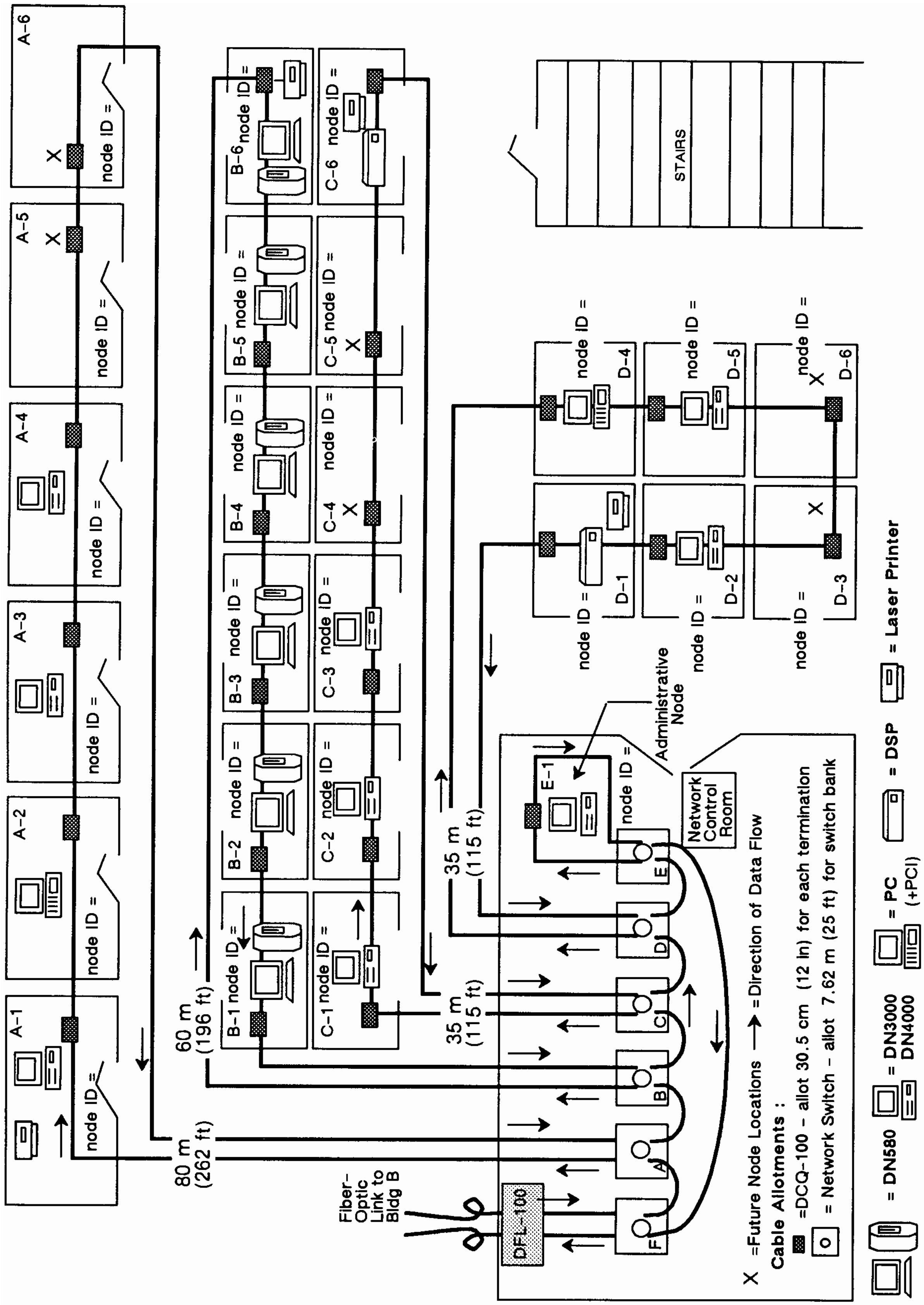


Figure 4–7. Sample ATR Network Layout Diagram

Chapter 5

Planning for ATR on Shielded Twisted Pair Cable

This chapter provides planning information for using Apollo Token Ring on shielded twisted pair cable. It also provides distance and deactivated node limitations that you need to be aware of when planning for Apollo Token Ring with shielded twisted pair cable.

5.1 Cabling

There are two types of twisted pair cable: unshielded and shielded. **Unshielded twisted pair (UTP)** generally refers to the type of cable that is used for interconnecting telephone systems. UTP does not have a shield and has an impedance of 100 ohms at data frequencies greater than 1MHz. Though it was designed for voice transmission, it is becoming a very popular medium for data transmission because of its low cost and managability. StarLAN and 10BaseT are examples of LANs that use UTP for interconnection. Although UTP cannot be used with Apollo Token Ring (ATR), you can connect an Apollo node to Ethernet on unshielded twisted pair using the HP28664A Twisted Pair MAU.

Shielded twisted pair generally refers to IBM Type 1 cable. Type 1 differs from UTP in that it is fully shielded and has an impedance of 150 ohms at data frequencies greater than 1 Mhz. Type 1 cable was designed for the transmission of data only and has less crosstalk and attenuation than UTP cable. This kind of cable can be used to connect ATR equipment providing Type 1 adapter cables are used.

The IBM cabling system is a data communication wiring standard developed by IBM as a general cabling strategy for multiple types of IBM computer systems. The IBM cabling sytem is normally configured as a star-wired ring, with each office wired directly back to the wiring closet. The IBM cabling system can be used for non-IBM systems. For example, an IEEE 802.5 Token Ring specifies a subset of the IBM cabling system as its connection. The IBM cabling system allows different types of cables, of which Types 1,2,6 and 9 can be used with the Apollo Type 1 adapter cable for connection with an Apollo Token Ring. Note that you can set up an Apollo network using IEEE 802.5 protocols, as opposed to setting up an Apollo Token Ring on IEEE 802.5 or IBM cabling. See Chapter 10 for more information.

5.2 Type 1 Cable on Apollo Token Ring

Some advantages of using shielded twisted pair cable over coax cable for ATR include the following:

- Type 1 cable enables the use of an industry-standard cable plant that can be used with other types of LANs besides ATR.
- The transmit and receive wire are in the same cable jacket making it more manageable.
- There is greater immunity to differences in the electrical system ground between workstations.

Some possible disadvantages of using shielded twisted pair for ATR include the following:

- Effective distance is only 75% of what it is with coax cable.
- Depending on lobe lengths, a few consecutive deactivated nodes could cause network failure(see Section 5.6).

The Type 1 adapter cable allows the use of the IBM shielded twisted pair cabling system instead of coax cable for interconnecting an Apollo Token Ring (ATR). There are two versions of the Type 1 adapter. One version connects the ATR devices via a D-subminiature connector (CBL-BALUN-DSUB) and the other version connects via BNC connectors (CBL-BALUN-BNC). Both versions are 10 feet long and have an IBM data connector on one end for connection to the IBM cabling system (see Figure 5-1). Inside the housing for the data connector are transformers for matching the impedance of the 75 ohm coax system to the 150 ohm twisted pair system. The adapter only allows exclusive operation of ATR on the cabling system and cannot directly interface with any IBM computers or non-Apollo Token Ring equipment.

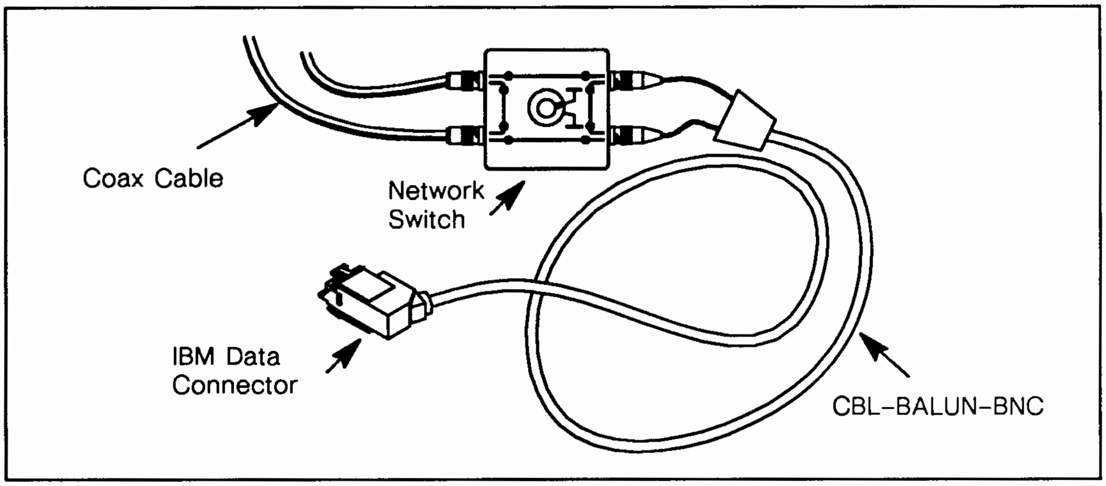


Figure 5-1. Apollo Token Ring Type 1 Network Adapter

The maximum effective distance between active ATR devices connected via Type 1 adapters through IBM Type 1 or 2 data cable is *750 m* (2460 ft) transmit to receive. Specific conditions can change the effective distance. The following sections provide general information on these conditions and the sources and quantities of signal loss.

Apollo Token Ring Network

5.2.1 Transition Loss

Each additional transition from a coax system to a twisted pair system will reduce the effective distance by 25 m (82 ft). This loss is caused by the signal going through one-half of the adapter.

5.2.2 Use of Other Cable Types

The use of Type 6 or Type 9 cable instead of Type 1 or Type 2 reduces the effective distance. Multiply the lengths of the Type 6 or Type 9 cables by 1.66 to find the equivalent distance of Type 1 cable. The use of RG62 coax instead of Type 1 or Type 2 cable increases the effective distance. Multiply the lengths of coax by 0.75 to find the equivalent distance of Type 1 or Type 2 cable. See Figure 5-4 for examples of cable types used in a network.

5.2.3 Deactivated Node Loss

Each deactivated node (bypassed or powered down) connected via a Type 1 adapter reduces the effective distance by an extra 50 m (164 ft). Each deactivated node connected via a coax cable reduces the effective distance by 25 m (82 ft).

5.2.4 Ground Differential

The maximum operational differential voltage between two workstations connected via Type 1 adapters is 30V. See *IBM Cabling System Planning and Installation Guide* for further information on grounding.

5.3 Other Components of a ATR Twisted Pair Network

In addition to the Type 1 adapter cable, there are several other components that are involved in building an ATR twisted pair network. Table 5-1, at the end of this chapter, provides a list of all the ATR twisted pair network components and their part numbers.

IBM Type 1 cable
Standard data communications cable consisting of two individually shielded #22 AWG solid copper twisted wire pairs, surrounded by braided shield and sheath. The orange and black wires are the transmit pair, and the green and red wires are the receive pair.

IBM Type 2 cable
Same as Type 1 but with four additional unshielded phone pairs placed outside the braided shield and under the sheath.

IBM Type 6 cable
A more flexible and higher loss #26 AWG stranded version of Type 1 that is typically used for patch cables.

IBM Type 9 cable
A smaller diameter and higher loss #26 AWG version of Type 1 used when there is limited space in the cable trays.

The IBM cabling system tester
A hand-held device used for checking for polartiy and continuity of the IBM cabling system.

Loop Wiring Concentrator (LWC)
An 8-connection, passive wiring hub with an extra I/O connection available for expansion. All LWC connections are self-shorting and are wired as a ring.

Distribution panel
The panel used in a wiring closet to terminate data cable runs to workstaions.

IBM data connector A 4–position, self–shorting data connector used in the IBM cabling system. When the connector is withdrawn, the transmit pair is looped back to the receive pair.

Patch cables Cables used in the wiring closet to interconnect the shielded twisted pair cabling plant and compatible devices.

Type 1 Face plate Plastic cover used for holding one IBM data connector. This plate fits over a single–device, NEMA standard electrical box.

Type 2 Face plate Same as Type 1 face plate with additional RJ45 connector for connection of phone pairs.

5.4 Star–wiring Apollo Token Ring

With ATR, the network failsafe relays are located in the nodes. Figure 5–2 shows a daisy–chained network, with the cable running only from one office to the next. Note that the distance (L equals cable length) that node A has to drive when node B drops out is equal to L1+L2.

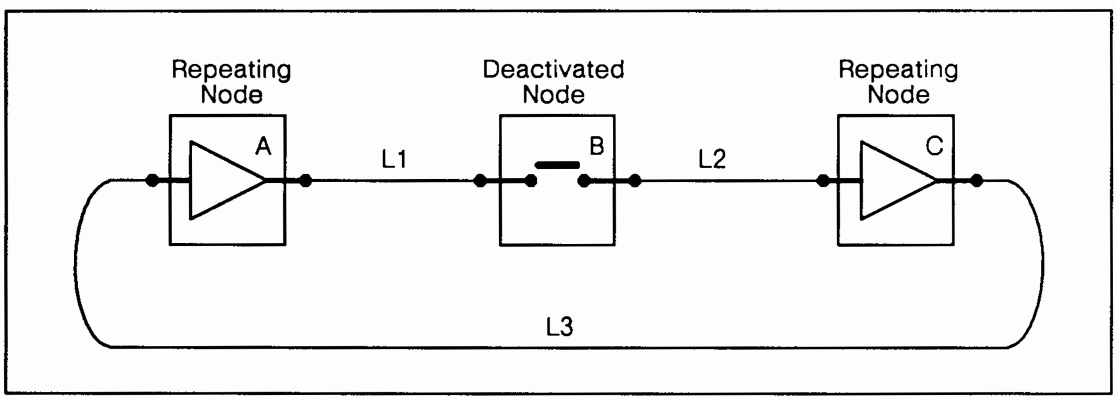


Figure 5–2. Daisy–Chained Network With Deactivated Node

In a star-wired ring, when station B becomes deactivated, station A must transmit up and down the deactivated segment of station B before the signal can be received by station C (see Figure 5-3). The total distance that A would have to drive would be equal to L2+L3+L4+L5.

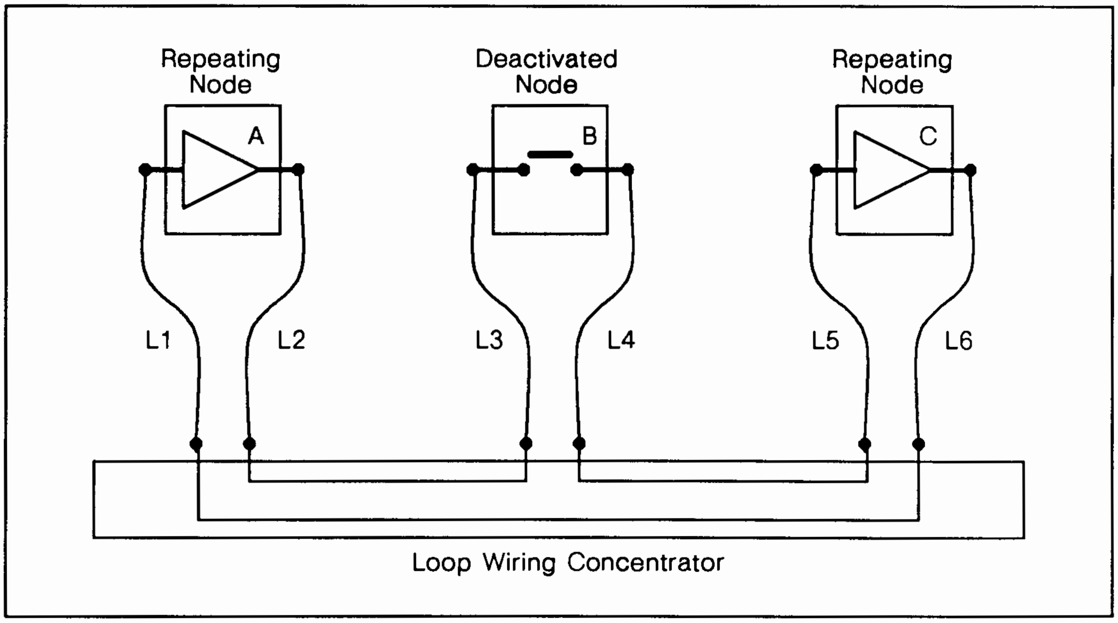


Figure 5-3. Star-Wired Network WIth Deactivated Node

Therefore, we recommend keeping the lobe lengths short to prevent contiguous deactivated nodes from bringing the network down. Though longer lobes are allowed, it is better to keep the lobe lengths less than 100 meters.

5.5 Calculating the Operating Margin

Operating margin is expressed in meters and is the remaining cable distance after adding up the loss budget (margin = effective distance - loss budget) and is expressed in meters. To ensure proper network operation, you must make sure that the operating margin of your network is greater than zero. To find the loss budget of a particular condition in the network, you need to account for all transitions, cable types, cable lengths and deactivated nodes between the transmitter of one active node to the receiver of another. The loss for each device is expressed as the equivalent cable distance on Type 1 cable in meters (see Figure 5-4).

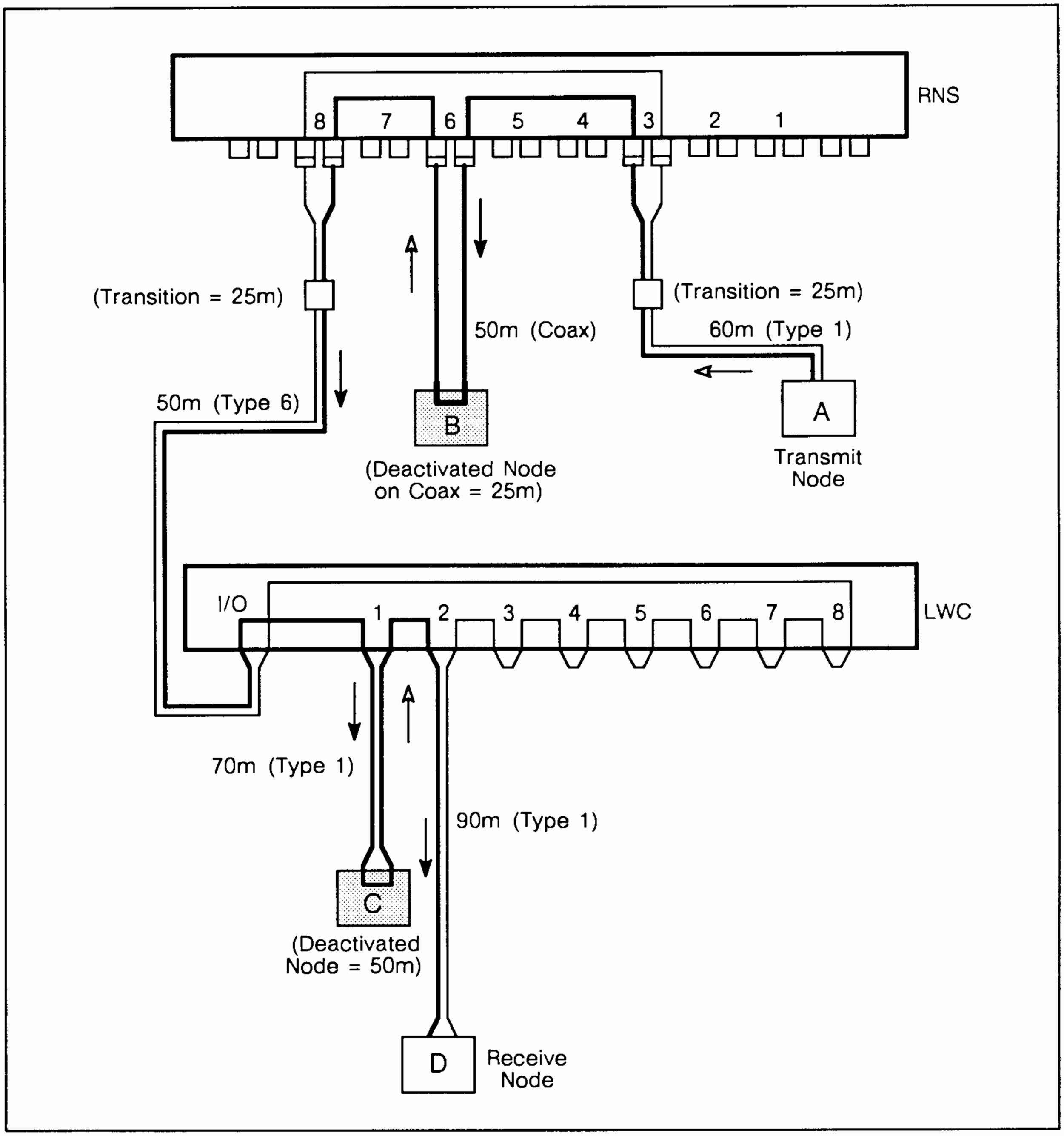


Figure 5-4. Operating Margin Example

Apollo Token Ring Network

In this example, if we assume that nodes B and C become deactivated, then the loss budget from node A to C would add up as follows:

60 meters of Type 1 from the transmit of node A to the adapter	60 m
Conversion from Type 1 to the ATR-RNS	25 m
50 meters of coax from the ATR-RNS to node B	37.5 m
Deactivated node loss of node B connected via a coax cable	25 m
50 meters of coax from node B to the ATR-RNS	37.5 m
Conversion from ATR-RNS to Type 1	25 m
50 meters of Type 6 cable to the LWC	83 m
70 meters from the LWC to node C	70 m
Deactivated node loss of node C connected via a Type 1 adapter	50 m
70 meters from node C to the LWC	70 m
90 meters of Type 1 from the LWC to the receiver of node D	90 m
Total loss budget	573 m

Since the maximum effective distance between active ATR devices connected via Type 1 adapters through Type 1 cable is 750 meters, the operating margin is 177 meters (750 m – 573 m).

5.6 Sample Networks

In Figure 5–5, all offices are wired as home runs back to the wire closet and are terminated at a 64–position distribution panel. The offices that use ATR are connected off the patch panel into a Loop Wiring Concentrator (LWC). Up to eight nodes can be patched into the LWC. The LWC I/O port is connected to a single port on the ATR–RNS via an ATR Type 1 Adapter Cable. The ATR–RNS sits logically at the top of the network, controlling eight LWCs, hence 64 nodes.

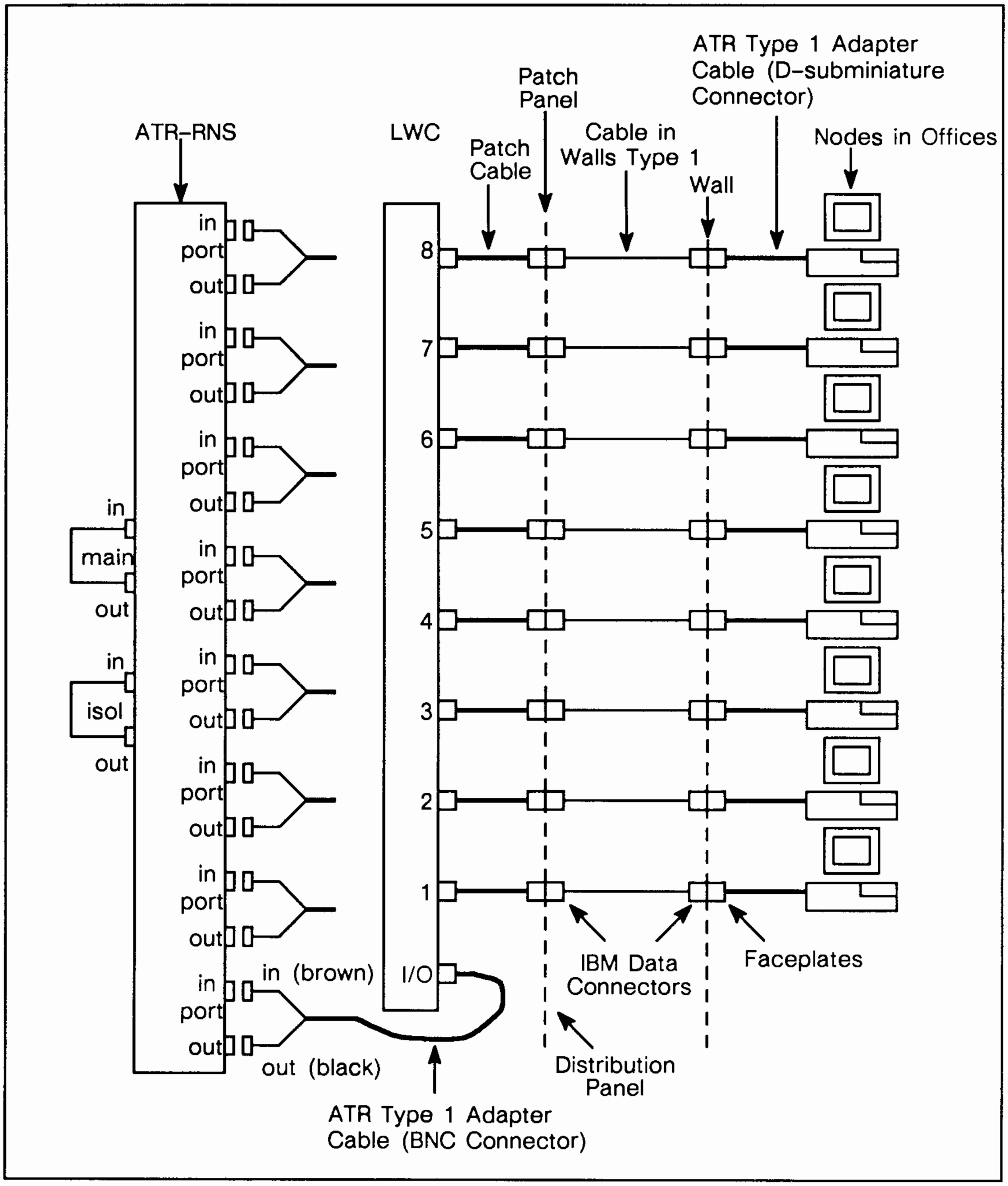


Figure 5-5. Sample Network Using the ATR-RNS and LWC

Figure 5-6 shows a 64-node ATR network on Type 1 cable using two LWCs.

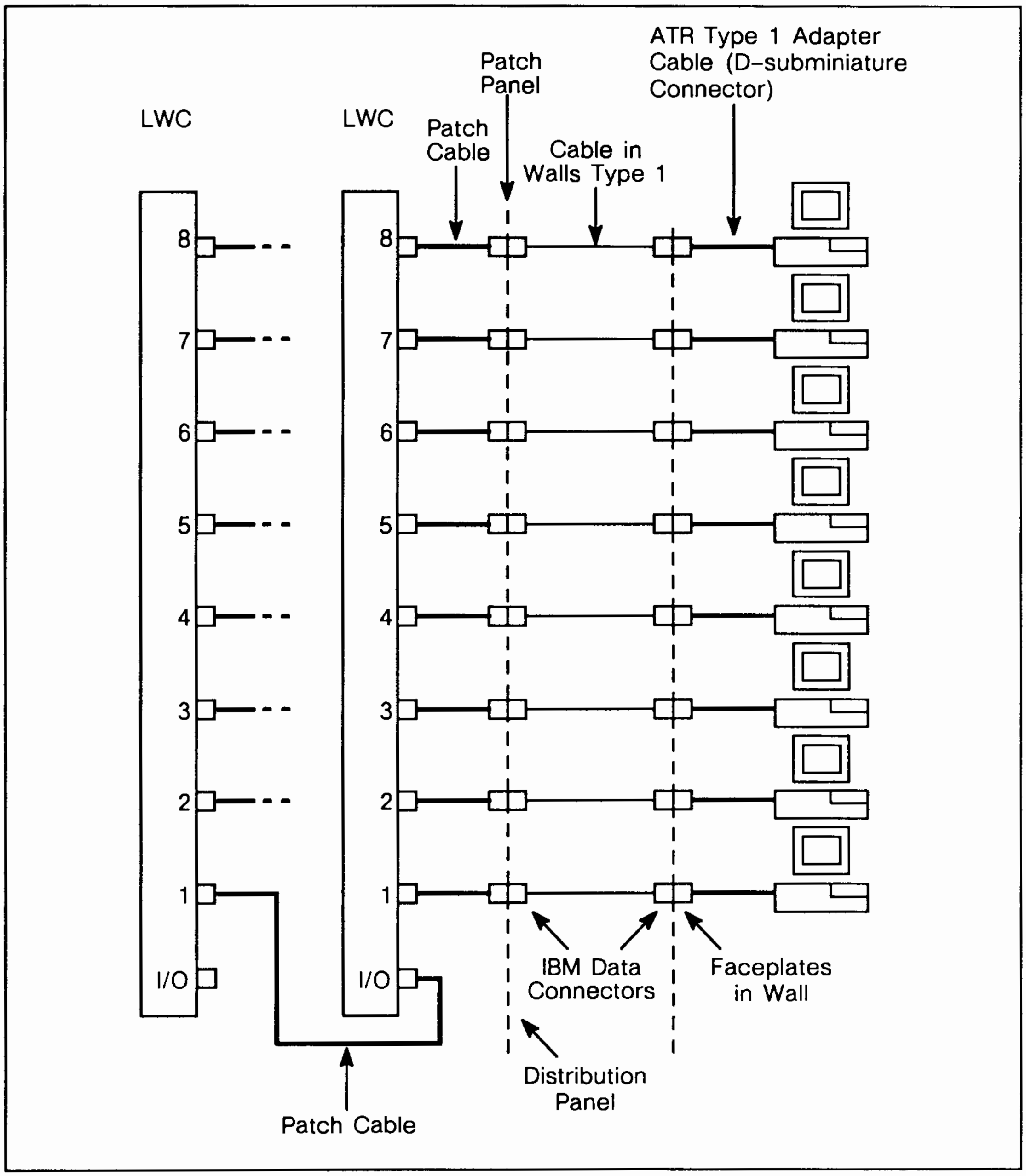


Figure 5-6. Sample Network Using Two LWCs

Figure 5-7 shows a simple 8-node network, where all the nodes are located in the same room and a single LWC connects them.

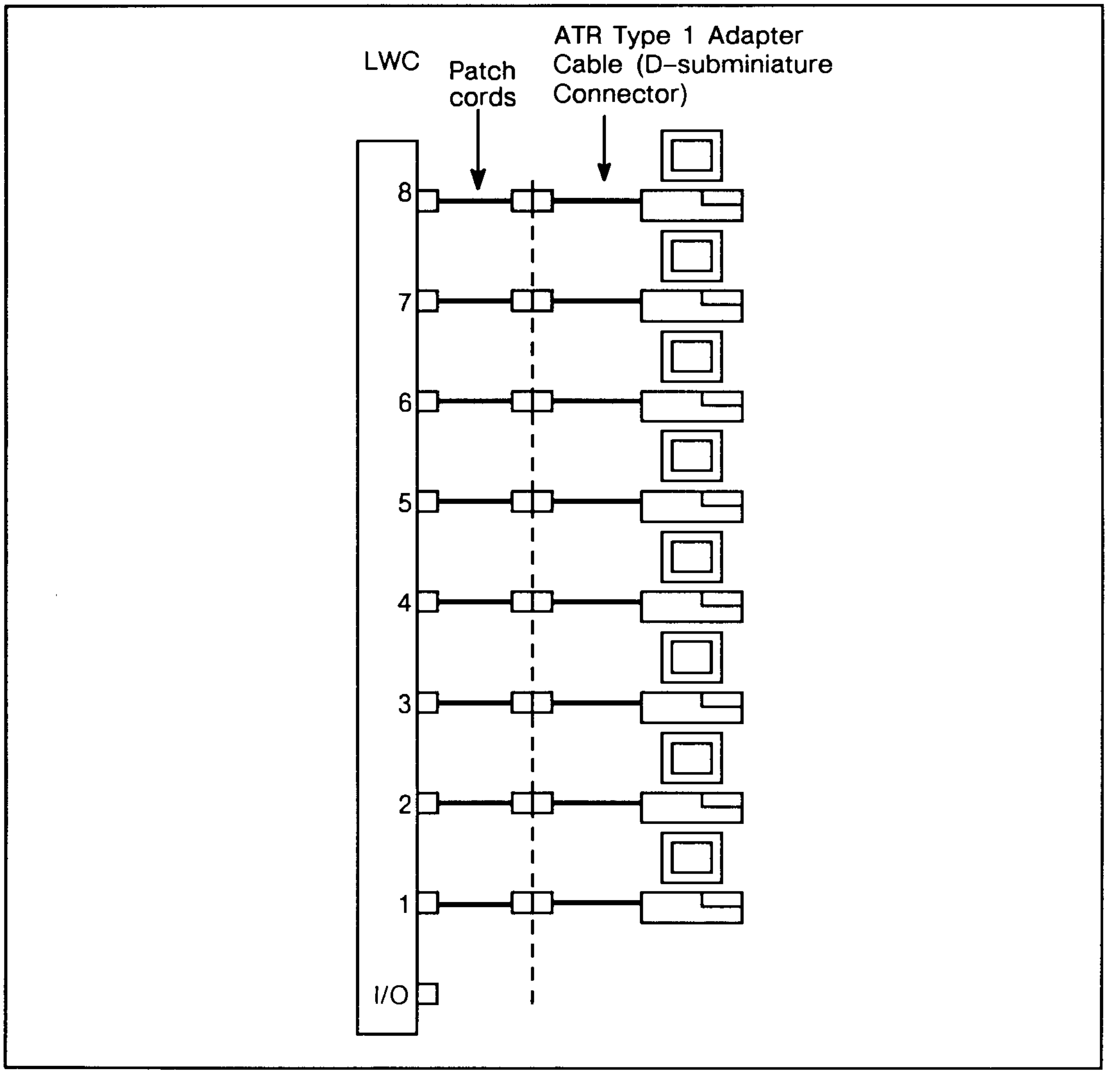


Figure 5-7. Simple Eight-Node Network

Table 5-1. ATR Twisted Pair Network Parts List

Part Name	Part Number	Apollo Direct Model Number	IBM Number
LWC	K2131	none	6091077
Distribution panel	K1458	ITR-19PANEL	8642520
Data connector	K1455	none	8310574
8 ft patch cable	K1453	ITR-CBLPATCH-8	8642551
30 ft patch cable	K1451	ITR-CBLPATCH-30	8642552
75 ft patch cable	K1452	ITR-CBLPATCH-75	6339134
150 ft patch cable	K1454	ITR-CBLPATCH-150	6339135
Type 1 adapater, BNC connector	K2120	CLB-BALUN-BNC	none
Type 1 adapter, D-subminiature connector	K2121	CBL-BALUN-DSUB	none
Type 1 faceplate		none	88310572
Type 1 faceplate surface mount		none	4760486
Type 2 faceplate		none	6091025
Type 2 faceplate surface mount		none	6091029
Equipment rack	K1459	ITR-19RACKFL	none
IBM Cabling System Planning and Installation Guide		none	GA27-3361
ATR-RNS	K1769	RNS-ATR	none
Type 1 PVC		none	4716748
Type 1 cable plenum		none	4716749
Type 1 outdoor cable		none	4716734
Type 2 PVC		none	4716739
Type 2 cable plenum		none	4716738
Type 6 PVC		none	4716743
Type 9 PVC		none	6339583

Chapter 6

FDDI Network Cables and Accessories

This chapter contains descriptions and specifications for the fiber–optic cables and accessories used in Apollo Fiber Distributed Data Interface (FDDI) networks. These cables and accessories are not available from Apollo; however, Section 6.6, "Vendor Ordering Information," provides a partial listing of manufacturers of fiber–optic products.

Apollo does provide the DFL–100 fiber interface unit to extend an ATR network. Do not confuse the DFL–100 product with the Apollo FDDI network. See Sections 3.2 and 4.1 for more information on the DFL–100 product.

6.1 FDDI Media Interface Connectors (MICs)

FDDI stations attach to the network's fiber–optic medium through **Media Interface Connectors (MICs)**. A MIC is made up of a MIC receptacle and a MIC plug; the MIC receptacle forms the station side of the connection, and the MIC plug forms the network side of the connection. The Apollo FDDI controller has built–in MIC receptacles. Your network cable plant must provide fiber–optic cable that is terminated with FDDI–compliant MIC plugs at node locations. Figure 6–1 shows two views of a typical MIC plug. **View A** shows the MIC plug and its matching receptacle; **View B** is a close–up front view of the MIC plug.

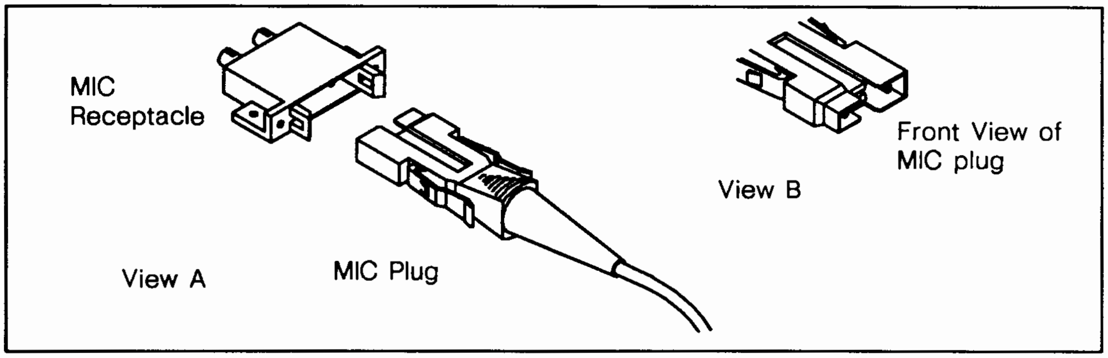


Figure 6–1. Two Views of a Typical MIC Plug

Devices that connect to the FDDI dual rings use MIC connectors. Because the DN10000 FDDI interface implements a dual attachment station (DAS), it has two MIC receptacles. MIC A provides the Primary Ring In and Secondary Ring Out connections, and MIC B provides the Primary Ring Out and Secondary Ring In connections. These MIC receptacles are physically keyed, as mandated by the FDDI Physical Medium Dependent (PMD) standard, to accept either

- Keyed MIC Plugs — The MIC A receptacle accepts only a MIC A keyed plug; the MIC B receptacle accepts only a MIC B keyed plug.
- Unkeyed MIC Plugs — Both MIC receptacles accept unkeyed MIC plugs. (FDDI requires keying for MIC receptacles, but requires only labeling for MIC plugs. MIC plug keying is optional.)

The purpose of keying and/or labeling for MIC receptacles and plugs is to help ensure that the proper connections are made when attaching a station to an FDDI network. Two other types of MICs, MIC M and MIC S, connect concentrators and single attachment stations (SASs) in FDDI networks. Apollo does not currently offer either concentrators or SASs.

The MIC receptacles on the Apollo FDDI controller accept any FDDI-conforming MIC plug, subject to keying requirements if the plug is keyed. Although we do not recommend any particular vendor's equipment, MIC plugs manufactured by AMP and Sumitomo meet FDDI specifications and operate satisfactorily with the Apollo FDDI controller.

6.2 Fiber–Optic Cable

Figure 6–2 shows the components of a typical duplex fiber–optic cable.

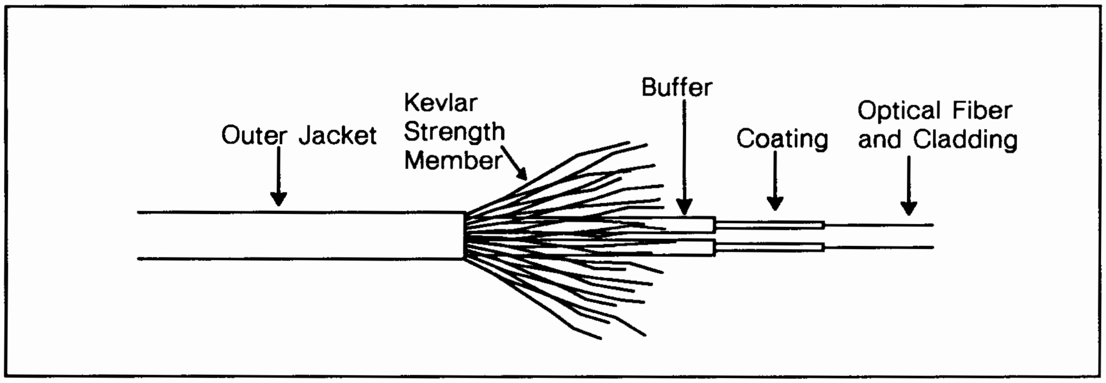


Figure 6–2. A Typical Duplex Fiber–Optic Cable

There are many possible variations of these basic components, but at the center of every fiber–optic cable is at least one **optical fiber**. The fiber itself is made of two physically inseparable parts: the central **core**, which is the fiber's transmission area, and the surrounding **cladding**, which is the fiber's boundary zone, causing reflection within the core so that light is transmitted down the fiber. Optical fiber is measured by the outer diameters of its core and cladding. Apollo FDDI networks support only 62.5/125 micron fiber, that is, fiber whose core measures 62.5 microns and whose cladding measures 125 microns. A micron (μm) equals one–millionth of a meter.

Surrounding the cladding is a plastic **coating** that absorbs shock and protects the fiber. The coating must be mechanically or chemically stripped before the cable is terminated for splicing or attaching a connector.

Surrounding the coated fiber is a **buffer** that may be either loose or tight. In loose buffer construction, the fiber is contained in a plastic tube that isolates the fiber from exterior mechanical forces and temperature changes. Tight buffer construction uses a direct extrusion of plastic over the basic fiber coating. Each type of buffer construction offers its own advantages—in terms of bend radius, tensile strength, impact and crush resistance, and attenuation change at low temperatures—for specific applications.

Surrounding the buffers in Figure 6–2 is a Kevlar **strength member**. The function of a strength member is to help free the fibers from stress, particularly during installation, by minimizing elongation and contraction. Other strength members commonly used in fiber–optic cable are fiberglass epoxy rods and steel wire.

Finally, the **outer jacket** protects the core from the external environment. Jackets made of various plastics are available, and the selection of the appropriate jacketing material depends on the application, for example, indoor versus outdoor. The jacketing material also determines the cable's flame rating as specified by the National Electrical Code (NEC). Specially rated cables must be used in risers and plenums unless installed in suitable conduits.

In addition, optical fiber is classified as either **single mode** or **multimode**, depending on the type of path that the light follows as it bounces down the core, reflecting off the core-cladding boundary. A **mode** is the path associated with a particular angle of reflection at the core-cladding boundary. Single-mode fiber, typically used with a laser source, allows only a single mode to travel down its extremely narrow core. Multimode fiber supports many modes, the higher order modes (those with the greater angles of reflection) having to travel farther down the core and thereby causing greater signal distortion than the lower order modes. Multimode fiber, typically used with an LED source, comes in two types: **step index** and **graded index**. Graded-index fiber supports longer distances and higher data rates than step-index fiber. Apollo's current FDDI networks support only graded-index multimode fiber.

The specifications that follow assure the interoperability of FDDI-conforming stations on lengths of fiber-optic cable as long as two kilometers between active stations. The optical core specifications are separated into two groups, mandatory and recommended. When both sets of specifications are met, the optical signal after two kilometers (or less) will meet the PMD receiver input specifications.

6.2.1 Optical Core Specifications

Although many types and sizes of fiber-optic cable are available, Apollo FDDI networks support only fiber-optic cable meeting the mandatory optical core specifications listed in Table 6-1.

Table 6-1. Mandatory Optical Core Specifications

Characteristic	Test Per	Specification
Fiber Type	—	Graded-Index Multimode
Core Diameter	EIA-455-58	62.5 µm, nominal
Cladding Diameter	EIA-455-27 or EIA-455-48	125 µm, nominal
Attenuation	EIA-455-53	11.0 dB maximum at 1300 nm (total attenuation between active stations)

In Table 6–1, the value for attenuation reflects maximum signal loss between active stations. This value includes both cable attenuation and cumulative signal loss resulting from such other components as splices, connectors, and switches.

While not mandatory, the optical core specifications listed in Table 6–2 are recommended for fiber–optic cable used in Apollo FDDI networks.

Table 6–2. Recommended Optical Core Specifications

Characteristic	Test Per	Specification
Fiber Type	—	Dual–Window
Numerical Aperture	EIA–455–47	0.275, nominal
Modal Bandwidth (–3 dB optical)	EIA–455–30 or EIA–455–51 with EIA–455–54	500.0 MHz/km min. at 1300 nm
Attenuation	—	2.5 dB/km max. at 1300 nm
Chromatic Dispersion	—	See Figure 6–3

In Table 6–2, **dual–window** refers to fiber that accepts two wavelengths of light, generally 850 and 1300 nm. **Numerical aperture** (NA) defines (as a sine) the maximum angle of incidence at which light will still enter a fiber's core. The NA shown in the table is equivalent to a calculated value of 0.29 when using the refractive index profile test methods in accordance with EIA–455–29 or EIA–455–44. The mapping between calculated NA and measured NA is still under study.

6.2.2 Fiber Chromatic Dispersion Parameters

Optical fiber's total bandwidth is the sum of its modal and chromatic bandwidths. The recommended minimum modal bandwidth is specified as 500 MHz/km at 1300 nm (see Table 6–2). Fiber chromatic bandwidth is controlled by specifying a range of permissible zero dispersion wavelengths and a maximum dispersion slope.

Sufficient chromatic bandwidth is assured when the zero dispersion wavelength (λ_0) and the dispersion slope (S_0) at λ_0 (as defined by EIA–455–168, EIA–455–169) fall within the highlighted area shown in Figure 6–3.

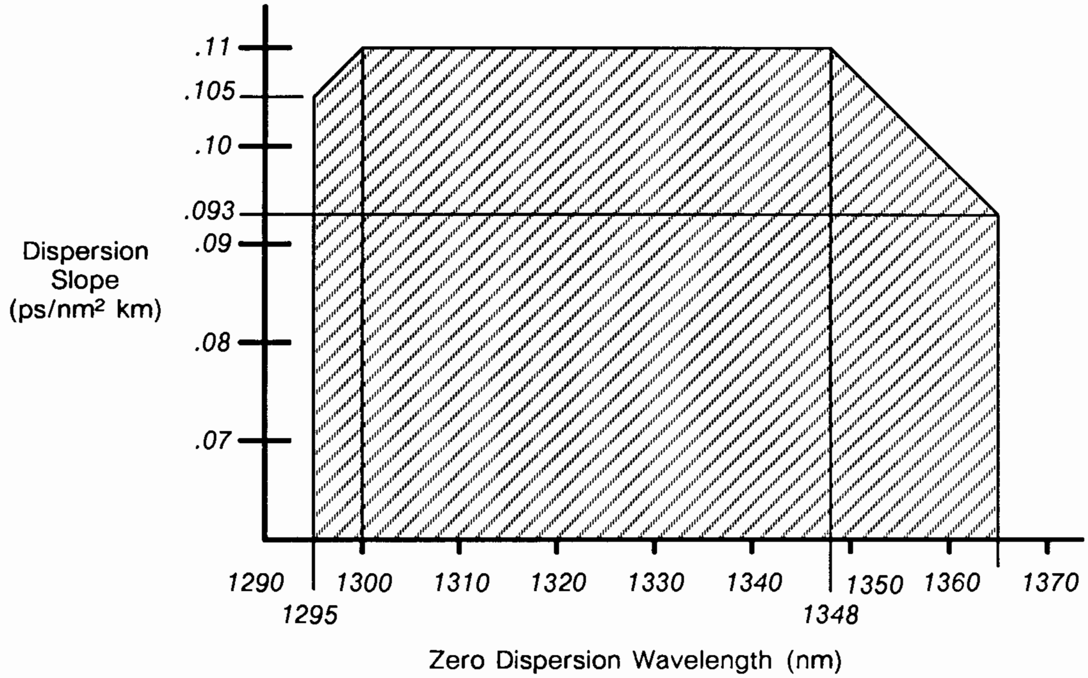


Figure 6–3. Minimum Dispersion Wavelength and Slope Limits

6.2.3 Mechanical Specifications

Many types of 62.5/125 µm fiber–optic cable are available, each suited to its own specific applications:

Light–duty Connects stations to wall or floor outlets; makes interconnections on patch panels.

Heavy–duty Used for cabling in walls and floors or for outdoor use.

Breakout Distributes fiber between floors and wiring closets, useful where cable goes directly to equipment or patch panels.

Plenum Runs above suspended ceilings and under raised floors.

Undercarpet Used in open office environments where no path is available for routing round cable.

Consult your vendor's catalog for complete specifications.

6.3 Fiber–Optic Splices and Connectors

Fiber–optic splices and connectors are used to join two sections of optical fiber. Splices and connectors have differing characteristics; in addition, there are several types of each. Generally speaking, use splices for relatively permanent connections or to ensure low optical signal loss, and use connectors for connections that are changed frequently and can tolerate somewhat higher optical signal loss.

6.3.1 Splices

A **splice** provides a permanent connection between two pieces of optical fiber, with a minimum of optical signal loss. Typically, this loss is about 0.25 dB. Some typical uses of splices are

- Joining sections of fiber to form a single, long cable run.
- Repairing broken cable, especially in a lengthy cable run. (When a break occurs in a short cable run, replacing the cable is sometimes more economical than splicing it.)
- Attaching prepared connector assemblies to the end of an optical fiber. This is usually easier than attaching a connector directly to a cable.

You can also use splices in your network control room to configure your network. This introduces a minimum of optical signal loss into the cable plant for each connection, but has the disadvantage that it creates an inflexible network. You cannot quickly or easily reconfigure such a network to isolate network faults or to add, delete, or move network resources.

There are two types of fiber–optic splices: fusion splices and butt–end splices. A **fusion** splice is created by fusing the ends of two fibers together with a strong electric charge. Fusion splices have marginally less optical loss than butt–end splices, but require expensive equipment and cannot be used in areas where the electric charge could cause fire or explosion.

Butt–end splices have only slightly more optical signal loss than fusion splices, and are easier and less expensive to install. A **butt–end splice** is formed by inserting the two fibers, one fiber at each end, into a quartz glass channel only slightly wider than the clad fiber. The fibers are held in place, butted end to end, by a crimping mechanism.

Easy–to–use splice kits are available from 3–Com and GE.

6.3.2 Connectors

Fiber–optic connectors provide a more flexible connection than splices—you can quickly and easily make or break the connection once the connector is attached to the optical fibers—but they suffer from greater optical signal loss than splices, and are more difficult to attach to the fiber initially. Connectors are also somewhat more expensive than butt–end splices.

Connectors are typically used where equipment is attached to fiber–optic cable, or in network control rooms where many connections are required and configurations are subject to change. Generally, connectors are *not* used to create long fiber runs by connecting segments of cable, or to repair cables; splices serve these purposes more effectively.

Several types of fiber–optic connectors are commonly available. The most commonly used type for applications such as FDDI is the **ST**, or **ST–compatible**, connector. These are relatively inexpensive and provide low attenuation. The spring–loaded, bayonet–style latch is easy to engage, and provides positive contact and excellent concentricity. The keying of the connector means that the coupling efficiency of a mated pair is constant over repeated connections. Typical signal loss is 0.5 dB.

ST or ST–compatible connectors are available from AT&T, AMP, and other vendors. Kits for terminating fiber–optic cable are available from AMP and other vendors.

6.4 Fiber–Optic Splice Cabinets and Patch Panels

If you have more than a few stations in your FDDI network, we recommend that you configure the network as a star–wired network with a network control room. In this configuration, each station connects directly to the network control room—rather than to the next node, as in a serial–wired ring—and all the interstation connections necessary to form a logical ring network are made in the network control room. Star–wired networks are easier to manage and test than serial–wired rings.

In the network control room, use splice cabinets and/or patch panels to organize your cables and provide easy access for splicing and connectorizing. Both splice cabinets and patch panels are (usually) rack–mounted trays or boxes that provide a place to terminate fiber with splices or connectors. In practice, most fiber–optic splice cabinets accommodate connectors, and most patch panels accommodate splices. Either one should provide

- Strain relief for individual cables at the rear of the unit
- Enough space, preferably padded with foam, for at least a foot of coiled cable

- A front panel with holes, slots, racks, and so on, for holding connectors and/or splices

- Easy access for working with the cables, splices, and connectors

Splice cabinets and patch panels are available from AT&T, 3M, and other vendors.

6.5 Tools for Working with Fiber–Optic Cable

As fiber–optic technology continues to develop, the array of tools for working with fiber–optic cable steadily expands, coming to market so quickly that existing catalogs are soon out of date. See Section 6.6, "Ordering Information," for the names of manufacturers that provide useful, up–to–date catalogs of fiber–optic tools and accessories.

The items listed below are only a representative sampling of the tools needed to install and maintain fiber–optic cable. Most of these tools have to do with attaching connectors or making splices.

Termination Kit	Includes the tools needed to terminate fiber–optic cable; that is, to prepare the fiber, polish the tips of the glass fibers, and attach a connector or a MIC plug.
Splice Kit	Includes the tools needed to prepare the fiber, center the two fibers on a common axis, and crimp the splice.
Epoxy	Cements the fiber inside the ferrule. Also stabilizes the tip of the fiber prior to polishing. Available as quick cure (requires heat gun or curing oven for fast curing) or as standard (24–hour) cure.
Heat Gun or Curing Oven	Hardens quick–cure epoxy.
Optical Source	Creates a suitable optical signal for testing attenuation across splices and connectors.
Optical Power Meter	Measures signal loss across splices or connectors. Used in conjunction with an optical source.
Fiber Microscope	Magnifies the polished fiber tips to inspect for grit or cracks.

6.6 Vendor Ordering Information

Below is a partial listing of manufacturers of fiber–optic products, including all those mentioned in this chapter. This listing is not complete, and we do not recommend these vendors over any others. Addresses and phone numbers may be subject to change.

AMP Incorporated
Harrisburg, PA 17105
Phone: 717–564–0100
Product Information Center; phone: 800–522–6752

AT&T
555 Union Boulevard
Allentown, PA 18103
Phone: 800–373–2447

Belden Fiber Optics
Technical Research Center
2000 South Batavia Avenue
Geneva, IL 60134
Phone: 312–232–8900; 800–323–0864

General Electric Company
Wire and Cable Department
General Electric Building
1285 Boston Avenue
Bridgeport, CT 06602
Phone: 203–382–3730

Sumitomo Electric Fiber Optics Corporation
78 Alexander Drive
Research Triangle Park, NC 27709
Phone: 919–541–8100

3–Com Corporation
3165 Kifer Road
Santa Clara, CA 95052
Phone: 408–562–6400; 800–NET–3COM

3M Corporation
9325 Progress Parkway
Mentor, OH 44060
Phone: 216–354–2101; 800–321–9668

Chapter 7

Planning an FDDI Network Layout

Proper design and layout are essential for an efficiently functioning network. This chapter provides guidelines for planning the cable layout and locating equipment for

- A serial-wired FDDI network
- A star-wired FDDI network

Although the information in this chapter will help you with an initial plan, we recommend that you work with a professional cable installer to design the final fiber–optic cable layout. Because of the special handling and installation techniques that fiber–optic cable requires, we do *not* provide an installation manual for fiber–optic cable.

While you plan your network, keep a copy of *Domain Hardware Site Planning Specifications* on hand. Refer to it for environmental requirements, including electrical requirements, service clearance requirements, and equipment dimensions.

7.1 Planning the Fiber–Optic Cable Layout

This section provides information about planning your fiber–optic cable layout.

NOTICE: This manual assumes that you are planning a dual–ring network consisting of primarily dual attachment stations (DASs). However, this manual does provide information to help plan for future integration of concentrators and single attachment stations (SASs).

7.1.1 Maximum Total Fiber Length

The FDDI Physical Medium Dependent (PMD) standard specifies a maximum total fiber length of 200 km *per network.*

7.1.2 Maximum Number of Stations

The PMD standard specifies a maximum of 1000 MACs *per network* (that is, a maximum of 500 Apollo dual attachment, dual-MAC stations per network).

Because adding, deleting, or moving stations in an FDDI network can be difficult (see Section 7.1.4), you should plan relatively static numbers of stations and determine their long-term locations.

A practical limit on the number of stations in a single FDDI network is your ability to provide adequate network services and maintain network reliability and performance. (Your network management tasks increase slightly with each new node and each new application.) However, the dual-ring architecture of FDDI provides a greater degree of fault tolerance than other networks, and its high bandwidth and station-to-station distance limits make it ideally suited to large network configurations.

7.1.3 Distance Between Stations

The PMD standard specifies a maximum fiber length of 2 km (6562 ft) between active stations. An **active station** is one that is actively participating in the network, *or* actively repeating the incoming signal on its outgoing fiber. A station in bypass mode, where the incoming signal is bypassed *optically* by the station, is *not* considered an active station. Such a station is effectively just another section of fiber-optic cable, incurring the signal loss associated with that cable segment and the connections to the bypass switch(es).

The 2-km distance limit assumes the use of fiber meeting all PMD cable plant specifications, and provides for a moderate amount of signal loss due to splices, connectors and switches. Alternative fibers may be used, provided that the optical signal at the end of each link meets the PMD receiver input specifications.

NOTICE: All fiber used in an Apollo FDDI network must meet the specifications given in Chapter 6.

The PMD standard for multimode fiber specifies a maximum signal loss of 11 dB between active stations. The greater the fiber length between two stations, the greater the signal loss between those stations. At greater than 11 dB signal loss, transmission errors may occur. (See Section 7.1.9)

You must design your network so that it is unlikely that a series of optically bypassed stations can cause the signal loss between the downstream and upstream active stations to exceed the maximum. Typically, there should be no more than three bypassed Apollo stations in a row between any two active stations. If your cable plant will have large numbers of fiber–optic splices, connectors, or switches, you must account for the signal loss introduced by each of them.

We recommend that you work with a cable installer who is familiar with both fiber–optics and the PMD standard. He or she can help you select an appropriate cable based on your requirements, and specify distance limits based on the cable selection, the expected number and type of splices and connectors, and the expected maximum number of simultaneously bypassed stations.

We also recommend that you keep an up–to–date network diagram that *accurately* records node locations, cable types and lengths, the types and locations of splices and connectors, and actual measurements of attenuation (signal loss) in each segment of fiber. This can help you avoid exceeding the maximum attenuation when bypassing several nodes in a row. (See Section 4.4 for more information.)

7.1.4 Planning Station Locations

Although fiber–optic cable has numerous benefits as a network medium, it does have the disadvantage that making and breaking connections between pieces of fiber is difficult and results in some degree of signal loss for each connection. Fiber–optic splices introduce very little signal loss, but form essentially permanent connections; the various types of connectors introduce a significant amount of signal loss, but have the advantage of flexibility. (You must account for signal loss due to splices and connectors when calculating cable length between stations. See Section 7.1.9)

Because of the difficulty of making and breaking fiber–optic connections, adding or deleting stations—or changing the location of a station—is difficult. These changes require interruption of network operation. For this reason, you should plan stable numbers and locations of FDDI stations.

If you do expect to add stations in the future, create a star–wired ring configuration and lay cable from the network control room to *all* expected locations. Future stations are then added to the network by splicing connections in the network control room. It is difficult to plan a serial–wired ring that includes enough extra cable to create new connections without splicing in new lengths of cable, and star–wired ring networks are easier to manage.

NOTICE: We do *not* recommend creating a star–wired network consisting of loops of several FDDI stations. In this configuration, if a station is unplugged from the network, the loop is broken and *none* of the stations on it can function unless the cable is spliced together. Instead, create a star–wired network where each station is on its own loop. Adding or removing stations is still difficult, but you can make all changes at the patch panel or splice cabinet in the network control room.

If your network spans multiple buildings, plan to locate stations on either end of interbuilding cable segments near the place where the cable enters the building, if possible due to the 200 km fiber length constraint.

7.1.5 Planning for Single Attachment Stations

Because SASs connect to the FDDI rings through concentrators, it is easier to add, delete, or change the location of SASs. A break in both rings is created when a DAS is unplugged from the network; if a SAS is unplugged, the concentrator it is attached to can bypass the connection (at least, the FDDI standards allow for that capability), so that no break in the ring occurs. A concentrator with an optical bypass switch can also bypass itself completely, isolating the SASs attached to it. These SASs can continue to operate among themselves as an isolated ring.

If you intend to add concentrators and SASs as they become available, plan a star-wired ring network, and locate concentrators in your network control room. This provides the greatest degree of flexibility and control of your network.

Keep in mind that, although it is possible to install a SAS (or two SASs) at a location wired to accommodate a DAS, doing so requires changing connectors, splices, and labeling at both ends of the connection. The FDDI connectors that terminate cables and plug into the FDDI stations and concentrators may be physically keyed; if so, you cannot use the same connector for DASs, SASs, and concentrators. In addition, labeling and the direction of data flow on a given fiber must change to accurately reflect the network's new configuration.

You must also decide whether to attach all SASs to the same ring (either the primary or the secondary), or whether to attach some SASs to one ring and others to the other ring. Some considerations are

- Unless a DAS or concentrator is configured with an internet protocol to route packets from one ring to the other, there is no logical connection between the two rings, and stations on different rings cannot communicate.

- If you attach all SASs to one ring and assign that ring to carry local traffic between stations, the other ring is left free to carry only DAS traffic in support of a particular application. For example, if you use the FDDI network as a backbone network connecting several other networks, the DAS–only ring may carry only internet traffic.

- If you attach SASs to both rings, a problem on one ring does not affect the SASs on the other ring.

7.1.6 Planning the Cable Route

You can route cable above a suspended ceiling, between walls, or under flooring. If your building does not lend itself to this, you can also route cable through raceways or cable troughs.

Be sure to adhere to all applicable building codes and fire regulations in choosing, routing, and installing fiber-optic cable.

WARNING: If your building uses the space above the suspended ceiling as a plenum for air exchange instead of employing air intake and return ducts, and your local laws have adopted National Electrical Code (NEC) guideline number 725-B (which addresses fire hazards), you must follow the guideline that prohibits routing PVC-jacketed cable in airways.

For locales outside North America, check your local electrical codes.

If you route PVC-jacketed cable in a plenum, you may install conduit in the plenum and route the cable through the conduit. Or, you may use cable that is specially jacketed for use in plenums.

When you plan your cable route, work with an electrical diagram of your building. Use the electrical diagram to ensure that the power required by a group of nodes and peripherals does not exceed the power provided by that ac loop.

If you are planning an FDDI network that spans multiple buildings, you must use cable designed for outdoor use for those sections of the network that connect buildings. Depending on the specific cable type and your local regulations, you may be able to run the outdoor cable all the way to the stations at either end of the interbuilding span, or you may have to splice on indoor-use cable at the points the outdoor cable enters the buildings.

As you plan the cable route, keep in mind that data in the rings flows from stations upstream to stations downstream, and that the dual FDDI rings are counter-rotating. That is, data on the secondary ring flows in the opposite direction from data on the primary ring. (Each DAS is both upstream and downstream in relation to both of its neighbors.)

NOTICE: You must decide on the direction of data flow in the rings *before* you lay the cable. When the cable installers cut a cable to terminate it, they will label the cable ends according to the direction of data flow that you've established.

7.1.7 Allotting Cable

Each DAS requires four fibers to connect to the network: Primary In, Primary Out, Secondary In, and Secondary Out. A SAS requires two fibers. (These are referred to as Slave In and Slave Out, and connect to Master Out and Master In, respectively, at the concentrator end of the connection, regardless of whether the SAS is logically on the Primary or Secondary ring). Typically, duplex cables are used indoors.

If you plan to install outdoor cable to connect two buildings in an FDDI network, the cable must contain four fibers. If *more* than two buildings are connected *serially*, only two fibers are required between any two of the buildings, but each building must connect to four fibers (see Figure 7-1 and Figure 7-2).

For interbuilding use, consider purchasing multichannel fiber-optic cable that contains more fibers (channels) than you intend to use immediately. Installing the cable can be a major undertaking, especially if you must dig trenches and bury conduit. By purchasing multichannel cable, you can increase your fiber-optic capacity with little additional labor. The presence of other channels allows you to attach other fiber-optic devices in the future.

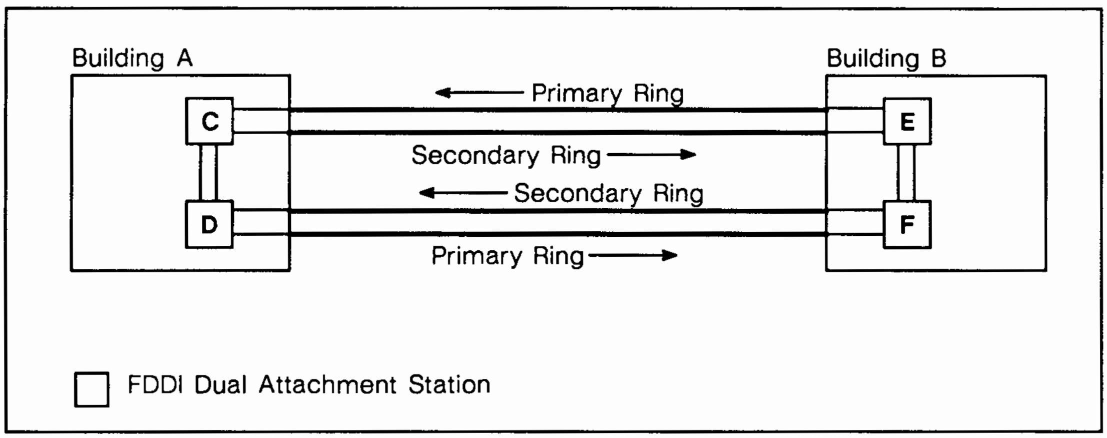


Figure 7-1. Interbuilding Cabling for Two Buildings

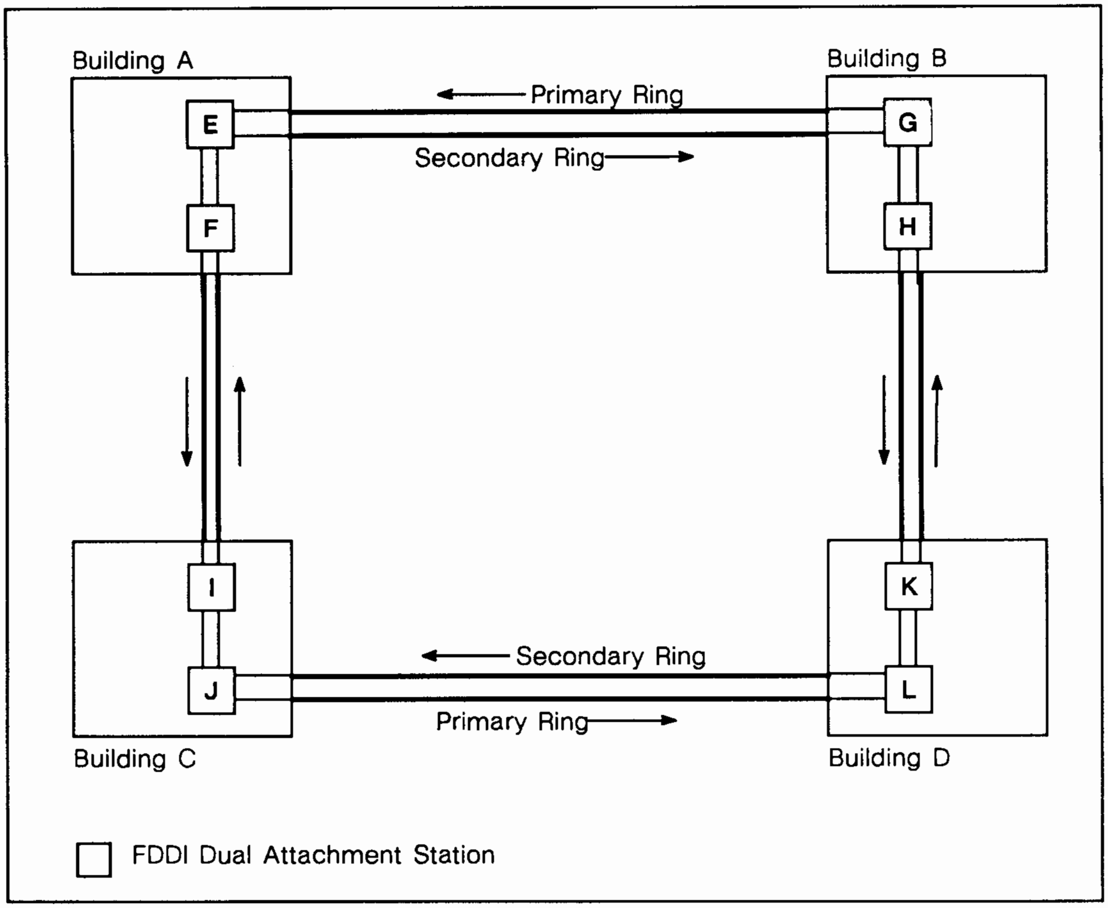


Figure 7–2. Interbuilding Cabling of Four Buildings for a Serial Configuration

If you plan to route cable in raceways, measure the distances accurately so that you will end up with enough cable at node locations to make a proper termination.

You will need approximately 30 cm (1 ft) of cable to attach FDDI connectors at each station location. You must also provide enough cable to reach from where the cable enters a room to where the station is physically located. In most cases 3 to 6 m (10 to 20 ft) is sufficient.

For a star–wired network, allow enough length on each cable to reach from where the cables enter the network control room to where the patch panel or splice cabinet is physically located. Allow an additional 30 cm (1 ft) per cable to make splices or attach fiber–optic connectors.

Because each fiber–optic splice or connector requires approximately 30 cm (1 ft) on each side of the connection, be sure to include enough extra length at every point in your network where you expect to make present or future connections. This extra length is particularly important if you use splices and your network configuration is likely to change frequently.

7.1.8 Physical Cable Considerations

All fiber–optic cable used in Apollo FDDI networks must meet the specifications given in Chapter 6. Using non–FDDI compliant cable might result in signal attenuation.

Cable manufacturers produce fiber–optic cable pieces with a *maximum length of 2 km* (6562 ft). If you need to install a length of fiber–optic cable longer than 2 km, you must attach the 2–km length to the additional length. To minimize signal loss over the link, we recommend that you splice the cable, rather than install a patch panel with connectors and bushings.

Outdoor cables can be installed in interior locations in conduit, *provided that no local or national (NEC) fire and smoke restrictions apply*. However, if you plan to route your network between buildings, you might consider purchasing a light–duty cable and splicing it to the outdoor cable at the point where the outdoor cable enters your building.

NOTICE: If you need to route fiber–optic cable in plenum space, you may need to purchase a specially jacketed cable. Check your local building code.

7.1.9 Calculating Signal Attenuation

Attenuation results from the light wave's passage through bypass switches, connectors, splices, patch panels, and the cable itself. Plan to calculate attenuation for any station–to–station link in your network that meets one or more of the following criteria:

- Uses non–FDDI compliant cable (some cables meet the requirements in Chapter 6 but are not FDDI compliant)
- Is greater than 2 km in length
- Connects through a patch panel
- Contains more than one splice
- May include one or more optically–bypassed stations

The maximum allowed attenuation between any two active stations is 11 dB. This figure includes the attenuation in the cable itself, and any signal losses incurred by splices, connectors, and bypassed stations. A bypassed Apollo FDDI station incurs a maximum loss of 2 dB. We recommend no more than three bypassed stations in a row between any two active stations (the combined loss of 6 dB in this configuration leaves only 5 dB available for loss in the cable, splices, and connectors). The loss incurred by particular types of cable, splices, and connectors varies; the manufacturers of these components should provide attenuation information. In addition, the total link loss includes the loss at the transmit Media Interface Connector (MIC), but not the loss at the receive MIC.

To calculate the cable plant loss between two adjoining stations, use the formula shown in Figure 7–3.

$$
\begin{aligned}
\text{Attenuation} = {} & \left(\begin{matrix}\text{Total Cable}\\ \text{Length (in km)}\end{matrix} \times \begin{matrix}\text{Attenuation}\\ \text{Per km}\end{matrix} \right) \\
& + \left(\begin{matrix}\text{Number of}\\ \text{Splices}\end{matrix} \times \begin{matrix}\text{Attenuation}\\ \text{Per Splice}\end{matrix} \right) \\
& + \left(\begin{matrix}\text{Number of}\\ \text{Connectors}\end{matrix} \times \begin{matrix}\text{Attenuation}\\ \text{Per Connector}\end{matrix} \right) \\
& + \left(\begin{matrix}\text{Loss at Transmit}\\ \text{MIC}\end{matrix} \right)
\end{aligned}
$$

Figure 7–3. Formula for Calculating Cable Plant Signal Attenuation

The following example shows the application of the formula to a specific station–to–station link:

5.0 dB	=	2 km fiber x 2.5 dB/km
+ 0.5 dB	=	2 splices x 0.25 dB/splice
+ 0.5 dB	=	1 connector x 0.5 dB/connector
+ 0.5 dB	=	Loss at transmit MIC

6.5 dB	=	Total Link Attenuation

NOTICE: There are *two* separate fiber–optic links between any two DASs: one carries traffic on the primary ring, the other carries traffic on the secondary ring. You must calculate the attenuation for both.

To calculate the aggregate loss between two adjoining active stations (including losses from optically bypassed stations in between), use the formula shown in Figure 7–4.

$$
\begin{aligned}
\text{Attenuation} = {} & \left(\begin{matrix}\text{Link 1}\\ \text{Attenuation}\end{matrix} + \begin{matrix}\text{Link 2}\\ \text{Attenuation}\end{matrix} + \ldots + \begin{matrix}\text{Link } n\\ \text{Attenuation}\end{matrix} \right) \\
& + \left(n-1 \times \begin{matrix}\text{2 dB Attenuation}\\ \text{Per Switch}\end{matrix} \right)
\end{aligned}
$$

Figure 7–4. Formula for Calculating Signal Attenuation Including Bypassed Stations

In Figure 7–4, **link attenuation** refers to the cable plant attenuation between a station and the station it is directly connected to. So, for example, consider a section of a network in which Station A is connected to Station B with Link 1, Station B is connected to Station C with Link 2, and Station C is connected to Station D with Link 3. Such a network section is shown in Figure 7–5.

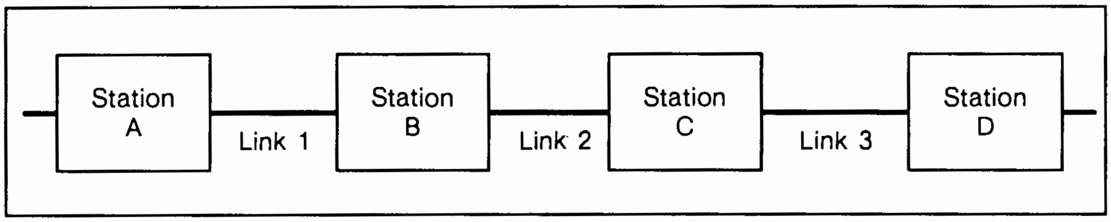


Figure 7–5. Example Network Section for Attenuation Calculation Example

In this case, you would insert three link attenuation values into the formula in Figure 7–4: the attenuation in Link 1, the attenuation in Link 2, and the attenuation in Link 3. Use the formula in Figure 7–3 to calculate the attenuation in each link. Because there is a total of three links, there are (3 – 1), or two, bypass switches in the optical path from Station A to Station D. The calculation can be done as follows:

2.5 dB	=	Calculated attenuation in Link 1
+ 0.9 dB	=	Calculated attenuation in Link 2
+ 1.3 dB	=	Calculated attenuation in Link 3
+ 4.0 dB	=	(2 bypass switches x 2 dB/switch)

8.7 dB	=	Total End–to–End Attenuation

Because the end–to–end attenuation is less than 11 dB, this bypassed configuration is acceptable.

NOTICE: There are *two* separate fiber–optic links between any two DASs: one carries traffic on the primary ring, the other carries traffic on the secondary ring. Both rings pass through the optical bypass switch in a bypassed FDDI station. You must calculate the attenuation in the optical path of *both* rings between two active stations.

Be sure your cable installers measure the *actual* attenuation for each link in the installed cable plant, and record this information on your network diagram (see Section 7.3 for information on making a network diagram). Calculations provide good estimates for planning purposes, but damaged or improperly installed fiber–optic components can suffer much greater attenuation than is specified for those components by their manufacturer.

When you know the actual attenuation for each link, you can accurately determine if a given number of bypassed stations will result in an acceptable or unacceptable level of attenuation between two active stations. As a general rule of thumb, we recommend no more than three bypassed stations in a row. This assumes relatively short link lengths, such as are encountered in typical office or laboratory sites. If you plan to bypass several stations with maximum-length station-to-station links, calculate the attenuation to ensure proper operation.

NOTICE: Apollo FDDI stations will interoperate, provided that the cable plant adheres to the specifications given in Chapter 6 and the optical signal at the end of each link meets the PMD receiver input specifications. The signal attenuation incurred by an optically bypassed Apollo FDDI station does not exceed 2 dB. Apollo makes no other express or implied claims to operate with other vendors' FDDI stations or with any particular cable plant.

7.1.10 Planning the Fiber–Optic Cable Installation

Although the procedures for installing fiber–optic and electrical cables are similar, you should make sure that your cable installers have received special training in laying fiber–optic cable.

There are several methods of installing fiber–optic cable in both indoor and outdoor locations (for example, routing through plenums, routing through conduit, direct burial, pulling through underground duct, and aerial installation using utility poles). Be sure that your installers follow the basic installation guidelines listed here, regardless of your location or the installation method they choose. Refer to Section B.3 for specific cable installation procedures.

7.2 Planning the Network Control Room for an FDDI Network

The network control room or area not only contains splice cabinets and/or patch panels for a star–wired ring, it also provides a centralized place for network record keeping and administration. In star–wired rings, the network control room is a valuable aid in network expansion and maintenance because you can connect or disconnect stations from one location. In small, serial–wired networks, you should plan for a network control area to contain at least a network diagram and a log book. Including a network control room in your network plan can simplify the process of adding new stations to your network in the future.

NOTICE: We do *not* recommend creating a star–wired ring network consisting of loops of several FDDI stations. In this configuration, if a station is unplugged from the network, the loop is broken and *none* of the stations on it can function unless the cable is spliced together. Instead, create a star–wired ring network where each station is on its own loop. You can then make all changes at the patch panel or splice cabinet in the network control room.

Plan a network control room near the center of your network. At a minimum, the control room should contain the following:

- A copy of the network diagram (See Section 7.3)
- A station to run network management and troubleshooting software
- A log book to record network problems and service calls
- A list of system administrators and service personnel and their phone numbers
- Splice cabinet(s) and/or patch panel(s) (for a star-wired network only)

With a star-wired network, plan for your system administrator to monitor the network to ensure that the network functions smoothly with a minimum of unnecessary interruptions. For network security, consider limiting access to this room by installing a locking door and giving keys to authorized personnel only.

7.3 Making an FDDI Network Layout Diagram

This section contains guidelines for creating a layout diagram for an FDDI network. It also includes a sample layout diagram. Use this information to create your own network diagrams. Not only is such a plan necessary for laying cable at the site, but network debugging is extremely difficult without proper network documentation.

Plan to post a layout diagram in the network control room, or where your system administrator and service personnel can easily consult it. A network diagram should show the following:

- A floor plan of your building.
- Office, room, and work area numbers. Use them to identify equipment locations.
- Office sizes. Use these to plan for adequate clearance for nodes and peripherals.
- The placement and length of each cable segment, including the number, type, and location of all splices or connectors in the cable segment.
- The *measured* optical attenuation in each fiber segment. This helps you determine when bypassed stations, added splices, or added connectors cause the optical attenuation to exceed the maximum.
- The location of all FDDI stations.

- The locations of future station sites. Plan your network to include any location that may contain a station in the future.
- Direction of data flow in each ring. This information aids troubleshooting by identifying upstream and downstream nodes. You can draw the primary and secondary rings in different colors to facilitate identification.

When your stations arrive, plan to add the node models, names, and IDs to this diagram. You should also plan to note the locations of nodes that contain key directories and files on the diagram. Plan to keep this document up to date as you add and move nodes and equipment. Updating the diagram should be one of your system administrator's regularly scheduled tasks.

If you plan to install interbuilding connections, note the locations of stations terminating interbuilding connections, the building entry points of the fiber–optic cable, and the fiber–optic cable layout. In addition, indicate the fiber–optic cable installation type (for example, burial or aerial).

If you plan to create an internet, note the locations of routing and gateway nodes and the layout of the transmission media that will connect the networks. If you plan to use T1 service to connect rings, you may not be able to indicate the media layout, but you should indicate the locations of T1 interface devices.

Figure 7–6 shows a sample cable layout diagram for a star–wired ring. Station locations, cable lengths, and attenuation between nodes are all noted. Future station locations are also included, marked with an "X." The diagram helps you determine the attenuation between active nodes so that you do not exceed the 11 dB maximum.

Note that some features of an FDDI network layout diagram, such as direction of data flow, are not shown in Figure 7–6. Note also that, due to space considerations, Figure 7–6 does not show distance and attenuation measurements for each duplex cable, nor does it show individual measurements for each fiber in the duplex cable.

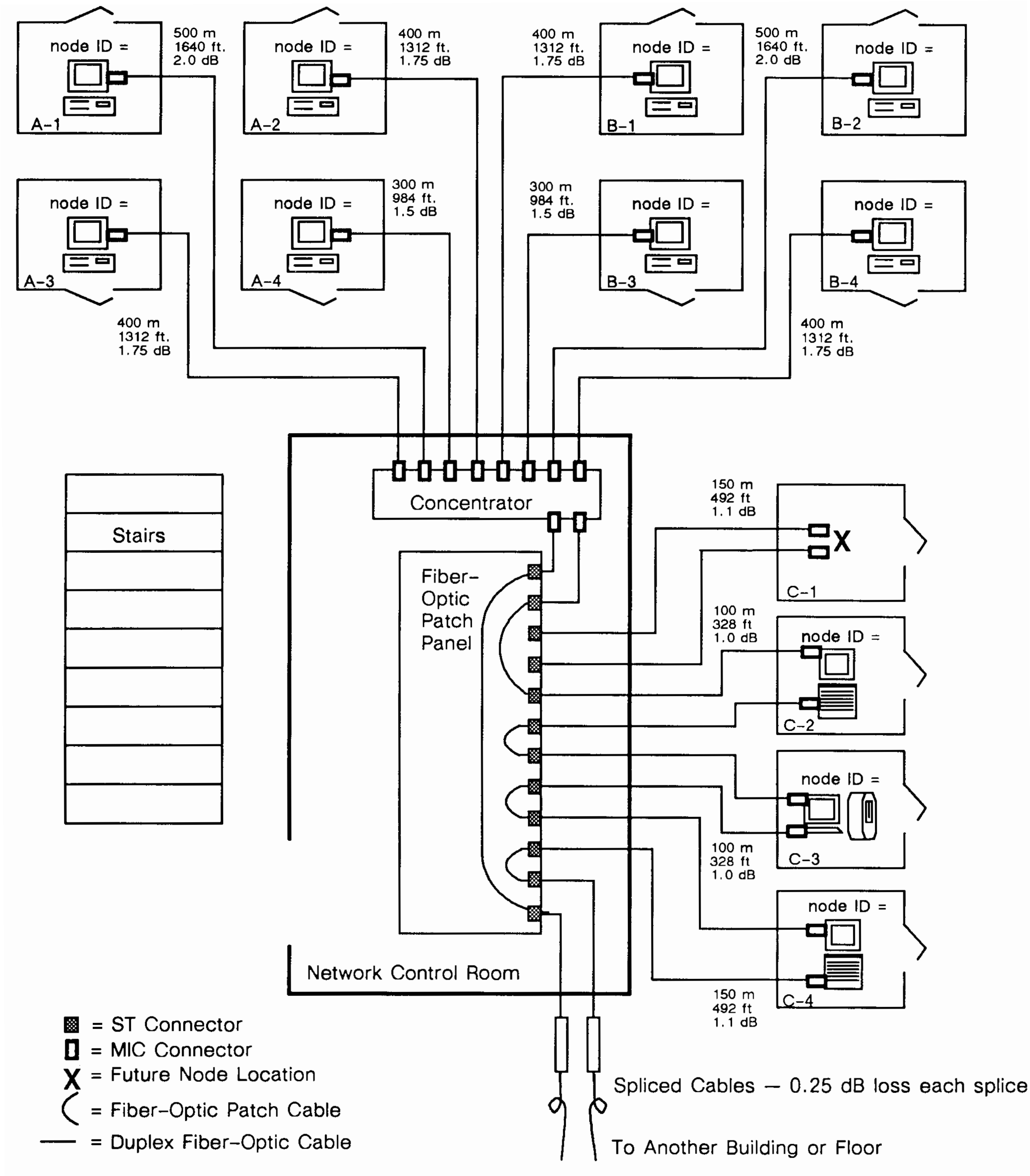


Figure 7-6. Sample FDDI Network Layout Diagram

Chapter 8

IEEE 802.3 Cable and Accessories

This chapter contains descriptions of the network cables and accessories for an IEEE 802.3 Network and discusses compatibility between devices designed to the Ethernet and IEEE 802.3 standards. The cables and accessories described here are available through the *Instant Apollo* Catalog. Refer to Appendix A for ordering information.

8.1 IEEE 802.3 and Ethernet Standards Compatibility

The Ethernet standards (Versions 1.0 and 2.0) and the IEEE 802.3 standard, contain specifications for the network media and for devices to be connected to the network media.

NOTICE: In many cases, these specifications are identical; in others, differences exist that can cause communication problems.

Devices conforming to the different standards can coexist and communicate properly over a common network medium. The overall guideline for setting up such a network is to *maintain consistency between devices that connect directly to each other*. Often, devices conform to several standards simultaneously and can connect to any other device. The documentation that arrives with each device states whether the device conforms to one, two, or all three standards.

The items that we offer through the *Instant Apollo* catalog conform to the IEEE 802.3 specifications. We guarantee the compatibility of these accessories and any node equipped to operate on an IEEE 802.3 network. To maximize network performance and integrity, accessories and devices that you purchase from other vendors for connection to Apollo nodes *must* conform to the IEEE 802.3 standard.

8.2 IEEE 802.3 Network Cables

The IEEE 802.3 standard specifies two types of coaxial cable for use in a CSMA/CD network:

- Standard thick coaxial cable (called 10Base5 Medium in the IEEE 802.3 standard)
- Thin coaxial cable (called 10Base2 Medium in the IEEE 802.3 standard)

This section briefly describes these cables and the connectors that attach to them. For physical and electrical specifications, consult the IEEE 802.3 specification.

Coaxial cable is vulnerable to electromagnetic interference, such as lightning. For links between buildings, we recommend that you attach lightning suppression devices to the cable, use coaxial cable rated for exterior installation, or use fiber-optic cable (see Section 8.5 for information about repeaters that connect to fiber-optic cable).

Refer to Chapter 9 for more information about planning the IEEE 802.3 network cable layout.

8.2.1 IEEE 802.3 Standard Cable, Connectors, and Terminators

There are two types of cable segments in a standard IEEE 802.3 network:

Coaxial Cable Segment A standard coaxial cable with a maximum length of 500 m (1640 ft), to which nodes and other devices are connected. Standard coaxial cable segments are terminated at each end with N-series terminators.

Link Segment A point-to-point link terminating in a repeater set. A link segment may be a length of standard coaxial cable or fiber-optic cable, whose maximum **propagation delay** does not exceed 2570 ns. *No nodes can be attached to a link segment.*

The standard IEEE 802.3 network cable (also called thick cable) is a 50-ohm, baseband coaxial cable. As shown in Figure 8-1, standard IEEE 802.3 cable is marked at 2.5-m (8.2-ft) intervals to guide transceiver placement (see Chapter 9 for more information about transceiver placement).

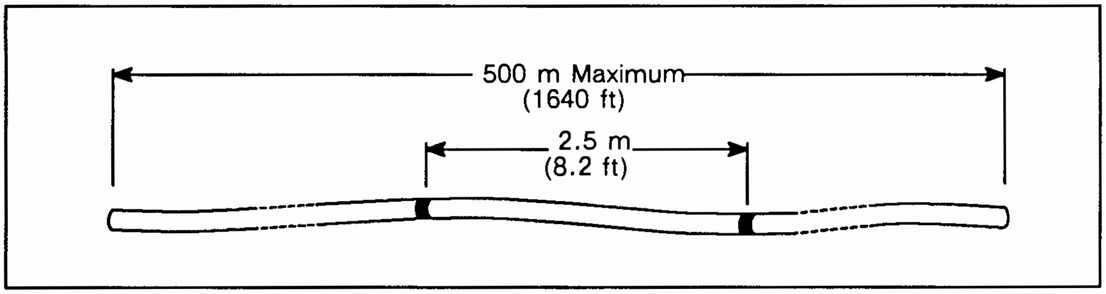


Figure 8-1. Standard IEEE 802.3 Cable

Although many types of coaxial cable closely match the specifications, you *must* use cable that conforms to the the IEEE 802.3 specifications *exactly* or you risk diminished network performance. You can purchase approved PVC- or TEFLON-jacketed standard IEEE 802.3 cable through the *Instant Apollo* catalog (see Appendix A for ordering information).

You must use N-series connectors and terminators with the standard IEEE 802.3 cable. You can attach N-series connectors to standard cable for terminating in transceivers (described in Section 8.4, "Cable Taps and Tapping Tools"). You can use N-series feedthrough adapters (also called barrel connectors) to connect standard cable sections to form a longer segment (up to the maximum length of 500 m or 1840 ft), or partition a standard cable segment into sections for network troubleshooting purposes. You can also attach N-series terminators to cable ends to eliminate signal reflections. Figure 8-2 illustrates these N-series accessories.

NOTICE: You *must* terminate each cable segment, or the network will not function.

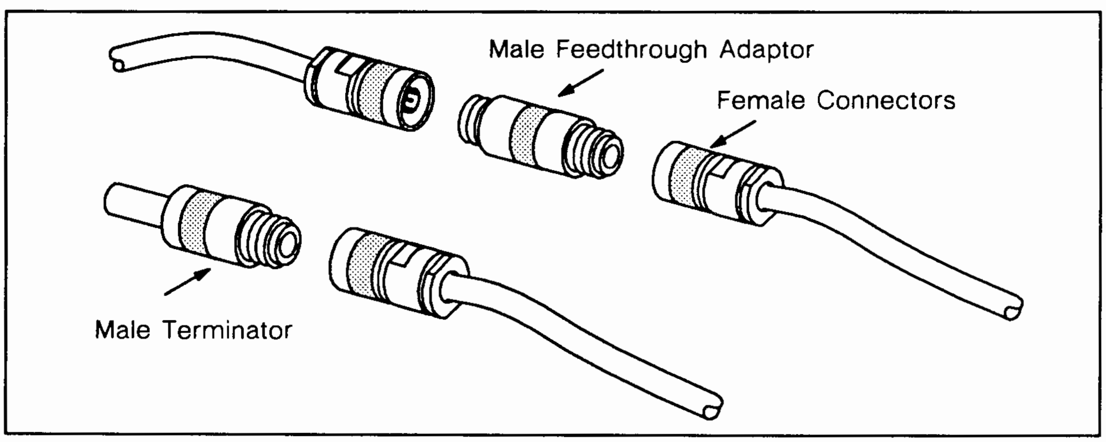


Figure 8-2. N-Series Cable Connectors and Terminators

N-series cable accessories are available through the *Instant Apollo* catalog (see Appendix A for ordering information).

8.2.2 IEEE 802.3 Thin Cable, Connectors, and Terminators

IEEE 802.3 thin cable (also called Thin Ethernet, Thin-net, or Cheapernet) is also specified in the IEEE 802.3 standard. The specification calls for a coaxial cable that is smaller in diameter than standard cable, shorter in length, and consequently lighter in weight and easier to handle. The maximum thin cable distance is 185 m and the minimum distance between nodes is .5 m. In addition, thin cable connects directly to the nodes; you do *not* need transceivers or transceiver cables external to the node. In the case of T-connectors, they must connect directly to the node, not through a length of cable. See Table 9-1 for more specifications. Figure 8-3 shows a thin cable segment.

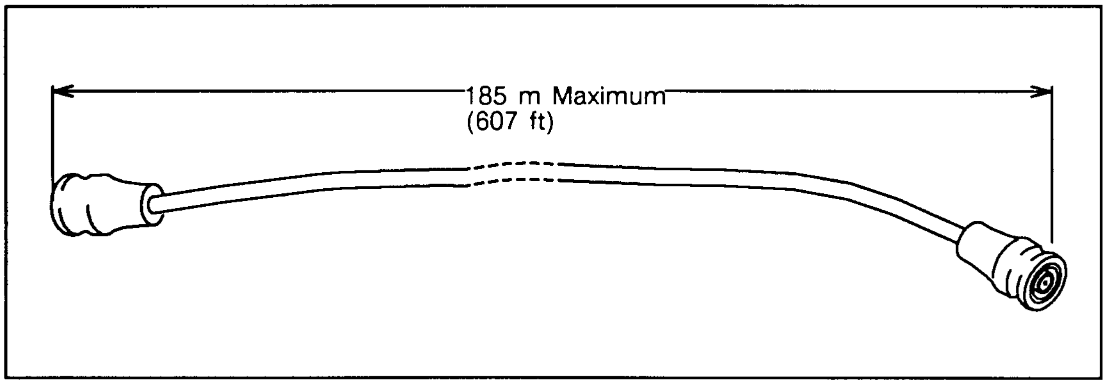


Figure 8-3. Thin Cable Segment

Currently, thin cable is available from the *Instant Apollo* catalog in four preterminated lengths: 5, 10, 20, and 50 m (18, 32, 85, and 184 ft). It is also available in 1000 ft reels and custom lengths. The cables are available with either PVC or TEFLON jacketing (see Appendix A for ordering information).

Thin cable attaches to nodes through BNC adapters called T-connectors. Figure 8-4 shows a T-connector and terminator.

You can use BNC-to-N-series adapters to connect a thin cable segment to a transceiver or other device equipped with N-series connectors. BNC transceiver taps are also available to connect a thin cable segment to a transceiver on the standard cable backbone (see Section 8.4, "Cable Taps and Tapping Tools" for more information).

T-connectors and terminators are available through the *Instant Apollo* catalog (see Appendix A for ordering information).

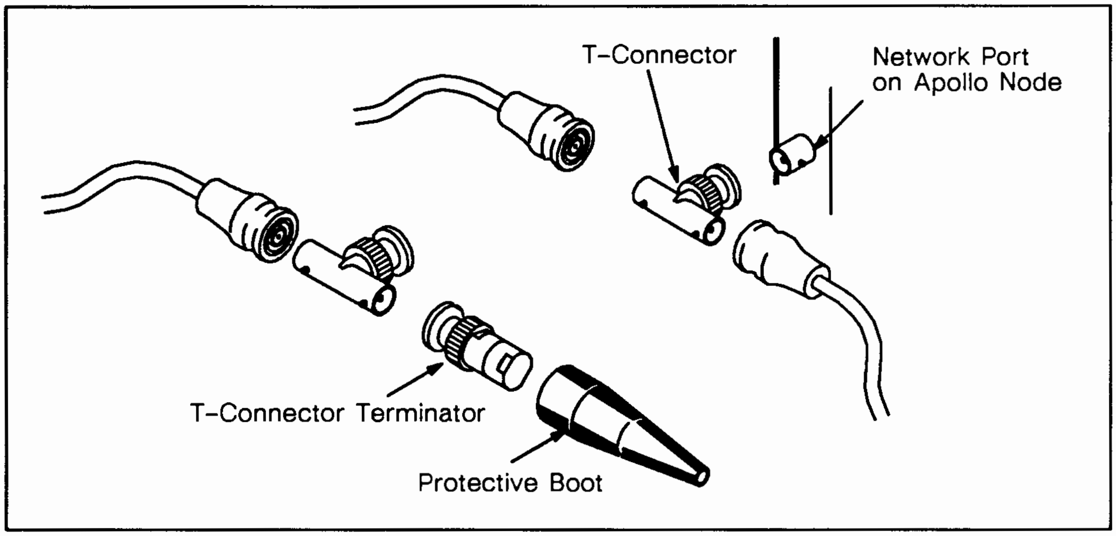


Figure 8-4. Thin Cable T-Connector and Terminator

8.3 Transceivers and Transceiver Cables

Transceivers are devices that transmit and receive signals. In an IEEE 802.3 network, transceivers are called MAUs (Medium Attachment Units). Do not confuse this with the IEEE 802.5 Multistation Access Unit, a wiring concentrator for the IBM Token Ring network. In a standard cable network, every node and network device attaches to the network through a transceiver. In addition to transmitting and receiving, transceivers

- Function as connection points on the network cable for nodes and other devices
- Provide power to drive the data signals over the network cable
- Detect signal collisions on the network cable
- Sense a busy or idle transmission path and convey that information to the attached node or device

Transceivers designed according to the IEEE 802.3 specifications provide an additional service, known as a **heartbeat test**. Following each data packet transmission the transceiver sends a short test signal (called **SQE** or Signal Quality Error) to the attached node or device. This signal indicates that the transceiver is operating properly. In the absence of the expected test signal, the node or device can record a transmission error.

NOTICE: Network controllers that conform to the Ethernet Version 1.0 specification *cannot* recognize the SQE as a test signal and interpret the SQE as a data packet collision on the network. To avoid error problems, ensure that you attach IEEE 802.3-compatible transceivers to Apollo nodes.

Also, transceivers designed according to IEEE 802.3 specifications include a feature known as **jabber control.** Jabber is a continuous transmission of erroneous bits from a faulty transceiver, which could potentially disable the network with a permanent collision. The transceiver jabber control feature prevents this from happening.

In an IEEE 802.3 Thin cabling system, transceivers do not exist as separate network attachment devices; nodes connect directly to the cable, and the transceiver functions are handled by components on the node's IEEE 802.3 network controller. This feature is called an **on-board** transceiver.

8.3.1 Transceiver Types

Two types of transceivers are available for use in an IEEE 802.3 network:

Single-Device Transceiver Connects a single node, repeater, or multiport transceiver to standard IEEE 802.3 network cable.

Multiport Transceiver Connects up to eight nodes or devices to a standard cable backbone. In a **cascaded** configuration, a multiport transceiver can connect up to 84 nodes. Some multiport transceivers can replace the backbone network to form a star-wired LAN.

Figure 8-5 and Figure 8-6 illustrate the two transceiver types. See Chapter 9 for an illustration of a multiport transceiver in cascaded and star-wired configurations.

Some single-device transceivers possess Light Emitting Diodes (LEDs) to indicate their various functions. These transceivers are particularly helpful in troubleshooting because you can tell at a glance whether the transceiver is receiving power, detecting collisions, or malfunctioning.

We offer several types of IEEE 802.3-compatible single-device transceivers and one type of multiport transceiver through the *Instant Apollo* catalog (see Appendix A for ordering information).

Refer to Chapter 9 for detailed information about placing transceivers in your IEEE 802.3 network.

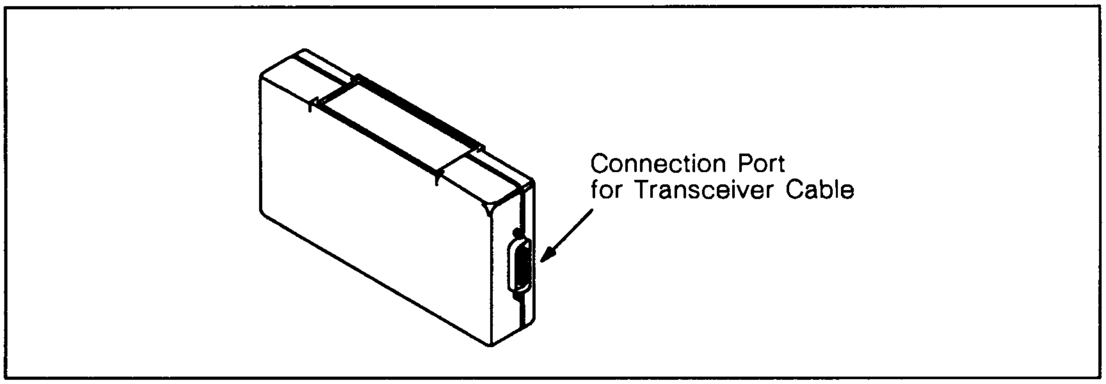


Figure 8–5. Single–Device Transceiver

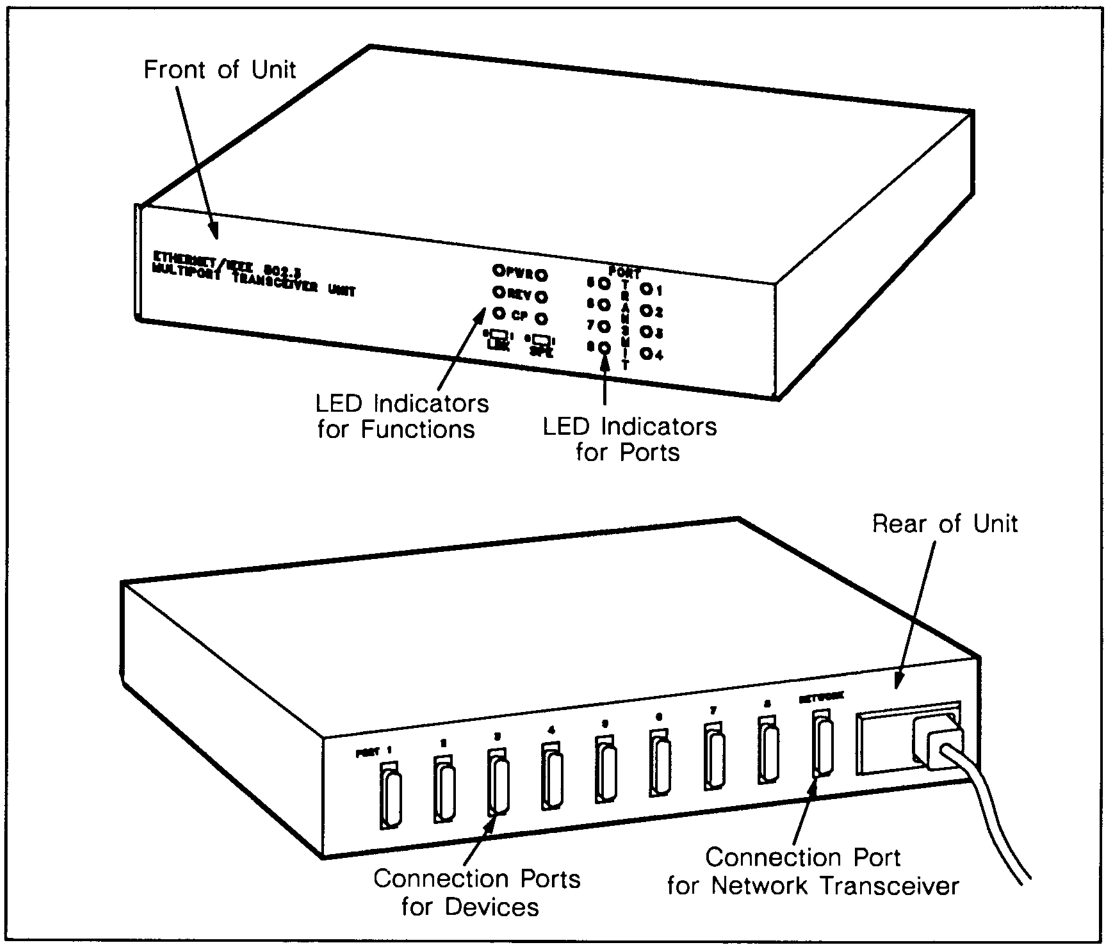


Figure 8–6. Multiport Transceiver

8.3.2 Transceiver Cables

Transceivers connect to nodes through special cables. In IEEE 802.3 networks, these cables are also called **AUI** (Attachment Unit Interface) cables. According to the IEEE 802.3 specifications, a transceiver cable is equipped with 15-pin connectors (one male, one female) and can be up to 50 m (184 ft) in length. Figure 8-7 shows a transceiver cable.

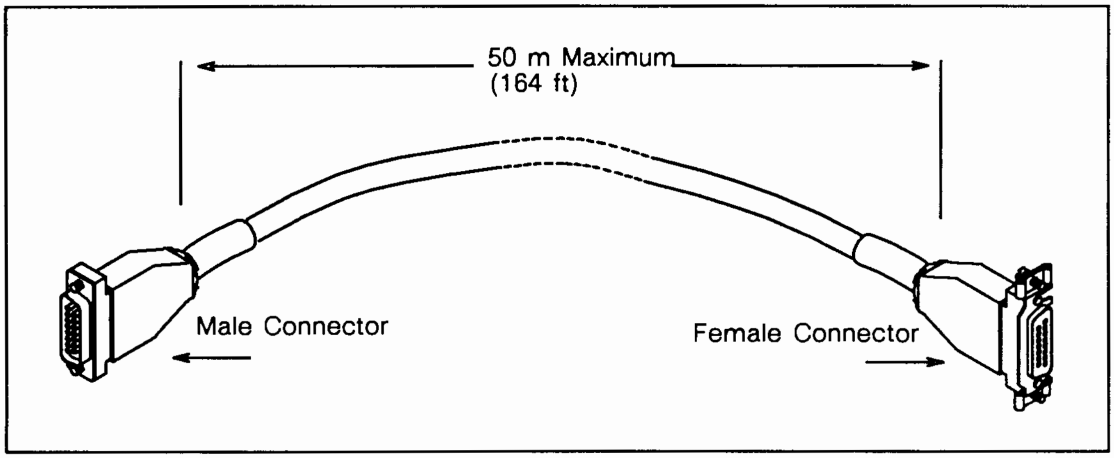


Figure 8-7. Transceiver Cable

Transceiver cables that conform to the IEEE 802.3 specification differ from Ethernet Versions 1.0 and 2.0 transceiver cables in their pin assignments and connector shielding. For network-wide operation and electrical integrity, you *must* maintain consistency in the overall node-to-transceiver compatibility. In other words, do *not* connect a transceiver cable that conforms to one standard to a transceiver or network device that conforms to a different standard.

NOTICE: To ensure network-wide operation and electrical integrity, connect *only* IEEE 802.3-compatible transceiver cables to Apollo nodes.

We currently offer IEEE 802.3 transceiver cables in 5, 10, and 20 m lengths (18, 32, and 85 ft) through the *Instant Apollo* catalog. You can connect these cables together to form a length up to 50 m (184 ft). The cables are available with either PVC or TEFLON jacketing (see Appendix A for ordering information).

8.4 Cable Taps and Tapping Tools

Single-unit transceivers connect to standard IEEE 802.3 cable through cable taps that connect easily to the transceiver. Three types of cable taps are commonly available:

N-Series Tap Connects to N-series connectors attached to the cable. This type of tap, sometimes called an **intrusive** tap, requires disconnecting the N-series feedthrough adapter, causing a momentary interruption in network service.

NonIntrusive Tap Penetrates the network cable and contacts the center conductor. This type of tap does *not* require cutting the cable, so you can add transceivers to the network *without* interrupting network operation. This type of tap is sometimes called a vampire or piercing tap.

BNC Tap Connects a Thin cable segment to a transceiver on the standard cable backbone.

Figure 8-8 illustrates N-series and nonintrusive taps.

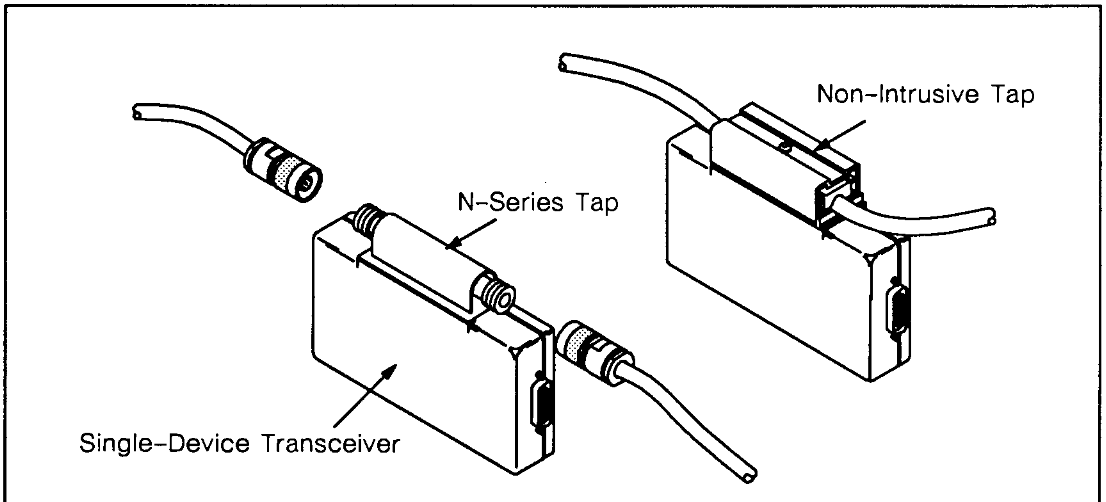


Figure 8-8. N-Series Transceiver Tap

A coring tool and nut driver simplify nonintrusive tap installation. These tools and both N-series and nonintrusive taps are available through the *Instant Apollo* catalog. Transceivers that are available through the catalog arrive with nonintrusive taps unless you order N-series taps. You can order the tools separately (see Appendix A for transceiver and tapping tool ordering information).

8.5 Repeaters

Repeaters extend the IEEE 802.3 network span and offer network topology options beyond a single maximum-length segment of 500 m (1840 ft) for standard coaxial cable, and 185 m (807 ft) for Thin cable. In addition to performing transmit and receive functions, repeaters

- Restore signal amplitude, waveform, and timing applied to normal data and collision signals
- Connect segments to form a single, larger network
- Provide network status information, such as the receive and collision activity on each segment, through LEDs
- Increase network reliability by providing **automatic segmenting**. This feature automatically partitions network segments when it detects errors such as excessive collisions.

Note that repeaters do *not* provide the functions of routing and gateway nodes, and cannot be used to join two networks into an internet. (See Chapters 2, 11 and 12 for information about internets.)

Repeaters are equipped with 15-pin connectors for attachment to standard cable through transceivers, or BNC connectors for connection to Thin cable. Some repeaters contain the transceiver hardware and thus eliminate the need for a separate transceiver.

NOTICE: You *must* disable the heartbeat test on the transceiver that attaches the repeater to the network; otherwise, the repeater regenerates the test signal and passes it on to the next segment where it can be interpreted as a collision signal. Follow the transceiver manufacturer's instructions for disabling the heartbeat test.

Several types of repeaters allow you to extend an IEEE 802.3 network:

Local Repeater — Connects two standard cable segments or a standard and Thin cable segment.

Multiport Repeater — Connects up to eight segments in a star-wired configuration. Currently, multiport repeaters exist for Thin cabling systems only.

Optical Repeater — Connects standard cable segments through fiber-optic cable channels. In some cases, a multiport repeater provides connection points for fiber-optic cable.

Fiber–optic cable is not susceptible to electromagnetic interference, and allows for greater distances between nodes than coaxial cable. These characteristics make fiber–optic cable ideal for interbuilding cable runs. The following figures show local, multiport, and optical repeaters.

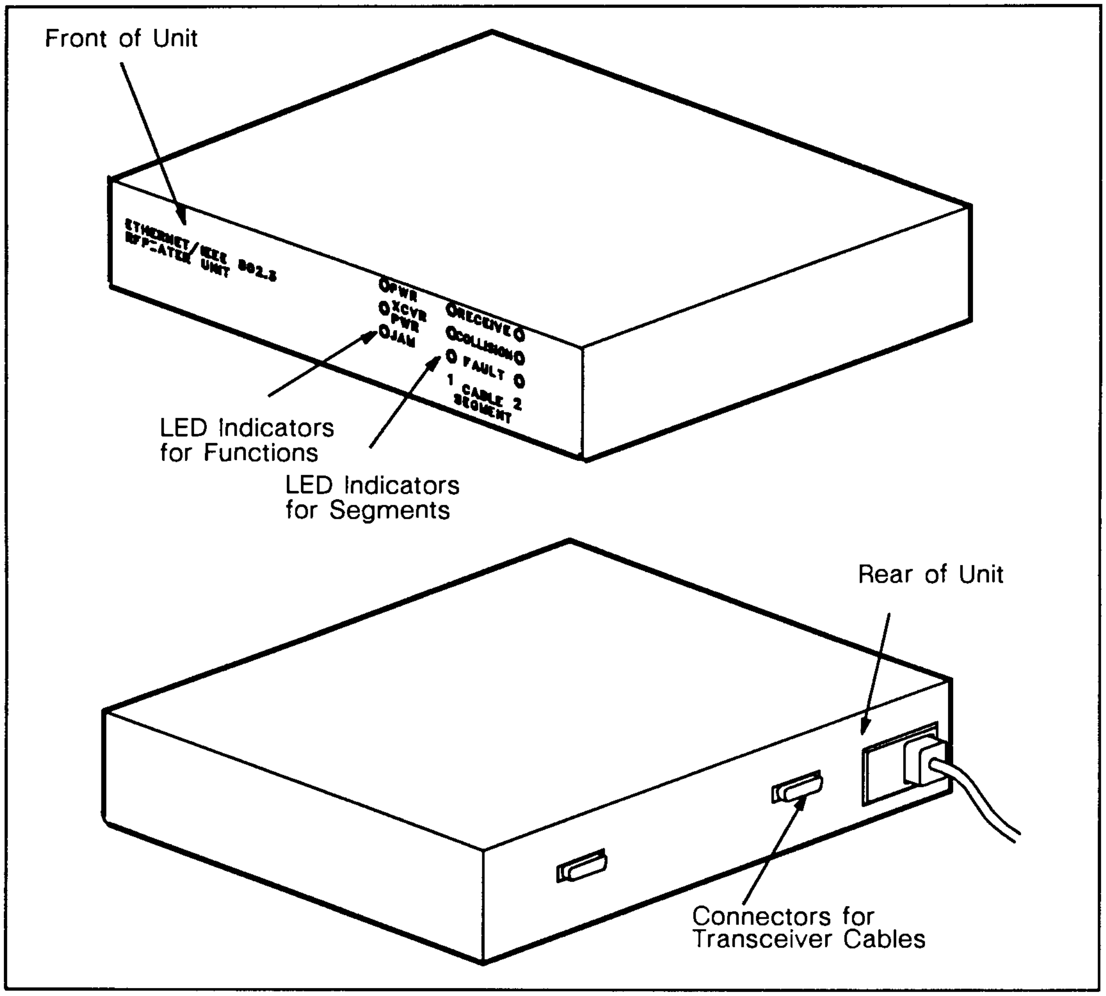


Figure 8–9. Local Repeater

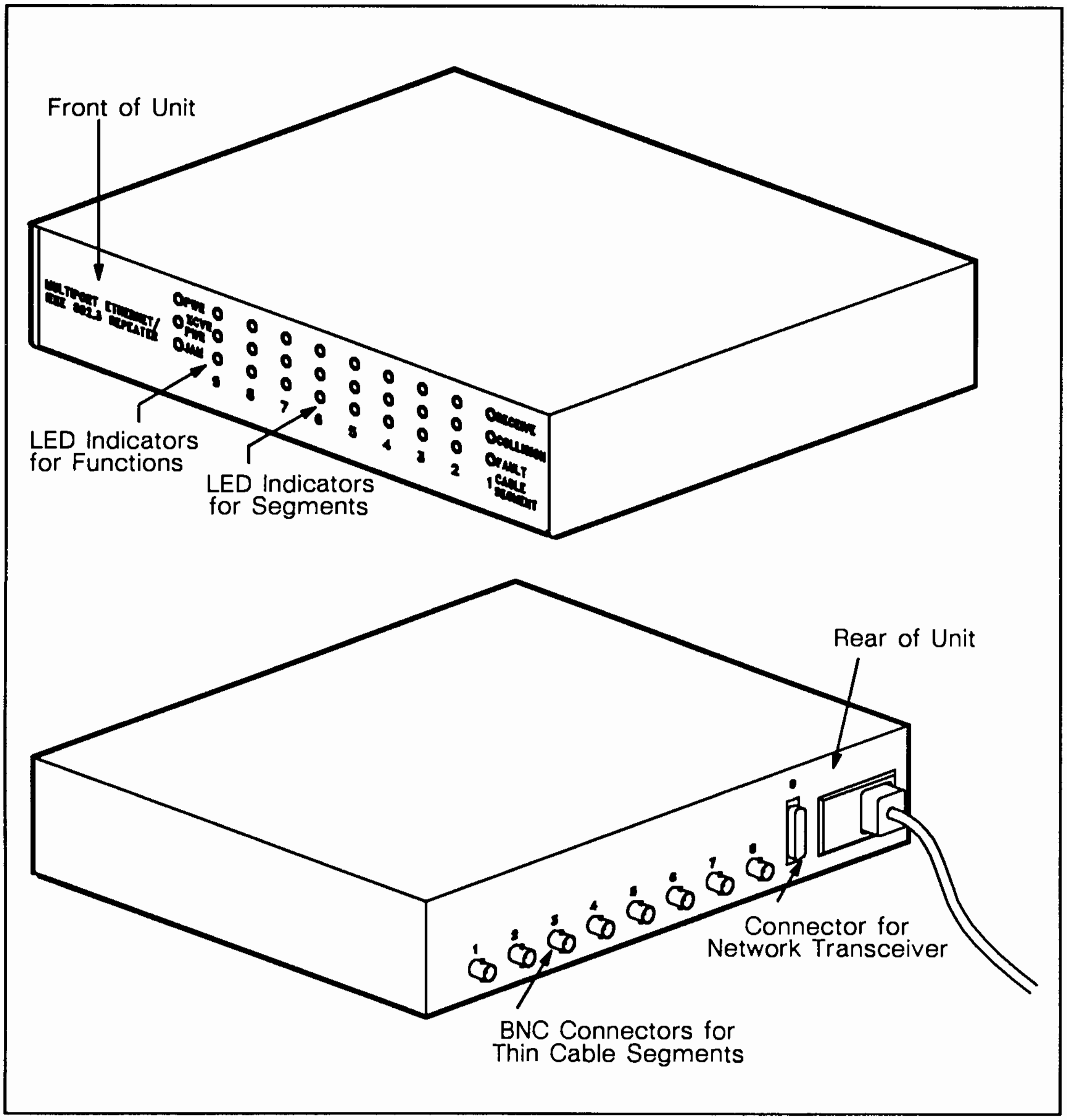


Figure 8–10. Thin Cable Multiport Repeater

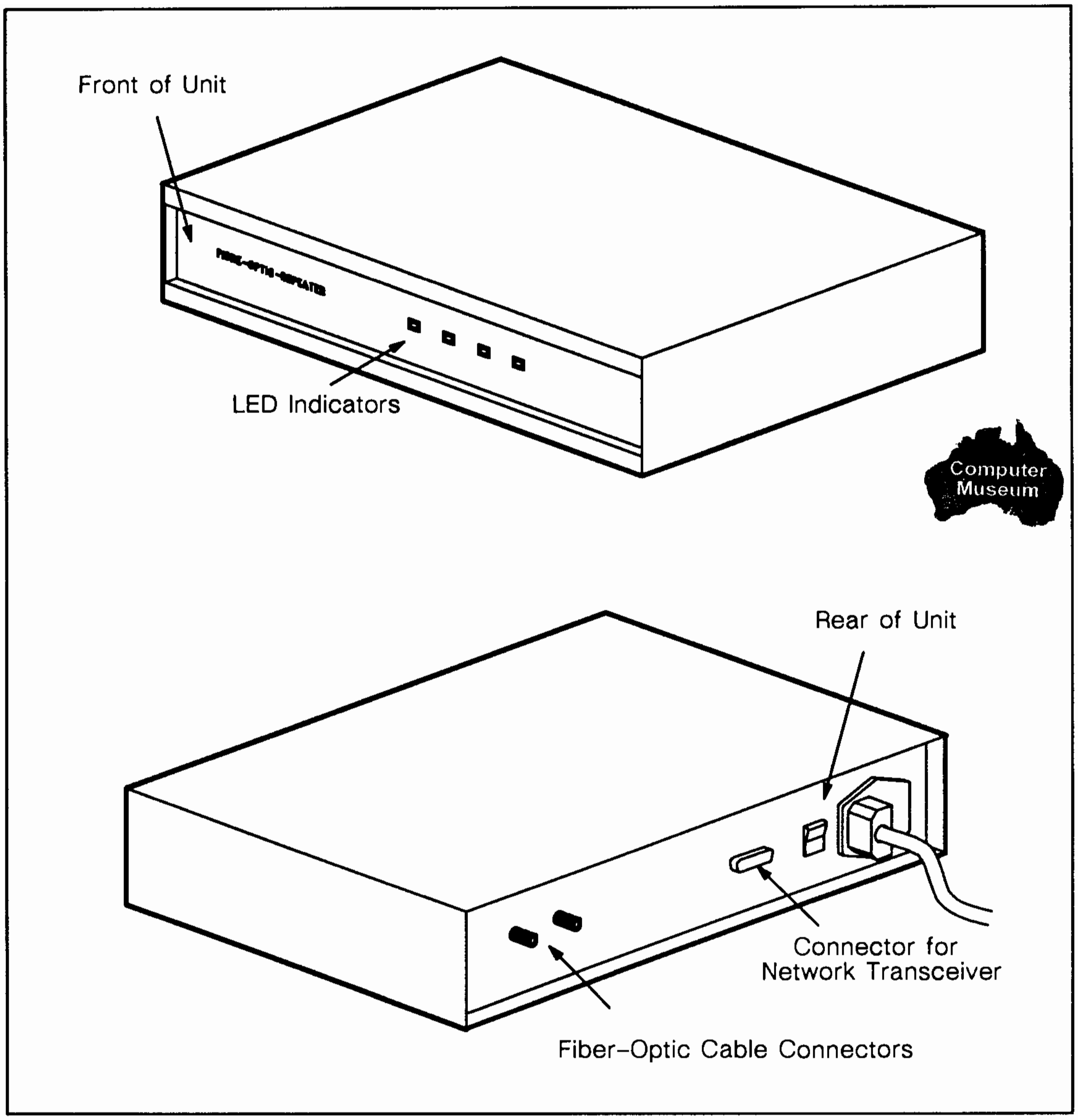


Figure 8-11. Optical Repeater

We offer all three types of repeaters through the *Instant Apollo* catalog (see Appendix A for ordering information).

See Chapter 9 for detailed information about planning an IEEE 802.3 network layout with repeaters.

Chapter 9

Planning an IEEE 802.3 Network Layout

The ANSI/IEEE 802.3 standard specifies detailed cable and equipment layout rules. This chapter summarizes these rules and provides guidelines for planning the following basic IEEE 802.3 network configurations:

- Standard IEEE 802.3 cable configurations
- Thin IEEE 802.3 cable configurations
- HP EtherTwist cable configurations

There are many networking devices on the market that comply with the IEEE 802.3 standard. These devices make possible many more configurations than we discuss here. For IEEE 802.3 network configuration details pertaining to a specific device, refer to the device manufacturer's documentation.

NOTICE: Failure to adhere to the IEEE 802.3 rules could result in an unreliable or inoperable network.

If you wish to connect IEEE 802.3 networks in a Domain or TCP/IP internet, use these guidelines to lay out the individual IEEE 802.3 networks. Then see Chapters 11 and 12 for internet hardware and planning information.

We recommend that you use this chapter to begin a layout plan and then consult a professional cable installer to design the final network layout.

While you plan your network, have on hand a copy of *Domain Hardware Site Planning Specifications*. Refer to it for node and peripheral environmental requirements, including electrical requirements, service clearance requirements, and dimensions.

9.1 Standard Cable Layout Considerations

This section summarizes the network configuration rules that apply to an IEEE 802.3 network configuration using standard coaxial cable. For Thin cable layout guidelines, see Section 9.2.

9.1.1 Standard Cable Segments

Standard coaxial cable segments form the network backbone, which contains transceivers (connected to nodes), repeaters, and other devices. Coaxial cable link segments are usually used to extend the network over large distances within a single building; fiber-optic link segments are usually used to extend the network between buildings.

NOTICE: To determine the maximum length of the link segment, your cable installer must use a **TDR** (Time Domain Reflectometer) or other device to measure the propagation delay of the transmission medium. For example, a 50-micron fiber-optic cable link segment can be about 500 m (1640 ft) in length.

In a single IEEE 802.3 network, the maximum transmission path between any two nodes cannot exceed *five* segments *in a series*. The total number of segments equals the number of coaxial cable segments plus the number of link segments. Figure 9-1 illustrates cable segments connected in series.

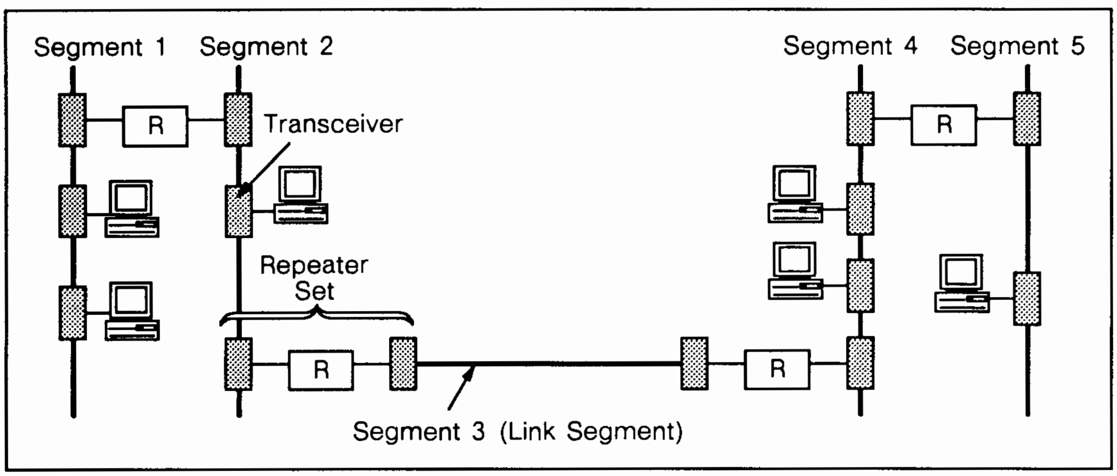


Figure 9-1. Standard Cable and Link Segments Connected in Series

Note that if there are *no* link segments in the transmission path, there can be a maximum of *three* coaxial cable segments. (The IEEE 802.3 standard states that this limitation is due to current repeater technology. Check with your repeater vendor about their configuration guidelines.)

To achieve a greater network span, you can use a double link segment. This is equivalent to two link segments joined in series, *without* a repeater set. Figure 9–2 shows such a configuration. (Other segment configurations are described in Section 9.1.2.)

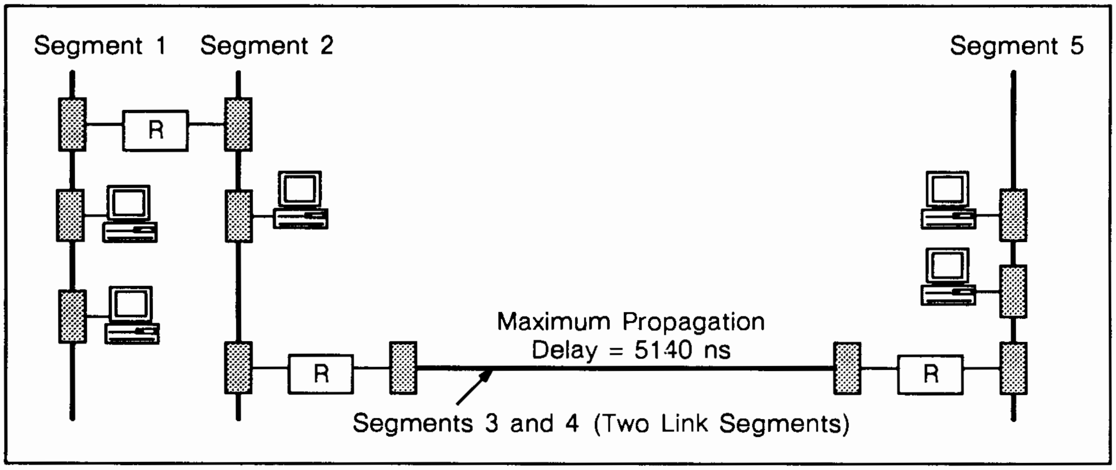


Figure 9–2. A Double Link Segment

By using a multiport transceiver or repeater, you can connect more than five segments in a **fan–out** or **cascaded** configuration (see Sections 9.1.6 and 9.1.7).

9.1.2 Maximum Transmission Path in a Single IEEE 802.3 Network

The rule that governs how you connect equipment in an IEEE 802.3 network is based on the *maximum transmission path between any two nodes in a single network*. The maximum transmission path takes into account the signal propagation delay imposed by the network cables, transceivers, repeaters, and the nodes themselves. This delay factor permits a maximum transmission path of

- Five segments
- Four repeater sets
- Two DTEs/MAUs (two nodes *or* two transceivers)

A *repeater set* consists of the repeater unit itself, plus the two transceivers and transceiver cables that connect the repeater unit to the networks. A **DTE** (Data Terminal Equipment) refers to a node that contains transceiver hardware. (Nodes that connect to Thin cable are so equipped.) A **MAU** (Medium Attachment Unit) refers to a transceiver.

A further condition states that no more than three of the segments in the transmission path can contain nodes. Therefore, the maximum transmission path contains two link segments and three coaxial cable segments. Figure 9–3 illustrates a network with maximum transmission paths.

In Figure 9–3, a data packet traveling from Node A to Node B travels through

- Five segments (Coax Segments 1, 2, and 4, plus Link Segments 1 and 3)
- Four repeater sets (R1, R2, R7, and R8)
- Two transceivers (the two attached to Node A and Node B)

A data packet traveling from Node A to Node C travels through

- Four segments (Coax Segments 1, 2, and 5, plus Link Segment 1)
- Three Repeater sets (R1, R2, and R9)
- Two nodes/transceivers (one transceiver attached to Node A and one on-board transceiver in Node C)

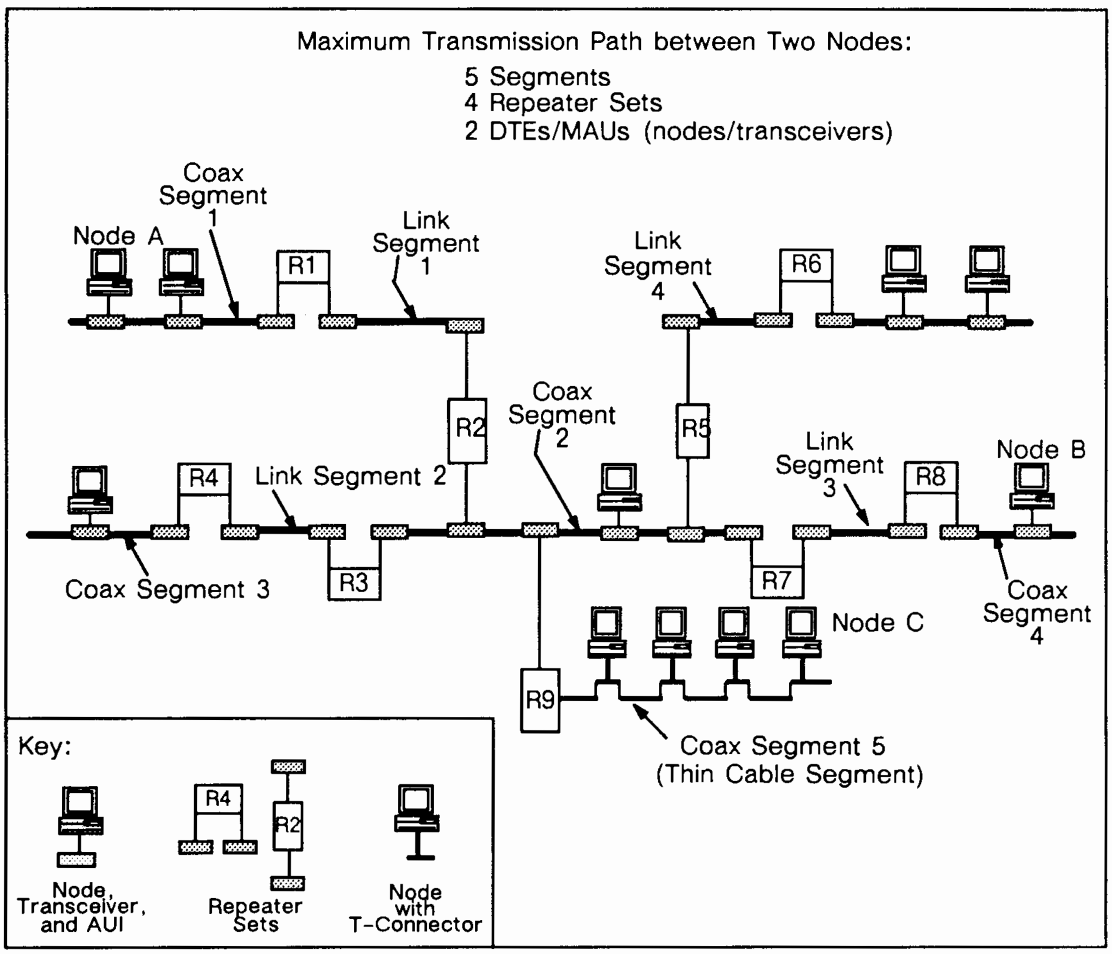


Figure 9–3. A Large IEEE 802.3 Network Illustrating Maximum Transmission Paths

9.1.3 Number of Nodes

A standard IEEE 802.3 cabling system can accept a maximum of 100 transceivers per segment. This maximum allows you to connect up to 100 nodes to a single segment using single-device transceivers, or hundreds of nodes using multiport transceivers.

The maximum number of nodes that a single IEEE 802.3 network (perhaps containing several segments) can contain is 1024. However, a network of this size may suffer performance problems during periods of heavy data traffic. A more common IEEE 802.3 network configuration (on a single network) contains less than one hundred nodes.

By using multiport transceivers and repeaters, you can add many nodes to your network while using only a single transceiver (see Sections 9.1.6 and 9.1.7).

9.1.4 Distance between Nodes

Standard IEEE 802.3 cable contains marker bands at 2.5-m (8.2-ft) intervals. These bands indicate the minimum spacing between transceivers and control the relative spacing of transceivers to reduce interference from signal reflections. The maximum spacing between nodes on a single segment is 500 m (1640 ft), the maximum segment length. *Always locate transceivers on marker bands*; in this way, you can avoid an incorrect placement.

The transceiver cable maximum length (50 m or 165 ft) gives you flexibility in placing nodes in work areas.

9.1.5 Cable Sectioning

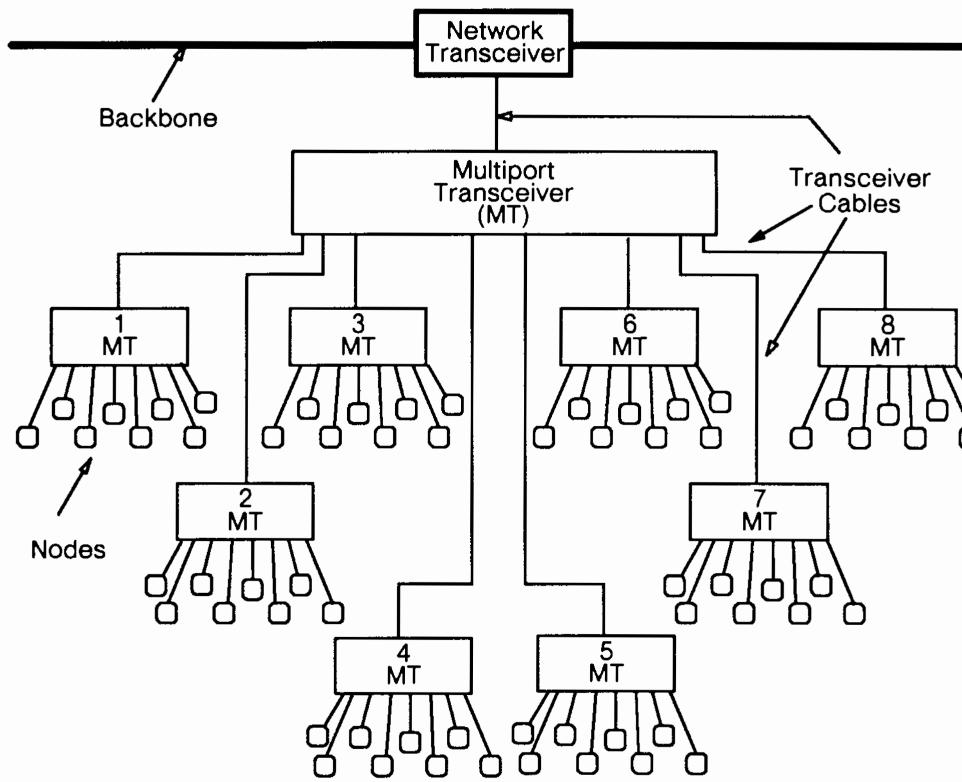
A maximum-length standard segment can consist of individual cable sections joined with N-series connectors and feedthrough adapters. The IEEE 802.3 specification recommends that these cable sections come from the *same manufacturer and lot*. If the individual sections do *not* come from the same manufacturer and lot, the slight differences in impedance levels of the various cables can interfere with signaling. To address this problem, the IEEE 802.3 specification states that each section must be one of the following standard lengths: 23.4, 70.2, or 117 m (76.7, 230.3, 383.8 ft).*

9.1.6 Multiport Transceiver Location

In standard cable networks, multiport transceivers eliminate the need to coil the backbone cable in areas with high concentrations of nodes. These transceivers attach to the backbone through a single-device transceiver and can support up to seven other devices. In a cascaded configuration, one multiport transceiver can support eight other multiport transceiv-

*These lengths have been calculated to reduce the possibility of signal reflections building up on the cable. See *ANSI/IEEE Standard 802.3 for Local Area Networks*.

ers, with each supporting eight nodes. Figure 9–4 illustrates eight multiport transceivers connecting 64 nodes in a cascaded or fan–out configuration.



Each transceiver has nine ports for connecting devices.
One port is dedicated to connecting to the network transceiver.

Figure 9–4. Multiport Transceiver in a Cascaded Configuration

In Figure 9–4, the single–device transceiver connected to the backbone cable counts as *one* of the 100 allowable transceivers on the segment, even though it supports 64 devices.

On close examination, you can see that the configuration in Figure 9–4 violates the maximum number of nodes and transceivers in the data path between two nodes. Between two nodes in different branches of the tree structure, data must travel through three transceivers; between a node in the tree and a node on the backbone cable, data must travel through four transceivers. However, this configuration is functional because it observes the maximum signal propagation delay time. In every case, the transceiver cable length is *less* than the 50–m (165–ft) maximum to compensate for delay imposed by the additional transceivers in the transmission path. The multiport transceiver manufacturer provides specific instructions for calculating the transceiver cable lengths.

A multiport transceiver can also function as a stand-alone, star-wired network, as shown in Figure 9-5.

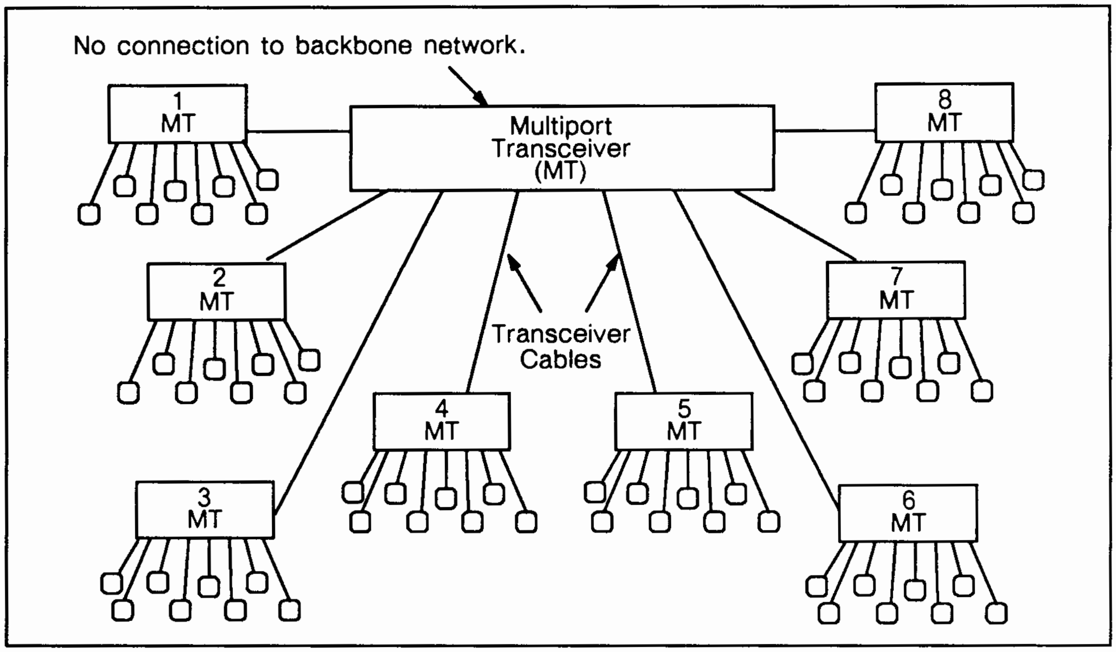


Figure 9-5. Multiport Transceiver in a Stand-Alone, Star-Wired Network

Although a single multiport transceiver can support many nodes, such a configuration introduces a *single point of failure* that can interrupt communication to and between the attached nodes. To minimize the impact of a multiport transceiver failure, plan to connect important resources to the same multiport transceivers as the nodes that are most dependent upon those resources. For example, connect diskless nodes to the same multiport transceiver as their partner nodes.

Ask your sales or service representative about ordering multiport transceivers through the *Instant Apollo* catalog.

9.1.7 Repeater Location

In a standard cable system, each local repeater you use can add a segment up to 500 m (1640 ft) long to your network. (A fiber-optic link segment can be longer. See Section 9.1.1.) Because repeaters attach to the network through transceivers, you can locate repeaters at 2.5 m (8.2 ft) intervals from nodes and connect them to transceiver cables up to 50 m (164 ft) long. (Repeaters that contain an on-board transceiver must also follow these placement guidelines.)

The transceivers that connect repeaters count toward the maximum of 100 transceivers on a coaxial cable segment. Therefore, when you connect segments with a repeater, each segment can contain up to 99 other devices. Figure 9–6 shows a network composed of two segments connected with a repeater.

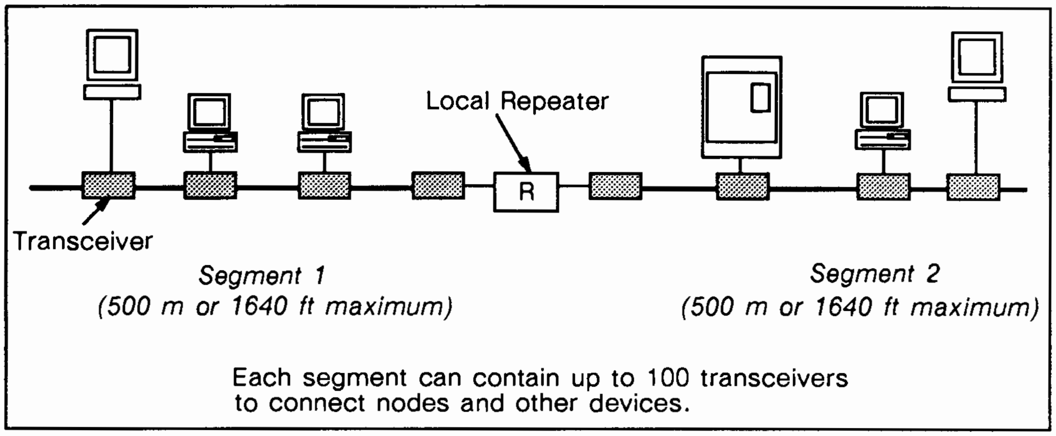


Figure 9–6. Two Segments Connected with a Local Repeater

To add multiple segments to your network, you can connect up to eight local repeaters to a multiport transceiver. Figure 9–7 shows a network composed of eight segments connected with local repeaters and a multiport transceiver. In this configuration, the local repeaters count as a single device on the segments to which they are attached. Each segment can be up to 500 m (1640 ft) in length and contain up to 99 other devices.

In Figure 9–7, the maximum transmission path between any two nodes consists of two segments, one repeater set, and two transceivers. For example, the transmission path between Nodes A and B consists of the following:

- Two segments (Segments 1 and 5)
- One repeater set (the multiport repeater unit, plus the two transceivers and transceiver cables that connect it to Segments 1 and 8)
- Two transceivers (the transceivers attached to Nodes A and B)

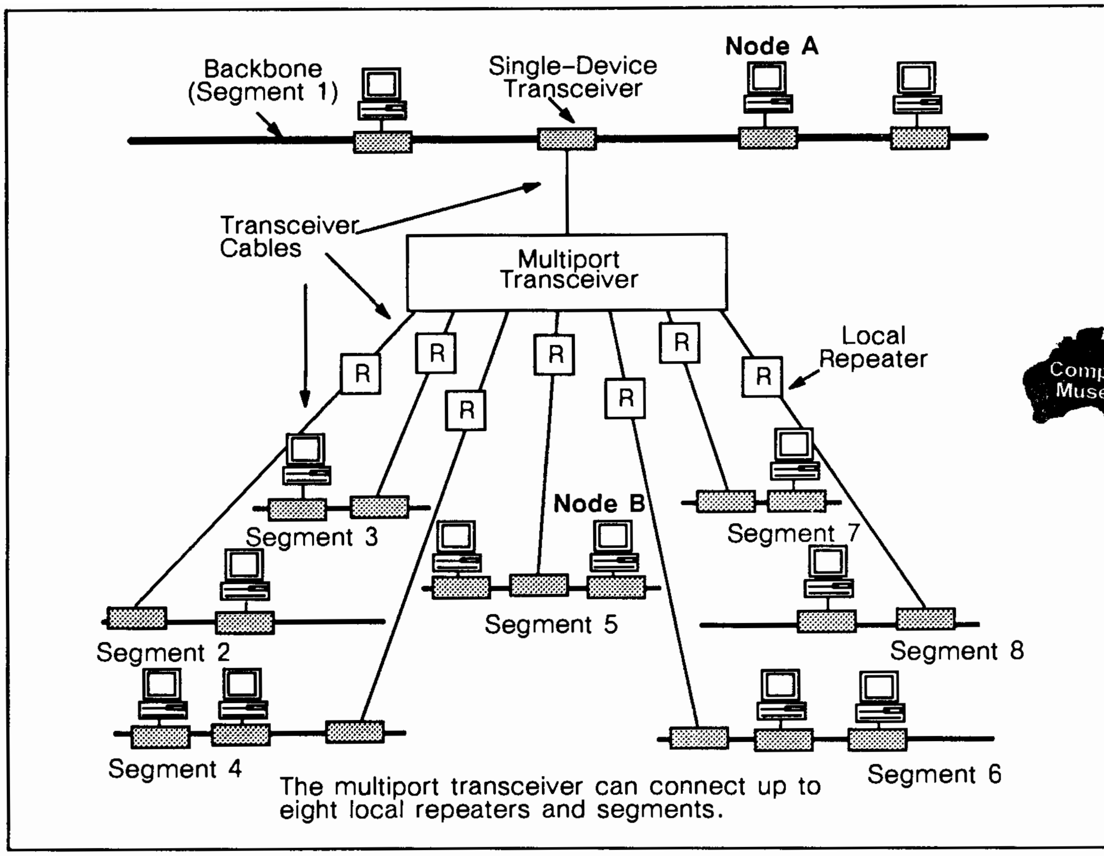


Figure 9–7. Multiple Local Repeaters Connected with a Multiport Transceiver

9.2 Thin Cable Layout Considerations

The IEEE 802.3 thin cabling system evolved to provide a low cost, easy to install network for personal computers. Although thin cabling systems are compatible with standard systems, most of the configuration rules for standard IEEE 802.3 cabling systems do not apply. The principal differences concern the coaxial cable type, segment lengths, and the absence of transceivers as separate network devices. Table 9–1 summarizes the differences between standard and thin cabling systems.

Table 9–1. Standard/Thin IEEE 802.3 Cabling System Comparison

Parameter	Standard 802.3 Cabling System	Thin 802.3 Cabling System
Data Rate	10 Mbps	10 Mbps
Segment Length	500 m (1640 ft)	185 m (600 ft)
Network Span	2438 m (8000 ft)	914 m (3000 ft)
Nodes per Segment	100	30
Nodes per Network	1024	1024
Node Spacing	2.5 m (8.2 ft) intervals on cable marker bands	0.5 m (1.6 ft) minimum separation
Coaxial Cable	1.0 cm (0.4 in) diameter 50 ohms	0.6 cm (0.25 in) diameter 50 ohms
Connectors	N–Series	BNC
Transceiver Interface	0.9 cm (0.38 in) diameter multiway cable with 15 pin, D–series connectors; length up to 50 m (165 ft)	Transceiver on controller; cable connects directly to node through BNC T–connector.
Installation Requirements	Complex tapping procedure; for best results, contact a professional cable installer	User–installable system

If you are unfamiliar with any of the terms in the table, refer to the standard cable descriptions in the previous section.

9.2.1 Maximum Transmission Path in a Single Thin Cable Network

The same maximum transmission path applies to both standard and thin cabling systems. However, determining the maximum transmission path can be difficult when your network contains multiport repeaters. See Figure 9–8 an illustration of how to count thin cable segments to determine the maximum transmission path.

9.2.2 Distance between Nodes

Unlike standard cable, thin cable contains no cable marker bands to guide you in placing nodes. The minimum cable length between nodes is 0.5 m (1.6 ft); the maximum length is 185 m (607 ft).

9.2.3 Thin Cable Repeater Configurations

Multiport repeaters for thin cable networks allow you to connect large numbers of nodes to a centralized control unit. Thin cable repeaters also provide for convenient attachment of a thin cabling system to a standard cable backbone. Figure 9–8 illustrates a Thin cable repeater configuration.

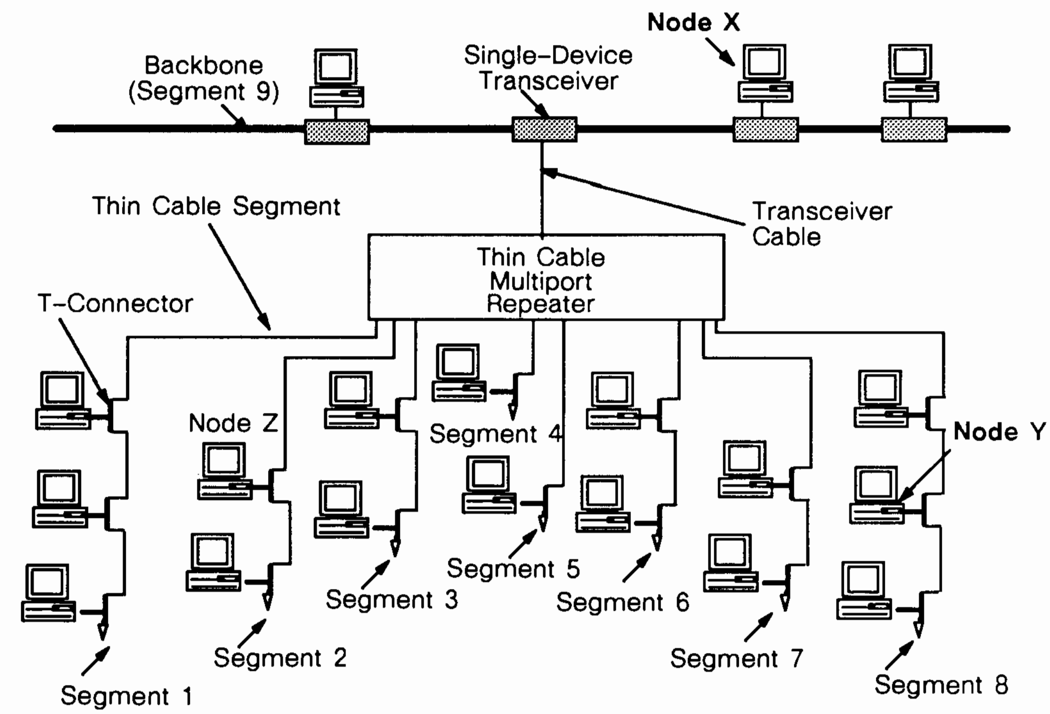


Figure 9–8. Thin Cable Repeater Configurations

In Figure 9–8, the repeater attaches to the backbone through a transceiver equipped with either a BNC tap or a BNC–to–N–series adapter (see Section 8.4 for information about these accessories).

The maximum transmission path between any two nodes in Figure 9–8 consists of two segments, one repeater set, and two nodes/transceivers. For example, the transmission path between Node X and Node Y consists of

- Two segments (Segments 8 and 9)
- One repeater set (the multiport repeater unit and the transceiver that connects it to the backbone)
- Two nodes and transceivers (the transceiver attached to Node X, plus Node Y itself)

The transmission path between Nodes Y and Z consists of

- Two segments (Segments 2 and 8)
- One repeater (the multiport repeater unit; no transceivers connected in this case)
- Two nodes (Nodes Y plus Node Z)

9.3 HP EtherTwist Cable Layout Considerations

An HP EtherTwist network is a local area network that runs over twisted pair cabling, the type used by telephones. EtherTwist networks are designed to be compatible with Type 10BaseT and IEEE 802.3 (Ethernet) networks and operate at 10 megabits per second.

9.3.1 Number of Nodes

Because EtherTwist is designed to be compatible with the IEEE 802.3 and 10BaseT standards, you cannot have more than 1024 nodes on a single network. For performance reasons, we recommend that a network contain no more than 500 nodes.

9.3.2 Cable Segment Length

In EtherTwist networks, the maximum recommended single segment of twisted pair cable is 100 m (328 ft). However, cable length may be extended beyond 100 m through the use of some types of twisted pair cable. The loss restriction is 11.5 dB and should not be exceeded. See your HP representative for specific cable lengths that will not exceed the allowable loss.

9.3.3 EtherTwist Hub Ports

Nodes in an EtherTwist network are connected in a star topology, joined at a central **hub**. (a hub is a multiport repeater). The EtherTwist hub has four ports:

- RS232
- AUI
- Thin coax
- 50–pin

The RS232 and AUI use 25–pin and 15–pin connectors, respectively. The 50–pin connector connects to either a 50–pin right angle or straight out connector or to an HP 28685A modular adapter. The modular adapter is a pocket–sized connect that fits onto the 50–pin port. You can attach 12 nodes (12 twisted pair cables with connectors) to the hub.

Hubs can also be connectd to a backbone, which can be either coaxial or fiber–optic cable.

- ThinLAN coaxial cable connects to the EtherTwist hub using the ThinLAN port.
- ThickLAN coaxial cable uses a ThickMAU to connect to an EtherTwist hub.
- Fiber–optic cable uses a fiber–optic MAU to connect to an EtherTwist hub.

9.3.4 EtherTwist Configuration Guidelines

The following restrictions apply when planning for EtherTwist networks:

- In a network where there is no bridge, there can be no more than four repeaters between any two nodes.
- In a network where there is no bridge, there can be no more than three segments of coaxial cable between any two nodes.
- There can be no more than eight bridges between any two nodes.
- There can be no more than 1024 nodes on a 10 Mbit network.
- There can be no more than 11.5dB loss per segment of twisted pair cable.
- There can be no more than four cross–connect blocks.

For more information on planning and configuring an EtherTwist network, refer to *HP AdvanceNet HPLAN Configuration Guide for IEEE 802.3 and Ethernet Networks.*

9.4 Planning a Network Control Room for IEEE 802.3 Networks

The network control room/area can contain repeaters and other networking devices, and function as a network management center. A system administrator assigned to the control room can monitor the devices to determine network status and identify problems.

NOTICE: Plan to install an extra transceiver on each network segment so that you can connect a diagnostic device to any segment. Figure 9–9 illustrates a control room with this feature.

Plan for the network control room to contain the following:

- A copy of the network layout diagram (see Section 9.5)
- Multiport repeaters and transceivers, and routing/gateway nodes (for internets)
- A log book to record network problems and service calls
- A list of system administrators and service personnel and their phone numbers
- Network monitoring and analyzing devices

For network security, consider limiting access to this room by installing a locking door and giving keys to system administrators only.

9.5 Making an IEEE 802.3 Network Layout Diagram

This section contains guidelines for creating a diagram for an IEEE 802.3 network. We've also included a sample layout diagram. Use this information to create your own network diagrams. Not only is such a plan necessary for laying cable at the site, but network debugging is extremely difficult without proper network documentation.

Use a building blueprint for your diagram. Plan to post a diagram in the network control room, or where your system administrator and service personnel can easily consult it. A network diagram should show the following:

- Equipment locations, including transceivers, nodes, and repeaters.
- The cable markers between each node (on standard cable only). This will help you determine free transceiver locations.
- Locations of future nodes. Plan your network to include any location that may contain a node in the future.
- Segment lengths and numbers. Also, identify repeaters by the segment numbers they connect.
- Office, room, and work area numbers. You will use them to identify equipment locations.
- Office sizes. You use these to plan for adequate clearance for nodes and peripherals.

When your nodes arrive, plan to add the node models, names, and IDs to this diagram. You should also plan to note the locations of key directories and files on the diagram. Plan to keep this document up to date as you add and move nodes and equipment. Updating the diagram should be one of your system administrator's weekly tasks.

If you plan to install a fiber-optic link, note the locations of the fiber-optic repeaters and the building entry points of the fiber-optic cable. In addition, indicate the fiber-optic cable installation type (for example, burial or aerial).

If you plan to create a Domain or TCP/IP internet, note the locations of the routing and gateway nodes and the layout of the transmission media that will connect the networks (see Chapters 11 and 12 for more information on internets).

Figure 9-9 shows a sample cable layout diagram for a IEEE 802.3 network.

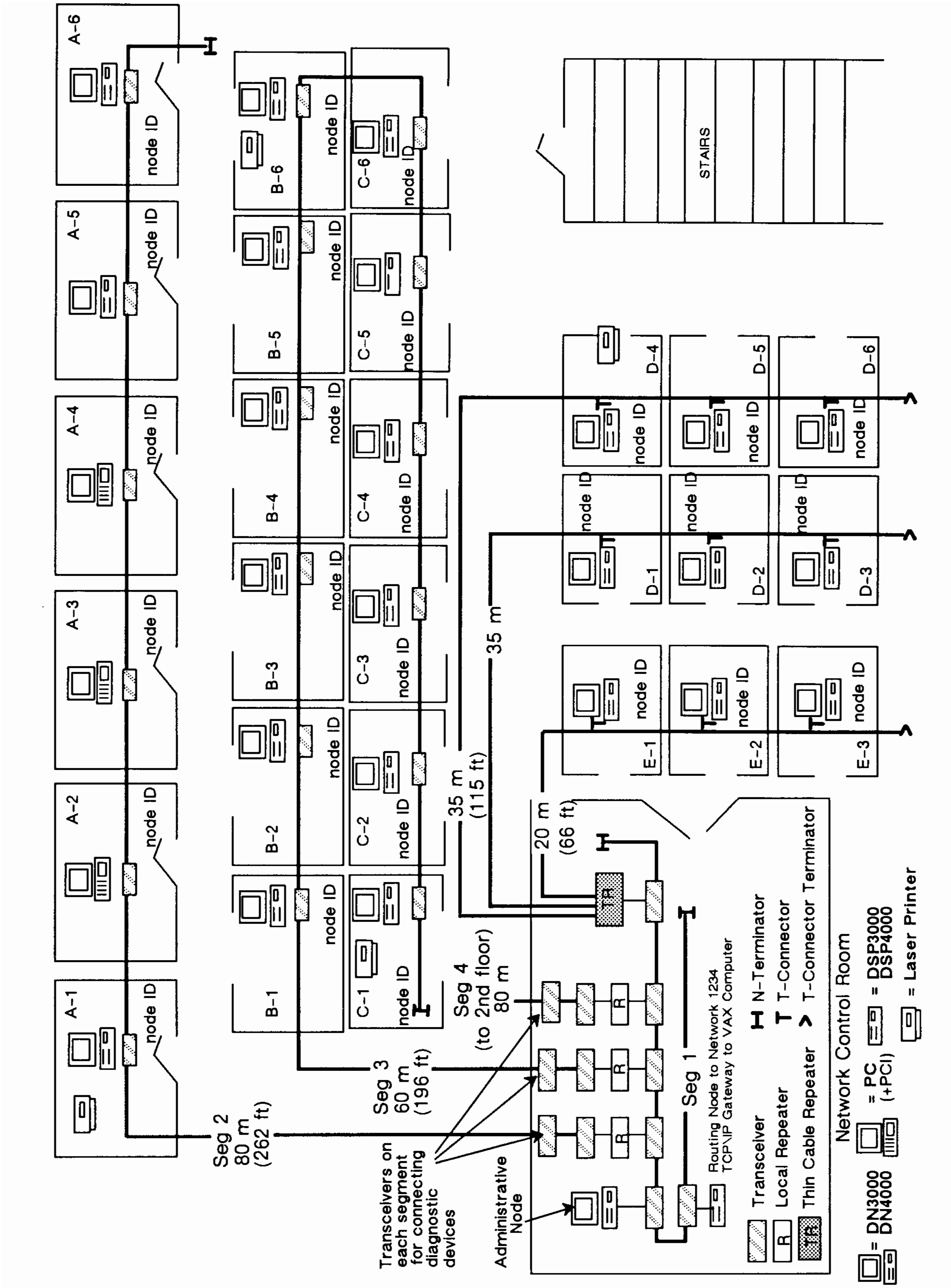


Figure 9–9. Sample IEEE 802.3 Network Layout Diagram

Chapter 10

IEEE 802.5 Cabling and Planning Information

This chapter contains descriptions of the cables and accessories for an IEEE 802.5 network that are available through the *Instant Apollo* catalog. See Appendix A for information to help you order this equipment.

If you are interested in running an Apollo Token Ring network across the IBM shielded twisted pair cabling system, see Chapter 5, "Planning for ATR on Shielded Twisted Pair Cable."

10.1 IEEE 802.5 Network Controller–AT

The IEEE 802.5 Network Controller-AT is fully compliant with the IEEE 802.5 standard and can connect to commercially available 802.5 wiring concentrators (or **Multistation Access Units, MAUs**) as well as to the wiring concentrators available from Apollo. Up to two IEEE 802.5 Network Controller-ATs can be installed in Apollo AT compatible bus-based workstations (with the exception of Series 10000 workstations). To order this communications board, consult your Apollo salesperson.

See Appendix C for a listing of other network controllers currently available for Apollo nodes. (See the Preface of this document for a complete list of related manuals and order numbers.)

10.2 Software Release 10.1

Software Release 10.1 or later is required for nodes that operate on an IEEE 802.5 network. The driver software for the IEEE 802.5 Network Controller–AT is included as part ot the standard operating system as of SR10.1, and the new network type is reflected in the output of network management commands. In addition, changes have been made to allow the TCP/IP software to recognize the new physical interface type defined for 802.5 networks.

When you use network management shell commands such as **lcnet**, **rtsvc**, **rtstat**, **lcnode**, and **netstat**, connections to an 802.5 network are indicated by "RING802.5_AT" in the output display. For example:

```
$  rtsvc

    Controller          Net ID      Service offered
==================    ========    =================
RING802.5_AT            29C50     Internet routing
RING                        0     Port not open
ETH802.3_AT             29CE0     Internet routing
FDDI                    29E20     Internet routing

$
```

See *Managing Domain/OS and Domain Routing in an Internet* for more information about using these commands.

To allow the TCP/IP software to support IEEE 802.5 network connections, a new physical network interface, **itr(0** or **1)**, has been defined at SR10.1. Physical network interfaces are defined and enabled with the **ifconfig** command within the node's **/etc/rc.local** startup file. For example:

```
/etc/ifconfig itr0 <ip-address>
```

For more information about using TCP/IP in internets, see *Configuring and Managing TCP/IP*.

10.3 IEEE 802.5 Multistation Access Units

Apollo offers four-lobe and eight-lobe Multistation Access Units, or MAUs. MAUs attach user devices to an 802.5 network. See Appendix A for ordering information.

10.3.1 Eight-Lobe MAU

This MAU unit provides access to an IEEE 802.5 network for up to eight devices. Cables from the attaching units are plugged directly into the access unit. The unit can be interconnected to other access units to form larger networks.

The unit may be installed in a standard 19-inch rack or in a component housing for wall or table-top installation. No external power source is required for this MAU. This unit can operate in an environment with a temperature range of 10° to 40°C (50° to 105°F) with relative humidity ranging from 8% to 80%. The wet bulb temperature should not exceed 26.7°C (80°F).

The access unit comes with a cable bracket to help you organize and identify the cables attached to a rack-mounted MAU.

10.3.2 Four-Lobe MAU

Up to four devices may be connected to this access unit by means of Type 3 unshielded cable and modular telephone connectors. Attaching devices must be equipped with Type 3 line filters. Up to 18 of these access units can be connected together to allow a maximum of 72 devices on a network.

This access unit is a powered design, requiring a wall-mounted power supply. The power supply available through Apollo provides power for up to five access units.

The access unit comes with a mounting bracket, allowing the unit to be mounted on any flat surface. The bracket attaches to a standard junction box with machine screws.

This MAU provides adequate noise margin when using Type 3 cable if the distance from any station (user device) to the last access unit in the network is 500 feet or less. This distance can be the total length of any combination of trunk cables and lobe cables. This limitation does not refer to the distance between stations, which can be as long as 1000 feet if only one access unit is installed.

10.3.3 Four-Lobe MAU Power Supply

This external, wall-mounted, plug-in power supply is required for operation of the four-lobe MAU offered by Apollo. This power supply changes the voltage received from a wall outlet from 110V to 15V.

Up to five MAUs can be powered by this device. Power is passed from one unit to the next by a trunk cable. If only two access units are connected together, the power supply can be connected to either unit. If more than two MAUs are connected, the power supply must be connected to the unit closest to the center of the span of units.

10.4 IEEE 802.5 Connectors and Cables

Apollo provides one type of connector, two types of connector cables, and a modular data cable.

10.4.1 Universal Data Connector

Figure 10–1 shows the Universal Data Connector. This connector provides an IBM Data Connector on one end of the connector and an RJ11 modular receptacle on the other end. The **Universal Data Connector** allows access to the IBM Cabling System using standard modular data and telephone company products.

The Universal Data Connector can be used in the back of IBM distribution panels. Terminate Type 3 cable in the wiring closet with RJ11 modular connectors and then plug the RJ11 modular connectors into the modular receptacles on the ends of the Universal Data Connectors. At terminal sites, attach the Universal Data Connector to an IBM wall faceplate with the modular receptacle inside the wall and the IBM Data Connector end on the outside of the wall to terminate Type 3 cable running through walls.

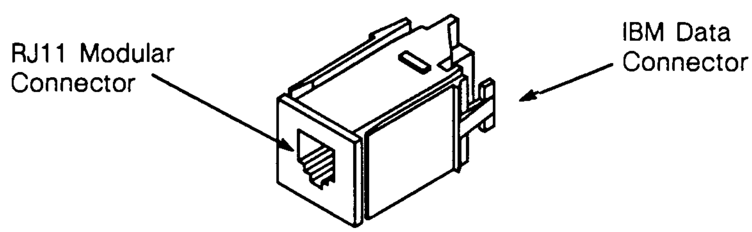


Figure 10–1. Universal Data Connector

10.4.2 PC Adapter Card Cable

This cable assembly is used to connect an IBM Personal Computer (PC) to an IEEE 802.5 MAU. The cable assembly is eight feet in length. One end of the cable is terminated with a D-type connector to attach to the back of the PC. The other end of the cable is terminated with a data connector that plugs into the MAU faceplate.

10.4.3 Patch Cables

These multipurpose cables have a data connector attached to each end. They are used between

- Distribution panel connectors and MAUs
- MAUs in the same network in a wiring closet
- Attaching devices and MAUs in component housings
- Attaching devices and wall faceplates
- MAUs and repeaters

Patch cables are available in the following lengths:

- 8 ft (2.55 m)
- 30 ft (9.14 m)
- 75 ft (23 m)
- 150 ft (46 m)

10.4.4 Modular Data Cables

Modular data cables are used in a variety of ways in modular wire management systems. This cable has RJ11 modular connectors at both ends and comes in three lengths:

- 7 ft (2.15 m)
- 14 ft (4.30 m)
- 25 ft (7.62 m)

10.5 Distribution Panel and Racks

Apollo offers a standard-sized distribution panel and floor rack.

10.5.1 Distribution Panel

This distribution panel can mount up to 64 data connectors and can be used as a patch panel in wiring closets. Cable guides are provided for cable dressing. Constructed of durable metal, the panel mounts easily in a 483-mm (19-inch) distribution rack that complies with EIA and IEC standards.

10.5.2 Floor Mount Distribution Rack

This 19-inch wide floor mount distribution rack holds the distribution panel and MAUs available from Apollo as well as other IEEE 802.5 network equipment.

10.6 Planning and Installing IEEE 802.5 Networks

At this time, Apollo does not provide its own planning and installation documentation for the IEEE 802.5 standard network type. As a service to our customers, this chapter lists a number of documents available from other vendors that may be useful in planning and installing 802.5 networks.

IBM Token-Ring Network Introduction and Planning Guide	GA27-3677
IBM Cabling System Planning and Installation Guide	GA27-3361
IBM Token-Ring Network Installation Guide	GA27-3678
IBM Token-Ring Network Telephone Twisted-Pair Media Guide	GA27-3714

Chapter 11

Internet Hardware Products

This chapter provides detailed information about the hardware used for connecting networks to create a Domain or TCP/IP internet. This chapter also includes information on the Serial Controller–AT and the Channel Controller–AT. See Chapter 2 for an introduction to internets.

11.1 Types of Internet Hardware Configurations

Apollo has two types of hardware configurations that you can use to create an internet:

- A point–to–point link configuration
- A direct connection configuration

A point–to–point link configuration uses two Apollo nodes and an IEEE 802.3 link segment, an IEEE 802.5 link segment, T1 service, or X.25 to connect exactly two Apollo Token Ring networks.

A direct connection configuration uses an Apollo node as a direct connection between two or more networks. Using this type of configuration, you can connect networks of the same type (for example, two or more ATR networks) or of a different type (for example, an ATR network to an IEEE 802.3 network).

The Apollo nodes used in these configurations are called routing and gateway nodes. The routing nodes are used in Domain internets and the gateway nodes are used in TCP/IP internets. These nodes contain one or more network controller boards that perform the function of relaying messages between the connected networks.

Our internet hardware architecture allows you to configure the routing and gateway nodes with more than one network controller. The specific type and number of network controllers that can be used in these nodes depends on the type of node, the type of system bus in the node, and the amount of electrical power the node is able to provide for the additional controllers. Table 11–2 at the end of this chapter provides information about the network controllers that can be used in routing and gateway nodes.

11.2 Creating Point–to–Point Links

A point–to–point link connects two Apollo networks to form a simple internet that can support both Domain and/or TCP/IP communications. The connected networks can be separated by a distance which may be as short as a building–to–building connection, or as long as a connection between two cities. You can use the following communications media for the point–to–point link:

- IEEE 802.3 link segment
- IEEE 802.5 link segment
- T1 communications media provided by AT&T Accunet T1.5 Digital Service, or an equivalent service provided by your local telephone company or other telecommunications company
- X.25 on the Serial Controller–AT

11.2.1 Point–to–Point Link Using an IEEE 802.3 Link Segment

To attach to an IEEE 802.3 link segment, the routing or gateway nodes connect to IEEE 802.3 repeaters through IEEE 802.3 transceiver cables. Figure 11–1 shows this configuration. See Chapters 8 and 9 for detailed information about IEEE 802.3 networks and hardware components.

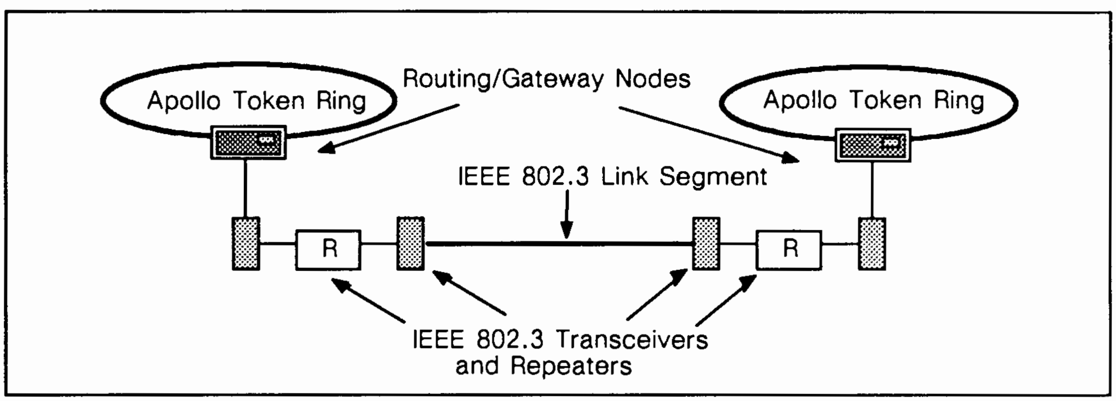


Figure 11–1. An Internet with an IEEE 802.3 Link Segment

Note that the internet shown in Figure 11-1 can be a Domain and/or TCP/IP internet.

11.2.2 Point-to-Point Link Using an IEEE 802.5 Link Segment

To attach to an IEEE 802.5 link segment, the routing or gateway nodes connect to IEEE 802.5 repeaters through IEEE 802.5 MAUs (transceivers). Figure 11-2 shows this configuration.

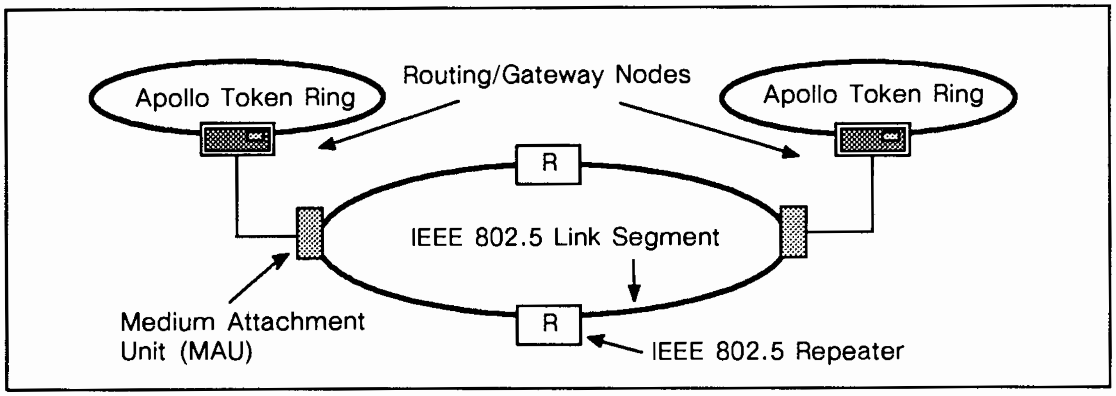


Figure 11-2. An Internet with an IEEE 802.5 Link Segment

11.2.3 Point-to-Point Link Using T1 Service

A point-to-point link using AT&T Accunet T1.5 Digital Service is most appropriate for internets covering geographic distances of more than 3 km (9842 ft or about 1.9 miles). Telephone companies offer T1 service on a variety of communications media, including telephone lines, microwave links, and satellite links. Over long distances, a T1 network often employs several different media, for example, telephone lines and a satellite link. T1 technology guarantees a certain level of service regardless of the media.* Figure 11-3 shows an internet using T1 lines, the Channel Controller-AT boards, and a third-party router to connect an Apollo Token Ring, an IEEE 802.3 network, and an IEEE 802.5 network.

NOTICE: T1 links can be used between Apollo Token Ring, IEEE 802.3, and IEEE 802.5 networks because T1 interface devices are supported by the Domain/Bridge-C software (SR10.3 or later) or Domain/Bridge-A network controller (SR 9.7 to SR10.2.).

Domain/Bridge-C runs on any **sau7** node (DN35XX/DN4XXX) and supports IEEE 802.3, IEEE 802.5, and ATR networks. It also meets the RS-449/422, V.35, and X.21 specifications.

*T1 data transfer rate is guaranteed to be 1.36 megabits per second; service uptime is guaranteed at 98%. Consult a T1 vendor for more information.

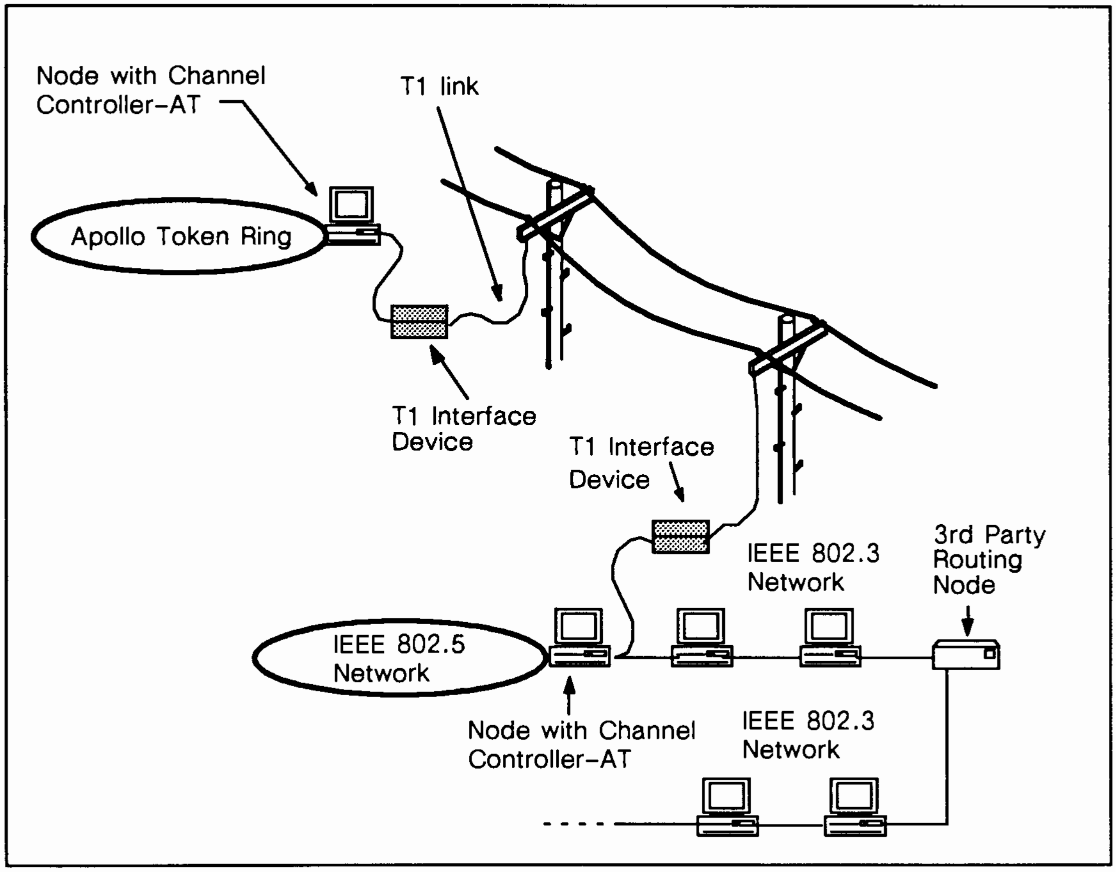


Figure 11-3. A Point-to-Point Link Using T1 Service

Note that the internet shown in Figure 11-3 can be a Domain and/or TCP/IP internet.

11.2.3.1 T1 Installation Considerations

To arrange for T1 service between Apollo networks, contact your local telephone operating company, AT&T, or other telecommunciations company. If your establishment has a telecommunications group, the communications personnel should be able to help you plan a suitable link for your internet, as well as to coordinate the purchase or lease and installation of the necessary equipment (see Section 11.2.3.2 for more information). Otherwise, contact a telecommunications specialist to conduct an in-depth study of your site and recommend a configuration.

The communications specialist should consider the following issues when contracting for service with a T1 vendor:

- Environmental suitability of your site: for example, distance between rings, geographical and environmental characteristics of the area.
- The timetable for installing the equipment: T1 installation frequently involves long lead times. Be sure to ascertain your vendor's lead time early in the planning phase.
- Site licensing requirements.
- Installation service and continuing vendor support for the equipment that you purchase or lease.

NOTICE: Analyze your need for a T1 backup link in case of failure in the primary link. The communications vendor may be able to suggest efficient methods of providing backup service.

11.2.3.2 T1 Interface Device Requirements

The T1 interface device that you select must meet the specifications for AT&T Accunet T1.5 data circuit terminating equipment. The device must transmit at 1.544 megabits per second in **full-duplex** mode and supply the transmit and receive data clocks at between 1 and 2 MHz. The data terminal equipment on the T1 interface device must meet the EIA RS-449/RS-422, V.35, or X.21 specifications* to exchange data with the Domain/Bridge network controller. In addition, the device must transmit signals that meet the DSX-1 specification** for T1 signal speed, format, and 1's density. Note that for the most efficient operation, end-to-end propagation delay should be less than 100 milliseconds.

You *must* use the same types of T1 interface devices at each end of the point-to-point link. Otherwise, if you use two different devices, Domain/Bridge may not be able to transmit packets to each other. However, if you plan to have several point-to-point links in your internet, you may use a different type of interface device for each point-to-point link.

Consult your T1 vendor to determine where the vendor will terminate the communications lines. The T1 interface devices must be located within 25 feet of the routing or gateway nodes because our interface cable is 25 feet long. Plan to locate these nodes and T1 devices in network control rooms where the system administrators can monitor them.

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* The Electronic Industries Association Standard RS-449 and RS-422 are available from the EIA Engineering Department, 2001 Eye Street, N.W., Washington, D.C. 20006.

** The DSX (Digital Cross Connect) specifications are documented in *Bell System Technical Reference for High Capacity Terrestrial Digital Service*, publication number 41451, and in the *AT&T Compatibility Bulletin #119*.

11.2.3.3 T1 Interface Devices

We have successfully tested the Domain/Bridge product with the following devices*:

- Avanti TPAC-1.5, T1 Programmable Access Controller
- Verilink 551 VCCS Clear Channel System

These devices include an internal transcoder, clear channel device, and Channel Service Unit (CSU). The transcoder and clear channel device provide the minimum 1s density required for a T1 signal. The CSU provides electrical isolation between customer equipment and the T1 lines, as well as signal drive conditioning necessary for a T1 signal. These internal CSUs do *not* change signal format, 0 density, or framing.

NOTICE: Although these products meet our requirements and performed well during testing, we make no representation or warranty regarding the products or their vendors.

To connect either the Avanti or Verilink units requires that you install a Channel Controller-AT Executive Processor board with either an RS-449/422 or V.35 serial link. The Avanti unit requires several programmed settings in order to function properly with Domain/Bridge. You can ask the vendor to program these settings for you. The Verilink unit needs no special settings prior to installation.

If you use another type of device or elect not to purchase a transcoder, clear channel device, and CSU for either of the listed devices, you will need to purchase or lease the equipment from the T1 vendor or the device vendor. The device you choose *must* transmit data with the T1 recommended 1s density.

Arrange to have the vendor install and test the T1 interface devices at the same time that you install Domain/Bridge. In this way, you can ensure proper installation and a full test of the internet's capabilities.

* For information about these devices, contact Avanti Communications Corporation, Aquidneck Industrial Park, Newport, RI 02840, and Verilink Sales Company, Inc., 127 Route 59, Suite A-1, Monsey, N.Y. 10952

11.2.4 Point-to-Point Link Using X.25 on the Serial Controller-AT

You can create a point-to-point link by using the Domain/X.25 software with the Serial Controller-AT communications controller and an appropriate modem.

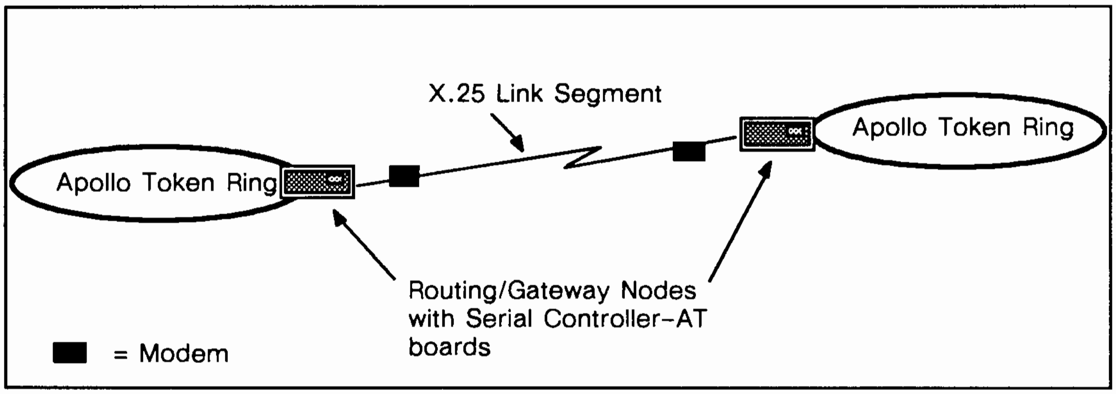


Figure 11-4. An Internet Using an X.25 Link Segment

11.3 Creating Direct Network Connections

You can configure your internet so that a single Apollo node can directly transfer messages between networks. Our internet architecture allows you to configure our AT compatible bus systems and DN10000 VME bus systems to simultaneously reside on up to four networks, thus allowing direct communication between these networks. Note, however, that a maximum of *two* of each network type is allowed. For example, a single Apollo node can connect to two IEEE 802.3 networks and two ATR networks (see Figure 11-5).

NOTICE: The actual number of network controllers allowed in any one system is also governed by the availability of bus slots and electrical power. When planning your system configurations, you must not only consider the network controllers, but the other controller boards as well.

All of the network controllers used in all our systems can support simultaneous Domain and TCP/IP communications (when they are running the proper software). Refer to Table 11-2 for a summary of the network controllers that can be used in Apollo nodes to directly connect networks to form an internet.

11.4 Serial Controller–AT

When you install the Serial Controller–AT in an Apollo node or server equipped with a PC AT compatible bus, it provides high-speed, full-duplex, serial communications between a Apollo network and a target (non-Apollo) network. This is made possible by the following features:

- You can separately configure each of the controller's two serial ports to support the RS-232-C, RS-449/422, V.35, or X.21 electrical interface standards. (We refer to the RS-449/422 interface as RS-449 in this manual.)

- The Serial Controller–AT supports a number of communications software products.

- You can connect your Apollo network to a target (non-Apollo) network.

The following subsections briefly describe these features.

11.4.1 Supported Electrical Interface Standards

The Serial Controller–AT provides two serial ports, labeled Channel 1 and Channel 2. Each of these channels can support a different electrical interface standard. By installing the jumpers on the controller as described in *Installing the Serial Controller–AT*, you can configure any one of the following electrical interfaces for each channel:

- RS-232-C

- RS-449

- V.35

- X.21

An important feature of the Serial Controller–AT is that you can configure the *same* electrical interface for each of the two channels and run them simultaneously, or you can configure a *different* electrical interface for each channel and run both interfaces simultaneously. For example, you can configure an RS-232-C interface for both Channel 1 and Channel 2 and run these identical interfaces at the same time. Alternatively, you can configure an RS-232-C interface for Channel 1 and a V.35 interface for Channel 2, and run these different interfaces at the same time.

Refer to the *Installing the Serial Controller–AT* manual for more detailed planning information.

11.4.2 Supported Communications Software Products

Currently, you can run several communications software products on the Serial Controller-AT. For a complete list of supported communications software products, contact your Apollo Sales Representative.

You must *purchase these products separately* from the Serial Controller-AT hardware. For more information about using these products with the Serial Controller-AT, we suggest you do the following:

- See your local sales representative for the correct version of the communications software to run on the Serial Controller-AT.
- Read the release document that ships with that version of the software.

11.4.3 Connection to a Target Network

The communications software products you use with the Serial Controller-AT determine your target network. You can think of a target network as a non-Apollo network with which an Apollo network can communicate. For example, if you use the Domain/SNA products with the Serial Controller-AT, your Apollo network can be connected to an IBM SNA target network.

In this manual, we use the term target network to mean any non-Apollo network you can access by installing the Serial Controller-AT in your PC AT compatible Apollo node or server.

The documentation for your communications software product describes the hardware requirements for the target network. The Preface lists the documentation titles for the communications software products that currently run on the Serial Controller-AT.

11.5 Channel Controller-AT

The Channel Controller-AT is an intelligent, 2-board communications controller that you can install in a Domain workstation or server equipped with a PC AT compatible bus. By using the controller with the appropriate IBM bus and tag cables and communications software, you can connect your Apollo network to an IBM System/370 I/O interface multiplexer channel. In addition, the Channel Controller-AT Executive Processor provides two high-speed serial lines for full-duplex, serial communications between an Apollo network and a target network.

The Channel Controller–AT offers the following features:

- Four separately available controller configurations
- A separately available 2–MB Memory Add–On Kit for the Executive Processor
- The ability to independently configure each of the Executive Processor's two serial ports to support the RS–232–C, RS–449/422, RS–485, V.35, and X.21 electrical interface standards
- Support for a variety of Apollo serial and channel–attached communications software products
- Utility programs for hardware diagnostics, protocol tracing, and error logging

Note that the Channel Controller–AT can be installed in most nodes and does not require a dedicated node.

Channel Controller–AT Configurations

Select the Channel Controller–AT configuration that supports the type and memory requirements of the communications software you plan to run. For information about the memory requirements of the software products that run on the Channel Controller–AT, see your Apollo Sales Representative.

You can purchase and install the Channel Controller–AT in any of the configurations shown in Table 11–1.

Table 11–1. Channel Controller–AT Configurations

Configuration	**Type(s) of Communications Software Supported**
Channel Controller–AT 2–Board Set	Channel–attached and serial products (can run these separately or simultaneously)
Executive Processor with 512 KB of DRAM	Serial products only
Executive Processor with 2 MB of DRAM	Serial products only
Channel Processor Add–On	Channel–attached products only

For information about the Channel Controller–AT, refer to *Planning for and Installing the Channel Controller–AT*.

11.6 Internet Hardware Summary

Table 11–2 summarizes the network controllers currently available for Apollo nodes and lists the physical limitations of the various bus types. For the best performance and increased reliability, we recommend that you run the latest standard software release on all the routing and gateway nodes.

Following the table, we describe two internet topologies that illustrate various internet hardware combinations.

NOTICE: Although the information in this table was current at the time of publication, we suggest that you consult your sales representative.

Table 11-2. Network Controller Summary

Node and Bus Type	Supported Networks	Network Controller Product Name	Other Required Hardware	Sources for Other Required Hardware
DN2500 DN3XXX DN4XXX DSP3XXX DSP4XXX AT compatible	ATR	Apollo Token Ring Network Controller-AT (earlier systems also use a 2-slot version of this controller board)	Cables, switches, and connectors	We supply through *Apollo Direct Channel*
	IEEE 802.3	802.3 Network Controller-AT	Transceiver and cable, or T-connector for Thin cable	We supply through *Apollo Direct Channel*
	IEEE 802.5	802.5 Network Controller-AT	Cables, connectors, and MAUs	We supply through *Apollo Direct Channel*
DN10000 VME	ATR	Hi-Perf ATR Network Controller (optional) (V-NET-ATR)	Cables, switches, and connectors	We supply through *Apollo Direct Channel*
	IEEE 802.3	Hi-Perf 802.3 Network Controller-VME (V-NET-ETH-PLUS)	Transceiver and cable, or T-connector for Thin cable	We supply through *Apollo Direct Channel*
DN10000 AT compatible	IEEE 802.5	802.5 Network Controller-AT	Cables, connectors, and MAUs	We supply through *Apollo Direct Channel*
DN10000 Xbus	FDDI	Series 10000 FDDI Network Controller	Cables, MIC plugs concentrators, splices, and connectors	Third-party vendors

Node Type	Maximum Controller Configuration
DN2500	One controller (ATR, IEEE 802.3 , or IEEE 802.5).
DN3XXX/DN4XXX	Up to 4 controllers total, maximum of 2 of any given type (ATR, IEEE 802.3, or IEEE 802.5)
DN10000 (AT compatible)	Up to 2 IEEE 802.5 controllers total.
DN10000 (VME)	Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3
DN10000 (Xbus)	1 FDDI controller

From Table 11–2, you see that you can use different combinations of routing and gateway nodes, network controllers, and point-to-point links to create Domain and/or TCP/IP internets. For example, Figure 11–5 shows a heterogeneous internet made up of both Domain and TCP/IP internets. This internet contains the following:

- A DN3000 equipped with two 802.3 network controllers (Node A)
- A DN4000 equipped with an Apollo Token Ring controller and an 802.3 controller (Node B)

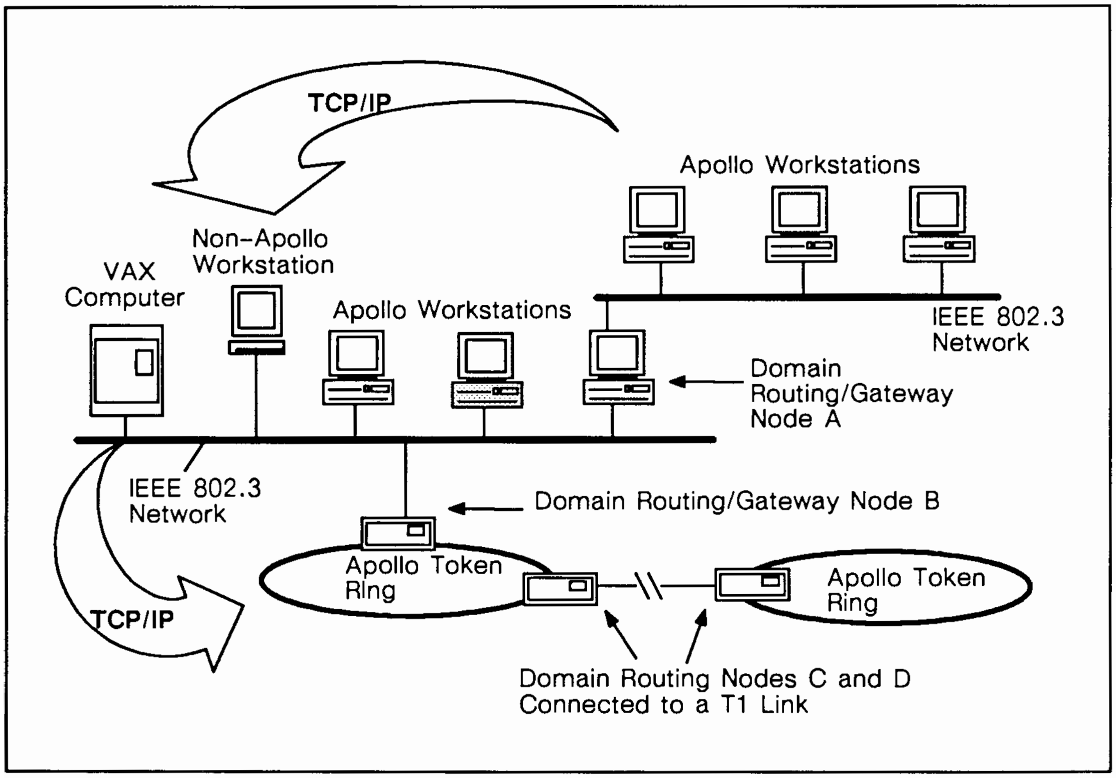


Figure 11–5. A Domain–TCP/IP Internet

In this figure, Apollo nodes on any network can communicate with Apollo nodes on any other network. In addition, all of the Apollo nodes on all of the networks can communicate with the non–Apollo systems (and with other Apollo nodes) using TCP/IP.

Figure 11–6 illustrates an internet linked by a single Apollo node that contains several network controllers. In this example, the routing (or gateway) node (an AT compatible bus system) contains two Apollo Token Ring controllers plus two IEEE 802.3 network controllers. All of the Apollo nodes can communicate with TCP/IP and/or Domain protocols.

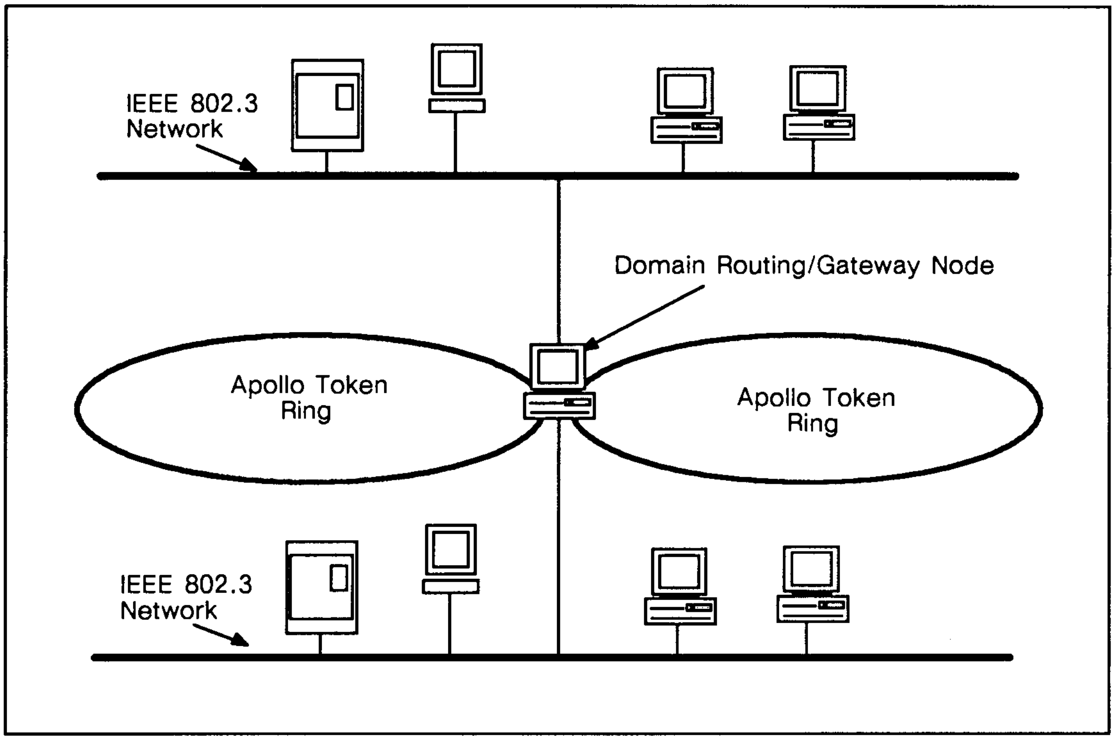


Figure 11-6. A Single Node Joining Four Networks

Chapter 12

Planning an Internet Topology

This chapter contains general information to help you plan your Domain and TCP/IP internet topologies. It also contains specific configuration information about Domain internets. For details about configuring a TCP/IP internet, refer to *Configuring and Managing TCP/IP*.

The first two sections in this chapter discuss resource planning and internet design (with the view to solving network problems involving resource allocation and network access control). These sections apply to both Domain and TCP/IP internets (unless stated otherwise). The third and fourth sections provide planning and configuration information specific to Domain and TCP/IP internets, respectively. Note that in some cases the information in the third and fourth sections may apply to both types of internets. Keep in mind that although we use the terms **Domain internet** and **TCP/IP internet**, both TCP/IP and Domain communications are typically used within a single heterogenous internet.

At the end of this chapter we've included a brief list of the information you need to make an internet diagram. For a complete list of planning tasks, see the "Domain Internet Planning Checklist" at the back of this manual.

12.1 Planning Resources

One of the most important aspects of internet planning is resource allocation. To reduce data traffic through the routing and gateway nodes, and to maximize efficiency in an internet, plan to allocate adequate resources to *each* network in the internet.

NOTICE: Apollo nodes *cannot* boot from partners on other networks in the internet, so plan to locate diskless nodes and their partners on the same network.

Routing is a CPU– and network–intensive application. CPU resources given to other applications, contention for access to the network, and competition for memory between communications software and other applications detract from the performance of the routing or gateway node. Therefore, using the routing or gateway node as a computational or peripheral server can slow communication in the internet. Also, while combining Domain and TCP/IP protocols on a single routing or gateway node makes the most efficient use of the hardware, in internets where performance is the priority you should plan to dedicate nodes to either Domain *or* TCP/IP communication service. Alternatively, some third–party router vendors are supporting Apollo protocols at this time.

The following section includes some additional suggestions to help in resource planning.

12.2 Designing an Internet to Solve Network Problems

As discussed in the previous section, you must distribute internet network resources to use them most efficiently. An additional concern in internet planning is network access control. This section contains some examples of internet topologies that solve typical network problems involving resource allocation and access control.

12.2.1 Problem 1 — Placing an Important Resource

You may have one resource that users need to access frequently or quickly (without transmission delays), for example:

- Program compiler, library, or insert files
- CAD/CAM database
- Electronic mail system database
- Storage media
- Specialized printer or other input/output device

Figure 12–1 shows an internet topology that allows fast access from any point in the internet to an important resource located on Network A. The transmission path from any node in the internet to Network A contains only one hop. (A **hop** is a data packet's passage through a routing or gateway node on the way to its destination.) For example, the transmission path from Node X contains one hop to Network A; the transmission path from Node Y also contains one hop to Network A.

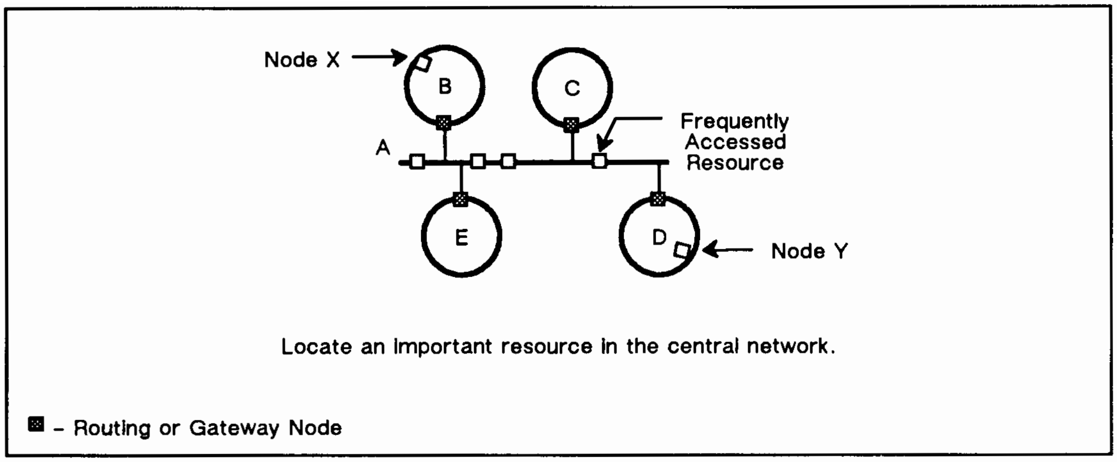


Figure 12-1. Placing an Important Resource

12.2.2 Problem 2 — Ensuring Access at All Times

If you need to ensure continuous access to a resource or network (during service calls on the routing or gateway node, or during communication link failures, for example), plan an internet topology that incorporates redundant communication paths, as illustrated in Figure 12-2.

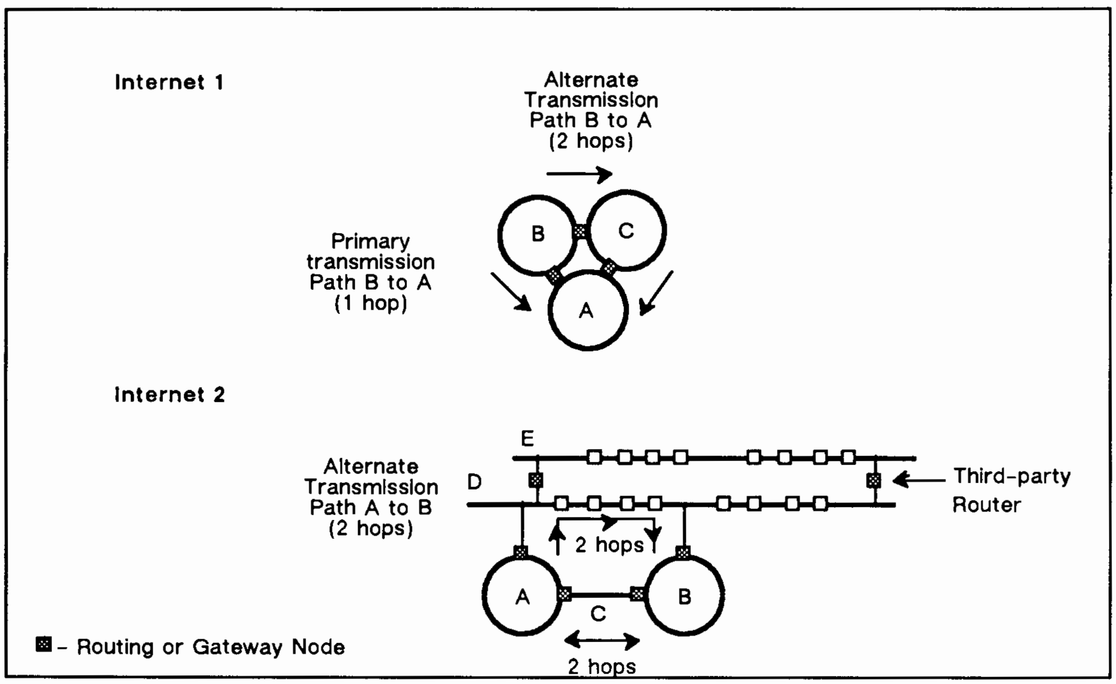


Figure 12-2. Using Redundant Communication Paths

Planning an Internet Topology

In Figure 12–2, Internet 1 provides alternate routes between all the networks; if one routing or gateway node or network is not operating, users in Network B can still reach Network A. Internet 2 provides an alternate route between Networks A and B through linking network C, and between Networks D and E through redundant routing or gateway nodes.

12.2.3 Problem 3 — Limiting Access

You may have a network with users who want internet service only for short periods of time and do not want to allow access by others most of the time. For example, a group of engineers who run test programs on one network may want to limit access to their nodes by others; however, they want to join the internet to use electronic mail. Figure 12–3 shows two examples where the internets are designed so that a system administrator can limit communications to Network D. See *Managing Domain/OS and Routing in an Internet* for information about starting and stopping the Domain internet communication process(es). Refer to *Configuring and Managing TCP/IP* for information about starting and stopping TCP/IP communication processes.

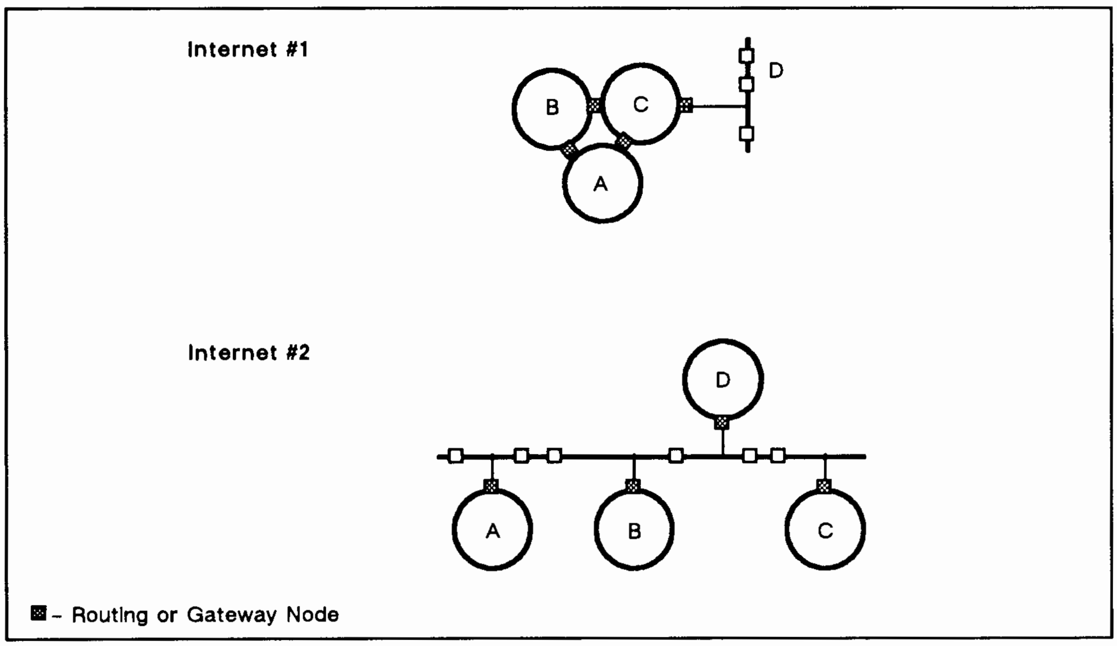


Figure 12–3. Limiting Access in an Internet

Because of the design and administration of Internet #1 in Figure 12–3, the node that links Network D to the rest of the network spends little time handling internet communication, and the tasks themselves are light. This node is a good candidate for a shared application such as a computational or peripheral server. In this case, the application would suffer minimal performance degradation because the internet communication demands are few. The design of Internet #2 enables Network D to be switched out of the network thus limiting access to it from the other networks.

12.2.4 Problem 4 — Isolating a Development Network

Your site may have a network that is devoted to hardware or software development. Because of its experimental nature, the network is often unstable. Such a network can be part of an internet because interruptions in one network do *not* affect the operation of the other networks.

Any supported internet topology can accommodate an unstable network; however, you should not plan to use an unstable (and possibly nonfunctioning) network as an alternate communication path. The topologies shown in Figure 12-3 are suitable for a site that includes an unstable network. Even if the routing and gateway nodes operate continuously, an unstable Network D will not affect the data communications between the other networks.

12.3 Planning a Domain Internet

We often refer to the portion of an internet running Domain communications protocols as a **Domain internet**. The Domain communication protocol has some unique features in an internet, but is also subject to certain configuration rules.

NOTICE: Whether or not you run Domain protocols on your entire internet, the portion of the internet served by Domain *must* follow the configuration rules described in the following subsection.

12.3.1 Domain Internet Configuration Rules

The total number of hops between any two nodes depends on the internet's configuration. Following are four basic rules to keep in mind:

- The transmission path for a data packet can include a maximum of 15 hops. This includes hops the data packet must travel if one or more networks are not operational.
- A Domain internet can contain a maximum of 64 networks of any type of network that we support (for example, both ATR and IEEE 802.3 networks). Point-to-point links (using an IEEE 802.3 link segment or T1 service) count toward the 64-network maximum.
- Minimum transmission rate over a single link must be at least one megabit per second with a maximum end-to-end delay of 100 microseconds (ms).

Our guidelines ensure that the time it takes a packet to traverse the internet stays within protocol specifications. As your internet configuration approaches the limits of our guidelines, you may experience unsatisfactory performance. You may need to reconfigure portions of the interent, the number of hops between networks, or remove or replace equipment that slows data transmission. Any of these elements, singly or in combination, can contribute to overall performance degradation.

12.3.2 Examples of Domain Internet Topologies

Figure 12–4 and Figure 12–5 contain examples of some Domain internet topologies. Note that there are many more possible topologies than those illustrated. In the figures, Apollo Token Ring networks are represented by circles, IEEE 802.3 networks by bold lines, and routing nodes by filled squares. All networks are numbered, including point-to-point links. In these examples, no transmission path includes more than six hops.

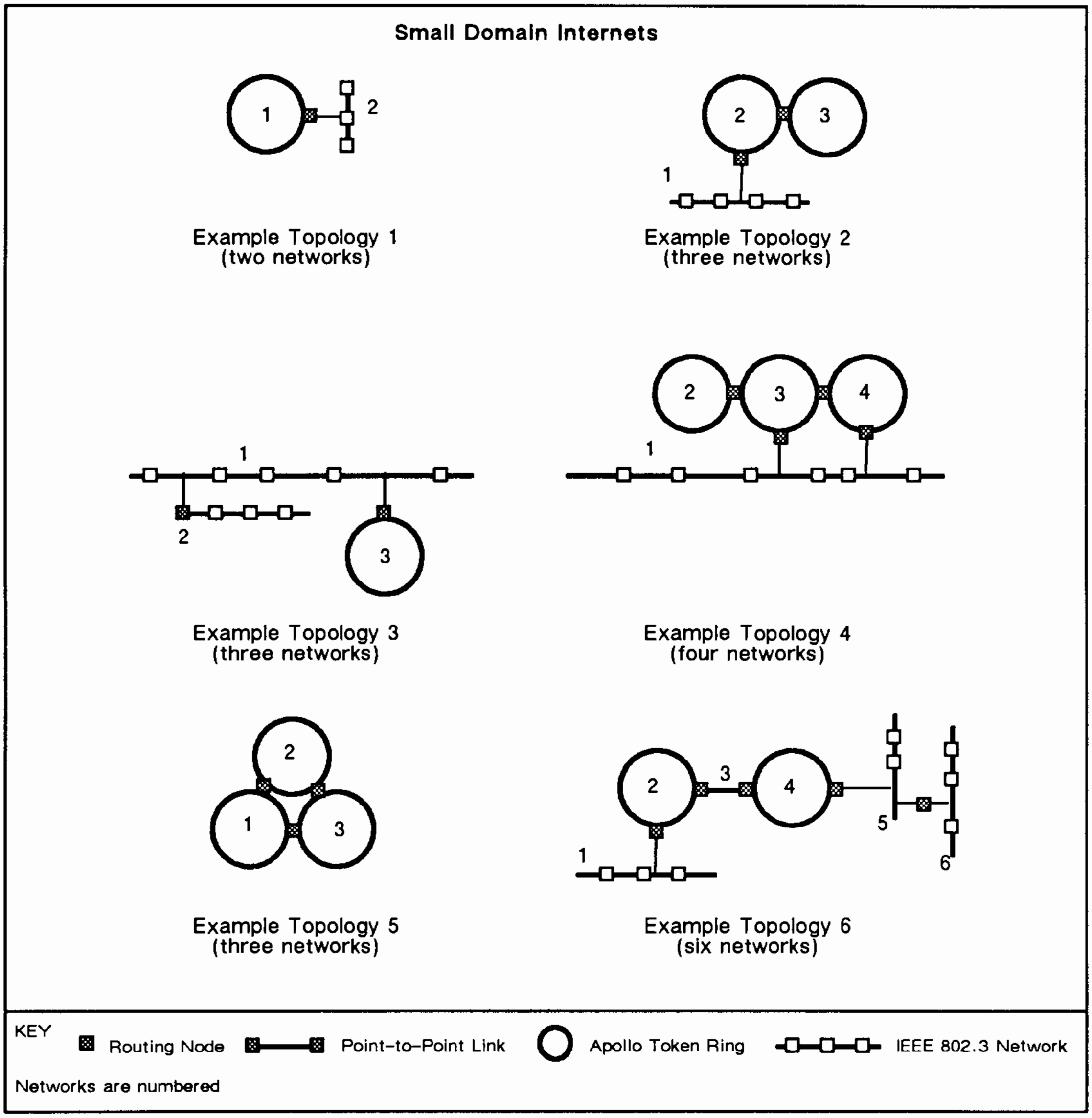


Figure 12–4. Small Domain Internet Topologies

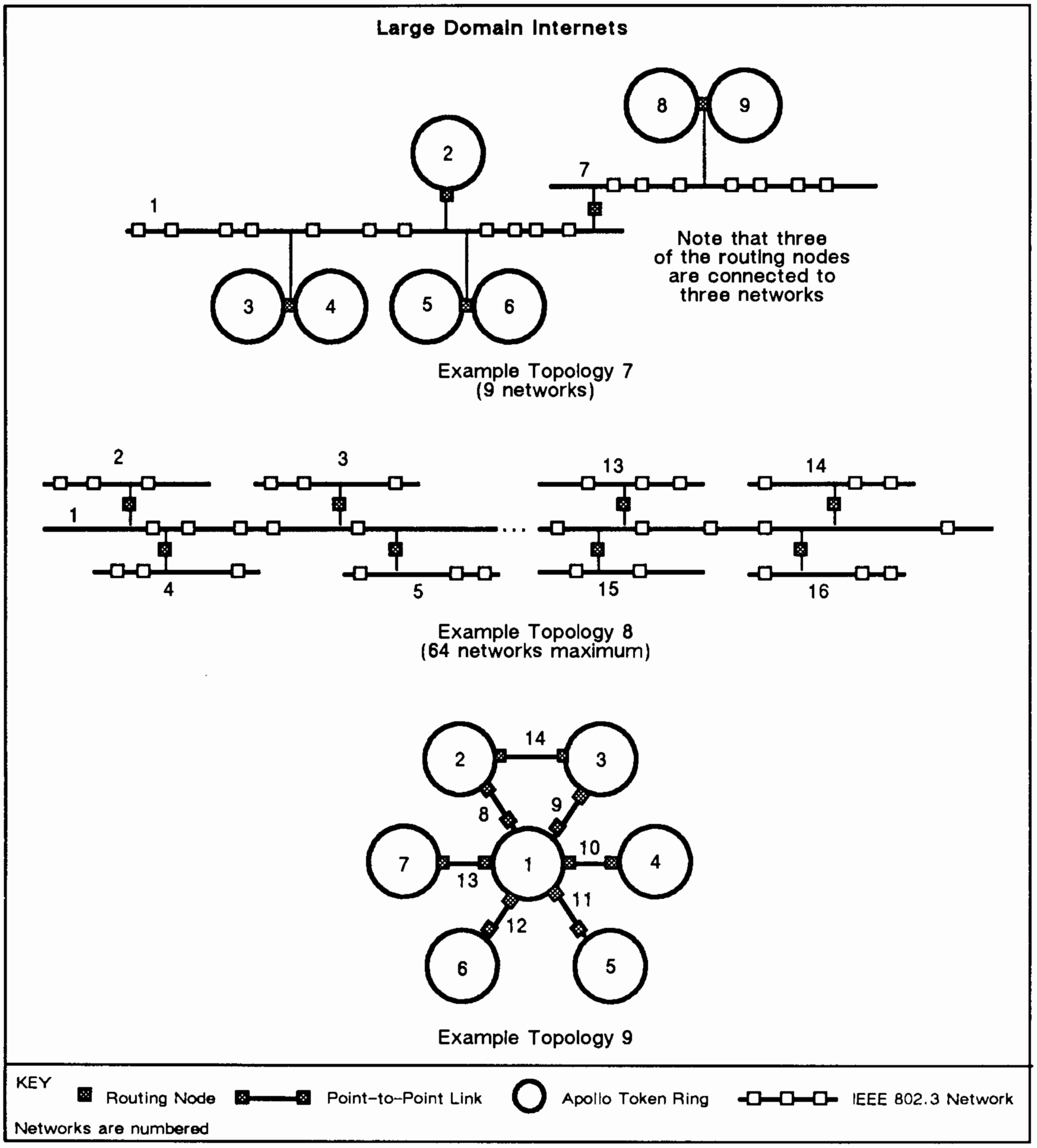


Figure 12–5. Large Domain Internet Topologies

12.3.3 Adaptive Routing

Under normal operation, routing nodes always send data over the *shortest* possible path, that is, the path with the least number of hops. If a path becomes unavailable, the routing nodes automatically select an alternate path if one is available. This is **adaptive routing**. You can take advantage of adaptive routing by designing the Domain portion of your internet so that it provides alternate transmission paths. In Figure 12–4 and Figure 12–5, example topologies 4, 5, and 9 provide alternate routes between some networks.

In Figure 12–6, in Internet 1, packets transmitted from Network A that are destined for Network B normally travel through Routing Node X directly to Network B, the path with the least number of hops. If there is an interruption in routing service on Routing Node X, the Routing Node Y automatically routes the packets over the alternate path, through Network C and Routing Node Z. When the short path is available again, the routing nodes automatically resume using it.

Internet #2 does *not* use adaptive routing. Packets transmitted from Network A to Network B use *one* routing node. The second routing node, even though it is operating normally, will not route packets unless the first routing node is not performing routing, or its network connection fails.

NOTICE: Providing several transmission paths does *not* increase the total amount of data or the number of messages per second that are transmitted between networks. Routing nodes will always send data packets over the shortest transmission path unless some routing node is not performing routing or some transmission link experiences a failure.

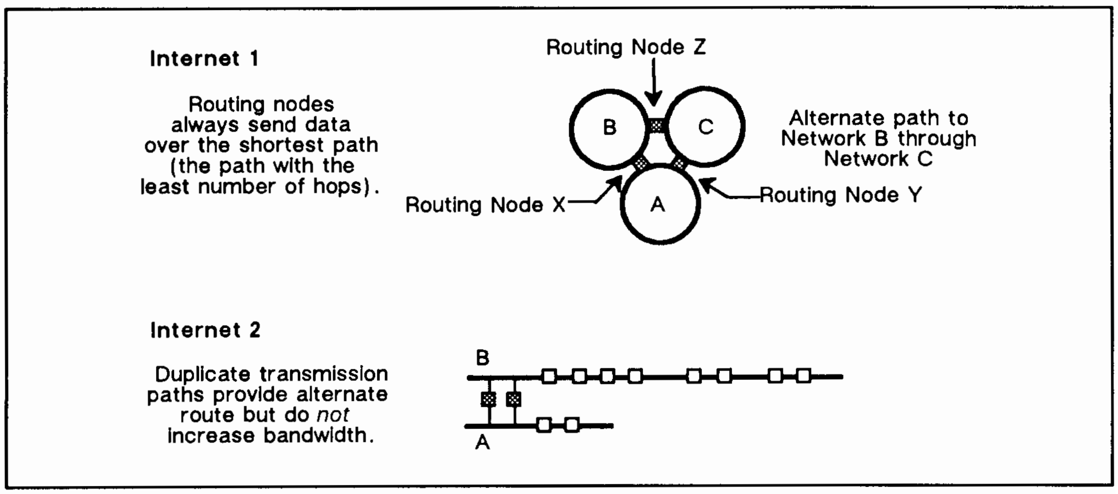


Figure 12–6. Adaptive Routing

12.3.4 Obtaining Domain Network Numbers

Each network in a Domain internet has a unique, 8-digit (32-bit) hexadecimal network number. When planning a Domain internet, you may choose any 8-digit hexadecimal numbers, provided that no networks in the internet have the same number. To avoid potential problems with duplicate network numbers, we recommend that you obtain network numbers from our list of unique network numbers. (Call the Apollo Response Center at 1-800-2-APOLLO to receive your numbers.)

12.4 Planning a TCP/IP Internet

Before you can use TCP/IP, you must first decide on an appropriate topology for your internet. You'll also have to decide whether your intenet will be made up of both Domain and TCP/IP internets, or just a single type of internet. Portions of your internet may include both Domain and TCP/IP internets.

This section describes some possible internet topologies that can be used to create a TCP/IP internet. Note, however, that the internet topologies discussed in this section can include both Domain and TCP/IP internets.

12.4.1 TCP/IP Internet Configuration Guidelines

Before you can configure a TCP/IP network, you must first

- Know the network topology.
- Determine which nodes will be TCP/IP hosts. Any Domain node on your network or internet can be a TCP/IP host.
- Determine which nodes (or node) will be the TCP/IP gateway nodes. In most cases, your Domain routing node can also be a TCP/IP gateway.
- Determine which node will be the TCP/IP administrative node. You'll probably have one administrative node on each TCP/IP network within your internet.

When you connect your TCP/IP internet to another TCP/IP internet, your TCP/IP hosts can communicate with the TCP/IP hosts on all the networks in the other TCP/IP internet. Consequently, even though you might have one TCP/IP gateway to a single TCP/IP internet, that internet might have many gateways to many other TCP/IP internets. With your single TCP/IP gateway, you can communicate with every other TCP/IP host in the two TCP/IP internets as long as the hosts are within 30 hops, the maximum number allowed.

NOTICE: Instead of a hop count, the TCP/IP protocol defines a parameter called the maximum time to live (MTTL) parameter which is measured in seconds. The value of the MTTL parameter converts to 30 hops.

For details about configuring a TCP/IP internet, see *Configuring and Managing TCP/IP*.

12.4.2 TCP/IP Configurations with AT Compatible Bus Hardware

This section shows the possible TCP/IP configurations using Apollo AT compatible bus nodes. Figure 12–7 is a simple configuration with all AT compatible bus nodes serving as TCP/IP hosts on an IEEE 802.3 network. All of the Apollo nodes contain the 802.3 Network Controller–AT board and TCP/IP software, so they can communicate with each other via Domain protocols or TCP/IP protocols. They can also communicate via TCP/IP to the Digital Equipment Corporation VAX computer. Because all the nodes are on a single network, there's no need to designate a TCP/IP gateway node.

NOTICE: Figure 12–7 is *not* an example of an internet topology. However, we've included it here to show how a single LAN network could use the TCP/IP protocol.

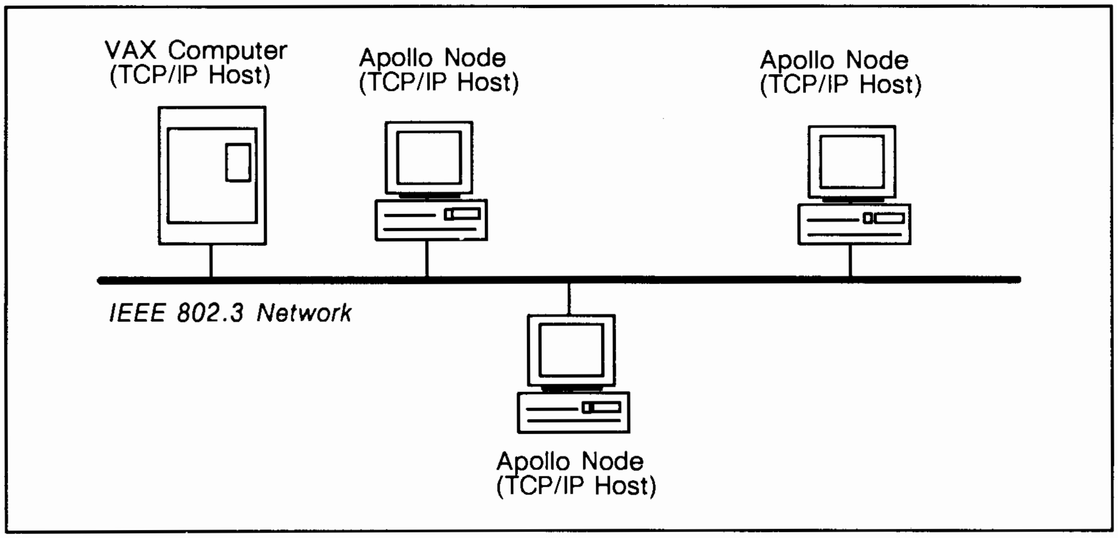


Figure 12–7. TCP/IP Hosts on an IEEE 802.3 Network

In Figure 12–8, we added a second IEEE 802.3 network to create an internet. To join the two networks we used a direct connection configuration with one TCP/IP gateway node. The TCP/IP gateway node contains two 802.3 Network Controller–ATs so that it can serve as a TCP/IP gateway between the two networks. Again, all Apollo AT compatible bus nodes contain the 802.3 Network Controller–AT board and TCP/IP software, so they can communicate with each other via Domain protocols or TCP/IP protocols.

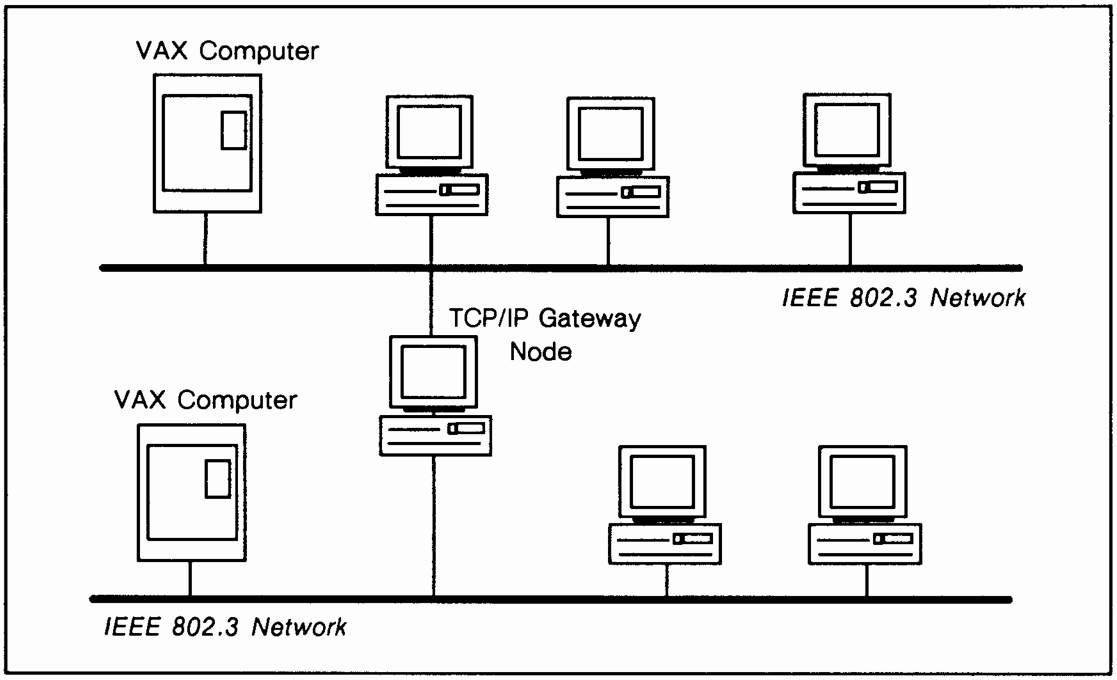


Figure 12–8. Direct Connection Internet Configuration Between Two IEEE 802.3 Networks

In Figure 12–9, an AT compatible bus node serves as a TCP/IP gateway between an Apollo Token Ring and an IEEE 802.3 network. The TCP/IP gateway node contains an ATR Network Controller–AT and an 802.3 Network Controller–AT. This configuration allows TCP/IP hosts on the IEEE 802.3 network to use resources on the Apollo Token Ring. Apollo workstations on the Apollo Token Ring can use the resources of all the computers on the IEEE 802.3 network. All Apollo nodes can communicate via TCP/IP and/or Domain protocols.

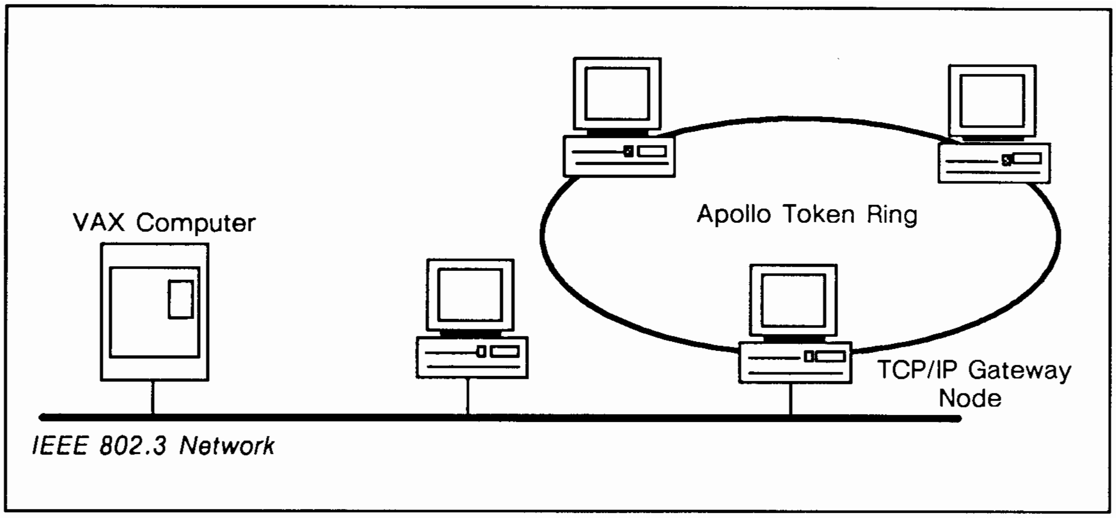


Figure 12–9. AT-Compatible TCP/IP Gateway Between an IEEE 802.3 and Apollo Token Ring Network

Figure 12–10 shows an AT compatible bus node that contains two ATR Network Controller–ATs so that it can serve as a TCP/IP gateway between two separate Apollo Token Ring networks. Note that this node can also serve as a Domain routing node to provide Domain routing service across the two networks.

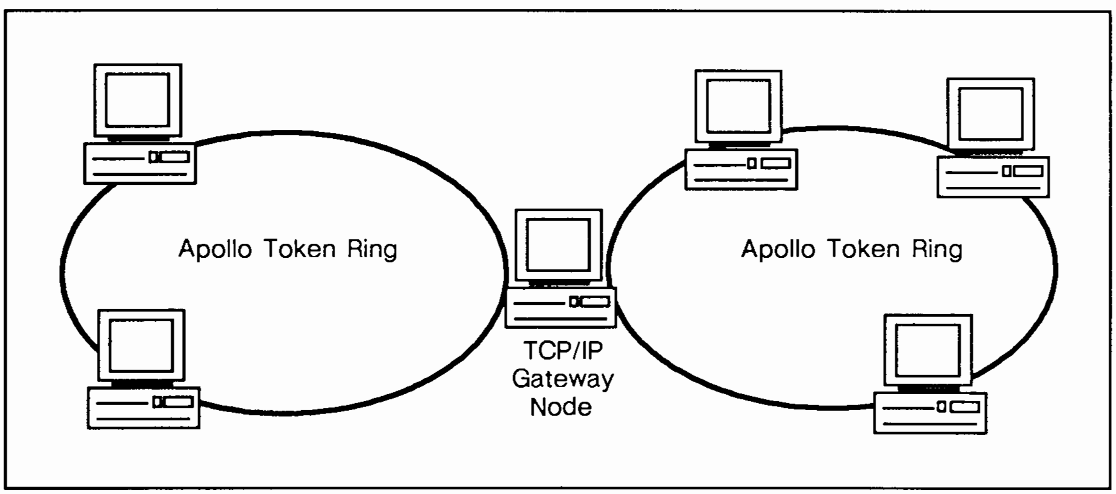


Figure 12–10. AT Compatible Node as a Gateway Between Two Apollo Token Rings

Figure 12–11 shows an AT compatible bus node serving as a TCP/IP gateway between two IEEE 802.3 networks and an Apollo Token Ring. In this case, the TCP/IP gateway node contains two 802.3 Network Controller–AT boards and one ATR Network Controller–AT. Each node on the Apollo Token Ring that runs TCP/IP can communicate with TCP/IP hosts on each IEEE 802.3 network. All Apollo nodes on each network can communicate via either TCP/IP or Domain protocols.

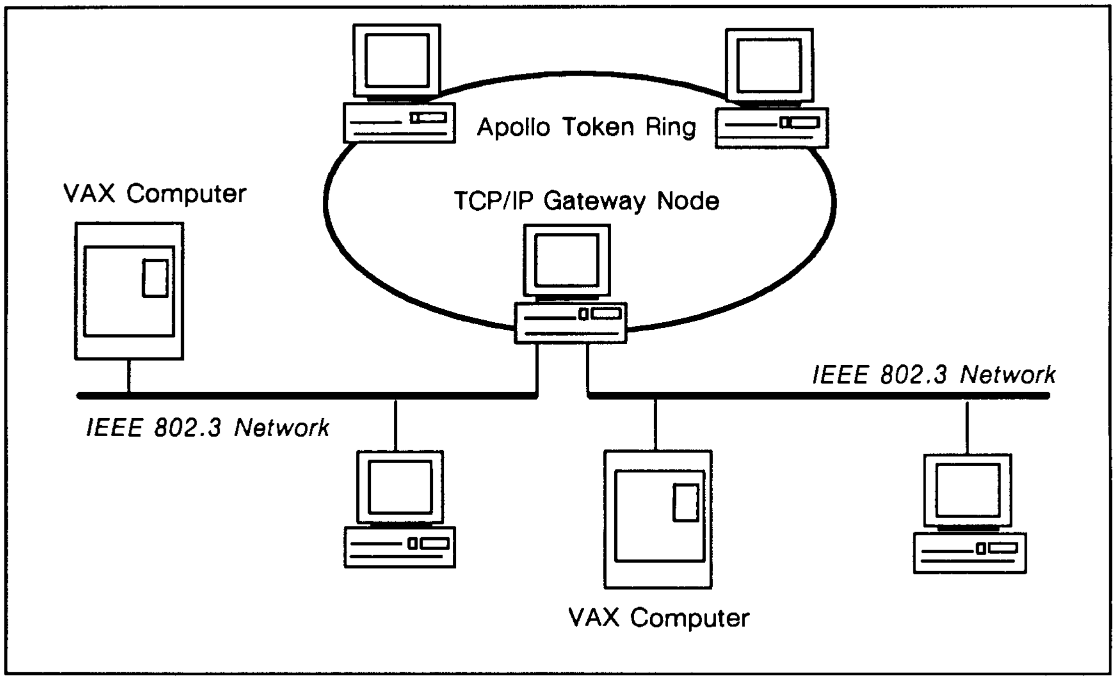


Figure 12-11. TCP/IP Gateway to Two IEEE 802.3 Networks and an Apollo Token Ring

Figure 12-12 shows the maximum number of networks that an AT compatible bus node used a TCP/IP gateway can contain. It can have up to four network controllers, but no more than two of the same type; that is, the TCP/IP gateway node can contain two Apollo Token Ring network controllers (ATR Network Controller-ATs) and two IEEE 802.3 network controllers (802.3 Network Controller-ATs).

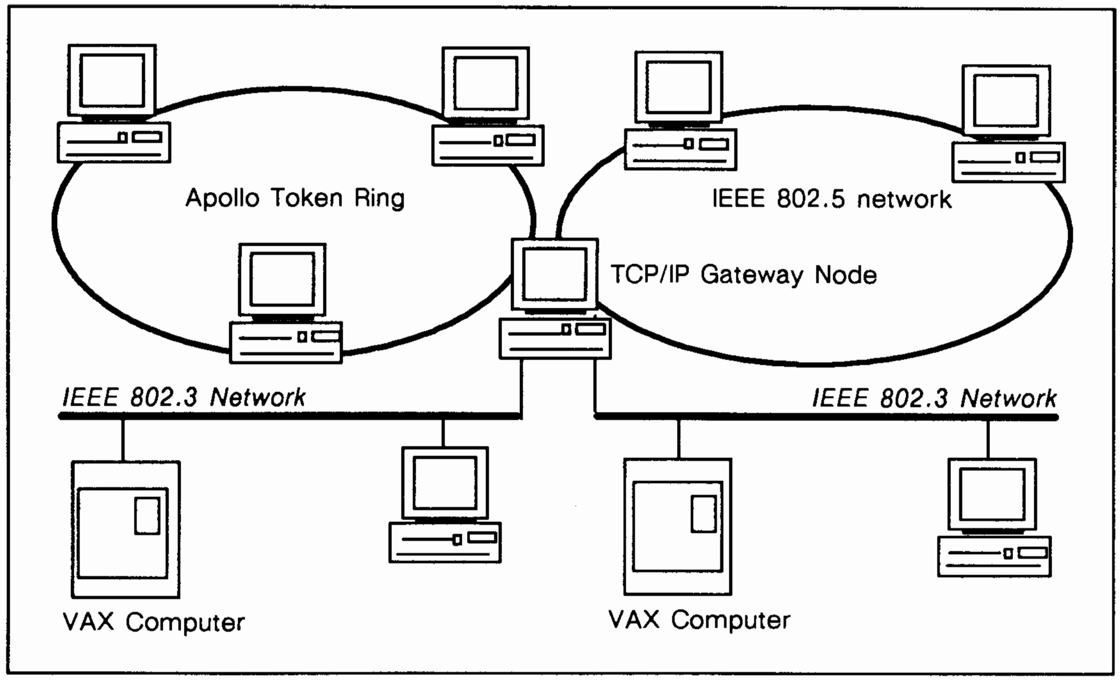


Figure 12–12. Maximum Number of Networks Connected to a Single TCP/IP Gateway Node

12.5 Creating an Internet Diagram

While your internet diagram need not be as elaborate as the sample network layouts at the end of Chapters 4 and 6, it can still be an indispensable tool for network planning and management. When you create your internet diagram you should include the following information:

- The network numbers for Domain internets
- IP addresses for TCP/IP internets
- The network services provided by the routing and gateway nodes (such as TCP/IP, Domain/Access, or Apollo/Integrated SNA) and the networks to which these services are available
- Any other processes running on the routing and gateway nodes (such as print servers)
- Node IDs of Domain routing nodes (and their partner nodes, if diskless)
- IP host names and addresses of all TCP/IP hosts and gateways (and their partner nodes, if diskless)
- The TCP/IP administrative node for each TCP/IP network within the internet
- The relative locations of the networks within the internet (an internet map)

See the "Internet Planning Checklist" at the back of this manual for a complete list of internet planning tasks.

For detailed information about managing a Domain internet, refer to *Managing Domain/OS and Routing in an Internet*. For detailed information about managing a TCP/IP internet, refer to *Configuring and Managing TCP/IP*.

Appendix A

Ordering Network Components from the *Instant Apollo* Catalog

This appendix contains information to help you order the ATR and IEEE 802.3 cable, connectors, and accessories available from the *Instant Apollo* catalog. For more information about ordering and installing fiber–optic cable and accessories see Appendix B.

The *Instant Apollo* catalog lists the components that you need to install and terminate network coaxial cable. To order a catalog or any of the components, call 1–800–225–5290 and request a catalog, or give the Catalog Sales Department the components' part numbers (listed in capital letters in Tables A–1 through A–4). We guarantee shipment of your components within 24 hours. The catalog is published semi–annually, so ask your sales representative about additions to the catalog.

NOTICE: Outside North America, customers should order components through their local sales offices.

The manual *Installing Coaxial Cable and Accessories for an Apollo Token Ring Network* (009860) is also available through the catalog. Use this manual to install and test the Apollo Token Ring network cable and connectors. If you plan to use a professional cable installer, review the manual to become familiar with our installation standards and techniques before you give it to the installer. Installation instructions for the IEEE 802.3 network transceiver and cable taps are shipped with the hardware.

Table A-2, which lists Apollo Token Ring network components and their catalog part numbers, is in matrix form to help you choose components that are *compatible*. Notice that some connectors fit only PVC-jacketed cable and others fit only TEFLON-jacketed cable. Notice also that the stripping tools are suitable for either wrench-crimp or tool-crimp terminations.

The *Instant Apollo* catalog contains many more useful items in addition to those listed here. Please obtain a copy for the most complete and up-to-date information.

NOTICE: Although the information in these tables was current at the time of publication, we suggest that you consult your sales representative.

Table A-1. Apollo Token Ring Coaxial Cable

Spool Length	HP Part Number (PVC Cable Catalog Number)	HP Part Number (Teflon Cable Catalog Number)
1000 ft	K1516 (NET-COAX-PVC)	K1511 (NET-COAX-FEP
500 ft	K1515 (NET-COAX-PV-500)	K1513 (NET-COAX-FP-500)
250 ft	K1514 (NET-COAX-PV-250)	K1512 (NET-COAX-FP-250)

Table A-2. Apollo Token Ring Network Component Usage Matrix

Catalog Numbers	**BNC Connectors**					**DQC-100**
	Crimp On Tool Type		Solder On Wrench Type		Feed-Through	
	NET-BNC -FEPC	*NET-BNC -PVCC*	*NET-BNC -FEPW*	*NET-BNC -PVCW*	*NET-BNC-ADAP*	*DQC-100*
Coaxial Cables						
NET-COAX -PVC		✓		✓	✓	✓
NET-COAX -FEP	✓		✓		✓	✓
Assembly Tools						
NET-STRIP-2			✓	✓		
NET-STRIP-3	✓	✓				✓
NET-CRIMP	✓	✓				
NET-WRENCH			✓	✓		
Network Switch *NET-SWT*	Use with all cable and connector types.					
Cable Tag *NET-TAG*	Use with all cable types.					

Table A-3 and Table A-4 list cables and accessories for IEEE 802.3 networks.

Table A-3. IEEE 802.3 Standard Cable Network Components

Standard 802.3 Cable and Accessories	**Catalog Order Number (Apollo Model Number)**	
Standard Cable (preterminated with N-series connectors)	*PVC*	*TEFLON*
23.5-meter length (76.8 ft)	K1070 (ETH-BKBN-76P)	K1071 (ETH-BKBN-76T)
70.2-meter length (230.3 ft)	K1065 (ETH-BKBN-230P)	K1066 (ETH-BKBN-230T)
117-meter length (383.9 ft)	K1067 (ETH-BKBN-383P)	K1068 (ETH-BKBN-383T)
Standard Cable Reels (unterminated, 304.8 m/1000 ft)	K1062 (ETH-BKBN-1000P)	K1063 (ETH-BKBN-1000T)
Single-Device Transceiver	K1118 (ETH-XCVR-3C)	
Single-Device Transceiver with Diagnostic LEDs	K1111 (ETH-XCVR-DIAG)	
Multiport Transceiver	K1112 (ETH-XCVR-MPS)	
Multiport Thin Ethernet Repeater	K1098 (ETH-RPTR-9C)	
Local Repeater	K1097 (ETH-RPTR-2C)	
Fiber-Optic Repeater	K1095 (ETH-RPTR-FIBER)	
Transceiver Cables	*PVC*	*TEFLON*
5-meter length (16.4 ft)	K1109 (ETH-TXCVR-5MP)	K1110 (ETH-TXCVR-5MT)
10-meter length (32.8 ft)	K1105 (ETH-TXCVR-10MP	K1106 (ETH-TXCVR-10MT
20-meter length (62.6 ft)	K1107 (ETH-TXCVR-20MP	K1108 (ETH-TXCVR-20MT
N-Series Terminator — male	K1061 (ETH-BKBN-TERM-M)	
N-Series Terminator — female	K1060 (ETH-BKBN-TERM-F)	
N-Series Feedthrough — male	K1057 (ETH-BKBN-ADAP-M)	
N-Series Feedthrough — female	K1056 (ETH-BKBN-ADAP-F)	
Screw-on Connector (TEFLON) male	K1058 (ETH-BKBN-FEPW-M)	
Scew-on Connector (PVC) male	K1059 (ETH-BKBN-PVCW-M)	
Standard-to-Thin Adapter	K1077 (ETH-CBNC-THCK)	
Tapping Tool Kit (reusable — includes instructions)	K1104 (ETH-TOOLS)	

Table A-4. IEEE 802.3 Thin Cable Network Components

Thin Cable and Accessories	**Catalog Order Number (Apollo Model Number)**	
Thin IEEE 802.3 Cable (preterminated with BNC connectors)	*PVC*	*TEFLON*
5-meter length (16.4 ft)	K1084 (ETH-CXCVR-5MP)	K1085 (ETH-CXCVR-5MT)
10-meter length (32.8 ft)	K1080 (ETH-CXCVR-10MP)	K1081 (ETH-CXCVR-10MT)
20-meter length (62.6 ft)	K1082 (ETH-CXCVR-20MP)	K1083 (ETH-CXCVR-20MT)
50-meter length (164 ft)	K1086 (ETH-CXCVR-50MP)	K1087 (ETH-CXCVR-50MT)
1K-meter length (3280 ft)	K1102 (ETH-TCOAX-PVC)	K1100 (ETH-TCOAX-FEP)
Bulk Thin IEEE 802.3 Cable and accessories	*PVC*	*TEFLON*
1000 ft. reel	K1102 (ETH-TCOAX-PVC)	K1100 (ETH-TCOAX-FEP)
Crimp Thin Ethernet Connectors	K1074 (ETH-CBNC-PVCC)	K1073 (ETH-CBNC-FEPC)
BNC Crimping Tool	K1078 (ETH-CRIMP-TOOL)	
T-Connector Terminator **	K1076 (ETH-CBNC-TERM)	
T-Connector	K1075 (ETH-CBNC-TEE)	
Feed-thru	K1072 (ETH-CBNC-ADAP)	

** One T-connector is packed with each 802.3 Network Controller-AT.

Appendixes

Table A-5. Catalog Numbers for ATR-RNS Units, Software, and Accessories

Item	Catalog Order Number
ATR-RNS Unit Shipped with one 2.9 ft (90 cm) Jumper cables and rack-mount hardware	RNS-ATR
NTC Software	SFW-RNS-ATR
ATR-RNS Manuals	
Planning for the ATR-RNS	12798-A00
Installing Coaxial Cable and Accessories for an Apollo Token Ring Network	009860-A00
Using the Network Topology Control (NTC) Software	013419-A00
Accessories	
RS-232 Cables	
Direct Connect	
Male-male 10 ft (3 m)	PCI-232-MM10
Male-male 25 ft (7.6 m)	PCI-232-MM25
Male-male 50 ft (15 m)	PCI-232-MM50
Male-female 10 ft (3 m)	PCI-232-MF10
Male-female 25 ft (7.6 m)	PCI-232-MF25
Male-female 50 ft (15 m)	PCI-232-MF50
Null Modem	
10 ft (3 m)	PCI-232-NULL10
50 ft (15 m)	PCI-232-NULL50
Null-Modem Adapter* Male-female	PCI-NULL-ADAP
19-Inch (48 cm) Rack	
Wall Rack (for a single unit)	ITR-19RACK-WL
Vertical Floor Rack (for multiple units)	ITR-19RACK-FL

*Purchase an adapter to convert a direct connect cable to a null-modem cable.

Table A-6. IEEE 802.5 Cable Network Components

IEEE 802.5 Accessories	**Catalog Order Number (Apollo Model Number)**
Patch Cables:	
8 ft (2.55 m)	K1453 (ITR-CBLPATCH-8)
30 ft (9.14 m)	K1451 (ITR-CBLPATCH-30)
75 ft (23 m)	K1452 (ITR-CBLPATCH-75)
150 ft (46 m)	K1454 (ITR-CBLPATCH-150)
PC Adapter Card Cable	K1450 (ITR-CBL-PCADAP)
Modular Data Cables:	
7 ft (2.15 m)	K1449 (ITR-CBL-MOD-7)
14 ft (4.30 m)	K1447 (ITR-CBL-MOD-14)
25 ft (7.62 m)	K1448 (ITR-CBL-MOD-25)
Multistation Access Units:	
8-lobe MAU	K1457 (ITR-MAU-8)
4-lobe MAU	K1441 (ITR-AU-4)
Power Supply	K1444 (ITR-AU4-PS)
Distribution Panel *	K1458 (ITR-19PANEL)
Floor Mount Distribution Panel Rack *	K1459 (ITR-19RACK-FL)
* Shipped within 10-14 days ARO.	

Table A-7. ATR Twisted Pair Network Parts List

Part Name	Part Number	Apollo Direct Model Number	IBM Number
LWC	K2131	none	6091077
Distribution panel	K1458	ITR-19PANEL	8642520
Data connector	K1455	none	8310574
8 ft patch cable	K1453	ITR-CBLPATCH-8	8642551
30 ft patch cable	K1451	ITR-CBLPATCH-30	8642552
75 ft patch cable	K1452	ITR-CBLPATCH-75	6339134
150 ft patch cable	K1454	ITR-CBLPATCH-150	6339135
Type 1 adapater, BNC connector	K2120	CLB-BALUN-BNC	none
Type 1 adapter, D-subminiature connector	K2121	CBL-BALUN-DSUB	none
Type 1 faceplate		none	88310572
Type 1 faceplate surface mount		none	4760486
Type 2 faceplate		none	6091025
Type 2 faceplate surface mount		none	6091029
Equipment rack	K1459	ITR-19RACKFL	none
IBM Cabling System Planning and Installation Guide		none	GA27-3361
ATR-RNS	K1769	RNS-ATR	none
Type 1 PVC		none	4716748
Type 1 cable plenum		none	4716749
Type 1 outdoor cable		none	4716734
Type 2 PVC		none	4716739
Type 2 cable plenum		none	4716738
Type 6 PVC		none	4716743
Type 9 PVC		none	6339583

Appendix B

DFL–100 ATR Extension Fiber–Optic Cable Information

This appendix contains various important information for fiber–optic cable installations using the DFL–100, including cable ordering information, instructions for calculating attenuation in the fiber–optic cable, and fiber–optic cable installation guidelines. Use the DFL–100 with fiber–optic cable to extend an Apollo Token Ring network. See Chapter 4 for more information. The Apollo FDDI newtork uses fiber–optic cable but is different from the DFL–100 product. Fiber–optic cable used for a DFL–100 installation may not necessarily be suitable for a future upgrade to an Apollo FDDI installation.

B.1 Ordering Fiber–Optic Cable for the DFL–100

Table B–1, Table B–2, and Table B–3 list our approved cable (50/125 µm and 62.5/125 µm) and connectors for use with the DFL–100. The tables also list vendors and part numbers. *Because of the degree of precision required to properly attach fiber–optic connectors, we recommend that, whenever possible, you purchase cable already terminated for connection to the DFL–100 fiber interface unit.* Following Table B–3 is a list of vendors outside North America that carry the same cables.

NOTICE: Contact your local (HP) office regarding network services, including analysis, design, installation, and certification.

Our recommended cables are heavy–duty cables suitable for *outdoor* installations. However, these cables can be installed in interior locations in conduit, provided that no local or national (NEC) fire and smoke restrictions apply.

If you plan to run fiber-optic cable indoors, you may consider purchasing a light-duty cable. In this case, you must ensure that the fiber portion of the cable meets our "optical core" specifications (see Chapter 3 for specifications).

NOTICE: *None* of the cables listed in the following tables are suitable for interior locations where fire and smoke restrictions apply. Belden Wire and Cable also manufactures TEFLON-jacketed fiber-optic cable which meets fire and smoke regulations.

Table B-1. Recommended Belden Wire and Cable 50/125 μm DFL-100 Fiber-Optic Cables

Number of Fiber Channels	Type of Fiber	Belden Part Number for Cable Assembly (unique number for Apollo customers)	Belden Part Number (cable only)	Belden Part Number * Break-Out Kit
2	50/125	550023B**		Not Needed
2	50/125	550023Y*** Installation: burial	229657	Not Needed
4	50/125	550024B		Not Needed
4	50/125	550024Y Installation: burial/aerial	227414	229865
6	50/125	550025B		Not Needed
6	50/125	550025Y Installation: burial/aerial	227416	229865
8	50/125	550026B		Not Needed
8	50/125	550026Y Installation: burial/aerial	227418	229865
10	50/125	550027B		Not Needed
10	50/125	550027Y Installation: burial/aerial	227413	229762

* Breakout kits do not include connectors.
**"B" suffix denotes SMA connectors installed on both ends.
***"Y" suffix denotes SMA connectors installed on one end only.

For non-US locales, see the international addresses listed later in this section.
For equivalent TEFLON-jacketed cables, contact Belden at the number listed above.

Table B-2. Recommended Belden Wire and Cable 62.5/125 µm DFL-100 Fiber-Optic Cables

Number of Fiber Channels	Type of Fiber	Apollo Part Number (cable only)	Belden Part Number Break-Out Kit (not including connectors)*
2	62.5/125	DFL-Fiber-2	229597
4	62.5/125	DFL-Fiber-4	229739
6	62.5/125	DFL-Fiber-6	229739
8	62.5/125	DFL-Fiber-8	229739
10	62.5/125	DFL-FIber-10	229738

* Contact Belden for information about ordering cables with breakout kits and connectors attached. One breakout kit is required for each end of the cable.

For equivalent TEFLON-jacketed cables, contact Belden at the number listed above.

If you order unterminated cable, we recommend using the connectors listed in Table B-3.

Table B-3. Recommended DFL-100 Fiber-Optic Connectors

Vendor	Connector Type	Part Number
Optical Fiber Technologies Inc. Billerica, MA	905	252-RB2-5
	906	252-S-RB2-6
Augat Fiberoptics Pawtucket, RI	905	698-DSC-125-5
	906	698-JSC-125-6
AT&T Allentown, P.A.	ST Series*	P2000A-C-125

*ST Connectors attach to patch panels; 905 and 906 connectors attach to the DFL-100 unit.

Customers in the U.S.A. can order the cables listed in Table B–1 and Table B–2 using the following address:

U.S.A.

Belden Wire and Cable
100 Pennsylvania Avenue Suite 450
Framingham, MA 01701

Customers outside the U.S.A. can order the cables listed in Table B–1 and Table B–2 from the following vendors:

Europe

Belden Electronics GmbH
Fuggarstrasse 2
4040 Neuss 1
West Germany

Canada

White Radio Limited
940 Gateway Drive
Burlington, Ontario
Canada, L7L 5K7

Australia

Belden Electronics
Suite 11, 2 Claremont St.
South Yarra, Vic. 3141
Postal Address: P.O. Box 322
Clayton, Vic. 3168
Australia

You should also note that cable manufacturers produce fiber–optic cable segments with a *maximum length of 2 kilometers*. If you need to install a 3-kilometer length of fiber–optic cable, you must attach a 2–kilometer length to a 1–kilometer length. Rather than install connectors and bushings, we recommend that you splice the cable using a GTE Corporation elastomeric splice or equivalent. For more information about splice materials, contact the Network Services group or your local Field Service or Sales representative.

Ensure that the splice joint is properly protected and strain–relieved. When you test the cable and splice, the splice should contribute *less than a 0.5 dB loss* in the cable assembly.

B.2 Calculating Attenuation in the DFL–100 Fiber–Optic Link

In certain cases, you may need to calculate the attenuation in your DFL–100 link to ensure its operation. Attenuation results from the light wave's passage through connectors, splices, patch panels, and the cable itself. Plan to calculate attenuation if your DFL–100 link meets any *two* of the following criteria:

- Spans the maximum allowable distance
- Connects through a patch panel
- Contains more than one splice

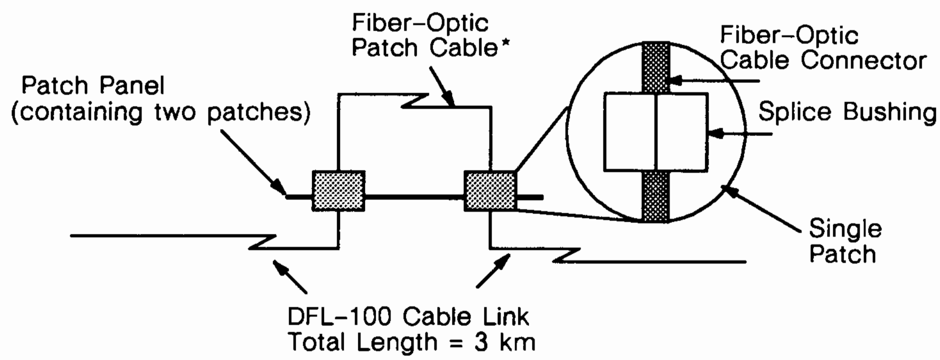
Table B–4 lists the data you need to calculate the loss over your link. The attenuation information about the fiber-optic cables we recommend is listed in the specifications in Chapter 3. Information about attenuation for connectors and splice materials should be provided by the component's vendor. You or our service person can use an optical power meter to measure attenuation over your link. (Our service person will test the link with an optical power meter before installing the DFL–100 fiber interface units.)

Table B–4. Attenuation Permitted in the DFL–100 Link

Cable Type	Maximum Loss Permitted through Cable, Connectors, Splices, and Patch Panels
50/125 μm	14 dB + 0 dB - 0.5 dB
62.5/125 μm	16 dB + 0 dB - 0.5 dB

Figure B–1 and Figure B–2 contain examples that show how to use the information in Table B–4 and the cable and component specifications to calculate loss in several types of DFL–100 links.

NOTICE: The values for dB loss through the patch panel and splices in Figure B–1 and Figure B–2 do *not* represent the average loss through these connections; the losses vary with the connector type and manufacturer.



For a 50/125 μm cable link that includes two patch connections, the equation is:

$$14.0\ \text{dB} \geq \text{cable length in km} \times \frac{4.0\ \text{dB}}{\text{km}}^{**} + \text{no. of patches} \times \text{dB loss per patch}$$

This equation with sample values is:

$$14.0\ \text{dB} \geq 3.0\ \text{km} \times \frac{4.0\ \text{dB}}{\text{km}} + 2 \times \frac{1.0\ \text{dB}}{\text{patch}}$$

$$14.0\ \text{dB} \geq 14.0\ \text{dB}$$

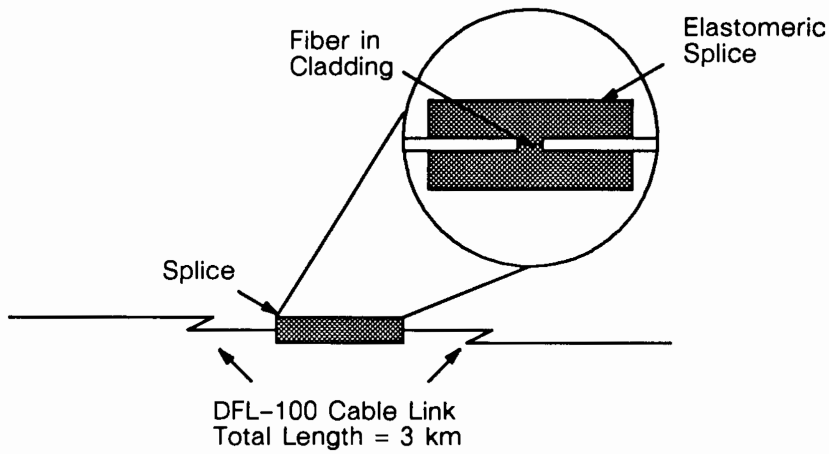
In this case, the patch connection does *not* increase the loss above the maximum.

* The patch cable type *must* match the link cable type.

** Maximum attenuation of cable at 850 nm, as specified.

Figure B–1. Sample Attenuation Calculations for DFL–100 Link with Patch Panel

If your calculations reveal that loss over your link exceeds the maximum, you must correct for the loss by installing connectors/splices with lower losses, or install a separate fiber–optic link for the DFL–100.



For a 62.5/125 µm cable link that includes several splices, the equation is:

$$16.0 \text{ dB} \geq \text{cable length in km} \ \frac{5.0 \text{ dB}}{\text{km}}^{*} + \text{no. of splices} \times \text{dB loss per splice}$$

This equation with sample values is:

$$16.0 \text{ db} \geq 3.0 \text{ km} \ \frac{5.0 \text{ dB}}{\text{km}} + 6 \times \frac{0.5 \text{ dB}}{\text{splice}}$$

$$16.0 \text{ db} \geq 18.0 \text{ dB}$$

In this case, the splices *increase* the loss above the maximum.

*Maximum attenuation of cable at 850 nm, as specified.

Figure B–2. Sample Attenuation Calculations for DFL–100 Link with Splice

If your link has not yet been installed, contact your fiber–optic cable manufacturer for more information about the attenuation through the cable. The manufacturer may be able to guarantee a lower loss than the maximum in our specification (see Chapter 3).

B.3 Fiber–Optic Cable Installation Guidelines

Ensure that your installers follow these basic guidelines regardless of the location of your installation or the method used to install the cable:

- *Test* the cable (for optic continuity and attenuation) while it is on the reel *and* after installation. In this way, you will know the cable was not damaged during installation.

- Do *not* pull on the fiber. Use a pulling method that pulls on the strength member of the cable. Note the location of the fiber within the cable and identify the strength member.

- Adhere *strictly* to the cable manufacturer's bend radius limits. Avoid tight loops, kinks, knots, and bends in the cable. (See Chapter 3 for bend radius limits for our approved cables.)

- Use a tension meter to monitor the cable pull tension. The meter should be sensitive to relatively low values. *Do not exceed recommended maximum load.*

- Clamp or secure cables in *vertical* raceways or ducts so that the cable weight is not supported only at the top. In outdoor locations, clamp cables at 3–ft intervals to avoid wind slapping and ice loading. Indoors, clamp cables at 50– to 100–ft (15.2– to 30.5–m) intervals.

- For installations of terminated cable assemblies, use enclosures to protect the connectors during pulling. *Do not pull on connectors or breakout kits.*

- Although heavy–duty cables are designed for burial, you may consider installing polyethylene gas pipe to form a conduit. This conduit provides added protection against environmental hazards such as crushing forces from rocky soil, damage by rodents, and freezing water inside the cable. (In contrast to an electrical conductor, no heat is generated by the light wave rays traveling on the fiber).

- For conduit installations, consider using a lubricant to minimize tensile forces on the cable. *Check the compatibility of the lubricant and the fiber–optic cable insulation.* Lubricants traditionally used in pulling electrical cable may chemically attack the fiber–optic jacketing.

- If you plan to use existing ducts to route the fiber–optic cable, ensure that the ducts are free of debris.

- Where the cable enters the building, clamp or secure fiber–optic cables to baseboards or walls. *Do not* lay unprotected fiber–optic cable over the floor where people may step on the cable and equipment may roll over it.

Appendix C

Network Controller Summary

This appendix contains a summary of the network controllers used in Apollo nodes.

C.1 Summary of Network Controller Information

Table C–1 summarizes the network controllers currently available for Apollo nodes, and lists the physical limitations of the various bus types. Although the information in this table was current at the time of publication, we suggest that you ask your sales representative for the latest information on nodes, network controllers, and software requirements (including minimum software release requirements).

Table C-1. Network Controller Summary

Node Type	Bus Type	Network Type	Network Controller Product Name
DN2500 DN3XXX DN4XXX DSP3XXX DSP4XXX	AT Compatible	ATR	Apollo Token Ring Network Controller–AT (Earlier systems also use a 2–slot version of this controller board.)
	AT Compatible	IEEE 802.3	802.3 Network Controller–AT
	AT Compatible	IEEE 802.5	802.5 Network Controller–AT
DN10000	VME	ATR	Apollo Token Ring Controller–VME
	VME	IEEE 802.3	Hi–Performance 802.3 Network Controller–VME
	AT Compatible	IEEE 802.5	802.5 Network Controller–AT
	X	FDDI	Series 10000 FDDI Network Controller

Node Type	Maximum Controller Configuration
DN2500	One controller (ATR, IEEE 802.3 , or IEEE 802.5).
DN3XXX/DN4XXX	Up to 4 controllers total, maximum of 2 of any given type (ATR, IEEE 802.3, or IEEE 802.5)
DN10000 (AT compatible)	Up to 2 IEEE 802.5 controllers total.
DN10000 (VME)	Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3
DN10000 (Xbus)	1 FDDI controller

Appendix D

Planning Checklists

D.1 Network Planning Checklist

This checklist outlines customer tasks in the order in which they should be performed. Use it to organize a timetable and to record the steps you take to plan and prepare your site for the network.

Assess Your Needs

- ☐ Inventory your current equipment to determine what you will connect in your new network.
- ☐ Obtain a diagram of the current cabling system, if any.
- ☐ Evaluate your current and planned applications.
- ☐ Analyze your organization's growth plan.
- ☐ Determine the number of users the network will initially support.
- ☐ Determine the geographic area to be covered by the network.
- ☐ Establish your price/performance goal.
- ☐ Determine your organization's requirements for adherence to standards.

Choose the Network Configuration

- ☐ Evaluate the abilities of the IEEE 802.3, IEEE 802.5, FDDI, and the Apollo Token Ring networks to meet your applications' requirements and other needs (see Chapter 2).
- ☐ Consider the degree of modularity required within each network.

- ☐ Serial–wired or star–wired Apollo Token Ring Network (see Chapters 2, 3, and 4)

- ☐ Segmented IEEE 802.3 network (see Chapters 2, 8, and 9)

☐ Evaluate the internet configuration options (see Chapters 2, 11, and 12).

Design a Preliminary Layout

☐ Obtain blueprints of the office/lab/work area layout.

☐ Obtain electrical wiring diagrams.

☐ Draw a preliminary cable layout diagram, using a diagram of the current cabling system, if applicable (see Chapters 3 and 4 for Apollo Token Ring, Chapter 6 and 7 for FDDI, Chapters 8 and 9 for IEEE 802.3, and Chapter 10 for IEEE 802.5).

☐ Plan the network control room/area (see Chapter 4 for Apollo Token Ring, Chapter 7 for FDDI networks, Chapter 9 for IEEE 802.3 networks, and Chapter 10 for IEEE 802.5 networks).

☐ Determine the environmental requirements of the nodes and peripherals (see *Domain Hardware Site Planning Specifications*.)

☐ Plan node and peripheral locations.

Plan for Efficiency/Reliability/Manageability

☐ Examine the layout diagram for network traffic patterns, resource use, and potential bottlenecks.

☐ Evaluate the available disk space and the speed/capacity of the file backup devices.

☐ Check critical resources that may need duplication/redundancy.

☐ Identify and eliminate single points of failure.

Produce the Final Layout Diagram

☐ Work with your cable installer to produce the final layout diagram.

Order The Hardware

☐ Order specified network cables, connectors, and other devices (see Appendix A for ordering information).

☐ Ascertain the delivery times for the nodes and peripherals, and order accordingly.

D.2 Internet Planning Checklist

This checklist outlines customer tasks in the order in which they should be performed. Use it to organize a timetable and to record the steps you take to plan and prepare your site for the network.

Several Months Before Installation

- ☐ Decide *how* you will connect your networks. Decide on:
  - ☐ Types of routing and/or gateway nodes and network controller types.
  - ☐ Standard software release for routing and gateway nodes.
  - ☐ Standard software release for other nodes in the internet.
  - ☐ Point-to-point link medium (if applicable).
- ☐ Draw a preliminary Internet Diagram. If you plan to partition an existing network, plan how you will:
  - ☐ Recable IEEE 802.5, FDDI, and Apollo Token Ring networks.
  - ☐ Section the cable segments in IEEE 802.3 networks.
- ☐ Order all hardware and software.
- ☐ Arrange for installation of point-to-point link medium (if applicable). Arrange for T1 service (if applicable).

Several Weeks Before Installation

- ☐ Arrange the hardware and software resources in each network in the internet. Make sure that each network has:
  - ☐ Printers and storage media.
  - ☐ All required software, e.g., source nodes, database source files and help files, program libraries, and insert files.
- ☐ Consult *Managing Domain/OS and Routing in an Internet* for information about staging a Domain internet installation.
- ☐ Consult *Configuring and Managing TCP/IP* for information about staging a TCP/IP internet installation.
- ☐ Update all nodes participating in the internet to the appropriate standard release.
- ☐ Install the point-to-point link (if applicable).

- ☐ Install and test the T1 equipment (if applicable).
- ☐ If you intend to connect your TCP/IP internet to the ARPANET, contact the Network Information Center at SRI International, 333 Ravenwood Ave, Menlo Park, CA. 94025, to obtain an offical IP network address.

Several Days Before Installation

- ☐ If you are partitioning an existing network, make sure that your preparations are complete so that you can quickly separate the networks when you are ready to start the routing and gateway nodes.
- ☐ Make *sure* that the routing and gateway nodes (or their disked partners) have been updated to the appropriate standard release.
- ☐ For Domain internets, decide on your network numbers. Call 1–800–2–Apollo (1–800–227–6556) if you want to obtain unique network numbers from us. (Outside North America, contact your Apollo representative.)
- ☐ For TCP/IP internets, select names and addresses for each TCP/IP host and create your /etc/hosts file and other administrative files (see *Configuring and Managing TCP/IP*).
- ☐ For TCP/IP internets, install the TCP/IP administrative files on all TCP/IP administrative nodes (see *Configuring and Managing TCP/IP*).
- ☐ Update your preliminary Internet Diagram with the network numbers and place a copy at each routing and gateway node.
- ☐ Place copies of *Managing Domain/OS and Routing in an Internet* and *Configuring and Managing TCP/IP* at each routing and gateway node.

One Day Before Installation

- ☐ Update each network's master topology list and your network layout diagrams (see *Managing Domain/OS and Routing in an Internet*, *Configuring and Managing TCP/IP*, and *Managing Aegis System Software*, *Managing BSD System Software*, or *Managing SysV System Software*).

On Installation Day

- ☐ Consult the network controller installation manuals to install and test the network controllers in the routing and gateway nodes.
- ☐ Consult *Managing Domain/OS and Routing in an Internet* for procedures to start your Domain internet(s).
- ☐ Consult *Configuring and Managing TCP/IP* for procedures to start your TCP/IP internet(s).

Glossary

Terms in **bold** type that appear in the definitions are also defined in this glossary.

Access Method

A technique for determining which **node** will be the next with the right to transmit over a shared medium.

Active Node

A node that is electrically and logically connected to the network. Nodes are connected to the network through a set of relays. Nodes are considered active when these relays are connected to the network and the node is receiving, reclocking, and transmitting data. Typically, these relays are connected when a node is running the operating system; however, the relays are also connected while the node is executing certain diagnostics from the **Mnemonic Debugger (MD)** program. The relays *bypass* the network when a node is logically disconnected with the **netsvc -n** command, sitting idle in the MD, or powered off. A node in this condition is considered *inactive*.

Adaptive Routing

In an **internet**, the process by which **routing nodes** determine the shortest transmission path for **packets** traveling between networks.

Alternate Network

In an **internet**, any network other than the one the **routing node** boots on. Each routing node connects to at least two networks. The routing node boots on its **principal network**; all other connected networks are alternate networks.

ANSI

The American National Standards Institute, a non-profit organization, made up of various expert committees, that publishes standards for use by national industries. ANSI has adopted the **IEEE** standards for **local area networks**.

ANSI/IEEE 802.3 Standard for Local Area Networks

A set of specifications for a **CSMA/CD** network, developed by the **IEEE** 802.3 committee and adopted by **ANSI**. The specifications include network **protocol** and hardware specifications.

Apollo Network

A network that provides Domain **distributed system** services. At present, this includes **Apollo Token Ring networks, IEEE 802.3** and **IEEE 802.5 networks**, and **FDDI networks**.

Apollo Token Ring Network

A 12-megabit-per-second **LAN** developed by Apollo Computer Inc., which uses a **token** to control access to the network by resident **nodes**.

AT&T ACCUNET T1.5 Digital Service

Data transmission service, developed by AT&T, that employs a **common carrier** service to transmit data over a wide geographic area.

Attachment Unit Interface (AUI)

A **transceiver** cable that conforms to IEEE 802.3 specifications.

Attenuation

A decrease in magnitude of current, voltage, or power in a signal in transmission. Attenuation is expressed in decibels or nepers.

Backbone

The principal network **segment** to which all **nodes** are connected, or to which other **segments** are connected.

Baseband Coaxial Cable

A two-conductor (signal and reference), common axis, high-frequency transmission medium that transmits over a single frequency band. Baseband signals are generally transmitted in digital form as voltage pulses.

Boot

Short for **bootstrap service**.

Bootstrap Service

A service provided by a short program, stored in the node's read-only memory, that loads the operating system (or any complex program) into a node's main memory. **Partner nodes** provide bootstrap service to **diskless nodes**.

Bridge

A device that physically connects two or more networks by relaying packets between the data link layers of the different physical media.

Broken Link Detection

A feature of the Apollo Token Ring network that allows a **downstream** node to detect the absence of a coherent signal from its **upstream** neighbor, and initiate a failure report.

Bus Network

A **topology** in which **nodes** tap into a common transmission medium and data propagates in both directions.

Bypass

A mechanism to avoid sending data to a faulty device or portion of the network.

CCITT

The Consultative Committee for International Telephone and Telegraph. An advisory committee established under the United Nations that is attempting to establish standards for inter–country data transmission on a world–wide basis.

Carrier Sense Multi–Access with Collision Detection (CSMA/CD)

A type of network **access method**, where **nodes** monitor the network and transmit **packets** when they sense a clear **channel**, and register **collisions** when they occur.

Cascaded

Nodes or other devices connected in a branching arrangement, where each device is a connecting point for a group of other devices.

Channel

A single path for electrical or optical transmission between two or more points.

Coaxial Cable

See **Baseband Coaxial Cable**.

Collision

A simultaneous transmission by two or more nodes over a common medium that results in destruction of the messages.

Common Carrier

An organization licensed to provide service that utilizes public resources, such as highways and airways. In the networking context, common carriers provide transmission services over airwaves or telephone lines.

Configuration

The arrangement of a computer system or network as defined by the nature, number, and the chief characteristics of its functional units. More specifically, the term configuration may refer to a hardware configuration or a software configuration.

CSMA/CD

See **Carrier Sense Multi–Access with Collision Detect**.

Data Packet

See **packet**.

Data Terminal Equipment (DTE)

The equipment that supplies and/or accepts data signals over a common transmission medium.

Diskless Booting

Loading the operating system into local memory from another **node's** disk.

Diskless Node

A **node** that does not contain a storage disk option, or is not directly connected to a storage disk unit. Diskless nodes must boot the operating system from another node's disk.

Distributed System

A computer system in which computing, storage, and other resources are dispersed throughout several or many locations.

Domain Internet

A system of two or more **Apollo networks** connected by **routers**.

Cross-Connect block

A termination block for twisted pair cabling that routes many wire pairs through a central location.

Downstream node

The **node** in an **Apollo Token Ring network** that is next in line to receive the **token**. See **Upstream Node** for contrast.

DTE

See Data Terminal Equipment.

Dual Attachment Concentrator (DAS/CON)

A dual attachment concentrator serves as an interface between the dual-ring FDDI network and the single attachment stations and concentrators.

Dual Attachment Station (DAS)

An FDDI station that connects directly to both rings of the FDDI network. A DAS has the potential to transmit and receive data on either ring, or on both rings simultaneously.

Duplex Fiber-Optic Cable

A fiber-optic cable that contains two fibers, one for transmitting data and one for receiving data.

Ethernet

A 10 Mbps **LAN**, developed by Digital Equipment Corporation, Intel, and Xerox Corporation, upon which the **IEEE 802.3 network** is based.

EtherTwist

A 10 Mbps **LAN** that runs over twisted pair cabling and is compatible with 10BaseT and Ethernet networks.

Fan-Out Configuration

A **topology** in which many device connections radiate from a single control unit or device.

FDDI

The Fiber Distributed Data Interface (FDDI) is a specification for a high-speed, fiber-optic ring network.

Full-Duplex

The capability to transmit in both directions simultaneously.

Gateway

Software that permits communication between two networks that use different **protocols**. A gateway translates packets from one protocol type to another and **routes** packets to their destination address. In internets, a single Domain node, properly equipped, may provide both Domain **internet** routing service and gateway service.

Ground Loop Current

A current flowing on the ground circuit. This current causes instability and errors.

Heartbeat Test

A short test signal generated by a transceiver to verify that the transceiver sent the data **packet**.

Heterogeneous Network

A network composed of dissimilar **host** computers, such as those of different manufacturers. See **Homogeneous Networks** for contrast.

Homogeneous Network

A network composed of similar **host** computers, such as those of one model or one manufacturer. See **Heterogeneous Networks** for contrast.

Hop

A data **packet**'s passage through a **routing** or **gateway node** on its way to its final destination.

Hub

A repeater used to connect several nodes in a local area network. A hub is a concentration point for data and repeats data from one node to all other connected nodes.

IEEE

The Institute of Electrical and Electronics Engineers. A national association, whose activities include publishing standards applicable to various electronic technologies. The IEEE technical committees are numbered and grouped by area. For example, the 800 committees study **local area network** technologies. The 802.3 committee produced the standard for a **CSMA/CD** local area network, which has been adopted by **ANSI.**

IEEE 802.3 network

A 10-megabit-per-second **LAN**, described by the **ANSI/IEEE 802.3 Standard for Local Area Networks**, which uses a **CSMA/CD** network access method.

Internet

A group of two or more networks that are connected by **routers** or TCP/IP **gateways**. A **Domain internet** is a system of two or more **Domain networks** connected by routers, whereas a **TCP/IP internet** is a system of two or more **Heterogeneous networks** connected by TCP/IP gateways.

Jabber

Continuous transmission from a faulty device. Jabber caused by a single transceiver can interrupt communications on an IEEE 802.3 network.

LAN

See **Local Area Network.**

LED

Light Emitting Diode, a semiconductor chip that emits light when activated. LEDs are commonly used as visible indicators to inform users that various components in a computer system or other electronic device are functioning.

Link Segment

In an IEEE 802.3 network, a **point-to-point link** terminating in a repeater set. No **nodes** can be attached to a link segment.

Local Area Network (LAN)

A data communications system that allows a number of independent devices to communicate with each other.

Local Network

The network to which a **node** is directly attached.

Local Repeater

A device for connecting two standard IEEE 802.3 cable **segments.**

Loop

A section of an **Apollo Token Ring network** where the data flow is controlled by a **network switch.**

MAU

See **Multistation Access Unit.**

Media Interface Connector (MIC)

The connector used to attach dual-attachment FDDI stations to the network's fiber-optic medium.

Medium Attachment Unit (MAU)

In an IEEE 802.3 network, a device for connecting nodes to the network that meets IEEE 802.3 specifications. The terms MAU and **Transceiver** are synonomous.

Multistation Acess Unit (MAU)

In an IEEE 802.5 (IBM Token Ring) network, a MAU is a wiring concentrator used to attach user devices to an IEEE 802.5 network.

Mnemonic Debugger (MD)

A low-level debugging facility that provides a set of commands and utility programs.

Network Architecture

The set of principles, including the organization of functions and the description of data formats and procedures, that governs the design and implementation of a user–application network.

Network Controller

A printed circuit board that passes bit streams between the network and the **node's** main memory. Coupled with the network **transceiver**, the controller also handles signal processing, encoding, and network media access.

Network Control Room

The room or area that serves as network administrative and management headquarters. The room usually contains network control hardware and network monitoring and analyzing devices.

Network Number

In a Domain **internet**, a unique, 8–digit (32–bit) hexadecimal number that identifies a Domain network.

Network Registry

A distributed database that identifies legitimate users of an **Apollo network**.

Network Switch

A device in a **star–wired Apollo Token Ring network** that opens/closes the data path to a network **loop**.

Node

Any point in a network where services are provided or communications channels are interconnected. A node could be a **workstation** or a **server processor**.

Optical Repeater

A **repeater**, equipped with fiber–optic cable connectors, that connects IEEE 802.3 cable **segments** through fiber–optic cable.

Packet

A sequence of binary digits that is transmitted as a unit in a computer network. A packet usually contains control information plus data.

Paging

The process of transferring sections of code or data into and out of main memory. A node might page a large file from the source node; a **diskless node** pages operating system code from the **partner node**.

Partner Node

A **node** that contains a disk option or is directly connected to a disk unit that supplies operating system services to a **diskless node**.

Peripheral Bus

In a **node**, the hardware interface, to which a number of device controllers may be connected, that manages data flow between the devices and the node's processor and storage.

Point–to–Point Link

A transmission path established for the purpose of connecting exactly two devices.

Port

A software access point for data entry or exit to a network controller.

Principal Network

The network on which a Domain **node** boots.

Propagation Delay

Slowing of signal transmission, often produced by electrical resistance in a transmission medium or device.

Protocol

A specification for coding messages exchanged between two communications processes.

Redundancy

Duplication of service. Networks can provide redundancy to increase the probability that communications can continue despite various failures.

Remote

Not directly connected or processed at another location.

Repeater

A device that receives, restores, and retimes signals from one **segment** of a network, and passes them on to another segment. Both segments must have the same type of transmission medium and share the same set of **protocols**, so that the repeater is not responsible for any translations.

Routing Process

The software process that controls the transmission of packets between networks. A routing process manages data transfer bewteen networks, maintains information about the **internet topology**, and supplies nonrouting nodes with information about the internet topology.

Routing Node

A **node** that is able to transmit **packets** between similar networks. A node that transmits packets between dissimilar networks is called a **gateway**.

Routing Service

Same as **Routing Process**.

Segment

In a **bus network**, segments are electrically continuous pieces of the bus, connected by **repeaters**. A segment is any length of LAN cable terminated at both ends. For twisted pair cables, count the total length between a hub and a node (including cable between a wall jack and the node and between a cross-connect block and the hub).

Serial-Wired Ring

A **local area network** in which **nodes** are connected in a single, unidirectional, closed transmission path.

Server Processor

A **node** that provides a specific service to a network. Examples include **routing** servers, **gateway** severs, print servers, terminal servers, and file servers.

Signal Quality Error (SQE)

An error condition reported by **transceivers** conforming to the IEEE 802.3 specification for **medium attachment devices**.

Single Attachment Station (SAS)

A station in an FDDI network that connects to only one of the two FDDI network rings. A SAS must attach to the network through a concentrator.

Single-Device Transceiver

A device for connecting a single **node**, **repeater**, or **multiport transceiver** to **standard** IEEE 802.3 network **cable**.

SNA

System Network Architecture, the networking system designed by IBM.

SQE

See **Signal Quality Error**.

Standard IEEE 802.3 Cable

A 50-ohm baseband coaxial cable, marked at 2.5-m (8.2-ft) intervals for use in an IEEE 802.3 network.

Star-Wired Apollo Token Ring Network

An Apollo Token Ring network whose cabling system is divided into **loops**. Each loop is terminated in a **network switch**, which opens/closes data paths to the loop.

Station

Short for **workstation**, computer, or terminal that provides computational services and is attached to a **local area network**. Also called a **node**.

ST Connector

A connector frequently used in fiber-optic networks to connect either dual- or single-attach stations.

System Administrator

The person who oversees network maintenance/operation.

Tap

An electrical connection permitting signals to be transmitted onto or received from a **bus network**.

TCP/IP Internet

An **internet** made up of networks containing dissimilar host computers that can commumicate with each other using TCP/IP protocols.

Thin IEEE 802.3 Cabling System

A lightweight, low-cost cable connecting **nodes** in an **IEEE 802.3 network**.

Token

A small bit pattern that circulates around a network. Ownership of the token enables a **node** to transmit over the network medium.

Topology

The physical and logical geometry governing placement of **nodes** in a computer network. Also, the layout of the transmission medium for a network.

Topology Determination

A feature of the Apollo Token Ring network that allows each node in the network to determine the order in which all other nodes are joined in the network.

Transceiver

A device that transmits and receives signals.

Transmission Control Protocol and Internet Protocol (TCP/IP)

A standard protocol, defined by the Defense Advance Research Projects Agency (DARPA), that provides communication services to different host computers over a variety of physical networks.

Universal Data Connector

This connector provides access to the IBM Cabling System using standard modular data and telephone company products. It has an IBM Data Connector on one end of the connector and an RJ11 modular connector on the other end.

Upstream Neighbor

The **node** in an **Apollo Token Ring network** that has most recently received the **token** and/or transmitted a data **packet**. See **Downstream Node** for contrast.

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