CHAPTER 10: TRANSMISSION MEDIA

10.1 Introduction

- Transmission media are actually located below the physical layer and are directly controlled by the physical layer.
- We could say that transmission media belong to layer zero.

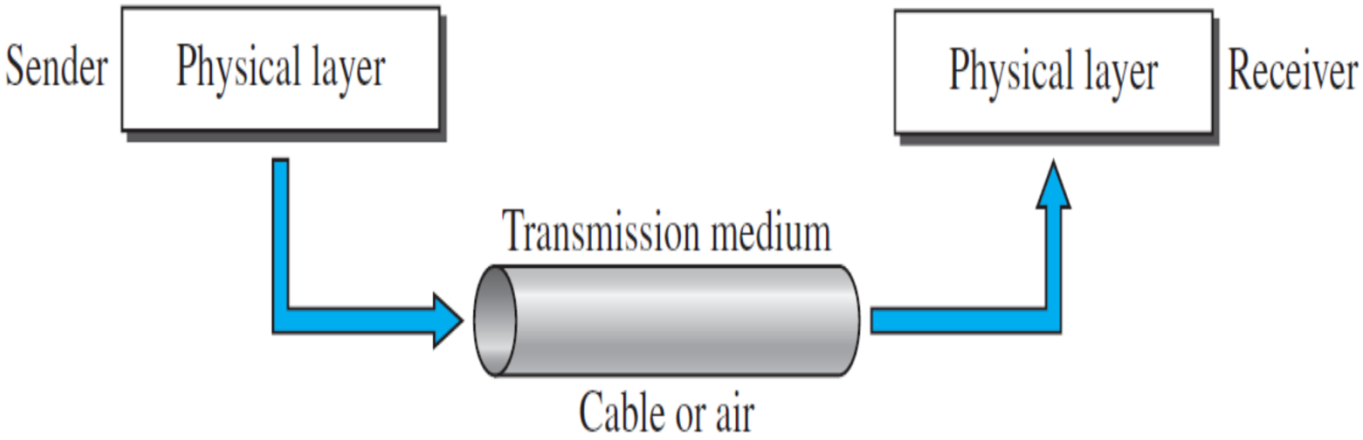

Figure *Transmission medium and physical layer*

- A **transmission medium** can be broadly defined as anything that can carry information from a source to a destination.
- The air can also be used to convey the message.
- Transmission media can be divided into two broad categories: guided and unguided.
- Guided media include twisted-pair cable, coaxial cable, and fiber-optic cable.
- Unguided medium is free space.

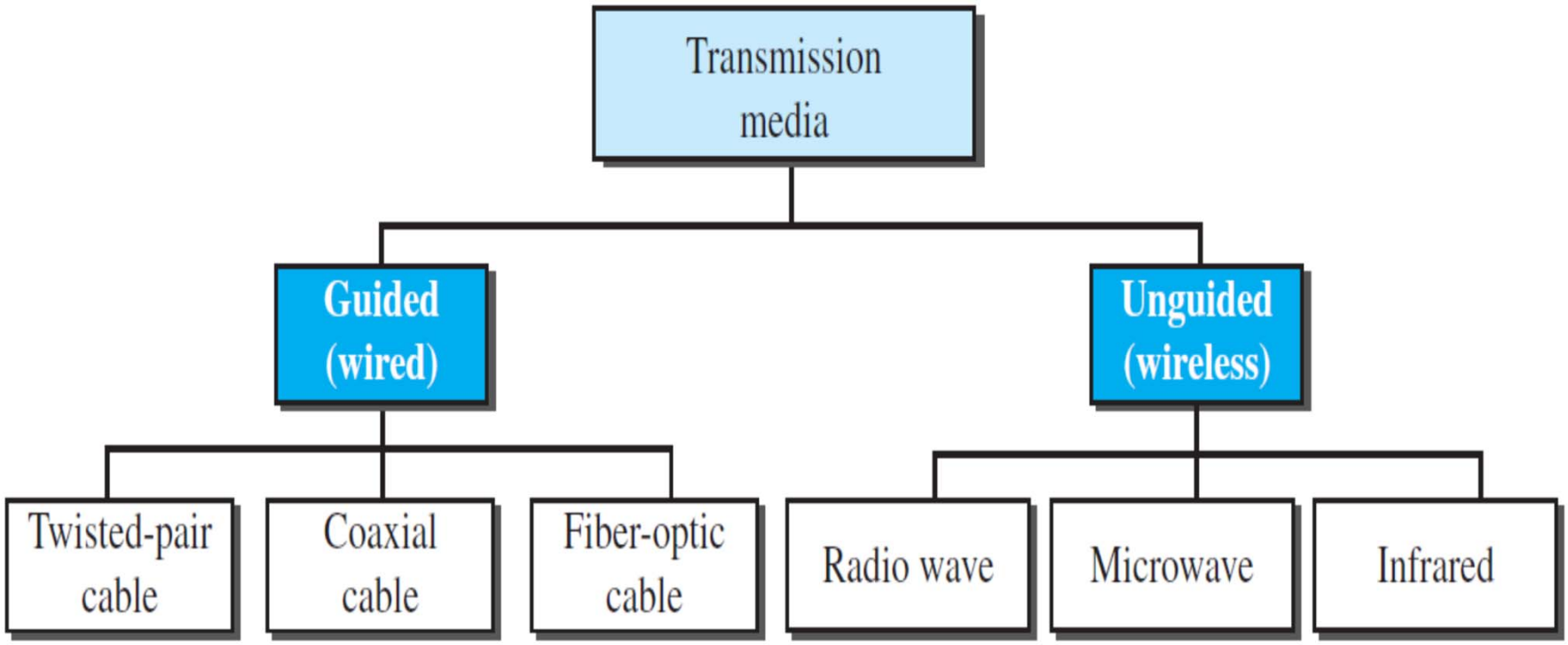

Figure *Classes of transmission media*

10.2 GUIDED MEDIA

- **Guided media,** which are those that provide a conduit from one device to another, include **twisted-pair cable, coaxial cable,** and **fiber-optic cable.**
- A signal traveling along any of these media is directed and contained by the physical limits of the medium.
- Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current.
- **Optical fiber** is a cable that accepts and transports signals in the form of light.

10.2.1 Twisted-Pair Cable

- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together.
- One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference.

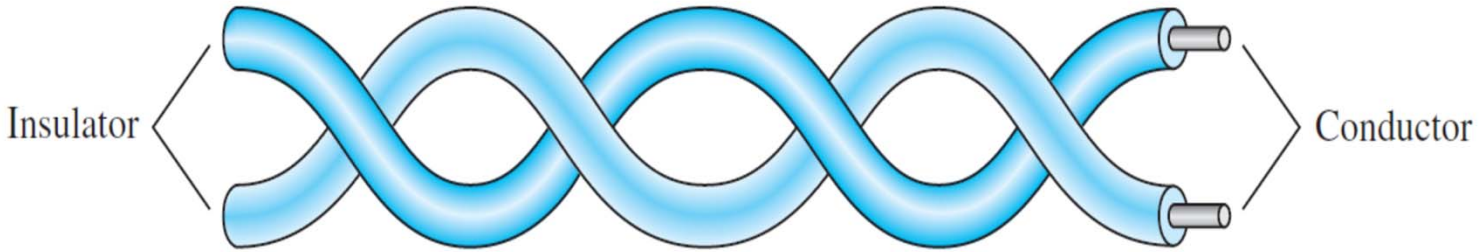

Figure *Twisted-pair cable*

Unshielded Versus Shielded Twisted-Pair Cable

- The most common twisted-pair cable used in communications is referred to as ***unshielded twisted-pair* (UTP).**
- IBM has also produced a version of twisted-pair cable for its use, called ***shielded twisted-pair* (STP).**
- STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors.
- Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

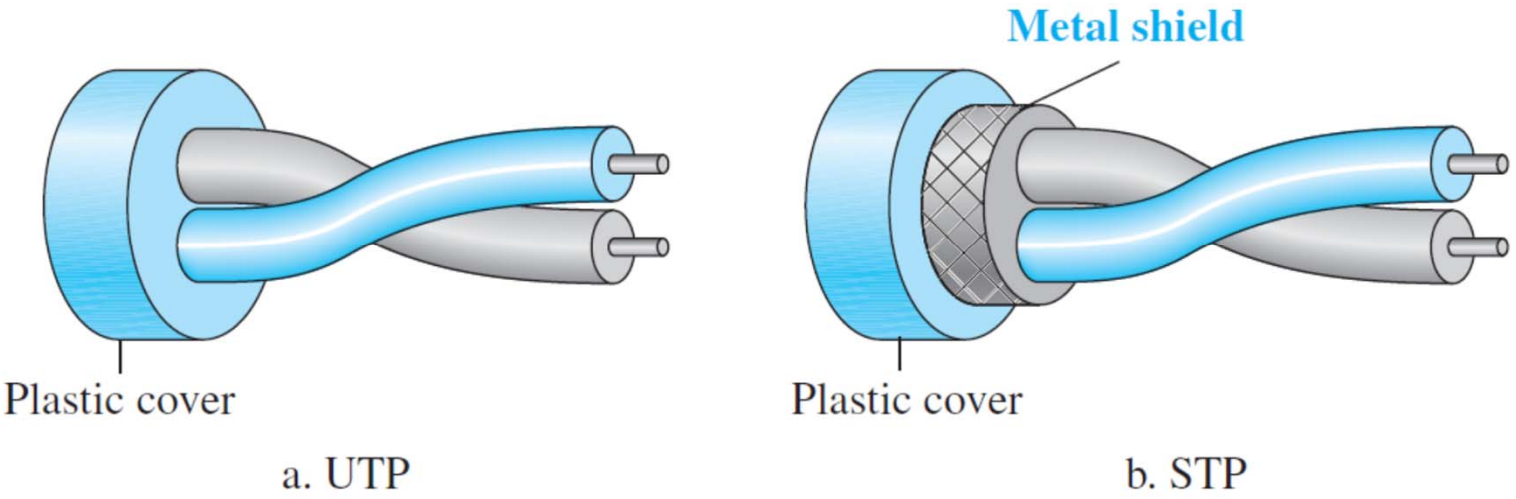

Figure *UTP and STP cables*

- ***Connectors***
- The most common UTP connector is **RJ45** (RJ stands for registered jack).

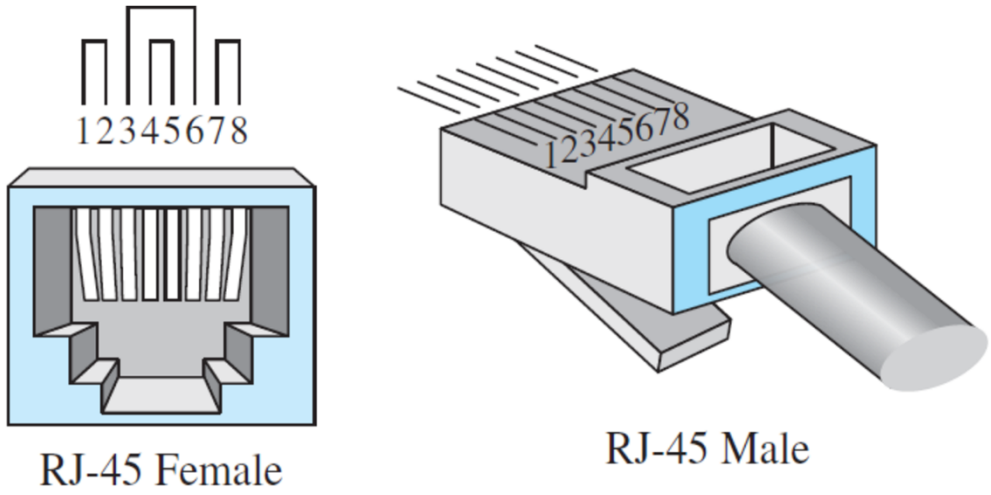

Figure *UTP connector*

Applications

- Twisted-pair cables are used in telephone lines to provide voice and data channels.
- The local loop—the line that connects subscribers to the central telephone office— commonly consists of unshielded twisted-pair cables.
- The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.
- Local-area networks, such as 10Base-T and 100Base-T, also use twisted-pair cables.

10.2.2 Coaxial Cable

- Coaxial cable (or *coax*) carries signals of higher frequency ranges than those in twisted pair cable.
- Instead of having two wires, coax has a central core conductor of solid or stranded wire enclosed in an insulating sheath.
- The outer metallic wrapping serves both as a shield against noise.
- This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.

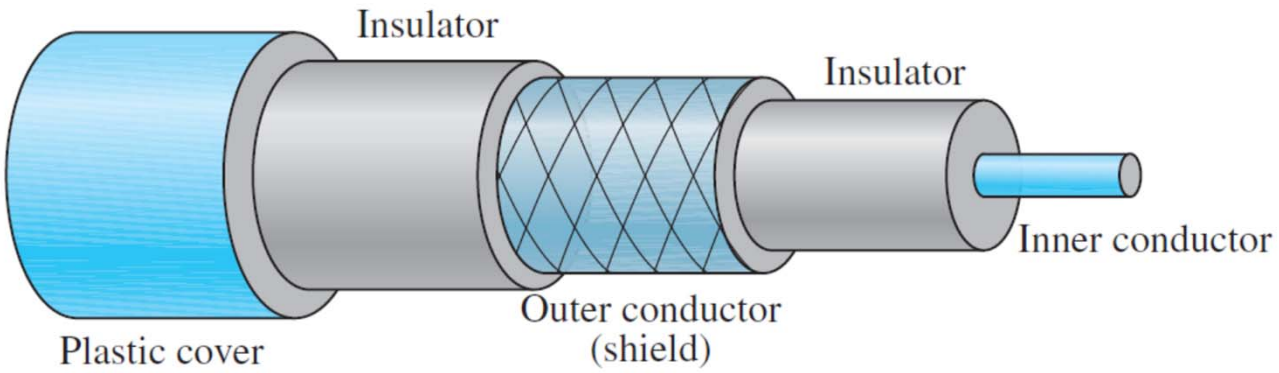

Figure *Coaxial cable*

Coaxial Cable Connectors

- To connect coaxial cable to devices, we need coaxial connectors.
- The most common type of connector used today is the **Bayonet Neill-Concelman (BNC)** connector.

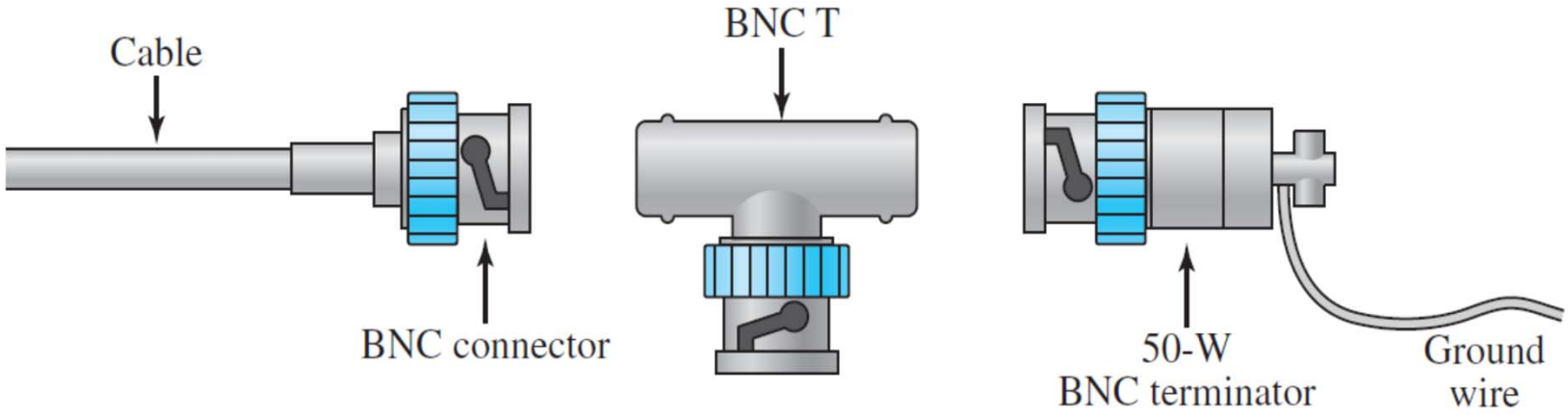

Figure *BNC connectors*

- Three popular types of these connectors: the BNC connector, the BNC T connector, and the BNC terminator.
- The BNC connector is used to connect the end of the cable to a device, such as a TV set.
- The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or other device.
- The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

Applications

- Coaxial cable was widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals.
- Later it was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps.
- However, coaxial cable in telephone networks has largely been replaced today with fiber optic cable.
- Cable TV networks also use coaxial cables.
- Another common application of coaxial cable is in traditional Ethernet LANs.

10.2.3 Fiber-Optic Cable

- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- Light travels in a straight line as long as it is moving through a single uniform substance.
- If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction.
- If the **angle of incidence** *I* is less than the **critical angle,** the ray **refracts** and moves closer to the surface.
- If the angle of incidence is equal to the critical angle, the light bends along the interface.
- If the angle is greater than the critical angle, the ray **reflects** and travels again in the denser substance.

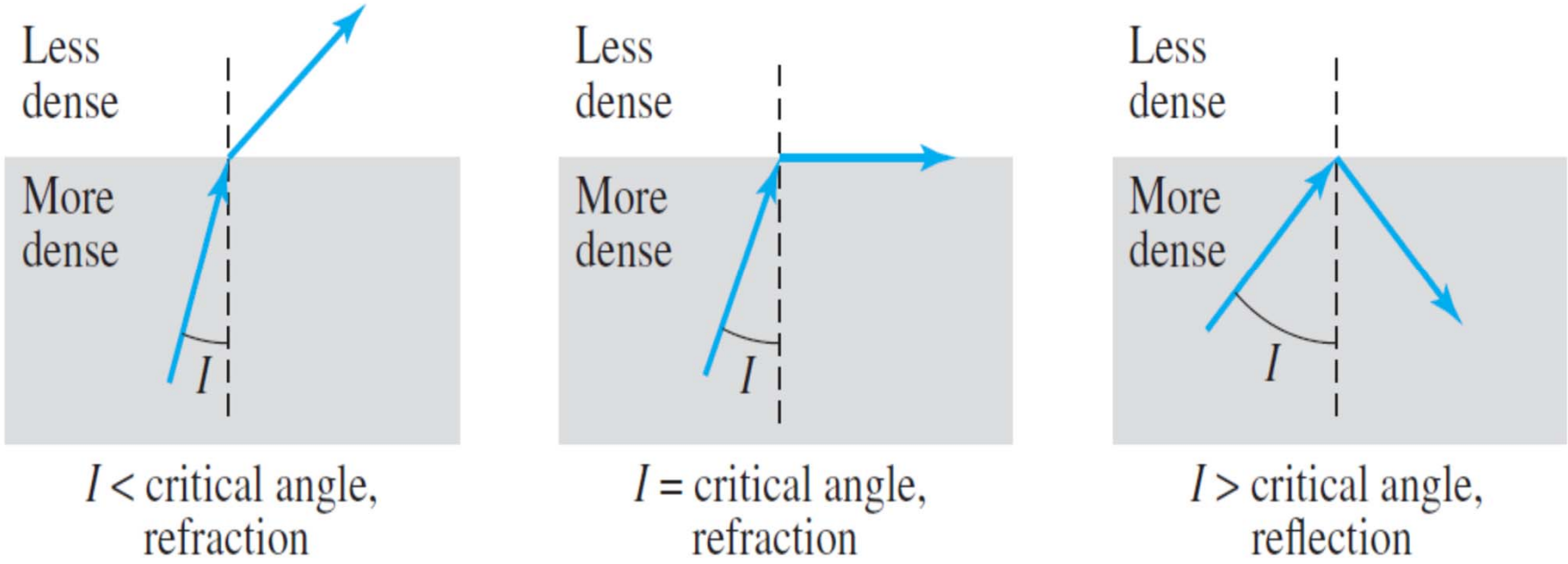

Figure *Bending of light ray*

- A glass or plastic **core** is surrounded by a **cladding** of less dense glass or plastic.

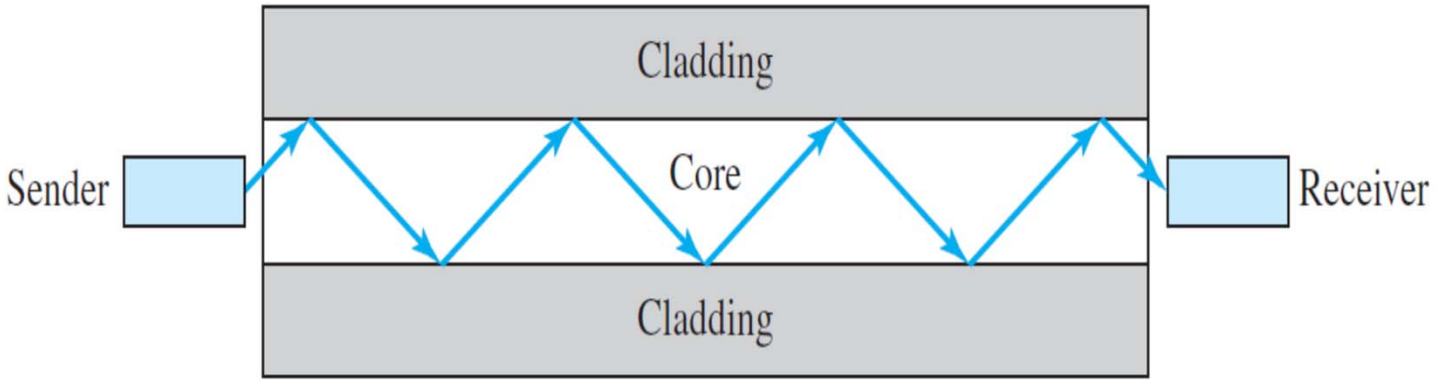

Figure *Optical fiber*

- ***Propagation Modes***
- Current technology supports two modes (multimode and single mode) for propagating light along optical channels, each requiring fiber with different physical characteristics.
- Multimode can be implemented in two forms: step-index or graded-index.

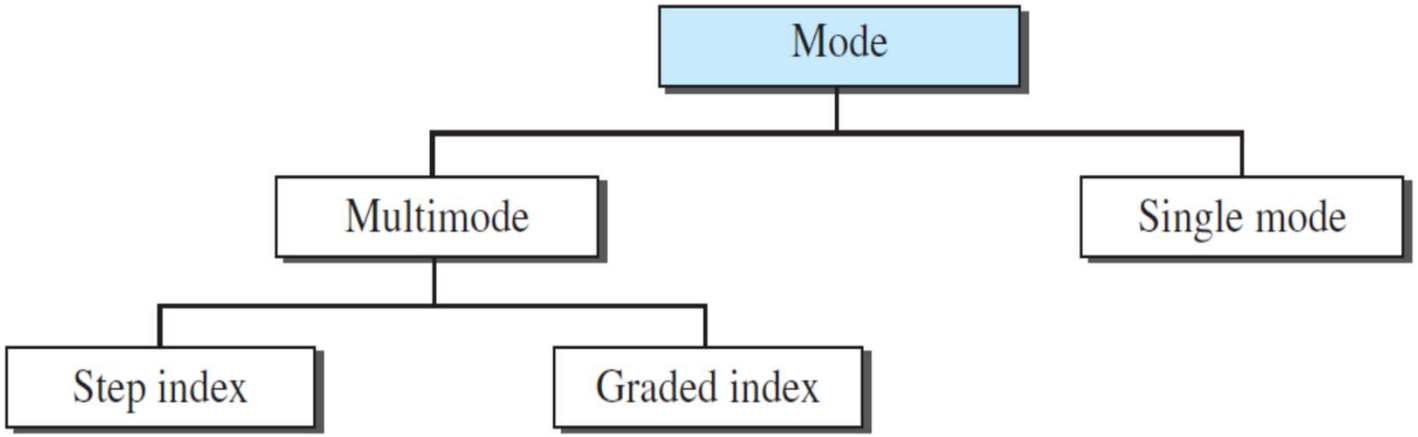

Figure *Propagation modes*

- In **multimode step-index fiber,** the density of the core remains constant from the center to the edges.
- A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
- A second type of fiber, called **multimode graded-index fiber,** decreases this distortion of the signal through the cable.
- ***Single-Mode***
- Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal.
- The **single-mode fiber** itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction).

- ***Applications***
- Fiber-optic cable is often found in backbone networks.
- The SONET network that provides such a backbone.
- Some cable TV companies use a combination of optical fiber and coaxial cable.

Advantages and Disadvantages of Optical Fiber

Advantages

❑ **Higher bandwidth.** Fiber-optic cable can support dramatically higher bandwidths than either twisted-pair or coaxial cable.

❑ **Less signal attenuation.** Fiber-optic transmission distance is significantly greater than that of other guided media.

- A signal can run for 50 km without requiring regeneration.
- We need repeaters every 5 km for coaxial or twisted-pair cable.

❑ **Immunity to electromagnetic interference.** Electromagnetic noise cannot affect fiber-optic cables.

❑ **Resistance to corrosive materials.** Glass is more resistant to corrosive materials than copper.

❑ **Light weight.** Fiber-optic cables are much lighter than copper cables.

❑ **Greater immunity to tapping.** Fiber-optic cables are more immune to tapping than copper cables.

- ***Disadvantages***
- ❑ **Installation and maintenance.** Fiber-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.
- ❑ **Unidirectional light propagation.** Propagation of light is unidirectional. If we need bidirectional communication, two fibers are needed.
- ❑ **Cost.** The cable and the interfaces are relatively more expensive than those of other guided media.
- If the demand for bandwidth is not high, often the use of optical fiber cannot be justified.

10.3 UNGUIDED MEDIA: WIRELESS

- **Unguided medium** transport electromagnetic waves without using a physical conductor.
- This type of communication is often referred to as ***wireless communication.***
- Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.
- Unguided signals can travel from the source to the destination in several ways: ground propagation, sky propagation, and line-of-sight propagation.

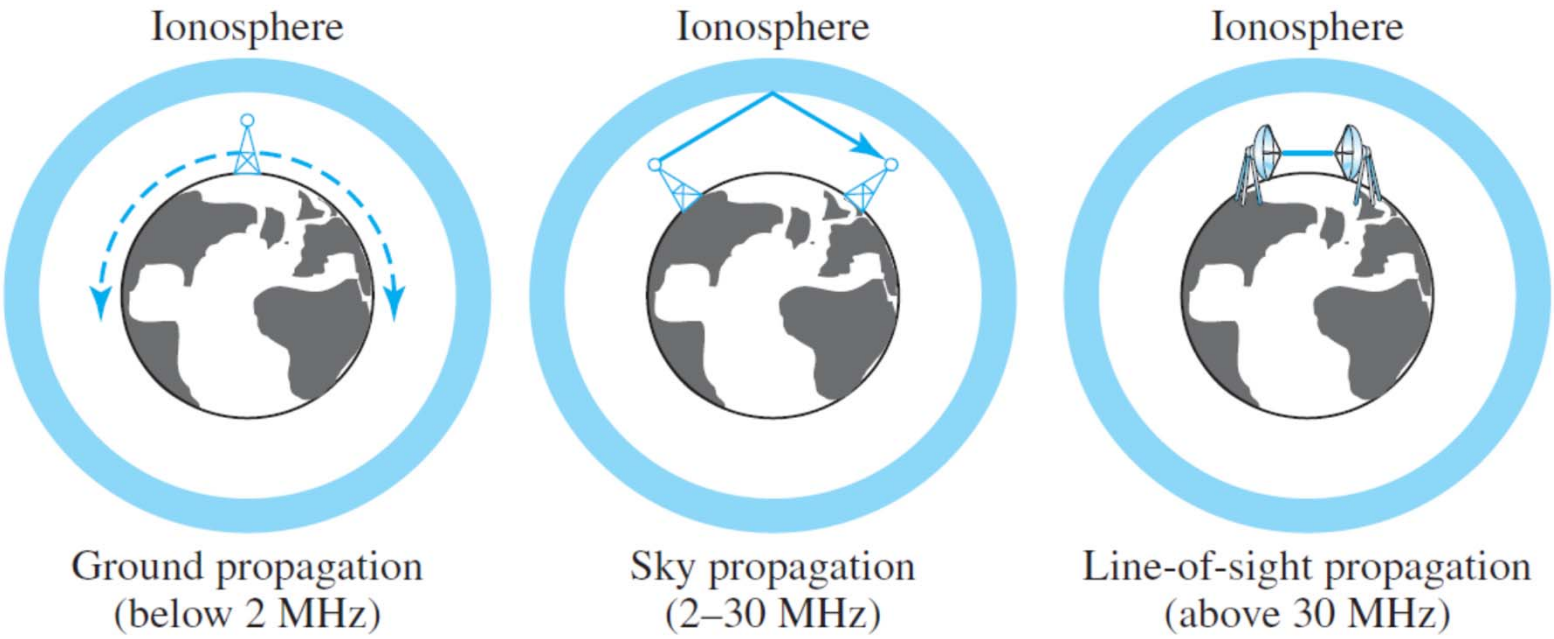

Figure *Propagation methods*

- In **ground propagation,** radio waves travel through the lowest portion of the atmosphere, hugging the earth.
- These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet.
- In **sky propagation,** higher-frequency radio waves radiate upward into the ionosphere where they are reflected back to earth.
- This type of transmission allows for greater distances with lower output power.
- In **line-of-sight propagation,** very high-frequency signals are transmitted in straight lines directly from antenna to antenna.
- Antennas must be directional, facing each other, and either tall enough or close enough together not to be affected by the curvature of the earth.
- We can divide wireless transmission into three broad groups: **radio waves, microwaves, and infrared waves.**

10.3.1 Radio Waves

- Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called **radio waves;**
- waves ranging in frequencies between 1 and 300 GHz are called **microwaves.**
- Radio waves are omnidirectional.
- Radio waves, particularly those waves that propagate in the sky mode, can travel long distances.
- This makes radio waves a good candidate for long-distance broadcasting such as AM radio.
- Radio waves can penetrate walls.

Omnidirectional Antenna

- Radio waves use **omnidirectional antennas** that send out signals in all directions.
- Figure shows an omnidirectional antenna.

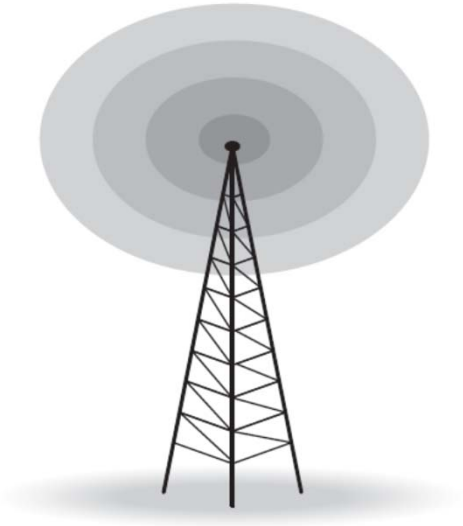

Figure *Omnidirectional antenna*

Applications

- The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers.
- AM and FM radio, television, maritime radio, cordless phones, and paging are examples of multicasting.

10.3.2 Microwaves

- Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves.
- Microwaves are unidirectional.
- When an antenna transmits microwaves, they can be narrowly focused.
- This means that the sending and receiving antennas need to be aligned.
- The unidirectional property has an obvious advantage.
- A pair of antennas can be aligned without interfering with another pair of aligned antennas.

Some characteristics of microwave propagation:

- ❑ Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall.
- ❑ Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.
- ❑ The microwave band is relatively wide, almost 299 GHz. Therefore wider sub-bands can be assigned, and a high data rate is possible.
- ❑ Use of certain portions of the band requires permission from authorities.

Unidirectional Antenna

- Microwaves need **unidirectional antennas** that send out signals in one direction.
- Two types of antennas are used for microwave communications: the parabolic dish and the horn.

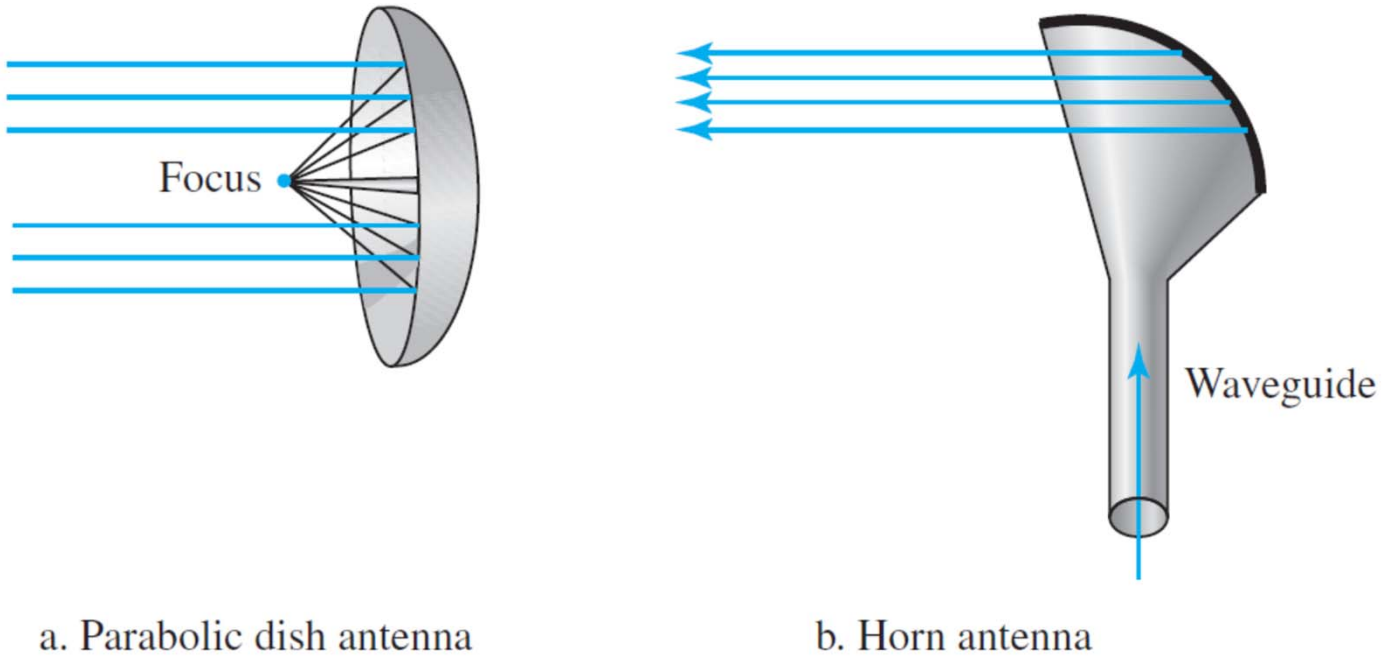

Figure *Unidirectional antennas*

Applications

- Microwaves, due to their unidirectional properties, are very useful when unicast (one-to- one) communication is needed between the sender and the receiver.
- They are used in cellular phones, satellite networks, and wireless LANs.

10.3.3 Infrared

- **Infrared waves,** with frequencies from 300 GHz to 400 THz, can be used for short-range communication.
- Infrared waves cannot penetrate walls.
- This advantageous characteristic prevents interference between one system and another.
- When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors.
- In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

Applications

- The infrared band has an excellent potential for data transmission.
- Can be used to transmit digital data with a very high data rate.
- Using these signals for communication between devices such as keyboards, mice, PCs, and printers.

Thank you all……..