

# A+ Guide to Managing & Maintaining Your PC

*Networking Types, Devices, and  
Cabling*

# Objectives

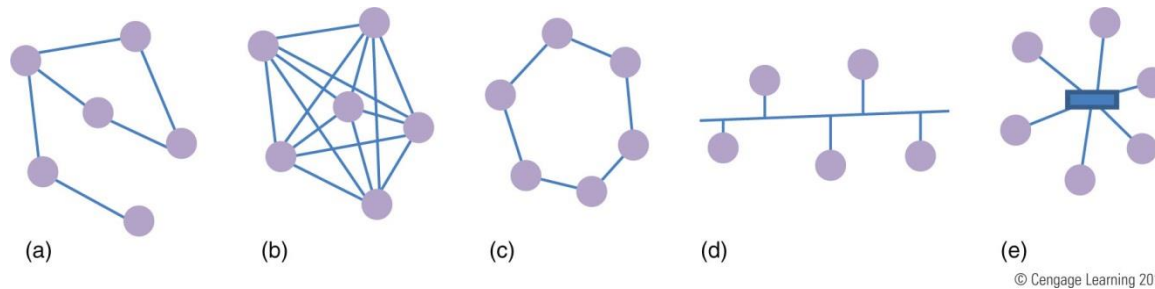
- Learn about network types and topologies
- Learn about the hardware used to build local networks
- Learn how to set up and troubleshoot the wiring in a small network

# Network Types and Topologies

- Networks can be categorized by technology used and size of the network
  - Personal Area Network (PAN): consists of personal devices such as a cell phone and notebook
  - Local Area Network (LAN): covers a small local area such as a home, office, or other building
  - Wireless LAN: covers a limited geographic area and is popular in places where cables are difficult to install
  - Metropolitan Area Network (MAN): covers a large campus or city
  - Wide Area Network (WAN): covers a large geographic area and is made up of small networks

# Network Types and Topologies

- Network topology: arrangement of connections between computers (also called physical topology)
  - Mesh network: each node on the network is responsible for sending and receiving transmissions to any other node without a central point of communication
  - Ring network: nodes form a ring (seldom used today)
  - Bus network: all nodes are connected in a sequential line (an older topology)
  - Star network: uses a centralized device to manage traffic on the network



**Figure 16-1** Network topologies: (a) mesh, (b) fully connected mesh, (c) ring, (d) bus, and (e) star

# Network Technologies Used for Internet Connections

- Internet Service Provider (ISP): used to connect to the Internet
  - Most common type of connections are DSL and cable Internet (cable modem)
- Bandwidth: measure of the maximum data transmission rate
- Data throughput: actual network transmission speed
- Latency: delays in network transmissions
  - Measured by the round-trip time it takes for a data packet to travel from source to destination and back

# Network Technologies Used for Internet Connections

- Cable Internet (cable modem)
  - Uses existing cable lines
  - Always connected (always up)
  - TV signals and PC data signals share same coax cable
  - Cable modem converts PC's digital signals to analog

# Network Technologies Used for Internet Connections

- DSL (Digital Subscriber Line)
  - Group of broadband technologies
    - Wide range of speeds
  - Uses ordinary copper phone lines and unused voice frequencies
  - Always connected
    - Some DSL services offer connect on demand
  - Can use the same phone line for voice and DSL at the same time

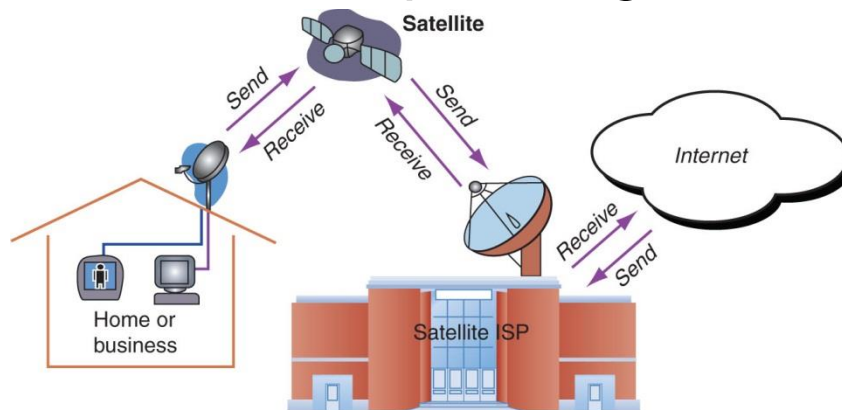


# Network Technologies Used for Internet Connections

- Cable Internet vs. DSL
  - Both can sometimes be purchased on a sliding scale
  - Cable modem shares TV cable infrastructure with neighbors
    - Service may become degraded
  - DSL uses dedicated phone line
    - Must filter phone line static
  - Similar setup for both
  - Installation completed by provider or user
  - Both use PC network port or USB port to connect cable modem or DSL modem

# Network Technologies Used for Internet Connections

- Satellite provides high-speed Internet connections in remote areas
  - Available everywhere (even airplanes)
  - Disadvantages: requires line-of-site connectivity and latency occurs when uploading



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**Figure 16-9** Communication by satellite can include television and Internet access

# Network Technologies Used for Internet Connections

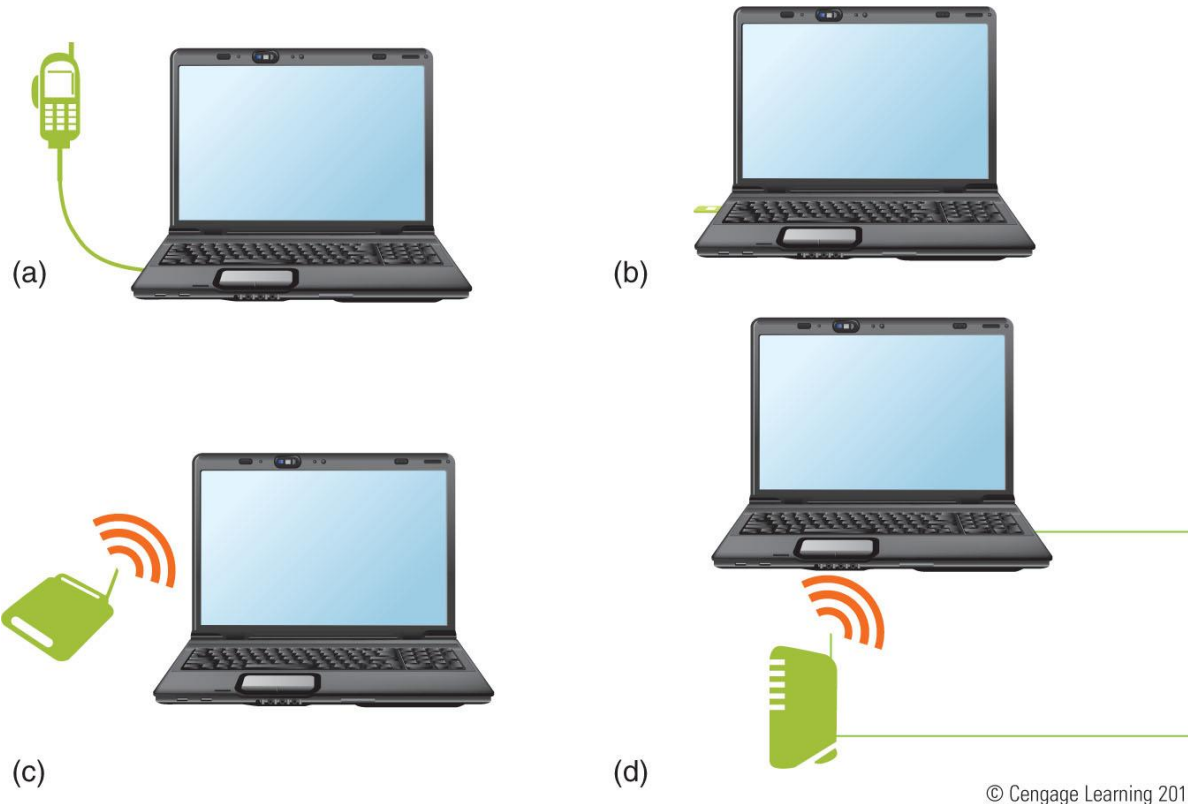
- Fiber optic - dedicated point-to-point (PTP)
  - No line sharing
  - Broadband fiber-optic cable
    - Television, Internet data, voice communication
  - Verizon technology: Fiber Optic Service (FiOS)
  - Upstream and downstream speeds and prices vary

# Network Technologies Used for Internet Connections

- WiMAX or 802.16 wireless
  - Supports up to 75 Mbps with a range of up to several miles
  - WiMAX version 2.0 can support up to 1 Gbps for fixed users and up to 100 Mbps for mobile users
  - WiMAX cellular towers are generally placed 1.5 miles apart
  - Sometimes used as a last-mile solution for DSL and cable Internet technologies
  - Some laptops have a built-in WiMAX modem to connect to 4G networks that use WiMAX

# Network Technologies Used for Internet Connections

- Cellular WAN covers a wide area
  - Made up of cells created by base stations
  - Cell phone network competing technologies
    - GSM (Global System for Mobile Communications)
      - Requires devices have a SIM card that contains a microchip to hold subscription data
    - CDMA (Code Division Multiple Access)
      - Do not require a SIM card in a cellular device
- 4G (Fourth Generation) technology: fastest speed for cellular data
- 2G and 3G technology is still used



**Figure 16-13** Four external devices a computer or network can use to make a cellular Internet connection

# Hardware Used By Local Networks

- In this section you will learn about:
  - Desktop and laptop devices
  - Hubs
  - Switches
  - Bridges
  - Other network devices
  - Cables and connectors these devices use

# Wired and Wireless Network Adapters

- Network adapter: direct connection to a network
  - Might be a network port on motherboard or a network interface card (NIC)
  - Might also be an external device connected via USB port
  - Provides RJ-45 port (looks like a large phone jack)



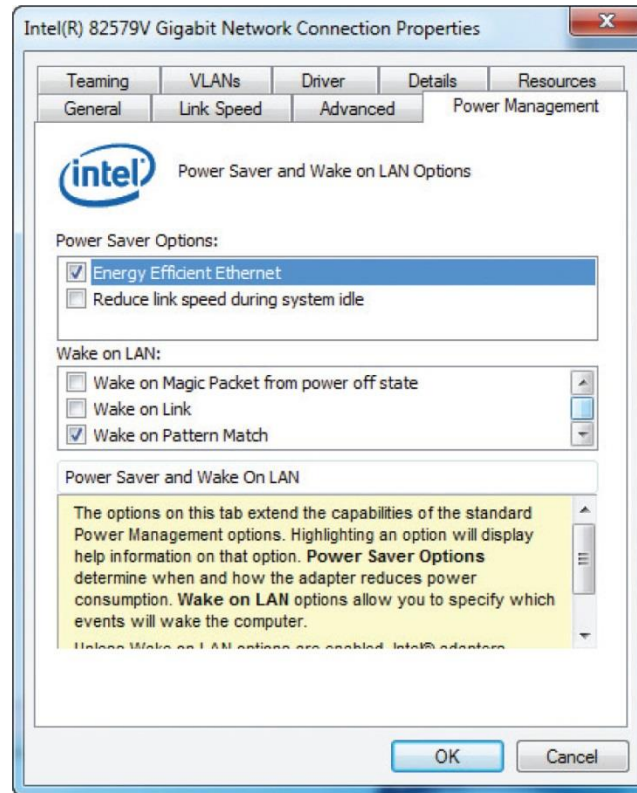
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**Figure 16-15** USB device provides an Ethernet port



# Wired and Wireless Network Adapters

- Features to be aware of when selecting an adapter:
  - The slot a NIC uses
    - May need to uninstall or disable existing network port
  - Ethernet speeds
    - 10 Mbps, 100 Mbps, 1 Gbps, and 10 Gbps
  - MAC address – every network adapter has one
    - 48-bit unique ID number hard-coded by manufacturer
  - Status indicator lights
    - Used to indicate connectivity and activity
  - Wake-on-LAN – wakes up the computer when it receives certain communication on the network

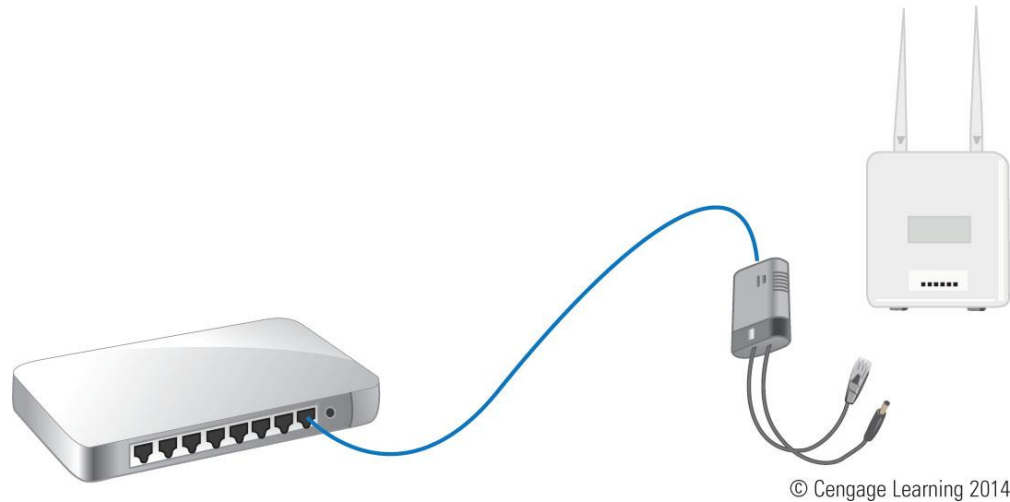


Source: Microsoft Windows 7

**Figure 16-20** Enable variations of Wake on LAN based on what type of software is allowed to wake up the computer

# Wired and Wireless Network Adapters

- Features to be aware of when selecting an adapter (cont'd):
  - Quality of Service (QoS)
    - Ability to control which applications have priority on the network
    - Must be configured on the router and the network adapter of each computer
  - Power over Ethernet (PoE)
    - Allows power to be transmitted over Ethernet cable
    - Might be available on high-end wired adapters
    - Used where electrical outlets may not be available



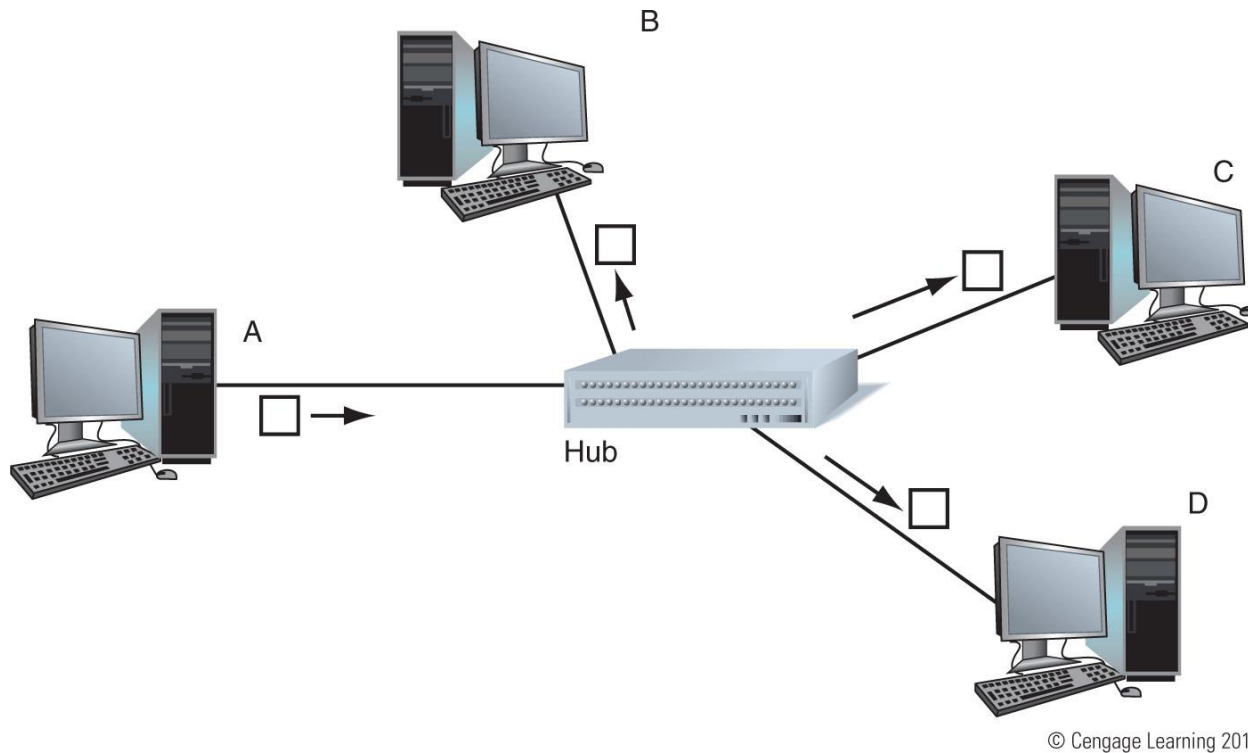
**Figure 16-22** Use a PoE splitter if the receiving device is not PoE compatible

# Dial-Up Modems

- POTS (Plain Old Telephone Service) or Dial-up
  - Least expensive, slowest Internet connection
  - Uses: travel, broadband down, saving money
  - Desktop computers modem cards provide two phone jacks (RJ-11 jacks)
  - Twisted-pair cabling is used
    - Pairs of wires are twisted together to reduce crosstalk
  - Last modem standard: V.92

# Hubs and Switches

- Most wired networks use a star bus topology: nodes connected to a centralized hub or switch
- Hub: pass-through device (outdated technology)
  - No regard for data or frame's destination
- Switch: keeps a table of all devices connected to it
  - When a frame is received, switch searches its MAC address table for the destination MAC address and sends frame only to the device with that address
  - If destination MAC address is not in table, switch sends frame out all ports (except receiving port)

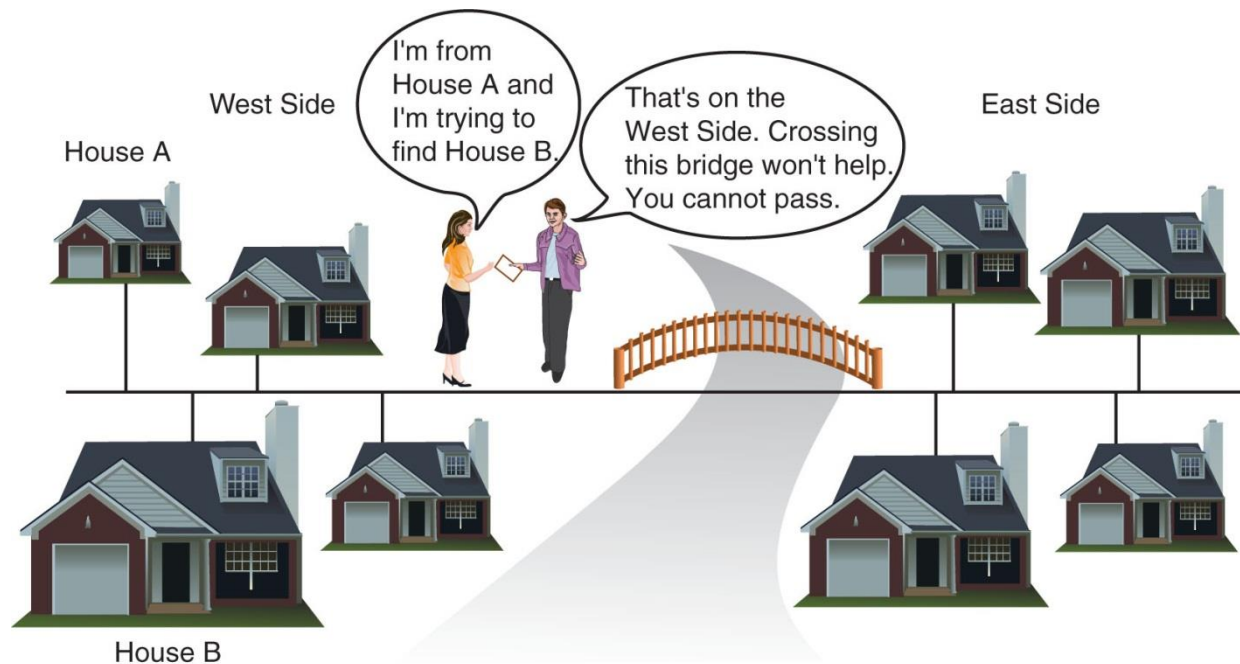


**Figure 16-24** Any data received by a hub is replicated and passed on to all other devices connected to it

# Wireless Access Points and Bridges

- Allows wireless device connection to LAN
  - Devices communicate through access point
  - May double as a router
  - Can also be a bridge
    - A bridge is a device that stands between two segments of a network and manages network traffic between them
    - Keeps a table of MAC addresses just like a switch





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**Figure 16-28** A bridge is an intelligent device making decisions concerning network traffic

# Other Network Devices

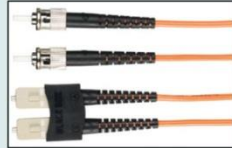
- ***Network Attached Storage (NAS) device***: contains bays for holding hard drives and also includes an Ethernet port to connect to a network
  - Most support RAID
- ***VoIP phone***: Voice over Internet Protocol
  - A TCP/IP protocol that manages voice communication over the Internet
  - VoIP phone connects directly to a network
- ***Internet appliance***: type of thin client designed to make it easy for a user to connect to the Internet
  - Sold years ago but are no longer popular

# Ethernet Cables and Connectors

- Types of Ethernet cabling:
  - Twisted-pair – most popular cabling for local networks
    - Unshielded (UTP) and shielded twisted pair (STP)
    - UTP cable is least expensive and most common
    - Rated by category: CAT3 through CAT6a
    - Consists of four pairs of twisted wires (8 wires total)
  - Coaxial cable: single copper wire with braided shield
    - No longer used for networking
  - Fiber-optic: glass strands inside protective tubing
    - Transmit signals as pulses of light
    - Two types: single-mode and multimode

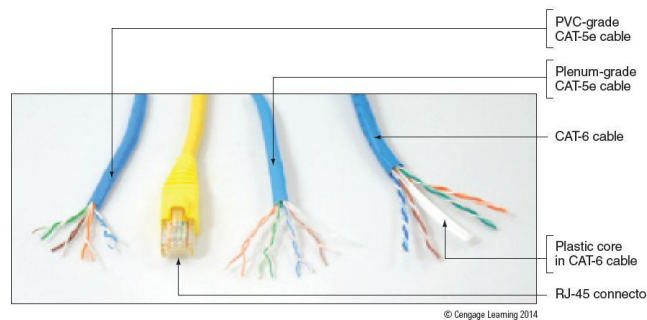
Cable System	Speed	Cables and Connectors	Example of Connectors	Maximum Cable Length
10Base2 (ThinNet)	10 Mbps	Coaxial cable uses a <b>BNC connector</b> .	 © Albert Lozano/Shutterstock.com	185 meters or 607 feet
10Base5 (ThickNet)	10 Mbps	Coaxial uses an AUI 15-pin D-shaped connector.	 Courtesy of Black Box Corporation	500 meters or 1,640 feet
10BaseT, 100BaseT (Fast Ethernet), 1000BaseT (Gigabit Ethernet), and 10GBaseT (10-Gigabit Ethernet)	10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps	Twisted pair (UTP or STP) uses an RJ-45 connector.	 © Olga Lipatova/Shutterstock.com	100 meters or 328 feet

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Cable System	Speed	Cables and Connectors	Example of Connectors	Maximum Cable Length
10BaseF, 10BaseFL, 100BaseFL, 100BaseFX, 1000BaseFX, or 1000BaseX (fiber optic)	10 Mbps, 100 Mbps, 1 Gbps, or 10 Gbps	Fiber-optic cable uses ST or SC connectors (shown to the right) or LC and MT-RJ connectors (not shown).	 Courtesy of Black Box Corporation	Up to 2 kilometers (6,562 feet)

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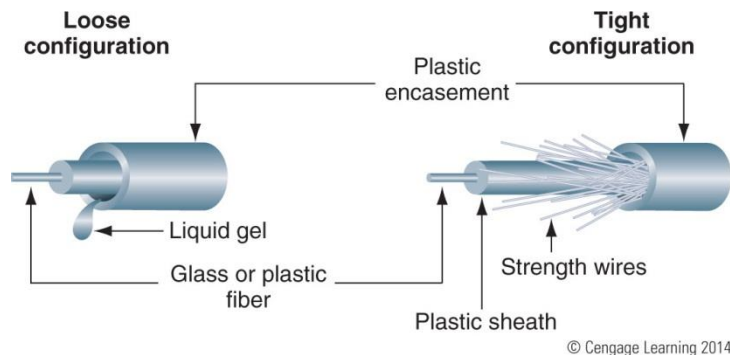
**Table 10-2** Variations of Ethernet and Ethernet cabling



**Figure 16-30** The most common networking cable for a local network is UTP cable using an RJ-45 connector



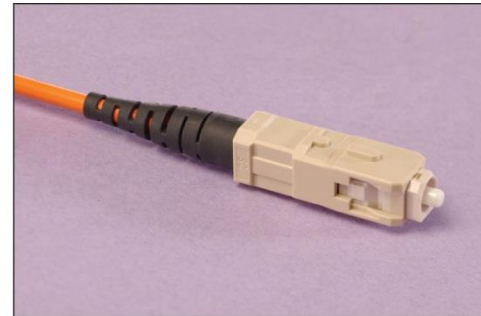
**Figure 16-31** Coaxial cable and a BNC connector are used with ThinNet Ethernet



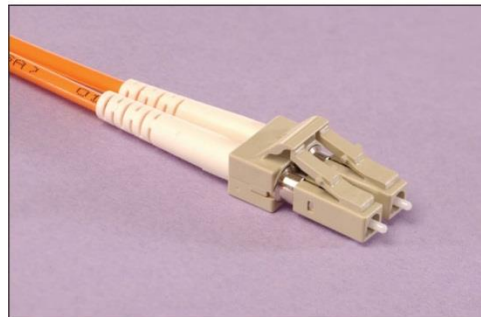
**Figure 16-33** Fiber-optic cables contain a glass core for transmitting light



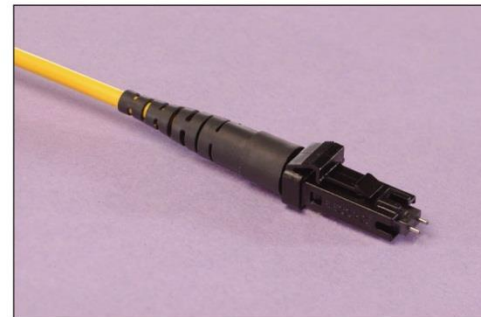
(a) ST (straight tip)



(b) SC (standard connector)



(c) LC (local connector)



(d) MT-RJ (mechanical transfer RJ)

Courtesy Fiber Communications, Inc.

**Figure 16-34** Four types of fiber-optic connectors: (a) ST, (b) SC, (c) LC, and (d) MT-RJ

# Ethernet Cables and Connectors

- Ethernet types (categorized by speed):
  - 10-Mbps Ethernet – invented by Xerox in 1970s
  - 100-Mbps Ethernet (also known as Fast Ethernet or 100BaseT)
    - Uses STP or UTP cabling rated CAT-5 or higher
    - 100BaseFX uses fiber-optic cable
  - 1000-Mbps Ethernet (also known as Gigabit Ethernet)
    - Becoming most popular choice for LAN technology
    - Uses same cabling and connectors as Fast Ethernet
  - 10-Gigabit Ethernet
    - Uses fiber-optic cable

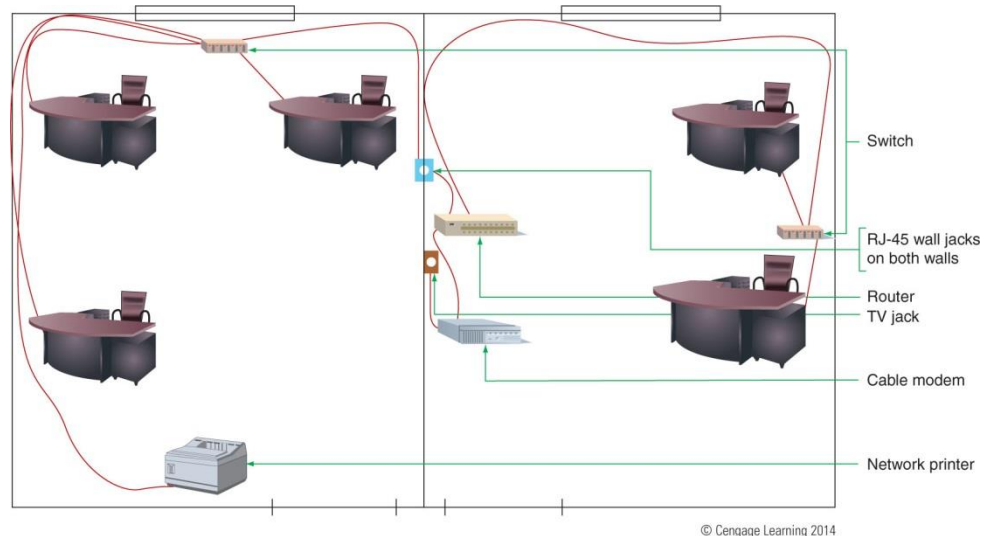
# Setting Up and Troubleshooting Network Wiring

- To set up a small network, you will need:
  - Computers, switches, network cables, a router, and a device that provides Internet access (cable modem)
- Regarding cabling, be sure:
  - Cables are out of the way and not a trip hazard
  - Cables don't exceed the recommended length (100 meters for twisted pair)
  - Use cables rated at CAT-5e or higher
- Uses switches rated at the same speed as your router and network adapters



# Setting Up and Troubleshooting Network Wiring

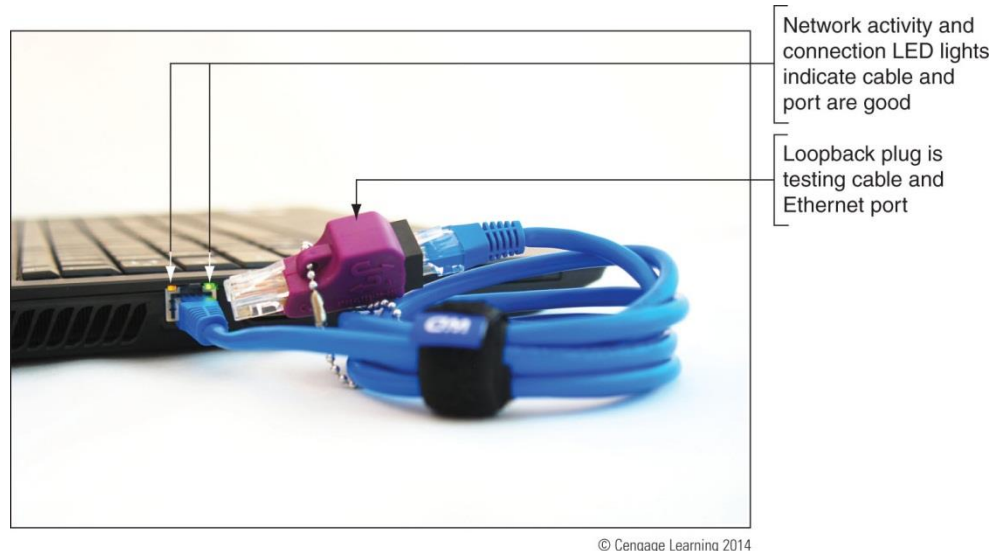
- Place wireless access point/router near the center of the area where you want your wireless hotspot
  - Router needs to have access to cable or DSL modem



**Figure 16-35** Plan the physical configuration of a small network

# Tools Used By Network Technicians

- *Loopback plug*: used to test a network cable or port
  - Also used to find out which port on a switch matches up with a wall jack



**Figure 16-36** A loopback plug verifies the cable and network port are good

# Tools Used By Network Technicians

- *Cable tester*. used to test a cable
  - Can also find out what type of cable it is if it is not labeled and to locate the ends of a network cable in a building
  - Has two components: remote and the base



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**Figure 16-37** Use a cable tester pair to determine the type of cable and/or if the cable is good

# Tools Used By Network Technicians

- *Network multimeter*: can test cables, ports, and network adapters
  - Can detect Ethernet speed, duplex status, default router on a network, length of a cable, voltage levels of PoE, and other network statistics
  - Many can document test results and upload results to a PC

# Tools Used By Network Technicians

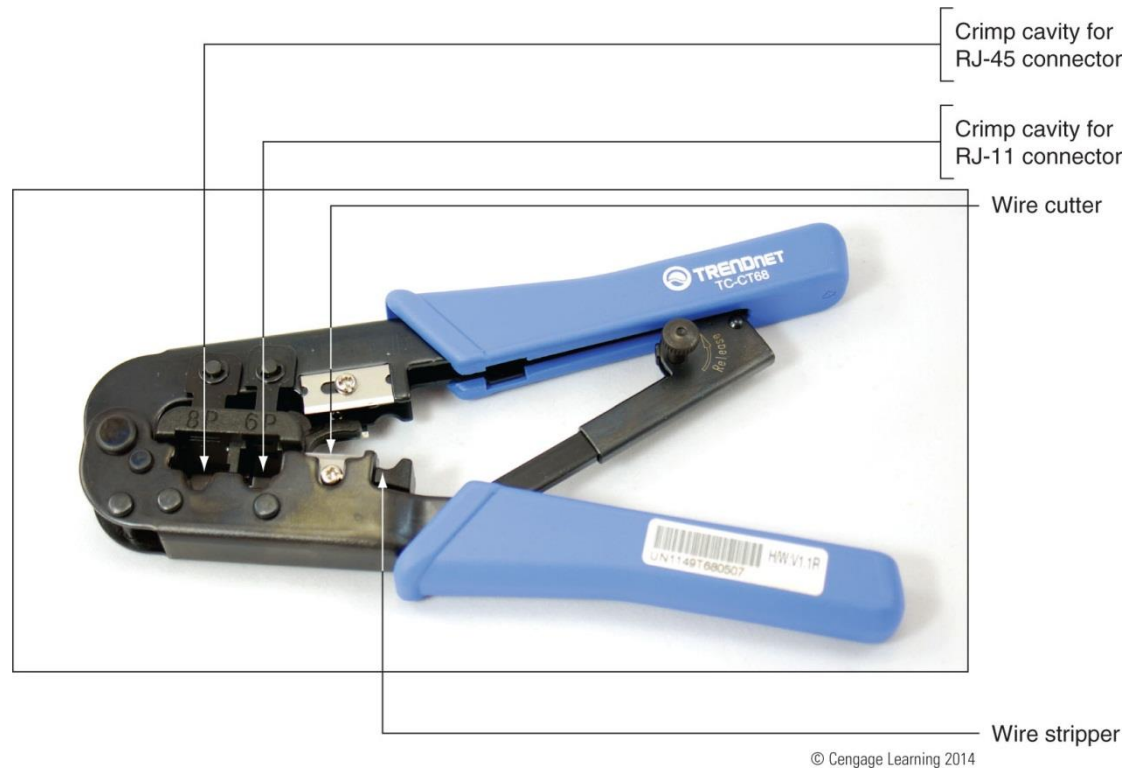
- *Toner probe*: two-part kit used to find cables in walls
  - Toner connects to one end of cable and puts out a continuous tone while a probe is used to search the walls for the tone



**Figure 16-40** A toner probe kit by Fluke Corporation

# Tools Used By Network Technicians

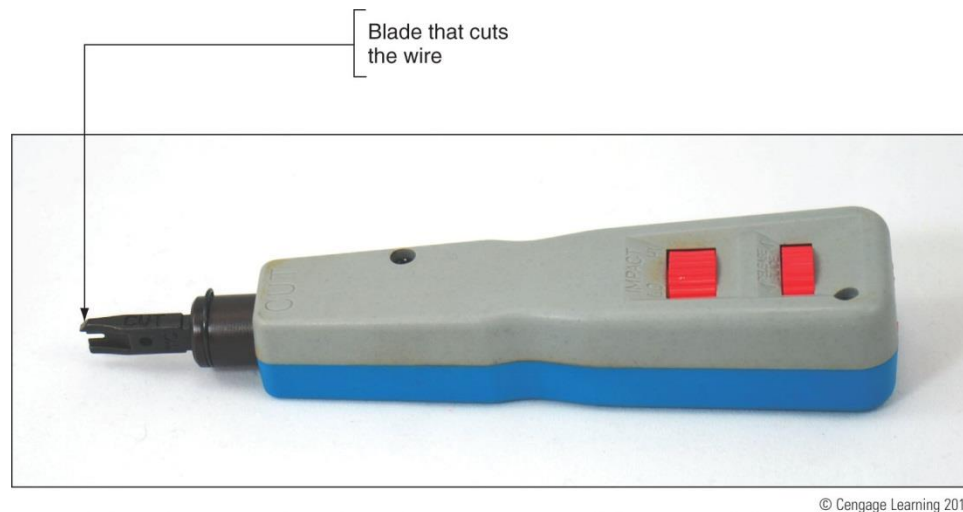
- *Wire stripper*: used to build your own network cable
  - Cuts away the plastic jacket or coating around wires
- Crimper: used to attach a terminator or connector to the end of a cable
  - Can serve double-duty as a wire cutter and stripper



**Figure 16-41** This crimper can crimp RJ-45 and RJ-11 connections

# Tools Used By Network Technicians

- *Punchdown tool*: also called an impact tool
  - Used to punch individual wires into slots in a keystone RJ-45 jack that is used in an RJ-45 wall jack

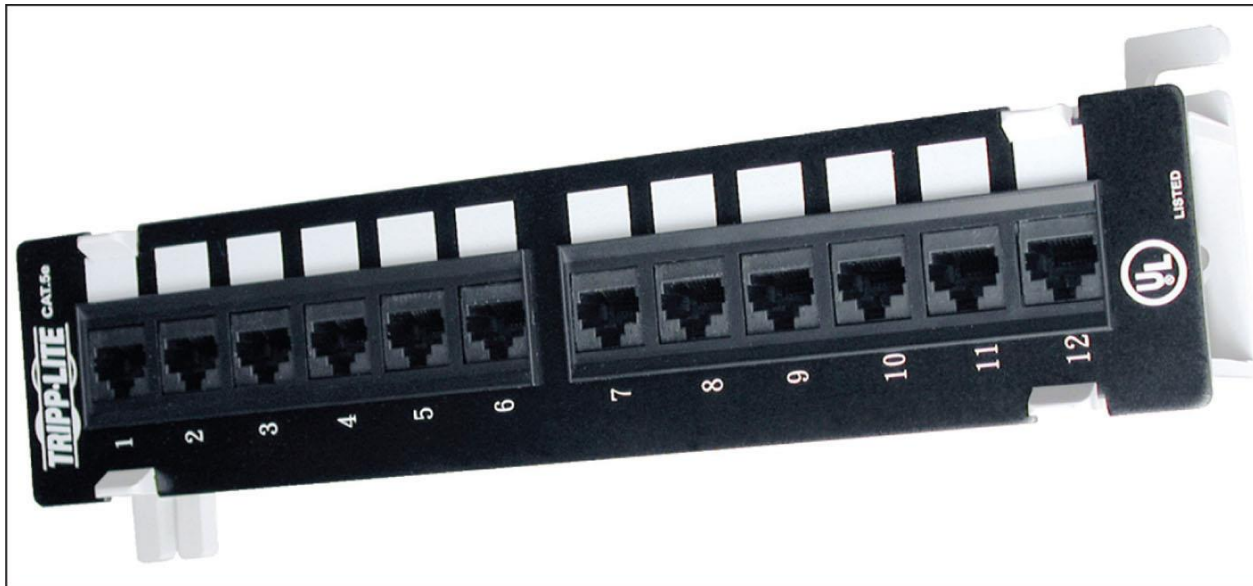


**Figure 16-42** A punchdown tool forces a wire into a slot and cuts off the wire



# Tools Used By Network Technicians

- *Patch panel*: provides multiple network ports for cables that converge in one location
  - Each port is numbered on the front of the panel
  - Keystone jacks are color-coded for the wires to be inserted on the back of the panel
  - Punchdown tool is used to terminate



Courtesy of Tripp Lite

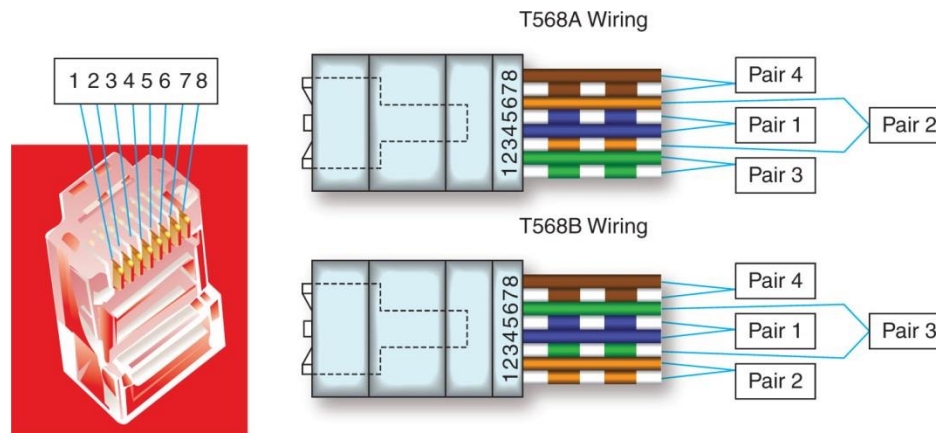
**Figure 16-43** A patch panel provides Ethernet ports for cables converging in an electrical closet

# How Twisted-Pair Cables and Connectors Are Wired

- **Straight-through cable:** used to connect a computer to a switch or other network device
  - Also called a patch cable
- **Crossover cable:** used to connect two like devices such as a hub to a hub or a PC to a PC
  - Transmit and receive lines are reversed
- RJ-45 connector has eight pins
  - 10BaseT and 100BaseT Ethernet use only four pins
  - Gigabit Ethernet uses all eight pins








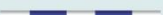




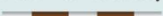
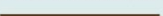
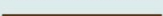
# How Twisted-Pair Cables and Connectors Are Wired

- Twisted pair cabling is color-coded in four pairs
  - Solid wire and a striped wire are in a pair
- Two standards for wiring: T568A and T568B



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**Figure 16-44** Pinouts for an RJ-45 connector

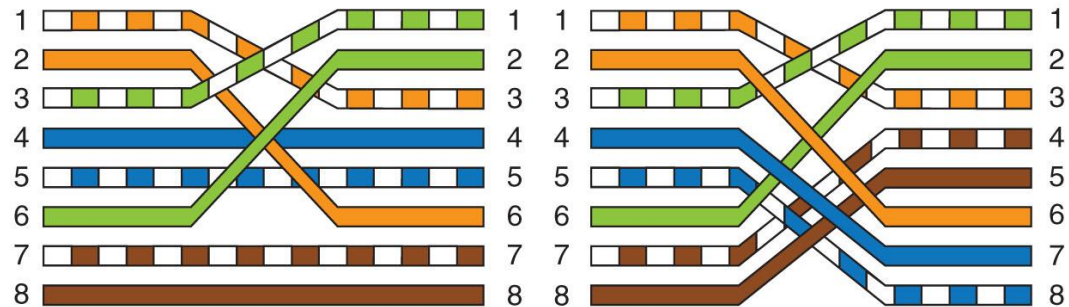
Pin	100BaseT Purpose	T568A Wiring	T568B Wiring
1	Transmit+	Pair 3: White/green 	Pair 2: White/orange 
2	Transmit-	Pair 3: Green 	Pair 2: Orange 
3	Receive+	Pair 2: White/orange 	Pair 3: White/green 
4	(Used only on Gigabit Ethernet)	Pair 1: Blue 	Pair 1: Blue 
5	(Used only on Gigabit Ethernet)	Pair 1: White/blue 	Pair 1: White/blue 
6	Receive-	Pair 2: Orange 	Pair 3: Green 
7	(Used only on Gigabit Ethernet)	Pair 4: White/brown 	Pair 4: White/brown 
8	(Used only on Gigabit Ethernet)	Pair 4: Brown 	Pair 4: Brown 

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**Table 10-3** The T568A and T568B Ethernet standards for wiring RJ-45 connectors

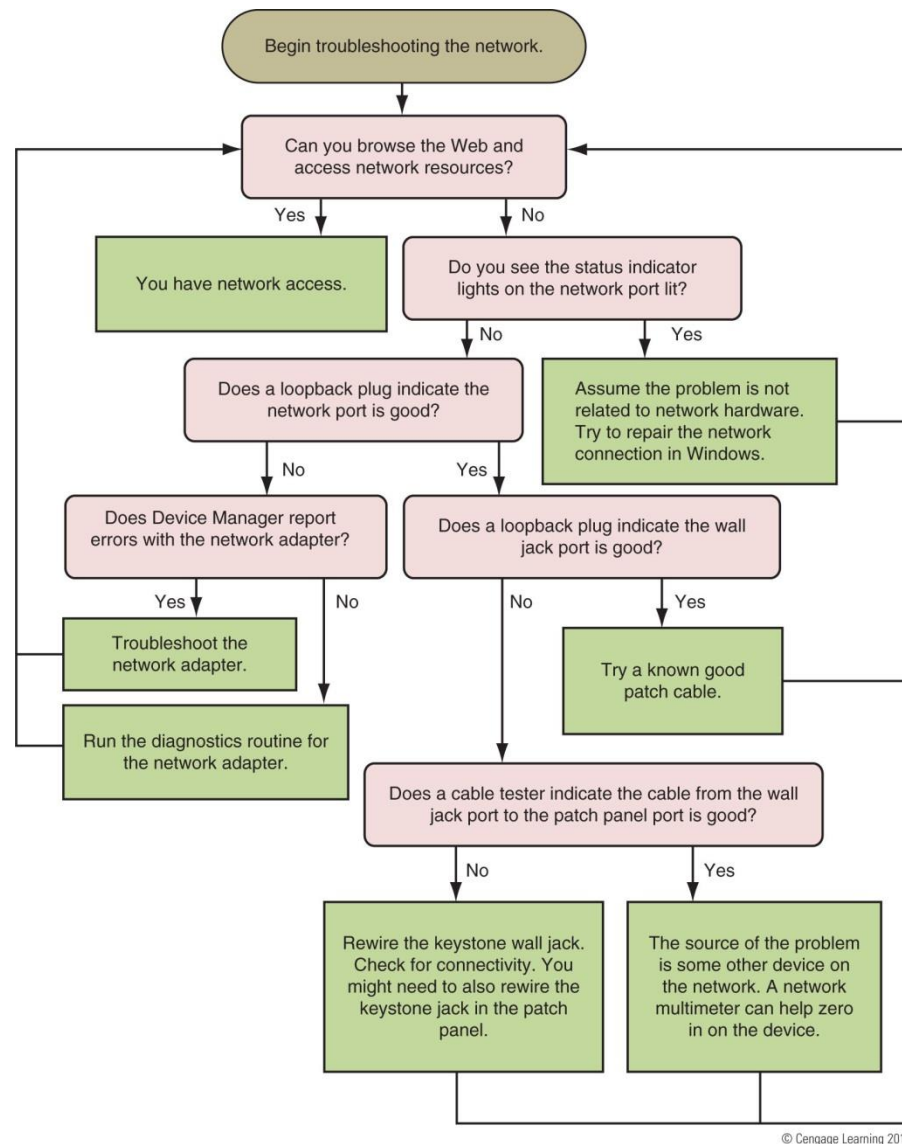
# How Twisted-Pair Cables and Connectors Are Wired

- When working with existing wiring be sure to find out if wiring is using T568A or T568B
  - If not sure, use T568B because it is most common



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**Figure 16-45** Two crossed pairs in a crossover cable is compatible with 10BaseT or 100BaseT Ethernet; four crossed pairs in a crossover cable is compatible with Gigabit Ethernet



**Figure 16-57** Flowchart to troubleshoot networking problems related to hardware

# Summary

- Networks are categorized in size as a PAN, LAN, Wireless LAN, MAN, or WAN
- Topologies include: mesh, ring, bus, star, and hybrid network topology
  - Ethernet uses the star or hybrid (star bus) topology
- Network performance is measured in bandwidth and latency
- Two most popular ways to connect to the Internet are cable Internet and DSL
- Technology used by cell phones for data is called 3G or 4G



# Summary

- Networking hardware includes: network adapters, dial-up modems, hubs, switches, routers, wireless APs, bridges, cables, and connectors
- Most popular Ethernet cable is twisted pair using RJ-45 connectors
- Switches and older hubs are used as a centralized connection point for devices
- Other network devices include a NAS, a VoIP phone, and older/outdated Internet appliances
- Twisted pair cabling is rated by category: CAT-3, CAT-5, CAT-5e, CAT-6, and CAT-6a

# Summary

- Networking tools include: loopback plug, cable tester, multimeter, tone probe, wire stripper, crimper, and punchdown tool
- RJ-45 connector has eight pins
- Two standards used to wire network cables are T568A and T568B
- Two types of network cables are straight through and crossover cables
- When troubleshooting, tools that can help are status indicator lights, loopback plugs, cable testers and network multimeter