Chapter 7
Networks and Communication Devices

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Learning Objectives (1)

• Define a computer network and its purpose.
• Describe several uses for networks.
• Understand the various characteristics of a network, such as topology, architecture, and size.
• Understand characteristics about data and how it travels over a network.
Learning Objectives (2)

• Name specific types of wired and wireless networking media and explain how they transmit data.
• Identify the most common communications protocols and networking standards used with networks today.
• List several types of networking hardware and explain the purpose of each.
Overview

- This chapter covers:
  - Networking concepts and terminology
  - What a computer network is and what it is used for
  - Other common networking and communications applications
  - Technical issues related to networks, including general characteristics of data transmission, and types of transmission media in use today
  - Explanation of the various communications protocols and networking standards in use today
  - Various types of hardware used with a computer network
What Is a Network?

• A network is a connected system of objects or people
• **A computer network** is a collection of computers and other hardware devices connected together so users can share hardware, software, and data, and electronically communicate
  – Converging with telephone and other communications networks
  – Range from small private networks to the Internet
  – Essential in most businesses

**USES FOR COMPUTER NETWORKS**

- Sharing an Internet connection among several users.
- Sharing application software, printers, and other resources.
- Facilitating Voice over IP (VoIP), e-mail, videoconferencing, messaging, and other communications applications.
- Working collaboratively; for example, sharing a company database or using collaboration tools to create or review documents.
- Exchanging files among network users and over the Internet.
- Connecting the computers and the entertainment devices (such as TVs, gaming consoles, and stereo systems) located within a home.

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How It Works

**Wireless Power**

- Powers/recharges devices via wireless signals and magnetic induction
- Two competing standards: Qi and PMA
- Requires charging surface; can use built-in or external charging receiver
- Charging surfaces may be built into walls, homes, cars, garage floors, etc. in the future

With wireless charging, smartphones and other mobile devices can be recharged simply by placing them on a wireless charging surface.
Networking Applications: The Internet and Telephone Service

• The Internet – the largest computer network in the world
• Telephone service
  – POTS Network was one of the first networks
    • Still provides telephone service to landline phones
  – **Mobile phones** (wireless phones) use a wireless network for communications
    • **Cellular (cell) phones** must be within range of cell tower to function
    • **Dual-mode phones** allow users to make telephone calls using more than one communications network
      – Cellular/Wi-Fi dual-mode phones
  • **Satellite phones** communicate via satellite technology
    – Most often used by individuals such as soldiers, journalists, wilderness guides, and researchers
Examples of Mobile Phones

**CELLULAR PHONES**
Can be used wherever cellular phone coverage is available.

**SATELLITE PHONES**
Can be used virtually anywhere.

FIGURE 7-2
Types of mobile phones.
Broadcasting and GPS Applications

• Television and radio broadcasting
  – Over the air networks still used to deliver TV and radio content to the public
  – Also includes cable TV networks, satellite TV networks, and private closed-circuit television (CCTV) systems

• The **global positioning system (GPS)** uses 24 GPS satellites for location and navigational purposes
  – GPS receivers use the GPS system to determine their exact geographic location
  – GPS III is under development and will be more powerful and accurate than the current system
GPS Applications

- **Individuals:** Hiking, driving directions, maps, work data, Web searches, social media, etc.
- **Workers:** Location information, guide vehicles and equipment, emergency workers, etc.
- **Military:** To guide munitions and trucks, and to track military aircraft, ships, and submarines.
Monitoring Systems

• Monitoring systems use networking technology to determine the current location or status of an object
  – RFID-based systems
    • Monitor the status of objects
  – GPS-based monitoring systems
    • Monitor the physical location of objects
    • Vehicle and child monitoring systems
  – Electronic medical monitors
    • Home healthcare
  – Sensor systems
    • Shipping, home automation (smart thermostats), etc.
Examples of Monitoring Systems

**FIGURE 7-4**
GPS-based child monitoring systems. Allow parents to track their children in real time.

**FIGURE 7-5**
Smart thermostats. This thermostat (left) contains a variety of sensors and can be controlled remotely via a mobile app (right).
Multimedia Networking

- Multimedia networking involves distributing digital multimedia content, typically via a home network
  - Smart TVs, streaming media players, etc.
- Placeshifting - Allows individuals to view multimedia content at a more convenient location (i.e., Slingbox)
Videoconferencing, Collaborative Computing, and Telecommuting

- **Videoconferencing** uses computers, video cameras, microphones, and networking technologies to conduct face-to-face meetings over a network
  - Telepresence videoconferencing more closely mimics a real-time meeting environment

- Collaborative computing (workgroup computing) enables individuals to work together on documents and projects
  - Markup tools, collaboration software, shared documents, etc.

- With **telecommuting**, individuals work from a remote location (usually home) and communicate with their places of business and clients using networking technologies
  - Allows for employee flexibility
  - Greener computing
Example of Telepresence Videoconferencing

**FIGURE 7-7**
Telepresence videoconferencing.

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Telemedicine

- **Telemedicine** uses networking technology to provide medical information and services
  - Remote monitoring and consultations
  - Remote diagnosis
  - Provides individuals in rural locations access to medical care
  - Necessary for long-term space exploration
  - **Telesurgery** involves robot-assisted surgery where doctor’s physical location is different from that of the patient and robot
Examples of Telemedicine Applications

REMOTE DIAGNOSES
Teleconferencing systems and remote diagnostic equipment enable physicians to receive and review patient data and interact with patients and/or on-site medical staff in order to make remote diagnoses.

REMOTE CONSULTATIONS
Teleconferencing systems enable physicians to talk with patients and consult with other physicians.

TELSURGERY
Telesurgery systems enable surgeons to control a surgical robot remotely in order to operate via the Internet or a private network.

FIGURE 7-8
Examples of telemedicine applications.
Network Characteristics: Wired vs. Wireless Networks

• A **wired network** is a network in which computers and other devices are physically connected to the network with cables
  – Found in schools, businesses, and government facilities

• A **wireless network** is a network in which computers and other devices are connected to the network without physical cables
  – Data is typically sent via radio waves
  – Found in homes, schools, and businesses
  – A public wireless **hotspot** is a location that provides wireless Internet access to the public

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Inside the Industry

High-Tech Stadiums

• Professional sports venues are increasingly including wireless access and other technology
  – Free Wi-Fi
  – Seat tablet holders
  – In-game apps
  – HD video boards
  – In-seat ordering
  – Paperless ticketing

The Levi’s Stadium, home to the San Francisco 49ers football team.
Network Topologies

• The physical topology of a network indicates how the devices in the network are arranged
  – **Star network**: All network devices connect to a central device
    • If the central device fails, the network cannot work
  – **Bus network**: All network devices connect to a central cable
  – **Mesh network**: Network devices are interconnected so that messages can take any of several possible paths
Basic Network Topologies

**FIGURE 7-9**
Basic network topologies.

- **STAR NETWORKS**
  Use a central device to connect each device directly to the network.

- **BUS NETWORKS**
  Use a central cable to connect each device in a linear fashion.

- **MESH NETWORKS**
  Each computer or device is connected to multiple (sometimes all of the other) devices on the network.
Client-Server Networks

- Client-server networks
  - Client: A computer or other device on the network that requests and utilizes network resources
  - Server: The computer dedicated to processing client requests
Peer-to-Peer (P2P) Networks

• P2P networks
  – All computers work at the same functional level
  – Users have direct access to the computers and devices attached to the network
  – Internet P2P networks
  • Content is exchanged over the Internet directly between users
Network Size and Coverage Area

• **Personal area networks (PANs)** connect an individual’s personal devices
  – Devices must be physically located close together

• **Local area networks (LANs)** connect devices located in a small geographic area

• **Metropolitan area networks (MANs)** cover a metropolitan area such as a city or county

• **Wide area networks (WANs)** cover a large geographic area
  – The Internet
Personal Area Networks (PANs) and Metropolitan Area Networks (MANs)

**FIGURE 7-12**
A fitness PAN.

**FIGURE 7-13**
Municipal Wi-Fi.
This MAN covers downtown Riverside, California.
Intranets, Extranets, and Virtual Private Networks (VPNs)

• An **intranet** is a private network designed to be used by an organization’s employees
  – Set up like the Internet

• An **extranet** is a company network accessible by authorized outsiders

• A **virtual private network (VPN)** provides a private, secure path over the Internet
  – Provides authorized secure access to a private network via the Internet
  – Uses tunneling and special encryption technology
  – Without a VPN, passwords, credit card numbers, etc. sent via a hotspot can be intercepted
Quick Quiz (1)

1. Which term describes a group of private secure paths set up using the Internet?
   a. VPN
   b. WAN
   c. LAN

2. True or False: With a bus network, all devices are connected directly to each other without the use of a central hub or cable.

3. A private network that is set up similar to the World Wide Web for use by employees of a specific organization is called a(n) __________.

Answers:

1) a; 2) False; 3) intranet
Data Transmission Characteristics: Bandwidth and Signal Representation

- Bandwidth is the amount of data that can be transferred in a given period of time
  - Measured in bits per second (bps), Kbps (thousands), Mbps (millions), or GFbps (billions)
- **Analog signals vs. digital signals**
  - Analog: Data is represented by continuous waves
    - Conventional telephones
  - Digital: Data is represented by two discrete states (0s and 1s)

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Transmission Type and Timing

- **Serial transmission:** Data is sent one bit at a time, one after another, along a single path
  - Typically used with networking media
- **Parallel transmission:** Data is sent in a group of bits with each bit taking a different path
  - Most often used within computer components
Ways of Timing Serial Transmissions

• Synchronous transmission
  – Blocks of data are transferred at regular, specified intervals
  – Most data transmissions within a computer and over a network are synchronous

• Asynchronous transmission
  – Data is sent when ready without being synchronized
  – Start bits and stop bits used to identify the bits that belong in each byte

• Isochronous transmission
  – Data is sent in time to be delivered at the time it is needed
Examples of Transmission Timing

SYNCHRONOUS TRANSMISSIONS
Data is sent in blocks and the blocks are timed so that the receiving device knows when they will arrive.

RECEIVING DEVICE

SENDING DEVICE

Data is sent in blocks.

Dear Mary, Today we did quite a bit in class. The professor introduced a speaker who talked about...

ASYNCHRONOUS TRANSMISSIONS
Data is sent one byte at a time, along with a start bit and a stop bit.

RECEIVING DEVICE

SENDING DEVICE

Start bit

Stop bit

One byte (character) of data.

ISOCHRONOUS TRANSMISSIONS
Data is sent when it is ready but only after requesting and being assigned the bandwidth necessary for all the data to arrive at the correct time.

RECEIVING DEVICE

SENDING DEVICE

Video portion of movie

Audio portion of movie

Data is sent in time to arrive when it is needed.

FIGURE 7-16
Transmission timing. Most network transmissions use synchronous transmission.
Transmitted Data Direction

• Simplex transmission
  – Data travels in a single direction only
  – Relatively uncommon

• Half-duplex transmission
  – Data travels in either direction but only one way at a time
  – Used with some network transmissions

• Full-duplex transmission
  – Data travels in both directions at the same time
  – Most often used with network transmissions
Delivery Methods

• Circuit switching
  – Dedicated path over a network is established between sender and receiver; all data follows that path

• Packet switching
  – Messages are separated into small units called packets and travel along the network separately; packets are reassembled once destination is reached

• Broadcasting
  – Data is sent out to all other nodes on the network and retrieved only by the intended recipient; primarily used with LANs
Examples of Data Delivery Methods

**CIRCUIT-SWITCHED NETWORKS**
Data uses a dedicated path from the sender to the recipient.

** PACKET-SWITCHED NETWORKS**
Data is sent as individual packets, which are assembled at the recipient’s destination.

**BROADCAST NETWORKS**
Data is broadcast to all nodes within range; the designated recipient retrieves the data.

**FIGURE 7-17**
Circuit-switched, packet-switched, and broadcast networks.

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Wired Networking Media

• **Twisted-pair cable**
  – Pairs of insulated wires twisted together
  – Used for telephone and network connections (LANs)

• **Coaxial cable**
  – Thick center wire surrounded by insulation
  – Used for computer networks and cable television delivery

• **Fiber-optic cable**
  – Utilizes hundreds of thin transparent clear glass or plastic fibers over which lasers transmit data as light
  – Used for high-speed communications
Examples of Wired Network Transmission Media

**FIGURE 7-18**
Wired network transmission media.
Wireless Networking Media

• With wireless networking media, data is sent through the airwaves using radio signals
  – The electromagnetic spectrum is the range of common electromagnetic radiation (energy)
    • Radio frequencies are assigned by the FCC and are measured in hertz (Hz)
    • Different parts of the spectrum have different properties, which make certain frequencies more appropriate for certain applications
  • Wireless spectrum is the RF band (up to 300 GHz)
    – Unlicensed frequencies can be used for any application
    – Wireless networks often use frequencies in the 2.4GHz and 5 GHz bands
The Electromagnetic Spectrum

**FIGURE 7-19**
The electromagnetic spectrum. Each type of communication is assigned specific frequencies within which to operate.

- **Gamma Rays**: Extremely high frequency (radio astronomy, etc.)
- **X-Rays**: Ultra high and super high frequency (UHF television, cell phones, GPS, satellite communications, radar, Wi-Fi, WiMAX, Bluetooth, etc.)
- **Ultraviolet (UV)**: Very high frequency (VHF television, FM radio, etc.)
- **Visible Light**: Medium and high frequency (AM radio, short-wave radio, CB radio, etc.)
- **Infrared (IR)**: Extremely low frequency to low frequency (metal detectors, sonar, radio beacons, etc.)
- **Radio Frequency (RF)**:
Cellular Radio Transmissions

• Cellular radio transmissions use cellular towers within overlapping honeycomb-shaped zones called cells
  – Calls are transferred from cell tower to cell tower as the individual moves
  – Cell tower forwards call to the MTSO
  – MTSO routes call to the recipient’s phone
  – Data sent via cell phones works in similar manner

• The speed of cellular radio transmissions depends on the type of cellular standard being used
Example of How Cellular Phones Work

1. The sender (in this example, the passenger in the car) makes a call using a cell phone.

2. The call is transmitted as radio waves to the tower located in the same cell as the sender.

3. The tower transmits the call to the switching office via a wireless signal or an underground cable.

4. When the sender travels out of the current cell, the next tower takes over seamlessly.

5. The Mobile Telephone Switching Office (MTSO) routes the call to the appropriate telephone network; in this example, the regular telephone network.

6. The recipient answers the phone (in this example, using a conventional phone at home).

FIGURE 7-20
How cellular phones work.
Microwave and Satellite Transmissions

- Microwaves use high-frequency radio signals that are sent and received using microwave stations or satellites
  - Signals are line of sight, so microwave stations are usually built on tall buildings, towers, mountaintops
- **Microwave stations** are earth-based stations that transmit signals directly to each other within a range of 30 miles
  - Stations designed to communicate with satellites (television and Internet services) are called satellite dishes
Communication Satellites

- **Communication satellites** are launched into orbit to send and receive microwave signals from earth
  - Traditional satellites use geosynchronous orbit 22,300 miles above the earth
  - A delay of less than one half-second is common when signals travel from earth to satellite and back
  - Low earth orbit (LEO) satellites have less delay and are used with satellite telephones
  - Medium earth orbit (MEO) satellites are most often used for GPS systems
Example of How Satellite Internet Works

1. Data, such as a Web page request, is sent from the individual’s computer to the satellite dish via a satellite modem.

2. The request is sent up to a satellite from the individual’s satellite dish.

3. An orbiting satellite receives the request and sends it down to the satellite dish at the ISP’s operations center.

4. The ISP’s operations center receives the request (via its satellite dish) and transfers it to the Internet.

5. The request travels over the Internet as usual. The requested information takes a reverse route back to the individual.

FIGURE 7-21
How satellite Internet works.
Infrared (IR) Transmissions

• **Infrared (IR) transmissions** send data as infrared light rays
  – Like an infrared television remote, requires line of sight
  – Because of this limitation, many formerly IR devices (wireless mice, keyboards) now use RF technology

• IR is sometimes used to beam data between some mobile devices, game consoles, and handheld gaming devices
Quick Quiz (2)

1. Which transmission media transmits data as light pulses?
   a. coaxial cable
   b. fiber-optic cable
   c. twisted-pair cable

2. True or False: Cellular radio is a form of wireless network transmission.

3. Space-based devices that are launched into orbit around the earth to receive and transmit microwave signals to and from earth are called _____.

Answers:
1) b; 2) True; 3) communications satellites
Communications Protocols and Networking Standards

• **Protocol**
  – A set of rules for a particular situation
  – Communications protocol
    • A set of rules that determine how devices on a network communicate

• **Standard**
  – A set of criteria or requirements approved by a recognized standards organization
  – Address how networked computers connect/communicate
  – Needed to ensure products can work with other products
TCP/IP

• **TCP/IP** is the most widely used communications protocol
  – Consists of two protocols
    • Transmission Control Protocol (TCP)
      – Responsible for delivery of data
    • Internet Protocol (IP)
      – Provides addresses and routing information
  – Uses packet switching to transmit data
  – TCP/IP support is built into almost all operating systems
    • IP addresses are used to identify computers and devices on networks
Example of How TCP/IP Works

1. Each message is split into packets.
2. The packets are addressed to the same destination.
3. The packets may travel the same or different routes to the destination.
4. The packets are reassembled into the message at the destination.

FIGURE 7-22
How TCP/IP works. TCP/IP networks (like the Internet) use packet switching.
Other Internet Communications Protocols

• HTTP (Hypertext Transfer Protocol) and HTTPS (Secure Hypertext Transfer Protocol)
  – Used to display Web pages

• FTP (File Transfer Protocol) and SFTP (Secure File Transfer Protocol)
  – Used to transfer files over the Internet

• SMTP (Simple Mail Transfer Protocol and POP3 (Post Office Protocol)
  – Used to deliver e-mail over the Internet
Ethernet (802.3)

- **Ethernet (802.3)** is the most widely used standard for wired networks
  - Typically used with LANs that have a star topology
  - Works with twisted-pair, coaxial, and fiber-optic cabling
  - Continually evolving
  - Most common today are Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet
  - 40 Gigabit Ethernet and 100 Gigabit Ethernet standards ratified in 2010
  - 400 Gigabit and Terabit Ethernet standards are currently being explored
# Ethernet Standards

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>MAXIMUM SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>10BASE-T</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>Fast Ethernet (100BASE-T or 100BASE-TX)</td>
<td>100 Mbps</td>
</tr>
<tr>
<td>Gigabit Ethernet (1000BASE-T)</td>
<td>1,000 Mbps (1 Gbps)</td>
</tr>
<tr>
<td>10 Gigabit Ethernet (10GBASE-T)</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>40 Gigabit Ethernet</td>
<td>40 Gbps</td>
</tr>
<tr>
<td>100 Gigabit Ethernet</td>
<td>100 Gbps</td>
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<tr>
<td>400 Gigabit Ethernet*</td>
<td>400 Gbps</td>
</tr>
<tr>
<td>Terabit Ethernet*</td>
<td>1,000 Gbps (1 Tbps)</td>
</tr>
<tr>
<td>*Under consideration for development</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 7-23**

Ethernet standards.
Power over Ethernet (PoE)

• PoE allows electrical power to be sent along the cables on an Ethernet network along with data
  – Devices are not plugged into an electrical outlet as long as they are connected to Ethernet ports that support PoE
  • PoE injector can be used to send power to the device if needed
  – Most often used in business networks with remote devices (outdoor networking hardware, cameras, etc.)
  – Can also be used to place networked devices near ceilings or other locations where a nearby power outlet may not be available
Examples of Power over Ethernet (PoE) Devices

**FIGURE 7-24**

With Power over Ethernet (PoE), devices are powered through Ethernet cables.
Powerline and G.hn

• Powerline
  – Allows networking via ordinary electrical outlets
  – Broadband over Powerline (BPL): Can deliver Internet via existing outdoor power lines but is not widely used
  – HomePlug Powerline: Networks computers over existing powerlines
    • HomePlug AV2 can also network home entertainment devices

• G.hn
  – A unified world-wide standard for creating home networks over any existing home wiring—phone lines, power lines, and coaxial cable
Example of a HomePlug Powerline Network

**FIGURE 7-25**
HomePlug Powerline networks. Enable you to network devices over existing power lines.

- **THE INTERNET**
- **Router** connects to a Powerline adapter.
- **PC** connects to a Powerline adapter.
- **Router and PC** are connected via the home’s electrical wiring.
- **Powerline adapter**
Wi-Fi (802.11)

• **Wi-Fi (802.11)** is a family of wireless networking standards using IEEE standard 802.11
  
  – Current standard for wireless networks in homes and offices
  
  – Built into many everyday objects today
  
  – Designed for medium-range transmission; speed and distance depends on Wi-Fi standard, solid objects in the way, interference, etc.
Wi-Fi SD Cards

- Upload photos wirelessly and automatically from camera to computer, mobile device, or cloud photo service
- Some include location information
- Some sync photos and videos to cloud account
- Can share photos quickly with others as well as have backups
- Protects data if camera is stolen

Eyefi Mobi cards.
Wi-Fi Standards

- The most widely used standards are 802.11n and 802.11ac
- Wi-Fi products are backward compatible

<table>
<thead>
<tr>
<th>WI-FI STANDARD</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11b</td>
<td>An early Wi-Fi standard; supports data transfer rates of 11 Mbps.</td>
</tr>
<tr>
<td>802.11g</td>
<td>An older Wi-Fi standard; supports data transfer rates of 54 Mbps and uses the same 2.4 GHz frequency as 802.11b, so their products are compatible.</td>
</tr>
<tr>
<td>802.11a</td>
<td>An older Wi-Fi standard; supports data transfer rates of 54 Mbps, but uses a different radio frequency (5 GHz) than 802.11b/g (2.4 GHz), making the standards incompatible.</td>
</tr>
<tr>
<td>802.11n</td>
<td>A current Wi-Fi standard; supports speeds up to about 450 Mbps and has twice the range of 802.11g. It can use either the 2.4 GHz or 5 GHz frequency.</td>
</tr>
<tr>
<td>802.11ac</td>
<td>The newest Wi-Fi standard; supports speed up to about three times faster than 802.11n and uses the 5 GHz frequency (though most 802.11ac routers are dual band to also support 2.4 GHz devices for backward compatibility).</td>
</tr>
<tr>
<td>802.11ax*</td>
<td>A proposed Wi-Fi standard; expected to support speeds of more than 2 Gbps.</td>
</tr>
</tbody>
</table>

* Expected by 2018
WiMAX (802.16)

- **WiMAX (802.16)** is a set of standards for longer range wireless networking connections, typically MANs
  - Fixed WiMAX
    - Designed to provide Internet access fixed locations (hotzones)
    - Typical hotzone radius is between 2 and 6 miles
    - Possible to provide coverage to an entire city by using multiple WiMAX towers
  - Mobile WiMAX (802.16e)
    - Mobile version of the standard
    - Being replaced with cellular standards
Example of WiMAX vs. Wi-Fi Coverage

**FIGURE 7-29**
WiMAX vs. Wi-Fi.
A WiMAX hotzone is larger than a Wi-Fi hotspot and so has a greater range; it can provide service to anyone in the hotzone, including mobile users.
Cellular Standards

• First Generation – Analog and voice only
• 2G – Digital, both voice and data, faster
• 3G – A current standard, uses packet switching
  – Typical speeds are between 1 and 4 Mbps
  – HSDPA/UMTS, EV-DO
• 4G – A faster current standard, uses packet switching
  – Typical speeds are between 3 to 15 Mbps
  – LTE, LTE-Advanced, LTE-Unlicensed (LTE-U)
• 5G – Next generation; under development
Bluetooth

- **Bluetooth** is a networking standard for very short-range wireless connections
  - Typical range is about 10 meters (33 feet)
  - Designed to connect devices wirelessly
    - Keyboard/mouse to a PC, send print jobs to a printer, connect a wireless speaker to a smartphone, send photos from a smartphone to another smartphone or a PC, etc.
  - Can transmit through clothing or other objects
  - Devices form piconets when connected (8 devices max)
  - Bluetooth 4 (Bluetooth Smart) is energy efficient
Examples of Bluetooth Devices

The desktop computer, keyboard, and mouse form a piconet to communicate with each other.

**FIGURE 7-31**
**Bluetooth.** Bluetooth is designed for short-range wireless communications.

**FIGURE 7-32**
Bluetooth tennis racket.

Tennis racket has built-in Bluetooth.

Data is sent to the app in real time.

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Wi-Fi Direct, WiGig, and Wireless HD

- **Wi-Fi Direct** is a standard for connecting Wi-Fi devices directly, without using a router or an access point.

- **WiGig (802.11ad)** and **WirelessHD (WiHD)** are used to wirelessly connect computers and home entertainment devices together.

**FIGURE 7-33**

Wi-Fi Direct. Allows Wi-Fi devices to connect directly to one another.
ZigBee, Z-Wave, and Low-Power Wi-Fi (802.11ah)

• ZigBee (802.15)
  – Designed for inexpensive and simple short-range networking, particularly sensor networks

• Z-Wave
  – Devices can communicate with each other and be controlled via home control modules, computers, or smartphones
    • Primarily used for home automation

• Low Power Wi-Fi (802.11ah) is under development
  – Designed to network sensors and other devices in home automation networks
  – Operates in the 900 MHz band
## Examples of Wireless Networking Standards

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>WIRELESS STANDARD</th>
<th>APPLICATION</th>
<th>APPROXIMATE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short range</strong></td>
<td>Bluetooth, WiGig</td>
<td>To connect peripheral devices to a computer or mobile device or to connect devices together.</td>
<td>33 feet</td>
</tr>
<tr>
<td></td>
<td>WiGig WirelessHD (WiHD)</td>
<td>To connect and transfer multimedia content between home consumer electronic devices (computers, TVs, DVD players, printers, etc.).</td>
<td>33 feet</td>
</tr>
<tr>
<td></td>
<td>ZigBee Z-Wave Low Power Wi-Fi (802.11ah)</td>
<td>To connect a variety of home, personal, and automation devices.</td>
<td>33 feet–164 feet</td>
</tr>
<tr>
<td><strong>Medium range</strong></td>
<td>Wi-Fi (802.11)</td>
<td>To connect computers and other devices to a local area network.</td>
<td>100–300 feet indoors; 300–900 feet outdoors</td>
</tr>
<tr>
<td></td>
<td>Wi-Fi Direct</td>
<td>To connect computers and other devices directly together.</td>
<td>600 feet</td>
</tr>
<tr>
<td><strong>Long range</strong></td>
<td>WiMAX Mobile WiMAX</td>
<td>To provide Internet access to a large geographic area for fixed and/or mobile users.</td>
<td>6 miles non-line of sight; 30 miles line of sight</td>
</tr>
<tr>
<td></td>
<td>Cellular standards (3G, 4G, 5G)</td>
<td>To connect mobile phones and other devices to a cellular network for telephone and Internet service.</td>
<td>10 miles</td>
</tr>
</tbody>
</table>

**FIGURE 7-34**

Examples of wireless networking standards.
Trend

Smart Homes

• Home automation
  – Use Z-Wave, Bluetooth, or Wi-to control lights, door locks, thermostats, etc.
• Smart door locks can be unlocked via proximity sensors and Bluetooth 4.0
  – Can send temporary keys to others
  – Can check on status of locks and keys online

Using your smartphone as your door key.
Networking Hardware

• A **network adapter** is used to connect a computer to a network
  – Also called **network interface card (NIC)** when in the form of an expansion card

• A **modem** is a device that enables a computer to communicate over analog networking media
  – Term is often used interchangeably with network adapter

• Most computers and mobile devices today come with a built-in network adapter and/or modem
Examples of Network Adapters and Modems

FIGURE 7-35
Network adapters and modems.
Switches and Routers

• A **switch** is a central device that connects devices in a wired network but only sends data to the intended recipient
  – Contains ports to which devices are connected
  – Hub is similar but sends data to all recipients

• A **router** connects multiple networks: Two LANs, two WANS, LAN and the Internet, etc.
  – Passes data to intended recipient only
  – Can plan the most efficient path
  – Are used to route traffic over the Internet
Wireless Access Points, Wireless Routers, and Bridges

• A **wireless access point** allows devices to connect to a network

• A **wireless router** is a router with a built-in wireless access point and, typically, a switch
  – If so, it can connect both wireless and wired devices to a network and connect that network to the Internet
  – Travel and mobile broadband routers are available

• A **bridge** is used to connect two LANs together
  – In a home network, often used to wirelessly connect a group of wired devices (TV, Blu-ray player, etc.) to a home network
Examples of Wireless Routers

**CONVENTIONAL WIRELESS ROUTERS**
This 802.11ac router also includes a switch and wireless access point.

**TRAVEL WIRELESS ROUTERS**
This 802.11a/b/g/n router enables multiple devices to share a single wired Internet connection.

**MOBILE BROADBAND ROUTERS**
This 3G/4G router creates a mobile hotspot, which enables multiple devices to share a mobile broadband connection.

**FIGURE 7-36**
Wireless routers.
Provide wireless users access to each other and an Internet connection.
Other Networking Hardware

• **Repeaters** amplify signals along a network
• **Range extenders** are repeaters for a wireless network
• **Antennas** are devices used for receiving or sending radio signals
  – Some network adapters and routers can use an external antenna
  – Can be directional or omnidirectional
  – Strength measured in decibels (dB)
• **Multiplexers** combine transmissions from several different devices to send them as one message
  – Frequently used with fiber-optic cables and other high-capacity media to increase data throughput
Examples of Networking Hardware

**FIGURE 7-37**
Networking hardware. As shown in this example, many different types of hardware are used to connect networking devices.
Quick Quiz (3)

1. What is a protocol used to transfer data over the Internet?
   a. Wi-Fi
   b. Bluetooth
   c. TCP/IP

2. True or False: The most common protocol used with wired networks is Wi-Fi.

3. A(n) ________ is a router that contains a built-in wireless access point.

Answers:
1) c; 2) False; 3) wireless router
Summary

• What Is a Network?
• Networking Applications
• Network Characteristics
• Data Transmission Characteristics
• Networking Media
• Communications Protocols and Networking Standards
• Networking Hardware