Understanding Computers Today and Tomorrow

Chapter 7:

Networks

Learning Objectives

1. Define a computer network and its purpose.
2. Describe several uses for networks.
3. Understand the various characteristics of a network, such as topology, architecture, and size.
4. Understand characteristics about data and how it travels over a network.
5. Name specific types of wired and wireless networking media and explain how they transmit data.

Overview

- This chapter covers:
  - Common networking and communications applications
  - Networking concepts and terminology
  - Technical issues related to networks, including general characteristics of data transmission, and types of transmission media in use today

What is a Network?

- Network
  - A connected system of objects or people
- Computer network
  - A collection of computers and other hardware devices connected together so users can share hardware, software, and data, and electronically communicate
- Computer networks are converging with telephone and other communications networks
- Networks range from small private networks to the Internet (largest network in the world)
- In most businesses, computer networks are essential

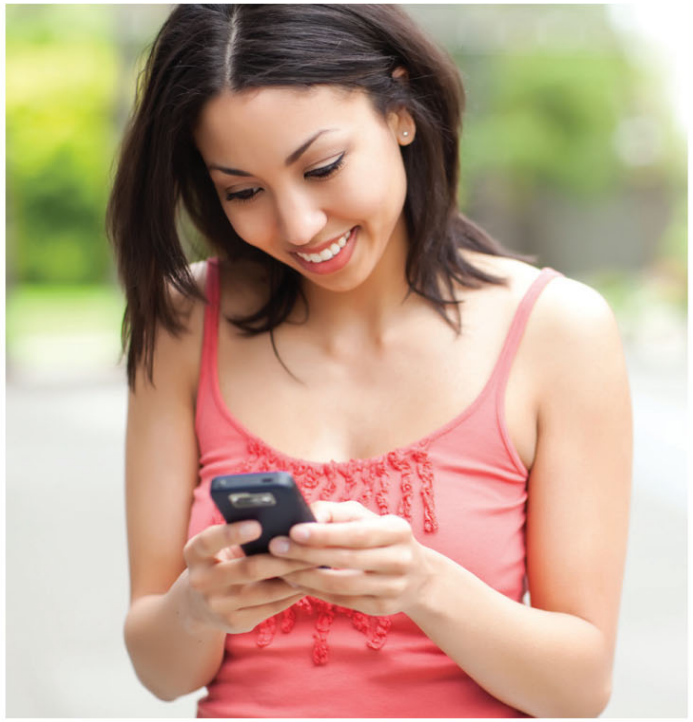
Networking Applications

- The Internet
  - Largest computer network in the world
- Telephone Service
  - POTS (Plain old telephone service) Network
    - One of the first networks
    - Still used today to provide telephone service to landline phones
  - Mobile Phones (wireless phones)
    - Use a wireless network for communications
    - Twice as many mobile phones used worldwide than landline phones

Networking Applications

- 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 can switch seamlessly between the Wi-Fi network and a cellular network
- Satellite Phones
  - Used where cell service is not available
  - Most often used by individuals such as soldiers, journalists, wilderness guides, and researchers

Networking Applications



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

Courtesy of Iridium

SATELLITE PHONES
Can be used virtually anywhere.

FIGURE 7-2
Types of mobile phones.

Networking Applications

- Television and Radio Broadcasting
  - Still used to deliver TV and radio content to the public
  - Other networks involved with television content delivery are cable TV networks, satellite TV networks, and private closed-circuit television systems
- Global Positioning System (GPS) Applications
  - Uses satellites and a receiver to determine the exact geographic location of the receiver
  - Commonly used by individuals to determine their exact location

Networking Applications

- Used on the job by surveyors, farmers, and fishermen
- Used to guide vehicles and equipment
- Used by the military to guide munitions and trucks, and to track military aircraft, ships, and submarines
- Geocaching

FIGURE 7-3
GPS receivers.
Allow people to determine their exact geographical location, usually for safety or navigational purposes.

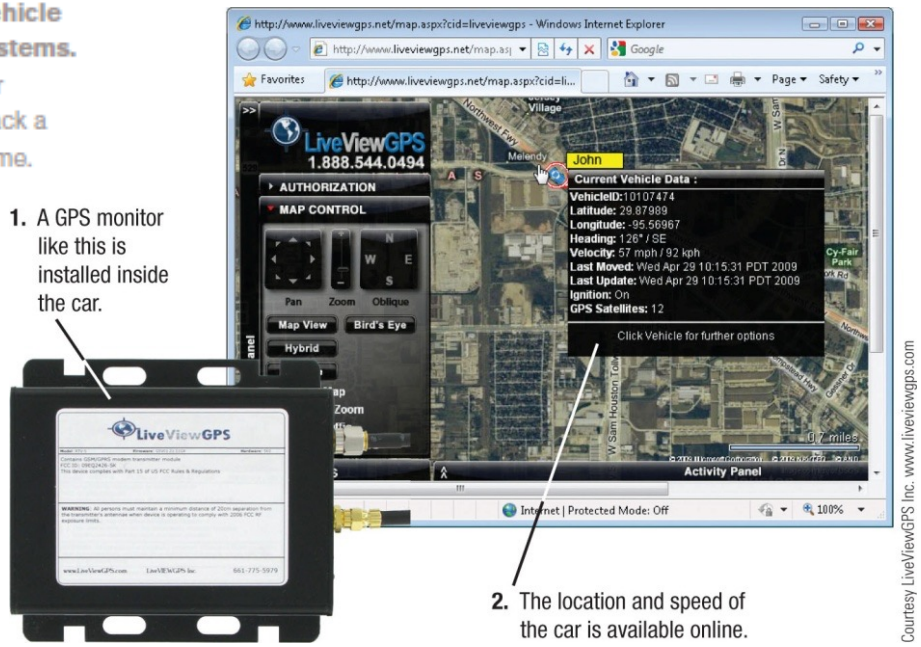
Networking Applications

- 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--*OnStar*
    - Electronic Medical Monitors
      - Home health care

Networking Applications

- Sensor Networks
  - Devices that respond to heat, light, pressure and generate a measurable electrical signal

FIGURE 7-4
GPS-based vehicle monitoring systems.
Allow parents or employers to track a vehicle in real time.



Courtesy LiveViewGPS Inc. www.liveviewgps.com

Courtesy of Intel Corporation

FIGURE 7-5
Home medical monitoring systems.

Networking Applications

- Multimedia Networking
  - Distributing digital multimedia content, typically via a home network
    - Necessary networking capabilities are often built into devices being used
    - Might need to use multimedia networking device such as a digital media receiver or digital media streamer
    - Placeshifting Content
      - Allows individuals to view multimedia content at a more convenient location, i.e., Slingbox

Networking Applications

FIGURE 7-6
Placeshifting. Products like the Slingbox are used to placeshift multimedia content to the user's current location.

Networking Applications

- Videoconferencing, Collaborative Computing, and Telecommuting
  - Use of computers, video cameras, microphones, and networking technologies to conduct face-to-face meetings between people located in different places
  - Telepresence Videoconferencing
    - A setup that more closely mimics a real-time meeting environment

Life-size video images of remote participants appear on the display screen.

FIGURE 7-7
Telepresence videoconferencing.

Networking Applications

- Collaborative Computing (workgroup computing)
  - Enables individuals to work together on documents and projects
- 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

Networking Applications

- Telemedicine
  - Use of networking technology to provide medical information and services
    - Remote monitoring and consultations
    - Remote diagnosis
    - Telesurgery
      - Doctor's physical location is different from the patient's physical location
      - Robot assisted
      - Will be needed for long-term space exploration

Networking Applications

Courtesy InTouch Health, Inc.

Courtesy InTouch Health, Inc.

REMOTE CONSULTATIONS
Using remote-controlled teleconferencing robots, physicians can "virtually" consult with patients or other physicians in a different physical location (left); the robot transmits video images and audio to and from the doctor (via his or her computer) in real time (right).

FIGURE 7-8
Examples of telemedicine applications.

Courtesy, University of Rochester

REMOTE DIAGNOSIS
At remote locations, such as this New York childcare center, trained employees provide physicians with the real-time data (sent via the Internet) they need to make a diagnosis.

Photo made available by St. Joseph's Healthcare Hamilton

TELESURGERY
Using voice or computer commands, surgeons can now perform operations via the Internet; a robotic system uses the surgeon's commands to operate on the patient.

Network Characteristics

- Wired vs. Wireless Networks
  - Wired
    - A network in which computers and other devices are physically connected to the network with cables
    - Found in homes, schools, businesses, and government facilities
  - Wireless
    - A network in which computers and other devices are connected to the network without physical cables
    - Data is typically sent via radio waves

Network Characteristics

- Found in homes, schools, and businesses
- Wi-Fi hotspots found in coffeehouses, businesses, airports, hotels, and libraries

- Network Topologies
  - How the devices in the network are arranged
    - Star Networks
      - All networked devices connect to a central device such as a server
      - If the central device fails, the network cannot work

Network Characteristics

FIGURE 7-9
Basic network topologies.

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

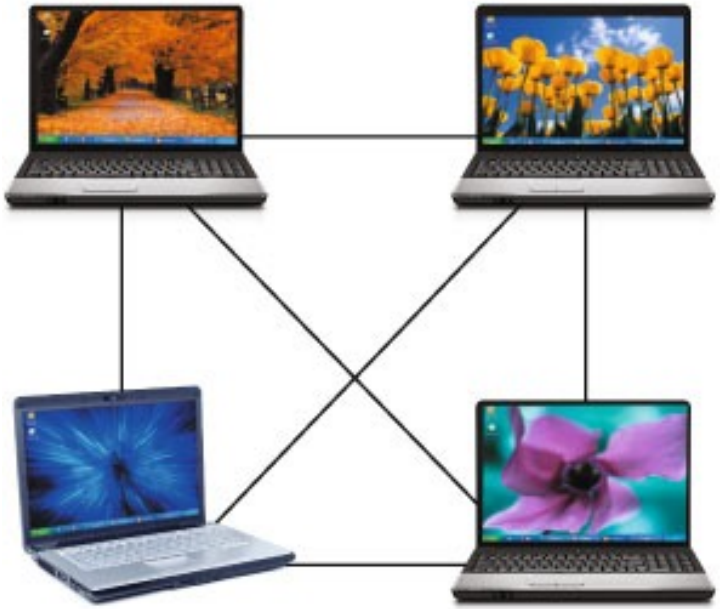
Network Characteristics

- Bus Network
  - All network devices are connected to a central cable
  - Data is transmitted down the bus line from one device to another
  - If bus line fails, the network cannot function
- Mesh Networks
  - A network in which there are multiple connections between the devices on the network so that data can take any of several paths
  - Full Mesh and Partial Mesh topologies
- Some networks use a combination of topologies

Network Characteristics

FIGURE 7-9
Basic network topologies.

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

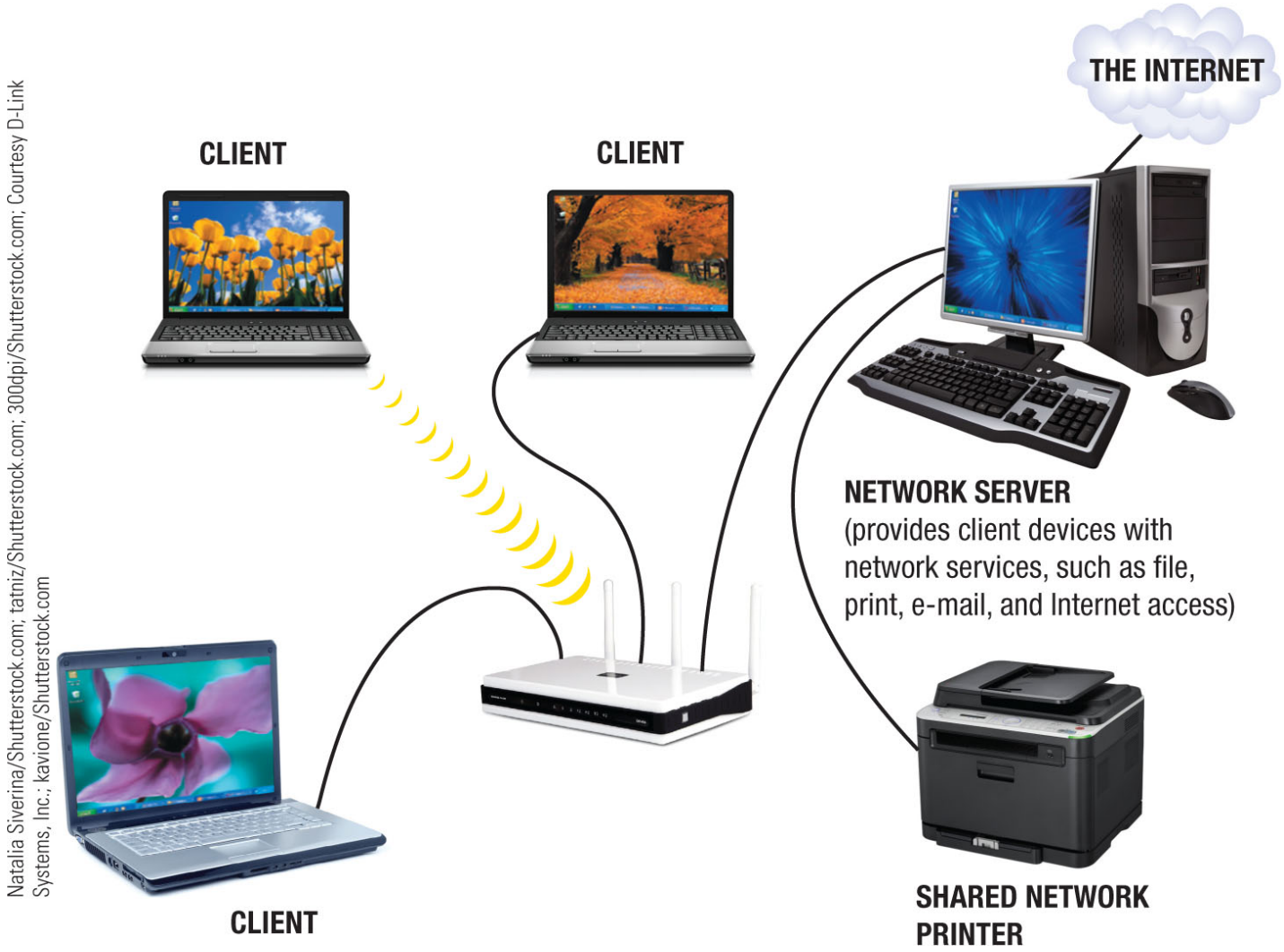


MESH NETWORKS
Each computer or device is connected to multiple (sometimes all of the other) devices on the network.

Network Characteristics

- Network Architectures
  - The way networks are designed to communicate
  - Client-Server Networks
    - Client
      - Computer or other device on the network that requests and utilizes network resources
    - Server
      - Computer dedicated to processing client requests

Network Characteristics



Natalia Siverina/Shutterstock.com; tatniz/Shutterstock.com; 300dpi/Shutterstock.com; Courtesy D-Link Systems, Inc.; kavione/Shutterstock.com

FIGURE 7-10
Client-server networks. With this type of network, client computers communicate through one or more servers.

Network Characteristics

- Peer-to-Peer (P2P) Networks
  - Central server is not used
  - All computers on the network work at the same functional level
  - Users have direct access to the computers and devices attached to the network
  - Less complicated and less expensive to implement than client-server networks
  - Internet P2P Computing
    - Content is exchanged over the Internet directly between users

Network Characteristics

FIGURE 7-11
Peer-to-peer networks. With this type of network, computers communicate directly with one another.

Natalia Siverina/Shutterstock.com; Courtesy D-Link Systems, Inc.; kavione/Shutterstock.com; tatniz/Shutterstock.com

P2P HOME NETWORKS
Devices connect and communicate via the home network.

INTERNET P2P NETWORKS
Devices connect and communicate via the Internet.

Network Characteristics

- Network Size and Coverage Area
  - Personal Area Networks (PANs)
    - Connect an individual's personal devices
      - Personal computer, mobile phone, digital camera
      - 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
    - Two or more LANs connected together

Network Characteristics

- Intranets and Extranets
  - Intranet
    - Private network designed to be used by an organizations' employees
    - Set up like the Internet
  - Extranet
    - Network that is accessible by authorized outsiders
- Virtual Private Networks (VPNs)
  - Secure path over the Internet that provides authorized users a secure means of accessing a private network via the Internet
  - Uses tunneling and special encryption technology

Network Characteristics

Courtesy of Mozilla

FIGURE 7-12
WPANs. Wireless PANs connect and synchronize an individual's devices wirelessly.

Courtesy of Riverside

FIGURE 7-13
Municipal Wi-Fi. This MAN covers downtown Riverside, California.

Quick Quiz

1. Which of the following describes a group of private secure paths set up using the Internet?
   a. VPN
   b. WAN
   c. WSN
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) _____.

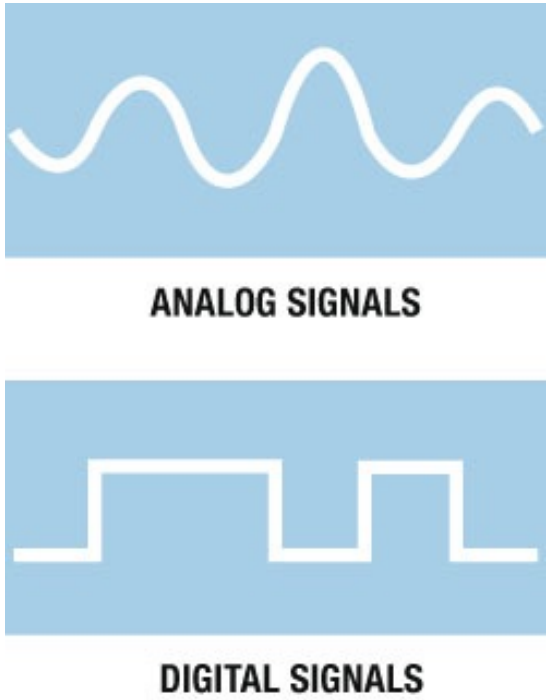
Answers:

1) a; 2) False; 3) intranet

Data Transmission Characteristics

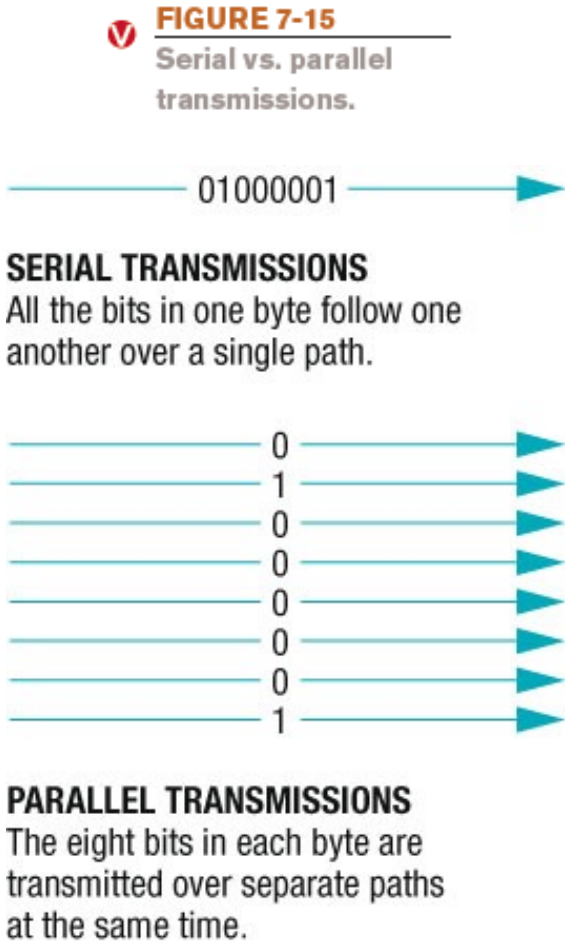
- Bandwidth
  - The amount of data that can be transferred in a given period of time
  - Measured in bits per second (bps), Kbps (thousands), Mbps (millions), or Gbps (billions)
- Analog vs. Digital Signals
  - Most data is sent using digital signals
    - Data represented by two discrete states: 0s and 1s
  - Conventional telephone systems use analog signals
    - Represent data with continuous waves

FIGURE 7-14
Analog vs. digital signals.



Data Transmission Characteristics

- Transmission Type and Timing
  - Serial vs. Parallel Transmission
    - Serial
      - Data sent one bit at a time, one after another, along a single path
    - Parallel
      - Data sent at least one byte at at time with each bit in the byte taking a different path



Data Transmission Characteristics

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

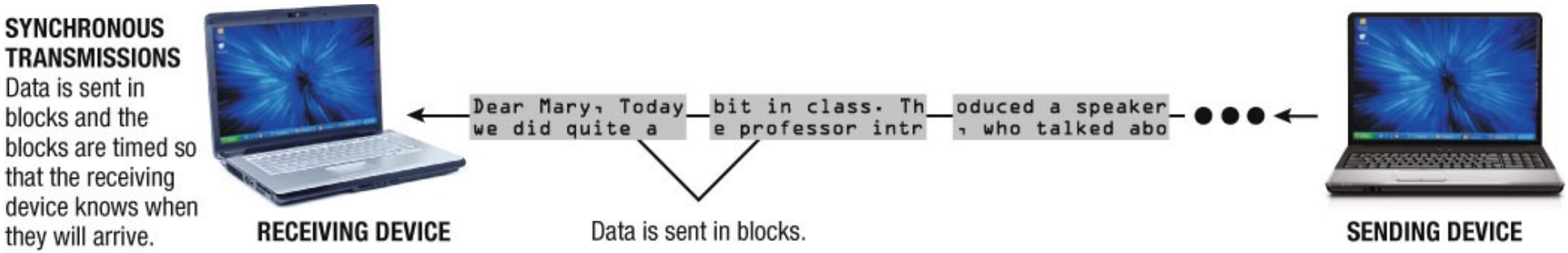


FIGURE 7-16
Transmission timing. Most network transmissions use synchronous transmission.

Data Transmission Characteristics

- 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 sent at the same time as other related, data

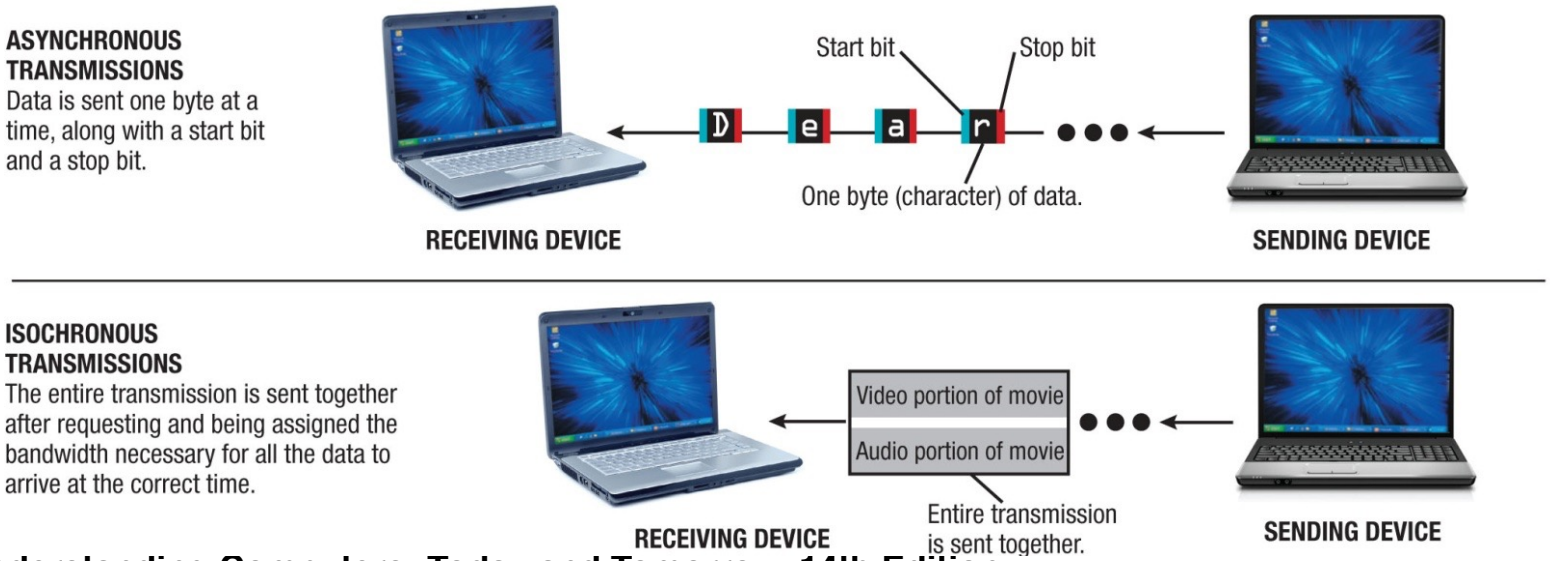


FIGURE 7-16
Transmission timing. Most network transmissions use synchronous transmission.

Data Transmission Characteristics

- Simplex Transmission
  - Data travels in a single direction only
- Half-Duplex Transmission
  - Data travels in either direction but only one way at a time
- Full-Duplex Transmission
  - Data travels in both directions, both ways at the same time

Data Transmission Characteristics

- Delivery Method
  - Circuit-Switching
    - Dedicated path over a network is established between sender and receiver and all data follows that path
  - Packet-Switching
    - Messages are separated into small units called packets and travel along the network separately
    - Used to send data over the Internet
  - Broadcasting
    - Data is sent out to all other nodes on the network and retrieved only by the intended recipient
    - Primarily used with LANs

Data Transmission Characteristics

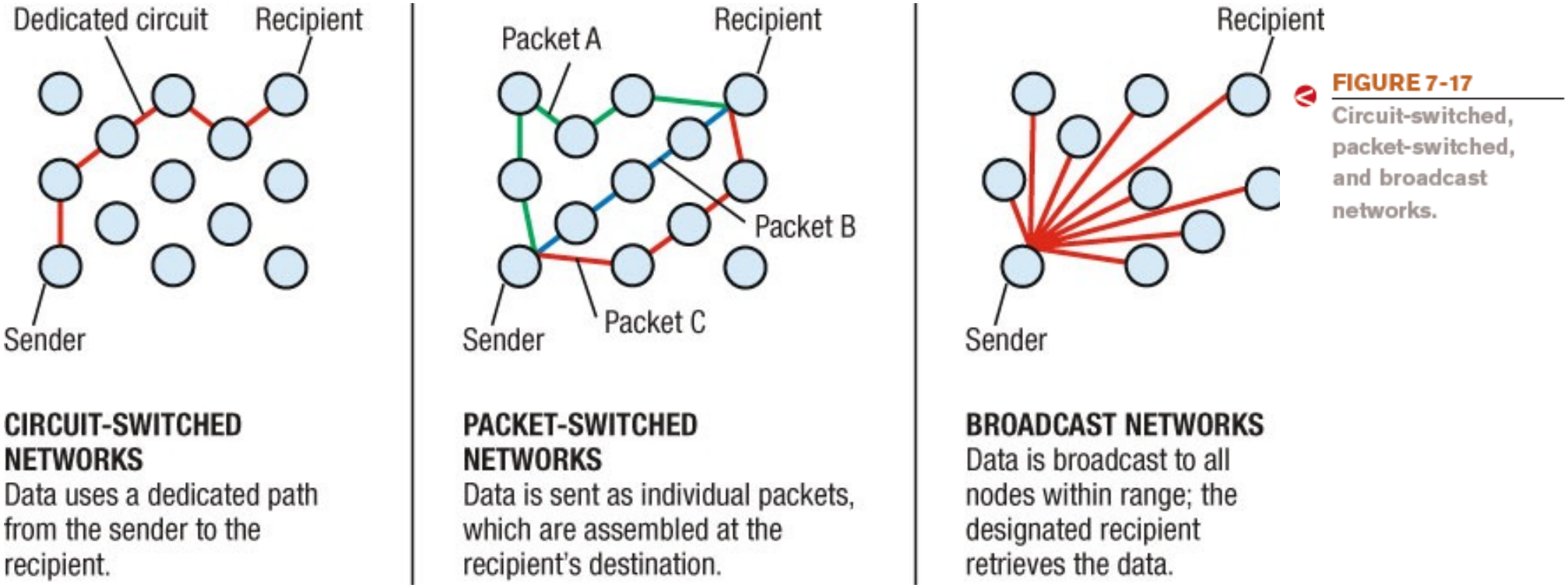
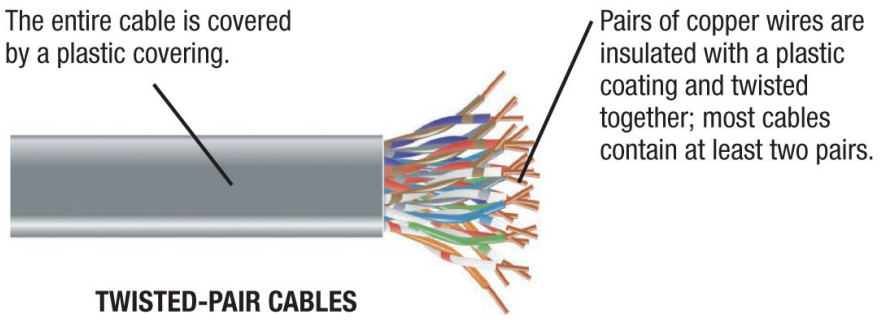


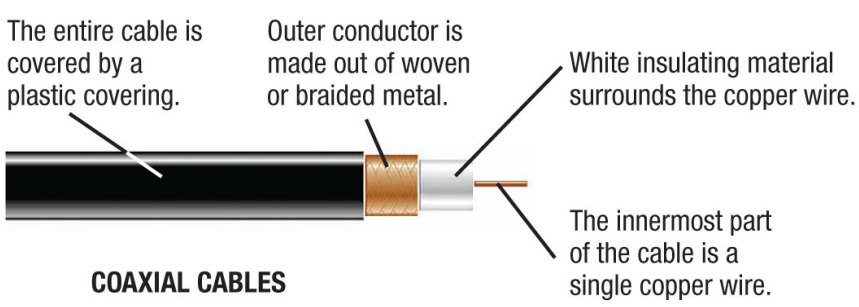
FIGURE 7-17
Circuit-switched, packet-switched, and broadcast networks.

Networking Media

- 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, short-run telephone transmissions, 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

Networking Media





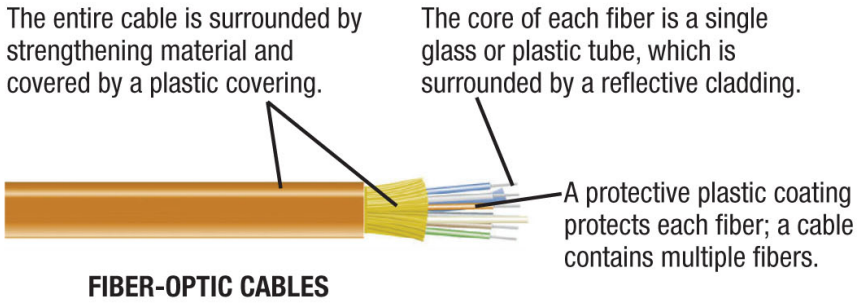


FIGURE 7-18
Wired network transmission media.

Courtesy of Black Box Corporation; Courtesy Belkin International, Inc.

Networking Media

- Wireless Networking Media
  - Data is sent through the airwaves using radio signals
  - The Electromagnetic and Wireless Spectrum
    - Radio frequencies are assigned by the FCC (Federal Communications Commission) and are measured in hertz (Hz)
    - The electromagnetic spectrum is the range of common electromagnetic radiation (energy) that travels in waves
    - Different parts of the spectrum have different properties, which make certain frequencies more appropriate for certain applications

Networking Media

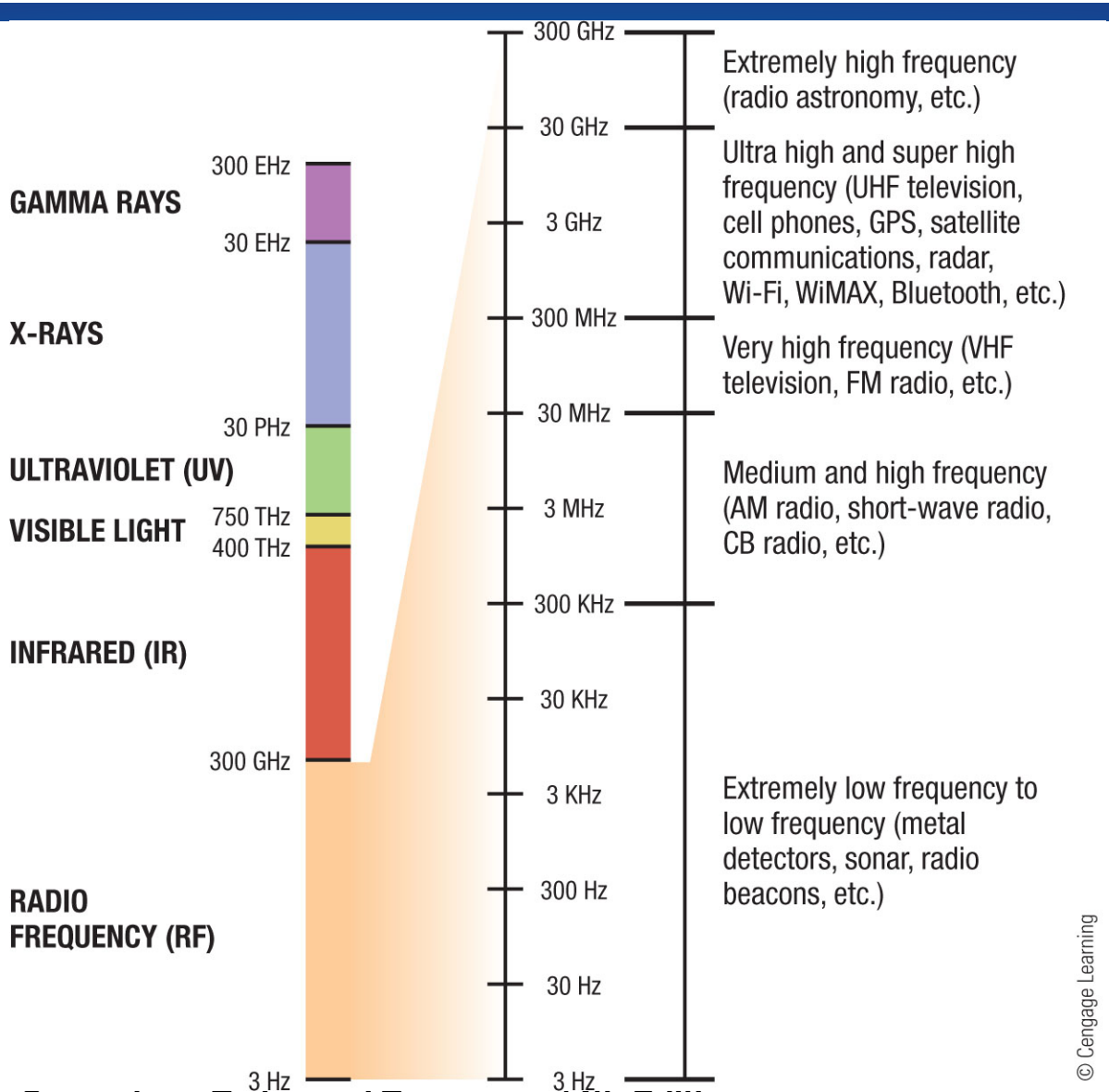


FIGURE 7-19
The electromagnetic spectrum. Each type of communication is assigned specific frequencies within which to operate.

Networking Media

- Frequencies assigned to an application usually consist of a range of frequencies to be used as needed.
- Most wireless networking applications use frequencies in the RF band at the low end of the spectrum—up to 300 GHz
  - Often called the *wireless spectrum*
- The 900 MHz, 2.4GHz, 5 GHz, and 5.8 GHz frequencies are within an unlicensed part of the spectrum and can be used by any product or individual
  - Cordless landline phones, garage door openers, Wi-Fi, WiMAX, and Bluetooth

Networking Media

- Cellular Radio Transmissions
  - Use cellular towers within 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 (Mobile Telephone Switching Office)
  - MTSO routes call to the recipient's phone
  - Data sent via cell phones works in similar manner
  - Cell phone transmission speed depends on the cellular standard being used

Networking Media

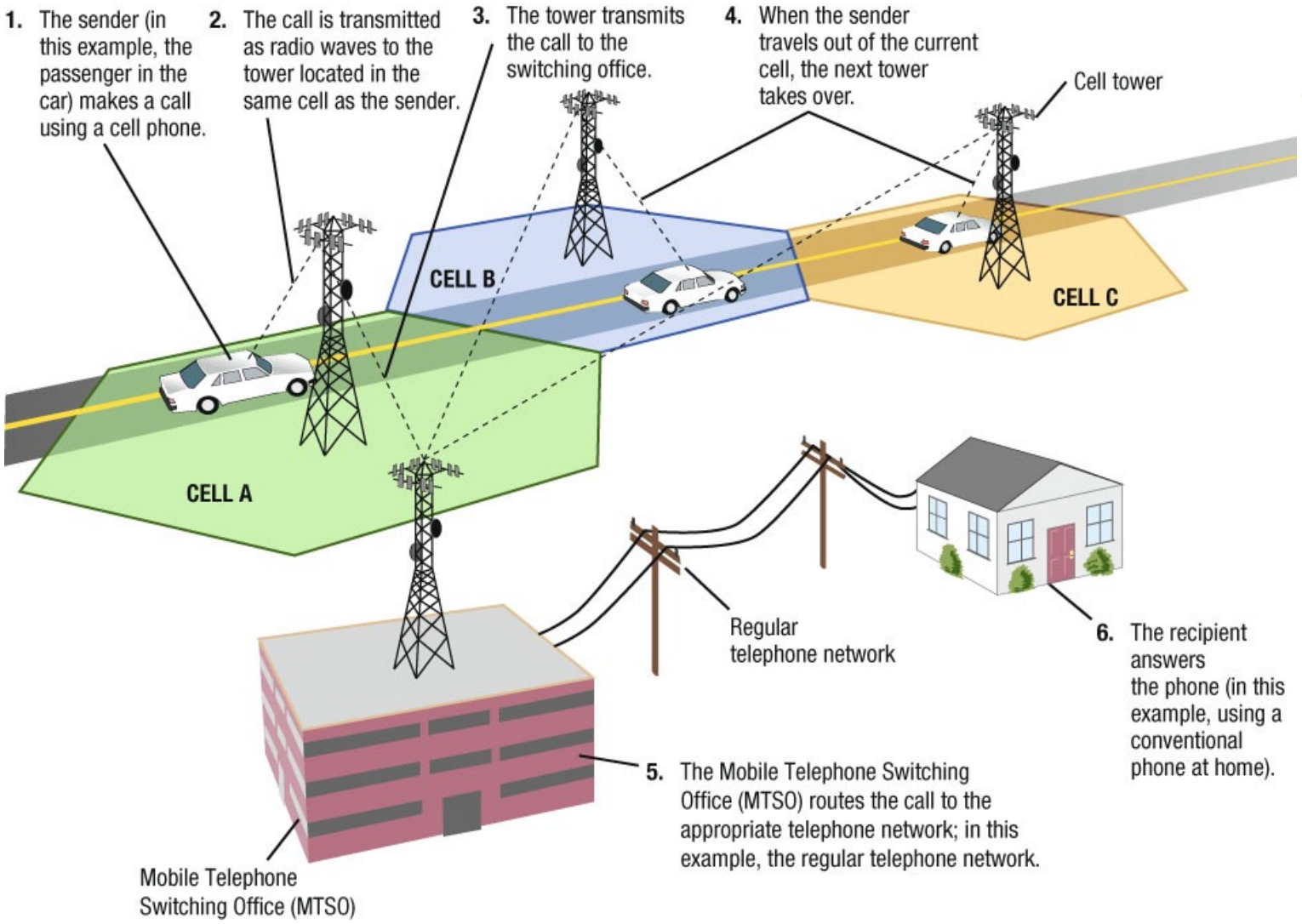


FIGURE 7-20
How cellular phones work.

Networking Media

- Microwave and Satellite Transmissions
  - 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
    - Microwave stations designed to communicate with satellites (television and internet services) are called satellite dishes

Networking Media

- 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 half a second is common when signals travel from earth to satellite and back
  - Low earth orbit (LEO) satellites were developed to combat delay
  - Medium earth orbit (MEO) satellites are most often used for GPS systems

Networking Media

FIGURE 7-21
How satellite Internet works.

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

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

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

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.

tatniz/Shutterstock.com; Hughes Network Systems LLC

Networking Media

- Infrared (IR) Transmissions
  - Sends data as infrared light rays
  - Like an infrared television remote, IR requires line of sight
  - Because of this limitation, many formerly IR devices (wireless mice, keyboards) now use RF technology
  - IR is still sometimes used to beam data between portable computers or gaming systems, or send documents from portable computers to printers

Quick Quiz

1. Which of the following 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. A device located in space that orbits the earth to provide communications services is called a(n) _____.

Answers:

1) b; 2) True; 3) satellite