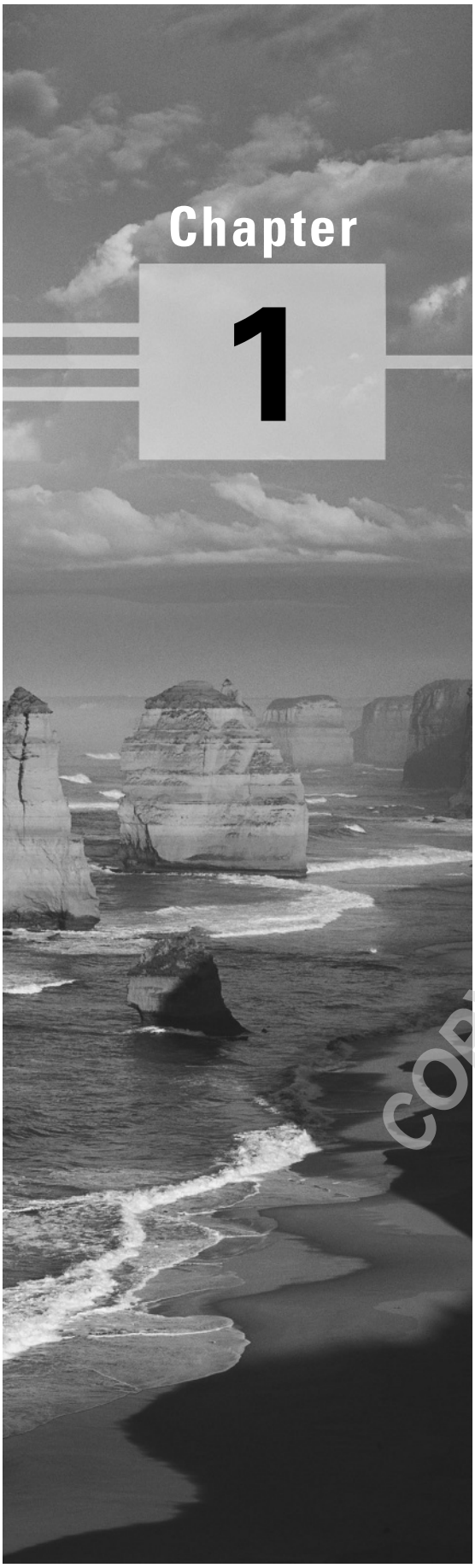


Chapter

1

Introduction to Networking

THE CIW EXAM OBJECTIVE GROUPS COVERED IN THIS CHAPTER:

- ✓ **Identify networking and its role in the Internet.**
- ✓ **Identify the infrastructure required to support Internet connections.**

The Internet has become a valuable part of our lives. It seems like any information you need is now available to you at the drop of a hat; if you just log on, you'll find what you're looking for in an instant. The Internet has made individuals, schools, towns, and businesses accessible from anywhere in the world, and its importance in our daily lives has reached new proportions.

As businesses and organizations continue to reach places farther and farther away through their websites, the need for knowledgeable professionals with specific skills to get those websites up and running, properly maintained, and flexible for innovation, has become vital.

The Certified Internet Webmaster (CIW) program tests individuals on the most important web functions and awards certifications based on knowledge and skill. The CIW Internet Foundations exam (1D0-410) is the initial exam for all CIW certifications, setting the pace for Internet professionals worldwide.

The CIW Internet Foundations exam covers the basic concepts of the Internet, from general networking to web authoring and e-business. We'll start our discussion with networking, since it lays the groundwork for how the Internet functions. If the Internet were an ocean, you would not have access to it without the rivers and lakes, or the *networks*, that flow to that ocean.

In this chapter, you will learn about networking basics, which include the history and evolution of networks, network categories, and network topologies.

Networking Evolution

Originally, computer networks were operated on a centralized, or *mainframe*, model. Early computers were very expensive to purchase,

operate, and maintain. These computers had very little processing power and storage capability. Users concentrated their computer work on analyzing and storing important numerical data. There were few qualified professionals available to even configure and administer individual computers, much less entire networks. Early computers also suffered from reliability problems (that computer manufacturers later learned to resolve through improved hardware and software). All of these factors limited the existence of networks to large, well-funded institutions, such as universities and large companies.

By the late 1980s, however, the personal computer (PC) had gained wide popularity among business users. The personal computer was powerful, small, and relatively inexpensive. All sizes of businesses used the personal computer to automate routine tasks such as word processing and accounting. Also, new kinds of software such as spreadsheets and personal information managers became easier to use on a PC.

Many business networks eventually adopted the client/server model, which used a more modular approach than the mainframe scenario had provided. Personal computers could be used as client *workstations*, connected to mainframes. Personal computer manufacturers developed specialized servers to store files and run printing services. This allowed small to medium-sized businesses to create powerful networking solutions at a lower price than that of mainframe solutions.

The advent of the Internet led to another shift to web-based, increasingly decentralized computing. Changes in the telecommunications industry, along with many technological advances, made networking an affordable and necessary feature of doing business.

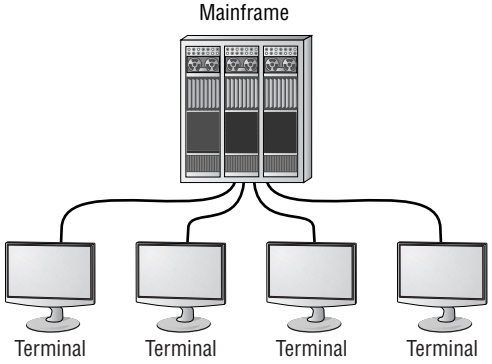
Mainframes

Mainframe computing, also called centralized computing, provided the first practical network solution. This centralized approach employed central servers, or mainframes, and remote terminals. Usually, these terminals were diskless, or "dumb" stations or terminals, that could only request information. Diskless terminals could not store or read data locally, but data storage was relatively expensive and providing local storage was cost prohibitive.

In these systems, most information processing occurs on the mainframe, not on the terminal. One example of a mainframe application is a Customer Information Control System (CICS) transaction program. CICS mainframe

servers specialize in enabling transactions in a distributed environment, using the COBOL (Common Business Oriented Language) programming language. Sending properly formatted information from a mainframe to a client involves a great deal of processing by the mainframe. When a terminal sends an information request, this query is sent to the mainframe. The mainframe processes the query and obtains the desired information from a database or other source. After this processing is finished, the mainframe structures the information, which is then returned to the terminal. Figure 1.1 shows a mainframe model.

FIGURE 1.1 Mainframe model



The mainframe computing model has two principal liabilities. The first is that the mainframe must handle all the processing work. The users are limited by the mainframe's computing capacity and storage space.

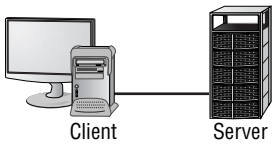
The second liability is that the data sent between the terminal and the mainframe occupy a relatively large amount of the network's *bandwidth*. Bandwidth refers to the amount of data a connection can carry within a given time. The mainframe wastes time waiting to communicate, when that time could be used for actual computations. This delay is called *latency*. In heavily used networks, these two liabilities can combine to create unacceptable network congestion.

Because of the massive investments in mainframes over the decades by universities, businesses, and other institutions, the mainframe model is still quite prevalent and will not disappear soon. However, with the advent of the Web and more sophisticated computing technologies, web-based interfaces and other bridging technologies will change or replace the traditional "dumb terminal" and mainframe environment.

Client/Server Model

The *client/server model*, also called *distributed computing*, reduces network congestion by dividing processing tasks between the client (the front end) and the server (the back end). The *client* is a system or application that requests a service from another computer (the server), while the *server* provides information or connections to other computers on the network. The back-end computer is generally more powerful than the front end and is responsible for storing and presenting information. A client/server example is illustrated in Figure 1.2.

FIGURE 1.2 The client/server model



The Client/Server Model Database

The information passed between client and server in this model is stored in an organized, tabular format in a *database*. To enable transactions between these databases and users, the client/server model must translate human-readable language into machine-readable code. Thus far, the most efficient way to accomplish this is by using SQL (pronounced as "sequel"), the programming language. SQL allows users to phrase queries on the front end that can be understood by the back end. Requesting data from a server in SQL involves the following process:

1. The user requests data.
2. The client machine translates the request into SQL.
3. The client sends the request to the server.
4. The server processes the request, which might involve communicating with a remote database or server.
5. The server delivers the response to the client.
6. The client delivers the response to the computer screen.

The key difference between this retrieval model and the one used by mainframes is that the client processes much of this request. In both models, the data is stored on a central computer—a mainframe or a server.

The client/server model contains two types of databases: single database servers and distributed databases. In a system with a single database, one computer would contain the data and would also have to answer any search or transaction requests.

A distributed database involves information storage across several machines, while still allowing searches and transactions to occur as if the information were stored centrally. The primary advantage of this approach is that it divides the task among several powerful computers and network connections. Such distribution tends to decrease the number of network bottlenecks. As you might expect, any bottleneck can lead to increased latency in a computer system.

Client/Server Advantages

In addition to sharing task processing, client/server benefits include a modular approach to computing. Because the client/server model allows you to add new system components, you may not be limited to one specific solution.

In the early years of networking, network administrators had to choose among several competing proprietary networking standards. Large computer companies such as IBM, Xerox, and DEC had each developed their own networking systems, and they were usually incompatible with one another. It was difficult and expensive to install DEC equipment on an IBM network, for example.

However, with the advent of open standards such as Transmission Control Protocol/Internet Protocol (TCP/IP) and Open Database Connectivity (ODBC), systems from different manufacturers could work together more efficiently. For example, today, Linux and Windows NT/2000 servers can use the TCP/IP protocols to work together, allowing businesses to scale solutions according to customer demand.

The client/server model is deemed *scalable* because it gives you the ability to adjust to new demands. This model also allows users more control over their own files, including where the files are stored, who may have access, and other important features.

Two-Tier and Three-Tier Computing

In *two-tier computing*, one computer is responsible only for formatting the information on the screen. The other computer is responsible for both the

processing logic and the data storage. Traditional client/server relationships are similar to two-tier computing in that both computers are responsible for part of the processing task. Client/server relationships distribute the task more evenly between the two computers than the traditional systems do. This allows network administrators to choose and install computers that may be specialized for data storage, display, and other specific needs.

To reduce network congestion, developers have further divided the client/server process into three parts. The client is the first tier, a shared server or other network element is the second tier, and the server and database are the third tier. In three-tier computing, the client is responsible only for rendering the information into a suitable user interface. The second tier acts as an intermediary that processes the information before sending it to the server, which then queries the database. Logical functions, such as the parsing of queries and statements, occur at this tier. The third tier in the conceptual model is the database. Three-tier computing requires additional investment in hardware and software, but the cost and time savings realized by users may be worth the additional expense.

Migration to Client/Server Architecture

The combined use of high-performance workstations (terminals or personal computers connected to a network) and server systems support the same features found in mainframe operating systems, but at a much lower price. Furthermore, thousands of off-the-shelf applications are available for workstation operating systems.

Client/server architecture allows considerable flexibility in distributing resources on the network. With this flexibility comes additional complexity; you'll need to understand the types of client nodes that are appropriate for your organization. Identifying a suitable client/server configuration involves the analysis of the following:

- The types of applications that characterize your computing environment
- The users and their requirements
- The computing and network architecture

We will revisit these general issues throughout this book.

Networking Evolved: Web-Based Networking

Anyone who has used the World Wide Web is familiar with web-based networking, also called *collaborative computing*. Because of its association with the Internet, web-based networking is a unique networking type. Web-based networking can use both mainframe and client/server models. Using TCP/IP and other protocols and the Web, internetworks have allowed networks to become more distributed and decentralized.

Intranets at School and in the Workplace

Intranets bring web-based networking in-house, supplying a network for use by employees or members of a specific organization. If you attend a college or university, there is a good chance that you have access to some kind of intranet. Academic institutions have found that a well-designed intranet can increase employee and student satisfaction by providing constant access to grades, schedules, forms, and other important information. This can make regular processes such as class registration more efficient. An academic intranet can also reduce publishing and distribution costs, eliminating the need to print and maintain forms, newsletters, and other materials.

Corporations have seen some of the benefits of intranets as well. Intranets can help control employee use of the Internet by offering a single point for relevant news and information. An intranet can also be used as a gateway to existing information systems that are housed on mainframes. Consolidating corporate information resources in an intranet can increase employee productivity and help focus corporate operations.

Some corporations use their intranets to leverage employee knowledge by having departmental representatives create and update relevant content. The St. Paul Companies developed an intranet system with easy-to-use standards and authoring applications, based on Microsoft products such as Front Page, Internet Information Server (IIS), and Word. The IT department was responsible for maintaining the intranet, while content development was distributed among the departments. Only one to two days of training was required, and one or two representatives of each department or work unit were recruited to maintain the content.

In some cases, web-based computing represents a radical form of three-tier computing. Heavily distributed networks, such as extranets and virtual private networks (VPNs), also rely on the web browser to provide a consistent user interface with complex server mechanisms.

The benefit of utilizing web-based networking is that it combines the power of mainframe computing with the scalability of the client/server model. Furthermore, because web-based networking relies on the use of a familiar, ubiquitous, and often free web browser, information can be obtained without specialized software.

The goal of web-based networking is to provide an open, global solution that allows users to obtain information and conduct transactions. With the advent of e-commerce solutions, such as online shopping, secure transactions, and personal information management, web-based networking continues to develop as a powerful computing model.

Businesses use *extranets* to connect enterprise intranets to the global Internet. Extranets are designed to provide access to selected external users to expedite the exchange of products, services, and key business information.

Networking Categories

We can describe networks as groups of computers, designed to communicate in certain ways. Each computer must be programmed to transmit and receive data in ways the other computers in the network can understand. Obviously, it is much easier and less expensive to use standard sets of technologies to set up the various parts of a network. As we will see in this section, than are many kinds of networking technology standards.

All computer networks consist of the same three basic elements:

Protocols communication rules on which all network elements must agree. You will learn about networking protocols in the next chapter.

Transmission media a method for all networking elements to interconnect. You will learn about transmission media later in the book.

Network services resources (such as printers) that need to be shared with all network users. You will learn about network services later in the book.

Two basic types of networks exist, each using variations of these three basic elements: peer-to-peer and server-based. A third network architecture—enterprise network—combines features of both peer-to-peer and server-based networks.

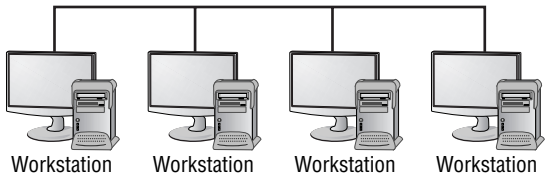
Peer-to-Peer Networks

When two or more computers are linked to each other without centralized controls, a *peer-to-peer network* is created. In a peer-to-peer network, each computer in the network has as much control as the next. In this situation, each computer functions as a *host*. (A host computer is either a client or a workstation that other computers use to gain information. Any host can share its resources with other systems on the network.)

A peer-to-peer network architecture does not require dedicated resources, such as file servers.

Typically, peer-to-peer networks tend to be less expensive and easier to work with than client/server networks. However, a peer-to-peer network is less secure, because file and account management can be distributed across the networked computers. Additionally, the larger a peer-to-peer network becomes, the slower it can get. Peer-to-peer networks usually support about 10 or fewer users, which is much less than a properly configured server-based network could do. Figure 1.3 shows a peer-to-peer network.

FIGURE 1.3 Peer-to-peer network model



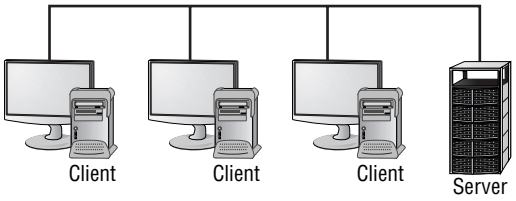
Examples of peer-to-peer PC networking products include the following:

- Artisoft LANtastic
- Novell NetWare Lite
- Microsoft Windows 95/98/Me

Server-Based Networks

A *server-based* network is a configuration of nodes, some of which are dedicated to providing resources to other hosts on the network. *Nodes* are processing locations on a network, such as a computer, printer, or other device. Each node has a unique network address. Dedicated nodes that make their resources available to other computers are called *servers*. These resources can include printers, applications, and documents. Figure 1.4 shows a server-based network.

FIGURE 1.4 Server-based network model



Server-based networks offer security because a central database can keep track of which resources each user can access. The server administrator can set up the network to allow each user access only to the specific files and directories they need to use. It is also much easier to backup and store duplicate copies of files stored on a server-based network, as network files are located in a central place.

However, dedicated servers can be expensive. Each server may require larger hard drives and more RAM than a typical client workstation requires. Servers are usually located in their own room, which should be locked to restrict physical access to these computers. An IT department that has its own servers may also require a full-time network administrator to configure, supervise, backup, and maintain their servers properly.

Examples of server nodes include such things as print servers, files servers, mail servers, and web servers. Client nodes can access these resources over the network. Examples of network operating systems that are suitable for installation on server nodes in a client/server network include:

- AppleTalk Network for Macintosh
- Linux
- Microsoft Windows NT/2000/XP
- Novell NetWare
- UNIX

Enterprise Networks

Enterprise networks provide connectivity among all nodes in an organization, regardless of their geographical location, and run the organization's mission-critical applications. Enterprise networks can include elements of both peer-to-peer and server-based networks.

An enterprise network may consist of several different networking protocols. *Protocols* are the rules that control network communications. An enterprise network can also combine network architectures.

Systems on enterprise networks are capable of translating packets of one architecture into another (acting as *gateways*). Additionally, an enterprise network can support multiple architectures (multiprotocol systems). (Gateways and multiprotocol systems will be discussed later, in Chapter 2.)

Network Topologies

Topologies are basic configurations that information systems professionals use to physically connect computer networks. Several popular topologies used to connect computer networks include the *bus*, *star*, *ring*, and *hybrid designs*.

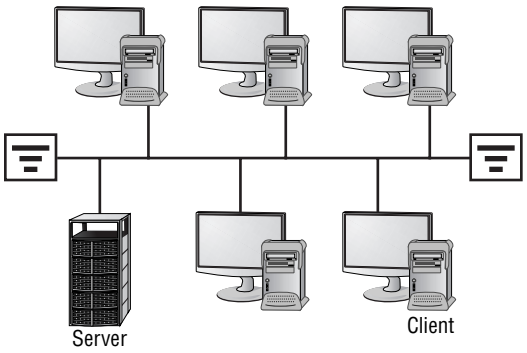
Bus Topology

Bus topology networks require that all computers, or nodes, tap into the same cable. When a computer sends data on a bus network, that data is broadcast to all nodes on the network. The term *bus* describes the electrical bus or cable that connects all the computers in the network. Network data must be transmitted to each computer along the cable. Only the destination computer reads the sent message; the rest of the computers ignore the data. A bus topology is shown in Figure 1.5.

Small offices often use bus networks because they are easy and inexpensive to install. No dedicated server is needed, so bus networks are often less complex than other network types.

Bus networks usually need terminators, small electrical devices that absorb signals, at each end of the network to ensure that network traffic does not echo back through the network. Otherwise, the network can become congested with old traffic very quickly, much like a microphone getting feedback from being placed near a speaker. Since terminators are easy to find in computer-retail stores, it is easy to avoid this feedback effect on the bus network.

FIGURE 1.5 Bus topology with terminators



Using bus topologies has its advantages and disadvantages, as you can see in Table 1.1.

TABLE 1.1 Advantages and Disadvantages of Bus Topologies

Advantages	Disadvantages
Bus networks are relatively simple, inexpensive, easy to operate, and reliable.	Isolating problems is difficult; if a cable breaks, the entire network will be affected.
Bus networks use cable efficiently.	The network is likely to slow during peak traffic periods, because more data must pass by each computer.

Real World Scenario

Installing a Bus Network in a Small Office

You are responsible for the personal computers in a small, three-person office. The computers run Windows Me. You and your colleagues have been passing files back and forth on floppy disks, but you are starting to get more and more large files that can't be shared this way.

One of your co-workers suggests purchasing a Zip drive for each of the three computers. A Zip drive is similar to a floppy drive, but uses special high-capacity disks that are slightly larger than floppy disks. This would

allow your team to pass bigger files to one another. Depending on the model, a Zip drive can store 100 or 250MB on a Zip disk.

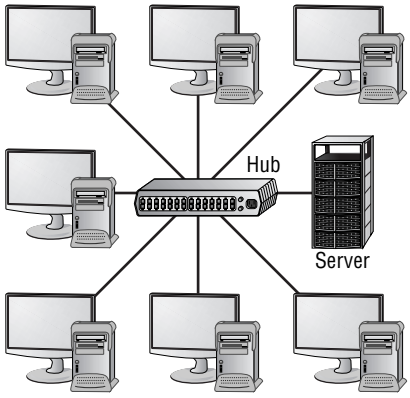
Your other co-worker suggests setting up a network. This would allow your team to set up shared directories on one or more of the three computers, and avoid the cost of buying the Zip drives for the current or any new computers.

In the real world, the easiest way to set up a network in this case is to use the peer-to-peer networking features in Windows Me. Because it is difficult to run cable in your particular office, you decide to install a bus network, as it requires the least amount of cabling. This reduces the cost of the network to just the setup time and the cable.

Star Topology

If a bus network grows too big, a *star* network will often be used as the replacement topology. Star topology networks connect network nodes through a central concentrating device, usually a hub. (We will discuss hubs in detail in Chapter 2.) Star networks, like the one shown in Figure 1.6, require more cabling than bus networks, because each computer must have its own network cable that connects to the hub.

FIGURE 1.6 Star topology



Because each computer's network connection terminates in the hub, the star topology arrangement greatly reduces the risk of an entire network

failure. For example, if a cable breaks or a node fails, only that cable segment or node will be affected. The rest of the network will continue to function.

A common weak point of a star network is the hub itself, because if this central connection point fails, the entire star network will go down. Hubs are usually located in a hidden area, because the only time a hub is usually handled is when installing or disconnecting a new cable segment. This hidden placement can ensure that the hub will not be disturbed and reduce the likelihood of jeopardizing the stability of the network.

There are advantages and disadvantages to using star topologies, as listed in Table 1.2.

TABLE 1.2 Advantages and Disadvantages of Star Topologies

Advantages	Disadvantages
The network is usually not affected if one computer fails.	If the hub (or centralized connection point) malfunctions, the entire network can fail.
Network expansion and reconfiguration are relatively simple.	Star networks require more cable than bus networks.
Network management and monitoring can be centralized.	

Real World Scenario

Converting a Bus Network to a Star Network

In the previous example of a bus network, adding an additional user to the network would require adding an additional segment of cable somewhere on the network. Bus networks can accommodate occasional additions like this.

Suppose, however, you knew you would be adding three computers to the bus network over the next six months. As you plan the installations, you are unsure where these computers will go. Each time you add a computer, you will have to insert a segment of cable somewhere in the network to maintain the bus. This makes the task of adding additional cable segments to the bus network increasingly difficult.

It may be more practical to purchase a hub and rewire the bus network with a star topology. In a star network, you simply connect a new cable between the hub and each new computer. If you convert the network to a star configuration, you will no longer need the two terminators, so they should be removed from the network, also.

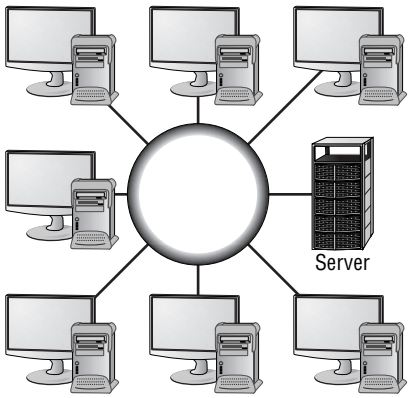
Ring Topology

Ring topologies do not have a central connection point. Instead, a cable connects one node to another, until a "ring" is formed, connecting each computer. When a node sends a message, each computer in the ring processes the message. If a computer is not the destination node, it will pass the message to the next node, until the message arrives at its destination. As each node retransmits or repeats the data, it also amplifies the signal. This allows ring networks to span a greater distance than star or bus networks.

If none of the nodes on the network accepts the message, it will make a loop around the entire ring and return to the sender.

An example of the ring topology is shown in Figure 1.7.

FIGURE 1.7 Ring topology



Ring networks can connect through a central device called a Multistation Access Unit (MAU). The MAU can keep a ring network running, even if a mode isn't working. We'll go into more detail about MAUs in Chapter 2.

Table 1.3 discusses the advantages and disadvantages of ring topologies.

TABLE 1.3 Advantages and Disadvantages of Ring Topologies

Advantages	Disadvantages
All computers have equal access to data.	Network expansion or reconfiguration will affect network operation.
During peak usage periods, the performance is equal for all users.	Isolating problems is difficult on a ring topology network.
Ring networks perform well with heavy network traffic.	If one node fails, the entire network can fail.
Ring networks can span longer distances than other types of networks.	

Hybrid Networks

Larger networks usually combine elements of the bus, star, and ring topologies. This combination is called a *hybrid* topology. Hybrids allow the expansion of several existing networks by connecting them within an overall topology.

For instance, in a typical star ring network, two or more ring networks are connected into a star network, using a MAU as a centralized hub. Each ring network continues to serve its existing users, but by connecting them through a hub, users on one ring network can access resources on a different ring network.

In a star bus network, two or more star topologies are connected using a bus "trunk." In this situation, the bus trunk serves as the network's *backbone*. The backbone is the highest level in the computer network hierarchy, to which smaller networks typically connect. The backbone makes the connection between the star networks.

The star bus network shown in Figure 1.8 demonstrates that each star network contains two nodes and is connected by linear bus trunks. This topology is excellent for larger companies, because the backbone can implement media that support high data transmissions. However, the hybrid topology is not without its foibles. Table 1.4 discusses the advantages and disadvantages of hybrid topologies.

FIGURE 1.8 Star Bus Network

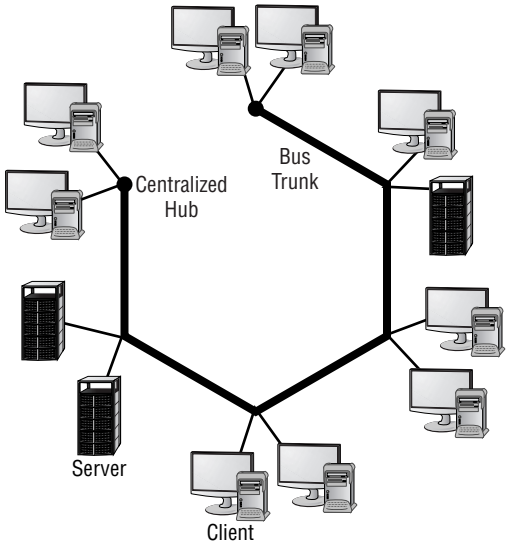


TABLE 1.4 Advantages and Disadvantages of Hybrid Topologies

Advantages	Disadvantages
Network expansion can be accomplished by choosing an appropriate network topology for the requirements. Server administrators can allow user access to the network through one or more methods.	Hybrid networks are more difficult to design, optimize and maintain than the star, bus, or ring topologies.

Mesh Topology

Mesh topologies connect devices with multiple paths so that redundancies exist, ensuring that a connection can always be made, even if one is lost. All devices are cross-connected so the best path can be chosen at any given moment in the event of a connection failure. Figure 1.9 shows a mesh topology based on the star bus hybrid topology.

FIGURE 1.9 Mesh topology

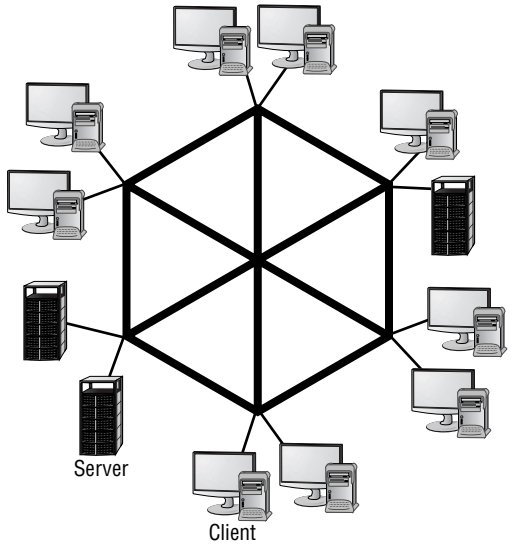


Table 1.5 lists the advantages and disadvantages of mesh topologies.

TABLE 1.5 Advantages and Disadvantages of Mesh topologies

Advantages	Disadvantages
If one connection is terminated, another can be chosen to deliver the data to the destination.	Additional hardware and cable can make mesh topologies more expensive and difficult to install and maintain.

Physical versus Logical Topologies

Star, bus, ring, hybrid networks, and mesh are all examples of *physical topologies* in that they refer to the way in which the various devices are connected to the network. But there is also something called *logical topologies*, a term which refers to a generated signal's actual path over a network. Bus and ring can also be classified as both logical and physical topologies.

For instance, a bus logical network generates a signal to all devices on the network and a ring logical network generates a signal that travels in one direction along a determined path. To put it more simply, physical topology

connotes the actual connection to the network—the physical connection of cables and machines. Logical, however, refers to the type of signal running through the physical connection. This distinction between physical and logical topologies is very important for you to understand.

Network Operating Systems

A *network operating system (NOS)* is the program that allows users and administrators to manage and access resources on a computer network. A NOS helps integrate network computers by facilitating orderly, reliable communication throughout the entire network. Important functions of the operating system include managing multiple users on a network, providing access to file and print servers, and implementing network security.

A NOS enables clients to access remote drives (those drives not on the user's machine) as if they were on the client's own machine. A NOS can also allow servers to process requests from clients, and determine whether an individual client has permission to use a particular network resource.

Similar to a client/server relationship, part of the NOS must be run on the client workstation, while another part of the NOS must run on one or more servers. Some network operating systems can also be used to set up a peer-to-peer network. In this case, each node would serve as both the client and the server.

This section will discuss four of the most popular network operating systems:

- Novell NetWare
- Microsoft Windows NT/2000/XP
- UNIX
- Linux

The following sections explain important aspects of the four major NOSs and their vendors.

Novell NetWare

Novell Corporation was founded in 1983, and helped popularize the local area network (LAN) market. *Novell NetWare* is the most widely installed family of network operating systems. NetWare uses standalone servers that

provide such LAN services as file storage, network printing, and directories. The most recent version is called NetWare 6.

Before version 5, NetWare was a proprietary NOS that communicated using the Internetwork Packet Exchange (IPX) protocol, the Sequenced Packet Exchange (SPX) protocol, and the NetWare Core Protocol (NCP). These protocols were necessary for all Novell network computers to communicate.

You will learn more about networking protocols later in the next chapter.

With version 5, NetWare started supporting TCP/IP as its networking protocol and Java as its primary application language. Because TCP/IP is the standard protocol of the Internet and Java is a programming language that operates across platforms (e.g., on Windows, UNIX, and so forth), server administrators could use NetWare 5 to easily integrate existing NetWare installations with Internet services such as web servers. In NetWare 6, Novell added remote file, printing, and directory services for Internet users.

Microsoft Windows NT, Windows 2000, and Windows XP

Originally, Novell NetWare overshadowed earlier Microsoft network operating systems in terms of features and market share, then Microsoft released the Windows NT network operating system in 1993. Eventually, the tables turned, and Windows NT became widely implemented in the corporate world because it supported a variety of networking schemes, including Novell NetWare and TCP/IP. The NT family included features that helped business users easily integrate and network Windows workstations, so businesses began adopting Windows 3.1 and Windows 95 computers as workstations. Back in the early days of implementation, the available versions of the Microsoft NOS were Windows NT Workstation, meant for use on client computers, and Windows NT Server, meant (as its name indicates) for the server.

In 1999, Microsoft introduced the Windows 2000 family of operating systems. Windows 2000 was the first Microsoft operating system specifically designed to use TCP/IP as its primary networking protocol, while still supporting other networking protocols. Three versions of Windows 2000 were released: Windows 2000 Server, Windows 2000 Advanced Server, and Windows 2000 Professional. Windows 2000 Server and Advanced Server

provided businesses with a server operating system for applications and e-commerce. Windows 2000 Professional was designed for network clients, especially business users and advanced home users. Windows 2000 supported more types and brands of computer hardware and software than Windows NT did, including additional support for portable computers, advanced power management, and (Universal Serial Bus) USB connections.

Windows NT 4.0 and Windows 2000 both use TCP/IP as the default network protocol, and have a user interface similar to Windows 95/98/Me.

Then, in October 2001, Microsoft introduced the Windows XP desktop operating system. Windows XP is based on the Windows 2000 operating system, and is designed for high reliability and ease of use.

Like Windows NT and Windows 2000, Windows XP also uses TCP/IP as its default network protocol suite. However, Windows XP looks and behaves differently from earlier Windows operating systems; Microsoft introduced a streamlined, adaptive user interface that can customize itself based on the individual user's actions and patterns. Windows XP also incorporates advanced web technology into the operating system, providing easier user access to Internet services.

Microsoft XP is available in two versions:

- Microsoft XP Home Edition, which includes features such as digital imaging, audio file recording, an Internet firewall, broadband and dial-up connection management, and enhanced game compatibility. Home Edition is recommended for home use, hence the ingenious name.
- Microsoft XP Professional Edition, which adds corporate networking and Internet security features to the Home Edition features. XP Professional is recommended for business users and advanced home users.

UNIX

Computer scientists at AT&T developed the initial version of the *UNIX* operating system in 1969. UNIX (pronounced YOO-nicks) is used as a network operating system for the majority of non-PC networks. During the early development of the Internet, UNIX became the established choice of server administrators. Today, UNIX in its many forms remains the dominant Internet network operating system.

You should think of UNIX as a family of similar operating systems. At its core, UNIX offers a command-line interface that requires users to type in very specific commands. This facet of UNIX is often a difficult obstacle for beginning users. Although UNIX is a robust client/server operating system, the command-line interface sometimes resembles a mainframe computing model, where the user is explicitly requesting specific services from a remote server.

Because there are more than 600 UNIX commands, *graphical user interfaces (GUIs)* were developed to simplify UNIX operations. These GUIs include X-Windows, enhanced with the Open Look or Motif GUI. A GUI is a user-friendly environment that replaces the command line with a desktop. The user points and clicks on graphical pictures or icons and uses a handheld device called a mouse. (The developers of Microsoft Windows used these GUIs as a starting point for their work, which was originally developed to simplify command-based DOS operations.)

Many hardware vendors offer some variant of UNIX as a primary or secondary operating system. Popular UNIX versions include Sun Solaris, Digital UNIX, Berkeley Systems Distribution (BSD), Hewlett Packard HP-UX, Tarantella UNIXWare, and IBM AIX. Many IBM mainframes can run UNIX. The most recent Apple Macintosh operating system, OS X, is built on a version of UNIX, called Mach, developed at MIT.

Linux

While it is possible to run UNIX on a personal computer, relatively few users besides server administrators and advanced experts were interested in doing so. In 1991, a Finnish graduate student named Linus Torvalds decided to create his own version of UNIX for the personal computer, using portions of the UNIX operating system registered under the GNU licensing scheme; the GNU public license allowed developers to change the actual source code of UNIX and add new features, as long as the developers shared their innovations with any other interested people.

Torvalds decided to build his UNIX operating system completely within the GNU framework. He also posted requests for programming help on the Internet, and made the source code of his project available for anyone to download, use, and modify. This kind of software development model is called *open source computing*. Much of the early development of the Internet was done on an open source model. Over time, the Linux project grew, and Linus became the lead developer and coordinator for the operating system, which he called *Linux* (pronounced LIH-nucks).

Thousands of individuals and hundreds of companies have assisted in the development of Linux. Some companies have developed retail Linux distributions, which often include additional applications, utilities, and features not provided in the freely available versions, called *distributions*. Popular Linux distributions include Red Hat, Mandrake, Caldera, and Debian.

Microsoft's competitors have also assisted in the development of Linux, partly as a response to the growing popularity of Microsoft operating systems and software. IBM, for instance, offers versions of Linux for use as a network operating system for some of its mainframe computers.

Linux is sometimes used as a desktop operating system on personal computers. Some users even choose to run Linux instead of Microsoft Windows. Some people and organizations prefer Linux because of its low cost, and its ability to run applications at high speed. The Brazilian and Chinese governments have selected Linux over Microsoft Windows as their preferred network operating system.

Depending upon the distribution, installing a Linux operating system can range from very easy to very difficult. You can also purchase a personal computer with a Linux distribution already installed and optimized for your needs.

Many Linux application programs are written by groups of programmers who are also Linux users and who follow open source guidelines. However, there are relatively few commercial software companies that have released Linux-compatible software, when compared to the large commercial market for Microsoft Windows software. Still, you can purchase software that allows Windows or Macintosh software to run on a Linux operating system. Microsoft Internet Explorer and Netscape web browsers are even available in versions compatible with some Linux distributions.

Linux is primarily used as a network operating system, and has become a popular way to host Internet services. Apache server, which runs on Linux, is the most widely used Internet server, based on the number of websites hosted.

Linux in the Workplace and Home

Many companies use Linux to help provide specific industrial solutions. The GNU public license allows anyone to create their own version of Linux, with the specific features they need. Developers can reduce the size of Linux by paring unneeded features, to the point that a Linux operating system can be burned onto a microchip and included in many kinds of computing products.

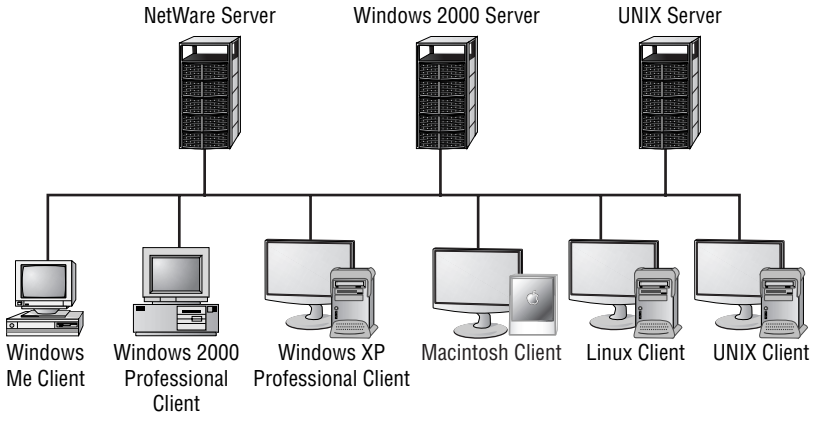
Several companies have developed inventory management systems and point-of-sale terminals using Linux operating systems.

Linux operating systems are often used in cable television set top boxes. Linux has also been used in the TiVo television recorder. In both of these devices, the cable or telephone line connection that is required for operation can also be used to send updates to the operating system.

Interoperability

All four NOSs can communicate across a network with one another. This feature, called *interoperability*, makes it easier for corporations with different clients and servers to create a network where the computers use different operating systems. Figure 1.10 shows a possible network that comprises a variety of NOSs, each of which can communicate with the others.

FIGURE 1.10 NOS interoperability



Summary

In this chapter, you learned about the development of computer networks. Mainframe computing required one computer to handle all the users on a network. Client/server computing is the networking model on which the

Internet and the World Wide Web were developed. Web-based computing builds upon the mainframe and client/server models, and adds the ability to distribute network services across the Internet.

We also discussed how networks need protocols, media, and services to function. We reviewed three network models. Peer-to-peer networks allow two or more computers, or nodes, to communicate and share files with each other. Server-based computing adds a dedicated computer for file storage and other services. Enterprise computing combines aspects of peer-to-peer and server-based computing.

We also examined various network topologies, including the bus, star, ring, mesh, and hybrid designs. Each topology performs certain tasks better than others. The bus is easy to set up, but supports a small number of computers. Star networks require additional cable and hardware, but allow easier troubleshooting. Ring networks can span greater distances than bus and star networks, but require special hardware to increase network reliability. Mesh networks can transmit signals quickly and reliably, but require multiple cable hookups. Hybrid topologies allow network designers to use two or more different topologies to gain needed features.

For many computers, a NOS is required to access the Internet. We looked at popular NOSs from Microsoft and Novell, and also discussed UNIX and Linux. We discussed interoperability, and the role of TCP/IP as a common networking protocol.

In the next chapter, we will see how network elements fit into the Internet.

Exam Essentials

Understand networking and its importance in today's data communications marketplace. Networking connects one or more computers to other computers in different locations. Utilizing networks, organizations cut costs by connecting quickly, sharing information, and benefiting from the use of cheaper, personal computers, thus breaking away from use of mainframes.

Be able to identify and describe the function of servers, workstations, and hosts. Servers store and control access to information. Users can use a workstation to request and work on data. A workstation can also be called a host. Computers on networks can also be called nodes.

Be able to identify and describe the three kinds of network architectures. A peer-to-peer network connects two or more computers without a server. Peer-to-peer networks are less secure and support fewer users than a server-based network, which has at least one server running a network operating system (NOS). Enterprise networks combine peer-to-peer and server-based networks, and may include gateways and multiprotocol systems.

Know the three basic elements of networks. Protocols are communication rules for computers. Transmission media provide a method of connection. Network services are resources like printers and servers that are shared among network users.

Be able to identify and describe the five types of network topologies. Bus networks connect two or more computers along a sequence of cable. Star networks use a central hub to connect computers. Ring networks pass network data around a ring of computers. Mesh networks interconnect computers to ensure reliability. Hybrid networks can combine elements of these topologies.

Understand the differences between logical and physical topologies. A logical topology is the signal's actual path within a network. A physical topology is the actual physical connections of the network, such as hub, star, ring, or hybrid.

Know the major network operating systems. Novell NetWare, Microsoft Windows NT/2000/XP, UNIX, and Linux are the most popular network operating systems. All these systems use TCP/IP for network communications. Each of these systems can also be configured to host a web server, mail server, and other kinds of Internet servers.

Key Terms

Before you take the exam, be certain you are familiar with the following terms:

backbone
bandwidth
bus
client
client/server model
database

Enterprise networks
extranets
graphical user interfaces (GUIs)
host
hybrid
interoperability
Intranets
latency
Linux
logical topologies
mainframe
mesh
network operating system (NOS)
network
nodes
Novell NetWare
open source computing
peer-to-peer network
protocol
ring
server
server-based
star
two-tier computing
UNIX
workstations

Review Questions

1. Which exam is required to receive any CIW certification?
   - **A.** CIW Site Designer (1D0-420)
   - **B.** CIW Foundations (1D0-410)
   - **C.** CIW Server Administrator (1D0-450)
   - **D.** CIW E-Commerce Designer (1D0-425)

2. In the early history of computing, before the personal computer, which model of networking was most commonly used?
   - **A.** Microsoft Windows
   - **B.** Enterprise
   - **C.** Mainframe
   - **D.** Web-based

3. Which term is defined as the communication delay caused by sending delays between two computers?
   - **A.** Latency
   - **B.** Mainframe
   - **C.** Terminal
   - **D.** Bus

4. In a two-tier client/server computing model, which of the following tasks does the client perform?
   - **A.** Searches for data
   - **B.** Formats and sends data
   - **C.** Provides centralized data storage
   - **D.** Requests and displays data

5. Amanda is designing part of a network using a three-tier client/server computing model. She is responsible for the second tier of the network. What task does the second tier perform?

   A. Requests data

   B. Retrieves data

   C. Formats data

   D. Displays data

6. The software application usually running on the end user's computer host can be called which one of the following?

   A. Server

   B. Client

   C. Network

   D. Mainframe

7. What type of network can connect customers and vendors to the internal networks of a business?

   A. Intranet

   B. Extranet

   C. Internet

   D. Internetwork

8. In web-based networks, the web browser provides what function?

   A. Server

   B. Client

   C. Data storage

   D. Protocols

9. Which one of the following choices best describes a peer-to-peer network?

   A. This network can connect as few as two computers.

   B. A hub is required.

   C. This network can connect up to 20 computers.

   D. A network operating system is required.

10. John is evaluating the following operating systems for installing on a server in a server-based network. Which choice is the least suitable?

   A. Microsoft Windows 2000

   B. Linux

   C. Microsoft Windows 95

   D. Novell NetWare 6

11. Which of the following choices apply to ring and bus networks?

   A. Cabling is easier on these networks than on star networks.

   B. If one node fails, the entire network can fail.

   C. These networks handle heavy traffic well.

   D. Network management is centralized.

12. Brad is installing a star network. Which one of the following pieces of hardware will he need to install?

   A. Server

   B. Terminator

   C. Multistation access unit

   D. Hub

13. Which type of network topology can use a Multistation Access Unit (MAU)?

    A. Peer-to-peer

    B. Bus

    C. Ring

    D. Star

14. Which network topology can span the greatest distance without the use of additional networking hardware?

    A. Hybrid

    B. Bus

    C. Mesh

    D. Ring

15. What is the name of the feature that allows all network operating systems to work with each other?

    A. Transparency

    B. Interoperability

    C. Scalability

    D. Latency

16. Which one of the following types of networks does not require dedicated servers?

    A. Enterprise

    B. Server-based

    C. Peer-to-peer

    D. NetWare

17. A network operating system most closely resembles which of the following network models?

    A. Mainframe

    B. Client/server

    C. Star

    D. Enterprise

18. Which of the following is the best description of the backbone of a computer network?

    A. The backbone is the level at which smaller networks are typically connected.

    B. The backbone connects computers on a peer-to-peer network.

    C. The backbone is the device that connects computers in a star network.

    D. The backbone is the device that connects computers in a ring network.

19. Which of the following network operating systems is used most often on Internet servers?

    A. UNIX

    B. Novell NetWare

    C. Microsoft Windows NT

    D. Microsoft Windows 2000

20. The Linux operating system is derived from which earlier operating system?

    A. Microsoft Windows

    B. Novell NetWare

    C. Mainframe operating systems

    D. UNIX

Answers to Review Questions

1. B. The CIW Foundations exam is required to receive any CIW certification. The code number at VUE and Prometric is 1D0-410. The CIW Site Designer (1D0-420) and CIW E-Commerce Designer (1D0-425) exams count towards the CIW Professional certification, and you must pass both to receive the Master CIW Designer certification. The CIW Server Administrator (1D0-450) exam also counts towards the CIW Professional certification, and is required for the Master CIW Administrator and Master CIW Web Site Manager certifications.
2. C. Mainframe computers were the first networking model to be used. Microsoft Windows was designed for the IBM personal computer. With the advent of personal computers, the other two models became possible.
3. A. Latency is the term that correctly describes the time one computer waits for another computer to receive a message. A mainframe is a type of computer. A terminal is used to communicate with a mainframe. A bus connects computers on a network, and is a type of network topology.
4. D. The client must send to the server a request for data. The server searches for the data in its storage areas and sends it. In a mainframe model, the server would also format the data for display.
5. A. In a three-tier client server model, the first tier is the client. The client is responsible for data formatting and display. The second tier requests the data. The third tier, the server, retrieves the data.
6. B. The term “client” can refer to the computer that is accessing a server or the software application on that computer. The server provides data that is requested by the end user, through a client application. Data is sent through the network. A mainframe provides data access and controls terminals.
7. B. An extranet is used to allow secure access by external parties into an internal business network. Intranets provide access for employees. An Internet and internetwork refer to large combinations of networks.

8. B. The web browser is sometimes called the universal client, because it is an application for viewing many different kinds of data. The server can provide network services, such as files and printing. Data storage is not performed within a web browser. Protocols are used to format data for transmission on a network.

9. A. A peer-to-peer network connects two or more computers, allowing each computer to act as a host. A star network topology requires a hub—a peer-to-peer network does not need a hub. Peer-to-peer networks are not recommended for connecting 10 or more computers. You do not need a network operating system to set up a peer-to-peer network.

10. C. John should not use Microsoft Windows 95. Windows 95 can be used as a network client, but does not have the recommended features for a network server. Microsoft Windows 2000, Novell NetWare 6, and Linux are suitable network server operating systems.

11. B. The only choice that applies to ring and bus networks is B. A token ring network without a MAU and a bus network can fail if a single node is not operating. Cabling a ring network can be more difficult than a star network if a central MAU is not used. Bus networks handle heavy traffic poorly, while ring networks do well. Bus networks lack a server, so network management is actually decentralized.

12. D. Brad will need to use a hub as a concentration point to tie all the computers in his star network together. A server is not required in a star topology. A terminator must be used at each end of a bus network. MAUs are use on ring networks.

13. C. The MAU is used in a ring network to help keep the network running if a node fails. Bus networks use a single cable to connect all computers. Peer-to-peer networks do not use a MAU and are not a network topology type. Star networks use a hub to connect all computers.

14. D. The ring topology can span the greatest distance without extra hardware, because each node amplifies the signal that is sent to the next computer. Without a specific design, we cannot say that a hybrid topology would work best. Bus networks work best at short distances. Mesh networks use a great deal of cable to interconnect nodes, which can limit signal distance.

15. B. Interoperability refers to a general set of features and services that help define a network operating system. Transparency is an attribute of an image file. Scalability refers to the operating system's ability to handle larger amounts of data. Latency is the delay time between two computers.

16. C. Server-based networks must have at least one server. Enterprise networks combine peer-to-peer and server-based networks, so there must be a server. In a peer-to-peer network, no servers are required. A Novell NetWare network uses a server for network file storage.

17. B. Networking operating systems work on a client/server model. In the mainframe model, users access a mainframe computer by using a terminal. Star is a network topology—network operating systems tend to support multiple topologies. Peer-to-peer is a type of network. Network operating systems support enterprise networks.

18. A. A backbone is the highest level in the computer network hierarchy. It typically connects two or more smaller networks to each other. Cables or another transmission medium connect peer-to-peer computers. Hubs connect computers on a star network. A MAU can be used to connect computers on a ring network.

19. A. Of these choices, UNIX is installed on the most Internet servers.

20. D. Linux is one of many variants of the UNIX operating system. Microsoft Windows and Novell NetWare were developed separately from Linux. There are many kinds of mainframe operating systems; IBM offers a version of Linux for mainframes.