# Chapter Three

## Conducted and Wireless Media

Data Communications and Computer Networks: A Business User's Approach

Seventh Edition

# After reading this chapter, you should be able to:

- *Outline* the characteristics of twisted pair wire, including the advantages and disadvantages
- *Outline* the differences among Category 1, 2, 3, 4, 5, 5e, 6, and 7 twisted pair wire
- *Explain* when shielded twisted pair wire works better than unshielded twisted pair wire
- *Outline* the characteristics, advantages, and disadvantages of coaxial cable and fiber-optic cable
- *Outline* the characteristics of terrestrial microwave systems, including the advantages and disadvantages

# After reading this chapter, you should be able to (continued):

- *Outline* the characteristics of satellite microwave systems, including the advantages and disadvantages as well as the differences among low-Earth-orbit, middle-Earth-orbit, geosynchronous orbit, and highly elliptical Earth orbit satellites
- *Describe* the basics of cellular telephones, including all the current generations of cellular systems
- *Outline* the characteristics of short-range transmissions, including Bluetooth

# After reading this chapter, you should be able to (continued):

- *Describe* the characteristics, advantages, and disadvantages of Wireless Application Protocol (WAP), broadband wireless systems, and various wireless local area network transmission techniques
- *Apply* the media selection criteria of cost, speed, right-of-way, expandability and distance, environment, and security to various media in a particular application

# Introduction

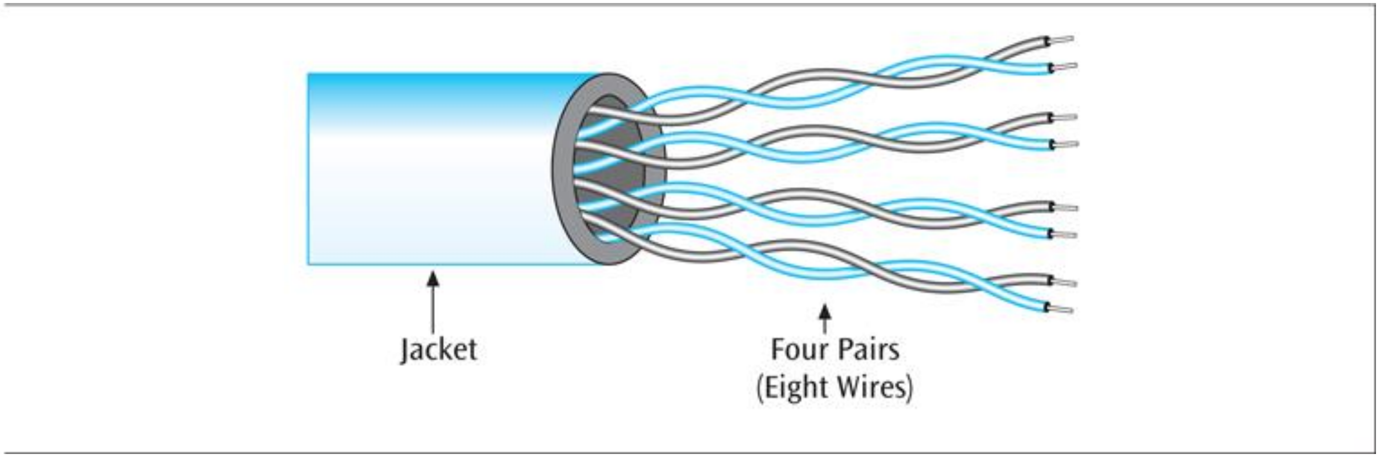
- The world of computer networks *would not exist* if there were no medium by which to transfer data
- The two major categories of media include:
  - Conducted media
  - Wireless media

# Twisted Pair Wire

- *One* or *more pairs* of single conductor wires that have been twisted around each other
- *Twisted pair wire is classified by category*. Twisted pair is currently Category 1 through Category 7, although Categories 1, 2 and 4 are nearly obsolete
- Twisting the wires helps *to eliminate electromagnetic interference* between the two wires
- *Shielding* can further help *to eliminate interference*

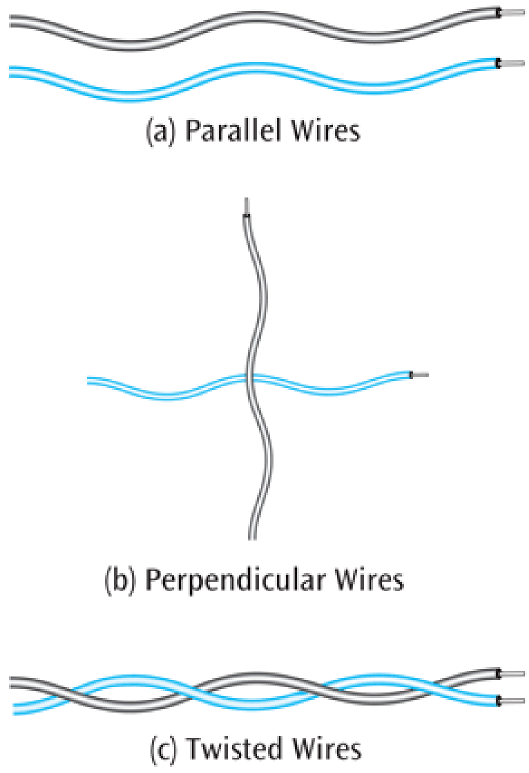
# Twisted Pair Wire (continued)

**Figure 3-1**
*Example of four-pair twisted pair wire*



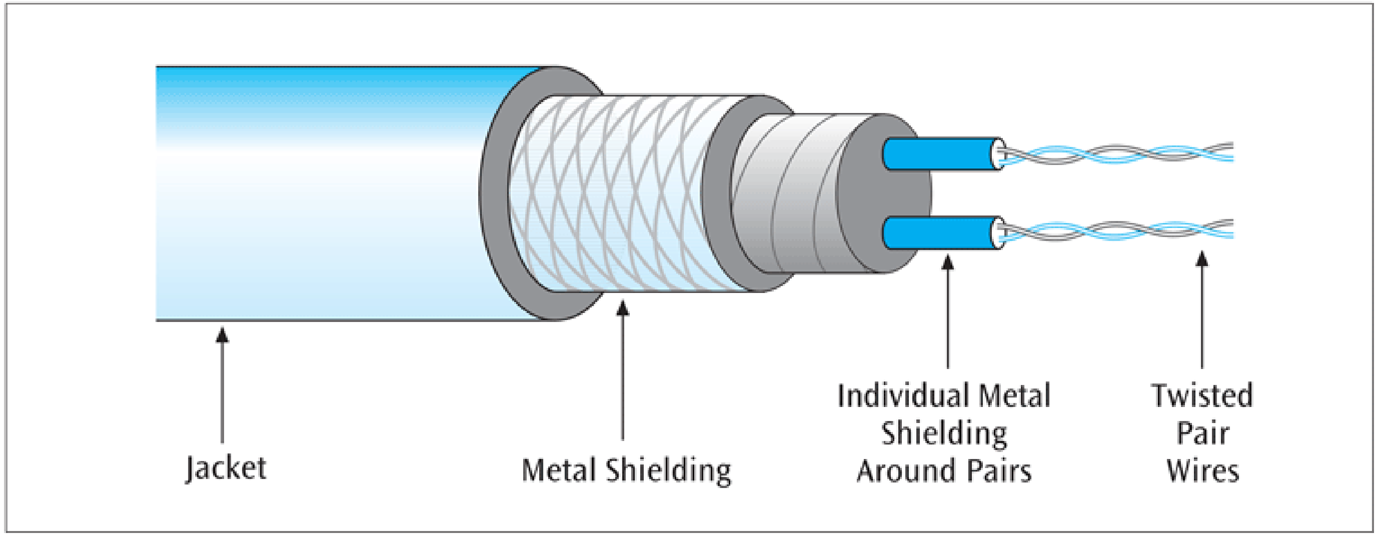
# Twisted Pair Wire (continued)

**Figure 3-2**
*(a) Parallel wires—greater chance of crosstalk*
*(b) Perpendicular wires—lesser chance of crosstalk*
*(c) Twisted wires—crosstalk reduced because wires keep crossing each other at nearly perpendicular angles*



# Twisted Pair Wire (continued)

**Figure 3-3**
*An example of shielded twisted pair*



# Twisted Pair Wire (continued)

**Table 3-1**

*A summary of the characteristics of twisted pair wires*

| UTP Category | Typical Use | Maximum Data Transfer Rate | Maximum Transmission Range | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Category 1 | Telephone wire | <100 kbps | 5–6 kilometers (3–4 miles) | Inexpensive, easy to install and interface | Security, noise, obsolete |
| Category 2 | T-1, ISDN | <2 Mbps | 5–6 kilometers (3–4 miles) | Same as Category 1 | Security, noise, obsolete |
| Category 3 | Telephone circuits | 10 Mbps | 100 m (328 ft) | Same as Category 1, with less noise | Security, noise |
| Category 4 | LANs | 20 Mbps | 100 m (328 ft) | Same as Category 1, with less noise | Security, noise, obsolete |
| Category 5 | LANs | 100 Mbps (100 MHz) | 100 m (328 ft) | Same as Category 1, with less noise | Security, noise |
| Category 5e | LANs | 250 Mbps per pair (125 MHz) | 100 m (328 ft) | Same as Category 5. Also includes specifications for connectors, patch cords, and other components | Security, noise |
| Category 6 | LANs | 250 Mbps per pair (250 MHz) | 100 m (328 ft) | Higher rates than Category 5e, less noise | Security, noise, cost |
| Category 7 | LANs | 600 MHz | 100 m (328 ft) | High data rates | Security, noise, cost |

# Twisted Pair Summary

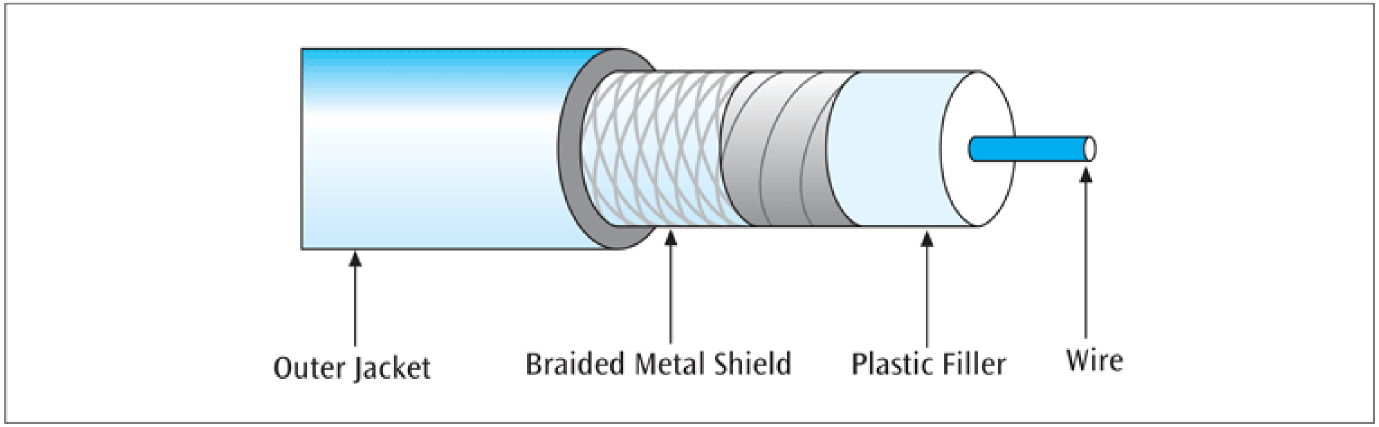
- Most common form of wire
- Relatively inexpensive
- Easy to install
- Carries high data rates (but not the highest)
- Can suffer from electromagnetic noise
- Can be easily wire-tapped
- Comes in shielded and unshielded forms

# Coaxial Cable

- A *single wire* wrapped in a foam insulation surrounded by a braided metal shield, then covered in a plastic jacket. Cable comes in various thicknesses
- ***Baseband coaxial*** technology uses **digital signaling** in which the cable carries only *one channel* of digital data
- ***Broadband coaxial*** technology transmits **analog signals** and is capable of supporting *multiple channels*

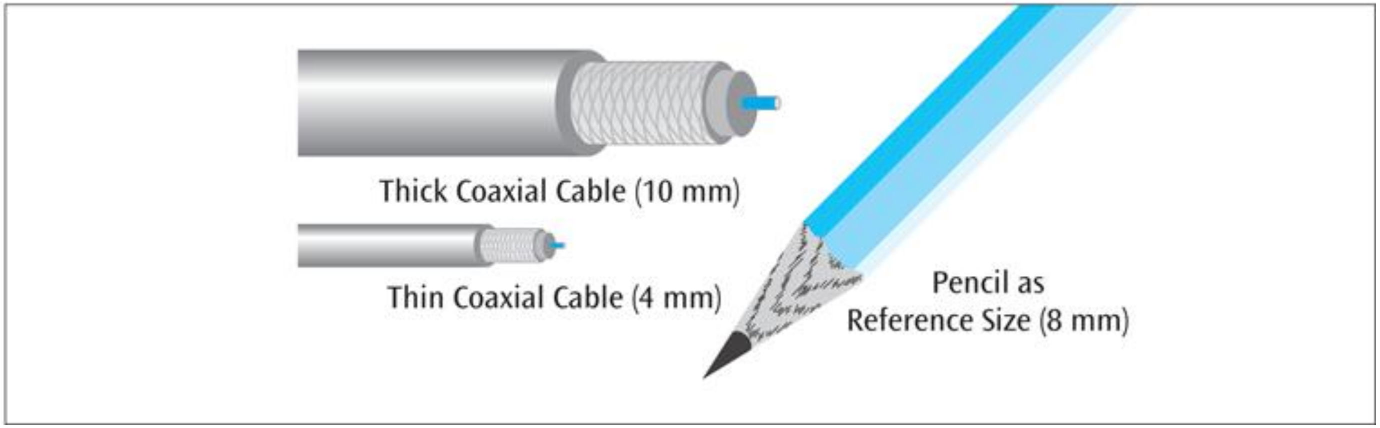
# Coaxial Cable (continued)

**Figure 3-4**
*Example of coaxial cable showing metal braid*



# Coaxial Cable (continued)

**Figure 3-5**
*Examples of thick coaxial cable and thin coaxial cable*



# Coaxial Cable Summary

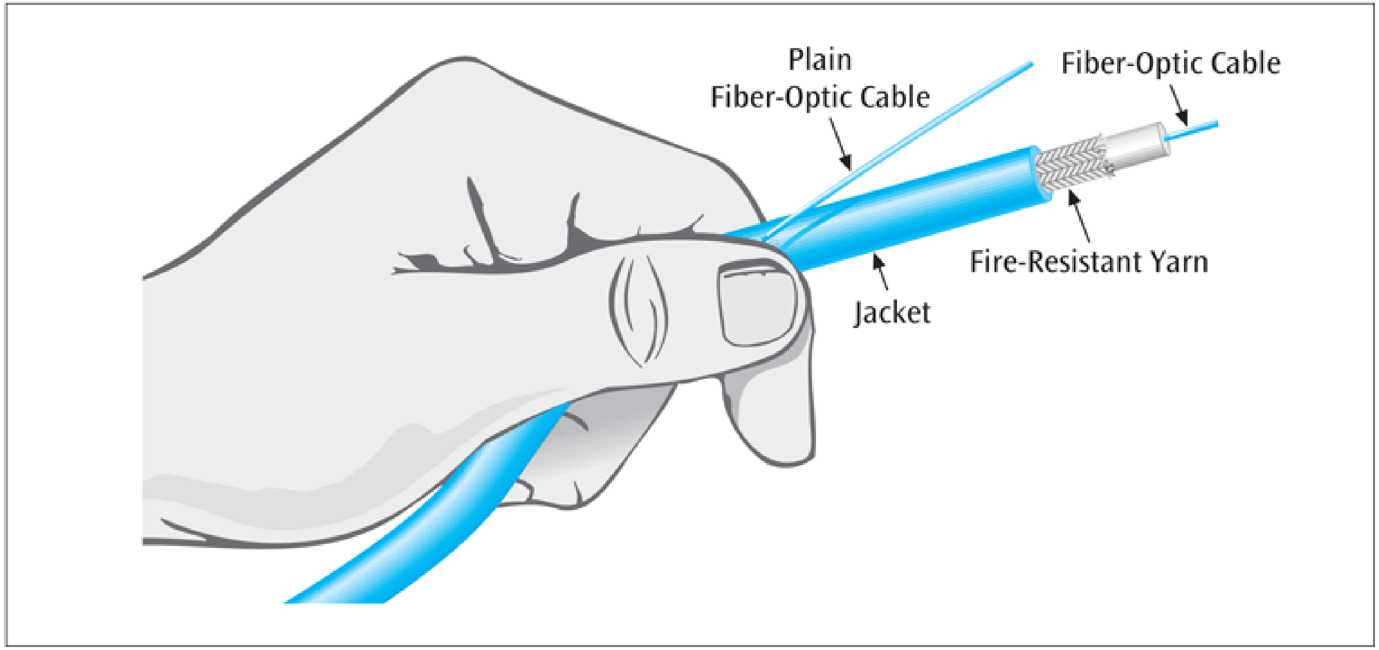
- A single wire surrounded by a braided shield
- Because of shielding, can carry a wide bandwidth of frequencies
- Thus is good with applications such as cable television
- Not as easy to install as twisted pair
- More expensive than twisted pair

# Fiber-Optic Cable

- A *thin glass* cable approximately a little thicker than a human hair surrounded by a plastic coating and packaged into an insulated cable
- A photo diode or laser generates pulses of light which travel down the fiber optic cable and are received by a photo receptor

# Fiber-Optic Cable (continued)

**Figure 3-6**
*A person holding a plain fiber-optic cable and a fiber-optic cable in an insulated jacket*



# Fiber-Optic Cable (continued)

- Fiber-optic cable is capable of supporting millions of bits per second for 1000s of meters
- *Thick cable* (62.5/125 microns) causes more ray collisions, so you have to transmit slower. This is step index multimode fiber. Typically use LED for light source, shorter distance transmissions
- *Thin cable* (8.3/125 microns) – very little reflection, fast transmission, typically uses a laser, longer transmission distances; known as single mode fiber

# Fiber-Optic Cable (continued)

**Figure 3-7**
*A fiber-optic cable with multiple strands of fiber*

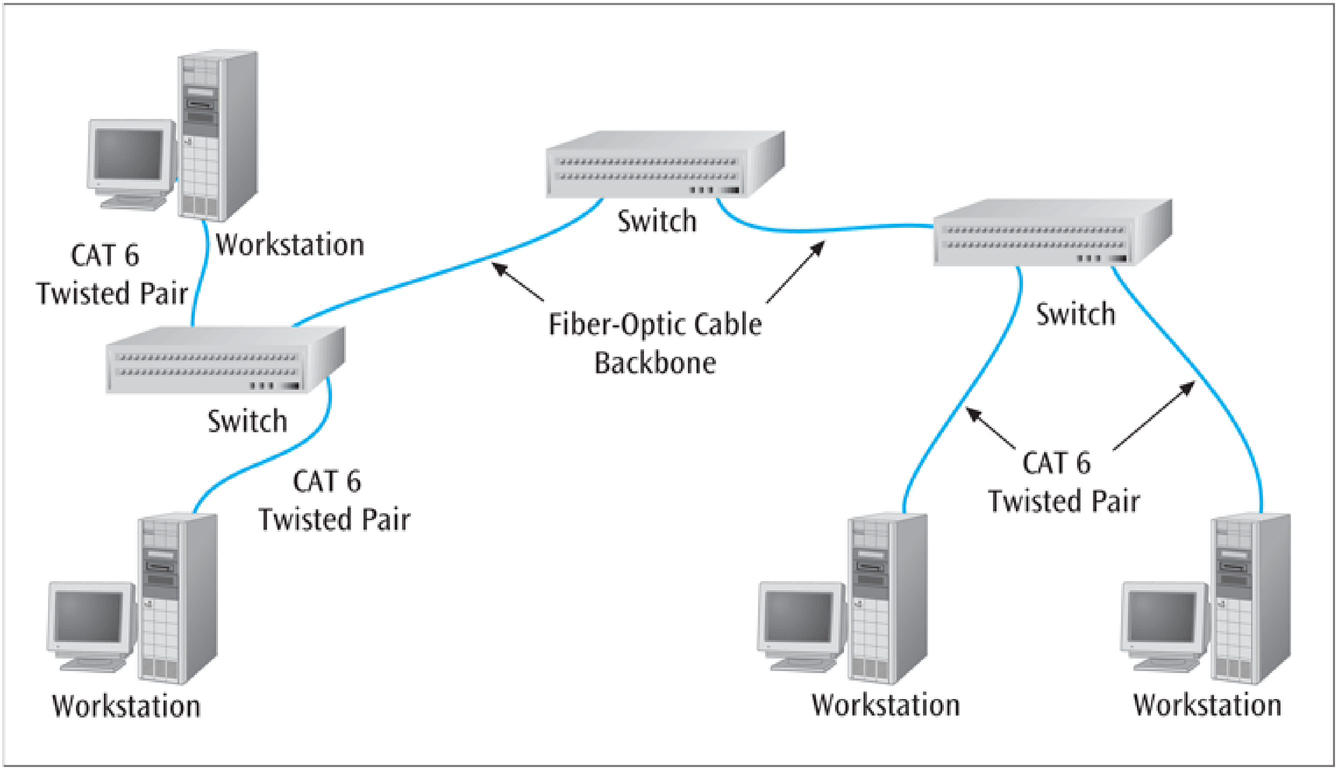
# Fiber-Optic Cable (continued)

- Fiber-optic cable is susceptible to *reflection* (where the light source bounces around inside the cable) and *refraction* (where the light source passes out of the core and into the surrounding cladding)
- Thus, fiber-optic cable is not perfect either. *Noise is still a potential problem*

# Fiber-Optic Cable (continued)

**Figure 3-8**

*A fiber-optic backbone with Category 6 twisted pair running to the workstations*



# Fiber-Optic Cable (continued)

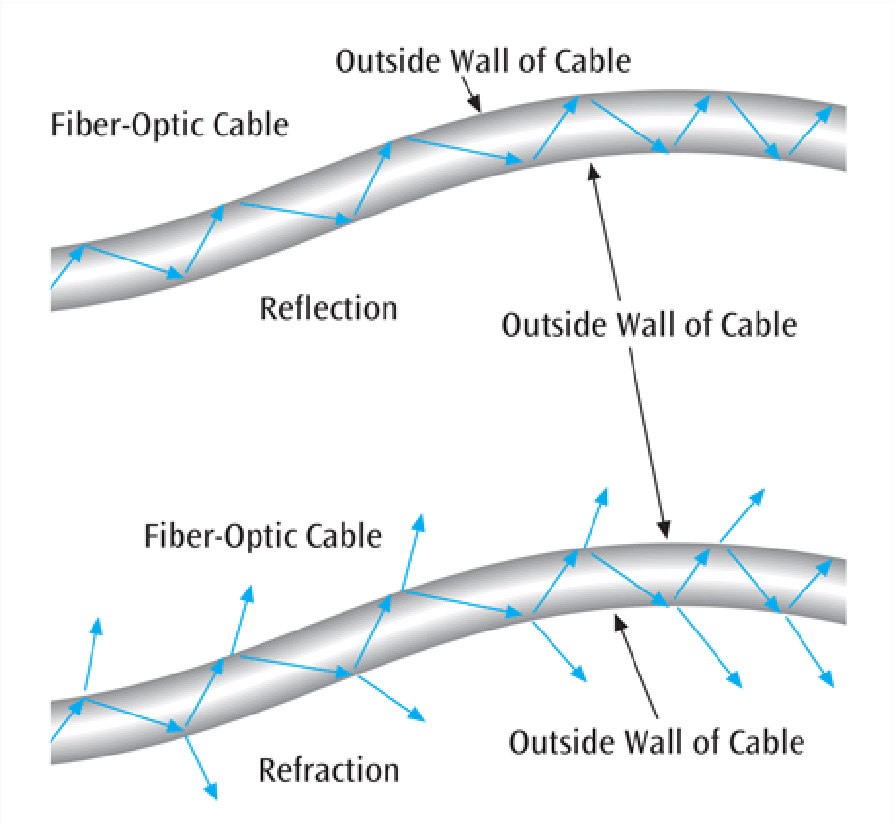



**Figure 3-9** *A simple demonstration of reflection and refraction in a fiber-optic cable*

# Fiber-Optic Cable Summary

- Fiber optic cable can carry the highest data rate for the longest distances
- Initial cost-wise, more expensive than twisted pair, but less than coaxial cable
- But when you consider the superiority of fiber, initial costs outweighed by capacities
- Need to fibers for a round-trip connection
- Not affected by electromagnetic noise and cannot be easily wiretapped, but still noise

# Conducted Media

**Table 3-3**

*A summary of the characteristics of conducted media*

| Type of Conducted Medium | Typical Use | Maximum Data Rate | Maximum Transmission Range | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Twisted pair Category 1, 3 | Telephone systems | <2 Mbps | 5–6 kilometers (3–4 miles) | Inexpensive, common | Noise, security, obsolete |
| Twisted pair Category 5, 5e, 6, 7 | LANs | 100–1000 Mbps | 100 m (328 feet) | Inexpensive, versatile | Noise, security |
| Thin Coaxial Cable (baseband single channel) | LANs | 10 Mbps | 100 m (328 feet) | Low noise | Security |
| Thick Coaxial Cable (broadband multichannel) | LANs, cable TV, long-distance telephone, short-run computer system links | 10–100 Mbps | 5–6 kilometers (3–4 miles) (at lower data rates) | Low noise, multiple channels | Security |
| LED Fiber-Optic | Data, video, audio, LANs | Gbps | 300 meters (approx. 1000 feet) | Secure, high capacity, low noise | Interface expensive but decreasing in cost |
| Laser Fiber-Optic | Data, video, audio, LANs, WANs, MANs | 100s Gbps | 100 kilometers (approx. 60 miles) | Secure, high capacity, very low noise | Interface expensive |

# Wireless Media

- Radio, satellite transmissions, and infrared light are all *different forms of electromagnetic waves* that are used to transmit data
- Technically speaking – in wireless transmissions, *space is the medium*
- Note in the following figure how each source occupies a different set of frequencies

# Wireless Media (continued)

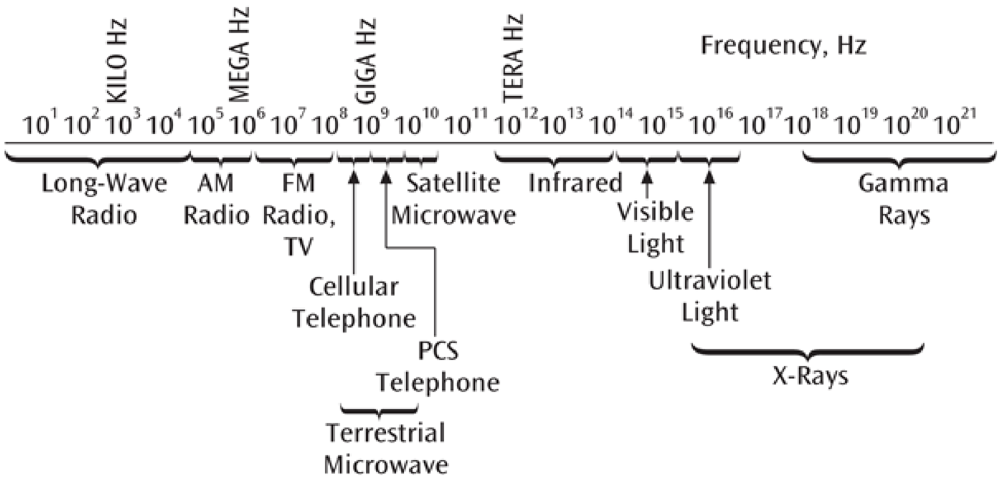



**Figure 3-10**
*Electromagnetic wave frequencies*

Approximate Frequencies

AM Radio $10^5$-$10^6$
FM Radio, TV $10^7$-$10^8$
Terrestrial Microwave $10^8$-$10^9$ (x00 MHz - x GHz)
Cellular Telephone $10^8$ (800 MHz)
Satellite Microwave $10^9$ (x GHz)
PCS Telephone $10^9$ (2000 MHz or 2 GHz)
Infrared $10^{12}$-$10^{14}$
Visible Light $10^{14}$
Ultraviolet Light $10^{15}$-$10^{16}$
X-Rays $10^{15}$-$10^{20}$
Gamma Rays $10^{18}$-$10^{21}$

# Terrestrial Microwave Transmission

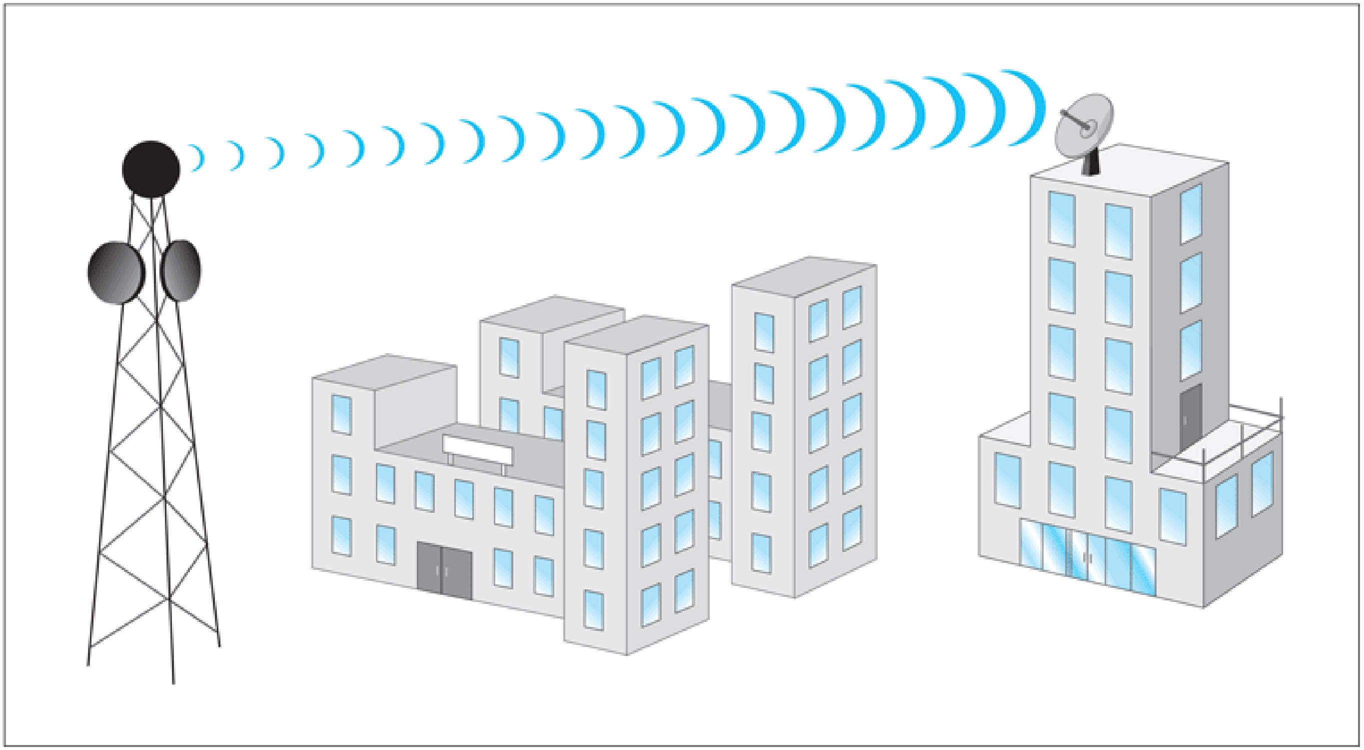
- Land-based, line-of-sight transmission
- Approximately 20-30 miles between towers
- Transmits data at hundreds of millions of bits per second
- *Signals will not pass through solid objects*
- Popular with telephone companies and business to business transmissions

# Terrestrial Microwave Transmission (continued)

**Figure 3-11**
*A typical microwave tower and antenna*

# Terrestrial Microwave Transmission (continued)

**Figure 3-12**
*A microwave antenna on top of a free-standing tower transmitting to another antenna on the top of a building*

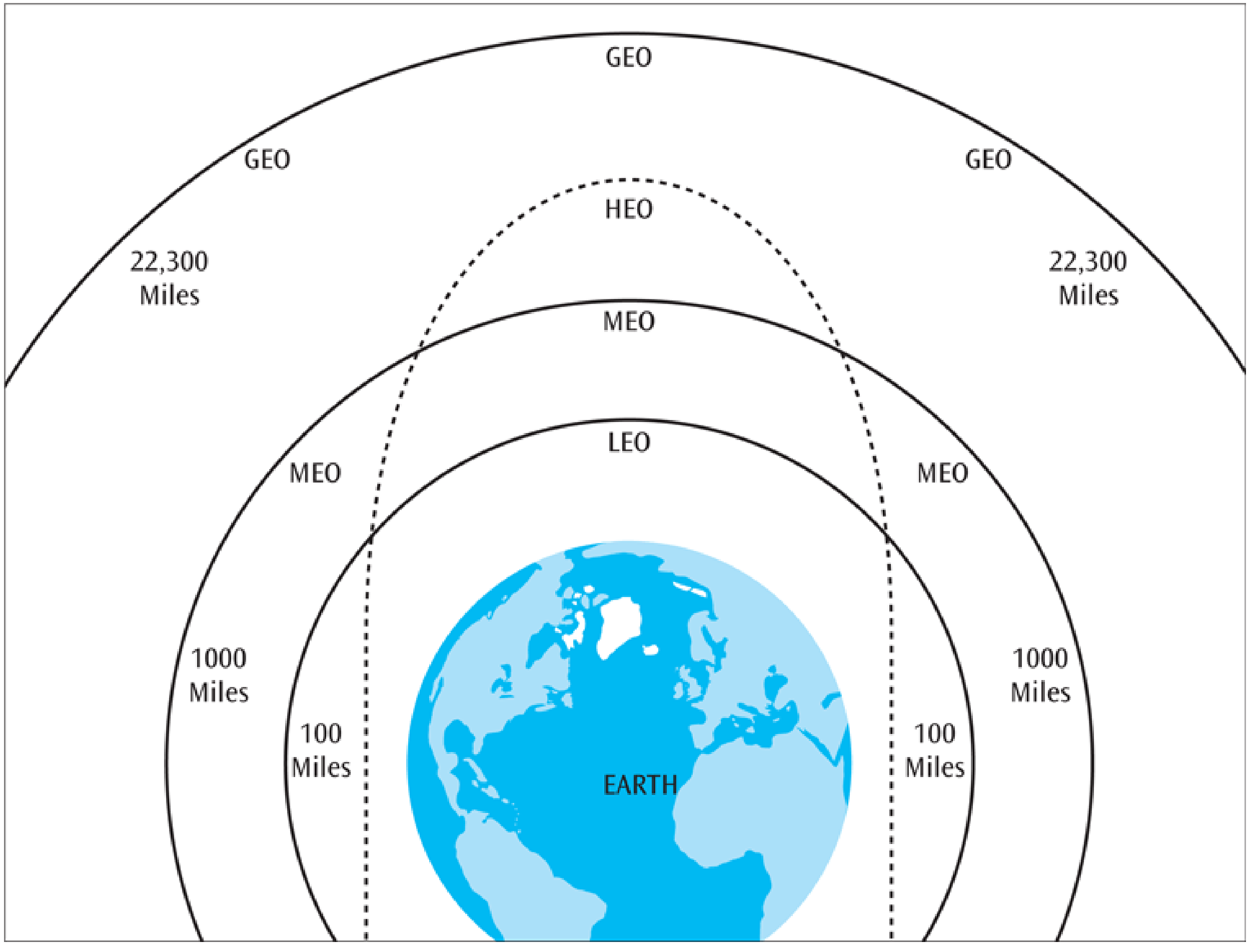


# Satellite Microwave Transmission

- Similar to terrestrial microwave except the signal travels from a ground station on earth to a satellite and back to another ground station
- Can also transmit signals from one satellite to another
- Satellites can be classified by how far out into orbit each one is (LEO, MEO, GEO, and HEO)

# Satellite Microwave Transmission (continued)

**Figure 3-13**
*Earth and the four Earth orbits: LEO, MEO, GEO, and HEO*



# Satellite Microwave Transmission (continued)

- LEO (Low-Earth-Orbit) – 100 to 1000 miles out
  - Used for wireless e-mail, special mobile telephones, pagers, spying, videoconferencing
- MEO (Middle-Earth-Orbit) – 1000 to 22,300 miles
  - Used for GPS (global positioning systems) and government
- GEO (Geosynchronous-Earth-Orbit) – 22,300 miles
  - Always over the same position on earth (and always over the equator)
  - Used for weather, television, government operations

# Satellite Microwave Transmission (continued)

- HEO (Highly Elliptical Earth orbit) – satellite follows an elliptical orbit
  - Used by the military for spying and by scientific organizations for photographing celestial bodies

# Satellite Microwave Transmission (continued)

- Satellite microwave can also be classified by its configuration (see next figure):
  - Bulk carrier configuration
  - Multiplexed configuration
  - Single-user earth station configuration (e.g. VSAT)

# Satellite Microwave Transmission (continued)

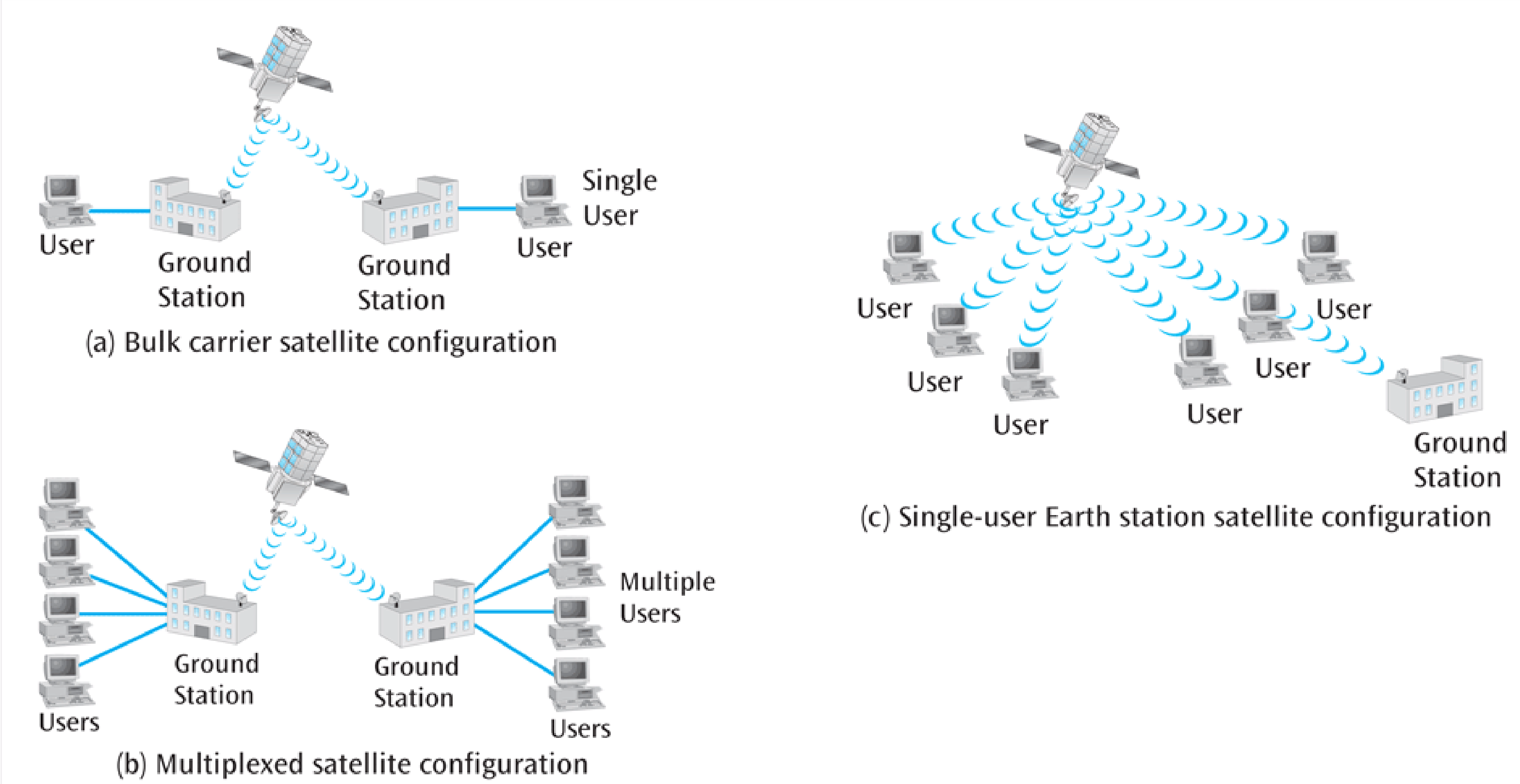
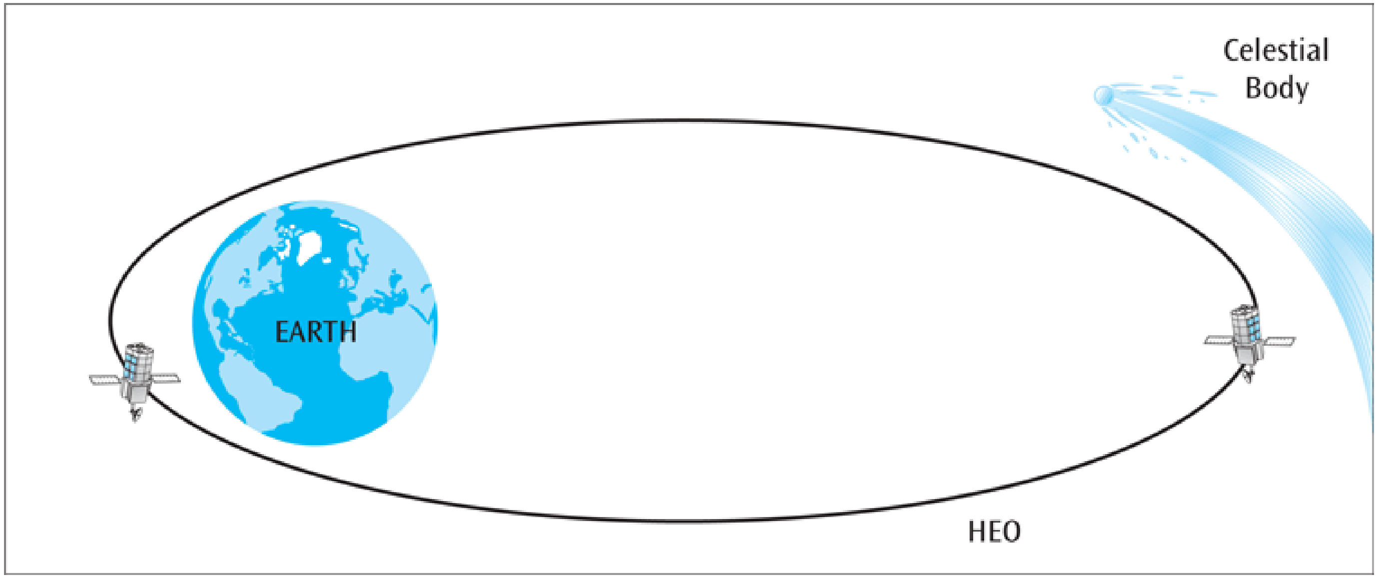



**Figure 3-14** *Bulk carrier facilities, multiplexed Earth station, and single-user Earth station configurations of satellite systems*

# Satellite Microwave Transmission (continued)

**Figure 3-15**
*Diagram of a highly elliptical Earth orbit satellite*



# Satellite Microwave Transmission (continued)

| Band Number | Symbol | Frequency | Common Use |
|---|---|---|---|
| 4 | VLF (very low frequency) | 3–30 kHz | Radio navigations systems |
| 5 | LF (low frequency) | 30–300 kHz | Radio beacons |
| 6 | MF (medium frequency) | 300 kHz–3 MHz | AM radio |
| 7 | HF (high frequency) | 3–30 MHz | CB radio |
| 8 | VHF (very high frequency) | 30–300 MHz | VHF TV, FM radio |
| 9 | UHF (ultra high frequency) | 300 MHz–3 GHz | UHF TV, cell phones, pagers |
| 10 | SHF (superhigh frequency) | 3–30 GHz | Satellite |
| 11 | EHF (extremely high freq) | 30–300 GHz | Satellite, radar systems |

# Satellite Microwave Transmission (continued)

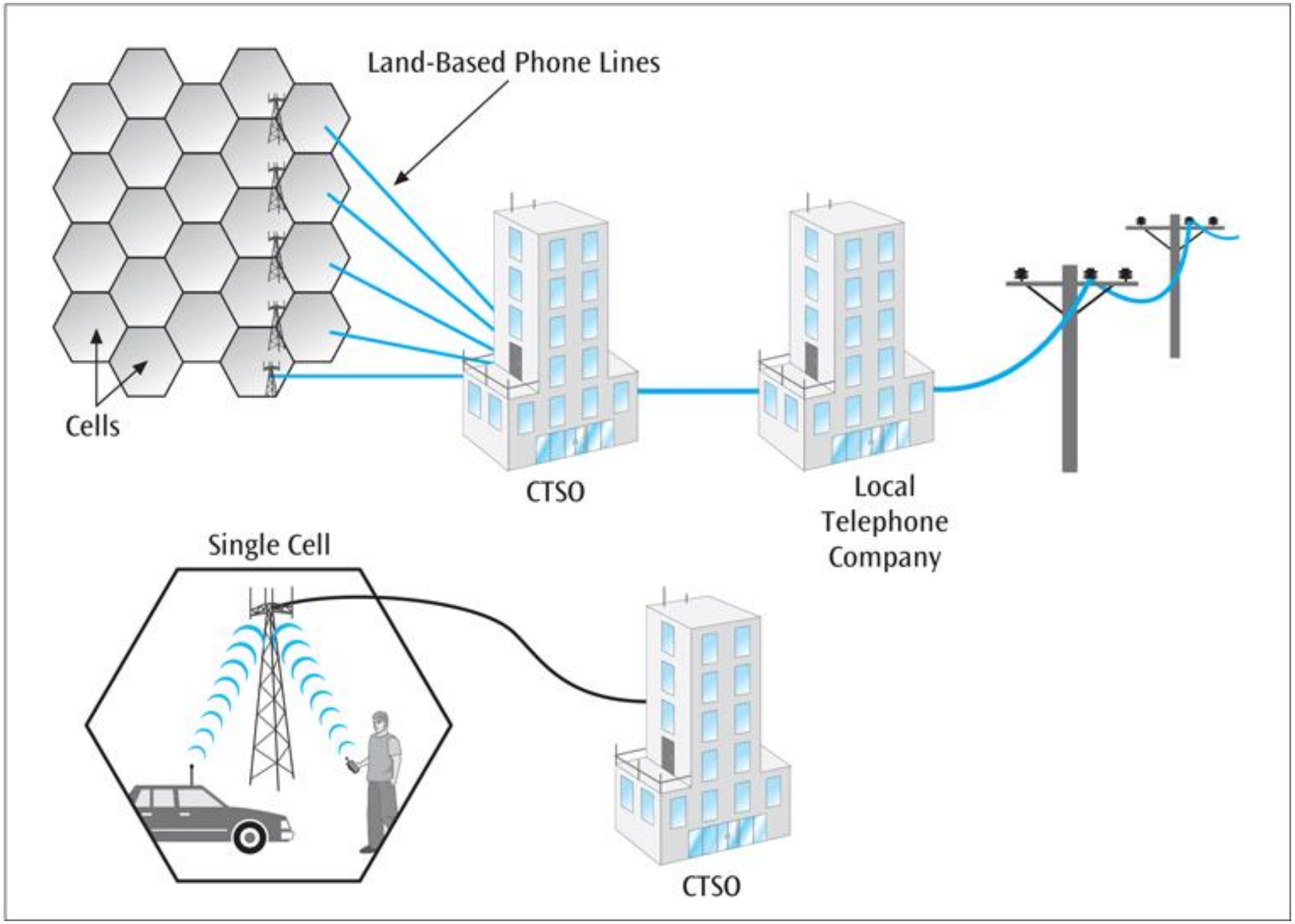
| Radar Band | Frequency | Common Use |
|---|---|---|
| L | ~1–2 GHz | GPS, government use, GSM cell phones |
| S | 2–4 GHz | Weather systems, digital satellite radio system |
| C | 4–8 GHz | Commercial satellite systems |
| X | ~7–12.5 GHz | Some communication satellites, weather |
| Ku | 12–18 GHz | NASA, television station remotes to station |
| Ka | 18–40 GHz | Communication satellites |
| V | 50–75 GHz | Not heavily used |
| W | 75–111 GHz | Misc (military, car radar systems) |

# Cellular Telephones

- Wireless telephone service, also called mobile telephone, cell phone, and PCS
- To support multiple users in a metropolitan area (market), the market is *broken into cells*
- Each cell has its *own transmission tower* and *set of assignable channels*

# Cellular Telephones (continued)

**Figure 3-16**
*One cellular telephone market divided into cells*



# Cellular Telephones (continued)

**Figure 3-17**
*A cellular telephone tower*

# Cellular Telephones (continued)

**Figure 3-18**
*Cell phone towers disguised as trees*

# Cellular Telephones (continued)

- Placing a call on a cell phone
  - You enter a phone number on your cell phone and press Send. Your cell phone contacts the nearest cell tower and grabs a set-up channel. Your mobile identification information is exchanged to make sure you are a current subscriber.
  - If you are current, you are *dynamically assigned two channels*: *one for talking*, and *one for listening*. The telephone call is placed. You talk.

# Cellular Telephones (continued)

- Receiving a call on a cell phone
  - Whenever a cell phone is on, it "pings" the *nearest cell tower every several seconds*, exchanging mobile ID information. This way, the cell phone system knows where each cell phone is.
  - When someone calls your cell phone number, since the cell phone system knows what cell you are in, the tower "calls" your cell phone.

# Cellular Telephones (continued)

- **1st Generation**
  - AMPS (Advanced Mobile Phone Service) – first popular cell phone service; used *analog signals* and ***dynamically*** *assigned channels*
  - D-AMPS (Digital AMPS) – applied digital multiplexing techniques on top of AMPS analog channels

# Cellular Telephones (continued)

- **2nd Generation**
  - PCS (Personal Communication Systems) – essentially all-digital cell phone service
  - PCS phones came in three technologies:
    - TDMA – Time Division Multiple Access
    - CDMA – Code Division Multiple Access
    - GSM – Global System for Mobile Communications

# Cellular Telephones (continued)

- **2.5 Generation**
  - AT&T Wireless, Cingular Wireless, and T-Mobile now using GPRS (General Packet Radio Service) in their GSM networks (can transmit data at 30 kbps to 40 kbps)
  - Verizon Wireless, Alltel, U.S.Cellular, and Sprint PCS are using CDMA2000 1xRTT (one carrier radio- transmission technology) (50 kbps to 75 kbps)
  - Nextel uses IDEN technology

# Cellular Telephones (continued)

- **3rd Generation**
  - UMTS (Universal Mobile Telecommunications System) – also called Wideband CDMA
    - The 3G version of GPRS
    - UMTS not backward compatible with GSM (thus requires phones with multiple decoders)
  - 1XEV (1 x Enhanced Version) –3G replacement for 1xRTT
    - two forms:
      - 1xEV-DO for data only
      - 1xEV-DV for data and voice

# Cellular Telephones (continued)

- **4th Generation**
  - LTE (Long Term Evolution) – theoretical speeds of 100 Mbps or more, actual download speeds 10-15 Mbps (Verizon currently has LTE)
  - WiMax – introduced in a couple slides – theoretical speeds of 128 Mbps; actual download speeds 4 Mbps (Sprint and Clearwire)
  - HSPA (High Speed Packet Access) – 14 Mbps downlink, 5.8 Mbps uplink; is this 3.5G or 4G?
  - HSPA+ – theoretical downlink of 84 Mbps, 22 Mbps uplink (T-Mobile) 3.5G or 4G?

# WiMax - Broadband Wireless Systems

- Delivers Internet services into homes, businesses and mobile devices
- Designed to bypass the local loop telephone line
- Transmits voice, data, and video over high frequency radio signals
- Maximum range of 20-30 miles and transmission speeds in Mbps
- IEEE 802.16 set of standards

# WiMax (continued)

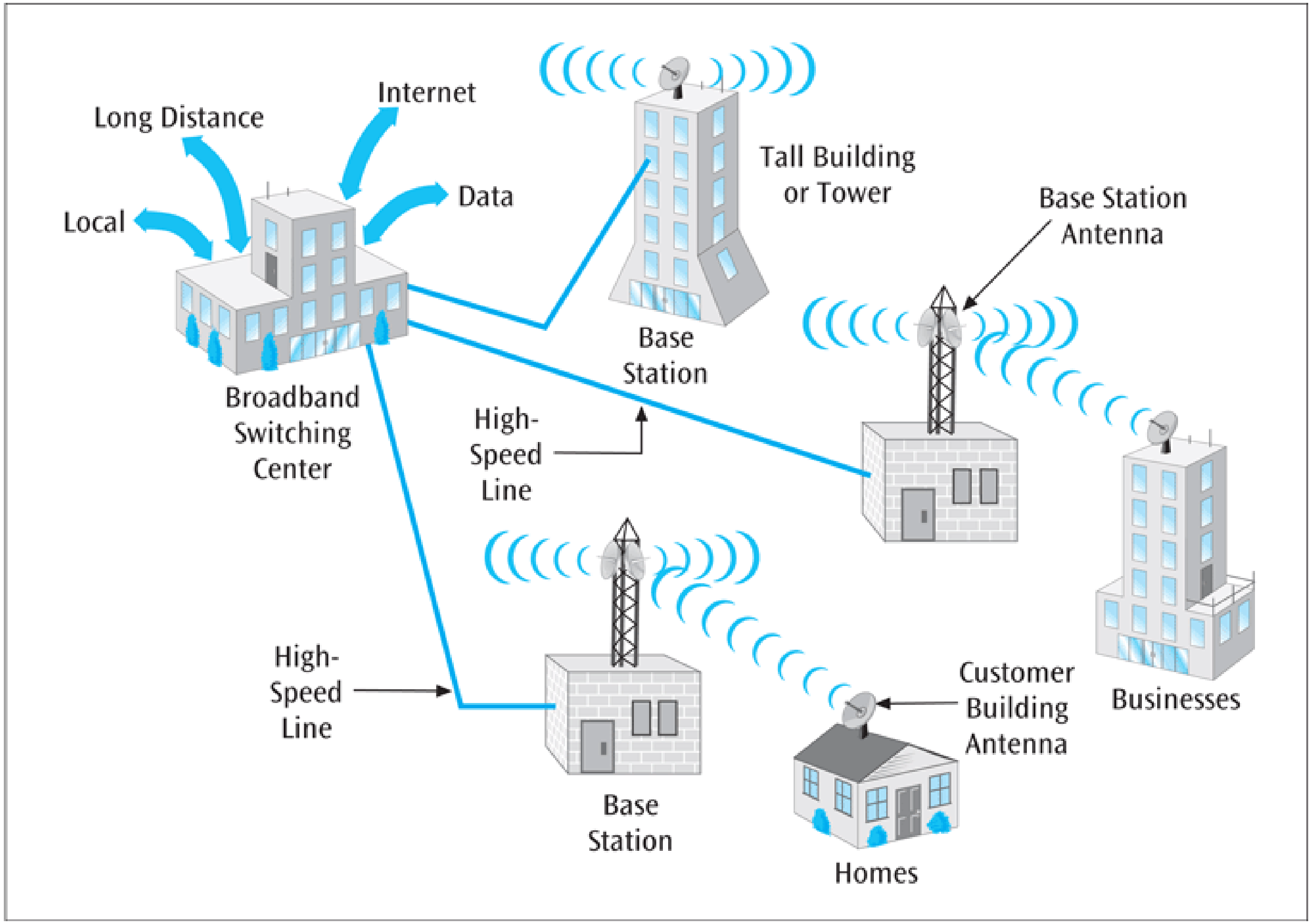



**Figure 3-19**
*Broadband wireless configuration in a metropolitan area*

# Bluetooth

- Bluetooth is a specification for short-range, *point-to-point* or *point-to-multipoint* voice and data transfer
- Bluetooth can transmit *through* solid, non-metal objects
- Its typical link range is from 10 cm to 10 m, but can be extended to 100 m by increasing the power

# Bluetooth (continued)

- Bluetooth will enable users to connect to a wide range of computing and telecommunication devices without the need of connecting cables
- Typical uses include phones, pagers, modems, LAN access devices, headsets, notebooks, desktop computers, and PDAs

# Wireless Local Area Networks (IEEE 802.11)

- This technology transmits data *between workstations* and *local area networks* using high-speed radio frequencies
- Current technologies allow up to 100 Mbps (theoretical) data transfer at distances up to hundreds of feet
- Three popular standards: IEEE 802.11b, a, g, n
- More on this in Chapter Seven (LANs)

# Free Space Optics and Ultra-Wideband

- Free space optics
  - Uses ***lasers***, or more economically, ***infrared*** transmitting devices
  - ***Line of sight*** between buildings
  - Typically ***short distances***, such as across the street
  - Newer auto-tracking systems keep lasers aligned when buildings shake from wind and traffic

# Free Space Optics and Ultra-Wideband (continued)

- Free space optics (continued)
  - Current speeds go from T-3 (45 Mbps) to OC-48 (2.5 Gbps) with faster systems in development
  - Major weakness is transmission thru fog
  - A typical FSO has a link margin of about 20 dB
  - Under perfect conditions, air reduces a system's power by approximately 1 dB/km
  - Scintillation is also a problem (especially in hot weather)

# Free Space Optics and Ultra-Wideband (continued)

- Ultra-wideband
  - UWB not limited to a fixed bandwidth but broadcasts over a wide range of frequencies simultaneously
  - Many of these frequencies are used by other sources, but UWB uses such low power that it “should not” interfere with these other sources
  - Can achieve speeds up to 100 Mbps but for small distances such as wireless LANs

# Free Space Optics and Ultra-Wideband (continued)

- Ultra-wideband (continued)
  - Proponents for UWB say it gets something for nothing, since it shares frequencies with other sources.  Opponents disagree
  - Cell phone industry against UWB because CDMA most susceptible to interference of UWB
  - GPS may also be affected
  - One solution may be to have two types of systems – one for indoors (stronger) and one for outdoors (1/10 the power)

# Infrared Transmissions

- Transmissions that use a focused *ray of light in the infrared frequency range*
- Very ***common*** with *remote control devices*, but can also be used for device-to-device transfers, such as PDA to computer

# ZigBee

- Based upon IEEE 802.15.4 standard
- Used for *low data transfer rates* (20-250 Kbps)
- Also uses *low power consumption*
- Ideal for heating, cooling, security, lighting, and smoke and CO detector systems
- ZigBee can use a *mesh design* – a ZigBee-enabled device can both accept and then pass on ZigBee signals

# Wireless Media (continued)

**Table 3-4**
*Summary of wireless media*

| Type of Wireless Medium | Typical Use | Maximum Data Transfer Rate | Maximum Transmission Range | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Terrestrial Microwave | Long-haul telecommunications, building to building | 100s-Mbps | 20–30 miles | Reliable, high speed, high volume | Long haul, expensive to implement, line-of-sight |
| Satellite LEO | Communications such as e-mail, paging, worldwide mobile phone network, spying, remote sensing, video conferencing | 100s-Mbps | Depends on number of satellites | High-speed transfers, very wide distance, some applications inexpensive | Some applications expensive, interference |
| Satellite MEO | GPS-style surface navigation systems | 100s-Mbps | Depends on number of satellites | High-speed transfers, wide distance | Expensive to lease, some interference |
| Satellite GEO | Signal relays for cable and direct television | 100s-Mbps | One-third the Earth's circumference (8000 miles) | Very long distance, high speed, and high volume | Expensive to lease, some interference |
| Satellite HEO | Global surveillance, scientific applications | 100s-Mbps | Variable | Variability of distance | Expensive |
| Cellular (AMPS and D-AMPS) | Cellular telephones | 19.2 kbps | Each cell: 0.5–50 mile radius, but nationwide coverage | Widespread, inexpensive applications | Noise |
| PCS | Cellular telephones | 9.6 kbps | Each cell: 0.5–25 mile radius | Digital, low noise | Slow data rates |
| GPRS, 1xRTT | Cellular telephones | 30–75 kbps | Each cell: 0.5–25 mile radius | Digital, low noise | Slow data rates |
| UMTS | Cellular telephones | 320 kbps | Each cell: 0.5–25 mile radius | Digital, low noise | |
| EV-DO | Cellular telephones | 500 kbps | Each cell: 0.5–25 mile radius | Digital, low noise | |
| Infrared | Short-distance data transfer | 16 Mbps | 1.5 miles | Fast, inexpensive, secure | Short distances, line of sight |
| WiMAX | Wireless Internet access | 30 Mbps | 30 miles | High speed | |
| Bluetooth | Short-distance transfer | 722 kbps | 30 feet (10 meters) | Universal protocol | Limited distances |

# Wireless Media (continued)

**Table 3-4**

*Summary of wireless media (continued)*

| Type of Wireless Medium | Typical Use | Maximum Data Transfer Rate | Maximum Trans-mission Range | Advantages | Disadvantages |
|---|---|---|---|---|---|
| Wireless LANs | Local area networks | 100 Mbps | <328 feet (<100 meters) | Relative ease of use | Several standards |
| Free Space Optics | Short-distance, high-speed transfers | 45 Mbps | 1000s feet (100s meters) | High speed | Line of sight, affected by fog |
| Ultra-wideband | Short-distance, high-speed transfers | 100 Mbps | <328 feet (100 meters) | High speed, not restricted to fixed frequencies | May interfere with other sources |
| ZigBee | Short-to-medium distance, low-speed transfers | 250 KBps | Unlimited distance (mesh) | Low power | Low transfer speeds |

# Media Selection Criteria

- Cost
- Speed
- Distance and expandability
- Environment
- Security

# Cost

- Different types of costs
  - Initial cost – what does a particular type of medium cost to purchase?  To install?
  - Maintenance / support cost
- ROI (return on investment) – if one medium is cheaper to purchase and install but is not cost effective, where are the savings?

# Speed

- Two different forms of speed:
  - Propagation speed – the time to send the first bit across the medium
    - This speed depends upon the medium
    - Airwaves and fiber are speed of light
    - Copper wire is two thirds the speed of light
  - Data transfer speed – the time to transmit the rest of the bits in the message
    - This speed is measured in bits per second

# Expandability and Distance

- Certain media lend themselves more easily to expansion
- Don’t forget right-of-way issue for conducted media and line-of-sight for certain wireless media

# Environment

- Many types of environments are hazardous to certain media
  - Electromagnetic noise
  - Scintillation and movement
  - Extreme environmental conditions

# Security

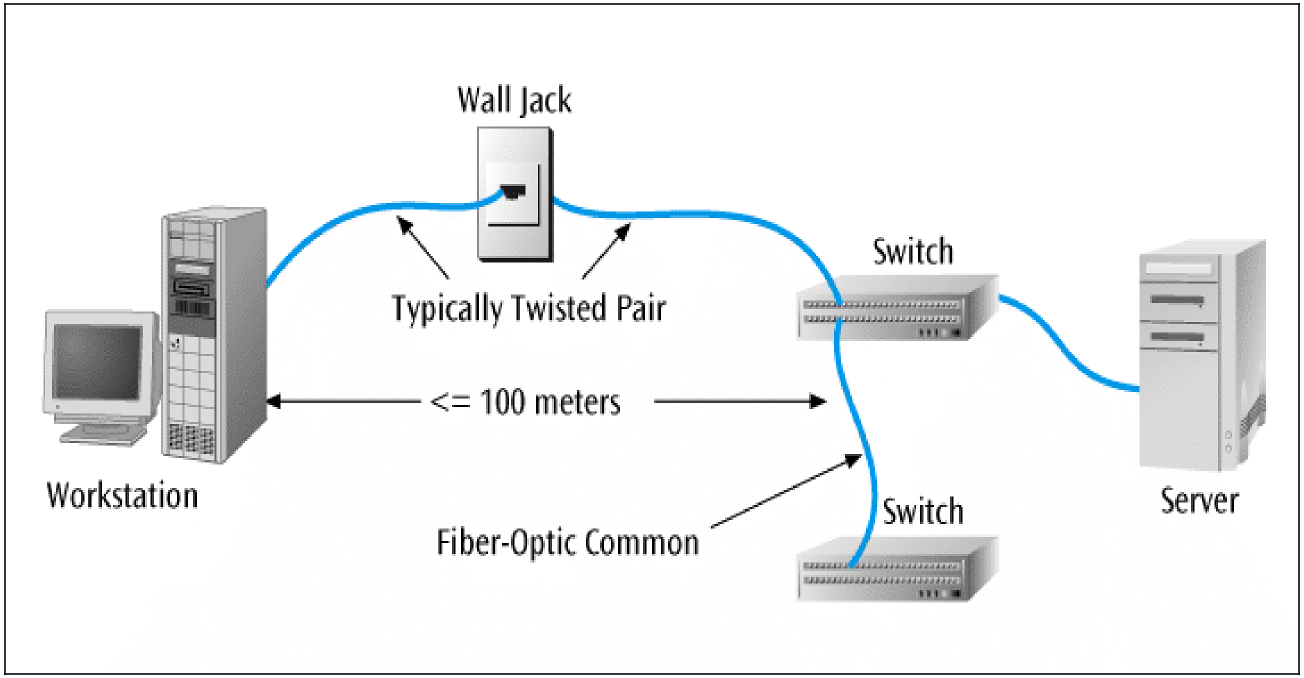
- If data must be secure during transmission, it is important that the medium not be easy to tap
  - Make the wire impervious to electromagnetic wiretapping
  - Encrypt the signal going over the medium

# Conducted Media in Action: Two Examples

- **First example** – simple local area network
  - Hub typically used
  - To select proper medium, consider:
    - Cable distance
    - Data rate

# Conducted Media in Action: Two Examples (continued)

**Figure 3-20**
*Example of a wiring situation involving a workstation and a local area network*



# Conducted Media in Action: Two Examples (continued)

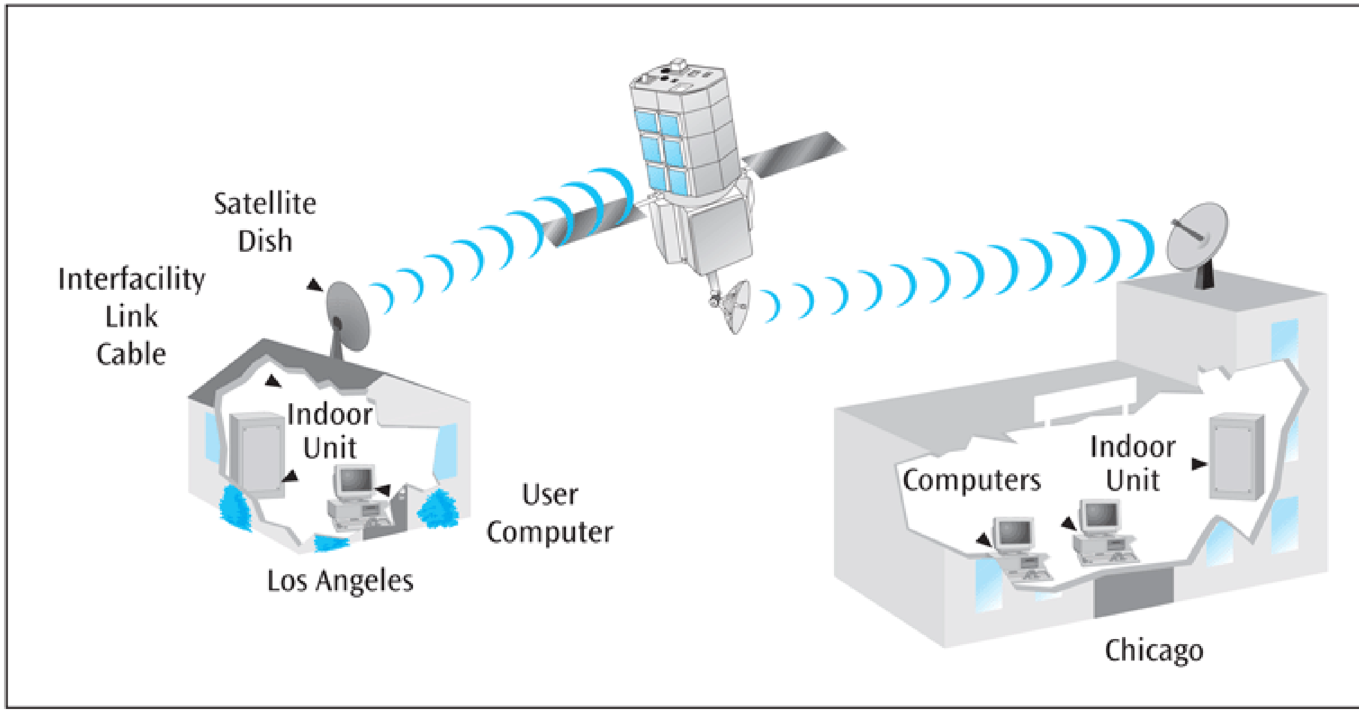
- **Second example** – company wishes to transmit data between buildings that are one mile apart
  - Is property between buildings owned by company?
    - If not consider using wireless
    - When making decision, need to consider:
      - Cost
      - Speed
      - Expandability and distance
      - Environment
      - Security

# Wireless Media In Action: Three Examples

- *First example* – you wish to connect two computers in your home to Internet, and want both computers to share a printer
  - Can purchase wireless network interface cards
  - May consider using Bluetooth devices
- *Second example* – company wants to transmit data between two locations, Chicago and Los Angeles
  - Company considering two-way data communications service offered through VSAT satellite system

# Wireless Media In Action: Three Examples (continued)

**Figure 3-21**
*VSAT satellite solution for DataMining Corporation*

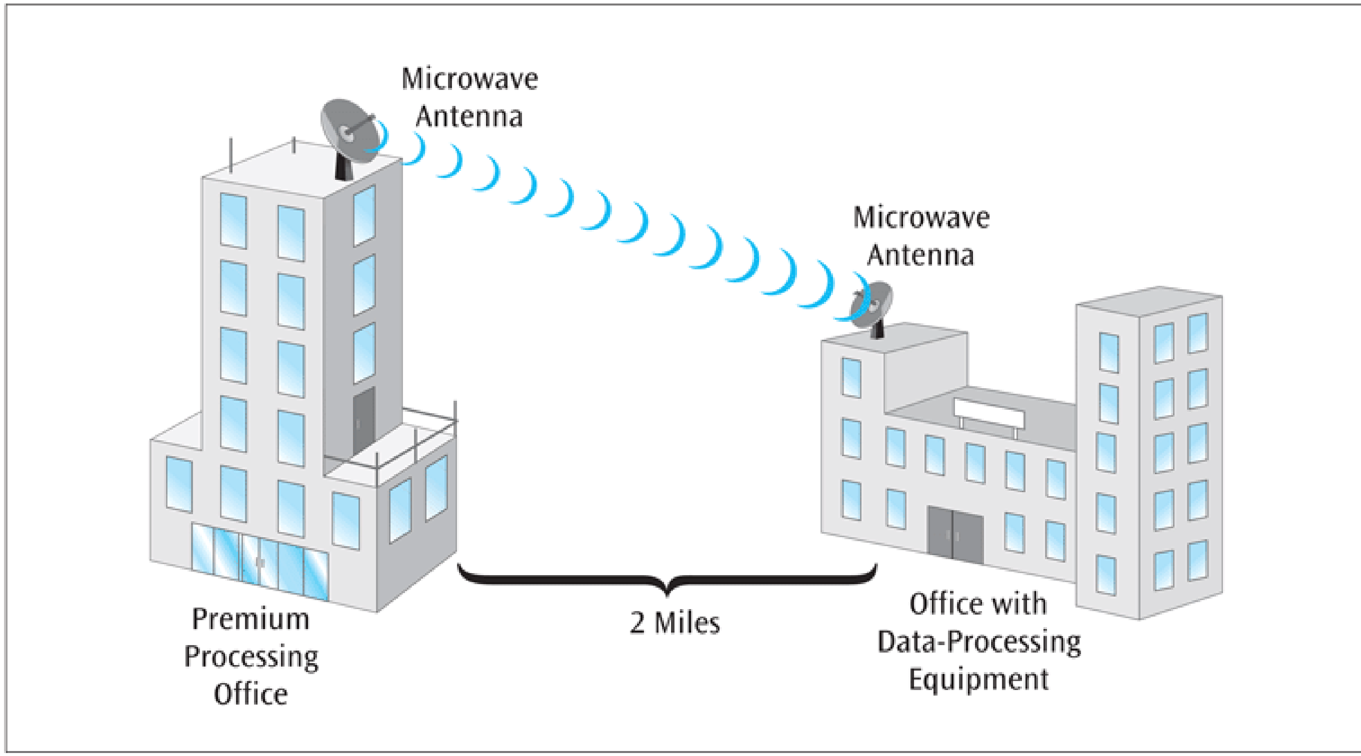


# Wireless Media In Action: Three Examples (continued)

- *Third example* – second company wishes to transmit data between offices two miles apart
  - Considering terrestrial microwave system

# Wireless Media In Action: Three Examples (continued)

**Figure 3-22**
*Microwave communication between American Insurance's corporate buildings*



# Summary

- All data communication media can be divided into ***two basic categories***: (1) physical or conducted media, and (2) radiated or wireless media, such as satellite systems
- The ***three types of conducted media*** are twisted pair, coaxial cable, and fiber-optic cable
- Twisted pair and coaxial cable are both metal wires and are *subject to electromagnetic interference*
- Fiber-optic cable is a glass wire and is impervious to electromagnetic interference
  - Experiences a lower noise level
  - Has best transmission speeds and long-distance performance of all conducted media

# Summary (continued)

- Several basic groups of wireless media exist: terrestrial microwave transmissions, satellite transmissions, cellular telephone systems, infrared transmissions, WiMAX, Bluetooth, Wi-Fi, free space optics, ultra-wideband, and ZigBee
- Each of the wireless technologies is designed for specific applications
- When trying to select particular medium for an application, it helps to compare the different media using these six criteria: cost, speed, expandability and distance, right-of-way, environment, and security