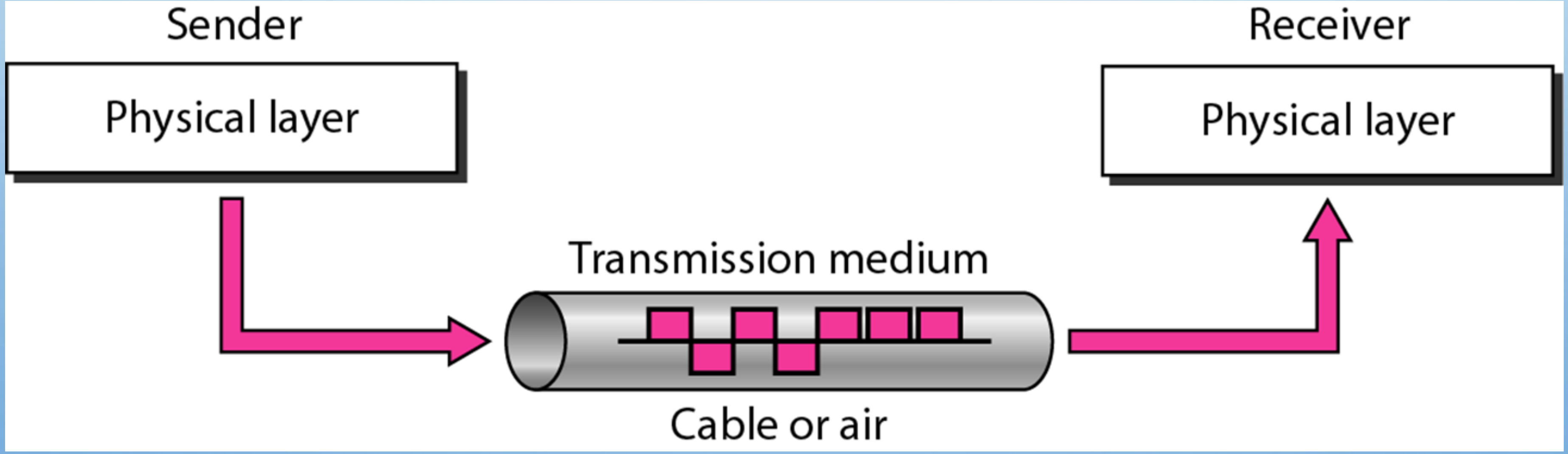
TRANSMISSION MEDIA

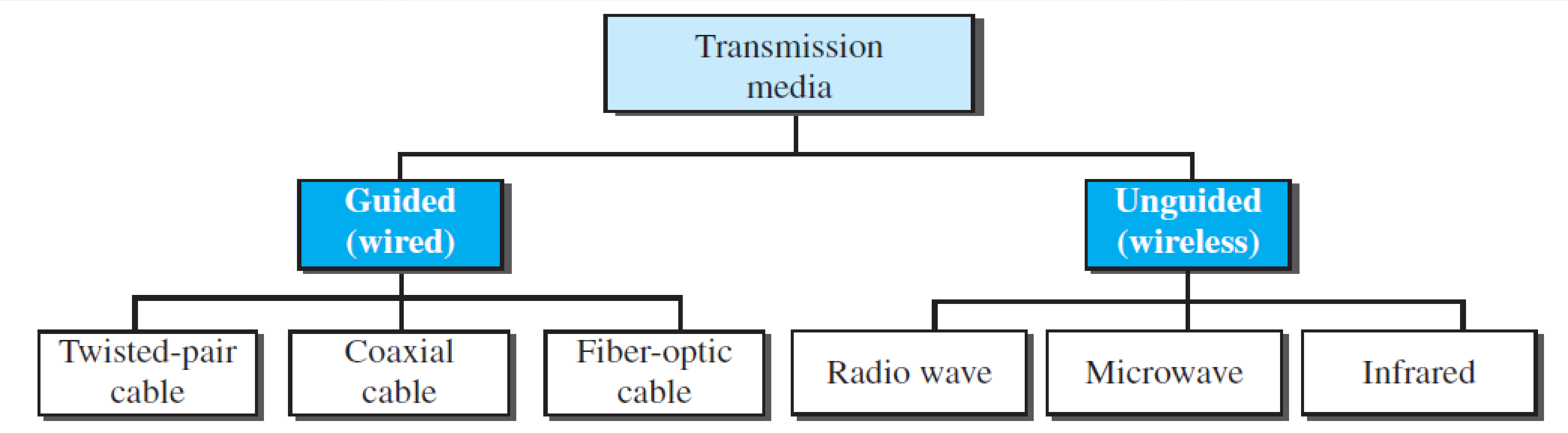
UNIT-I

TRANSMISSION MEDIA

- Transmission media are actually located below the physical layer and are directly controlled by the physical layer
- Anything that can carry information from a source to a destination



CLASSES OF TRANSMISSION MEDIA

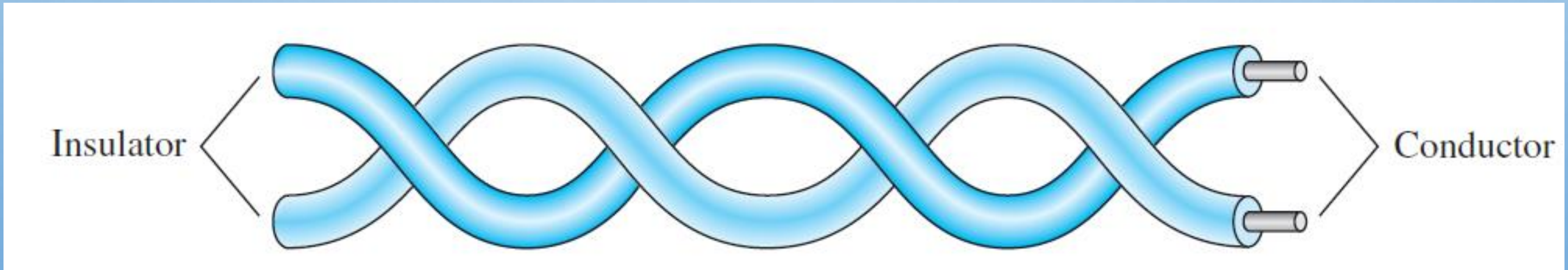


GUIDED MEDIA

- **Guided media,** 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.

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 other is the ground reference
- Interference (noise) and crosstalk may affect both wires and create unwanted signals are also present.

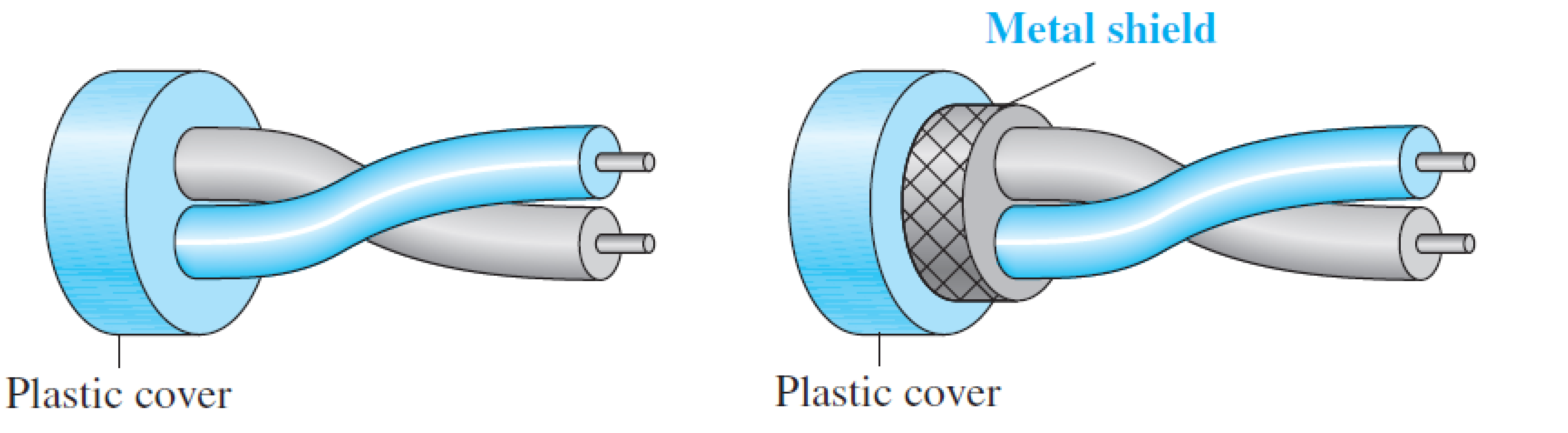


TWISTED-PAIR CABLE

- If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources
- (e.g., one is closer and the other is farther). This results in a difference at the receiver.
- Twisting makes it probable that both wires are equally affected by external influences (noise or crosstalk).
- The unwanted signals are mostly canceled out.
- the number of twists per unit of length (e.g., inch) has some effect on the quality of the cable.

UNSHIELDED VERSUS SHIELDED TWISTED-PAIR CABLE

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



a. UTP

b. STP

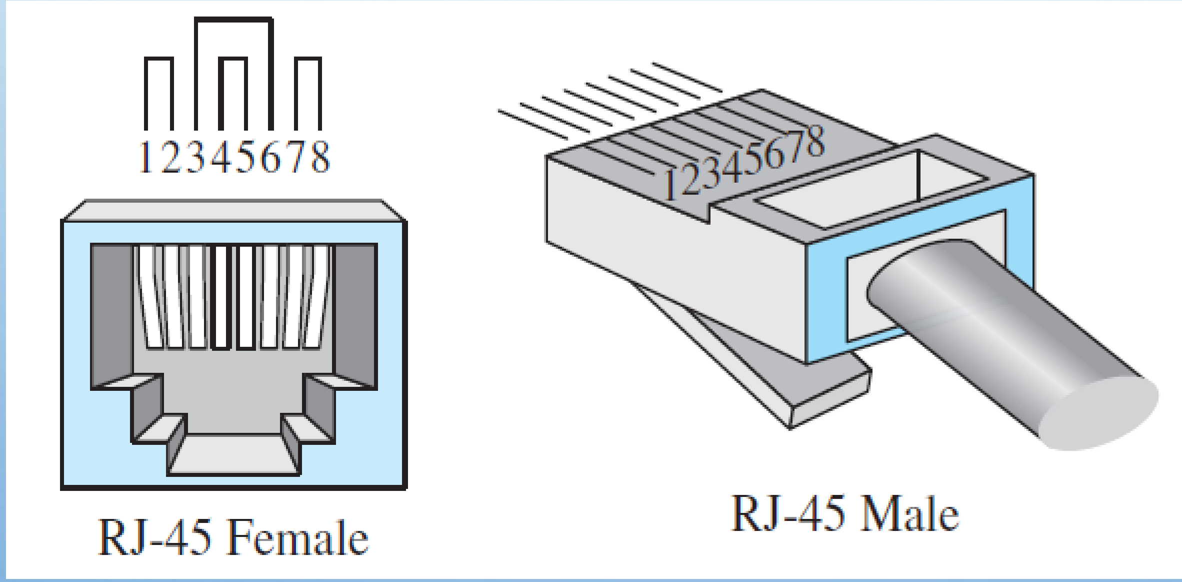
CATEGORIES OF UNSHIELDED TWISTED-PAIR CABLES

The Electronic Industries Association (EIA) has developed standards to classify UTP cable into seven categories

Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
5E	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk and increases the data rate.	600	LANs

CONNECTORS

- The most common UTP connector is **RJ45** (RJ stands for registered jack),
- The RJ45 is a keyed connector, meaning the connector can be inserted in only one way.



PERFORMANCE

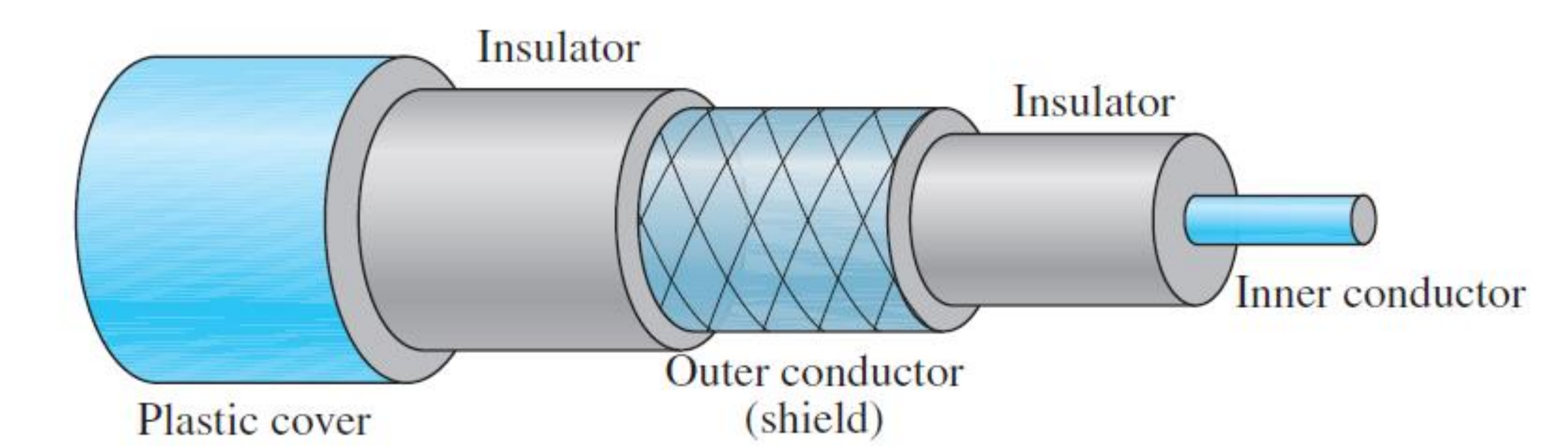
- Performance is measured by comparing attenuation versus frequency and distance.
- A twisted-pair cable can pass a wide range of frequencies.
- With increasing frequency, the attenuation, measured in decibels per kilometer (db/km), sharply increases with frequencies above 100 khz.
- ***Gauge*** is a measure of the thickness of the wire.

Applications

- Used in telephone lines to provide voice and data channels.
- The local loop—the line that connects subscribers to the central telephone office has utp cables.
- Local-area networks, such as 10base-t and 100base-t, also use twisted-pair cables

COAXIAL CABLE

- Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable
- It has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two.
- The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.
- This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover



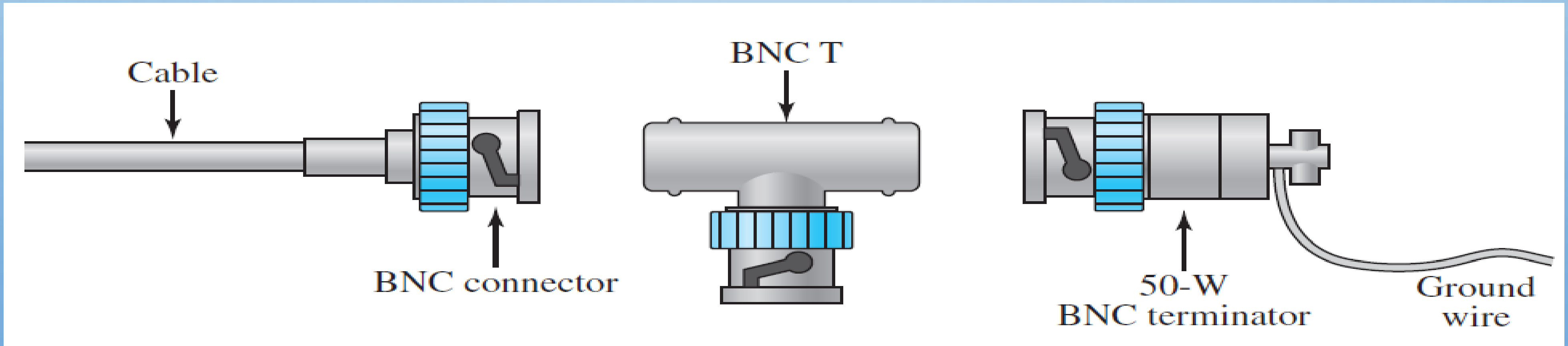
COAXIAL CABLE STANDARDS

- Coaxial cables are categorized by their **Radio Government (RG)** ratings.
- Each RG number denotes a unique set of physical specifications, including
  - the wire gauge of the inner conductor,
  - the thickness and type of the inner insulator,
  - the construction of the shield, and
  - the size and type of the outer casing.

Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

COAXIAL CABLE CONNECTORS

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



PERFORMANCE & APPLICATIONS

- The attenuation is much higher in coaxial cable than in twisted-pair cable.
- In other words, although coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.

Applications

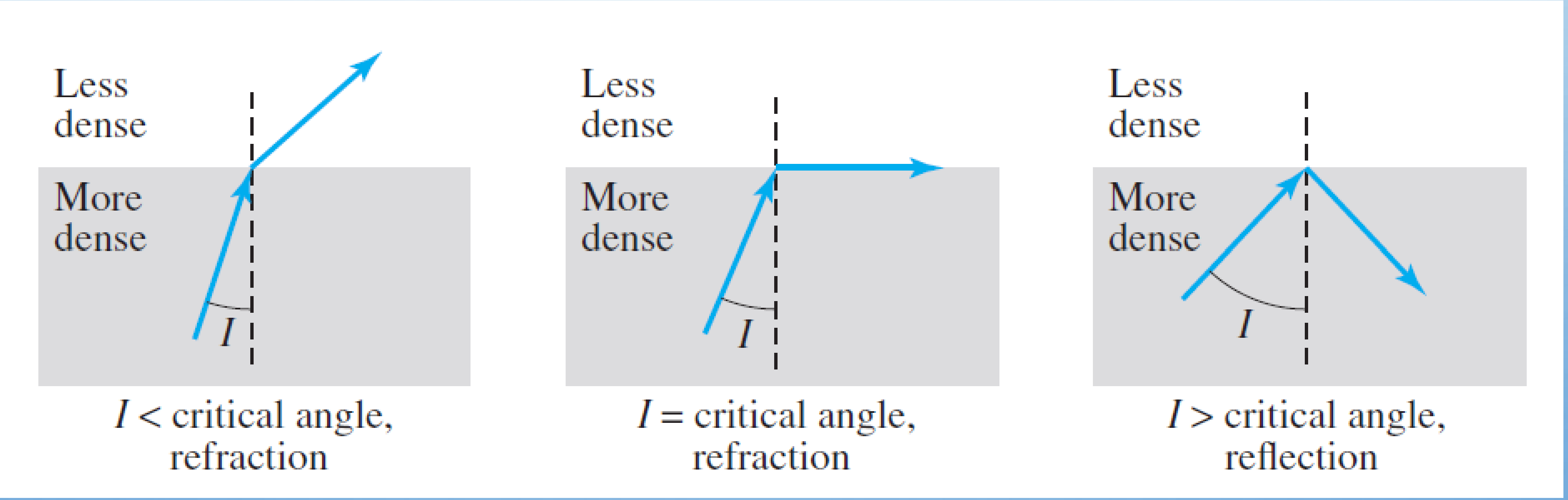
- Widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals.
- Used in digital telephone networks where a single coaxial cable could carry digital data up to 600 mbps.
- However, coaxial cable in telephone networks has largely been replaced today with fiberoptic cable.

APPLICATIONS

- Cable TV uses RG-59 coaxial cable
- The 10Base-2, or Thin Ethernet, uses RG-58 coaxial cable with BNC connectors to transmit data at 10 Mbps with a range of 185 m.
- The 10Base5, or Thick Ethernet, uses RG-11 (thick coaxial cable) to transmit 10 Mbps with a range of 5000 m.

FIBER-OPTIC CABLE

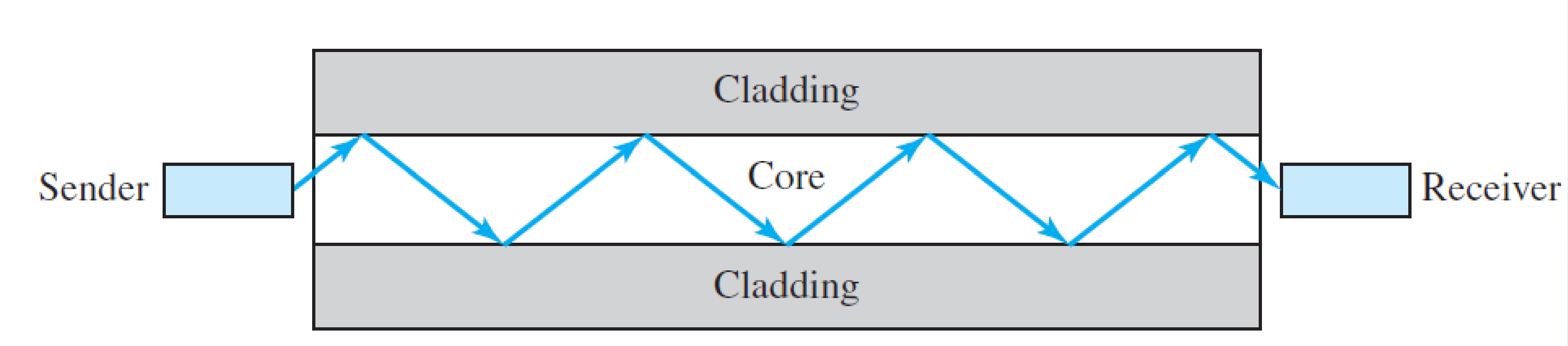
- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- Light travels in a straight line as long as it is moving through a single uniform substance.
- If a ray of light traveling through one substance suddenly enters another substance (of a different density), the ray changes direction.



RAY OF LIGHT

- if the angle of incidence I (the angle the ray makes with the line perpendicular to the interface between the two substances) 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 (makes a turn) and travels again in the denser substance.
- Optical fibers use reflection to guide light through a channel.
- A glass or plastic **core** is surrounded by a **cladding** of less dense glass or plastic.
- The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it

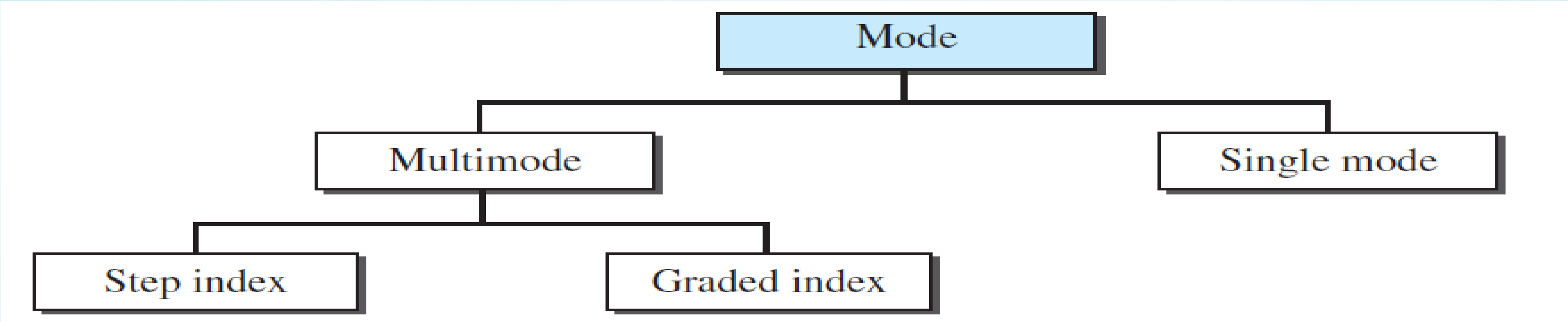
OPTICAL FIBER



Propagation Modes

- There are 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

PROPAGATION MODES



- Multimode is so named because multiple beams from a light source move through the core in different paths.
- In 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.
- At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion.
- The term step-index refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fiber.

PROPAGATION MODES

- A second type of fiber, called multimode graded-index fiber, decreases this distortion of the signal through the cable. The word index here refers to the index of refraction.
- The index of refraction is related to density.
- A graded index fiber, is one with varying densities.
- Density is highest at the center of the core and decreases gradually to its lowest at the edge.

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 is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction).
- The decrease in density results in a critical angle that is close enough to 90° to make the propagation of beams almost horizontal.
- All the beams arrive at the destination “together” and can be recombined with little distortion to the signal

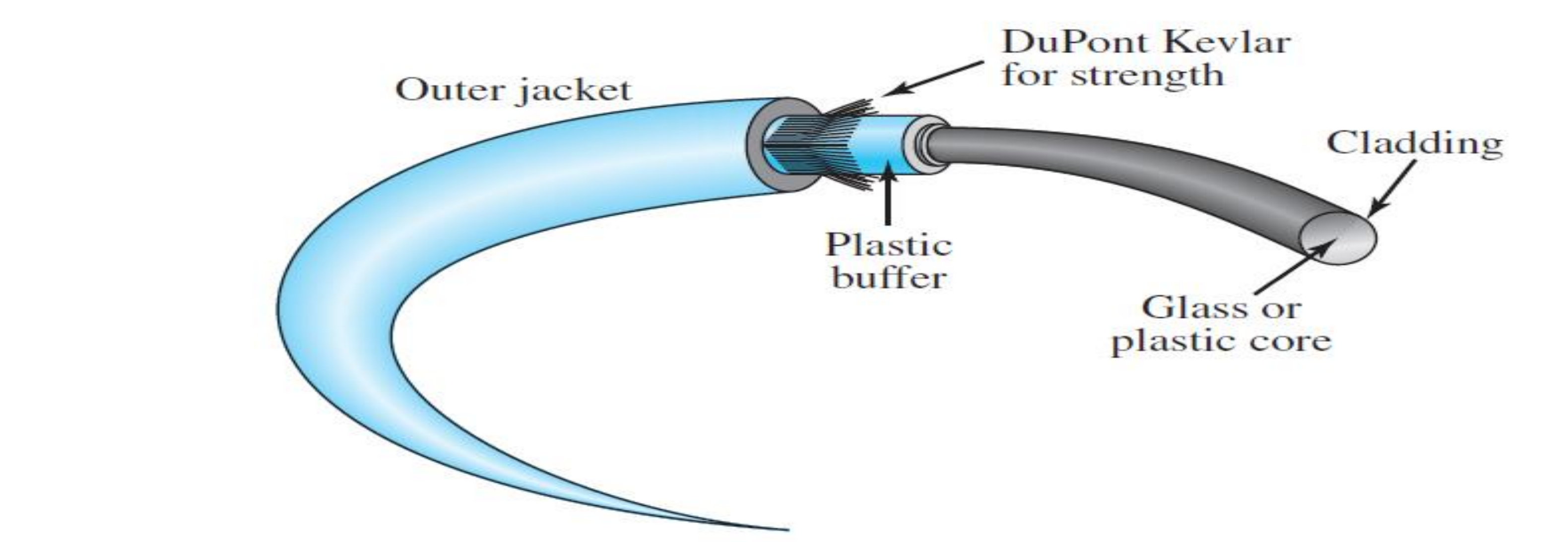
FIBER SIZES

- Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in micrometers

Type	*Core (μm)*	*Cladding (μm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

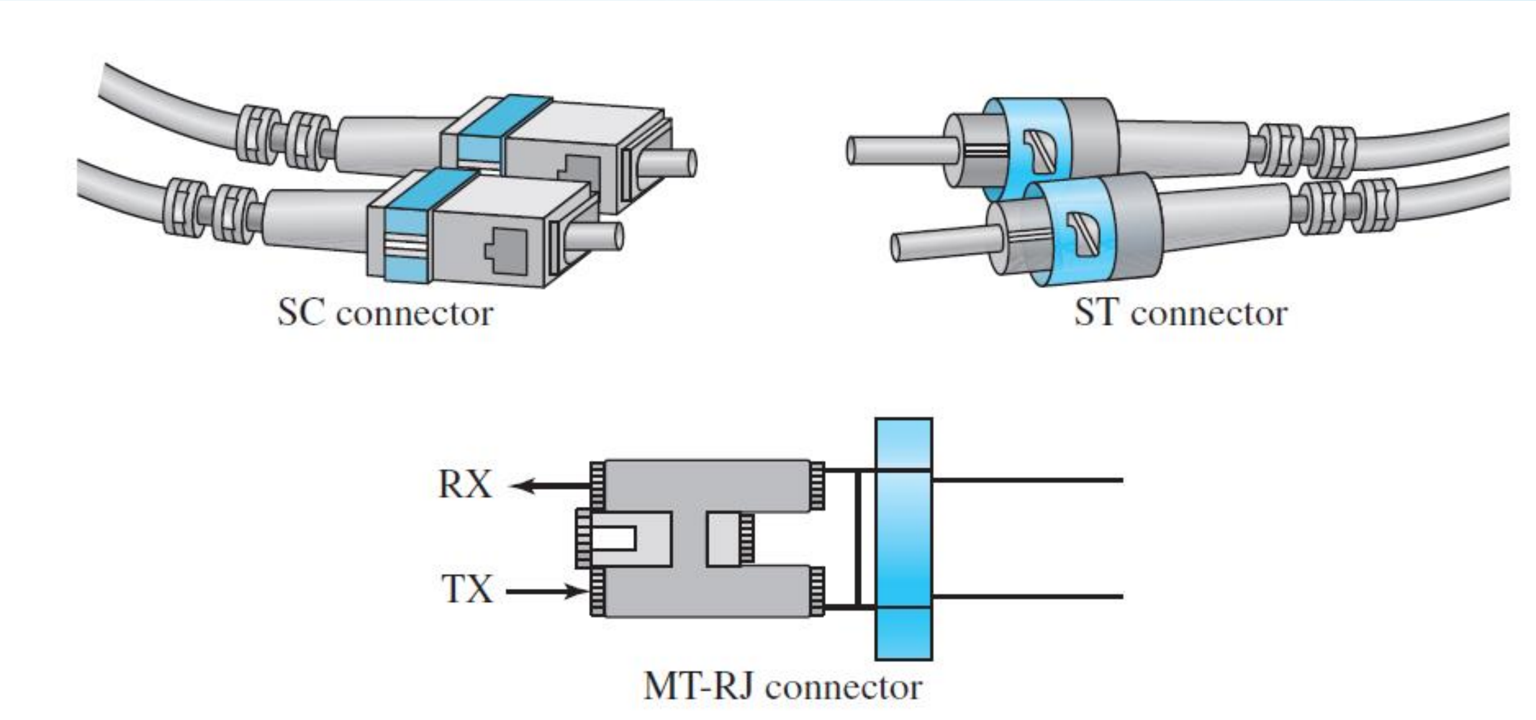
CABLE COMPOSITION

- The outer jacket is made of either PVC or Teflon. Inside the jacket are Kevlar strands to strengthen the cable.
- Kevlar is a strong material used in the fabrication of bulletproof vests. Below the Kevlar is another plastic coating to cushion the fiber.
- The fiber is at the center of the cable, and it consists of cladding and core.



FIBER-OPTIC CABLE CONNECTORS

- There are three types of connectors for fiber-optic cables
- The subscriber channel (SC) connector is used for cable TV.
- The straight-tip (ST) connector is used for connecting cable to networking devices.
- MT-RJ is a connector that is the same size as RJ45.



PERFORMANCE & APPLICATIONS

- Attenuation is flatter than in the case of twisted-pair cable and coaxial cable.
- The performance is such that we need fewer (actually one-tenth as many) repeaters when we use fiber-optic cable.

Applications

- Used in backbone networks because its wide bandwidth is cost-effective, can transfer data at a rate of 1600 Gbps.
- Some cable TV companies use a combination of optical fiber and coaxial cable, thus creating a hybrid network.

ADVANTAGES OF OPTICAL FIBER

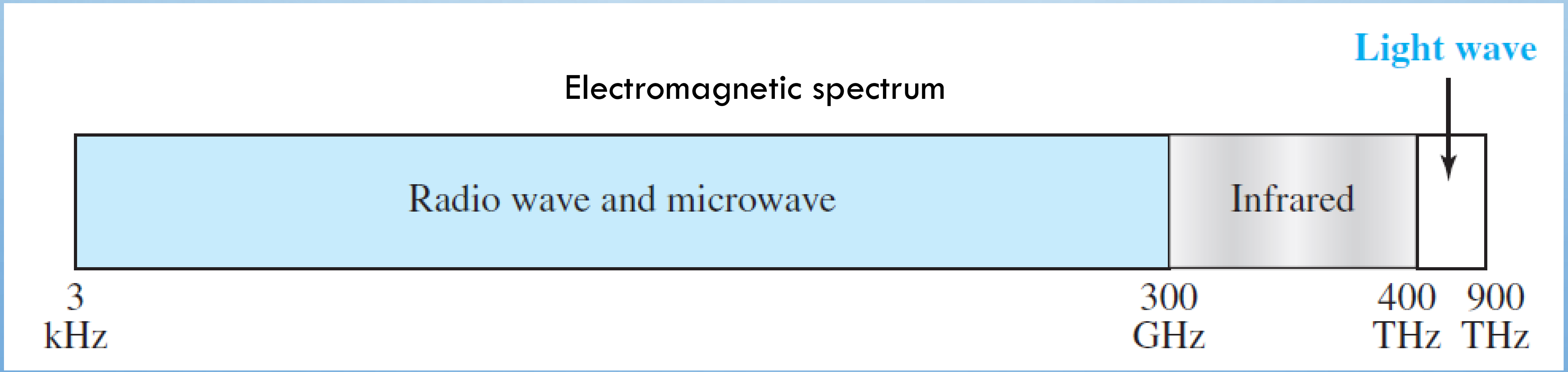
- Higher bandwidth.
- Less signal attenuation. A signal can run for 50 km without requiring regeneration. We need repeaters every 5 km for coaxial or twisted-pair cable.
- Immunity to electromagnetic interference. Electromagnetic noise cannot affect fiber-optic cables.
- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper.
- Light weight. Fiber-optic cables are much lighter than copper cables.
- Greater immunity to tapping.

DISADVANTAGES OF OPTICAL FIBER

- Installation and maintenance- require expertise
- 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.

UNGUIDED MEDIA: WIRELESS

- Unguided medium transport electromagnetic waves without using a physical conductor, 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



UNGUIDED SIGNALS

- In ground propagation, radio waves travel through the lowest portion of the atmosphere. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet.
- Distance depends on the amount of power in the signal: The greater the power, the greater the distance.
- In sky propagation, higher-frequency radio waves radiate upward into the where they are reflected back to earth.
- 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 is tricky because radio transmissions cannot be completely focused.

ELECTROMAGNETIC SPECTRUM

- The section of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges, called bands, each regulated by government authorities.
- These bands are rated from very low frequency (VLF) to extremely high frequency (EHF).

ELECTROMAGNETIC SPECTRUM

We can divide wireless transmission into three broad groups: radio waves, microwaves, and infrared waves.

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3–30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30–300 GHz	Line-of-sight	Radar, satellite

RADIO WAVES

- Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are called radio waves; waves ranging in frequencies between 1 and 300 GHz are called microwaves
- Radio waves are omnidirectional.
- This means that the sending and receiving antennas do not have to be aligned.
- The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band.
- Radio waves, can travel long distances and hence a good candidate for long-distance broadcasting such as AM radio.
- Radio waves can penetrate walls, is relatively narrow, just under 1 GHz
- When this band is divided into subbands, the subbands are also narrow, leading to a low data rate for digital communications.

OMNIDIRECTIONAL ANTENNA

- Radio waves use omnidirectional antennas that send out signals in all directions.
- Based on the wavelength, strength, and the purpose of transmission, we can have several types of antennas.

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

MICROWAVES

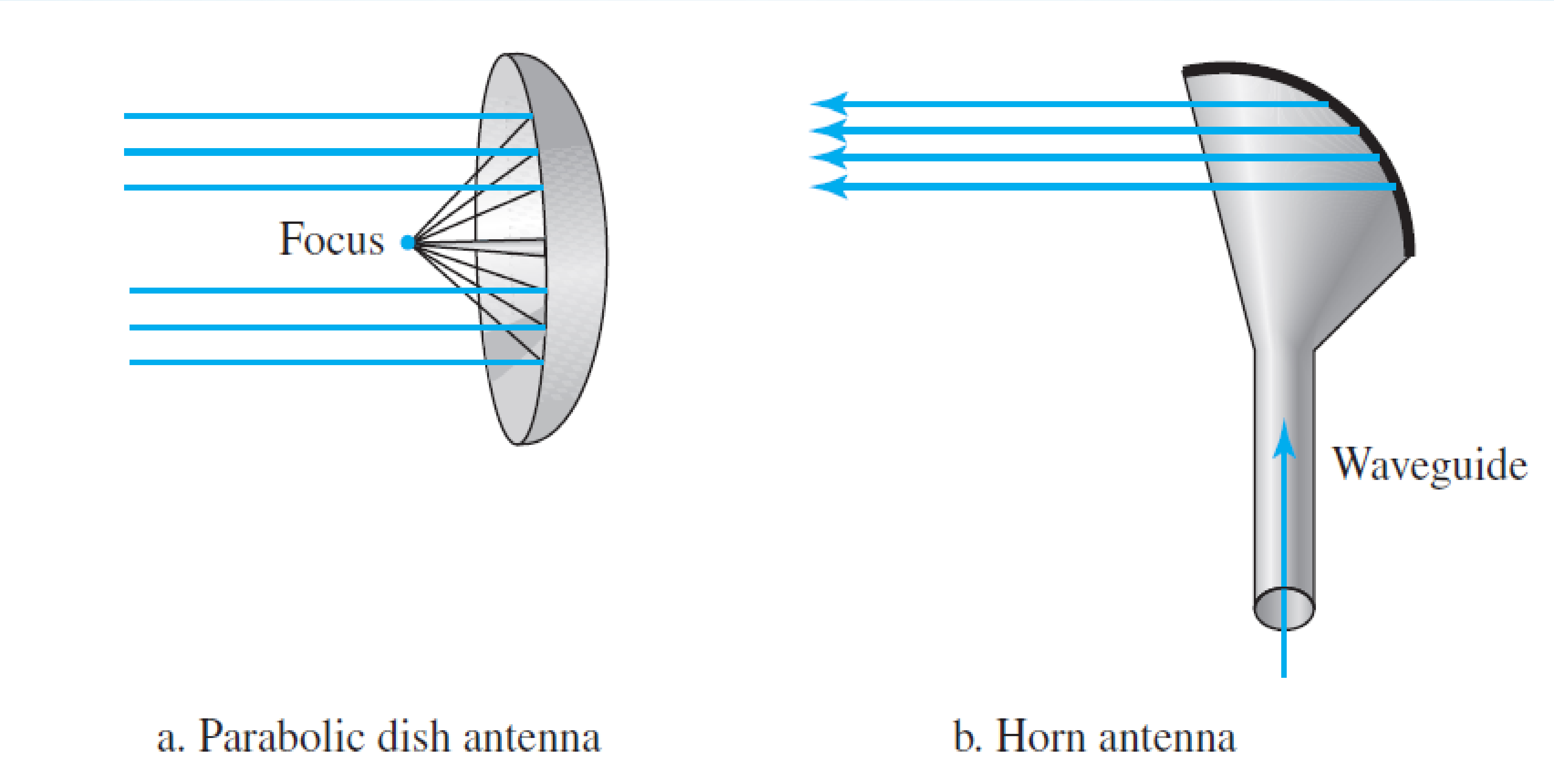
- Electromagnetic waves having frequencies between 1 and 300 GHz are microwaves.
- Microwaves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned.
- A pair of antennas can be aligned without interfering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

CHARACTERISTICS OF MICROWAVE PROPAGATION

- Microwave propagation is line-of-sight.
- The curvature of the earth as well as other blocking obstacles do not allow two short towers to communicate by using microwaves.
- Repeaters are often needed for long distance communication.
- Very high-frequency microwaves cannot penetrate walls.
- The microwave band is relatively wide, almost 299 GHz and a high data rate is possible.
- Use of certain portions of the band requires permission from authorities.

UNIDIRECTIONAL ANTENNA

- Two types of antennas are used for microwave communications: the parabolic dish and the horn



PARABOLIC DISH AND THE HORN

- A parabolic dish antenna is based on the geometry of a parabola: Every line parallel to the line of symmetry (line of sight) reflects off the curve at angles such that all the lines intersect in a common point called the focus.
- The parabolic dish works as a funnel, catching a wide range of waves and directing them to a common point.
- Outgoing transmissions are broadcast through a horn aimed at the dish.
- The microwaves hit the dish and are deflected outward in a reversal of the receipt path.
- A horn antenna looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem (resembling a handle) and deflected outward in a series of narrow parallel beams by the curved head.
- Received transmissions are collected by the scooped shape of the horn, in a manner similar to the parabolic dish, and are deflected down into the stem.

APPLICATIONS

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

INFRARED

- Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm
- to 770 nm), used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls →prevents interference
- A short-range communication system in one room cannot be affected by another system in the next room.
- Hence, useless for long-range communication.
- 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, almost 400 THz, has an excellent potential for data transmission with a very high data rate.
- The Infrared Data Association (IrDA), an association for sponsoring the use of infrared waves, has established standards for using these signals for communication between
- devices such as keyboards, mice, PCs, and printers.
- The standard originally defined a data rate of 75 kbps for a distance up to 8 m. The recent standard defines a data rate of 4 Mbps.
- Infrared signals defined by IrDA transmit through line of sight; the IrDA port on the keyboard needs to point to the PC for transmission to occur.

SUMMARY

- Transmission media are actually located below the physical layer and are directly controlled by the physical layer.
- A guided medium provides a physical conduit from one device to another.
- Twisted-pair cable consists of two insulated copper wires twisted together
- Coaxial cable consists of a central conductor and a shield.
- Fiber-optic cables are composed of a glass or plastic inner core surrounded by cladding, all encased in an outside jacket

SUMMARY

- Unguided media (free space) transport electromagnetic waves without the use of a physical conductor.
- Wireless data are transmitted through ground propagation, sky propagation, and line-of-sight propagation
- Wireless waves can be classified as radiowaves, microwaves, or infrared waves.
- Radio waves are omnidirectional; microwaves are unidirectional.

TEST YOUR UNDERSTANDING

- Name the two major categories of transmission media
- What are the three major classes of guided media?
- What is the function of the twisting in twisted-pair cable?
- How does sky propagation differ from line-of-sight propagation?