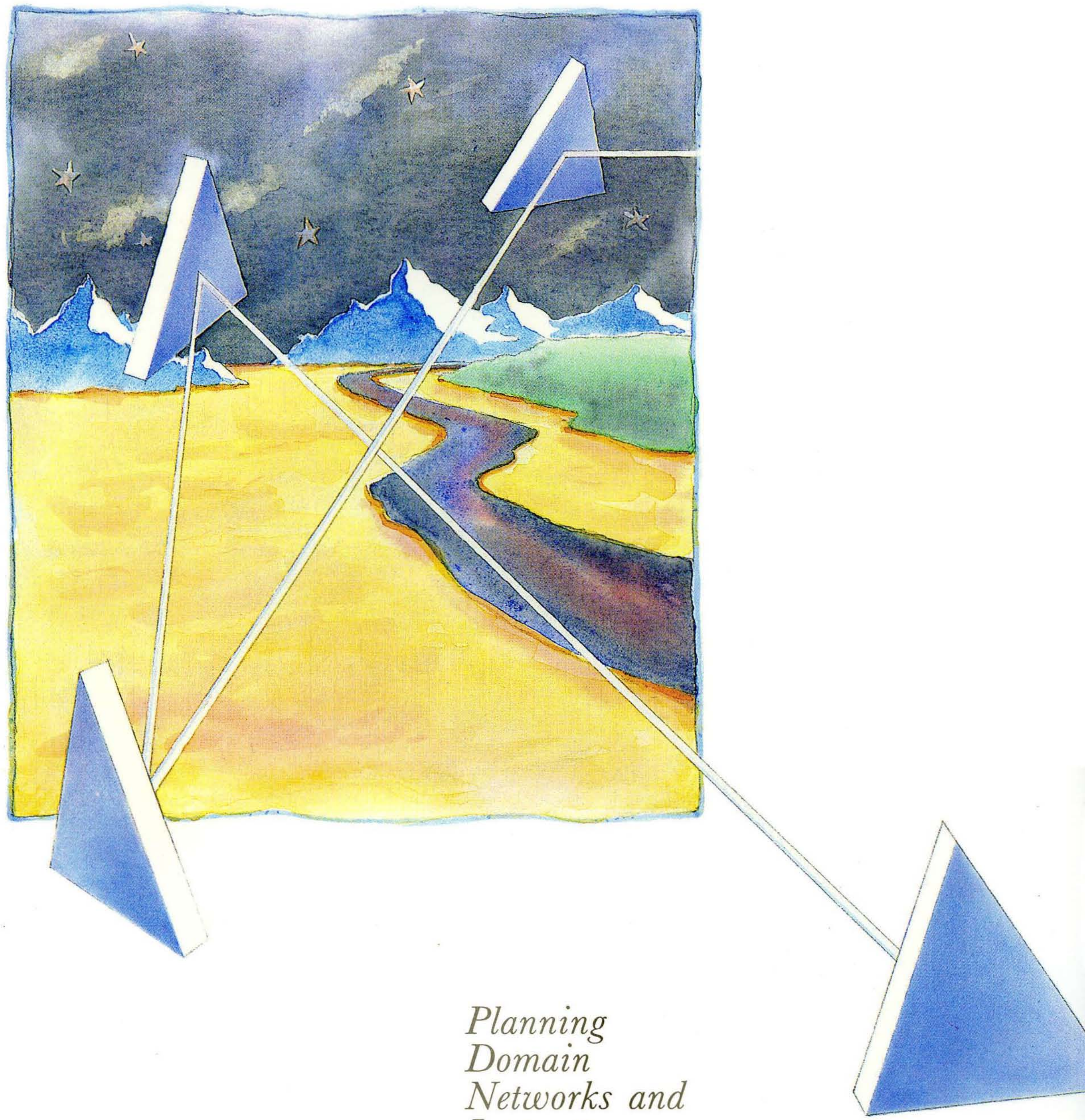

# *Planning Domain Networks and Internets*

*009916-A00*

apollo

# Planning Domain Networks and Internets

Order No. 009916-A00

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# Preface

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

This manual supersedes the following manuals:

- *Planning and Preparing a DOMAIN System Site*
- *Planning Domain Internets*
- *Planning for TCP/IP*

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 Domain 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 IEEE 802.3 network cables and accessories. |

| | |
|---|---|
| **Chapter 6** | Describes the basic configuration rules to consider when planning an IEEE 802.3 network installation. |
| **Chapter 7** | Describes the hardware used to connect networks in an internet. |
| **Chapter 8** | 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 Domain 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 SR10.0 refer to **/install/doc/apollo/os.v.10.0_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 *Domain 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 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 IEEE 802.3 networks, see *ANSI/IEEE Standard 802.3 for Local Area Networks* (FIPS PUB 107).

For more information about Apollo network and internet controllers, see *Installing the 802.3 Network Controller–AT* (009741), *Installing the Apollo Token Ring Controller–AT* (010616), *Unpacking and Installing the Domain/Bridge Controllers* (005697), and *Unpacking and Installing the EtherController–MB* (008265).

For a complete listing of network cables and accessories that we sell, see the *Instant Apollo* catalog. In North America, call Apollo Customer Services at 1–800–2–APOLLO (1–800–227–6556).

## Networking Terminology

Throughout this manual, you will see terms in **boldface** that refer to Domain networks or networking in general. These terms are usually defined when they first appear in the text, but are also defined in the Glossary at the back of the manual. (System command names also appear in lowercase bold type.)

## 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 SysV environment)

% **man mkapr** (in the BSD environment)

$ **help mkapr** (in the Aegis environment)

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. |
| ——— 田 ——— | This symbol indicates the end of a chapter. |

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## Chapter 2 Introduction to the Domain Network

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# Chapter 1

# Network Planning Goals and Responsibilities

Domain 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. 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 are

- 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.

These are *generic* goals; they apply *not only* to Domain networks, but to *all* the computer networks that serve an entire organization. The following sections elaborate on these goals, and provide basic guidelines for implementing them in your network.

## 1.1 Designing in Adaptability

Contemporary networks must accommodate growth and change. They must allow you to introduce new elements (e.g., 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 r*esource demands grow and change.

A modular network design also adapts easily to changing **configurations**. For example, failures in one or more groups can interrupt data flow, or you may need to temporarily partition the network for testing or other purposes. In a modular network, network operation can continue over alternate data paths.

## 1.2 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/subtract resources if needs change.

## 1.3 Tailoring the Network for Your Applications

Today, it is common for a network to support office automation, accounting, and business/project management 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 should also be able to determine the resource and data storage capacity needs of each application, as well as the application traffic patterns.

## 1.4 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 **network architecture**, such as the Domain system, that supports multiple users. We have discussed how an open network can adapt to growth and support 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.

In general, hardware costs 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.

## 1.5 Planning Responsibilities

As a network planner, it is your responsibility to plan your Domain 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 Chapters 3 and 5 for descriptions; see Appendixes A and B for ordering information.)
- Ensure that your site meets the environmental and electrical standards required for Domain 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 (formerly known as the *Domain System User 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

# Introduction to Domain Network Configurations

This chapter introduces Domain network configurations, topologies, transmission media, and connection devices. Table 2–1 at the end of the chapter summarizes the Domain network options currently available for our workstations and servers.

## 2.1 General Information about Network Configurations and Services

A Domain network provides complete computing resources and transparent access to all Domain nodes on the network. In addition, a Domain network provides access to non–Domain nodes and resources.

A Domain network can be configured as

- A single **Local Area Network (LAN)** — We currently support communications on two 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**.

  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 Domain or non–Domain networks in a local area or between widely separated areas (sites in different states, for example).

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

- Transparent information sharing among Domain nodes
- Distributed processing, including remote procedure call for Domain and non–Domain nodes
- Network device sharing, allowing multiple protocols, such TCP/IP, to share a single network controller.
- Diskless booting and remote paging for Domain 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–Domain systems

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

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* ETHERNET is a registered trademark of the Xerox Corporation.
**The ANSI/IEEE Standard is FIPS PUB 107.

As you read this chapter, keep in mind the number of nodes and other devices that you plan to connect in your Domain 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.

## 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 encoding of bits passed from one node on the ring to the next.

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. Because nodes must release the token after they complete a transmission, all the nodes on the network always 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 Domain node can create a map of the network topology (i.e., 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/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, The Star–Wired Ring).

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 newtork configurations are discussed:

- Serially–wired ring
- Star–wired ring
- Extended ATR using a Domain Fiber–Optic Extension (DFL–100)

### 2.3.1 The Serially–Wired Ring

The serially–wired ring contains nodes connected in a serial fashion. The serially–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.

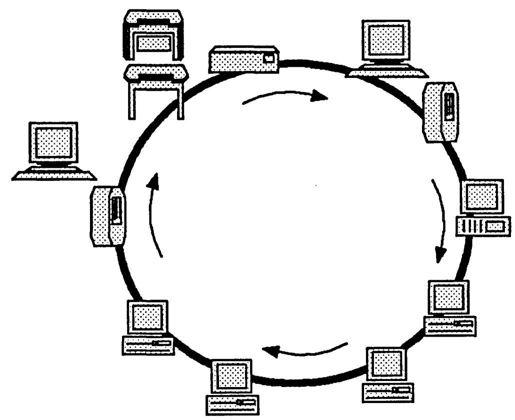

*Figure 2–1. Serially–Wired Apollo Token Ring Network*

## 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 a **network switch** as it enters and exits each loop.

The network switch allows you 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.

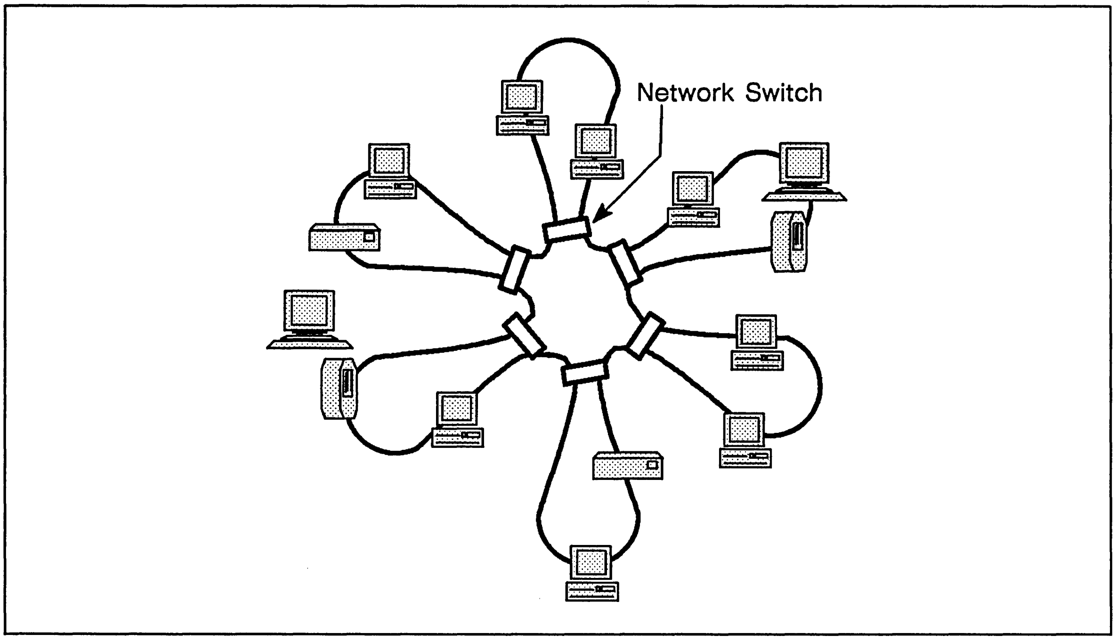


*Figure 2–2. Star–Wired Apollo Token Ring Network*

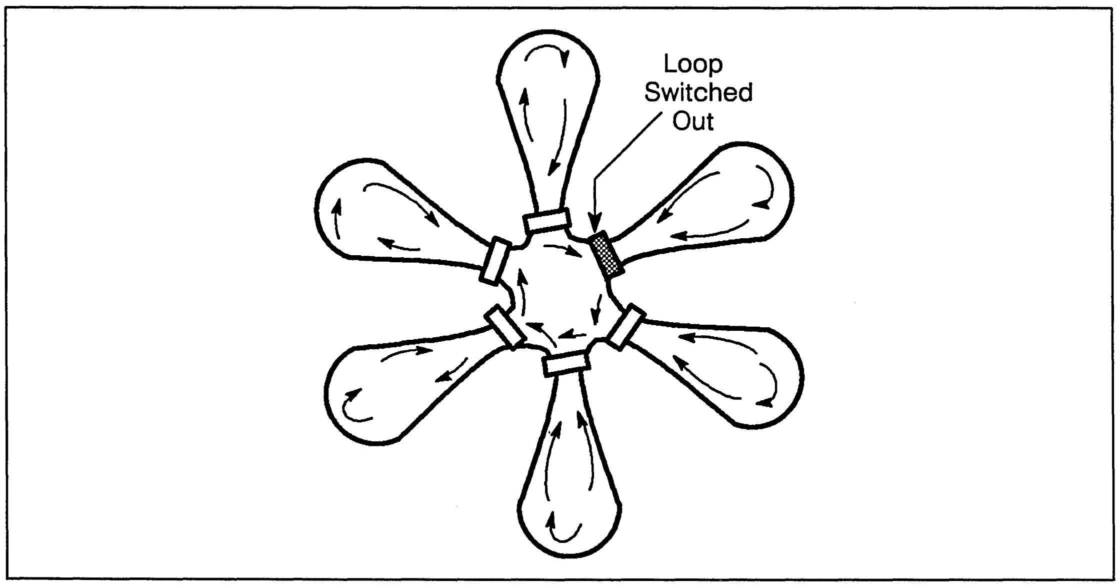


*Figure 2–3. Star–Wired Apollo Token Ring Network*

To design a ring to cover a larger area such as a multi–story 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.

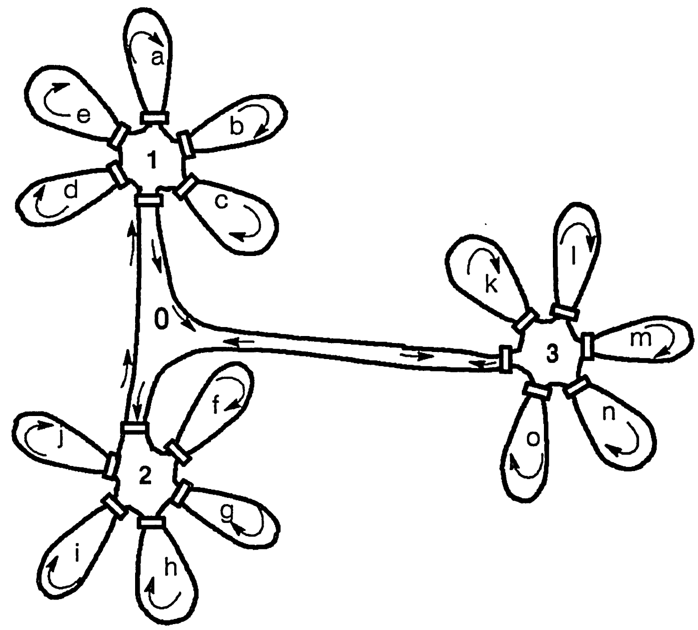


*Figure 2–4. Several Connected Star–Wired Configurations*

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 (e.g., 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

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.

Fiber-optic cable is strongly recommended for inter-building 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.

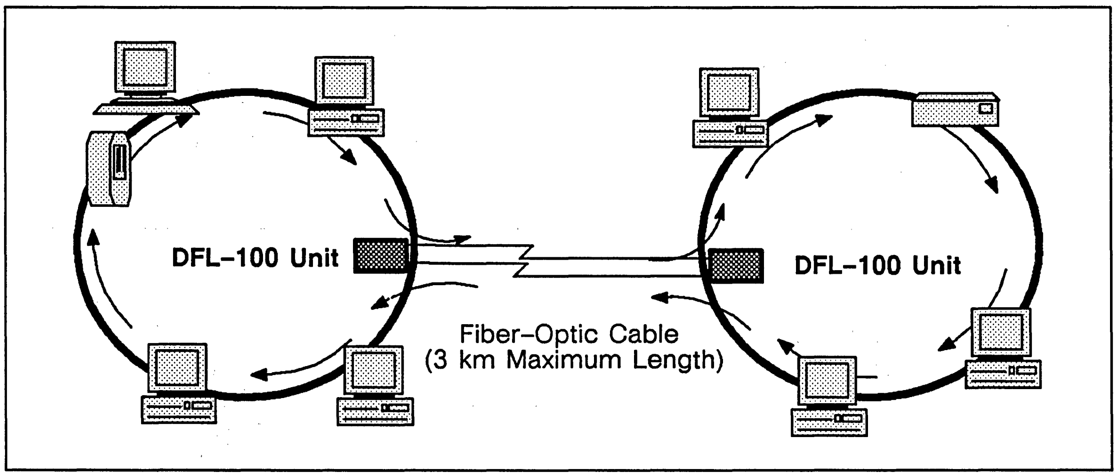


*Figure 2-5. Apollo Token Ring Network Extended with Fiber-Optic Cable*

Data passes through fiber-optic cable at the same rate that it passes through 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. Figure 2–6 shows an example where DFL–100s connect seven previously separate rings into *one* ring that spans seven sites.

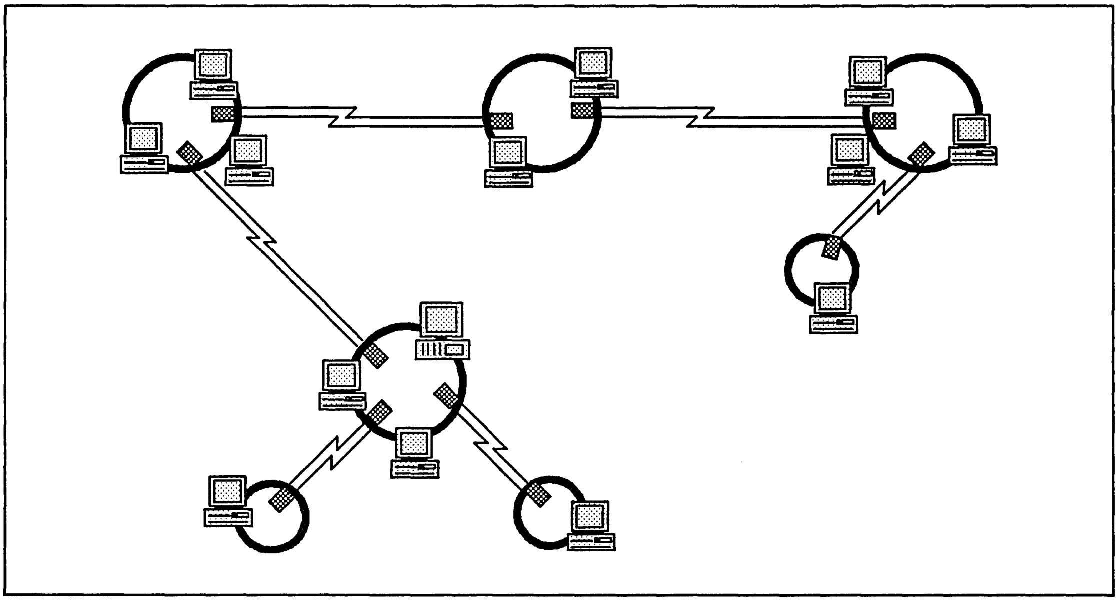

*Figure 2–6. DFL–100 Extended Ring Spanning Seven Sites*

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.

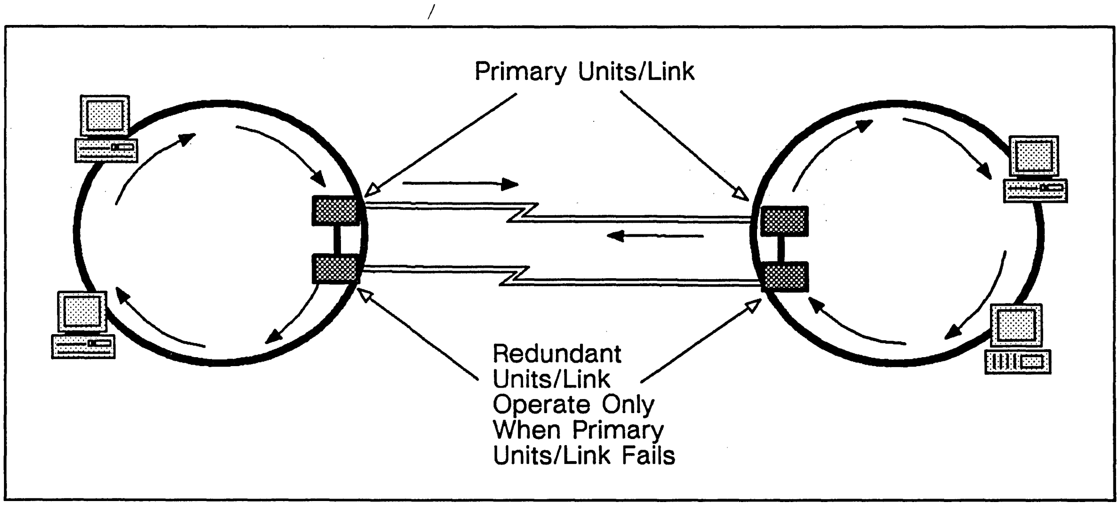


*Figure 2–7. Redundant DFL–100 Configuration*

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 The 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. 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 implementing Domain on an IEEE 802.3 network you can use your current cabling system to recieve full Domain service without the expense of installing new cable.

Perhaps the most significant disadvantage to the IEEE 802.3 network is the loss of performance which can occur as a result of the *collision and retransmission* mentioned earlier in this section. This problem becomes increasingly noticeable as you add more nodes to the network and data traffic increases, thus increasing the number of collisions and retransmissions.

Another problem with the IEEE 802.3 network is that the bus topology makes it difficult to pinpoint a single point of failure in the network. To aid in troubleshooting, many transceivers and repeaters provide automatic features that help identify failures, and several network monitoring and analyzing devices are also available. Despite these devices, it is still difficult to locate failures in an IEEE 802.3 network.

*ETHERNET Versions 1.0 and 2.0 were published jointly by Digital Equipment Corporation, Intel, and Xerox. The major differences between the ETHERNET standards and the IEEE 802.3 standard concern physical signaling, local Medium Attachment Unit (MAU) diagnostics, and packet composition.

## 2.5 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 5 and 6.

### 2.5.1 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 2–8 shows the simplest form of this network using only a single backbone cable.

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*IBM and PC AT are registered trademarks of International Business Machines Corporation.

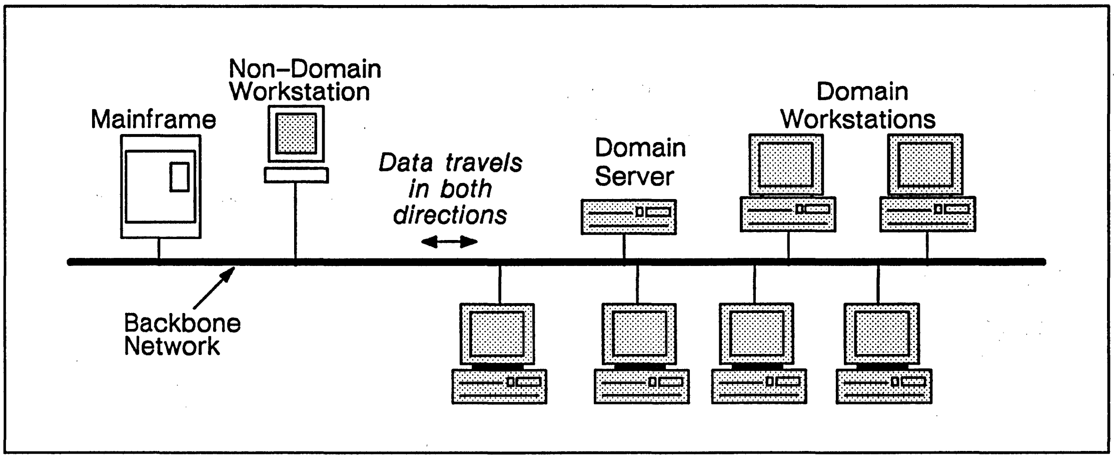


*Figure 2–8. Single–Backbone IEEE 802.3 Network*

## 2.5.2 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 2–9 shows a large IEEE 802.3 installation, in which several backbones are connected with **repeaters** and **multi–port transceivers** that are used to add large numbers of nodes to the network. (Refer to Chapters 5 and 6 for more information about IEEE 802.3 network devices.)

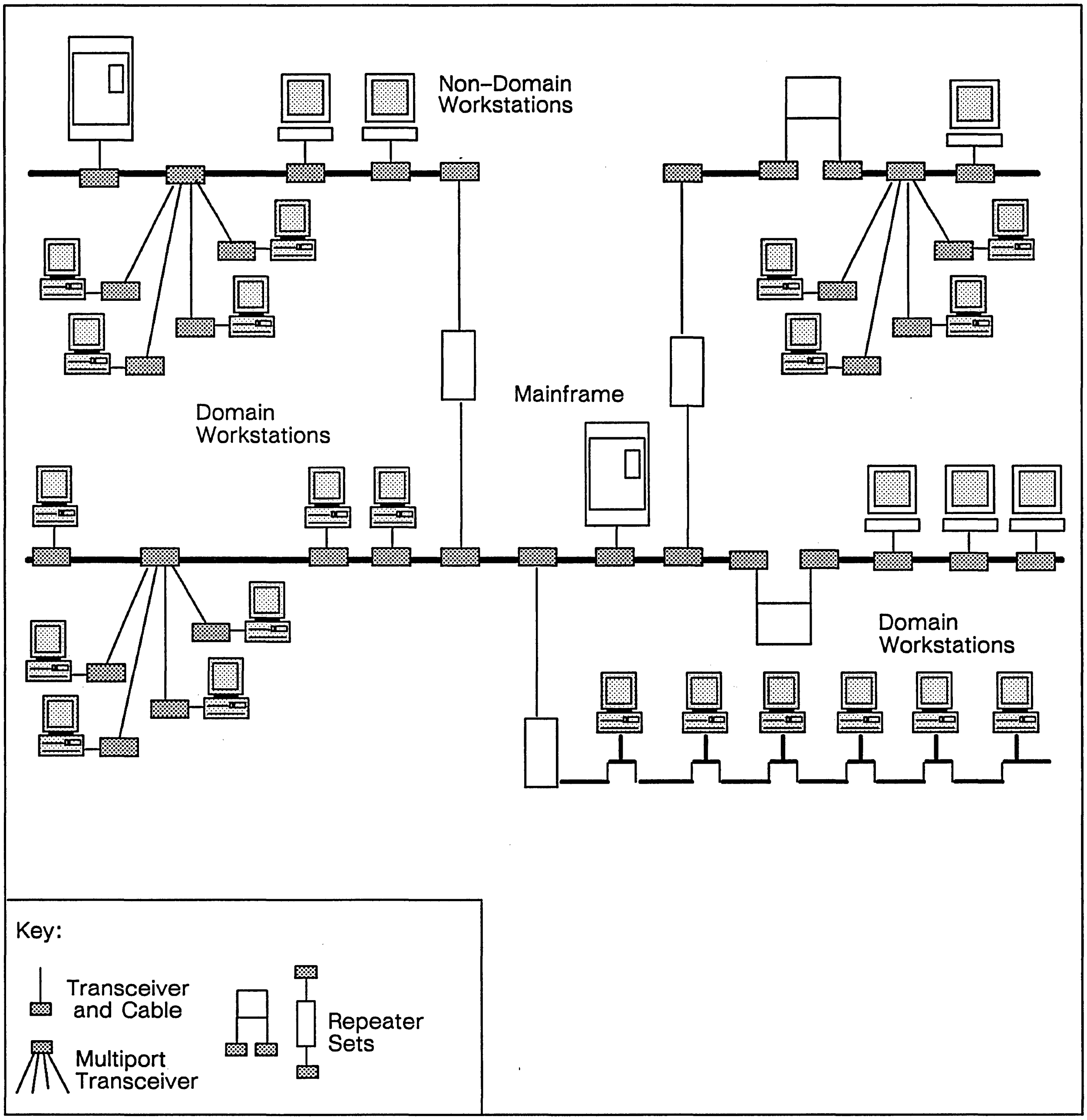


*Figure 2–9. Large IEEE 802.3 Network*

## 2.6 Internets

An internet is a system of two or more connected networks which may or may not be of the same type (e.g., Apollo Token Ring and IEEE 802.3 networks). The internet may use one or several communications **protocols** (e.g., 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 multi–vendor environments or over wide geographic areas.

### 2.6.1 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 services we call the Domain environment. Internets (or portions of an internet) running the Domain protocol are often referred to as *Domain internets.*

- TCP/IP[1] – An industry standard protocol providing multi–vendor 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[2] superminis. Additionally, other layered protocols, such as SNA and LU 6.2, which provide access to IBM[3] mainframes and networks, are also available.

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

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[1]TCP/IP service is part of standard Domain software at SR10, and operates under the Aegis, BSD, or SysV operating environments. With some restrictions, TCP/IP is also available for nodes running SR9.0 and later software revisions. (See Chapters 7 and 8 for more information about TCP/IP.)

[2]VAX is a registered trademark of Digital Equipment Corporation

[3]IBM is a registered trademark of International Business Machines Corporation.

### 2.6.2 Internet Physical Configurations

There are two types of Apollo internet configurations:

1. A simple internet configuration consisting of just two ATR networks
2. 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 conect the two ATR 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 Domain node is a TCP/IP host. Only a Domain node equipped with the proper network controller can function as a TCP/IP gateway.

A single Domain 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 Figures 2–10 and 2–11.

Figure 2–10 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 2–11 shows an Apollo Token Ring network directly connected to an IEEE 802.3 network by a single Domain node. In this example, the Domain node is equipped to provide both Domain routing service and gateway service. Thus, all the Domain workstations in Figure 2–11 can communicate with each other using Domain protocols, and all of the systems (Domain and non–Domain), 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 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 7 and 8.

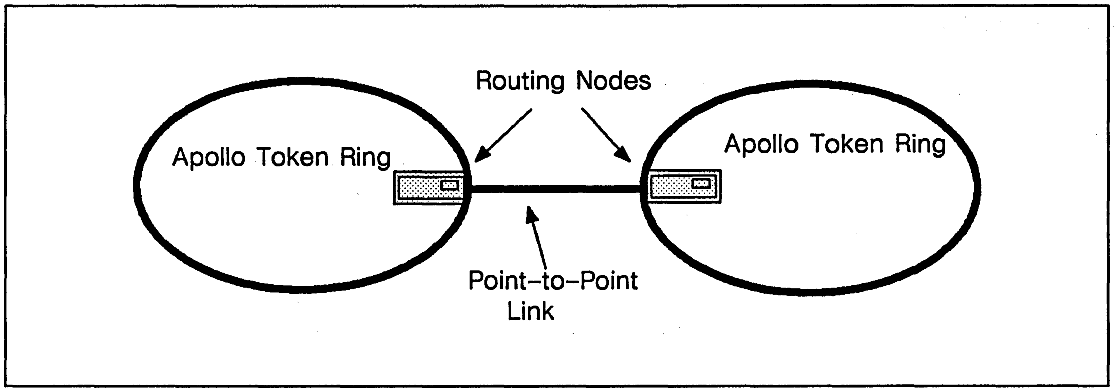


*Figure 2–10. Simple Internet*

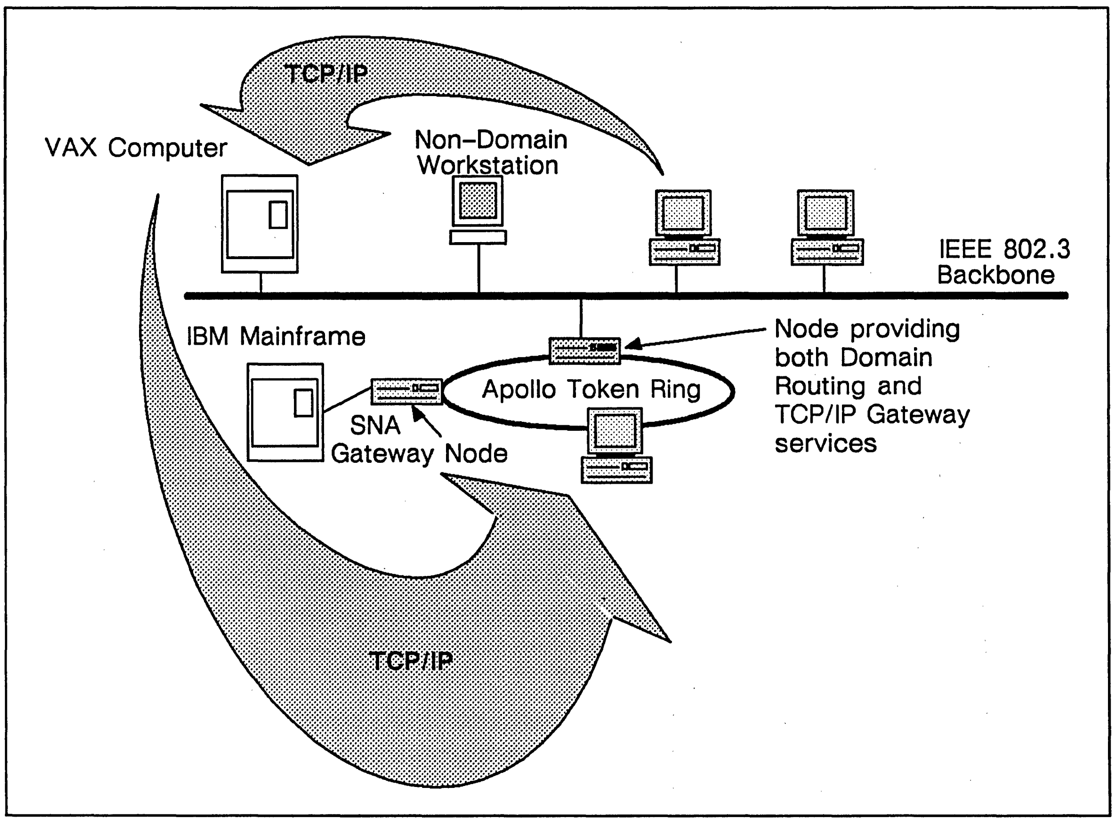


*Figure 2–11. Heterogeneous Internet*

### 2.6.3 Advantages and Limitations of Internets

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 7 and 8 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*.

Table 2–1 summarizes the network and internet information presented in this chapter.

## 2.7 Network and Internet Summary

The following table summarizes the network and internet information presented in this Chapter.

*Table 2-1. Network and Internet Summary*

| **Network Config-uration** | **Ideal Number of Nodes** | **Maximum Number of Nodes** | **Principal Application** | **Network Management Considerations** |
|---|---|---|---|---|
| Serially-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.<br>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.<br>Need network control area for switch monitoring/operating. |
| DFL-100 Extended Apollo Token Ring | (See Serially Wired and Star-Wired Apollo Token Rings above) | (See Serially 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. |
| Internet | Dependent on types of networks in the internet | Dependent on network types, see Chapters 4 and 6 | Increase overall flexibility, allow communication between diverse network types | Transparent communication between nodes on different networks.<br>Requires careful resource planning. |

# 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).

## 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.

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*TEFLON is a registered trademark of the Dupont Corporation.

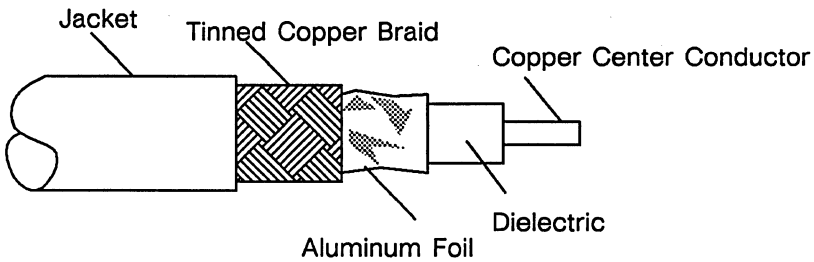



*Figure 3-1. Apollo Token Ring Coaxial Cable*

You, or a cable service agent that you designate, are responsible for purchasing, installing, and preparing your network cable. Table 3-1 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 3–1. 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)<br>10 / 0.70 ±0.10<br>50 / 1.40 ±0.10<br>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<br>(14°to 140°F) | -60°to 150°C<br>(-76°to 302°F) |
| Conductor Diameter | 0.00091 to 0.01016 mm<br>(0.036 to 0.040 in – 18 AWG) | 0.01016 mm<br>(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<br>100 % coverage | Aluminum/Mylar<br>100% coverage |
| Shield Braid | Tinned Copper<br>60% coverage<br>(minimum) | Tinned Copper<br>60% coverage<br>(minimum) |
| Minimum Bending Radius | 457 mm<br>(1.80 in) | 457 mm<br>(1.80 in) |
| Jacket Outside Diameter | Black PVC<br>6.86 mm ±0.25 mm<br>(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.
***SOLEF is a trademark of Solvay & Company.

### 3.1.2 The Domain/DQC

The Domain/DQC Quick Connect System allows you to instantly connect any Apollo node or server processor to the ring network *without interrupting the data flow*. 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.

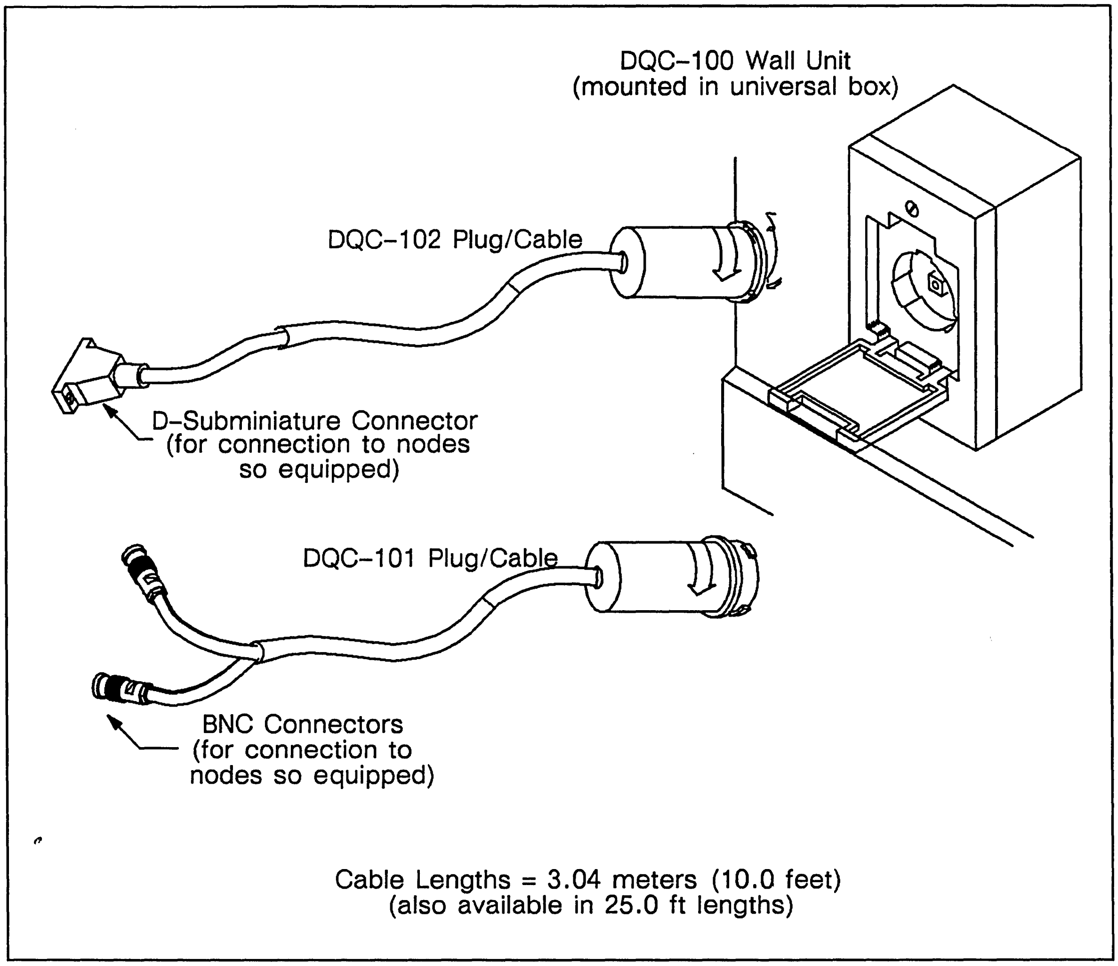



*Figure 3–2. The Domain/DQC Quick Connect System*

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 3–2 lists the types of U.S. utility boxes suitable for mounting the DQC–100 Wall Unit.

*Table 3–2. U.S. Standard Utility Boxes for Mounting the DQC–100*

| Vendor | Model No. | Metal Raceway |
|---|---|---|
| *Out–of–Wall Box* | | |
| Wire Mold Co.<br>Hartford, CT 06110 | Metal Box #5744 | #500 (can house 1 network cable)<br>#700 (can house 2 network cables) |
| *Partial In–Wall Box* | | |
| Wire Mold Co.<br>Hartford, CT 06110 | 800 Series B&C<br>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)<br>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 3–1 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

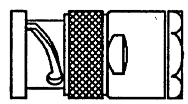
You can terminate the network coaxial cable with BNC connectors to attach network switches, the DFL–100 fiber interface units, and certain Apollo nodes. We recommend two types of BNC (bayonet–end) connectors for use in an Apollo Token Ring network: wrench crimp BNC connectors and tool crimp BNC connectors.

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 5 for information about IEEE 802.3 network attachment accessories.)

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



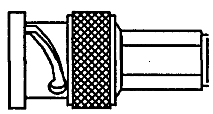




*Figure 3–3. BNC Connectors*

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*.

### 3.1.4 The Network Switch

The network switch makes it easy for you to create a star–wired configuration by providing a simple method for switching loops in and out of the network. As shown in Figure 3–4, the switch attaches to our coaxial cable with BNC connectors mounted on the switch.

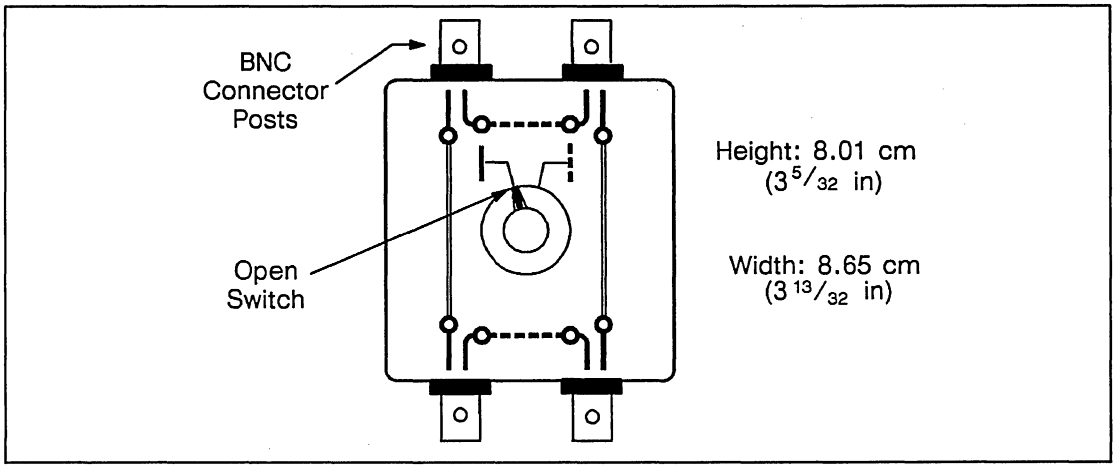



*Figure 3–4. The Network Switch*

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 3–5 illustrates how the switch operates.

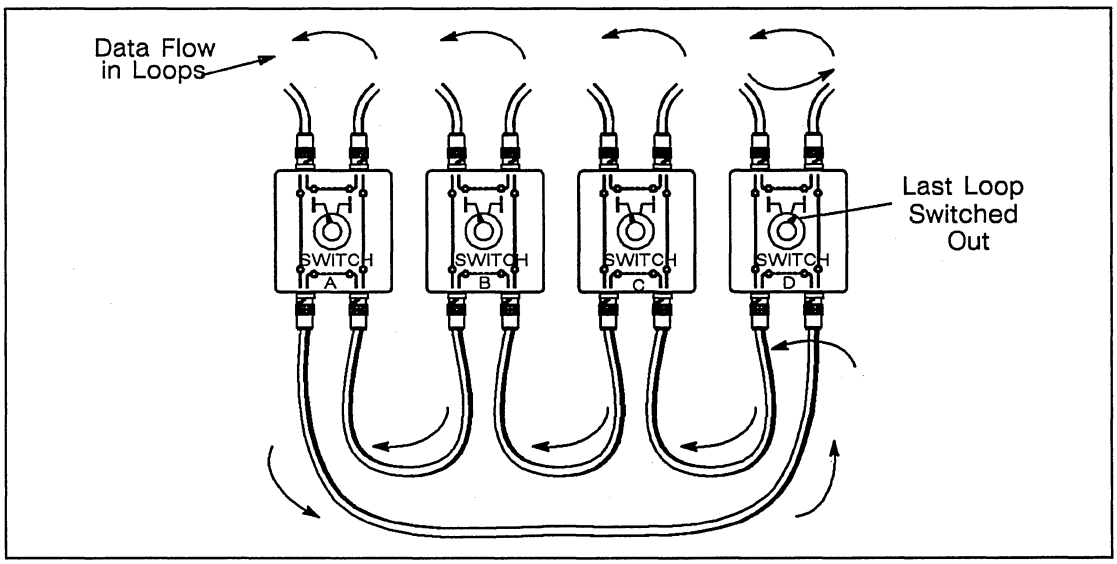



*Figure 3–5. Data Flow Through the Network Switch and Several Loops*

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.*

### 3.1.5 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 3–6 shows a blank cable tag and a completed tag for a cable bringing data *to* a node or switch.

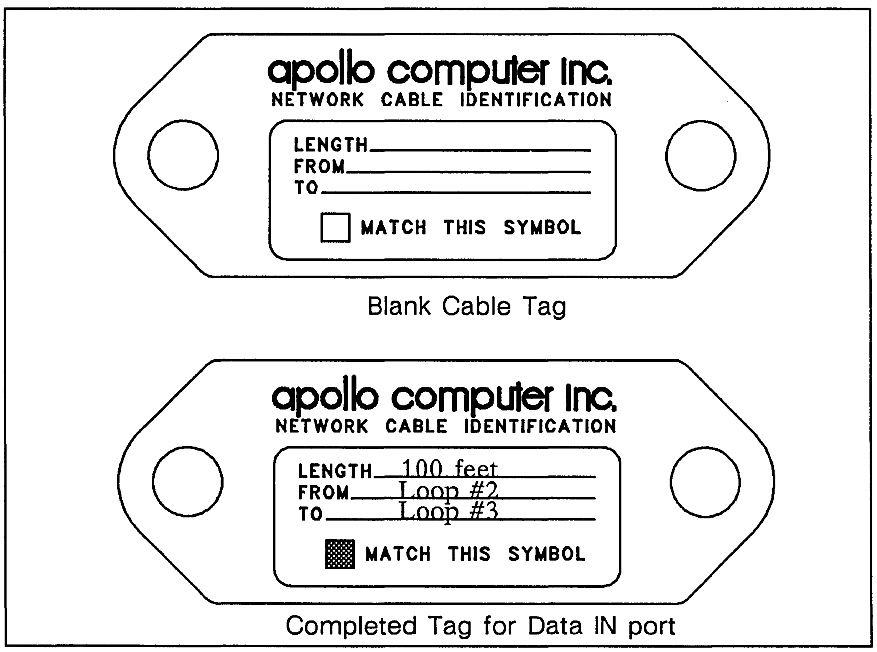



*Figure 3–6. Network Cable Tags*

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

This section describes the fiber–optic cable and accessories available for use with the Apollo Token Ring 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 3–3 and Table 3–4 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 3–7 illustrates the composition of fiber–optic cable.

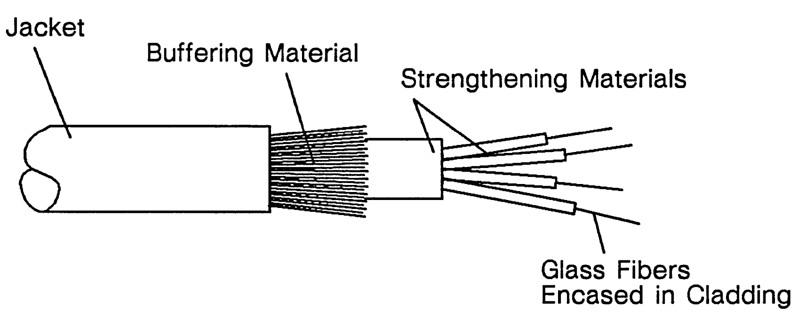



*Figure 3–7. Fiber–Optic Cable Cross Section*

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 3–3 and Table 3–4. To order suitable cable and connectors, refer to the vendor information in Appendix B.

We provide general fiber–optic cable installation information in Chapter 3. 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 3–3. 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<br>200 MHz/km at 1300 nm, minimum |
| Refractive Core Index | 1.466 at 850 nm, peak<br>1.460 at 1300 nm, peak |
| Operating Temperature | –10° to +50° C (+14° to +122° F)<br>2–channel burial installations<br>–40 °to +50° C (–40 °to +122 °F)<br>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 |

*Kevlar is a trademark of Dupont Corporation.

*Table 3-4. 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 | $0.27 \pm 0.01$ |
| Attenuation | 5.0 dB/km maximum at 850 nm<br>3.0 dB/km maximum at 1300 nm |
| Bandwidth | 160 MHz/km at 850 nm, minimum<br>200 MHz/km at 1300 nm, minimum |
| Refractive Core Index | 1.478 at 850 nm, peak<br>1.472 at 1300 nm, peak |
| Operating Temperature | $-10°$ to $+50°$ C ($+14°$ to $+122°$ F)<br>2-channel burial installations<br>$-40°$ to $+50°$ C ($-40°$ to $+122°$F)<br>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 3-5 lists the cables, connectors, and the purpose of the connectors.

*Table 3-5. 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 3-5, 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 3-8, 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*

* ST Series Connector is a trademark of AT&T.

*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.

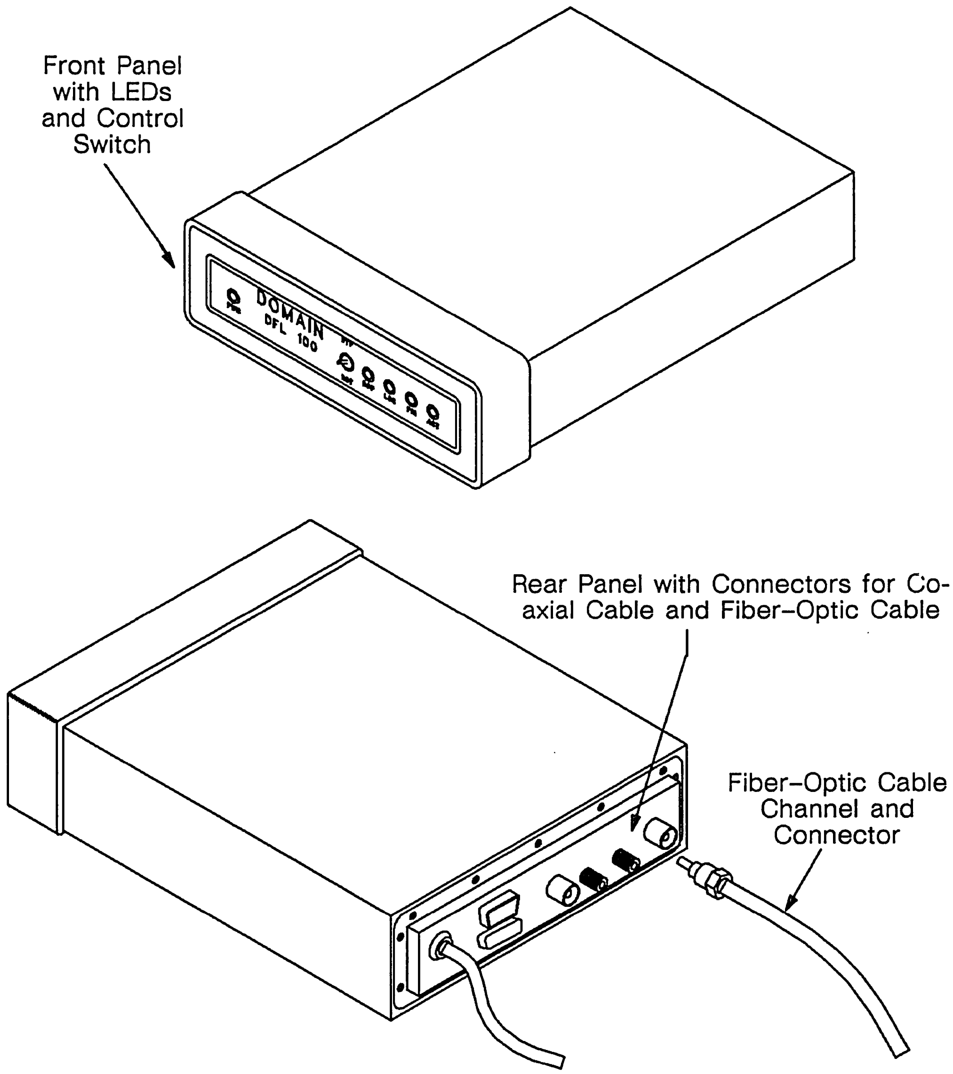



*Figure 3-8. The DFL-100 Fiber Interface Unit*

# Chapter 4

# Planning an Apollo Token Ring Network Layout

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

- A serially–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 Coaxiai 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, 7, and 8 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 7 and 8 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 (i.e., 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.

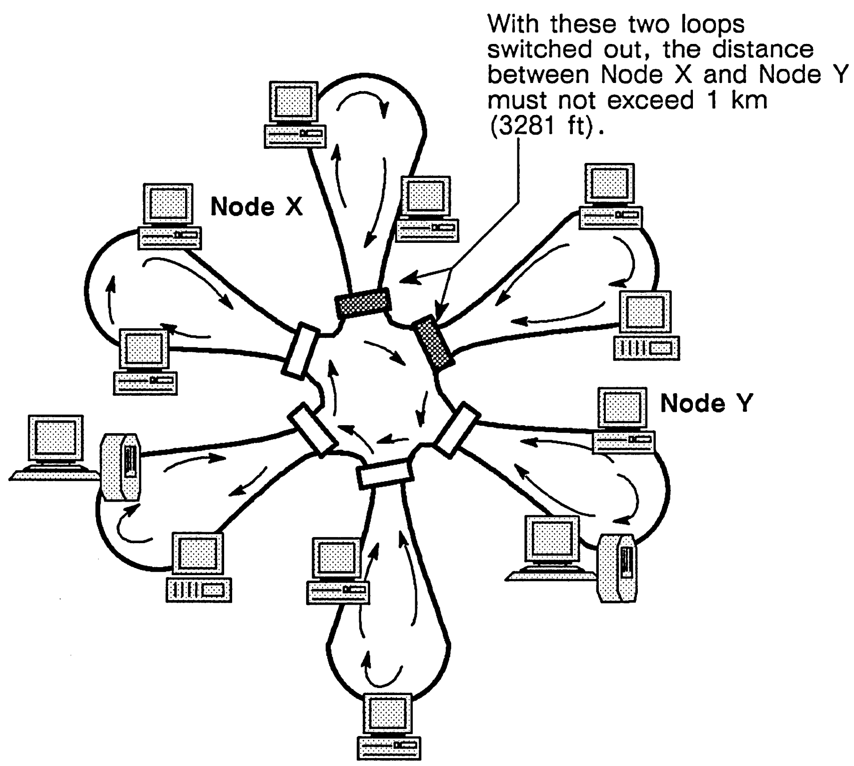



*Figure 4–1. Maximum Cable Length in a Star–Wired Apollo Token Ring Network*

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*.

### 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.

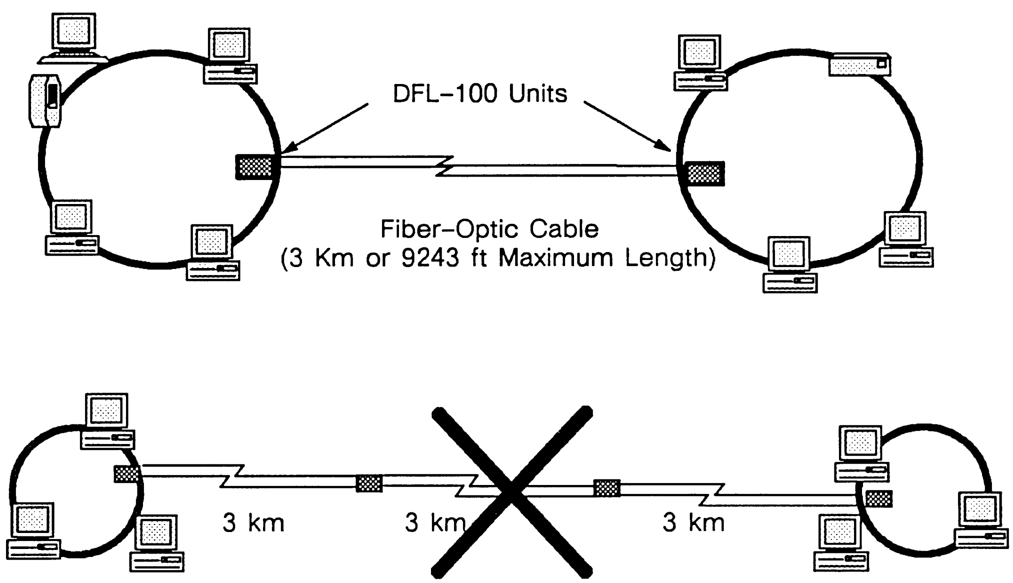



*Figure 4–2. Proper and Improper DFL–100 Configurations*

### 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.

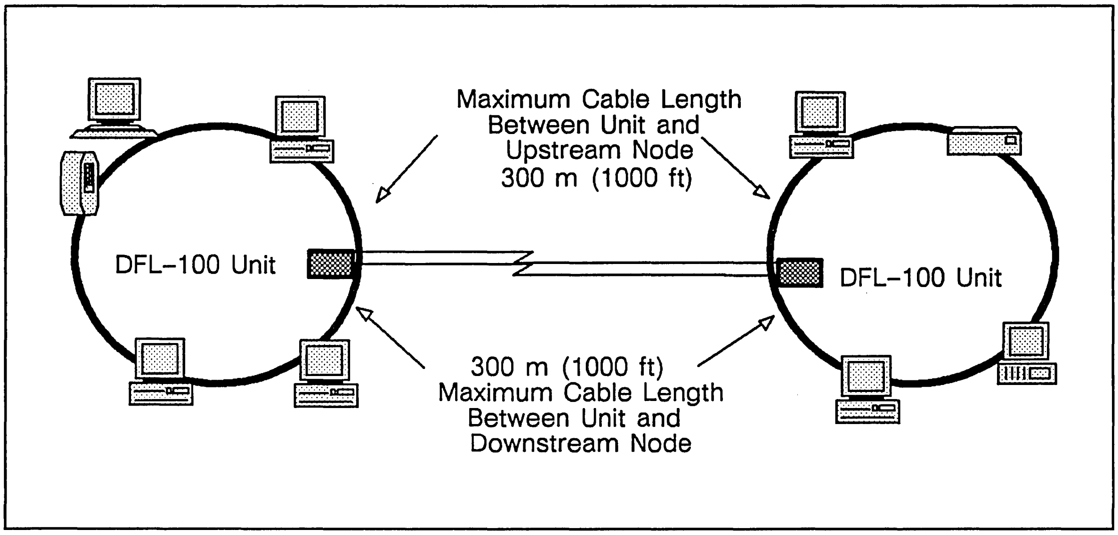



*Figure 4–3. Proper Placement of DFL–100 Units*

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.

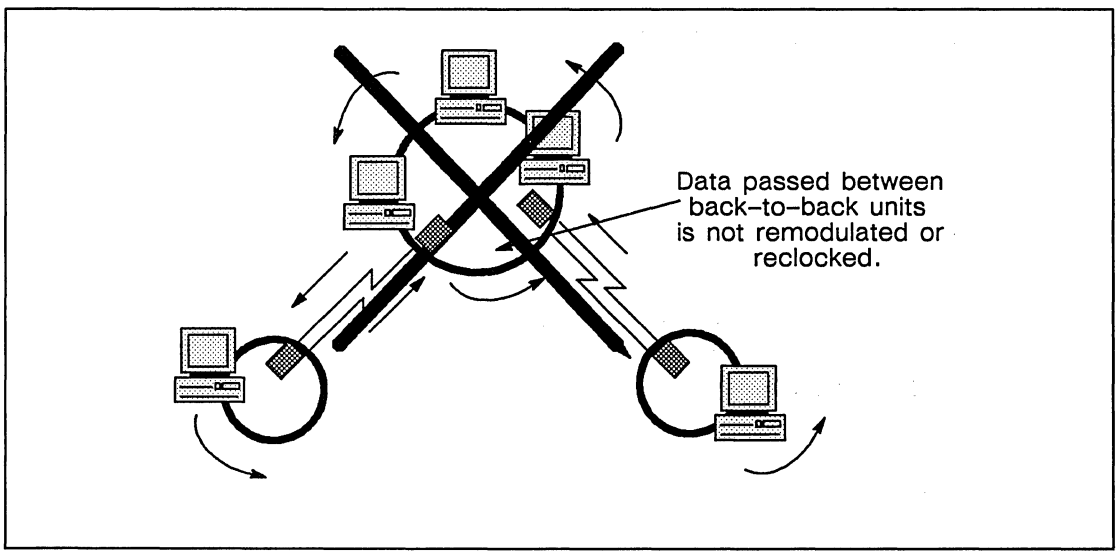



*Figure 4–4. An Unacceptable Back–to–Back DFL–100 Configuration*

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.

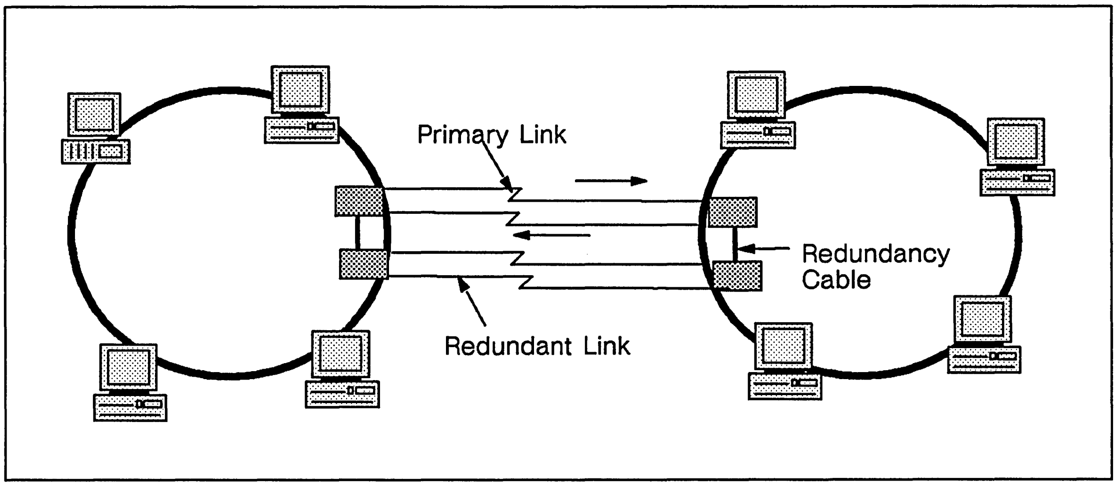



*Figure 4–5. A Redundant DFL–100 Configuration*

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.

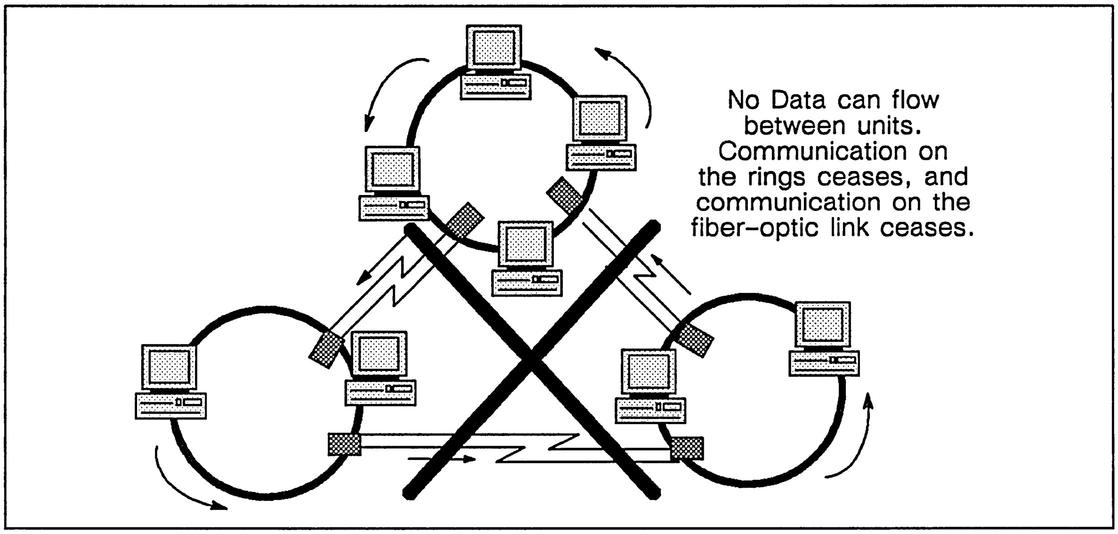



*Figure 4–6. An Inoperable Redundant DFL–100 Configuration*

## 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.

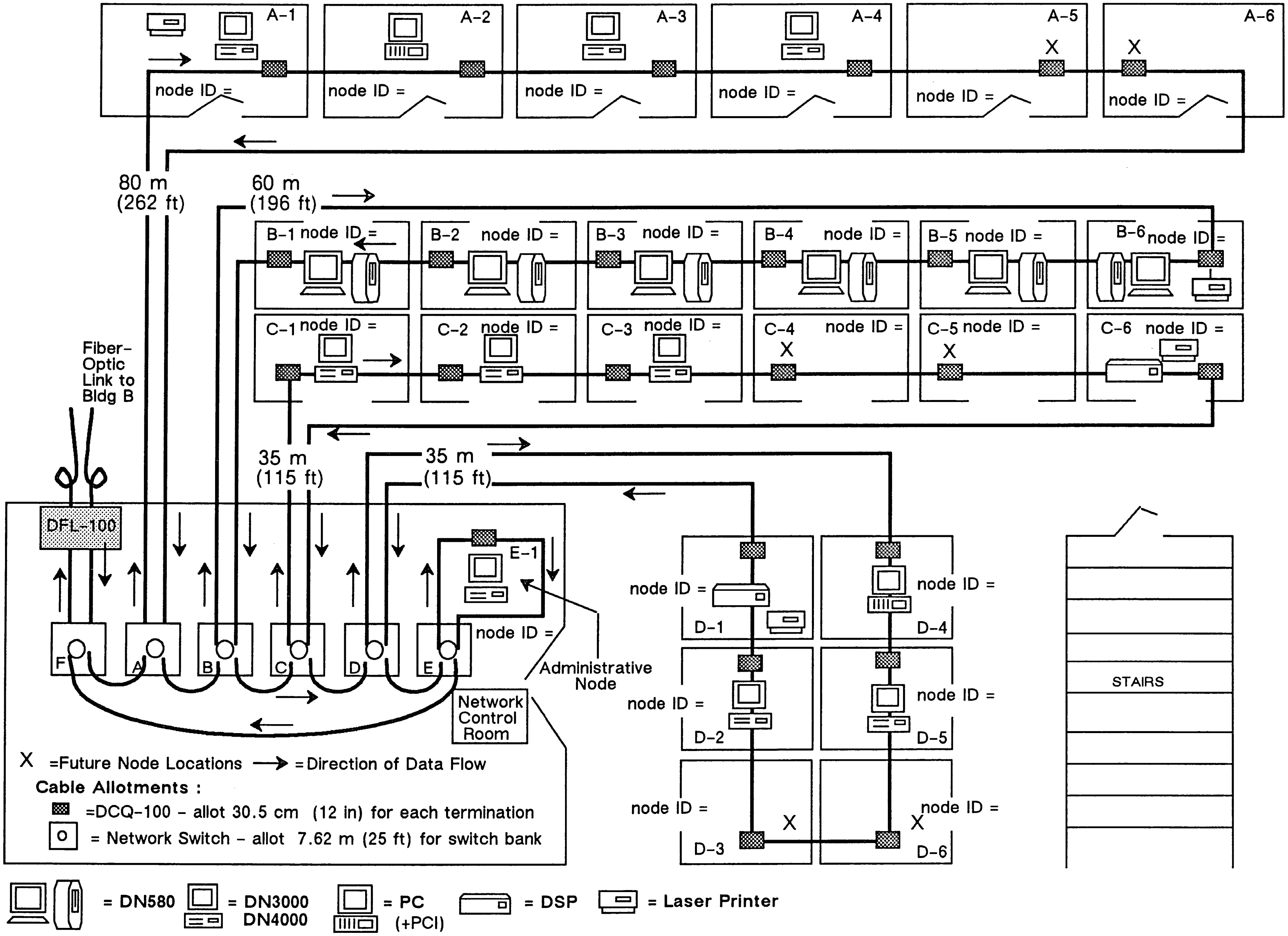



*Figure 4-7. Sample ATR Network Layout Diagram*

# Chapter 5

# 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.

## 5.1 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. 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.

## 5.2 IEEE 802.3 Network Cables

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

- Standard 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 or use coaxial cable rated for exterior installation, or use fiber–optic cable (see Section 5.5 for information about repeaters that connect to fiber–optic cable).

Refer to Chapter 6 for more information about planning the IEEE 802.3 network cable layout.

### 5.2.1 IEEE 802.3 Standard Cable, Connectors, and Terminators

The standard IEEE 802.3 network cable (also called thick cable) is a 50–ohm, baseband coaxial cable. As shown in Figure 5–1, standard IEEE 802.3 cable is marked at 2.5–m (8.2–ft) intervals to guide transceiver placement (see Chapter 6 for more information about transceiver placement).

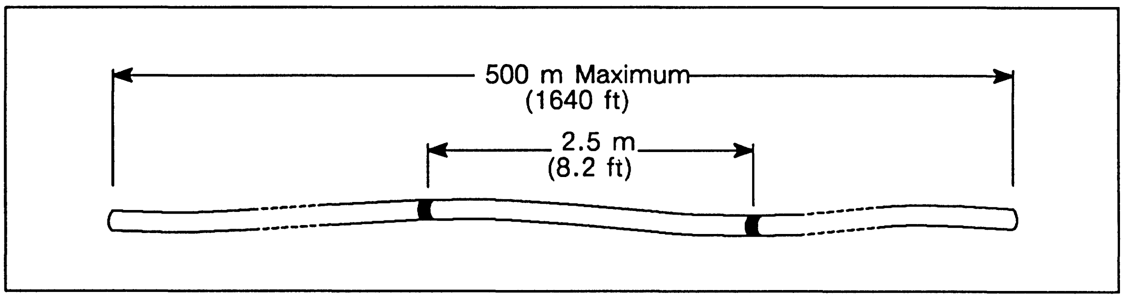



*Figure 5–1. Standard IEEE 802.3 Cable*

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).

N–series connectors attach to standard cable for terminating in transceivers (described in Section 5.4, "Cable Taps and Tapping Tools"). N–series feedthrough adapters (also called barrel connectors) allow you to connect standard cable sections to form a longer segment (up to the maximum length of 500 m or 1640 ft), or partition a standard cable segment into sections for network troubleshooting purposes. N–series terminators attach to cable ends to eliminate signal reflections. Figure 5–2 illustrates these N–series accessories.

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

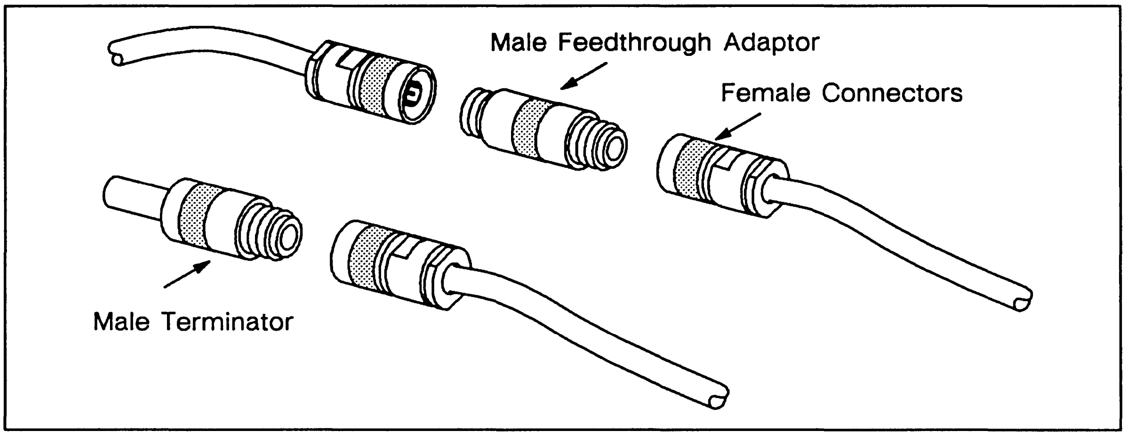



*Figure 5–2. N–Series Cable Connectors and Terminators*

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

### 5.2.2 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. In addition, Thin cable connects directly to the nodes; you do *not* need transceivers or transceiver cables external to the node. Figure 5–3 shows a Thin cable segment.

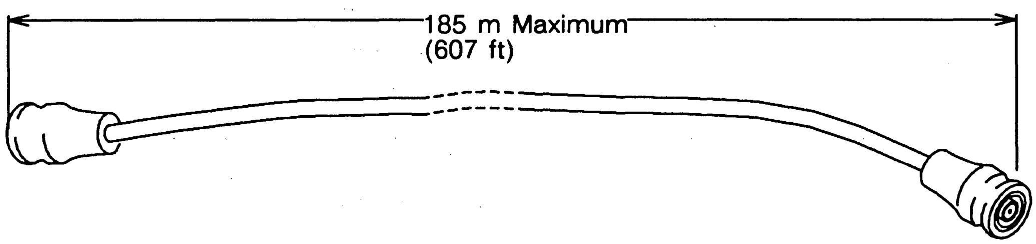



*Figure 5–3. Thin Cable Segment*

Thin cable is available from the *Instant Apollo* catalog in four preterminated lengths: 5, 10, 20, and 50 m (16, 32, 65, and 164 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 5–4 shows a T–connector and terminator.

BNC–to–N–series adapters allow you 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 5.4, "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).

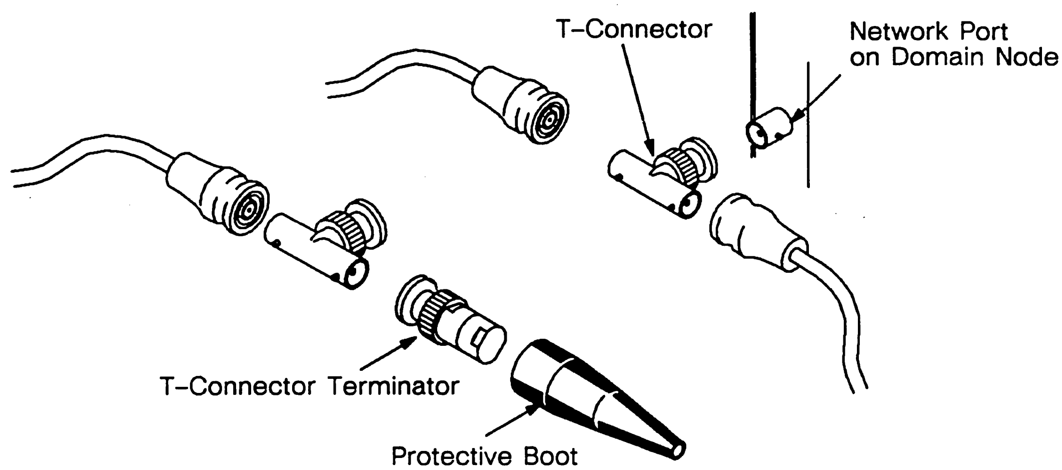



*Figure 5-4. Thin Cable T-Connector and Terminator*

## 5.3 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). 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 by disabling the output if the stream of bits lasts from 20 ms to 150 ms. The transceiver is reset by power cycling or by the absence of any signal on the network for 250 ms to 500 ms.

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.

### 5.3.1 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 64 nodes. Some multiport transceivers can replace the backbone network to form a star–wired LAN.

Figure 5–5 and Figure 5–6 illustrate the two transceiver types. See Chapter 6 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 6 for detailed information about placing transceivers in your IEEE 802.3 network.

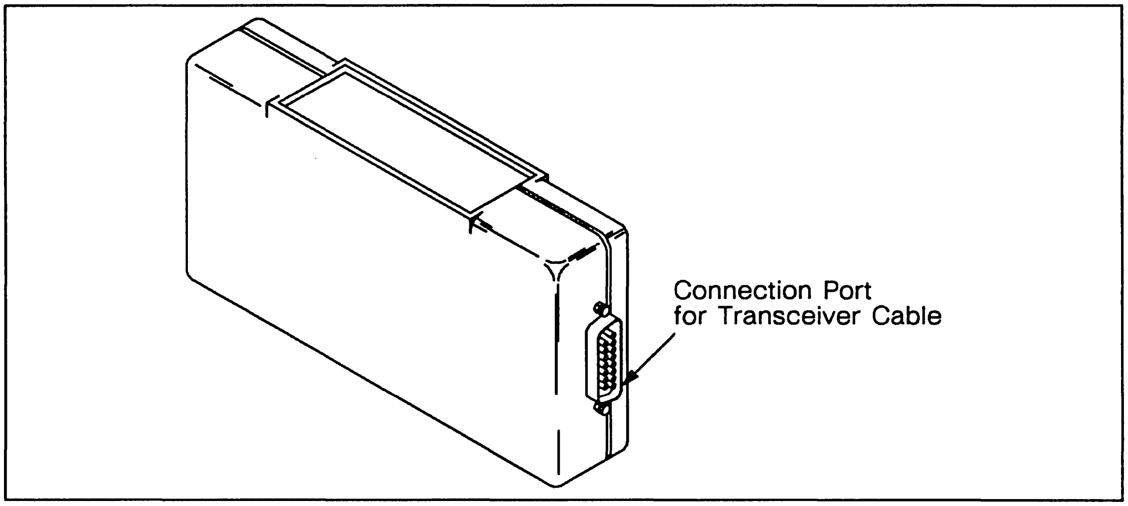



*Figure 5–5. Single–Device Transceiver*

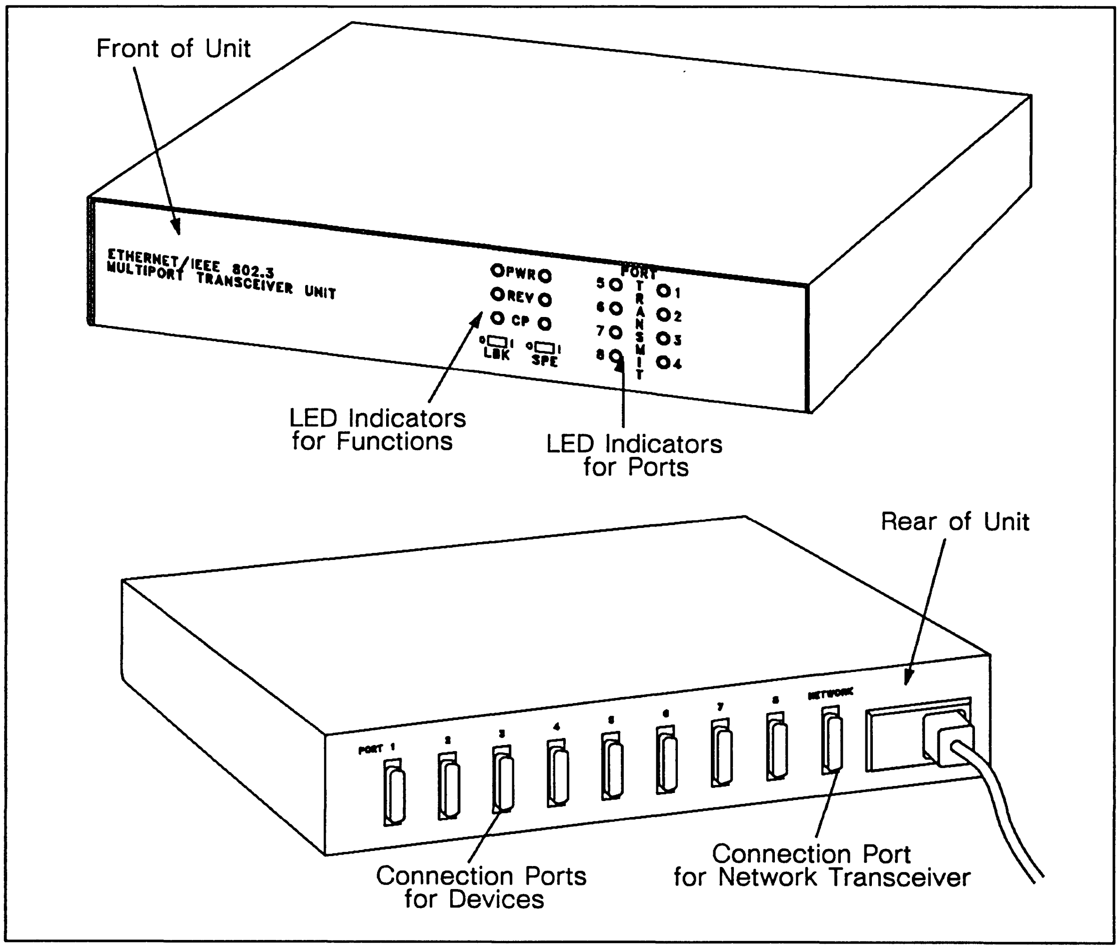



*Figure 5–6. Multiport Transceiver*

## 5.3.2 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 (164 ft) in length. Figure 5-7 shows a transceiver cable.

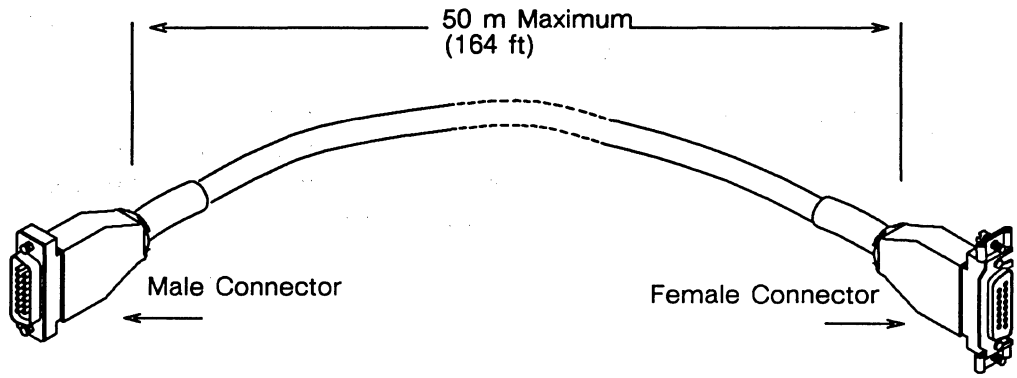



*Figure 5-7. Transceiver Cable*

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 offer IEEE 802.3 transceiver cables in 5, 10, and 20 m lengths (16, 32, and 65 ft) through the *Instant Apollo* catalog. You can connect these cables together to form a length up to 50 m (164 ft). The cables are available with either PVC or TEFLON jacketing (see Appendix A for ordering information).

## 5.4 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.

**Non-Intrusive 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 5-8 illustrates N-series and non-intrusive taps.

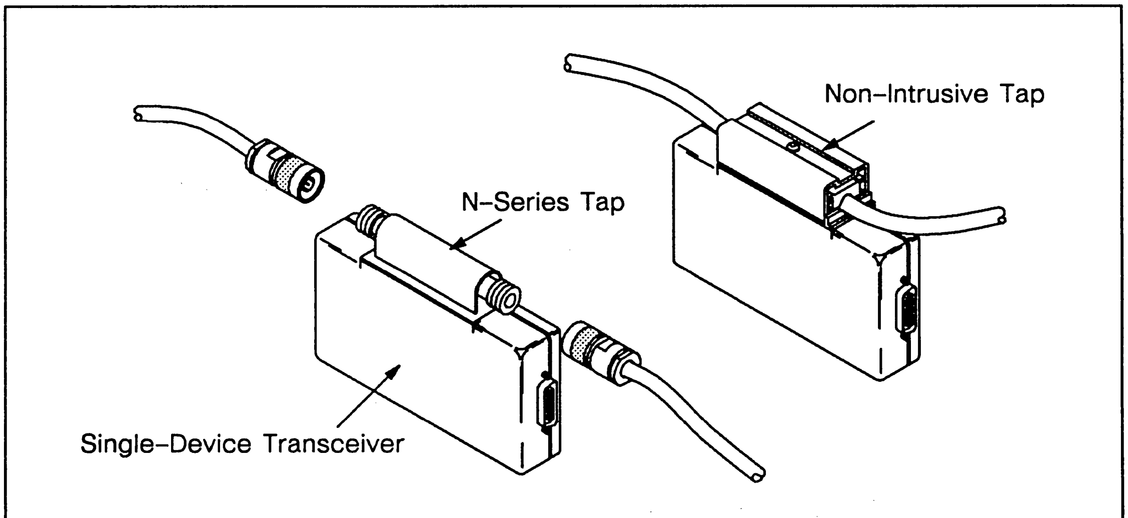



*Figure 5-8. N-Series Transceiver Tap*

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

## 5.5 Repeaters

Repeaters extend the IEEE 802.3 network span and offer network topology options beyond a single maximum–length segment of 500 m (1640 ft) for standard coaxial cable, and 185 m (607 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, 7 and 8 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.

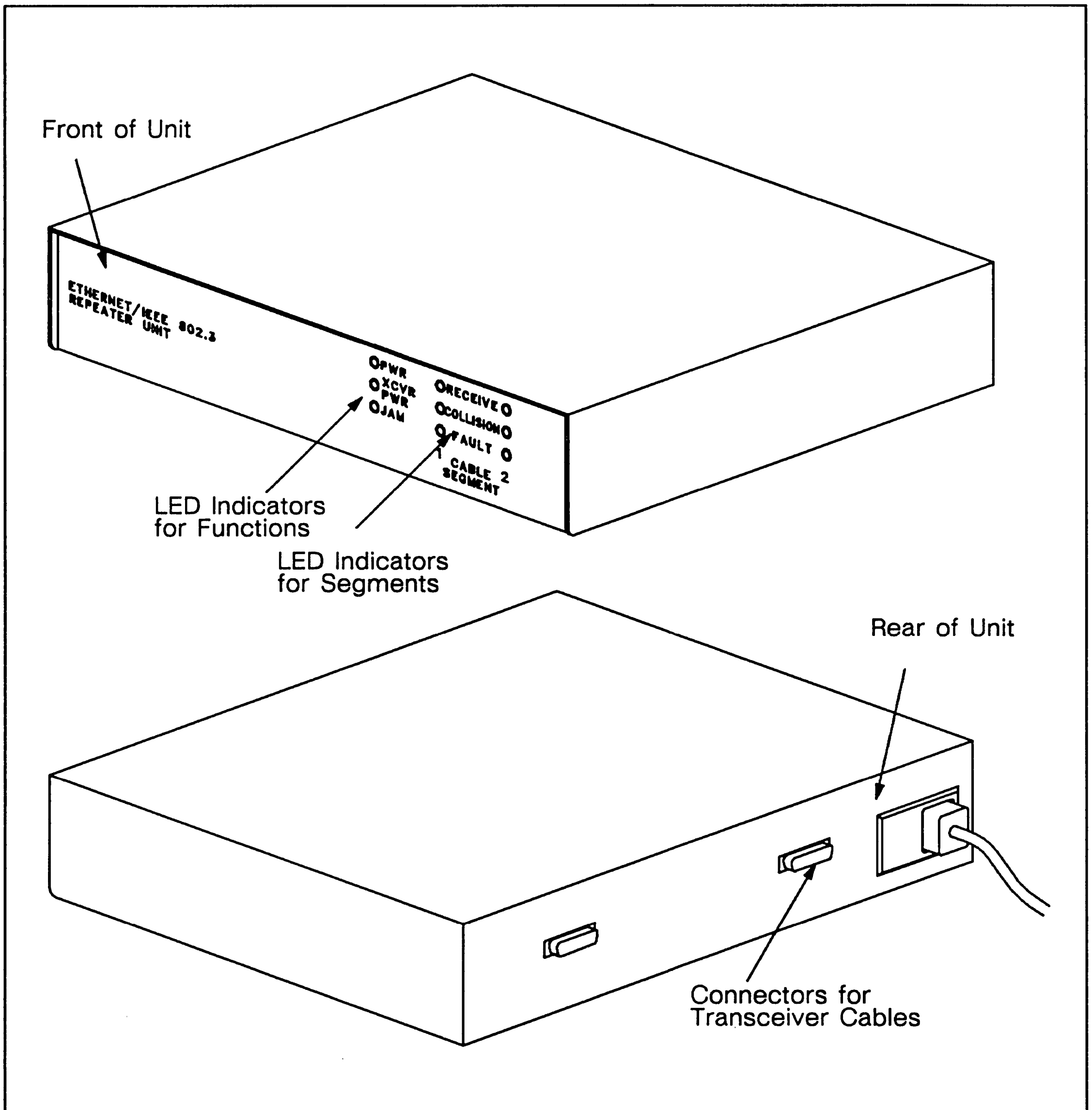



*Figure 5–9. Local Repeater*

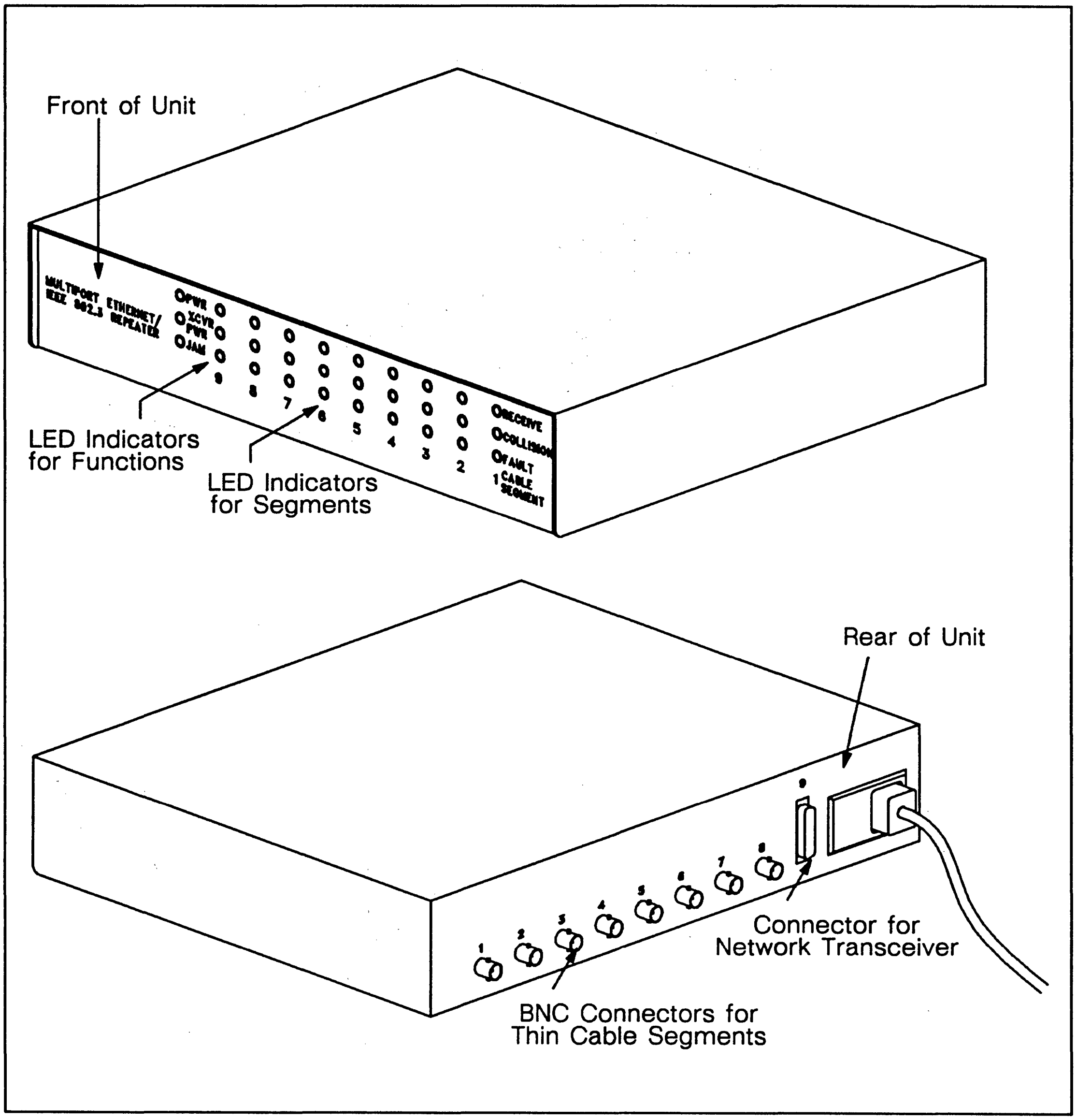



*Figure 5–10. Thin Cable Multiport Repeater*

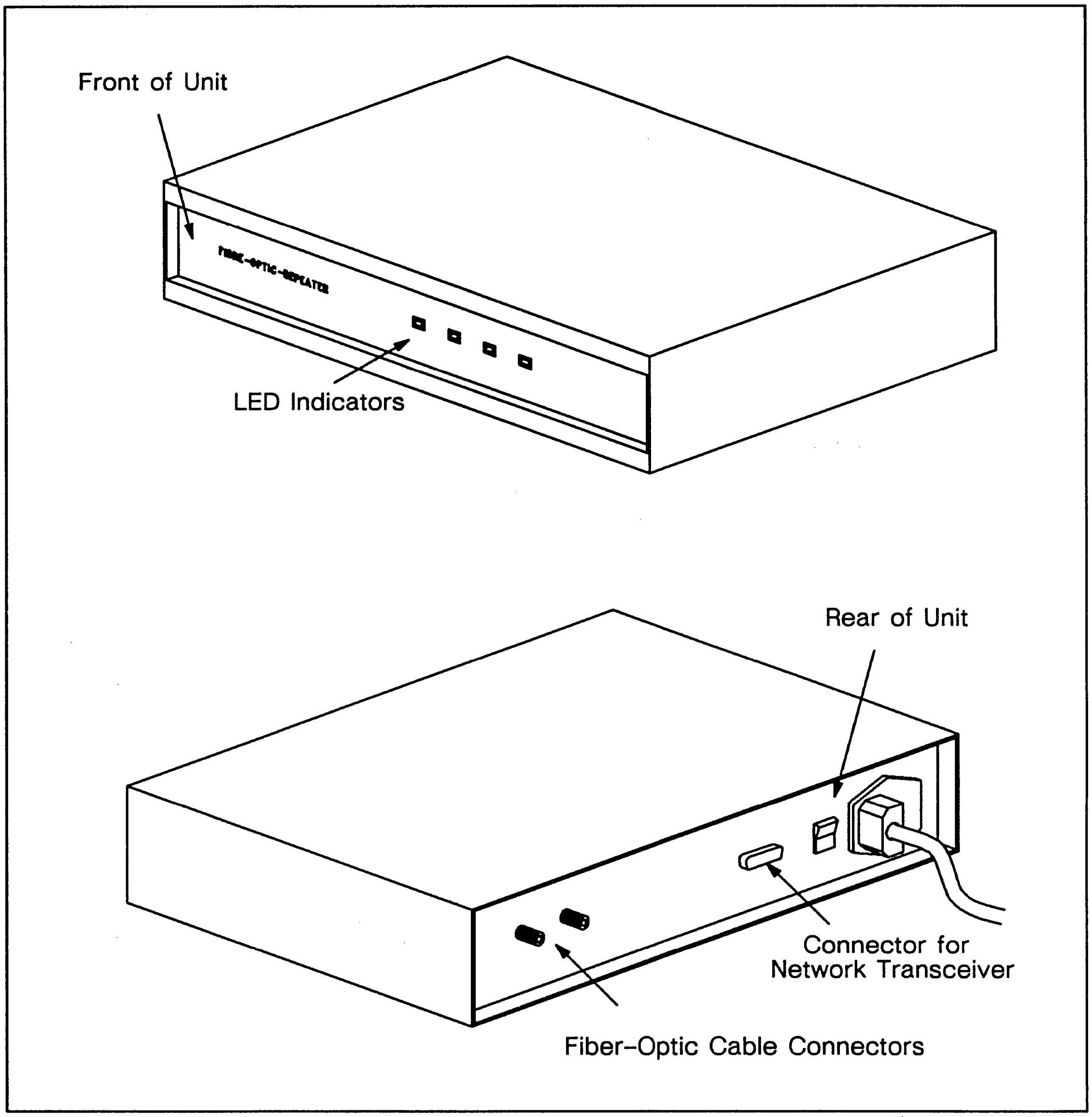



*Figure 5–11. Optical Repeater*

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

See Chapter 6 for detailed information about planning an IEEE 802.3 network layout with repeaters.

# Chapter 6

# 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
- Standard/Thin combinations

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 7 and 8 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.

## 6.1 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 6.2.

### 6.1.1 Standard Cable Segments

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 (see Section 5.2.1 for a description of 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.*

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

NOTICE: To determine the proper 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 6–1 illustrates cable segments connected in series.

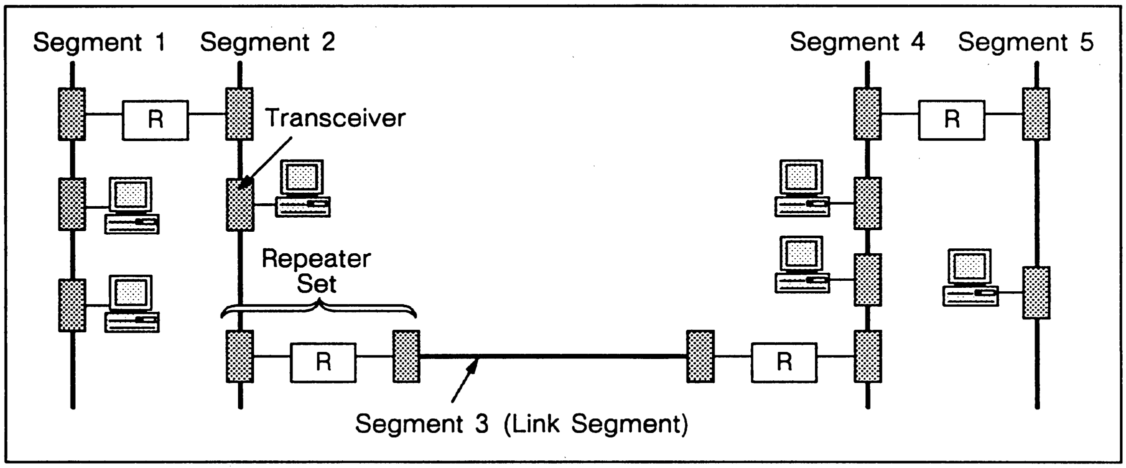



*Figure 6–1. Standard Cable and Link Segments Connected in Series*

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 6–2 shows such a configuration. (Other segment configurations are described in Section 6.1.2.)

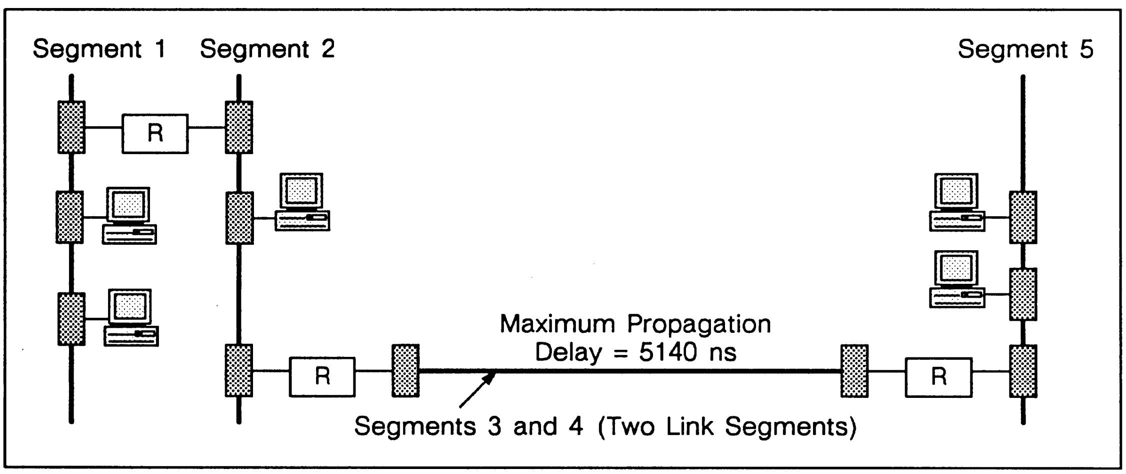



*Figure 6–2. A Double Link Segment*

By using a multiport transceiver or repeater, you can connect more than five segments in a **fan–out** or **cascaded** configuration (see Sections 6.1.6 and 6.1.7).

### 6.1.2 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 6–3 illustrates a network with maximum transmission paths.

In Figure 6–3, 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)

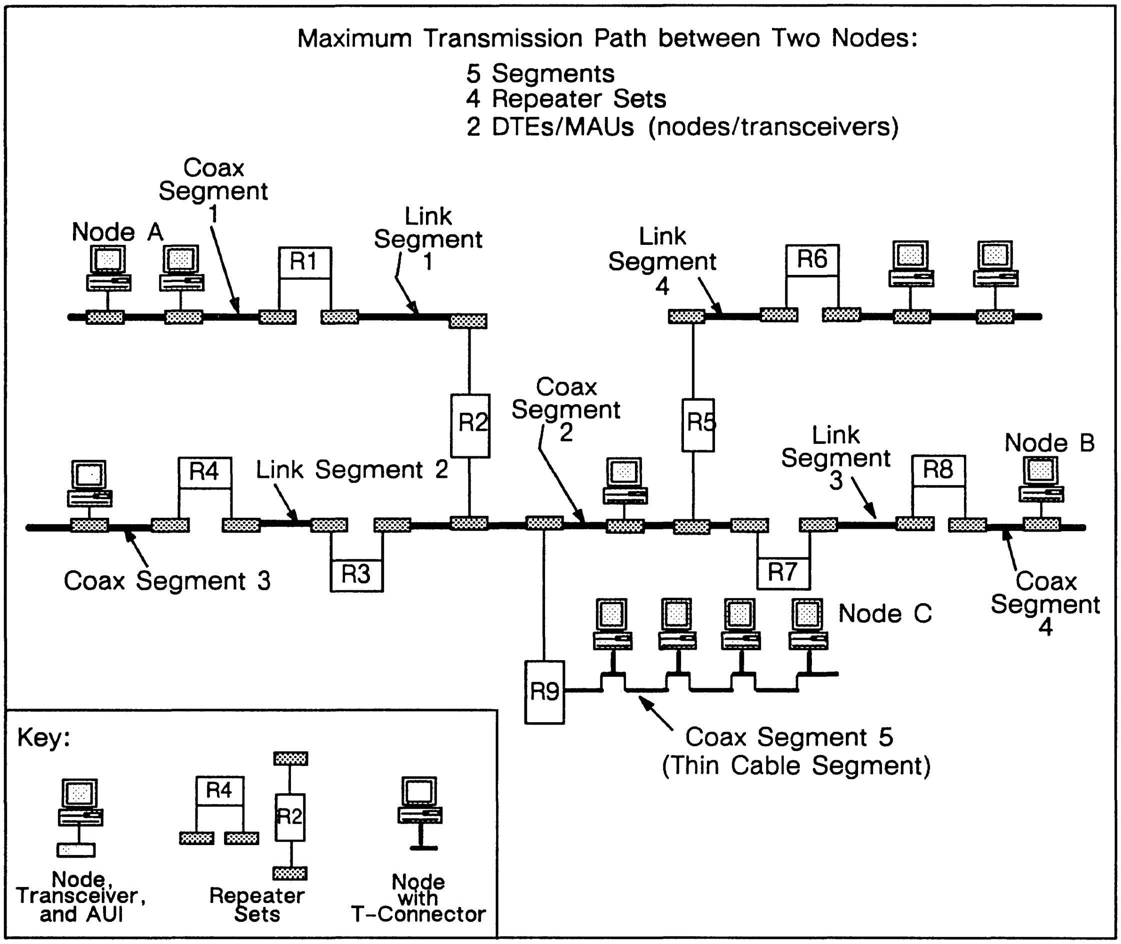



*Figure 6–3. A Large IEEE 802.3 Network Illustrating Maximum Transmission Paths*

## 6.1.3 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 6.1.6 and 6.1.7).

### 6.1.4 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.

### 6.1.5 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).*

### 6.1.6 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 transceivers, with each supporting eight nodes. Figure 6–4 illustrates eight multiport transceivers connecting 64 nodes in a cascaded or fan–out configuration.

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*These lengths have been calculated to reduce the possibility of signal reflections building up on the cable. See the 802.3 standard for more information about cable sectioning.

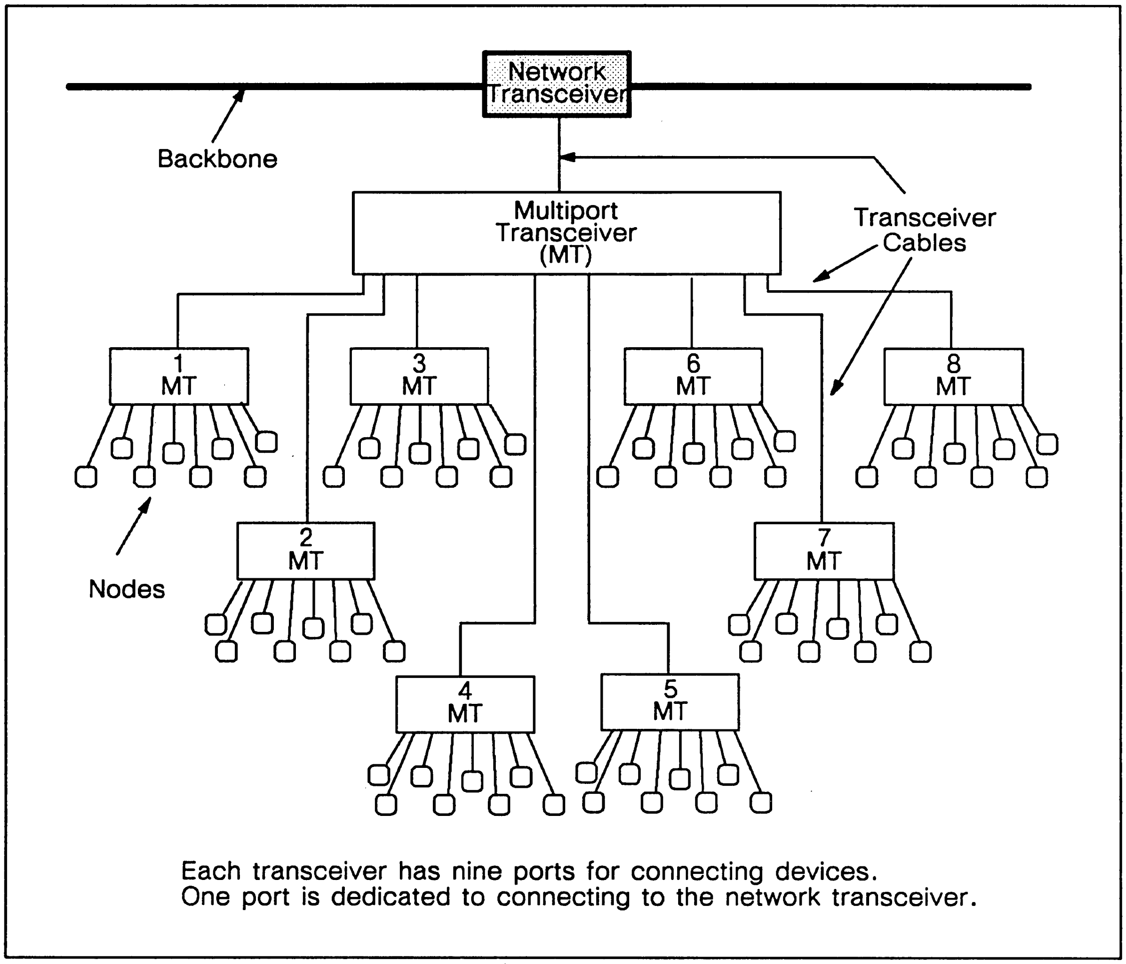



*Figure 6–4. Multiport Transceiver in a Cascaded Configuration*

In Figure 6–4, 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 6–4 violates the maximum number of nodes/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 6–5.

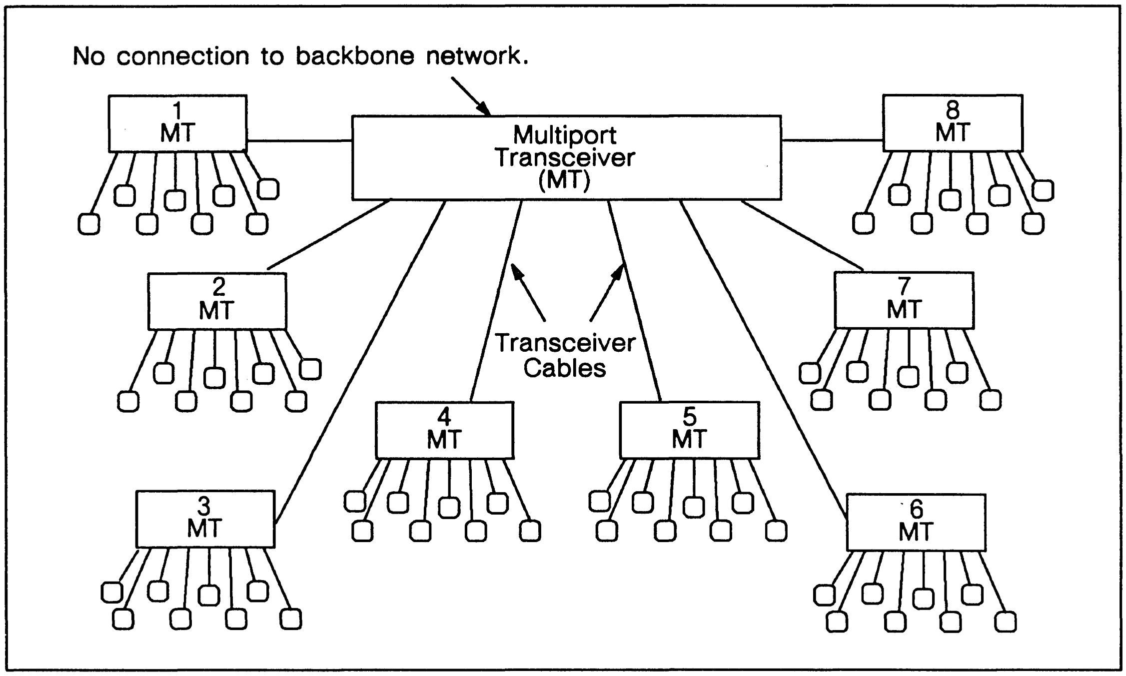



*Figure 6–5. Multiport Transceiver in a Stand–Alone, Star–Wired Network*

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.

## 6.1.7 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 6.1.1.) 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 6–6 shows a network composed of two segments connected with a repeater.

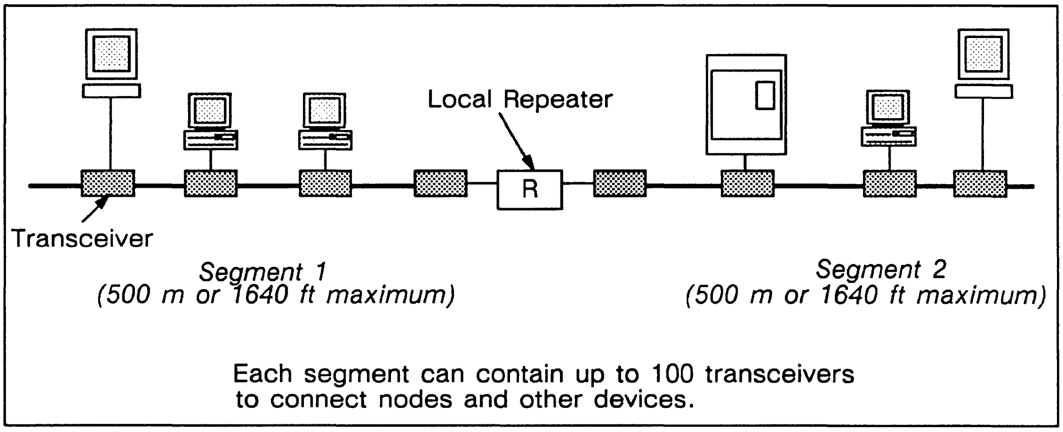



*Figure 6–6. Two Segments Connected with a Local Repeater*

To add multiple segments to your network, you can connect up to eight local repeaters to a multiport transceiver. Figure 6–7 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 6–7, 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

- 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)

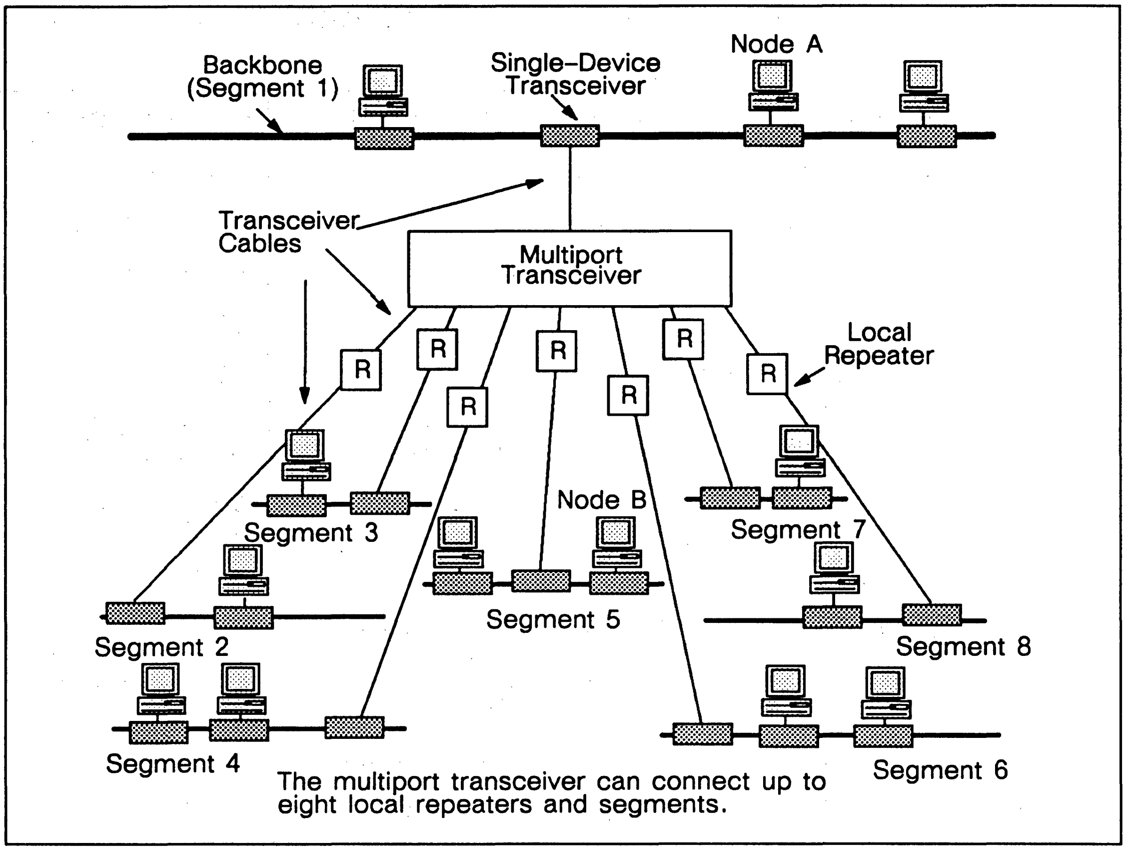



*Figure 6–7. Multiple Local Repeaters Connected with a Multiport Transceiver*

## 6.2 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 6–1 summarizes the differences between standard and Thin cabling systems.

*Table 6–1. 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.

### 6.2.1 Maximum Transmission Path in a Single Thin Cable Network

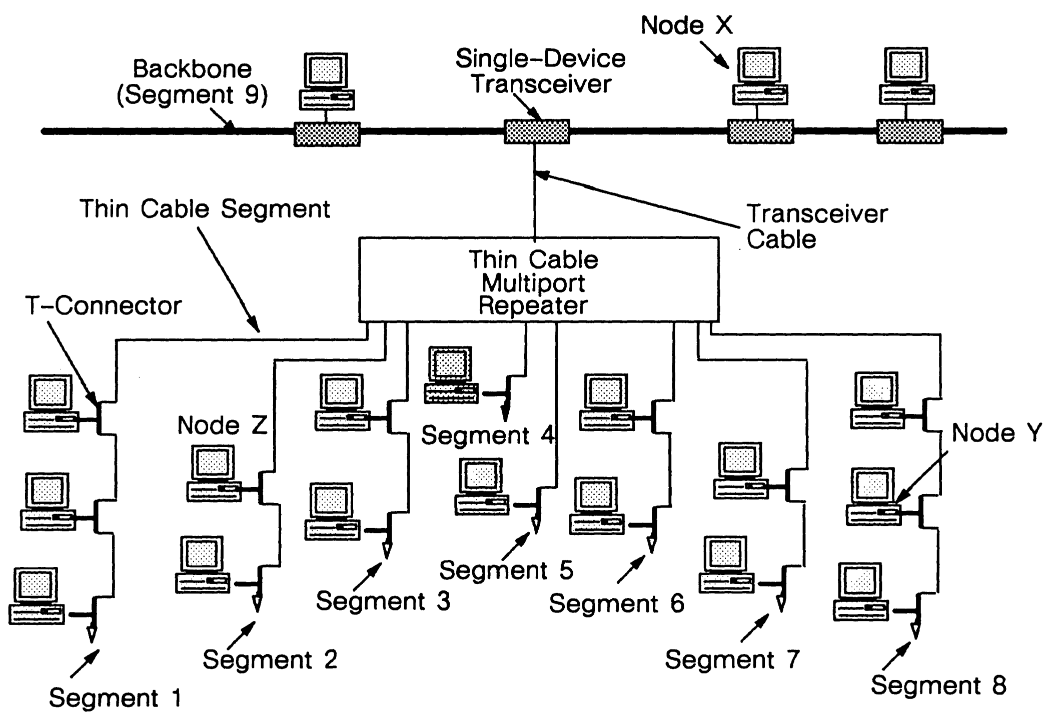
The same maximum transmission path applies to both standard and Thin cabling systems. However, determining the maximum transmission path can be difficult when your network contains multiport repeaters. See Figure 6–8 for an illustration of how to count Thin cable segments to determine the maximum transmission path.

### 6.2.2 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).

### 6.2.3 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 6–8 illustrates a Thin cable repeater configuration.




The multiport repeater has eight ports for connecting Thin cable segments plus one port for connecting a transceiver cable.

*Figure 6–8. Thin Cable Repeater Configurations*

In Figure 6–8, the repeater attaches to the backbone through a transceiver equipped with either a BNC tap or a BNC-to-N-series adapter (see Section 5.4, "Cable Taps and Tapping Tools," for information about these accessories).

The maximum transmission path between any two nodes in Figure 6–8 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/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)

## 6.3 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 6–9 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 6.4, "Making a Network Layout Diagram")
- 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.

## 6.4 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 (e.g. burial, 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 7 and 8 for more information on internets).

Figure 6-9 shows a sample cable layout diagram for a IEEE 802.3 network.

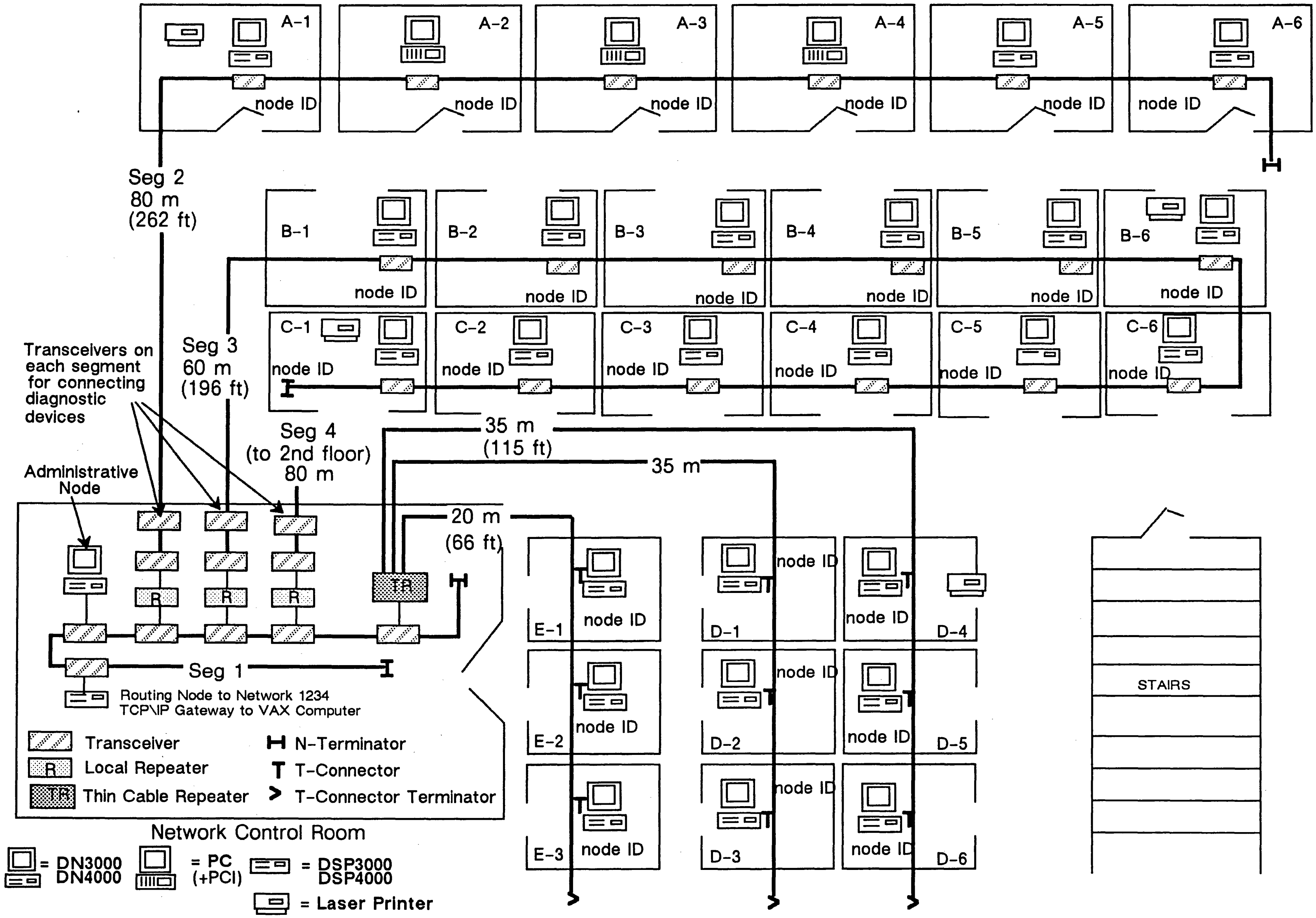



*Figure 6–9. Sample IEEE 802.3 Network Layout Diagram*

# Chapter 7

# Internet Hardware Products

This chapter provides detailed information about the hardware used for connecting networks to create a Domain or TCP/IP internet. See Chapter 2 for an introduction to internets.

## 7.1 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 or T1 service 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 7-1 provides information about the network controllers that can be used in routing and gateway nodes.

## 7.2 Creating Point-to-Point Links

A point-to-point link connects two Apollo Token Ring 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
- 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

**NOTICE:** Point-to-point links using digital networks with the CCITT G703 interface are also available to Domain customers overseas. Domain/Bridge G703 supports 2 Mbps communications over fiber-optic or other high-speed communication media. This product complies with the CCITT G-Series standards, which describe the overall specifications for high-speed telecommunication services used by European telephone companies (PTTs).

Domain/Bridge G703 hardware includes the IIC (Internet Interface Controller) plus the G703 media adapter card for DSP80 and DSP90 nodes. Domain/Bridge software (SR9.1.Bridge) is included to update nodes that run SR9.0. Internet routing software has been part of standard software since SR9.2. Contact our International Research and Development office at Apollo Computer, Zurich, Switzerland for more information.

### 7.2.1 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 7-1 shows this configura-

*Accunet is a registered trademark of AT&T

tion. See Chapters 5 and 6 for detailed information about IEEE 802.3 networks and hardware components.

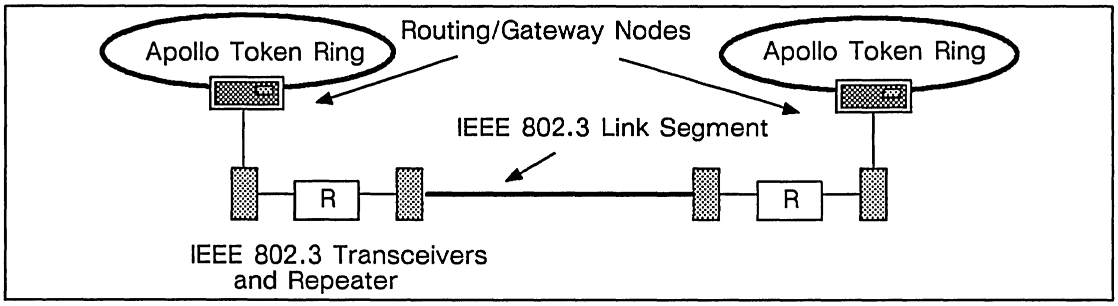



*Figure 7–1. An Internet with an IEEE 802.3 Link Segment*

Note that the internet shown in Figure 7–1 can be a Domain and/or TCP/IP internet.

### 7.2.2 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 7–2 shows an internet with T1 lines.

**NOTICE:** T1 links can be used only between ATR networks because T1 interface devices are supported only by the Domain/BridgeA network controller (refer to Table 7–1). Table 7–1 indicates that the Domain/BridgeA controller is a MULTIBUS controller that can be installed in a DSP90 MULTIBUS node. MULTIBUS nodes can have a maximum of two network controllers. One of these controllers is *always* an ATR network controller, which is supplied with the node. The second controller is optional, and can be *either* the Domain/BridgeA controller for use with TI networks, or an EtherController–MB for connecting to an IEEE 802.3 network or link segment.

*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.

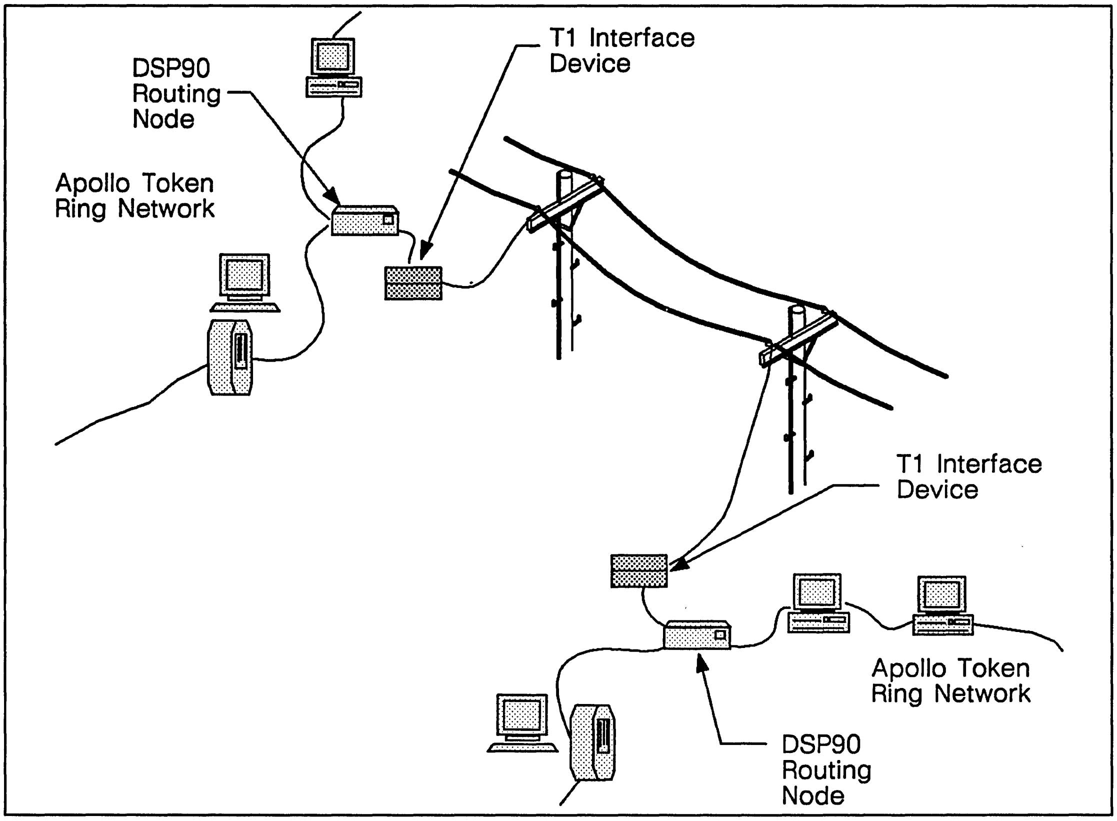



*Figure 7–2. A Point–to–Point Link Using T1 Service*

Note that the internet shown in Figure 7–2 can be a Domain and/or TCP/IP internet.

### 7.2.2.1 T1 Installation Considerations

To arrange for T1 service between Apollo Token Ring networks, contact your local telephone operating, 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 7.2.2.2 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: e.g., 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.

#### 7.2.2.2 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 and RS–422 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 1s 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, the Domain/Bridge network controllers 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 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 the *Bell System Technical* Reference for High Capacity Terrestrial Digital Service, publication number 41451, and in the *AT&T Compatibility Bulletin #119.*

#### 7.2.2.3 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.

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.

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

The Avanti unit requires several programmed settings in order to function properly with the Domain/Bridge hardware. You can ask the vendor to program these settings for you. For programming information, refer to *Installing the Domain/Bridge Controllers*.

The Verilink unit needs no special settings prior to installation. Refer to *Installing the Domain/Bridge Controllers* for information about how to connect both these devices to the Domain/Bridge hardware.

Arrange to have the vendor install and test the T1 interface devices at the same time that our service representative installs the Domain/Bridge equipment. In this way, both service representatives will be on hand to ensure a proper installation and to fully test the internet's capabilities. Refer to *Installing the Domain/Bridge Controllers* for information about how to connect the devices to the Domain/Bridge hardware.

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* 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.

**TPAC–1.5 is a registered trademark of the Avanti Communications Corporation.

## 7.3 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 VMEbus 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 7-4).

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 7-1 for a summary of the network controllers that can be used in Apollo nodes to directly connect networks to form an internet.

## 7.4 Internet Hardware Summary

Table 7-1 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.

*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.

*Table 7-1. Network Controller Summary*

| Node and Bus Type | Supported Networks | Network Controller Product Name | Other Required Hardware | Sources for Other Required Hardware |
|---|---|---|---|---|
| DN3000 DN4000 DSP3000 DSP4000 AT Compatible | ATR | Apollo Token Ring Network Controller–AT (earlier systems also use a 2–slot version of this controller board) | None | |
| | IEEE 802.3 | 802.3 Network Controller–AT | Transceiver and Cable, or T–connector for Thin cable | We supply through *Instant Apollo* |
| DN5xx–T VME | ATR | Controller included with node | None | |
| | IEEE 802.3 | 802.3 Network Controller–VME | Transceiver and Cable, or T–connector for Thin cable | We supply through *Instant Apollo* |
| DN10000 VME | ATR | Controller included with node | None | |
| | IEEE 802.3 | Hi–Perf 802.3 Network Controller–VME | Transceiver and Cable, or T–connector for Thin cable | We supply through *Instant Apollo* |
| DSP90 MULTIBUS | ATR | Controller included with node | None | |
| | T1 | Domain/BridgeA (for point–to–point links only) | T1 Interface Devices | T1 Vendor |
| | IEEE 802.3 | EtherController–MB (for point–to–point links only) | Transceiver and Cable, or T–connector for Thin cable | We supply through *Instant Apollo* |

| Bus Type | Maximum Controller Configuration |
|---|---|
| AT Compatible | Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3 |
| VME (for DN5xx–T) | Up to 3 controllers total, maximum of 1 ATR and 2 IEEE 802.3 |
| VME (for DN10000) | Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3 |
| MULTIBUS | Up to 2 controllers total, 1 ATR controller included with product, plus one other controller for point–to–point communications |

**NOTICE:** Although the information in this table was current at the time of publication, we suggest that you consult your sales representative for the latest information about nodes, network controllers, and software requirements.

From Table 7–1, 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 7–3 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)
- Two DSP90s equipped with Apollo Token Ring controllers and Domain/BridgeA controllers (Nodes C and D)

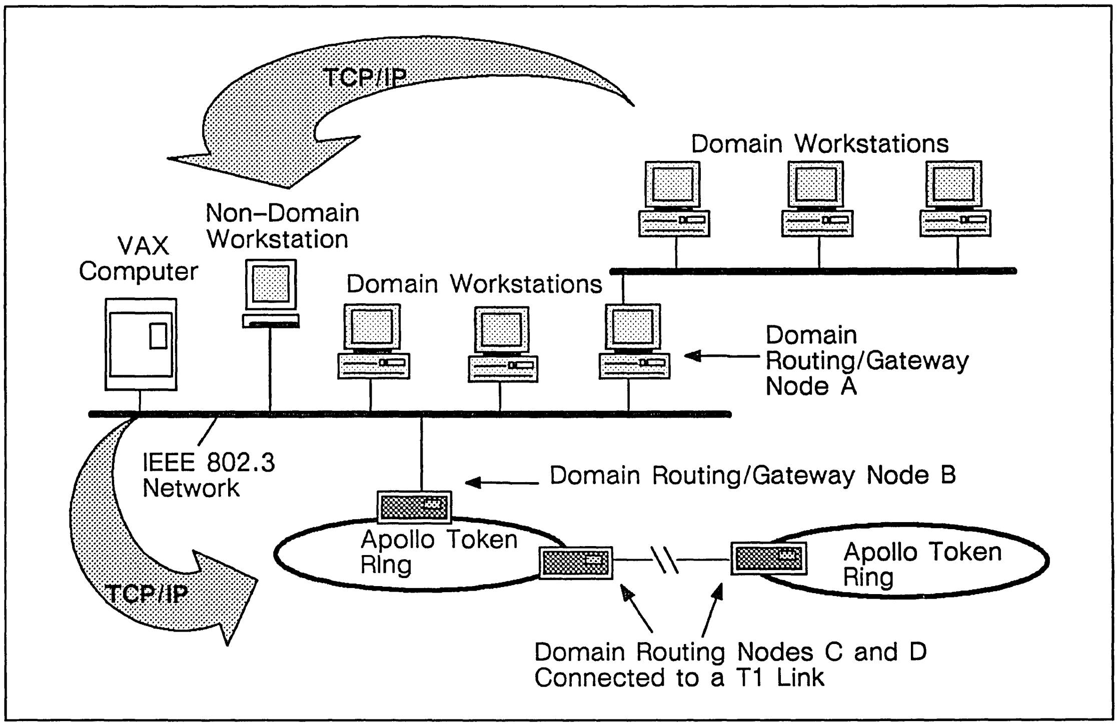



*Figure 7–3. A Domain–TCP/IP Internet*

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 7–4 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.

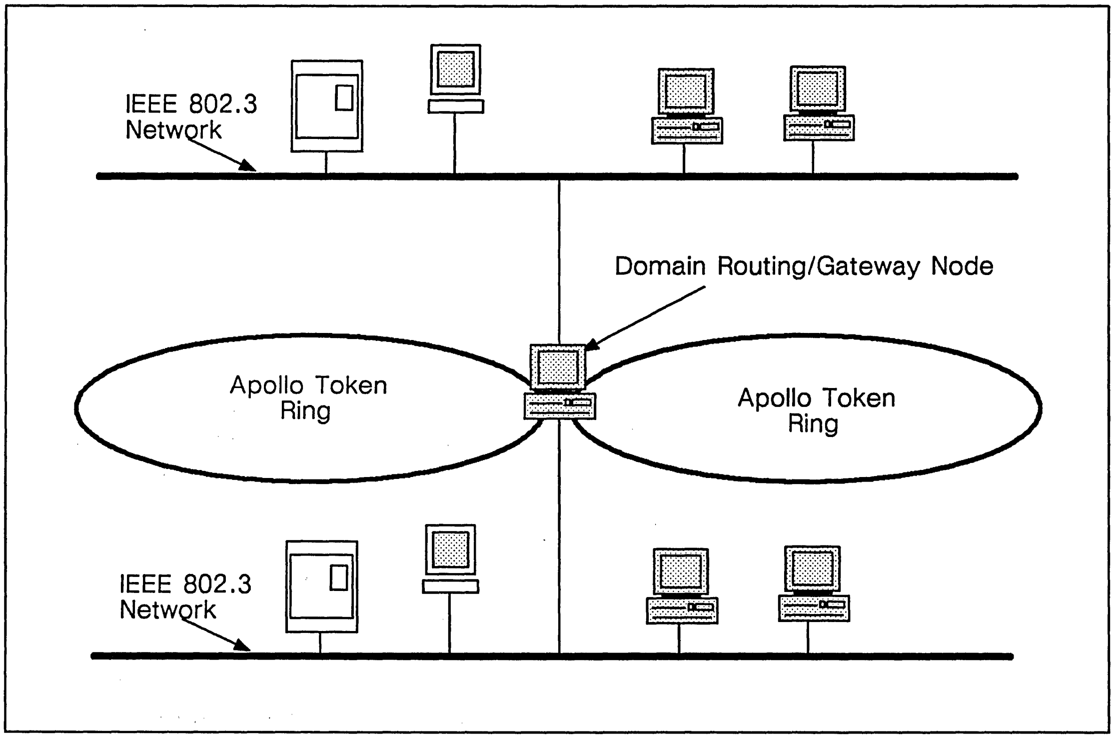



*Figure 7–4. A Single Node Joining Four Networks*

# Chapter 8

# 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.

## 8.1 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. For example, in a Domain internet, the routing software is designed to allow fast, transparent communication between nodes on separate networks; however, the software is *not* designed to run large programs between networks or to provide access to essential resources (such as printers or program compilers) on other networks.

**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.

The following section includes some additional suggestions to help in resource planning.

## 8.2 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.

### 8.2.1 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 8–1 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.

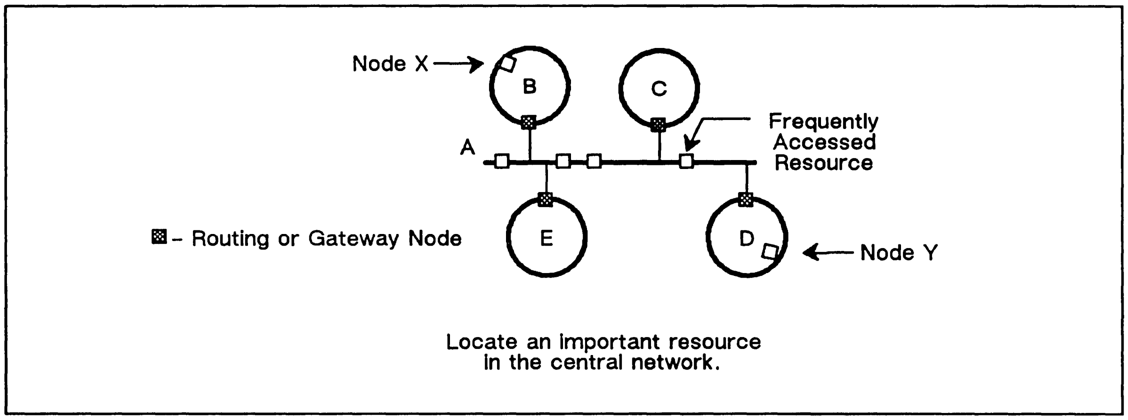



*Figure 8–1. Placing an Important Resource*

## 8.2.2 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 8–2.

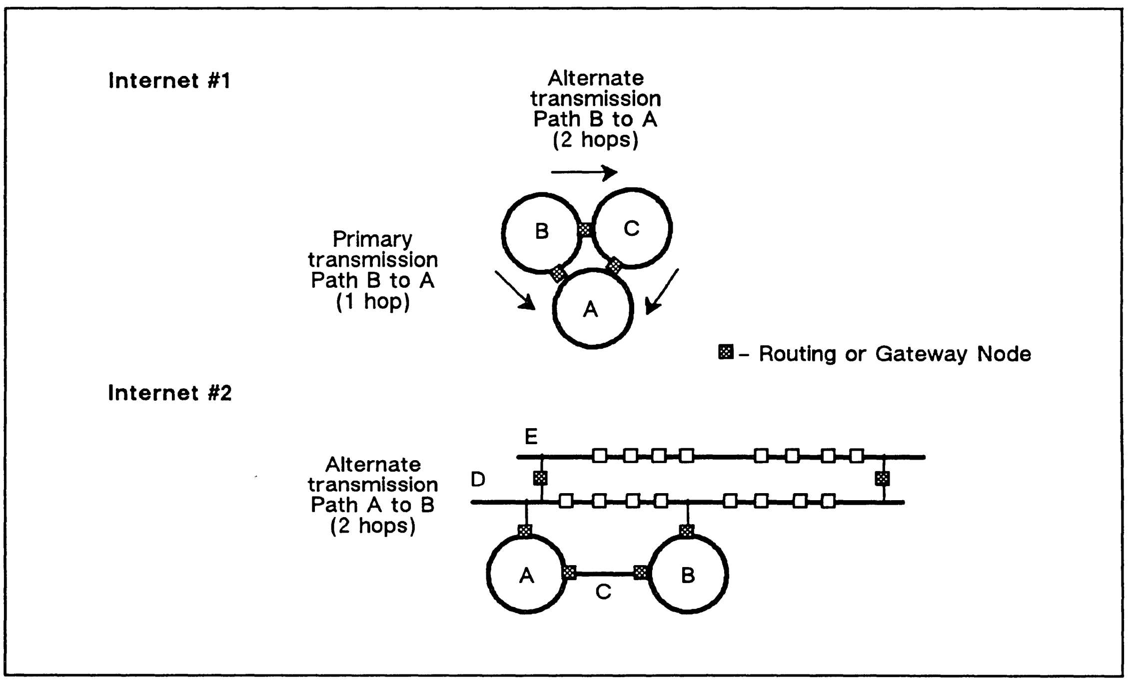



*Figure 8–2. Using Redundant Communication Paths*

In Figure 8–2, 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.

### 8.2.3 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 8–3 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.

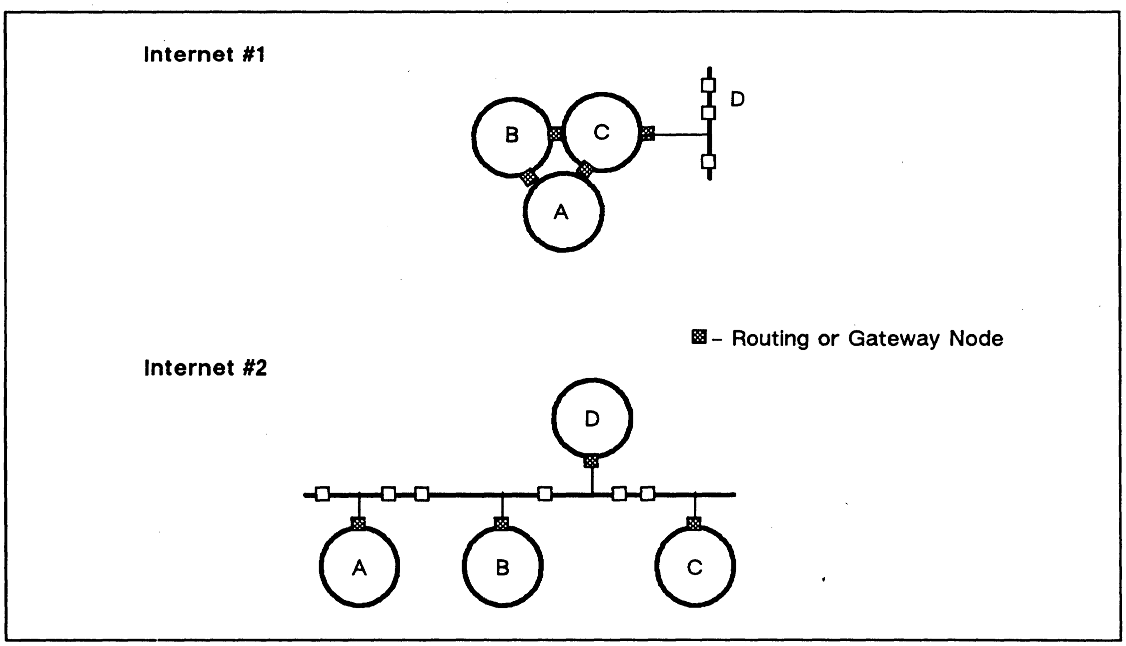



*Figure 8–3. Limiting Access in an Internet*

Because of the design and administration of Internet #1 in Figure 8–3, 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.

### 8.2.4 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 non-functioning) network as an alternate communication path. The topologies shown in Figure 8-3 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.

## 8.3 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.

### 8.3.1 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 sixteen 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.

### 8.3.2 Examples of Domain Internet Topologies

Figures 8–4 and and 8–5 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.

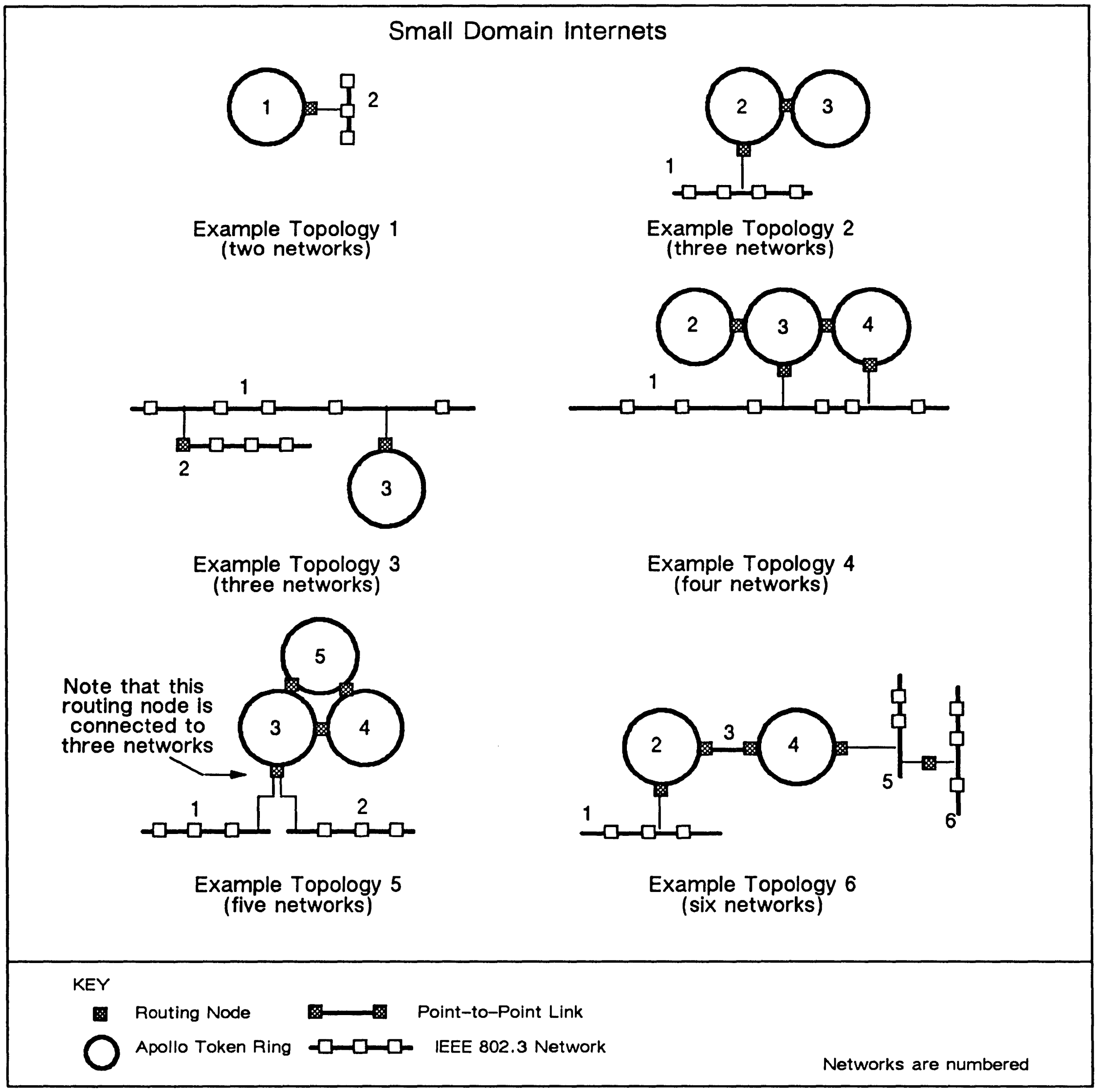



*Figure 8–4. Small Domain Internet Topologies*

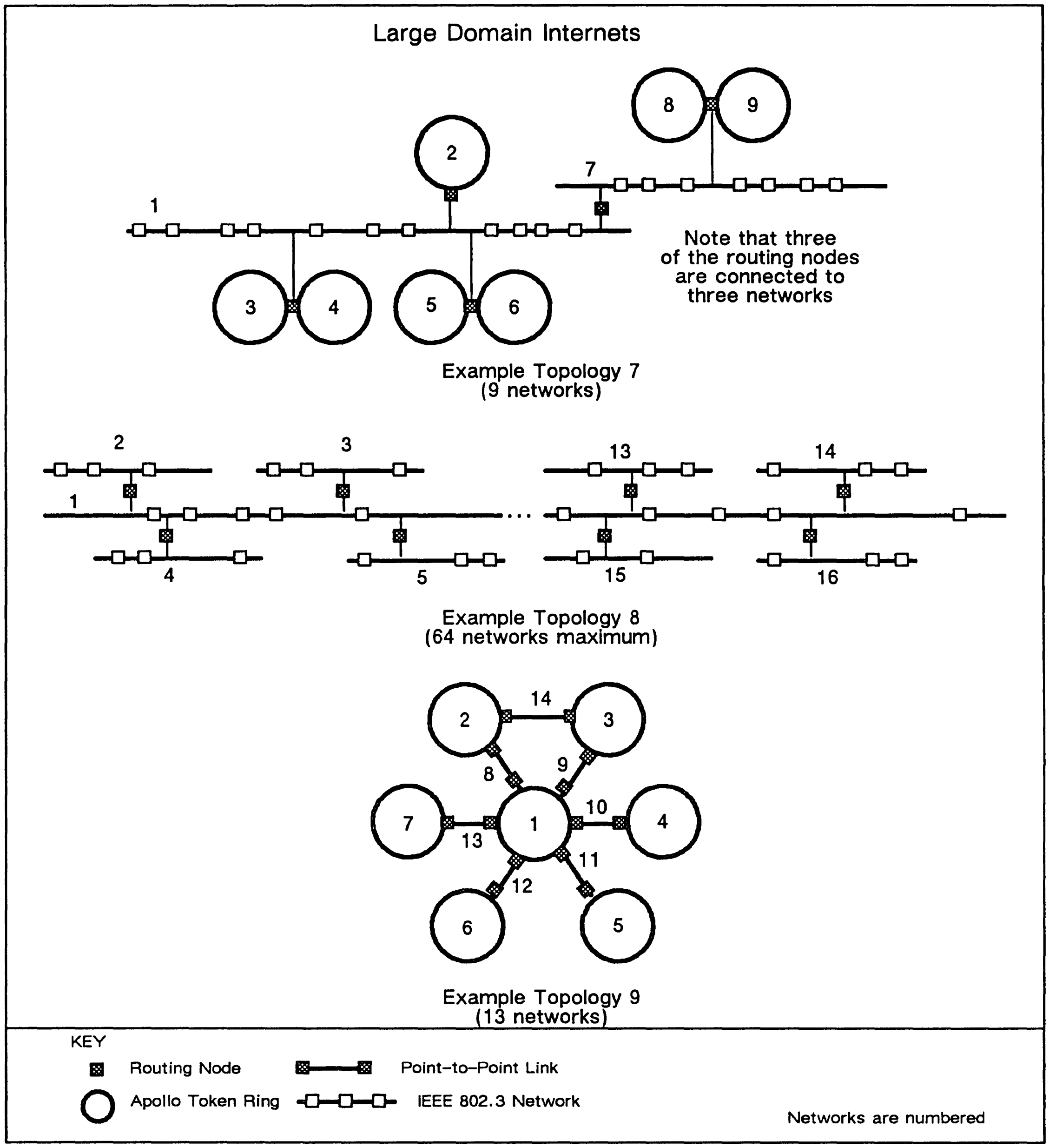



*Figure 8–5. Large Domain Internet Topologies*

## 8.3.3 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 implement adaptive routing by designing the Domain portion of your internet so that it provides alternate transmission paths. In Figures 8–4 and 8–5, example topologies 4, 5, and 9 provide alternate routes between some networks.

In Figure 8-6, 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.

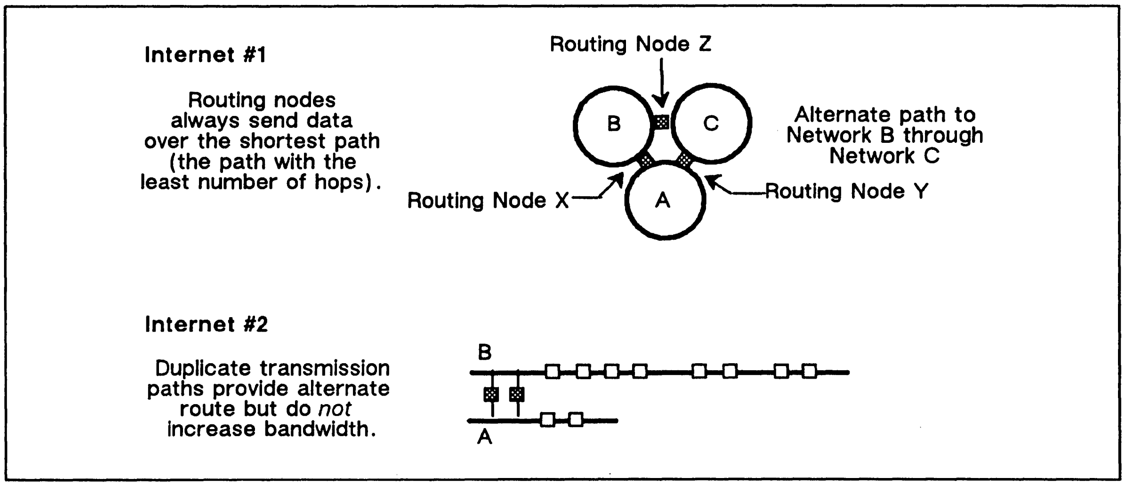



*Figure 8-6. Adaptive Routing*

### 8.3.4 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.)

## 8.4 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.

### 8.4.1 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. (For one exception, see Section 8.4.2.2).
- 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, the maximum number of hops allowed.

**NOTICE:** Instead of a hop count, the TCP/IP protocol defines a parameter called the maximum time to live (MTTL) parameter. However, the value of the MTTL parameter converts to 30 hops.

For details about configuring a TCP/IP internet, see *Configuring and Managing TCP/IP*.

## 8.4.2 Sample TCP/IP Internet Topologies

The following subsections describe possible TCP/IP topologies. The first subsection shows possible internet topologies for nodes with AT compatible buses. The second subsection shows possible internet topologies for nodes with MULTIBUS card cages and describes limitations with the MULTIBUS configuration. Note that all of the topologies shown in these subsections can include both Domain and TCP/IP internets.

### 8.4.2.1 TCP/IP Configurations with AT Compatible Bus Hardware

This section shows the possible TCP/IP configurations using Apollo AT compatible bus nodes. Figure 8–7 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 8–7, is *not* an example of an internet topology. However, we've included it here to show how a single network could use the TCP/IP protocol.

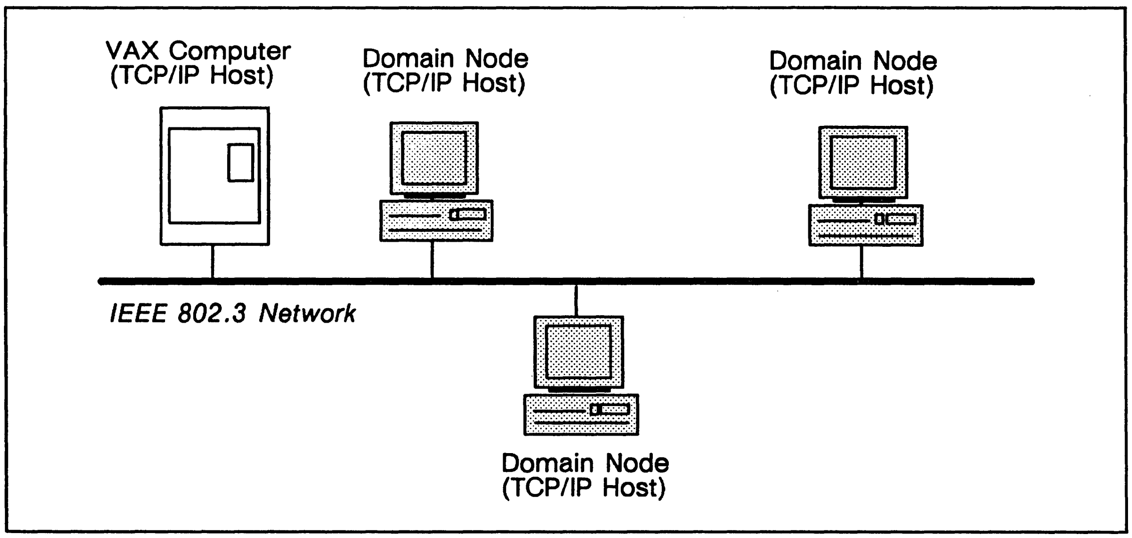



*Figure 8–7. TCP/IP Hosts on an IEEE 802.3 Network*

In Figure 8–8, 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.

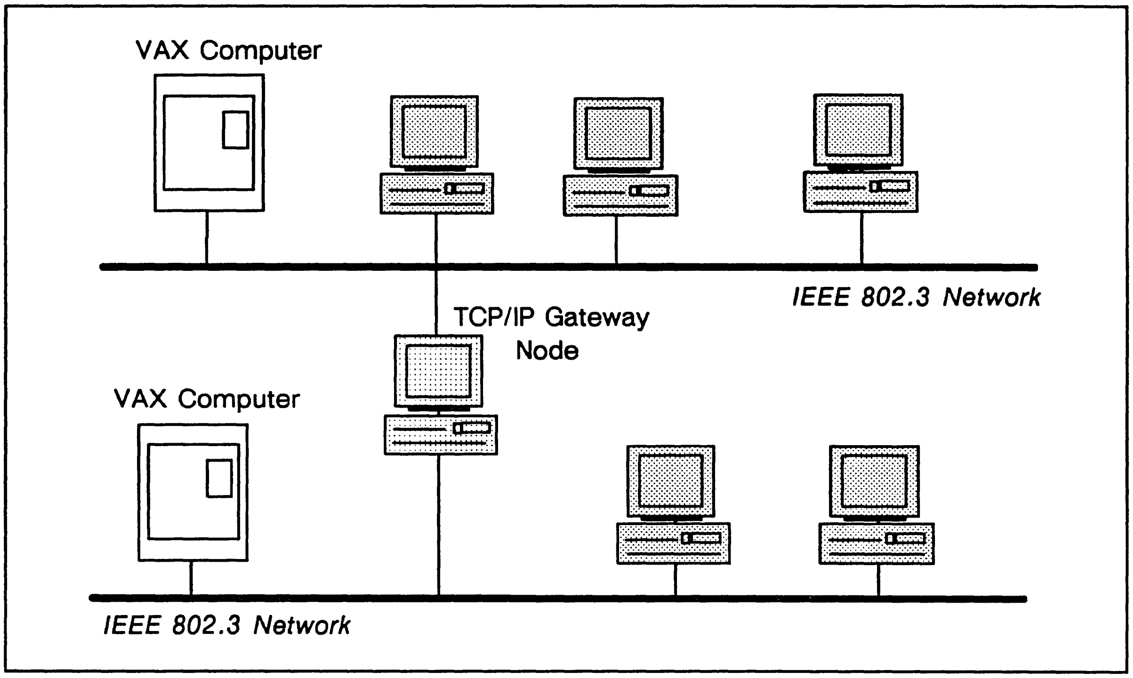



*Figure 8–8. Direct Connection Internet Configuration Between Two IEEE 802.3 Networks*

In Figure 8–9, 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.

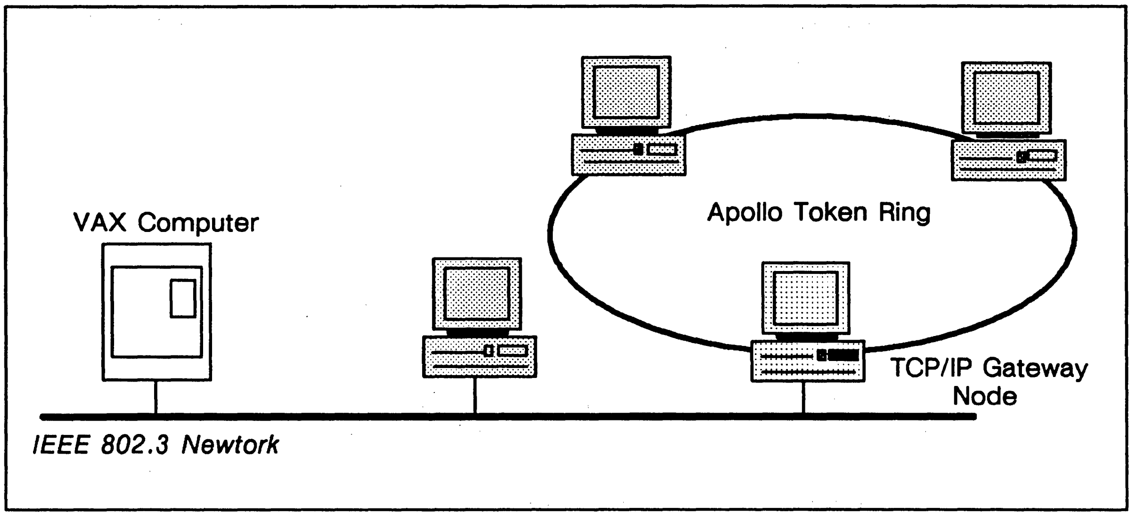



*Figure 8–9. AT–Compatible TCP/IP Gateway Between an IEEE 802.3 and Apollo Token Ring Network*

Figure 8–10 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.

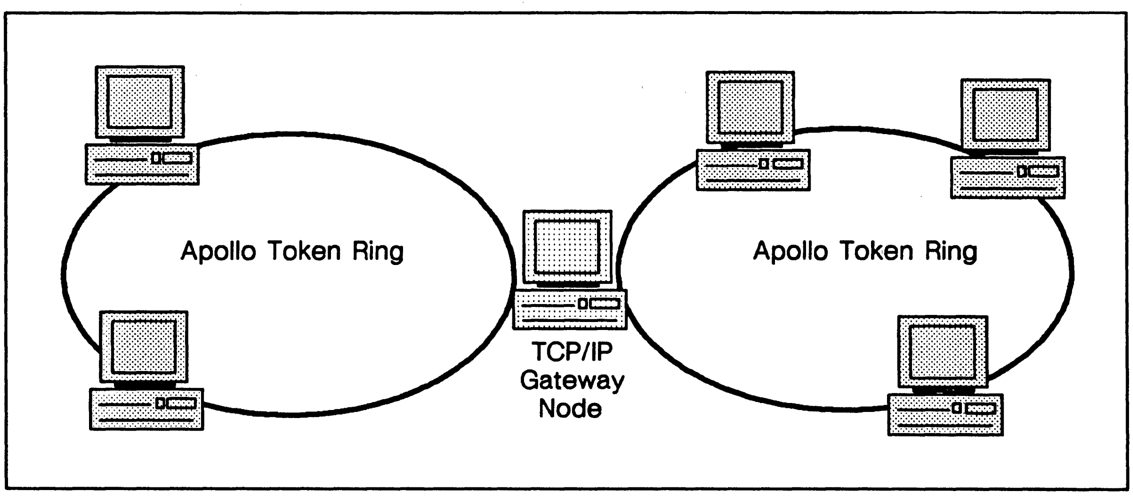



*Figure 8–10. AT Compatible Node as a Gateway Between Two Apollo Token Rings*

Figure 8–11 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.

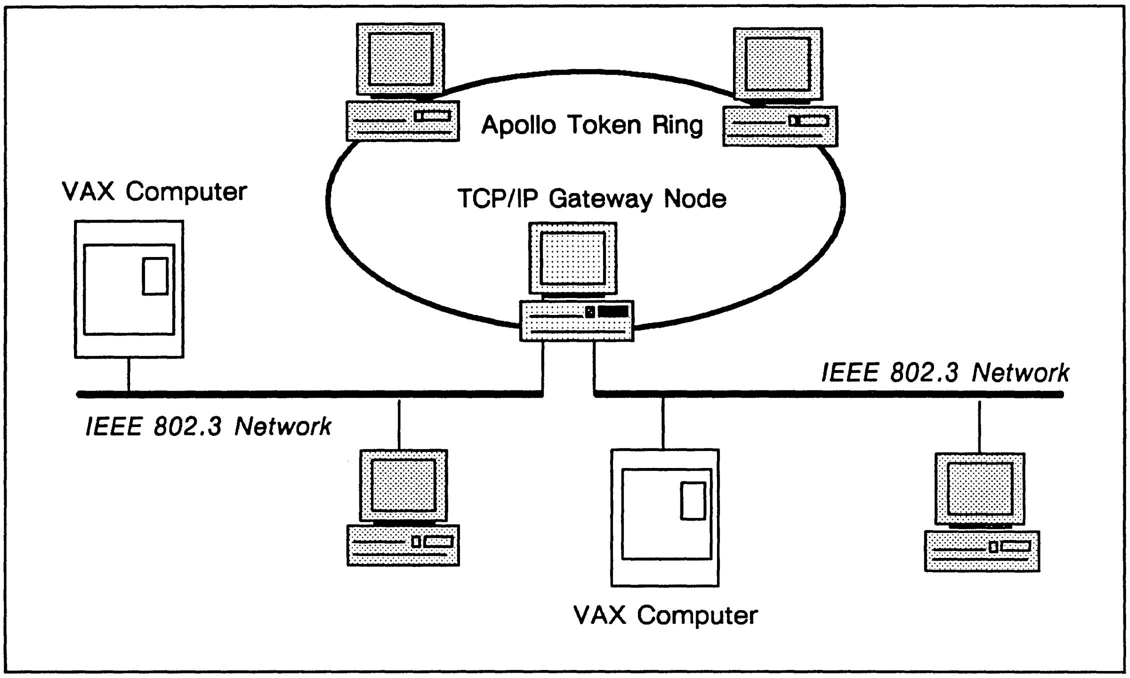



*Figure 8–11. TCP/IP Gateway to Two IEEE 802.3 Networks and an Apollo Token Ring*

Figure 8–12 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).

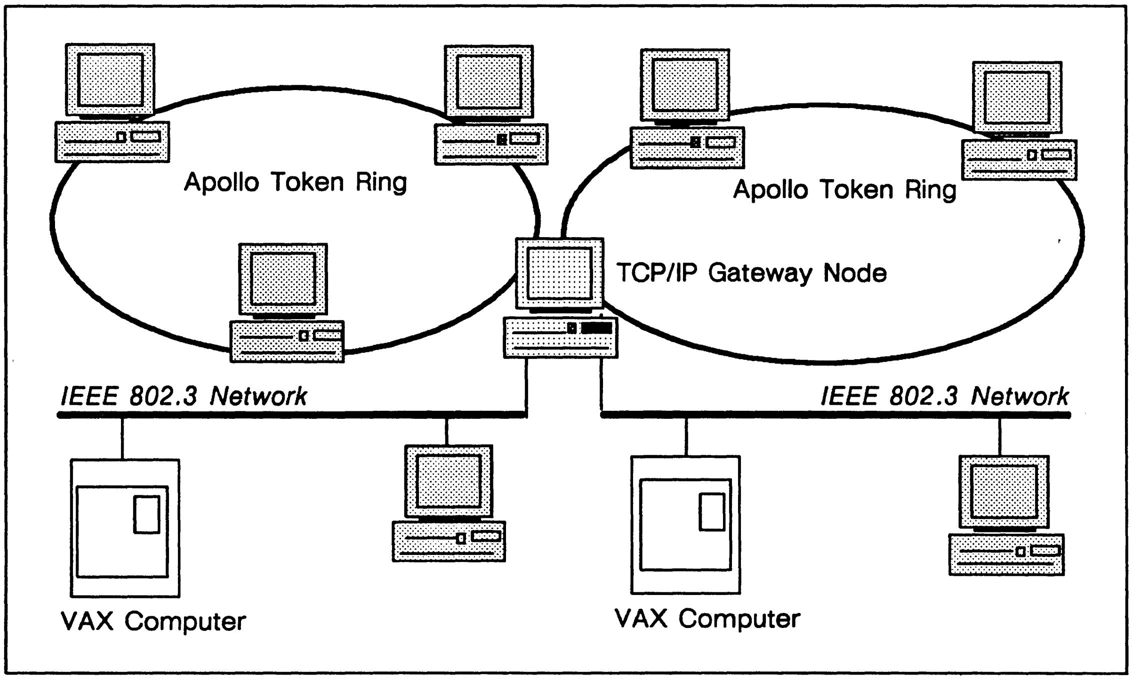



*Figure 8–12. Maximum Number of Networks Connected to a Single TCP/IP Gateway Node*

### 8.4.2.2 TCP/IP Configurations with MULTIBUS Hardware

This section shows the possible TCP/IP configurations that you can have when you have a MULTIBUS node serving as a TCP/IP gateway.

In Figure 8–13, two MULTIBUS nodes serve as TCP/IP gateways at either end of a point–to–point link. If the link is an IEEE 802.3 link segment, the MULTIBUS nodes must contain EtherController–MB network controllers. If the link is a T1 line, the MULTIBUS nodes must contain Domain/BridgeA network controllers. Nodes on each network can communicate via TCP/IP or Domain protocols.

**NOTICE:** The point–to–point link in this configuration is considered a subnet within the internet and must be assigned an Internet Protocol (IP) address. For information about IP addresses, refer to *Configuring and Managing TCP/IP*.

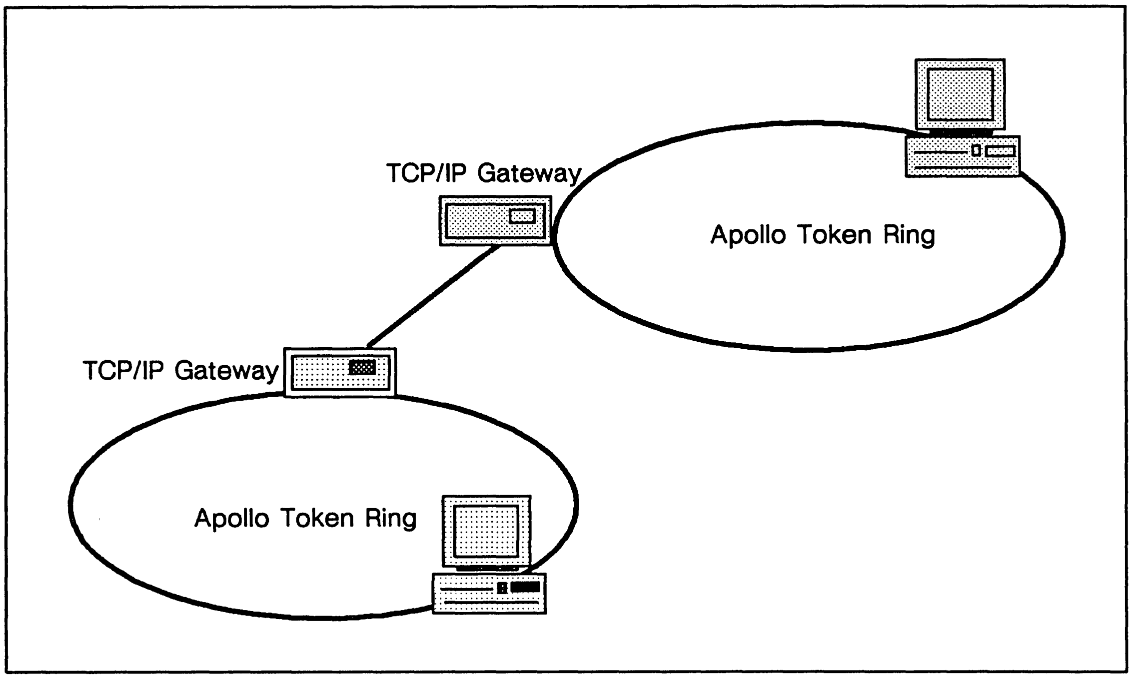



*Figure 8-13. Two MULTIBUS TCP/IP Gateway Nodes in a Point-to-Point Configuration*

In Figure 8-14, two MULTIBUS nodes containing EtherController-MB controllers connect Apollo Token Ring networks to an IEEE 802.3 network. The MULTIBUS TCP/IP gateway nodes can be configured to provide TCP/IP service but *not* Domain service.

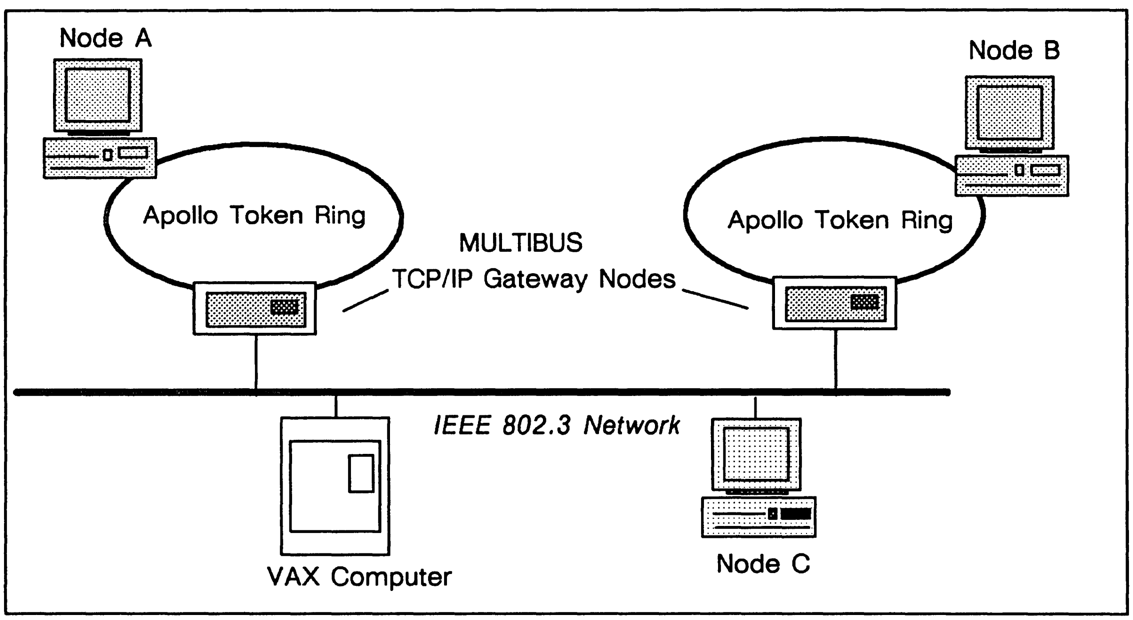



*Figure 8-14. MULTIBUS Gateway Nodes Connecting ATRs to an IEEE 802.3 Network*

Nodes A, B, and C in Figure 8–14 can communicate with each other via TCP/IP protocols but *cannot* communicate by means of Domain protocols. To allow the Apollo nodes to use Domain protocols as well as TCP/IP protocols, you must set up an internet configuration similar to the one shown in Figure 8–15.

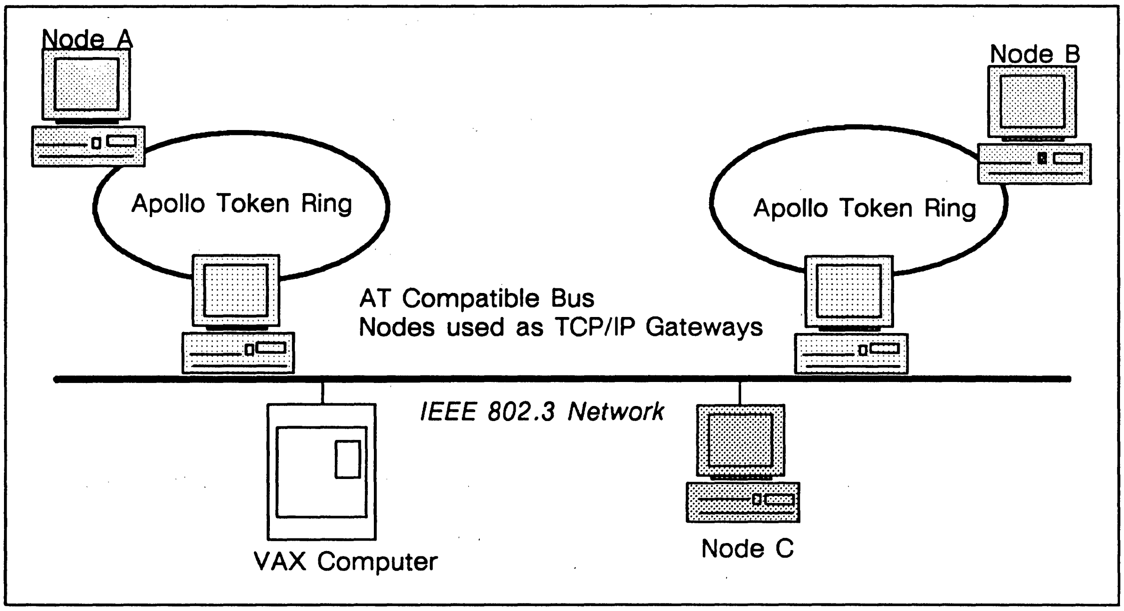



*Figure 8–15. Solution to MULTIBUS Configuration*

In Figure 8–15, AT compatible bus nodes equipped with 802.3 Network Controller–ATs are used as TCP/IP gateways to connect Apollo Token Ring networks to an IEEE 802.3 network. In this configuration, Nodes A, B, and C can communicate with each other through both Domain and TCP/IP protocols. The nodes can also communicate with the VAX computer using TCP/IP protocols.

## 8.5 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 Domain/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 *Confguring 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). *Outside North America, customers should order components through their local sales offices.* We guarantee shipment of your components within 24 hours. The catalog is published quarterly, so ask your sales representative about additions to the catalog.

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.

*Table A-1. Apollo Token Ring Coaxial Cable*

| **Spool Length** | **PVC Cable Catalog Number** | **Teflon Cable Catalog Numbers** |
|---|---|---|
| 1000 ft | NET-COAX-PVC | NET-COAX-FEP |
| 500 ft | NET-COAX-PVC-500 | NET-COAX-FEP-500 |
| 250 ft | NET-COAX-PVC-250 | NET-COAX-FEP-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** | |
|---|---|---|
| *Standard Cable (preterminated with N-series connectors)* | *PVC* | *TEFLON* |
| 23.5-meter length (76.8 ft) | ETH-BKBN-76P | ETH-BKBN-76T |
| 70.2-meter length (230.3 ft) | ETH-BKBN-230P | ETH-BKBN-230T |
| 117-meter length (383.9 ft) | ETH-BKBN-383P | ETH-BKBN-383T |
| Standard Cable Reels (unterminated, 304.8 m/1000 ft) | ETH-BKBN-1000P | ETH-BKBN-1000T |
| Single-Device Transceiver | ETH-XCVR-3C | |
| Single-Device Transceiver with Diagnostic LEDs | ETH-XCVR-DIAG | |
| Multiport Transceiver | ETH-XCVR-MP8 | |
| Multiport Thin Ethernet Repeater | ETH-RPTR-9C | |
| Local Repeater | ETH-RPTR-2C | |
| Fiber-Optic Repeater | ETH-RPTR-FIBER | |
| *Transceiver Cables* | *PVC* | *TEFLON* |
| 5-meter length (16.4 ft) | ETH-TXCVR-5MP | ETH-TXCVR-5MT |
| 10-meter length (32.8 ft) | ETH-TXCVR-10MP | ETH-TXCVR-10MT |
| 20-meter length (62.6 ft) | ETH-TXCVR-20MP | ETH-TXCVR-2-MT |
| N-Series Terminator - male | ETH-BKBN-TERM-M | |
| N-Series Terminator - female | ETH-BKBN-TERM-F | |
| N-Series Feedthrough - male | ETH-BKBN-ADAP-M | |
| N-Series Feedthrough - female | ETH-BKBN-ADAP-F | |
| Screw-on Connector (TEFLON) male | ETH-BKBN-FEPW-M | |
| Scew-on Connector (PVC) male | ETH-BKBN-PVCW-M | |
| Standard-to-Thin Adapter | ETH-CBNC-THCK | |
| Tapping Tool Kit (reusable — includes instructions) | ETH-TOOLS | |

*Table A-4. IEEE 802.3 Thin Cable Network Components*

| Thin Cable and Accessories | Catalog Order Number | |
|---|---|---|
| *Thin IEEE 802.3 Cable (preterminated with BNC connectors)* | *PVC* | *TEFLON* |
| 5-meter length (16.4 ft) | ETH-CXCVR-5MP | ETH-CXCVR-5MT |
| 10-meter length (32.8 ft) | ETH-CXCVR-10MP | ETH-CXCVR-10MT |
| 20-meter length (62.6 ft) | ETH-CXCVR-20MP | ETH-CXCVR-20MT |
| 50-meter length (164 ft) | ETH-CXCVR-50MP | ETH-CXCVR-50MT |
| 1K-meter length (3280 ft) | ETH-TCOAX-PVC | ETH-TCOAX-FEP |
| *Bulk Thin IEEE 802.3 Cable and accessories* | *PVC* | *TEFLON* |
| 1000 ft. reel | ETH-TCOAX-PVC | ETH-TCOAX-FEP |
| custom length | ETH-TCOAX-PVCCL | ETH-TCOAX-FEPCL |
| Crimp Thin Ethernet Connectors | ETH-CBNC-PVCC | ETH-CBNC-FEPC |
| BNC Crimping Tool | ETH-CRIMP-TOOL | |
| T-Connector Terminator ** | ETH-CBNC-TERM | |
| T-Connector | ETH-CBNC-TEE | |
| Feed-thru | ETH-CBNC-ADAP | |

** One T-connector is packed with each 802.3 Network Controller-AT.

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.

# Appendix B

# 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.

## 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 our Network Services group for information about fiber optic cable installation. The Network Services group will provide you with information about certification and verification procedures for DFL–100 and fiber optic cable installations.

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 50/125 µm DFL-100 Fiber-Optic Cables*

NOTES: Cables listed are manufactured by Belden Wire and Cable, 100 Pennsylvania Ave., Suite 450, Framingham, MA. 01701.
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.

| Number of Fiber Channels | Type of Fiber | Belden Part Number for Cable Assembly (unique number for DOMAIN customers) | Belden Part Number (cable only) | Belden Part Number Break-Out Kit * |
|---|---|---|---|---|
| 2 | 50/125 | 550023B** | | Not Needed |
| 2 | 50/125 | 550023Y***<br>Installation: burial | 229657 | Not Needed |
| 4 | 50/125 | 550024B | | Not Needed |
| 4 | 50/125 | 550024Y<br>Installation: burial/aerial | 227414 | 229865 |
| 6 | 50/125 | 550025B | | Not Needed |
| 6 | 50/125 | 550025Y<br>Installation: burial/aerial | 227416 | 229865 |
| 8 | 50/125 | 550026B | | Not Needed |
| 8 | 50/125 | 550026Y<br>Installation: burial/aerial | 227418 | 229865 |
| 10 | 50/125 | 550027B | | Not Needed |
| 10 | 50/125 | 550027Y<br>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.

*Table B-2. Recommended 62.5/125 µm DFL-100 Fiber-Optic Cables*

**NOTES:** Cables listed are manufactured by Belden Wire and Cable, 100 Pennsylvania Ave., Suite 450, Framingham, MA. 01701. 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.

| Number of Fiber Channels | Type of Fiber | Belden Part Number (cable only) | Belden Part Number Break-Out Kit (not including connectors)* |
|---|---|---|---|
| 2 | 62.5/125 | 225432 | 229597 |
| 4 | 62.5/125 | 225414 | 229739 |
| 6 | 62.5/125 | 225416 | 229739 |
| 8 | 62.5/125 | 225418 | 229739 |
| 10 | 62.5/125 | 225413 | 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.

*Table B-3. Recommended DFL-100 Fiber-Optic Connectors*

If you order unterminated cable, we recommend using these connectors:

| Vendor | Connector Type | Part Number |
|---|---|---|
| Optical Fiber Technologies Inc. Billerica, MA | 905<br>906 | 252-RB2-5<br>252-S-RB2-6 |
| Augat Fiberoptics Pawtucket, RI | 905<br>906 | 698-DSC-125-5<br>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 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<br>Fuggarstrasse 2<br>4040 Neuss 1<br>West Germany |
| **Canada** | White Radio Limited<br>940 Gateway Drive<br>Burlington, Ontario<br>Canada, L7L 5K7 |
| **Australia** | Belden Electronics<br>Suite 11, 2 Claremont St.<br>South Yarra, Vic. 3141<br>Postal Address: P.O. Box 322<br>Clayton, Vic. 3168<br>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

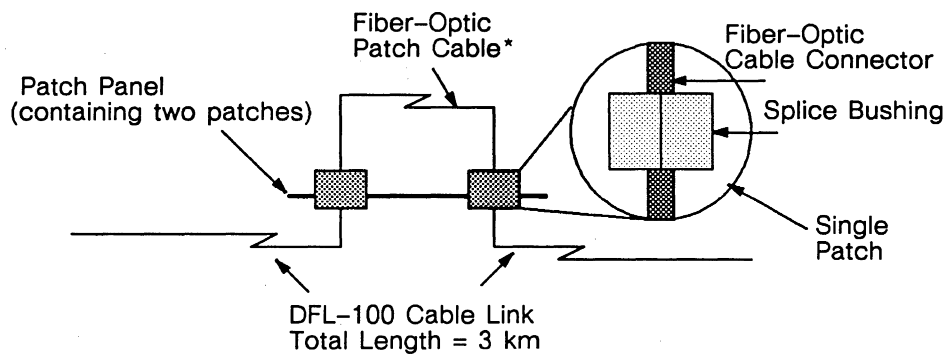
Table B–4 lists the data you need to calculate the loss over your link. The attenuation information about the fiber–optic cables we recommend is listed in the specifications in Chapter 3. Information about attenuation for connectors and splice materials should be provided by the component's vendor. You 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<br>- 0.5 dB |
| 62.5/125 µm | 16 dB + 0 dB<br>- 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:

$$14.0 \text{ dB} \geq \left(\begin{matrix}\text{cable length}\\ \text{in km}\end{matrix}\right)\left(\frac{4.0 \text{ dB}}{\text{km}}\right)^{**} + \left(\begin{matrix}\text{no. of}\\ \text{patches}\end{matrix}\right) \times \left(\begin{matrix}\text{dB loss}\\ \text{per patch}\end{matrix}\right)$$

This equation with sample values is:

$$14.0 \text{ dB} \geq 3.0 \text{ km} \left(\frac{4.0 \text{ dB}}{\text{km}}\right) + (2) \times \left(\frac{1.0 \text{ dB}}{\text{patch}}\right)$$

$$14.0 \text{ dB} \geq 14.0 \text{ dB}$$

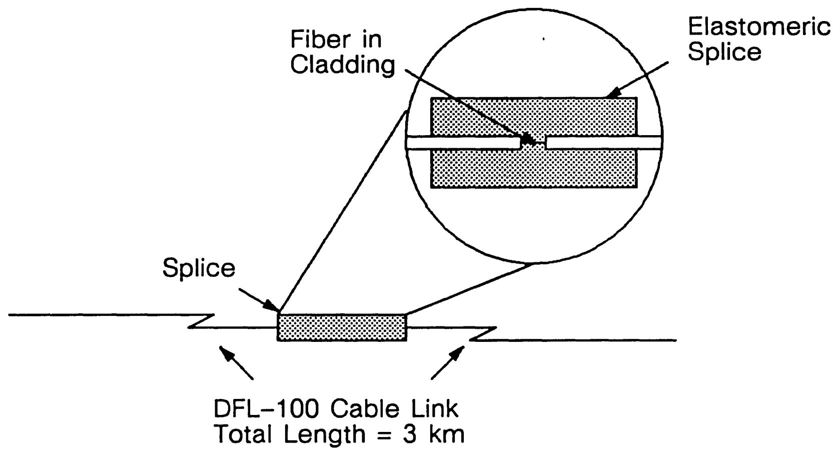
In this case, the patch connection does *not* increase the loss above the maximum.

* 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:

$$16.0\ \text{dB} \geq \left(\begin{matrix}\text{cable length}\\ \text{in km}\end{matrix}\right)\left(\frac{5.0\ \text{dB}}{\text{km}}\right)^{*} + \left(\begin{matrix}\text{no. of}\\ \text{splices}\end{matrix}\right) \times \left(\begin{matrix}\text{dB loss}\\ \text{per splice}\end{matrix}\right)$$

This equation with sample values is:

$$16.0\ \text{db} \geq \left(3.0\ \text{km}\right)\left(\frac{5.0\ \text{dB}}{\text{km}}\right) + \left(6\right) \times \left(\frac{0.5\ \text{dB}}{\text{splice}}\right)$$

$$16.0\ \text{db} \geq 18.0\ \text{dB}$$

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 Domain nodes.

## C.1 Summary of Network Controller Information

Table C–1 summarizes the network controllers currently available for Domain 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 |
|---|---|---|---|
| DN3000<br>DN4000<br>DSP3000<br>DSP4000 | 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 |
| DN5xx–T<br>DSP500–T | VME | ATR | Controller included with node |
| | VME | IEEE 802.3 | 802.3 Network Controller–VME |
| DN10000 | VME | ATR | Controller included with node |
| | VME | IEEE 802.3 | Hi–Perf 802.3 Network Controller–VME |
| DSP90 | MULTIBUS | ATR (native) | Controller included with node |
| | MULTIBUS | T1 | Domain/BridgeA (for point–to–point links only) |
| | MULTIBUS | IEEE 802.3 | EtherController–MB (for point–to–point links only) |

| Bus Type | Maximum Controller Configuration |
|---|---|
| AT Compatible | Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3 |
| VME (for DN5xx–T) | Up to 3 controllers total, maximum of 1 ATR and 2 IEEE 802.3 |
| VME (for DN10000) | Up to 4 controllers total, maximum of 2 ATR and 2 IEEE 802.3 |
| MULTIBUS | Up to 2 controllers total, 1 ATR controller included with product, plus one other controller for point–to–point communications |

# 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 network and the Apollo Token Ring network to meet your applications' requirements and other needs (see Chapter 2).
- ☐ Consider the degree of modularity required within each network.
  - ☐ Serially or star–wired Apollo Token Ring Network (see Chapters 2, 3, and 4)
  - ☐ Segmented IEEE 802.3 network (see Chapters 2, 5, and 6)
- ☐ Evaluate the internet configuration options (see Chapters 2, 7, and 8).

**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, Chapters 5 and 6 for IEEE 802.3 network).
- ☐ Plan the network control room/area (see Chapter 4 for Apollo Token Ring, Chapter 6 for IEEE 802.3 network).
- ☐ 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 Chapter 3 for Apollo Token Ring, Chapter 5 for IEEE 802.3 network, and Appendix A for ordering information).
- ☐ Ascertain the delivery times for the nodes and peripherals, and order accordingly.

## 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 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, intall 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, BSD, or 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 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 **Domain networks** connected by **routers**.

**Domain Network**

A network that provides Domain **distributed system** services. At present, this includes **Apollo Token Ring networks**, and **IEEE 802.3 networks**.

**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.

**ETHERNET**

A 10 Mbps **LAN**, developed by Digital Equipment Corporation, Intel, and Xerox Corporation, upon which the **IEEE 802.3 network** is based.

**Fan–Out Configuration**

A **topology** in which many device connections radiate from a single control unit or device.

**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.

**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 **Medium Attachment Unit.**

**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.

**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 a **Domain 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**.

**Serially 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–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**.

**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.

**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.

# Index

Symbols are listed at the beginning of the index. Entries in color indicate task-oriented information.

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## Reader's Response

Please take a few minutes to send us the information we need to revise and improve our manuals from your point of view.

Document Title: *Planning Domain Networks and Internets*
Order No.: 009916–A00 Date of Publication: August 1988

What type of user are you?

_____ System programmer; language ____________________

_____ Applications programmer; language ____________________

_____ System maintenance person

_____ System Administrator

_____ Student Programmer

_____ Other

_____ Manager/Professional

_____ Technical Professional

_____ Novice

How often do you use the Domain system? ____________________

What parts of the manual are especially useful for the job you are doing? ____________________

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