Test Specific

Network Topologies

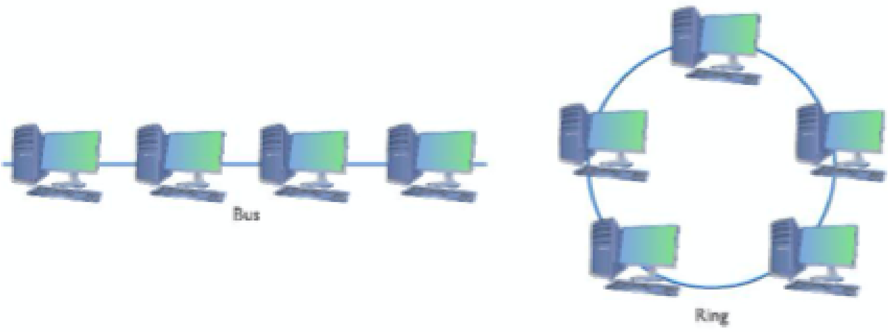
Computer networks employ many different *topologies*, or ways of connecting computers together. This section looks at both the historical topologies—bus, ring, and star; all long dead—and the modern topologies—hybrid and mesh. In addition, we will look at what parameters are used to make up a network topology.

Wireless networks employ topologies too, just not with wires. We'll cover the common wireless topologies—infrastructure and ad hoc—in Chapter 14.

Bus and Ring

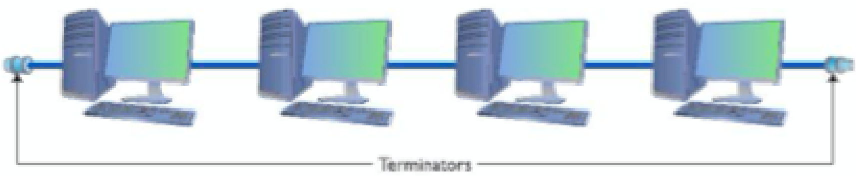
The first generation of wired networks used one of two topologies, both shown in Figure 2.1. A **bus topology** network used a single cable (i.e., the *bus*) that connected all the computers in a line. A **ring topology** network connected all computers on the network with a ring of cable.

Note that topologies are diagrams, much like an electrical circuit diagram. Real network cabling doesn't go in perfect circles or perfect straight lines.



• Figure 2.1 Bus and ring topologies

Data flowed differently between bus and ring networks, creating different problems and solutions. In bus topology networks, data from each computer simply went out on the whole bus. A network using a bus topology needed termination at each end of the cable to prevent a signal sent from one computer from reflecting at the ends of the cable, quickly bringing the network down (Figure 2.2).



• Figure 2.2 Terminated bus topology

used for sending, the other for receiving. In response to the demand for two-pair cabling, manufacturers often connect two fibers together to create *duplex* fiber-optic cabling (Figure 2.23).

• **Figure 2.23** Duplex fiber-optic cable

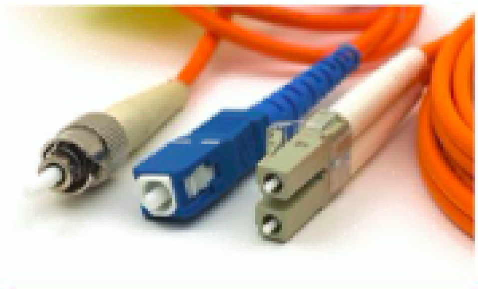
Light can be sent down a fiber-optic cable as regular light or as laser light. The two types of light require totally different fiber-optic cables. Most network technologies that use fiber optics use LEDs (light emitting diodes) to send light signals. A fiber-optic cable that uses LEDs is known as **multimode fiber (MMF)**.

A fiber-optic cable that uses lasers is known as **single-mode fiber (SMF)**. Using laser light and single-mode fiber-optic cables prevents a problem unique to multimode fiber optics called **modal distortion** (signals sent at the same time don't arrive at the same time because the paths differ slightly in length) and enables a network to achieve phenomenally high transfer rates over incredibly long distances.

> A *nano*—abbreviated as *n*—stands for 1/1,000,000,000, or one-billionth of whatever. Here you'll see it as a nanometer (nm), one-billionth of a meter. That's one tiny wavelength!

Fiber optics also defines the wavelength of light used, measured in nanometers (nm). Almost all multimode cables transmit 850-nm wavelengths, whereas single-mode transmits either 1310 nm or 1550 nm, depending on the laser.

Fiber-optic cables come in a broad choice of connector types. There are over one hundred different connectors, but the four you need to know for the CompTIA Network+ exam are ST, SC, LC, and MT-RJ. Figure 2.24 shows the first three; Figure 2.25 shows an MT-RJ connector.



• **Figure 2.24** From left to right: ST, SC, and LC fiber-optic connectors

Although all fiber connectors must be installed in pairs, the ST and SC connectors traditionally have unique ends. The LC and MT-RJ connectors are always duplex, meaning both the send and receive cables are attached. You can certainly find SC connectors or sleeves to make them duplex too, so don't get too caught up with which can be which. We'll revisit fiber-optic connectors in Chapter 4 when we discuss implementation of specific networking standards.

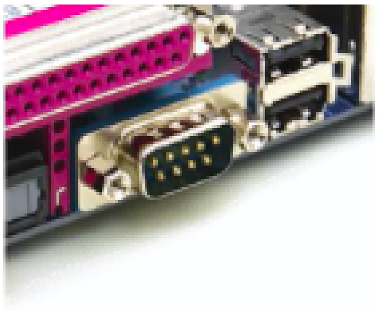
Other Cables

Fiber-optic and UTP make up almost all network cabling, but a few other types of cabling appear on the CompTIA Network+ exam: the ancient serial and parallel cables from the earliest days of PCs. These cables were used for networking, but they have not been in use for many years.

• **Figure 2.25** MT-RJ fiber-optic connector

Classic Serial

Serial cabling predates both networking and the personal computer. **RS-232**, the *recommended standard (RS)* upon which all serial communication took place on a PC, dates from 1969 and hasn't substantially changed in around 50 years. When IBM invented the PC way back in 1980, serial connections were just about the only standard input/output technology available, so IBM included two serial ports on every PC. The most common serial port at the end of the technology was a 9-pin, male D-subminiature (or **DB-9**) connector, as shown in Figure 2.26.



• Figure 2.26 Serial port

Serial ports offered a poor option for networking, with very slow data rates—only about 56,000 bps (note, that's *bits* per second!)—and only point-to-point connections. Serial ports were last used decades ago for connecting to networking devices, such as high-end switches, for configuration purposes only.

Parallel

Parallel connections are as ancient as serial ports. Parallel ran up to around 2 Mbps, although when used for networking, they tended to be much slower. Parallel was also limited to point-to-point topology, meaning directly connecting two devices with a single cable. They used a 25-pin female—rather than male—DB type connector called a **DB-25** (Figure 2.27). The **IEEE 1284** committee set the standards for parallel communication. (See the section "Networking Industry Standards—IEEE," later in this chapter.)

Fire Ratings

Did you ever see the movie *The Towering Inferno?* Don't worry if you missed it—*The Towering Inferno* was one of the better disaster movies of the 1970s, although it was no *Airplane!* Anyway, Steve McQueen stars as the fireman who saves the day when a skyscraper goes up in flames because of poor-quality electrical cabling. The burning insulation on the wires ultimately spreads the fire to every part of the building. Although no cables made today contain truly flammable insulation, the insulation is made from plastic, and if you get any plastic hot enough, it will create smoke and noxious fumes. The risk of burning insulation isn't fire—it's smoke and fumes.

To reduce the risk of your network cables burning and creating noxious fumes and smoke, Underwriters Laboratories and the National Electrical Code (NEC) joined forces to develop cabling *fire ratings*. The two most common fire ratings are PVC and plenum. Cable with a **polyvinyl chloride (PVC)** rating has no significant fire protection. If you burn a **PVC-rated cable**, it creates lots of smoke and noxious fumes. Burning **plenum-rated cable** creates much less smoke and fumes, but plenum-rated cable costs about three to five times as much as PVC-rated cable. Most city ordinances require the use of plenum cable for network installations. The bottom line? Get plenum!

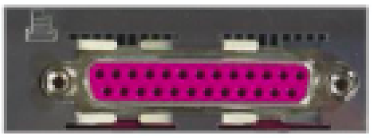
The space between the acoustical tile ceiling in an office building and the actual concrete ceiling above is called the **plenum**—hence the name for the proper fire rating of cabling to use in that space. A third type of fire

Tech Tip

What's in a Name, Part 2?

Most technicians call common fiber-optic connectors by their initials—such as ST, SC, or LC—perhaps because there's no consensus about what words go with those initials. ST probably stands for straight tip, *although some call it* snap and twist. *But SC and LC? How about* subscriber connector, standard connector, *or* Siemon connector *for the former, and* local connector *or* Lucent connector *for the latter?*

If you want to remember the connectors for the exam, try these: snap and twist *for the bayonet-style ST connectors;* stick and click *for the straight push-in SC connectors; and* little connector *for the…little…LC connector.*



• Figure 2.27 Parallel connector

Concentrate on UTP—that's where the hardest CompTIA Network+ exam questions come into play. Don't forget to give coax, STP, and fiber-optic a quick pass, and make sure you understand the reasons for picking one type of cabling over another. Even though the CompTIA Network+ exam does not test too hard on cabling, this is important information that you will use in real networking.

Look for a question on the CompTIA Network+ exam that asks you to compare plenum versus PVC cable best use.

rating, known as **riser**, designates the proper cabling to use for vertical runs between floors of a building. Riser-rated cable provides less protection than plenum cable, though, so most installations today use plenum for runs between floors.

Networking Industry Standards—IEEE

The **Institute of Electrical and Electronics Engineers (IEEE)** defines industry-wide standards that promote the use and implementation of technology. In February 1980, a committee called the 802 Working Group took over from the private sector the job of defining network standards. (Get it? 02/80?) The IEEE 802 committee defines frames, speeds, distances, and types of cabling to use in a network environment. Concentrating on cables, the IEEE recognizes that no single cabling solution can work in all situations and, therefore, provides a variety of cabling standards.

• Figure 2.28 Parallel cable marked IEEE 1284–compliant

IEEE committees define standards for a wide variety of electronics. The names of these committees are often used to refer to the standards they publish. The IEEE 1284 committee, for example, set standards for parallel communication, so you would see parallel cables marked "IEEE 1284–compliant," as in Figure 2.28.

The IEEE 802 committee sets the standards for networking. Although the original plan was to define a single, universal standard for networking, it quickly became apparent that no single solution would work for all needs. The 802 committee split into smaller subcommittees, with names such as IEEE 802.3 and IEEE 802.11. Table 2.4 shows the currently recognized IEEE 802 subcommittees and their areas of jurisdiction. The missing numbers, such as 802.2 and 802.12, were used for committees long-ago disbanded. Each subcommittee is officially called a Working Group, except the few listed as a Technical Advisory Group (TAG) in the table.

Table 2.4	Some IEEE 802 Subcommittees
IEEE 802.1	Higher Layer LAN Protocols (with many subcommittees, like 802.1X for port-based network access control)
IEEE 802.3	Ethernet (with a ton of subcommittees, such as 802.3ae for 10-Gigabit Ethernet)
IEEE 802.11	Wireless LAN (WLAN); specifications, such as Wi-Fi, and many subcommittees
IEEE 802.15	Wireless Personal Area Network (WPAN)
IEEE 802.18	Radio Regulatory Technical Advisory Group
IEEE 802.19	Wireless Coexistence Working Group
IEEE 802.20	Mobile Broadband Wireless Access (MBWA); (in hibernation)
IEEE 802.21	Media Independent Handover Services
IEEE 802.22	Wireless Regional Area Networks

Chapter 2 Review

Chapter Summary

After reading this chapter and completing the exercises, you should understand the following about cabling and topology.

Explain the Different Types of Network Topologies

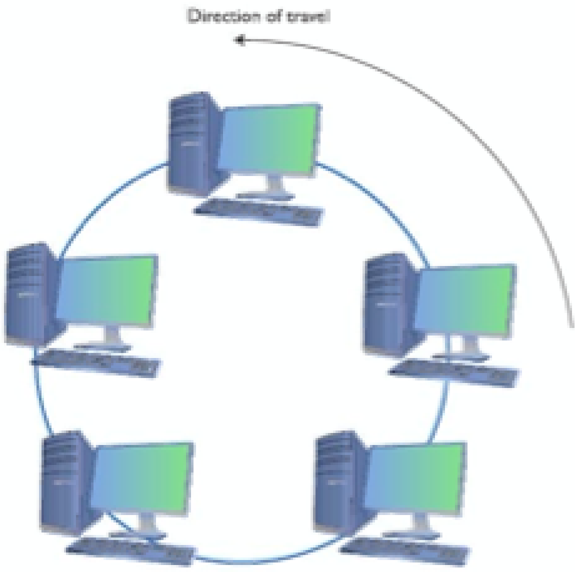
- A network's *topology* describes how computers connect to each other in that network. The network topologies referred to on the CompTIA Network+ objectives are called *bus*, *ring*, *star*, and *mesh*.
- In a bus topology, all computers connected to the network via a main line. The cable had to be terminated at both ends to prevent signal reflections.
- In a ring topology, all computers on the network attached to a ring of cable. A single break in the cable stopped the flow of data through the entire network.
- In a star topology, the computers on the network connected to a central wiring point, which provided fault tolerance.
- Networks turned to the two hybrid topologies, *star-bus* and *star-ring*, many years ago. Only star-bus is used today.
- In a mesh topology, each computer has a dedicated connection to two or more other computers. You'll see mesh in the context of wireless networks.

Describe the Different Types of Network Cabling and Connectors

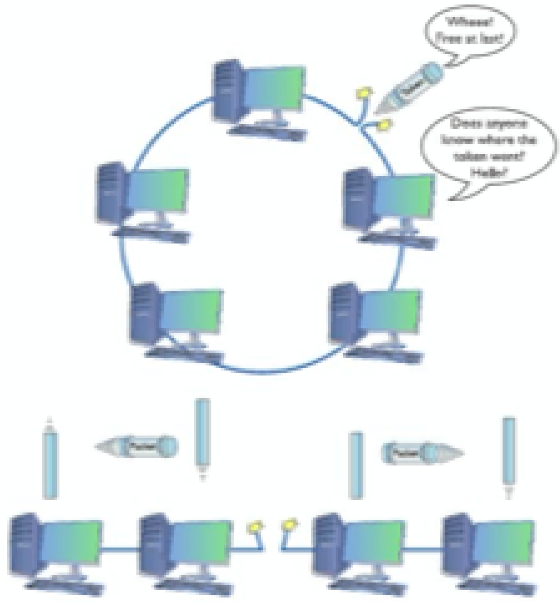
- Copper cabling comes in two forms: coaxial and twisted pair.
- Coaxial cable, or coax, shields data transmissions from EMI. Coax in various forms was widely used in early bus networks and used BNC connectors. Today, coax is used mainly to connect a cable modem to an ISP.
- Coax cables have an RG rating, with RG-6 being the predominant coax today.
- Twisted pair, which comes shielded or unshielded, is the most common type of networking cable today. UTP is less expensive and more popular than STP, though it doesn't offer any protection from EMI.
- UTP is categorized by its Cat rating, with Cat 5, Cat 5e, Cat 6, and Cat 6a being the most commonly used today.
- UTP uses RJ-45 connectors.
- Fiber-optic cabling transmits light instead of the electricity used in copper cables. It is thin and more expensive, yet less flexible and more delicate, than other types of network cabling.
- There are two types of fiber-optic cable based on what type of light is used. LEDs require multimode cable, whereas lasers generally require single-mode cable.
- All fiber-optic cable has four parts: the fiber itself; the cladding, which covers the fiber and helps it reflect down the fiber; buffer material to give strength; and the outer insulating jacket. Additionally, there are over one hundred types of connectors for fiber-optic cable, but ST, SC, LC, and MT-RJ are the most common for computer networking.
- Plenum-rated UTP is required by most cities for network installations.
- Serial cables adhered to the RS-232 standard; parallel cables adhered to the IEEE-1284 standard.

Describe the IEEE Networking Standards

- Networking standards are established and promoted by the Institute of Electrical and Electronics Engineers (IEEE).
- The IEEE 802 committee defines frames, speeds, distances, and types of cabling to use in networks. IEEE 802 is split into several subcommittees, including IEEE 802.3 and IEEE 802.11.



• **Figure 2.3** Ring topology moving in a certain direction



• **Figure 2.4** Nobody is talking!

In a ring topology network, in contrast, data traffic moved in a circle from one computer to the next in the same direction (Figure 2.3). With no end to the cable, ring networks required no termination.

Bus and ring topology networks worked well but suffered from the same problem: the entire network stopped working if the cable broke at any point (Figure 2.4). The broken ends on a bus topology network didn't have the required termination, which caused reflection between computers that were still connected. A break in a ring topology network simply broke the circuit, stopping the data flow.

• **Figure 2.5** Star topology

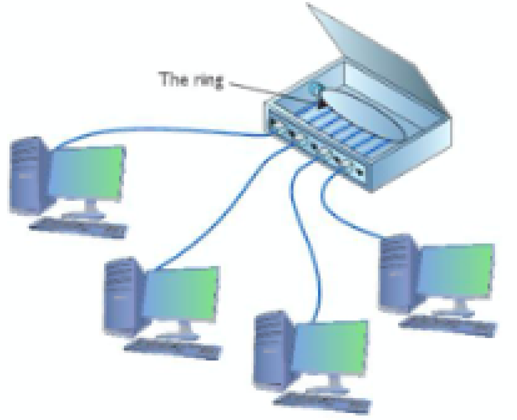
Star

The **star topology** used a central connection box for all the computers on the network (Figure 2.5). Star topologies had a huge benefit over ring and bus topologies by offering **fault tolerance**—if one of the cables broke, all of the other computers could still communicate. Bus and ring topology networks were popular and inexpensive to implement, however, so the old-style star topology networks weren't very successful. Network hardware designers couldn't easily redesign their existing networks to use a star topology.

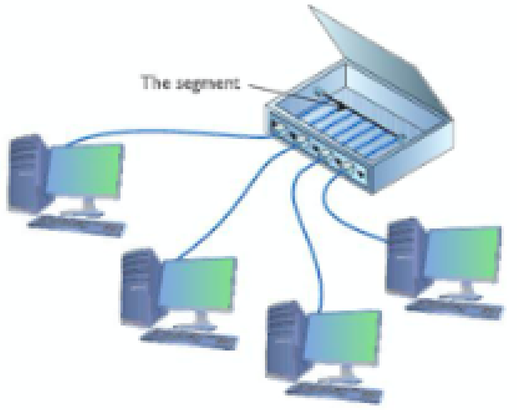
Hybrid

Even though network designers couldn't easily use a star topology, the benefits of star topologies were overwhelming, motivating smart people to come up with a way to use star topologies without requiring a major redesign—and the way they did so was ingenious. The ring topology network designers struck first by taking the entire ring and shrinking it into a small box, as shown in Figure 2.6.

This was quickly followed by the bus topology folks, who, in turn, shrunk their bus (better known as the **segment**) into their own box (Figure 2.7).



• **Figure 2.6** Shrinking the ring



• **Figure 2.7** Shrinking the segment

Physically, both of these hybrid designs looked like a star, but if you examined them as an electronic schematic, the signals acted like a ring or a bus. Clearly the old definition of topology needed a little clarification. When we talk about topology today, we separate how the cables physically look (the **physical topology**) from how the signals travel electronically (the **signaling topology** or **logical topology**).

Any form of networking technology that combines a physical topology with a signaling topology is called a **hybrid topology**. Hybrid topologies have come and gone since the earliest days of networking. Only two hybrid topologies, **star-ring topology** and **star-bus topology**, ever saw any amount of popularity. Eventually star-ring lost market share, and star-bus reigns as the undisputed "star" (pun intended) of wired network topologies.

Most techs refer to the signaling topology as the logical topology today. That's how you'll see it on the CompTIA Network+ exam as well. Look for a question on the exam that challenges you on logical versus physical topology.

The most successful of the star-ring topology networks was called Token Ring, manufactured by IBM.

Mesh

Topologies aren't just for wired networks. Wireless networks also need topologies to get data from one machine to another, but using radio waves instead of cables involves somewhat different topologies. Wireless devices can connect in a **mesh topology** network, where every computer connects to every other computer via two or more routes. Some of the routes between two computers may require traversing through another member of the mesh network. (See Chapter 14 for the scoop on wireless network types.)

There are two types of meshed topologies: partially meshed and fully meshed (Figure 2.8). In a **partially meshed topology** network, at least two machines have redundant connections. Every machine doesn't have to connect to every other machine. In a **fully meshed topology** network, every computer connects directly to every other computer.

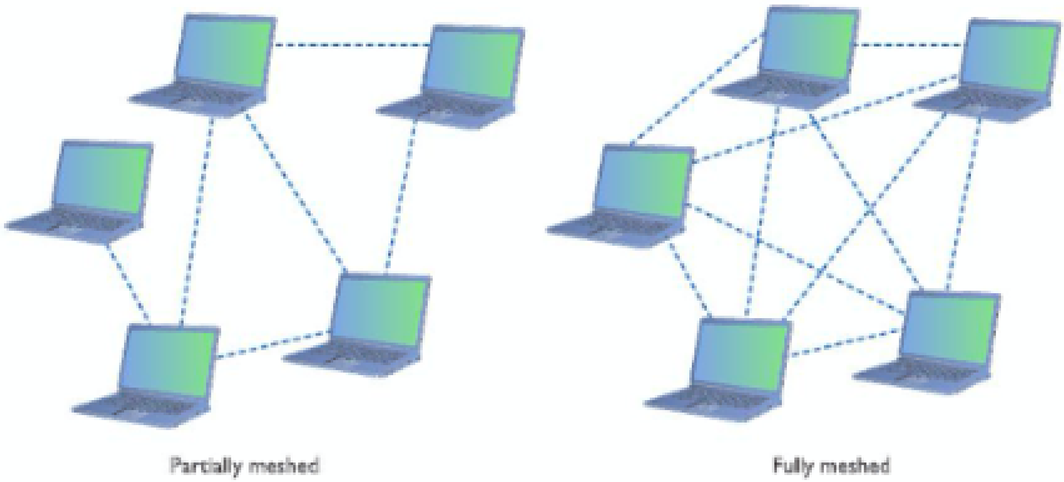


Figure 2.8 Partially and fully meshed topologies

Make sure you know the topologies: bus, ring, star, hybrid, and mesh.

Check out the excellent Chapter 2 "Topology Matching" Challenge! over at http://totalsem.com/007. It's a good tool for reinforcing the topology variations.

Parameters of a Topology

Although a topology describes the method by which systems in a network connect, the topology alone doesn't describe all of the features necessary to enable those networks. The term *bus topology*, for example, describes a network that consists of machines connected to the network via a single linear piece of cable. Notice that this definition leaves a lot of questions unanswered. What is the cable made of? How long can it be? How do the machines decide which machine should send data at a specific moment? A network based on a bus topology can answer these questions in several ways—but it's not the job of the topology to define issues like these. A functioning network needs a more detailed standard.

Over the years, manufacturers and standards bodies have created network technologies based on different topologies. A **network technology** is a practical application of a topology and other critical technologies that provides a method to get data from one computer to another on a network. These network technologies have names like 100BaseT, 1000BaseLX, and 10GBaseT. You will learn all about these in the next two chapters.

Cabling and Connectors

Most networked systems link together using some type of cabling. Different types of networks over the years have used different types of cables—and you need to learn about all these cables to succeed on the CompTIA Network+ exam. This section explores scenarios where you would use common network cabling.

All cables used in the networking industry can be categorized in two distinct groups: copper and fiber-optic. All styles of cables have distinct connector types that you need to know.

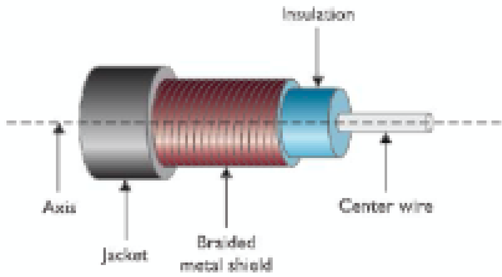
Copper Cabling and Connectors

The most common form of cabling uses copper wire wrapped up in some kind of protective sheathing, thus the term *copper cables*. The two primary types of copper cabling used in the industry are coaxial and twisted pair.

Both cable types sport a variety of connector types. I'll cover the connector types as I discuss the cable varieties.

Coaxial Cable

Coaxial cable contains a central conductor wire (usually copper) surrounded by an insulating material, which, in turn, is surrounded by a braided metal shield. The cable is referred to as coaxial (coax for short) because the center wire and the braided metal shield share a common axis or centerline (Figure 2.9).



• **Figure 2.9** Cutaway view of coaxial cable

Coaxial cable shields data transmissions from interference. Many devices in the typical office environment—including lights, fans, copy machines, and refrigerators—generate magnetic fields. When a metal wire encounters these magnetic fields, electrical current is generated along the wire. This extra current, called **electromagnetic interference (EMI)**, can shut down a network because it is easily misinterpreted as a signal by devices like NICs. To prevent EMI from affecting the network, the outer mesh layer of a coaxial cable shields the center wire (on which the data is transmitted) from interference (Figure 2.10).

Early bus topology networks used coaxial cable to connect computers together. Back in the day, the most popular cable used special bayonet-style connectors called **BNC connectors** (Figure 2.11). Even earlier bus networks used thick cable that required vampire connections—sometimes called *vampire taps*—that literally pierced the cable.

Tech Tip

What's in a Name?

Techs all around the globe argue over the meaning of BNC. A solid percentage says with authority that it stands for "British Naval Connector." An opposing percentage says with equal authority that it stands for "Bayonet Neill-Concelman," after the stick-and-twist style of connecting and the purported inventors of the connector. The jury is still out, though this week I'm leaning toward Neill and Concelman and their bayonet-style connector.

• **Figure 2.10** Coaxial cable showing braided metal shielding

• **Figure 2.11** BNC connector on coaxial cable

• Figure 2.12 F-type connector on coaxial cable

You'll find coaxial cable used today primarily to enable a cable modem to connect to an Internet service provider (ISP). That's the typical scenario for using coaxial cable: connecting a computer to the cable modem enables that computer to access the Internet. This cable is the same type used to connect televisions to cable boxes or to satellite receivers. These cables use an **F connector** (or **F-type connector**) that screws on, making for a secure connection (Figure 2.12).

Cable modems connect using one of two coaxial cable types. **RG-59** was used primarily for cable television rather than networking. Its thinness and the introduction of digital cable motivated the move to the more robust **RG-6**, the predominant cabling used today (Figure 2.13).

All coax cables have a **Radio Guide (RG) rating**. The U.S. military developed these ratings to provide a quick reference for the different types of coax. The only important measure of coax cabling is its **Ohm rating**, a relative measure of the resistance (or more precisely, characteristic impedance) on the cable. You may run across other coax cables that don't have acceptable Ohm ratings, although they look just like network-rated coax. Fortunately, most coax cable types display their Ohm ratings on the cables themselves (see Figure 2.14). Both RG-6 and RG-59 cables are rated at 75 Ohms.

Coaxial cabling is also very popular with satellite dishes, over-the-air antennas, and even some home video devices. This book covers cable and other Internet connectivity options in great detail in Chapter 13, "Remote Connectivity."

The Ohm rating of a piece of cable describes the impedance of that cable. *Impedance* describes a set of characteristics that define how much a cable resists the flow of electricity. This isn't simple resistance, though. Impedance is also a factor in such things as how long it takes the wire to get a full charge—the wire's *capacitance*—and more.

• Figure 2.13 RG-6 cable

• Figure 2.14 Ohm rating (on an older, RG-58 cable used for networking)

• Figure 2.15 Coaxial splitter

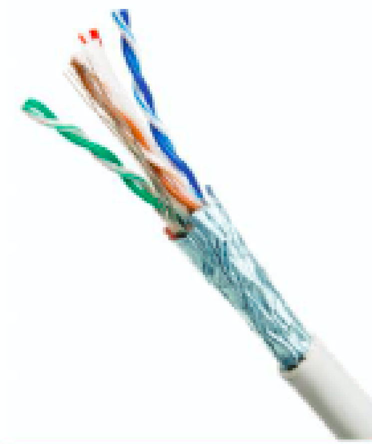
• Figure 2.16 Barrel connector

Given the popularity of cable for television and Internet in homes today, you'll run into situations where people need to take a single coaxial cable and split it. Coaxial handles this quite nicely with coaxial splitters like the one shown in Figure 2.15. You can also connect two coaxial cables together easily using a barrel connector when you need to add some distance to a connection (Figure 2.16). Table 2.1 summarizes the coaxial standards.

Table 2.1	Coaxial Cables		
Rating	**Ohms**	**Use**	**Connector**
RG-58	50	Networking	BNC
RG-59	75	Cable TV	F Type
RG-6	75	Cable TV	F Type

Twisted Pair

The most common type of cabling used in networks consists of twisted pairs of cables, bundled together into a common jacket. Each pair in the cable works as a team either transmitting or receiving data. Using a pair of twisted wires rather than a single wire to send a signal reduces a specific type of interference, called **crosstalk**. The more twists per foot, the less crosstalk. Two types of twisted-pair cabling are manufactured, shielded and unshielded.



• **Figure 2.17** Shielded twisted pair

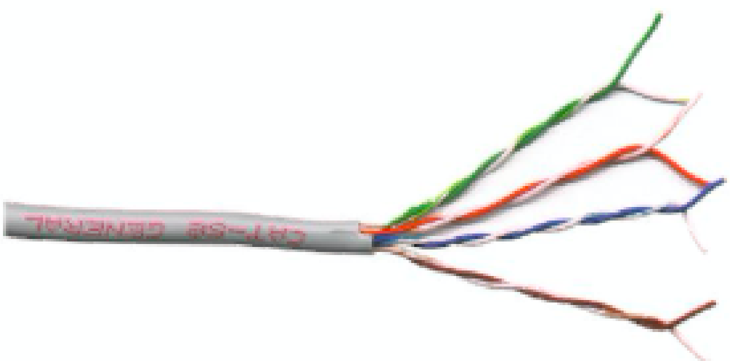
Shielded Twisted Pair **Shielded twisted pair (STP)** consists of twisted pairs of wires surrounded by shielding to protect them from EMI. There are six types, differentiated by which part gets shielding, such as the whole cable or individual pairs within the cable. Table 2.2 describes the six types. Figure 2.17 shows a typical piece of STP with the cladding partly removed so you can see the internal wiring.

Table 2.2	STP Standards
Name	**Description**
F/UTP	Foil shields the entire cable; inside, the wires are just like UTP.
S/UTP	A braid screen shields the entire cable; inside, the wires are just like UTP.
SF/UTP	A braid screen and foil shield the entire cable; the wires inside are just like UTP.
S/FTP	A braid screen shields the entire cable; foil shields each wire pair inside.
F/FTP	A foil screen shields the entire cable; foil shields each wire pair inside.
U/FTP	No overall shielding; each pair inside is shielded with foil screens.

You don't need to memorize the STP variations for the CompTIA Network+ exam. You will, however, see them in the field once you become a network tech. The typical scenario in which you'd deploy STP over UTP is in high-EMI environments.

Unshielded Twisted Pair **Unshielded twisted pair (UTP)** consists of twisted pairs of wires surrounded by a plastic jacket (Figure 2.18). This jacket does not provide any protection from EMI, so when installing UTP cabling, you must be careful to avoid interference from fluorescent lights, motors, and so forth. UTP costs much less than STP but, in most cases, performs just as well.

Twisted-pair cabling has been around since the 1970s, and evolving technologies demanded higher speeds. Over the years, manufacturers increased the number of twists per foot, used higher gauge cable, and



• **Figure 2.18** Unshielded twisted pair added shielding to make twisted pair able to handle higher data speeds. To help network installers get the right cable for the right network technology, the cabling industry developed a variety of grades called **category (Cat) ratings**. Cat ratings are officially rated in *megahertz (MHz)*, indicating the highest frequency the cable can handle. Table 2.3 shows the most common categories along with their status with the TIA (see the Tech Tip for more information).

Tech Tip

Industry Standards Bodies

Several international groups set the standards for cabling and networking in general. Ready for alphabet soup? At or near the top is the International Organization for Standardization (ISO). The American National Standards Institute (ANSI) is both the official U.S. representative to ISO and a major international player. ANSI checks the standards and accredits other groups, such as the Telecommunications Industry Association (TIA).

Table 2.3 Cat Ratings for Twisted Pair

Cat Rating	Max Frequency	Max Bandwidth	Status with TIA
Cat 3	16 MHz	16 Mbps	Recognized
Cat 4	20 MHz	20 Mbps	No longer recognized
Cat 5	100 MHz	100 Mbps	No longer recognized
Cat 5e	100 MHz	1 Gbps	Recognized
Cat 6[1]	250 MHz	10 Gbps	Recognized
Cat 6a[2]	500 MHz	10 Gbps	Recognized
Cat 7	600 MHz	10+ Gbps	Not recognized
Cat 7a[3]	1000 MHz	40–100 Gbps	Not recognized
Cat 8	2000 MHz	25–40 Gbps	Not recognized

[1] Cat 6 cables can use the full 100-meter length when used with 10/100/1000BaseT networks. With 10GBaseT networks, Cat 6 is limited to 55 meters.
[2] Cat 6a cables can use the full 100-meter length with networks up to 10GBaseT.
[3] Cat 7a cables can theoretically support 40 Gbps at 50 meters; 100 Gbps at 15 meters.

UTP cables handle a certain frequency or cycles per second, such as 100 MHz or 1000 MHz. You could take the frequency number in the early days of networking and translate that into the maximum throughput for a cable. Each cycle per second (or hertz) basically accounted for 1 bit of data per second. A 10 million cycle per second (10 MHz) cable, for example, could handle 10 million bits per second (10 Mbps). The maximum amount of data that goes through the cable per second is called the **bandwidth**.

The CompTIA Network+ exam is only interested in your knowledge of Cat 3, Cat 5, Cat 5e, Cat 6, Cat 6a, and Cat 7 cables. Further, you'll see the abbreviation for category in all caps, so CAT 5e or CAT 6a. (In the field you'll see category represented in both ways.)

For current networks, developers have implemented *bandwidth-efficient encoding schemes*, which means they can squeeze more bits into the same signal as long as the cable can handle it. Thus, the Cat 5e cable can handle a throughput of up to 1000 Mbps, even though it's rated to handle a frequency of only up to 100 MHz.

Because most networks can run at speeds of up to 1000 MHz, most new cabling installations use Category 6 (Cat 6) cabling, although a large number of installations use Cat 6a or Cat 7 to future-proof the network.

Try This!

Shopping Spree!

Just how common has Cat 6a or Cat 7 become in your neighborhood? Take a run down to your local hardware store or office supply store and shop for UTP cabling. Do they carry Cat 6a? Cat 7? What's the difference in price? If it's not much more expensive to go with the better cable, the expected shift in networking standards has occurred and you might want to upgrade your network.

Make sure you can look at twisted pair and know its Cat rating. There are two places to look. First, twisted-pair is typically sold in boxed reels, and the manufacturer will clearly mark the Cat level on the box (Figure 2.19). Second, look on the cable itself. The category level of a piece of cable is usually printed on the cable (Figure 2.20).

• Figure 2.19 Cat level marked on box of twisted-pair cabling

• Figure 2.20 Cat level on twisted-pair cabling

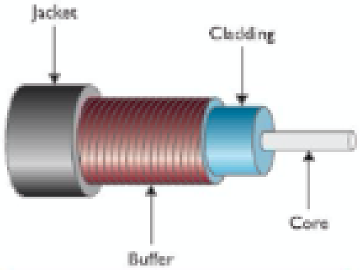
The old landline telephones plugged in with a **registered jack (RJ)** connector. Telephones used **RJ-11** connectors, designed to support up to two pairs of UTP wires. Current wired networks use the four-pair **8 position 8 contact (8P8C)** connectors that most techs (erroneously) refer to as **RJ-45** connectors (Figure 2.21). (A true *RJ45S* connector has slightly different keying and won't plug into a standard network port. They look very similar to the 8P8C connectors, though, so that is the name that stuck.)

• Figure 2.21 RJ-11 (left) and 8P8C/"RJ-45" (right) connectors

CompTIA follows the common usage for networking cable connectors. You will *not* see 8P8C on the exam; you will *only* see RJ-45.

Fiber-Optic Cabling and Connectors

Fiber-optic cable transmits light rather than electricity, making it attractive for both high-EMI areas and long-distance transmissions. Whereas a single copper cable cannot carry data more than a few hundred meters at best, a single piece of fiber-optic cabling will operate, depending on the implementation, for distances of up to tens of kilometers. A fiber-optic cable has four components: the glass fiber itself (the **core**); the **cladding**, which is the part that makes the light reflect down the fiber; **buffer** material to give strength; and the **insulating jacket** (Figure 2.22).



• Figure 2.22 Cross section of fiber-optic cabling

You might see the term *fiber cables* on the CompTIA Network+ exam to describe the two varieties of fiber-optic cables discussed in this section. Just as copper cables don't have copper connectors, fiber cables don't have *fiber connectors*, but that's the term used in the CompTIA Network+ Spare Parts list. I'll discuss cables and connector types shortly.

Fiber-optic cabling is manufactured with many different diameters of core and cladding. Cable manufacturers use a two-number designator to define fiber-optic cables according to their core and cladding measurements. The most common fiber-optic cable size is 62.5/125 µm. Almost all network technologies that use fiber-optic cable require pairs of fibers. One fiber is

For those of you unfamiliar with it, the odd little u-shaped symbol describing fiber cable size (µ) stands for *micro*, or 1/1,000,000.

Table 2.4	Some IEEE 802 Subcommittees
IEEE 802.1	Higher Layer LAN Protocols (with many subcommittees, like 802.1X for port-based network access control)
IEEE 802.3	Ethernet (with a ton of subcommittees, such as 802.3ae for 10-Gigabit Ethernet)
IEEE 802.11	Wireless LAN (WLAN); specifications, such as Wi-Fi, and many subcommittees
IEEE 802.15	Wireless Personal Area Network (WPAN)
IEEE 802.18	Radio Regulatory Technical Advisory Group
IEEE 802.19	Wireless Coexistence Working Group
IEEE 802.20	Mobile Broadband Wireless Access (MBWA); (in hibernation)
IEEE 802.21	Media Independent Handover Services
IEEE 802.22	Wireless Regional Area Networks