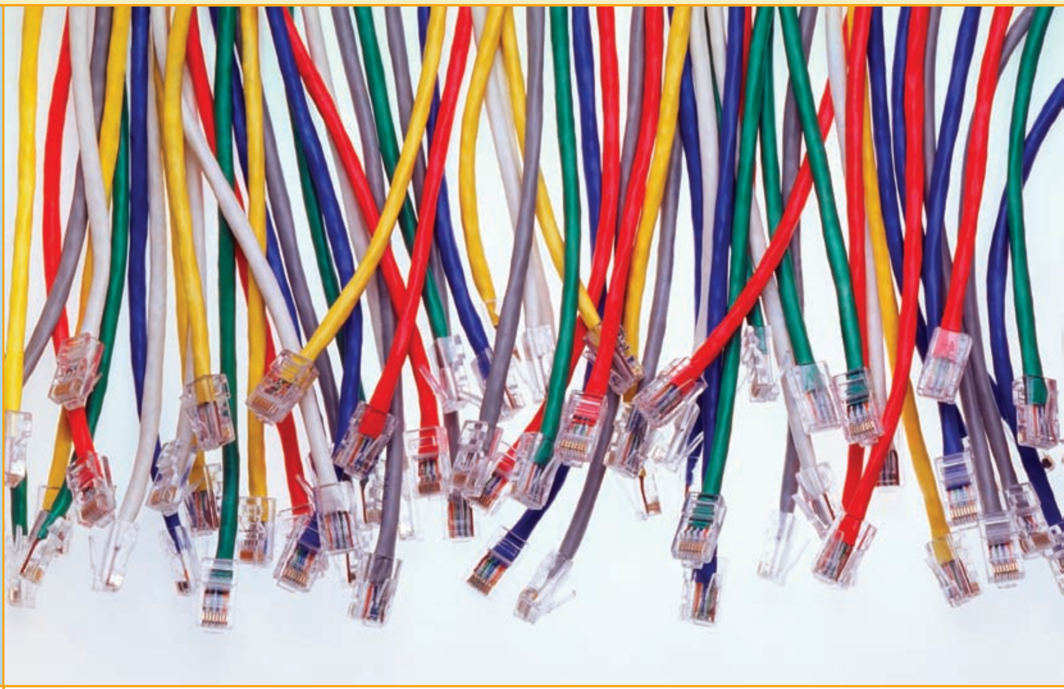
chapter 3 Cabling and Topology

"It's from someone who says she's a fan of my work on low-dimensional topology. And she's a fan of my . . . hair."

—CHARLIE EPPES, *NUMB3RS*



In this chapter, you will learn how to

- **Explain the different types of network topologies**
- **Describe the different types of network cabling**
- **Describe the IEEE networking standards**

Every network must provide some method to get data from one system to another. In most cases, this method consists of some type of cabling (usually copper or fiber-optic) running between systems, although many networks skip wires and use wireless methods to move data. Stringing those cables brings up a number of critical issues you need to understand to work on a network. How do all these cables connect the computers together? Does every computer on the network run a cable to a central point? Does a single cable snake through the ceiling, with all the computers on the network connected to it? These questions need answering! Furthermore, we need some standards so that manufacturers can make networking equipment that works well together. While we're talking about standards, what about the cabling itself? What type of cable? What quality of copper? How thick should it be? Who defines the standards for cables so that they all work in the network?

This chapter answers these questions in three parts. First, you will learn about **network topology**—the way that cables and other pieces of hardware connect to one another. Second, you will tour the most common standardized cable types used in networking. Third, you will discover the IEEE committees that create network technology standards.

Test Specific

Topology

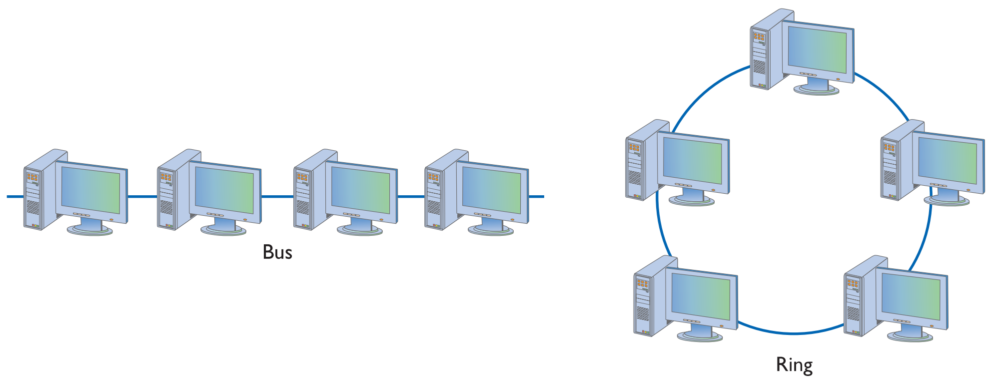
Computer networks employ many different *topologies*, or ways of connecting computers together. This section looks at both the historical topologies—bus, ring, and star—and the modern topologies—hybrid, mesh, point-to-multipoint, and point-to-point.

Bus and Ring

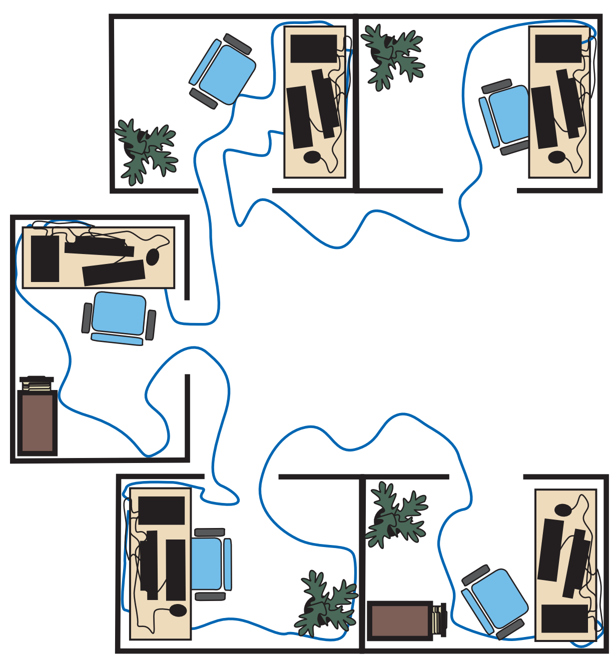
The first generation of wired networks used one of two topologies, both shown in Figure 3.1. A **bus topology** uses a single bus cable that connects all of the computers in line. A **ring topology** connects all computers on the network with a central ring of cable.

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 3.2 shows a bus topology network that illustrates how the cable might appear in the real world.

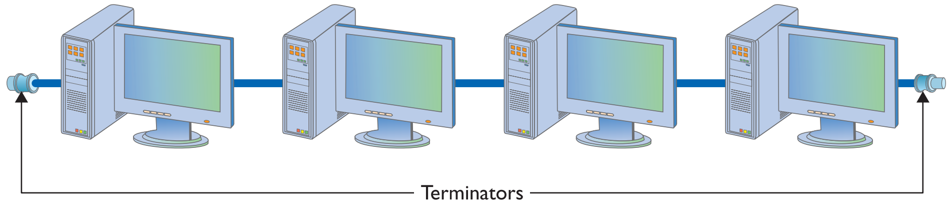
Data flows differently between bus and ring networks, creating different problems and solutions. In bus topology networks, data from each computer simply goes out on the whole bus. A network using a bus topology needs termination at each end of the cable to prevent a signal sent from one computer from reflecting at the ends of the cable, creating unnecessary traffic (Figure 3.3). In a ring topology network, in contrast, data traffic moves in a circle from one computer to



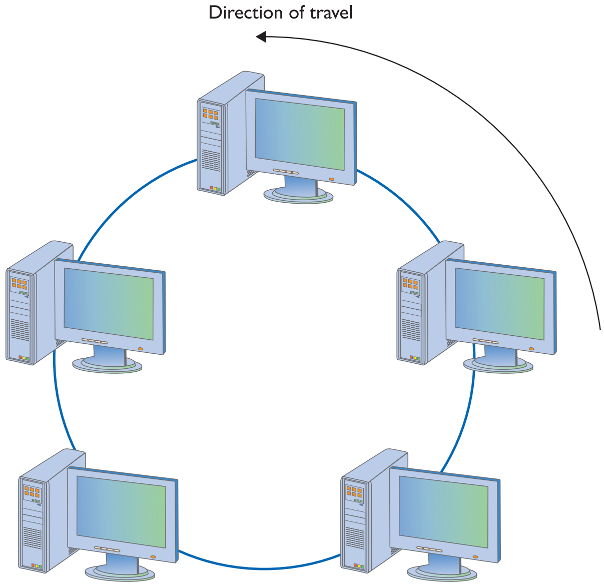
• Figure 3.1 Bus and ring topologies



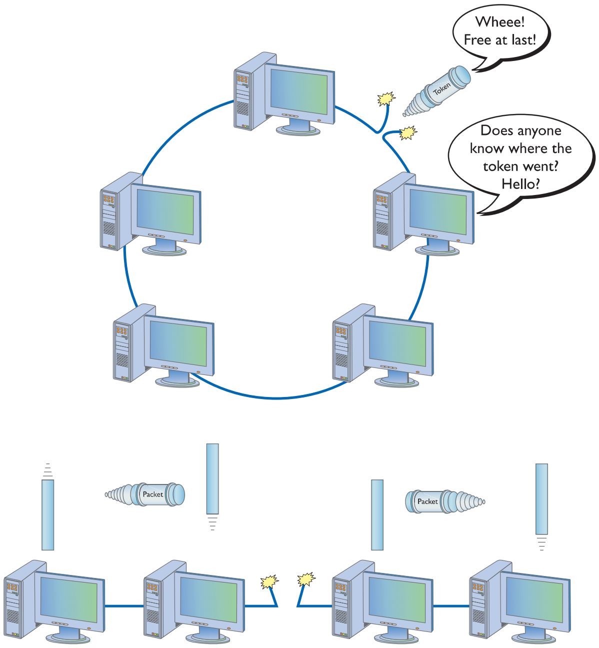
• Figure 3.2 Real-world bus topology



• Figure 3.3 Terminated bus topology



• Figure 3.4 Ring topology moving in a certain direction



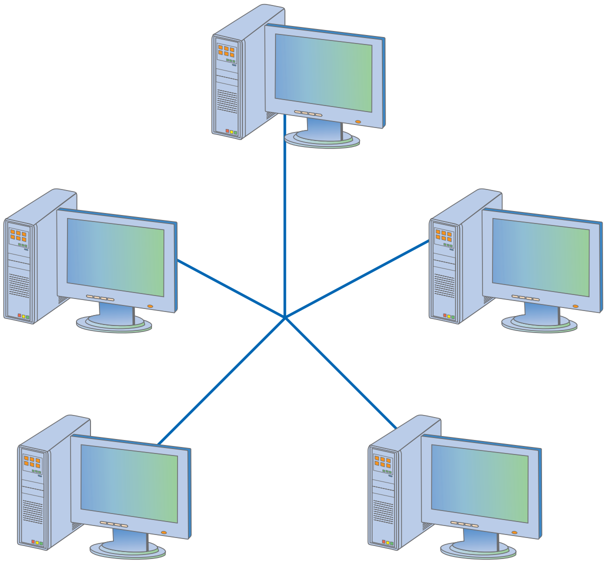
• Figure 3.5 Nobody is talking!

the next in the same direction (Figure 3.4). With no end of the cable, ring networks require 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. The broken ends on a bus topology aren't terminated, causing reflection between computers still connected. A break in a ring topology network simply breaks the circuit and stops the data flow (Figure 3.5).

Star

The **star topology** uses a central connection for all the computers on the network (Figure 3.6). Star topology had a huge benefit over ring and bus by offering **fault tolerance**—if one of the cables broke, all of the other computers could still communicate. Bus and ring were popular and inexpensive to implement, so the old-style star topology wasn't very successful. Network hardware designers couldn't easily redesign their existing networks to use star topology.



• Figure 3.6 Star topology

Hybrids

Even though network designers couldn't use a star topology, the benefits of star were overwhelming, motivating smart people to come up with a way to use star without a major redesign—and the way they did so was ingenious. The ring topology networks struck first by taking the entire ring and shrinking it into a small box, as shown in Figure 3.7.

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 3.8).

Physically, they looked like a star, but if you looked at it 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**).

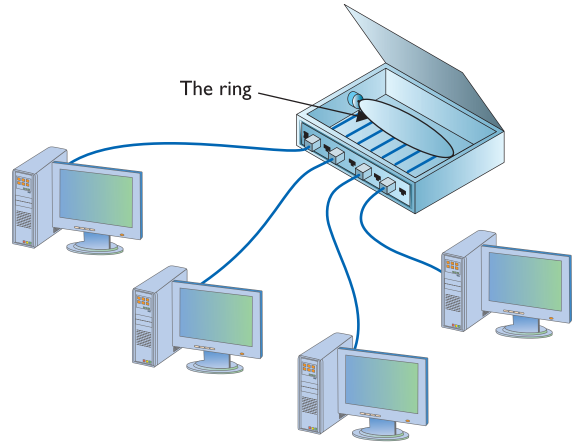


Figure 3.7 Shrinking the ring

Signaling topology is often known as logical topology.

We call any form of networking technology that combines a physical topology with a signaling topology a **hybrid topology**. Hybrid topologies have come and gone since the earliest days of networking. Only two hybrid topologies, **star-ring** and **star-bus**, ever saw any amount of popularity. Eventually star-ring lost market and star-bus reigns as the undisputed king of topologies.

Mesh and Point-to-Multipoint

Topologies aren't just for wired networks. Wireless networks also need a topology to get data from one machine to another, but using radio waves instead of cables makes for somewhat different topologies. Almost all wireless networks use one of two different topologies: mesh topology or point-to-multipoint topology (Figure 3.9).

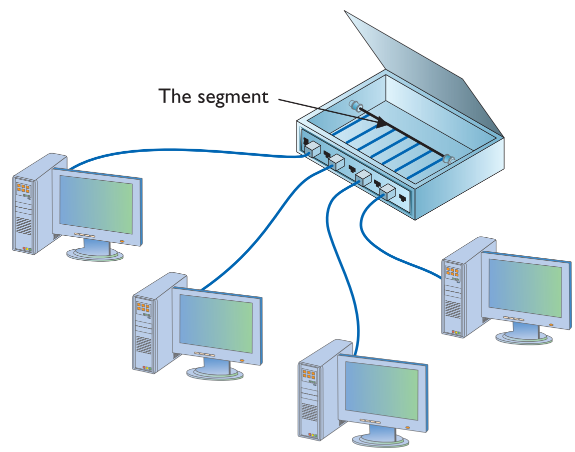


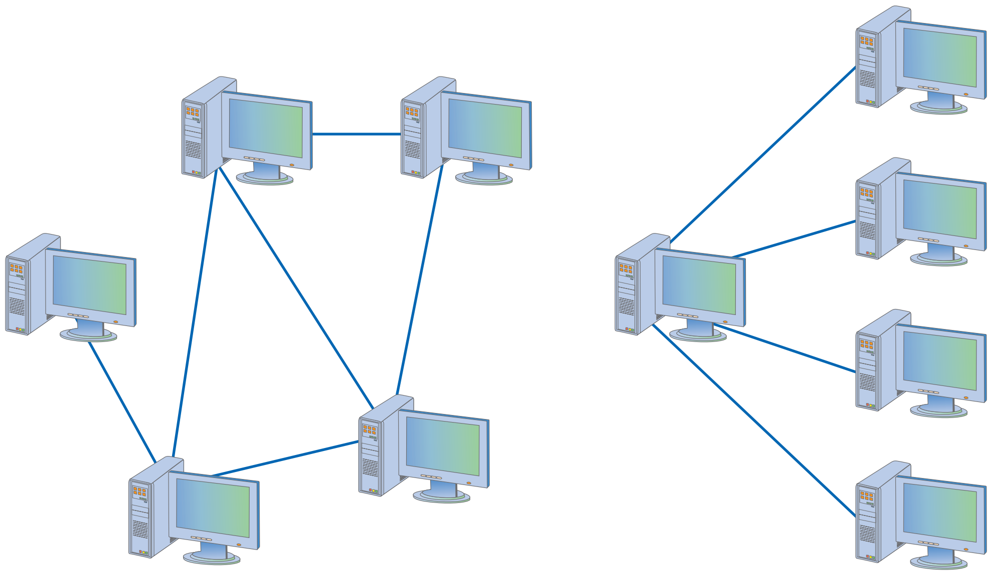
Figure 3.8 Shrinking the segment

Mesh

In a **mesh topology** network, 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.

There are two types of meshed topologies: partially meshed and fully meshed (Figure 3.10). 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.

If you're looking at Figure 3.10 and thinking that a mesh topology looks amazingly resilient and robust, it is—at least on paper. Because every computer connects to every other computer on the fully meshed network, even if half the PCs crash, the network still functions as well as ever (for the survivors). In a practical sense, however, implementing a fully meshed topology in a wired network would be an expensive mess. For example, even for a tiny fully meshed network with only 10 PCs, you would need *45* separate and distinct pieces of cable to connect every PC to every other PC. What a



• **Figure 3.9** Mesh and point-to-multipoint

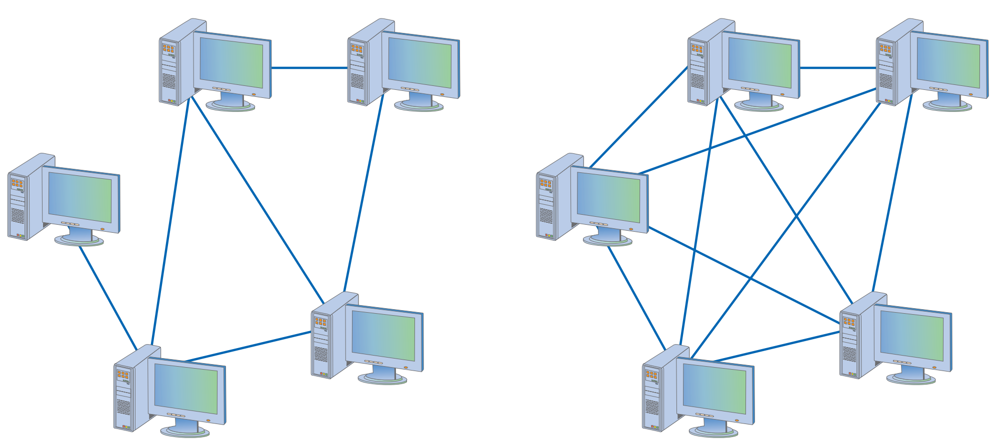
mesh mess! Because of this, mesh topologies have never been practical in a cabled network.

Make sure you know the formula to calculate the number of connections needed to make a fully meshed network, given a certain number of computers. Here's the formula:

y = number of computers

Number of connections = $y(y - 1)/2$

So, if you have six computers, you need 6(6 – 1)/2 = 30/2 = 15 connections to create a fully meshed network.



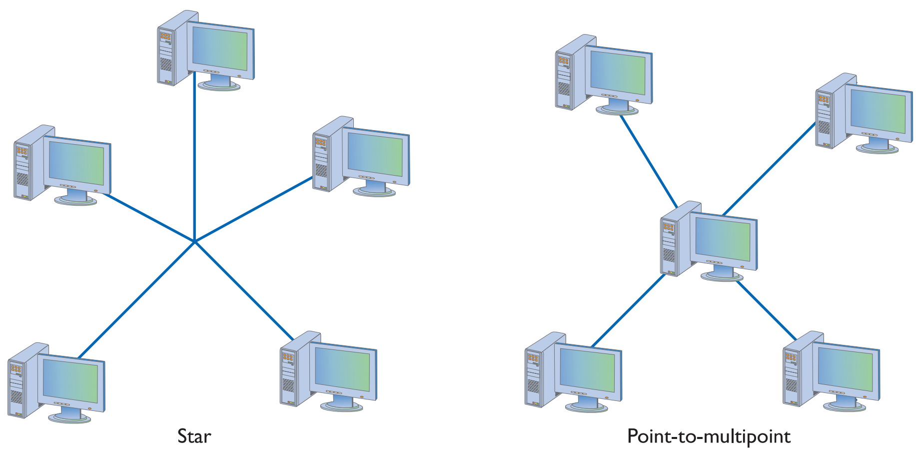
• **Figure 3.10** Partially and fully meshed topologies

Point-to-Multipoint

In a **point-to-multipoint topology**, a single system acts as a common source through which all members of the point-to-multipoint network converse. If you compare a star topology to a slightly rearranged point-to-multipoint topology, you might be tempted to say they're the same thing. Granted, they're similar, but look at Figure 3.11. See what's in the middle? The subtle but important difference is that a point-to-multipoint topology requires an intelligent device in the center, while the device or connection point in the center of a star topology has little more to do than send or provide a path for a signal down all the connections.

You'll sometimes find mesh or point-to-multipoint topology wired networks, but they're rare. The two topologies are far more commonly seen in wireless networks.

Point-to-multipoint topology is sometimes also called star topology, even though technically they differ.



• **Figure 3.11** Comparing star and point-to-multipoint

Point-to-Point

In a **point-to-point topology** network, two computers connect directly together with no need for a central hub or box of any kind. You'll find point-to-point topologies implemented in both wired and wireless networks (Figure 3.12).

• **Figure 3.12** Point-to-point

Parameters of a Topology

While 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 some number 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 a number of different 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, particular manufacturers and standards bodies have created several specific network technologies based on different topologies. A *network technology* is a practical application of a topology and other critical technologies to provide a method to get data from one computer to another on a network. These network technologies have names like 10BaseT, 1000BaseF, and 10GBaseLX. You will learn all about these in the next two chapters.

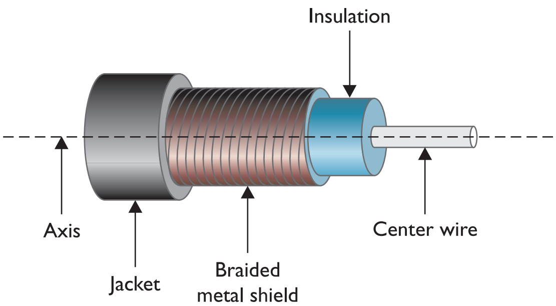
Make sure you know all your topologies: bus, ring, star, hybrid, mesh, point-to-multipoint, and point-to-point!

Cabling

The majority of networked systems link together using some type of cabling. Different types of networks over the years have used a number of different types of cables—and you need to learn about all these cables to succeed on the CompTIA Network+ exam! This section explores both the cabling types used in older networks and those found in today's networks.

All cables used in the networking industry can be categorized in three distinct groups: coaxial (coax), twisted pair, and fiber-optic. Let's look at all three.

Coaxial Cable



• **Figure 3.13** Cutaway view of coaxial cable

Coaxial cable contains a central conductor wire 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 3.13).

Coaxial cable shields data transmissions from **electromagnetic interference (EMI)**. Many devices in the typical office environment generate magnetic fields, including lights, fans, copy machines, and refrigerators. When a metal wire encounters these magnetic fields, electrical current is generated along the wire. This extra current—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 3.14).

Early bus topology networks used coaxial cable to connect computers together. The most popular back in the day used special bayonet-style connectors called **BNC connectors** (Figure 3.15). 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 across 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 Neil Concelman, after the stick-and-twist style of connecting and the purported inventor of the connector. The jury is still out, though this week I'm leaning toward Neil and his bayonet-style connector.*

• **Figure 3.14** Coaxial cable showing braided metal shielding

• **Figure 3.15** BNC 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). Connecting a computer to the cable modem enables that computer to access the Internet. This is the same type of cable used to connect televisions to cable boxes or to satellite receivers. These cables use an F-type connector that screws on, making for a secure connection (Figure 3.16).

• **Figure 3.16** F-type connector on coaxial cable

Cable modems connect using either RG-6 or, rarely, RG-59. 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 3.17).

All coax cables have an **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 3.18). Both RG-6 and RG-59 cables are rated at 75 Ohms.

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 3.19. It's also easy to connect two coaxial cables together using a barrel connector when you need to add some distance to a connection (Figure 3.20).

> Coaxial cabling is also very popular with satellite, over-the-air antennas and even some home video devices. The book covers cable and other Internet connectivity options in great detail in Chapter 14, "Remote Connectivity."

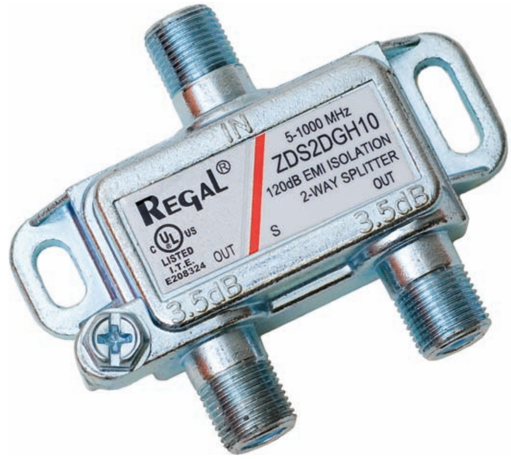
> The Ohm rating of a particular piece of cable describes the characteristic impedance of that cable. *Impedance* describes a set of characteristics that define how much a cable resists the flow of electricity. This isn't simple resistance, though. Impedance also factors in things like how long it takes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

Twisted Pair

The most overwhelmingly common type of cabling used in networks consists of twisted pairs of cables, bundled together into a common jacket. Networks use two types of twisted-pair cabling: shielded twisted pair and

• **Figure 3.17** RG-6 cable

• **Figure 3.18** Ohm rating (on an older, RG-58 cable used for networking)

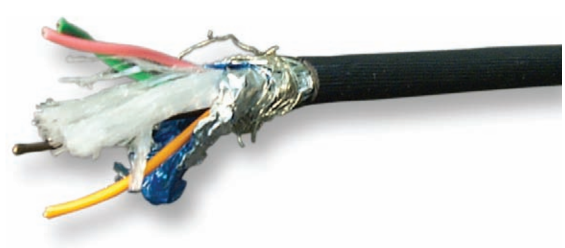


• Figure 3.19 Coaxial splitter

• Figure 3.20 Barrel connector

Have you ever picked up a telephone and heard a distinct crackling noise? That's an example of crosstalk.

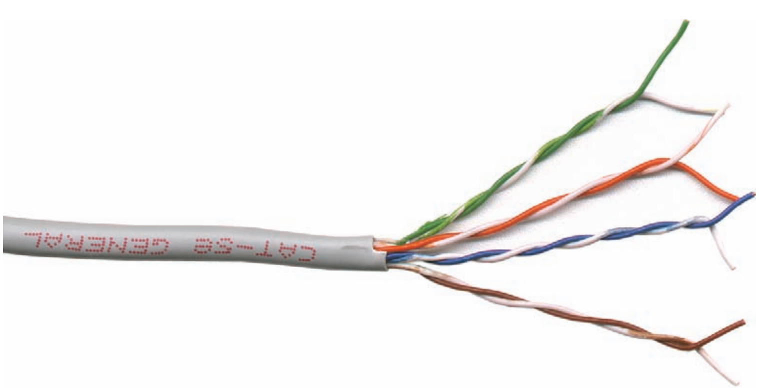
unshielded twisted pair. Twisted-pair cabling for networks is composed of multiple pairs of wires, twisted around each other at specific intervals. The twists serve to reduce interference, called **crosstalk**: the more twists, the less crosstalk.



• Figure 3.21 Shielded twisted pair

Shielded Twisted Pair

Shielded twisted pair (STP), as its name implies, consists of twisted pairs of wires surrounded by shielding to protect them from EMI. STP is pretty rare, primarily because there's so little need for STP's shielding; it only really matters in locations with excessive electronic noise, such as a shop floor with lots of lights, electric motors, or other machinery that could cause problems for other cables. Figure 3.21 shows the most common STP type: the venerable IBM Type 1 cable used in Token Ring network technology.



• Figure 3.22 Unshielded twisted pair

Unshielded Twisted Pair

Unshielded twisted pair (UTP) is by far the most common type of network cabling used today. UTP consists of twisted pairs of wires surrounded by a plastic jacket (see Figure 3.22). This jacket does not provide any protection from EMI, so when installing UTP cabling, you must be careful to avoid interference from light, motors, and so forth. UTP is much cheaper than, and in most cases does just as good a job as, STP.

Although more sensitive to interference than coaxial or STP cable, UTP cabling provides an inexpensive and flexible means to cable networks. UTP cable isn't exclusive to networks; many other technologies (such as

Cross Check

OSI Seven-Layer Model

You've seen UTP cabling before, when Tiffany accessed documents on Janelle's PC at MHTechEd. Refer to Chapter 2, "Building a Network with the OSI Model," and cross-check your memory. At what layer of the OSI seven-layer model would you put UTP cabling? For that matter, at what layer would you put *topology*?

telephone systems) employ the same cabling. This makes working with UTP a bit of a challenge. Imagine going up into a ceiling and seeing two sets of UTP cables: how would you determine which is for the telephones and which is for the network? Not to worry—a number of installation standards and tools exist to help those who work with UTP get the answer to these types of questions.

Not all UTP cables are the same! UTP cabling has a number of variations, such as the number of twists per foot, which determine how quickly data can propagate on the cable. To help network installers get the right cable for the right network technology, the cabling industry has 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 3.1 shows the most common categories.

UTP cables are rated to handle a certain frequency, such as 100 MHz or 1000 MHz, which originally translated as the maximum throughput for a cable. Each cycle, each hertz basically accounts for one bit of data. For example, a 10 million cycle per second (10 MHz) cable could accommodate 10 million bits per second (10 Mbps)—1 bit per cycle. The maximum amount of data that goes through the cable per second is called the **bandwidth**. Through the use of *bandwidth-efficient encoding schemes*, however, manufacturers squeeze more bits into the same signal, as long as the cable can handle it. Thus the CAT 5e cable can handle throughput of up to 1000 Mbps, even though it's rated to handle a bandwidth of only up to 100 MHz.

Because most networks can run at speeds of up to 1000 MHz, most new cabling installations use Category 5e (CAT 5e) cabling, although a large number of installations use CAT 6 to future-proof

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), of whom the American National Standards Institute (ANSI) is both the official U.S. representative and a major international player. ANSI checks the standards and accredits other groups, such as the Telecommunications Industry Association (TIA) and the Electronic Industries Alliance (EIA). The TIA and EIA together set the standards for UTP cabling, among many other things.

Table 3.1 CAT Ratings for UTP

CAT Rating	Max Frequency	Max Bandwidth	Status with TIA/EIA
CAT 1	< 1 MHz	Analog phone lines only	No longer recognized
CAT 2	4 MHz	4 Mbps	No longer recognized
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	1000 Mbps	Recognized
CAT 6	250 MHz	10000 Mbps	Recognized

The CompTIA Network+ exam is only interested in CAT 3, CAT 5, CAT 5e, and CAT 6.

Try This!

Shopping Spree!

Just how common has CAT 6 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 6? CAT 5? CAT 7? What's the difference in price? If it's not much more expensive to go with the better cable, that would indicate that the expected shift in networking standards has occurred and you might want to upgrade your network.

• Figure 3.23 CAT level marked on box of UTP

• Figure 3.24 CAT level on UTP

the network. CAT 5e cabling currently costs much less than CAT 6, although as CAT 6 gains in popularity, it's slowly dropping in price.

Make sure you can look at UTP and know its CAT rating. There are two places to look. First, UTP is typically sold in boxed reels, and the manufacturer will clearly mark the CAT level on the box (Figure 3.23). Second, look on the cable itself. The category level of a piece of cable is usually printed on the cable (Figure 3.24).

Anyone who's plugged in a telephone has probably already dealt with the registered jack (RJ) connectors used with UTP cable. Telephones use **RJ-11** connectors, designed to support up to two pairs of wires. Networks use the four-pair **RJ-45** connectors (Figure 3.25).

Tech Tip

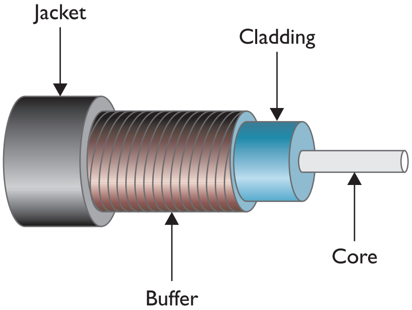
CAT 6a

If you have a need for speed, the latest update to the venerable UTP cable is Category 6a. This update doubles the bandwidth of CAT 6 to 550 MHz to accommodate 10-Gbps speeds up to 100 meters. Take that, fiber! (The 100-meter limitation, by the way, refers to the Ethernet standard, the major implementation of UTP in the networking world. Chapter 4 covers Ethernet in great detail.)

• Figure 3.25 RJ-11 (left) and RJ-45 (right) connectors

Fiber-Optic

Fiber-optic cable transmits light rather than electricity, making it attractive for both high-EMI areas and long-distance transmissions. While 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 3.26).



• Figure 3.26 Cross section of fiber-optic cabling

Fiber-optic cabling is manufactured with many different diameters of core and cladding. In a convenient bit of standardization, 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 used for sending, the other for receiving. In response to the demand for two-pair cabling, manufacturers often connect two fibers together like a lamp cord to create the popular duplex fiber-optic cabling (Figure 3.27).

• **Figure 3.27** Duplex fiber-optic cable

Fiber cables are pretty tiny! 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. Fiber-optic cables that use LEDs are known as **multimode**.

Fiber-optic cables that use lasers are known as **single-mode**. Using laser light and single-mode fiber-optic cables prevents a problem unique to multimode fiber-optics called **modal distortion** and enables a network to achieve phenomenally high transfer rates over incredibly long distances.

Fiber-optics also define the wavelength of light used, measured in nanometers (nm). Almost all multimode cables transmit 850-nm wavelength, while single-mode transmit either 1310 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 three you need to know for the CompTIA Network+ exam are ST, SC, and LC (Figure 3.28). LC is unique because it is a duplex connector, designed to accept two fiber cables.

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

Tech Tip

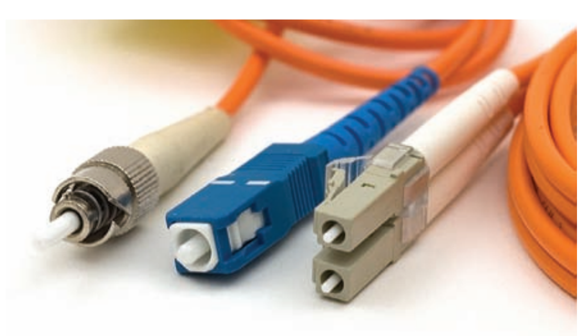
What's in a Name?

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, but SC and LC? How about subscriber connector, standard connector, or Siemon connector for the former; local connector or Lucent connector for the latter?

If you want to remember the connectors for the exam, try these: stick 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.*

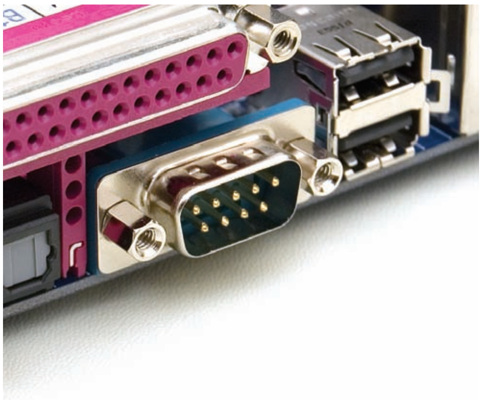
Other Cables

Fiber-optic and UTP make up almost all network cabling, but there are a few other types of cabling that may come up from time to time as alternatives to these two: the ancient serial and parallel cables from the earliest days of PCs and the modern high-speed serial connection, better known as FireWire.



• **Figure 3.28** From left to right: ST, SC, and LC fiber-optic connectors

These cables are only used with quick-and-dirty temporary connections, but they do work, so they bear at least a quick mention.

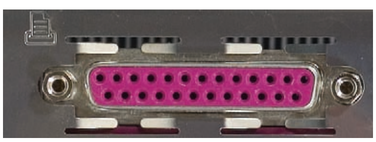


• Figure 3.29 Serial port

Classic Serial

Serial cabling not only predates networking, it also predates the personal computer. **RS-232**, the recommended standard (RS) upon which all serial communication takes places on your PC, dates from 1969 and hasn't substantially changed in around 40 years. When IBM invented the PC way back in 1980, serial connections were just about the only standard input/output technology available, and IBM added two serial ports to every PC. The most common serial port is a 9-pin, male D-subminiature connector, as shown in Figure 3.29.

Serial ports offer at best a poor option for networking, with very slow data rates—only about 56,000 bps—and only point-to-point connections. In all probability it's faster to copy something on a flash drive and just walk over to the other system, but serial networking does work if needed. Serial ports are quickly fading away and you rarely see them on newer PCs.



• Figure 3.30 Parallel connector

Parallel

Parallel connections are almost as old as serial. Parallel can run up to around 2 Mbps, although when used for networking it tends to be much slower. Parallel is also limited to point-to-point topology, but uses a 25-pin female—rather than male—DB type connector (Figure 3.30). The **IEEE 1284** committee sets the standards for parallel communication. (See the section "Networking Industry Standards—IEEE," later in this chapter.)

Microsoft has removed the ability to network with FireWire in Windows Vista.

Concentrate on UTP—that's where the hardest CompTIA Network+ exam questions lie. Don't forget to give coax, STP, and fiber 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 the real networking world.

FireWire

FireWire (based on the **IEEE 1394** standard) is the only viable alternative cabling option to fiber-optic or UTP. FireWire is also restricted to point-to-point connections, but it's very fast (currently the standard is up to 800 Mbps). FireWire has its own unique connector (Figure 3.31).

• Figure 3.31 FireWire connector

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 infamous disaster movies of the 1970s, but 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.

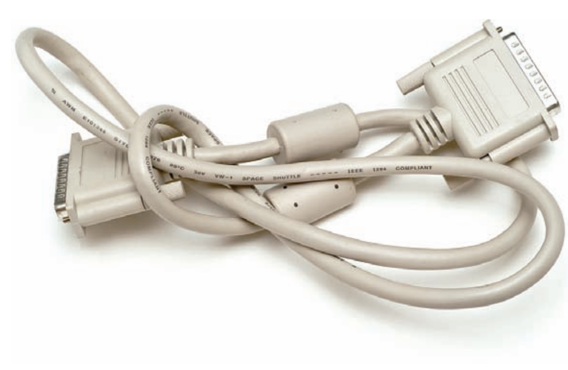
To reduce the risk of your network cables burning and creating noxious fumes and smoke, Underwriters Laboratories and the National Electrical Code (NEC) joined forces to develop cabling *fire ratings*. The two most common fire ratings are PVC and plenum. Cable with a **polyvinyl chloride (PVC)** rating has no significant fire protection. If you burn a PVC cable, it creates lots of smoke and noxious fumes. Burning **plenum**-rated cable creates much less smoke and fumes, but plenum-rated cable—often referred to simply as "plenum"—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 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 of 1980, a new committee called the 802 Working Group took over from the private sector the job of defining network standards. The IEEE 802 committee defines frames, speed, 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 thus provides a variety of cabling standards.

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, sets standards for parallel communication. Have you ever seen a printer cable marked "IEEE 1284–compliant," as in Figure 3.32? This means the manufacturer followed the rules set by the IEEE 1284 committee. Another committee you



• **Figure 3.32** Parallel cable marked IEEE 1284–compliant may have heard of is the IEEE 1394 committee, which controls the FireWire standard.

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 802.5. Table 3.2 shows the currently recognized IEEE 802 subcommittees and their areas of jurisdiction. I've included the inactive subcommittees for reference. The missing numbers, such as 802.4 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.

Memorize the 802.3 and 802.11 standards. Ignore the rest.

Some of these committees deal with technologies that didn't quite make it, and the committees associated with those standards, such as IEEE 802.4, Token Bus, have become dormant. When preparing for the CompTIA Network+ exam, concentrate on the IEEE 802.3 and 802.11 standards. You will see these again in later chapters.

Table 3.2	IEEE 802 Subcommittees
IEEE 802	LAN/MAN Overview & Architecture
IEEE 802.1	Higher Layer LAN Protocols
802.1s	Multiple Spanning Trees
802.1w	Rapid Reconfiguration of Spanning Tree
802.1x	Port Based Network Access Control
IEEE 802.2	Logical Link Control (LLC); now inactive
IEEE 802.3	Ethernet
802.3ae	10 Gigabit Ethernet
IEEE 802.5	Token Ring; now inactive
IEEE 802.11	Wireless LAN (WLAN); specifications, such as Wi-Fi
IEEE 802.15	Wireless Personal Area Network (WPAN)
IEEE 802.16	Broadband Wireless Access (BWA); specifications for implementing Wireless Metropolitan Area Network (Wireless MAN); referred to also as WiMax
IEEE 802.17	Resilient Packet Ring (RPR)
IEEE 802.18	Radio Regulatory Technical Advisory Group
IEEE 802.19	Coexistence Technical Advisory Group
IEEE 802.20	Mobile Broadband Wireless Access (MBWA)
IEEE 802.21	Media Independent Handover
IEEE 802.22	Wireless Regional Area Networks

Chapter 3 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 most common network topologies are called *bus*, *ring*, *star*, and *mesh*.
- In a bus topology, all computers connect to the network via a main line. The cable must be terminated at both ends to prevent signal reflections.
- In a ring topology, all computers on the network attach to a central ring of cable. A single break in the cable stops the flow of data through the entire network.
- In a star topology, the computers on the network connect to a central wiring point, which provides fault tolerance.
- Modern networks use one of two hybrid topologies: *star bus* or *star ring*. Star bus is overwhelmingly the most common topology used today.
- In a mesh topology, each computer has a dedicated line to every other computer. Mesh networks can be further categorized as partially meshed or fully meshed, both of which require a significant amount of physical cable. Networks techs are able to determine the amount of cable segments needed with a mathematical formula.
- In a point-to-multipoint topology, a single system acts as a common source through which all members of the network converse.
- Mesh and point-to-multipoint topologies are common among wireless networks.
- In a point-to-point topology, two computers connect directly together.

Describe the different types of network cabling

- Coaxial cable, or coax, shields data transmissions from EMI. Coax 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, and CAT 6 being the most commonly used today.
- Telephones use RJ-11 connectors, while UTP uses RJ-45 connectors.
- Fiber-optic cabling transmits light instead of the electricity used in CAT cable or coax. 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, while lasers generally require single-mode cable.
- All fiber-optic cable has three parts: the fiber itself; the cladding, which covers the fiber and helps it reflect down the fiber; and the outer insulating jacket. Additionally, there are over one hundred types of connectors for fiber-optic cable, but ST, SC, and LC are the most common for computer networking.
- Plenum-rated UTP is required by most cities for network installations.
- Serial cables adhering to the RS-232 standard and parallel cables adhering to the IEEE-1284 standard may be used to network two computers directly together. You can also use IEEE 1394 (FireWire) connections for direct connection, although not with Windows Vista.

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.
- The IEEE 1284 committee defines the standards for parallel communications, while the IEEE 1394 committee defines the standards for FireWire High-Performance Serial Bus.

Key Terms

bandwidth *(47)*
bus topology *(39)*
BNC connectors *(44)*
category (CAT) rating *(47)*
cladding *(48)*
coaxial cable *(44)*
core *(48)*
crosstalk *(46)*
electro-magnetic interference (EMI) *(44)*
fault tolerance *(40)*
fiber-optic cable *(48)*
fully meshed topology *(41)*
hybrid topology *(41)*
Institute of Electrical and Electronics Engineers (IEEE) *(51)*
IEEE 1284 *(50)*
IEEE 1394 *(50)*
insulating jacket *(48)*
mesh topology *(41)*
modal distortion *(49)*
multimode *(49)*
network topology *(38)*
Ohm rating *(45)*
partially meshed topology *(41)*
physical topology *(41)*
plenum *(51)*
point-to-multipoint topology *(43)*
point-to-point topology *(43)*
polyvinyl chloride (PVC) *(51)*
RG rating *(45)*
ring topology *(39)*
riser *(51)*
RJ-11 *(48)*
RJ-45 *(48)*
RS-232 *(50)*
segment *(41)*
shielded twisted pair (STP) *(46)*
signaling topology *(41)*
single-mode *(49)*
star topology *(40)*
star-bus topology *(41)*
star-ring topology *(41)*
unshielded twisted pair (UTP) *(46)*

Key Term Quiz

Use the Key Terms list to complete the sentences that follow. Not all terms will be used.

1. The _______________ is a network topology that relies on a main line of network cabling, normally coaxial cable.
2. The _______________ of a cable will determine its speed.
3. A(n) _______________ provides more fault tolerance than any other basic network topology.
4. When your network has all computers connected to a centrally located wiring closet, you have a physical _______________ network.
5. _______________ networks use more than one type of basic network topology.
6. CAT 5e cable is a type of _______________ wiring.
7. Coaxial cable uses a braided metal shield to protect data from _______________.
8. Network cabling can use either light or electricity to transmit data. The faster of these types uses light along _______________.
9. _______________-grade UTP must be installed in ceilings, while _______________-grade UTP is often used to connect one floor to another vertically in a building.
10. The twisting of the cables in UTP and STP reduces _______________.

Multiple-Choice Quiz

1. Which of the following are standard network topologies? (Select three.)
   - **A.** Bus
   - **B.** Star
   - **C.** Ring
   - **D.** Dual-ring

2. John was carrying on at the water cooler the other day, trying to show off his knowledge of networking. He claimed that the company had installed special cabling to handle the problems of crosstalk on the network. What kind of cabling did the company install?
   - **A.** Coaxial
   - **B.** Shielded coaxial
   - **C.** Unshielded twisted pair
   - **D.** Fiber-optic

3. Jill needs to run some UTP cable from one office to another. She found a box of cable in the closet and wants to make sure it's CAT 5 or better. How can she tell the CAT level of the cable? (Select two.)
   - **A.** Check the box.
   - **B.** Scan for markings on the cable.
   - **C.** Check the color of the cable—gray means CAT 5, yellow means CAT 6e, and so on.
   - **D.** Check the ends of the cable.

4. What topology provides the most fault tolerance?
   - **A.** Bus
   - **B.** Ring
   - **C.** Star-bus
   - **D.** Mesh

5. What organization is responsible for establishing and promoting networking standards?
   - **A.** Institute of Electrical and Electronics Engineers (IEEE)
   - **B.** International Standards Organization (ISO)
   - **C.** Federal Communications Commission (FCC)
   - **D.** International Telecommunications Association (ITA)

6. What aspects of network cabling do the IEEE committees establish? (Select three.)
   - **A.** Frame size
   - **B.** Speed
   - **C.** Color of sheathing
   - **D.** Cable types

7. What are types of coax cabling that have been used in computer networking? (Select three.)
   - **A.** RG-8
   - **B.** RG-45
   - **C.** RG-58
   - **D.** RG-62

8. What applications are best suited for fiber-optic cabling? (Select two.)
   - **A.** Short distances
   - **B.** Wireless networks
   - **C.** High-EMI areas
   - **D.** Long distances

9. What are the main components of fiber-optic cabling? (Select three.)
   - **A.** Cladding
   - **B.** Insulating jacket
   - **C.** Copper core
   - **D.** Fiber

10. What is the most popular size fiber-optic cabling?
    - **A.** 62.5/125 µm
    - **B.** 125/62.5 µm
    - **C.** 50/125 µm
    - **D.** 125/50 µm

11. Most fiber-optic installations use LEDs to send light signals and are known as what?
    - **A.** Single-mode
    - **B.** Multimode
    - **C.** Complex mode
    - **D.** Duplex mode

12. Why must the main cable in a bus topology be terminated at both ends?
    - **A.** To allow the signal to be amplified so it can reach both ends of the network
    - **B.** To prevent the signal from dropping off the network before reaching all computers
    - **C.** To prevent the signal from bouncing back and forth
    - **D.** To convert the signal to the proper format for a bus network
13. Where are you most likely to encounter a mesh network?
    - **A.** On any network using fiber-optic cable
    - **B.** On any network using plenum cable
    - **C.** On wireless networks
    - **D.** On wired networks
14. You are asked by your boss to research upgrading all the network cable in your office building. The building manager requires the safest possible cabling type in case of fire, and your boss wants to future-proof the network so cabling doesn't need to be replaced when network technologies faster than 1 Gbps are available. You decide to use CAT 5e plenum cabling throughout the building. Which objective have you satisfied?
    - **A.** Neither the building manager's nor your boss's requirements have been met.
    - **B.** Only the building manager's requirement has been met.
    - **C.** Only your boss's requirement has been met.
    - **D.** Both the building manager's and your boss's requirements have been met.
15. Which committee is responsible for wireless networking standards?
    - **A.** IEEE 802.2
    - **B.** IEEE 802.3
    - **C.** IEEE 802.5
    - **D.** IEEE 802.11

Essay Quiz

1. You work in the computer training department at your company. A newly developed mobile training program is being planned. The plan requires setting up five training computers in a particular department you use to train on weekly. Write a short essay that describes which network topology would be quickest to set up and tear down for this type of onsite training.
2. Your boss has decided to have cable run to every computer in the office, but doesn't know which type to use. In an effort to help bring the company into the 21st century, write a short essay comparing the merits of UTP and fiber-optic cabling.
3. The NICs on your company's computers all have dual 10-Mbps and 100-Mbps capability, yet users complain that the network is slow. Write a brief essay that explains what could be the cause of the problem.
4. Write a short essay describing how you would acquire 1500 feet of RG-58 coaxial cabling for use in your nonprofit organization's office space.
5. Your company has hired a group of new network techs and you've been tasked to do their training session on networking standards organizations. Write a brief essay detailing the IEEE and its various committees.

Lab Projects

• Lab Project 3.1

This lab project requires you to demonstrate knowledge of the four basic network topologies. Obtain four blank pieces of paper. Proceed to draw six boxes on each page to represent six computers—neatness counts! At the top of each sheet, write one of the following: bus topology, mesh topology, ring topology, or star topology. Then draw lines to represent the physical network cabling required by each network topology.

• Lab Project 3.2

In your studies of network cabling for the CompTIA Network+ certification exam, you realize you could use a simplified chart to study from and memorize. Build a reference study chart that describes the features of network cabling. Create your completed chart using a spreadsheet program, or simply a sheet of paper, with the column headings and names shown below. If you wish, you can start by writing your notes here.

Cable Type	Description	Benefits	Drawbacks
CAT 5			
CAT 5e			
CAT 6			
Thinnet			
Thicknet			
Fiber-optic			

• Lab Project 3.3

In this lab project, you will demonstrate knowledge of the different IEEE committees that are most prevalent today. Use the Internet to research each of these subcommittees: IEEE 802.3, IEEE 802.5, and IEEE 802.11. Give an example of where each type of technology might best be used.