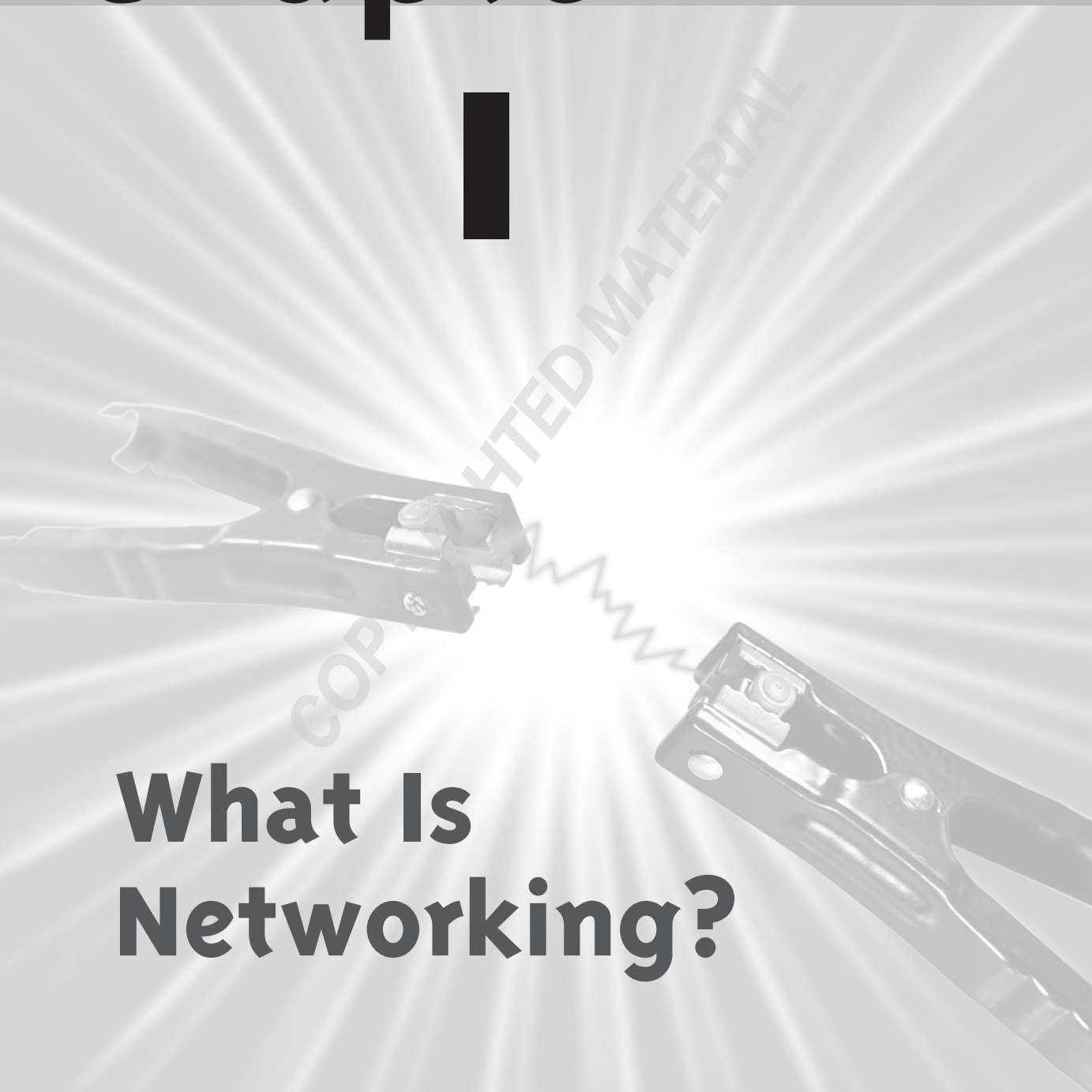
Chapter 1



What Is Networking?

A network is a system that allows communication to occur between two people or machines. In the world of computer networking, the rules for communication must be well defined. Communicating computers need to know the rules, so—like two people speaking the same language—they can communicate without delay. If the computers don't understand each other, nothing is accomplished; there is no Internet access, sharing of files, or printing; and all work stops. As a future CCNA, it will be part of your responsibility to help prevent this from happening.

In this opening chapter, you'll learn some of the fundamental terms and concepts behind computer networks. Topics include:

- Networking basics
- Types of networks
- The origins of the first networks
- The Internet

Networking Basics

internetwork
Two or more connected networks of similar or different communication types.

protocol
A set of rules used to define communication between two devices.

Networks are used to make work and communication more efficient. A network may connect together computers, printers, CD-ROM drives, scanners, and other equipment. The advantage of having computers and other machines connected together is that people can then pass information back and forth much more quickly. Before computer networks, people had to use cumbersome diskettes to share information, and before that, paper. Another advantage of using networks is that they allow people to share resources. Printers, hard disks, and applications can be shared, greatly reducing the costs of providing these resources to each person in a company.

A computer network is built around the idea that there are senders and receivers. The sender, or *source*, is a computer that wants to send information to another computer. The receiver is the computer that the information is sent to, also known as the *destination computer*. Often, computers are not the only machines communicating on a network. Other machines—such as printers with network capabilities—can also act as senders and receivers. A printer, computer, or any machine that is capable of communicating on the network is referred to as a *device* or *node*.

When devices are participating in communication on a network, they need some way to pass information among themselves. In most networks, cables are used to interconnect devices. Devices may be strung together like Christmas lights, with the cable going from device to device. In another layout, cables connect each device to a central location, like the spokes of a bicycle wheel. The cable usually used in networking is made of copper wires similar to the wires in telephone cable, but of a much higher quality. In addition to copper-wire cables, there are other types of media that can be used in networks, including cables made of glass and plastic. Most recently, network communication has been accomplished through the air using radio and microwave transmissions.

When two or more networks are connected together and able to communicate, it is called an **internetwork**. Internetworking is the capability of different networks to communicate using special hardware and software. Internetworking devices make it possible for two networks to communicate, even if they use different **protocols**.

Types of Networks

There are three main categories of networks:

- A local area network (LAN) is a small network of computers and printers in a single building or floor.
- A metropolitan area network (MAN) is a high-speed internetwork of LANs across a metropolitan area.
- A wide area network (WAN) connects LANs using the public switched telephone network.

Local, metropolitan, and wide area networks are quite different from one another. In addition to covering geographic areas of different sizes, the network types have varying installation and support costs associated with them.

Devices used within LANs can be relatively inexpensive and easy to maintain. In many cases, a single person can be responsible for all LAN-related issues. Often in very small offices, one person may take on the responsibilities of network support as an adjunct duty to their regular work. Other small- to medium-size offices hire consultants or a dedicated staff person to provide technical support they cannot provide themselves.

Larger networks, such as metropolitan and wide area networks, require more sophisticated networking equipment and support. The investment in a MAN or WAN is not only based on installation and equipment costs, but also on the costs of long-term support and on-site administration to keep the network running properly. Most larger networks require at least one full-time on-site administrator to maintain the network.

Today, because of the ease of access to the Internet, companies can connect to remote or distant locations without spending lots of money. A person working within a small local network with Internet access can share documents and files with people all over the planet, and even access servers at distant locations. The global reach of the Internet allows this kind of connectivity without the high cost of installation and support associated with private wide area networks.

NOTE

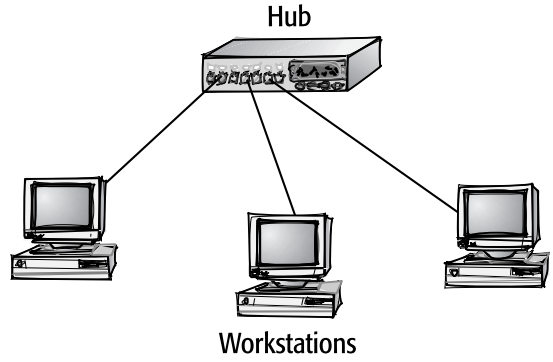
One additional type of network that is found today is the Campus Area Network, or CAN. This specialized network provides services through high-speed fiber-optic connections between buildings containing one or more LANs.

Local Area Networks

The **local area network (LAN)** plays an important part in the everyday functioning of schools, businesses, and government. LANs save people time, lower equipment costs by centralizing printers and other resources, and allow sensitive information to remain in a secure location. Recently, LANs have been used as tools to improve collaboration between employees and for job training using audio and video.

local area network (LAN)
The interconnection of computers, hubs, and other network devices in a limited area like a building.

A local area network is used to connect computers and other network devices together so that the devices can communicate with each other to share resources. Devices on a LAN are connected together using inexpensive cable. Due to limitations in distance, performance, and manageability, the LAN is usually confined to a single office or floor of a building.



hub
A network connectivity device that connects multiple network nodes together. Used primarily with Ethernet, it forwards all traffic it receives from one port to all other ports.

switch
A network connectivity device that connects multiple network nodes together. Used primarily with Ethernet, it forwards traffic based on the addresses found within that traffic, thus eliminating unnecessary network traffic on other ports.

In the preceding illustration, several computers are connected via a cable to a central device called a **hub**, or **switch**. Hubs and switches are common devices found on a network. The lines from the computers to the hub are the cables that allow data transmissions to pass from one computer to the others.

Today, many new local area networks are being installed using wireless technologies. Wireless LANs allow users to connect to network resources without the installation of cabling or wiring. They use wireless devices such as **access points**, or APs, to transmit and receive data.

Access point
A device that acts as a wireless hub, and allows wireless users to connect to a wired network. Also known as an AP.

Depending on the size of the company and the building, there may be one or more LANs. A company that is located in a multistory building with hundreds of employees may have a LAN on each floor. Between each floor, a **bridge** or a **router** is used to interconnect the LANs. Inside the LAN's computers, printers, and other network-capable devices are **network interface cards (NICs)** that allow the devices to communicate at any given moment at high speeds.

Local area networks have the following characteristics:

- They are used within small areas (such as in an office building).
- They offer high-speed communication—typically, 10Mbps or faster.
- They provide access for many devices.
- They use LAN-specific equipment such as repeaters, hubs, and network interface cards.

NOTE

When measuring how fast a network transmits information, you will typically use one of two different suffixes. Mbps stands for megabits per second, and is equal to one million bits transmitted per second. Kbps is kilobits per second, and is equal to roughly one thousand bits transmitted per second. For more information on bits and bytes, see Chapter 8.

bridge
A network device that splits a network into two or more parts for better performance. Information on one part of the network travels through the bridge only if it is intended for the other network.

router
A device used to select the best path for data travel to reach a destination on a different network.

network interface card (NIC)
The internal hardware installed in computers and other devices that allows them to communicate on a network.

metropolitan area network (MAN)
Two or more LANs interconnected over high-speed connections across a city or metropolitan area.

Metropolitan Area Networks

A **metropolitan area network (MAN)** is made up of LANs that are interconnected across a city or metropolitan area. MANs have become increasingly popular as a way of allowing local governments to share valuable resources, communicate with one another, and provide a large-scale private phone service. Although MANs are very expensive to implement, they offer a high-speed alternative to the slower connections found in WANs. MANs offer better speed because of the high-performance cable and equipment used to implement them.

MANs are also appealing to fairly large regional businesses that want to connect their offices. MANs can span as much as 50 to 75 miles, and they provide high-speed network access between sites.

Unlike LANs, in which there are many connections to devices, MANs typically will have just one connection to each site. This is due primarily to the excessive cost of the cable and the equipment. Creating a new MAN connection requires purchasing existing cables from a telecommunications company (the least-expensive option) or having new cables installed, which can cost hundreds of thousands of dollars.

Metropolitan area networks have the following characteristics:

- Sites are dispersed across a city or the surrounding area including the city.
- With the advent of MANs, historically slow connections (56Kbps–1.5Mbps) have given way to communication at hundreds of megabits per second and even gigabit speeds.

- They provide single points of connection between each LAN.
- They use devices such as routers, telephone and **ATM switches**, and microwave antennas.

ATM switch
A network device used by telecommunications companies like the local telephone company to support multiple connections on an ATM network.

NOTE

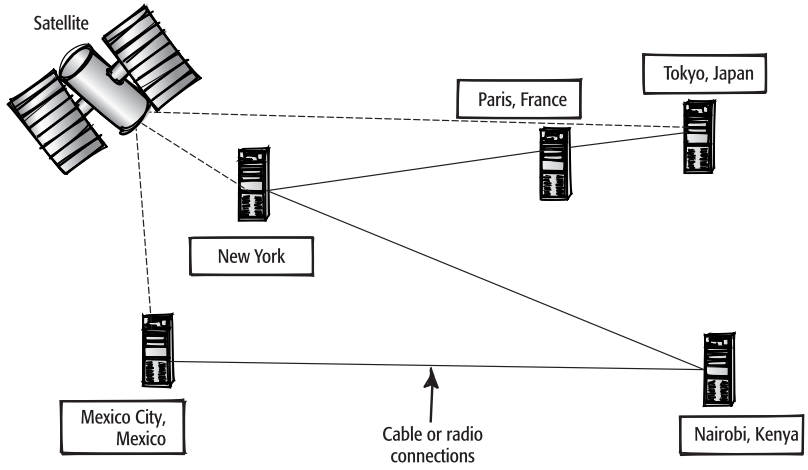
See Chapter 10 for more about ATM (Asynchronous Transfer Mode).

Wide Area Networks

wide area network (WAN)
Two or more LANs or MANs that are interconnected using relatively slow-speed connections over telephone lines.

A **wide area network (WAN)** interconnects two or more LANs (or MANs) over slow connections leased from the local telephone company. WANs run over telephone cables because they typically cover a wide geographical area—they may span cities, states, or even countries. Interconnecting LANs and MANs over great distances of land and water requires a lot of coordination and sophisticated equipment. In most cases, the telephone company is involved in providing the physical cable connection. When connections are required across the globe, other major telecommunications companies will provide **satellite** connectivity.

satellite
In telecommunications, a device that is sent into earth's orbit to travel around the earth and provide telecommunications services for voice and data.



The majority of WANs communicate at speeds between 56Kbps and 1.5Mbps, although speeds up to 45Mbps are available. In fact, the definition of a WAN as a slow-speed connection is changing rapidly. As you will learn in Chapter 14, new technologies are emerging that offer high-speed communication over the telephone network.

Wide area networks have the following characteristics:

- They can cover a very large geographical area; even span the world.
- They usually communicate at slow speeds (compared to LANs).
- Access to the WAN is limited—a LAN usually has only one WAN link that is shared by all devices.
- They use devices such as routers, **modems**, and WAN switches.

WAN links are how the Internet was created. By connecting many LANs together using WANs, all connected users are able to share information.

modem
A device that turns digital signals to analog, and vice versa, for communication on regular telephone lines.

Laying the Foundation: The Public Telephone System

public switched telephone network (PSTN)
The telephone infrastructure that relies on circuit switching or other switching technology to open and close circuits for voice conversations.

Federal Communications Commission (FCC)
A government agency that reports directly to the U.S. Congress. The FCC is charged with regulating interstate and international communications by radio, television, wire, satellite, and cable.

The telephone system is the cornerstone of the Internet. When information moves from a website in San Francisco to a computer in Philadelphia, data is transmitted across the **public switched telephone network (PSTN)**. The public switched telephone network comprises several different telecommunications companies that are interconnected, allowing businesses in different locations in the United States to communicate. Although these interconnections have existed for a long time, they were not always available for companies to use as they pleased.

Without the telecommunications laws that guaranteed that all homes would receive telephone service, much of what we know as the Internet would not exist. The infrastructure that is generally referred to as the *telephone system* was made possible by an idea proposed by Theodore Vail, then president of American Telephone and Telegraph Company (AT&T), in 1907. He proposed that AT&T be given a monopoly over the telephone system. He argued that because a home needed to receive telephone service from only one telephone company, it would not be necessary to have more than one telephone company in a given area. The U.S. government would be responsible for fairly regulating AT&T's activities. In exchange, AT&T would provide "universal access"—including service to rural communities.

In 1956, the Hush-a-Phone court case set an important precedent for using the public telephone network. The Hush-a-Phone company had created a device that attached to a telephone to block background noise. The device used no magnetic parts or electricity. AT&T sued Hush-a-Phone, citing that the monopoly granted them by the government prevented anyone from attaching a device to the telephone network. The court ruled in Hush-a-Phone's favor. Ten years later, AT&T sought to block Carter Electronics from attaching its electrical devices to the AT&T telephone network. In the Carterphone case, the **Federal Communications Commission (FCC)** ruled that other devices could be attached to the telephone network. This case and the preceding one are important to internetworking because they granted other companies the right to build and sell telephones and later to attach network devices to AT&T's telephone network.

The AT&T breakup into the Baby Bells and increased competition have helped to further expand the telecommunications infrastructure in the United States and around the world. The continuing deregulation of local telephone companies is furthering high-speed network access to the home at very affordable rates.

The Origin of Networks

In the world of computer networking, things change very rapidly. What's interesting is that the underlying technology does not change much at all. The network may be faster or more efficient, or have more functions, but the way it works is essentially the same. Network administrators need to be knowledgeable about the technologies that led to the networks of today. That knowledge may be useful when troubleshooting a problem or when trying to explain why the Internet works the way it does.

Some of the first networks were really just **mainframe** systems that ran over dedicated lines. In some cases, the lines ran long distances. The modern computing network really began to emerge with the development of two networks. The Semi Automatic Ground Environment (SAGE) was one of the early networks (1958) that was developed to link government computers at radar stations in the United States and Canada. In the 1960s, researchers at MIT developed the **Compatible Time-Sharing System (CTSS)** on an IBM mainframe. The time-sharing system allowed multiple users to run tasks concurrently on the same system. CTSS later included modems to connect over dedicated lines in the lab. A user dialed a single number to access the system. Eventually, the system was used campus-wide, and even provided some users access from home.

One of the first commercialized applications that utilized remote access for online transactions was installed for American Airlines in 1964. IBM's SABRE reservation system linked 2,000 machines in 65 cities to two IBM mainframes using telephone lines. These mainframes considered remote terminals to be "remote inquiry stations," and processed their requests. They could deliver information about any flight within three seconds.

mainframe
A large, powerful computing machine that stores and processes information, and that runs applications for the terminals that are attached to it.

Compatible Time-Sharing System (CTSS)
Developed in 1961 at MIT, CTSS had a capacity of up to 30 modems to give terminals access to run tasks concurrently. CTSS was the precursor to operating systems such as UNIX.

Network Communication

The mainframe systems in use in the 1960s and 1970s relied on the mainframe for all processing of information. Terminals attached to the mainframe would wait their turn as information was processed at the mainframe and sent back to each terminal's screen. These early networks were large, expensive, and difficult to use. On mainframe networks, adding an additional terminal was a very difficult and expensive undertaking. Still, these difficulties did not slow user demands. The emerging networks were seen as a way to share resources. They made it possible for more people to connect and communicate. The network could provide time-saving functions like modifying documents without retyping all of the information. Major changes occurred in networking in the early 1970s with the creation of communication protocols.

The first network protocols were **Token Ring**, **ARCNET**, and **Ethernet**. Each protocol used a different method for computers to access the network. The most significant of the three was Ethernet. Robert Metcalf, then a graduate student at Harvard University, first drew the concept for Ethernet on a piece of paper as part of his Ph.D. thesis. The purpose of the research project was to explore packet switching on the **ARPAnet** and **ALOHAnet** networks. Today, Ethernet is the most widely used access method for computer networks.

Token Ring
A network access method that relies on tokens to allow devices to transmit information.

ARCNET
A network access method that uses tokens such as Token Ring, but is much less expensive.

Ethernet
A network access method that allows any directly connected device to transmit on the network, provided that no one else is transmitting.

ARPAnet
The predecessor to the Internet, ARPAnet was developed by the Department of Defense's Advanced Research Projects Agency to provide reliable communication, even in the event of a partial network failure.

ALOHAnet
A network that connected the Hawaiian Islands using radio transmissions.

ARPAnet

While universities and private companies were extending networks using mainframes and terminals, the United States Department of Defense was developing its own network. In the early 1960s, the Advanced Research Projects Agency (ARPA) of the Department of Defense had begun work on a network called ARPAnet. ARPAnet was an experimental network that was created as a communication solution that could withstand a partial failure caused by a bomb attack. ARPAnet also gave top researchers at universities and government institutions the ability to collaborate. After almost a decade in development, the first nodes were connected at the University of California at Los Angeles, the University of California at Santa Barbara, the Stanford Research Institute, and the University of Utah. By 1971, there were 23 nodes connected to ARPAnet. The primary application in use was e-mail.

ARPAnet continued to grow rapidly in the 1980s. By 1989, the ARPAnet was dissolved as a single entity, leaving the public infrastructure known as the Internet and the military system renamed DARPAnet (Defense Advanced Research Projects Agency network). ARPAnet is significant both because it became the Internet and because it demonstrated the ability to interconnect different networks from around the world using the existing public telephone network.

The Internet

The Internet grew out of ARPAnet. ARPAnet's unique purpose of providing reliable service, even in the event of a partial failure, proved to be a critical function to the success of the Internet. Another reason for the rapid expansion of ARPAnet and the success of the Internet had to do with the distribution of a not-so-well-known piece of software called BSD UNIX.

By using BSD UNIX, and by funding a company called Bolt, Beranek and Newman, Inc., ARPA was able to expand the Internet to most university computer science departments. BSD UNIX, a computer operating system, proved to be the tool that universities needed to access ARPAnet and communicate with peers.

The Internet became more popular and gained support when the National Science Foundation formed **NSFNET**. NSFNET linked supercomputers at five educational centers, the University of Illinois at Urbana-Champaign, the University of California at San Diego, Princeton University, Cornell University, and Pittsburgh University. These sites soon led to the development of regional networks. NSFNET, with its powerful infrastructure, became the **backbone** of ARPAnet, thereby interconnecting more networks. In 1991, the NSF permitted the first use of the Internet for commercial purposes. By 1995, the popularity of the Internet had exploded, and the NSF decommissioned its own backbone infrastructure, leaving the Internet as a self-supporting industry.

The Future of the Internet

The Internet in use today looks very different than it did in 1990. At that time, there were fewer than 250,000 users on the Internet. It is estimated that there will be more than 300 million users worldwide in just a few years.

For the Internet to be able to handle the growing number of users, major improvements will have to be made in the infrastructure. Even now, the "backbone" of the Internet is being upgraded to the latest network technology. In addition, a second Internet has been built called **Internet 2** (the Abilene Project). Learn more about Internet 2 at `http://www.internet2.edu/`.

Internet 2 is a **very high performance Backbone Network Service (vBNS)**, sponsored by the NSF along with many other government and commercial partners. Internet 2 was developed and installed to support the research and communication needs of academia. To date, there are 95 university campuses, government agencies, and cooperatives connected across the United States, and more are being added. These 95 sites are linked together by twelve regional **gigabit Points of Presence (gigaPOPs)**.

NSFNET
The name for the network backbone funded and built by the National Science Foundation that connected many isolated networks to the ARPAnet.

backbone
The main connection point for multiple networks that carries the bulk of the traffic between different networks.

Internet 2
An internetwork connecting major university campuses, research institutes, and government agencies across the country for research and collaboration.

very high performance Backbone Network Service (vBNS)
The gigabit network developed and managed by MCI in cooperation with the National Science Foundation and other agencies.

gigabit Point of Presence (gigaPOP)
A site that is considered a main backbone provider for Internet 2, and is capable of supporting internetwork speeds in the gigabit range.

Review Questions

Terms to Know

- ❑ access point
- ❑ ALOHAnet
- ❑ ARCNET
- ❑ ARPAnet
- ❑ ATM switch
- ❑ backbone
- ❑ bridge
- ❑ Compatible Time-Sharing System (CTSS)
- ❑ Ethernet
- ❑ Federal Communications Commission (FCC)
- ❑ gigabit Points of Presence (gigaPOPs)
- ❑ hub
- ❑ Internet 2
- ❑ internetwork

1. Why was AT&T given a monopoly over local phone service?

2. What was the significance of the Carterphone case?

3. What governmental agency developed the ARPAnet?

4. What important invention was created by Robert Metcalf?

5. What are the four main characteristics of LANs?

6. When would a MAN be used?

7. Describe how WANs are different from LANs and MANs.

_____

_____

8. What are two reasons why ARPAnet and later the Internet were successful?

_____

_____

9. What network added to the overall capacity of the Internet, and in what way?

_____

_____

10. What is one of the major accomplishments of Internet 2?

_____

_____

Terms to Know

- ❑ local area network (LAN)
- ❑ mainframe
- ❑ metropolitan area network (MAN)
- ❑ modem
- ❑ network interface cards (NICs)
- ❑ NSFNET
- ❑ protocol
- ❑ public switched telephone network (PSTN)
- ❑ router
- ❑ satellite
- ❑ switch
- ❑ Token Ring
- ❑ very high performance Backbone Network Service (vBNS)
- ❑ wide area network (WAN)