SRM Institute of Science and Technology

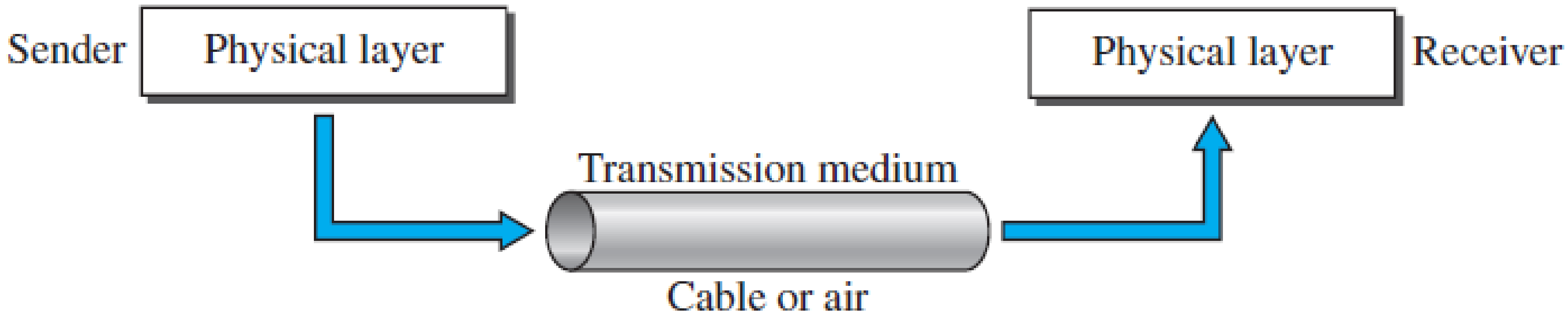
21CSC302J-COMPUTER NETWORKS

Unit- I

Transmission Media

Guided Media

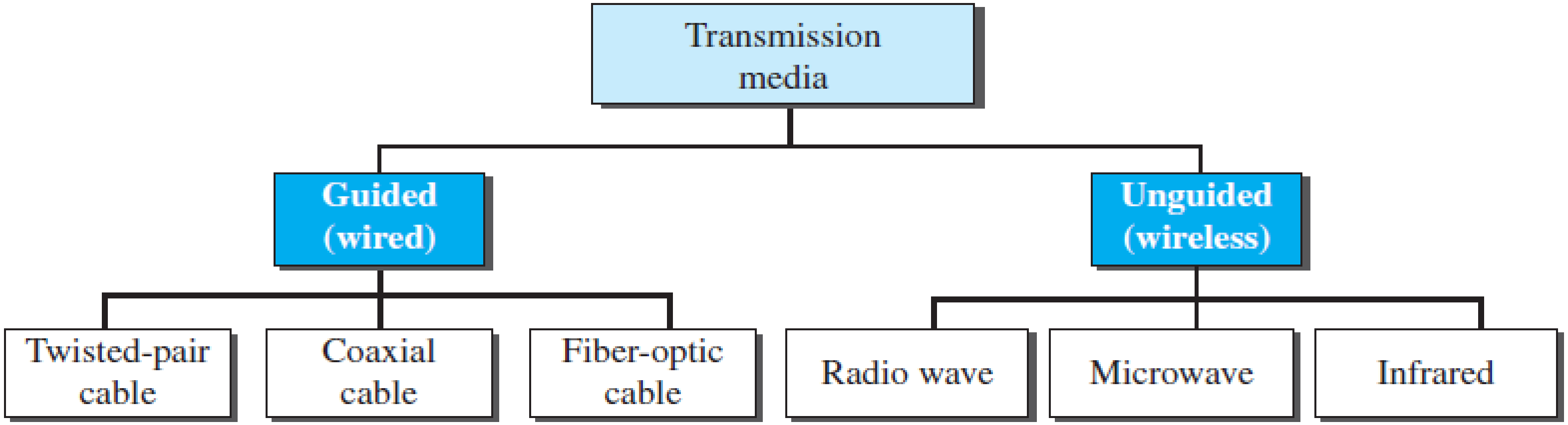
- Transmission media are actually located below the physical layer and are directly controlled by the physical layer.



- In telecommunications, 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***.



GUIDED MEDIA

- 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.

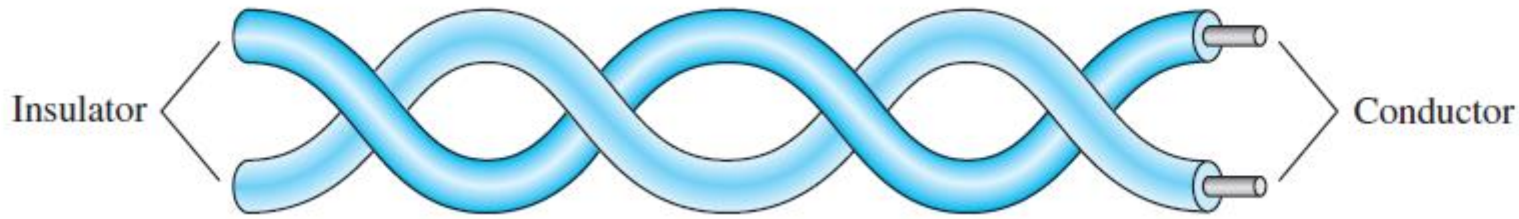
- Twisted-pair and coaxial cable use metallic (copper) conductors
  - **accept and transport signals in the form of electric current.**

- **Optical fiber** ***accepts and transports signals in the form of light.***

Twisted-Pair Cable

Twisted-Pair Cable

- 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,
- The other is used only as a ground reference.
- The receiver uses the difference between the two.
- Interference (noise) and crosstalk may affect both wires and create unwanted signals.

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*
  - *This results in a difference at the receiver.*
- By twisting the pairs, a balance is maintained.
- Twisting makes both wires are equally affected by external influences
- This means that the receiver, which calculates the difference between the two, receives no unwanted signals.

Twisted-Pair Cable

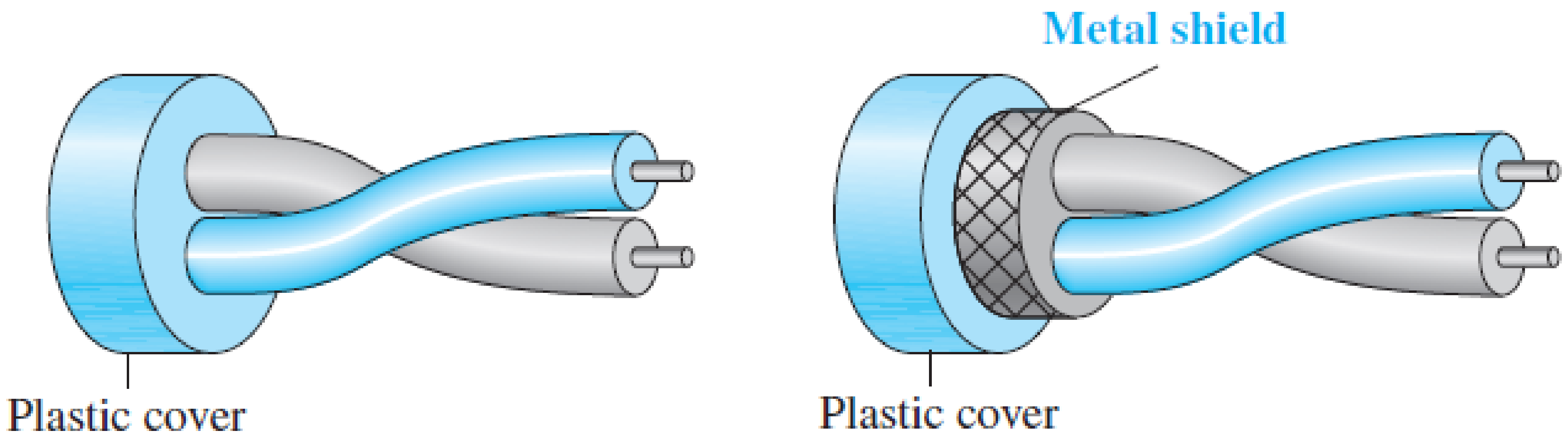
- The unwanted signals are mostly canceled out.

- It is clear that the number of twists per unit of length 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 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.

Unshielded Versus Shielded Twisted-Pair Cable



a. UTP   b. STP

Shielded Twisted-Pair Cable

- STP cable can support various megabits/sec for some kilometer and less expensive.
- It provides speed or throughput of approximate 10 to 100 Mbps.
- It can support maximum cable length about 100 meters.
- It gets low attenuation than UTP cable.
- STP is more expensive compare to UTP.
- STP contains must be grounding cable.

Unshielded Twisted-Pair Cable

- It provides the speed or throughput of almost 10 to 1000Mbps.
- It contains the maximum cable length of about 100 meter.
- UTP gets high attenuation than STP.
- It generates higher crosstalk to STP.
- It does not need grounding cable

UnShielded Twisted-Pair Cable

- UTP cables are mostly used in the computer network as well as in the telecommunication sector as telephone wires and Ethernet cables.

- It is small size, so easy to installation.

Unshielded Versus Shielded Twisted-Pair Cable

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

Unshielded Versus Shielded Twisted-Pair Cable

Category	*Specification*	*Data Rate (Mbps)*	*Use*
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

Performance

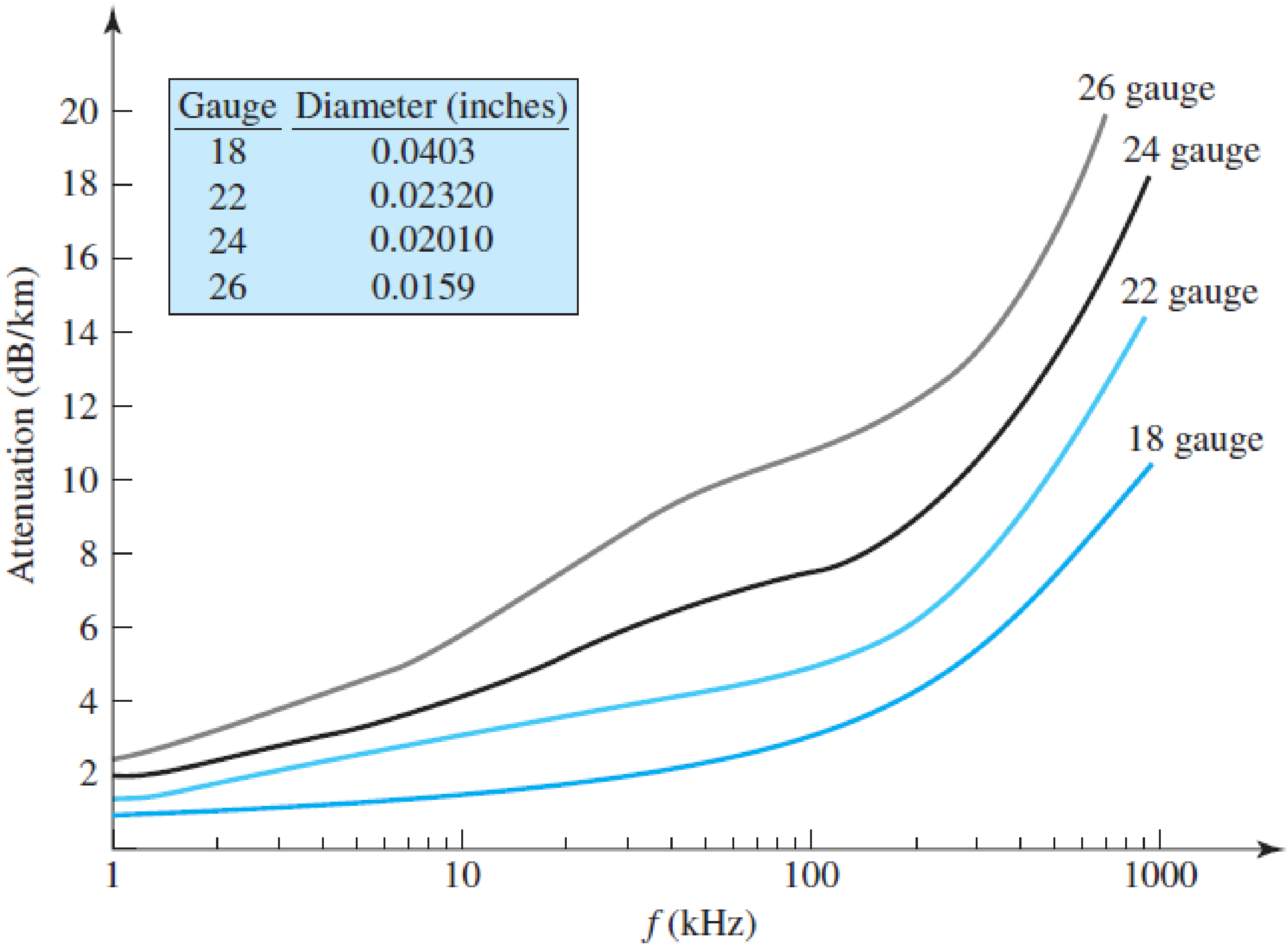
- **One way to measure the performance of twisted-pair cable is *to compare attenuation versus frequency and distance.***

- A twisted-pair cable can pass a wide range of frequencies.

- Figure shows 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.

Performance



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 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.

Categories of Twisted Pair cable

- Category 1 – UTP used in telephone lines with data rate < 0.1 Mbps
- Category 2 – UTP used in transmission lines with a data rate of 2 Mbps
- Category 3 – UTP used in LANs with a data rate of 10 Mbps
- Category 4 – UTP used in Token Ring networks with a data rate of 20 Mbps
- Category 5 – UTP used in LANs with a data rate of 100 Mbps
- Category 6 – UTP used in LANs with a data rate of 200 Mbps
- Category 7 – STP used in LANs with a data rate of 10 Mbps

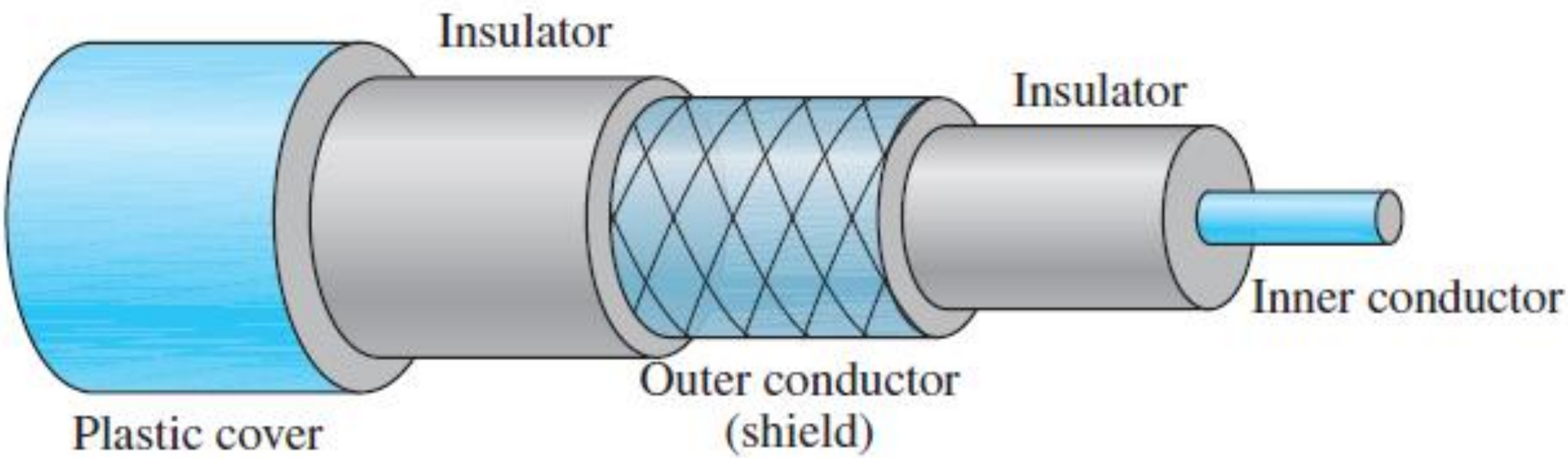
Coaxial Cable

- **Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable,**
  - ***the two media are constructed quite differently.***

- **Instead of having two wires,** ***coax 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.

Coaxial Cable



- 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.***

- Each cable defined by an RG rating is adapted for a specialized function, as shown in Table.

Coaxial Cable Categories

Table 7.2 *Categories of coaxial cables*

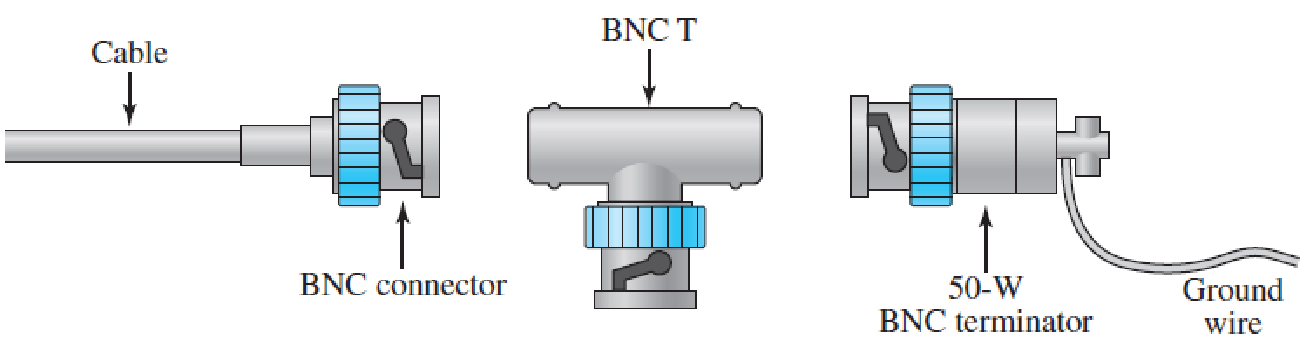
Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Coaxial Cable Connectors

- To connect coaxial cable to devices

- The most common type of connector used today is the Bayonet Neill-Concelman (BNC) connector.

- Figure shows three popular types of these connectors:
  - ***the BNC connector,***
  - ***the BNC T connector, and***
  - ***the BNC terminator.***



Coaxial Cable Connectors

- The BNC connector is used to connect the end of the cable to a device, such as a TV set.

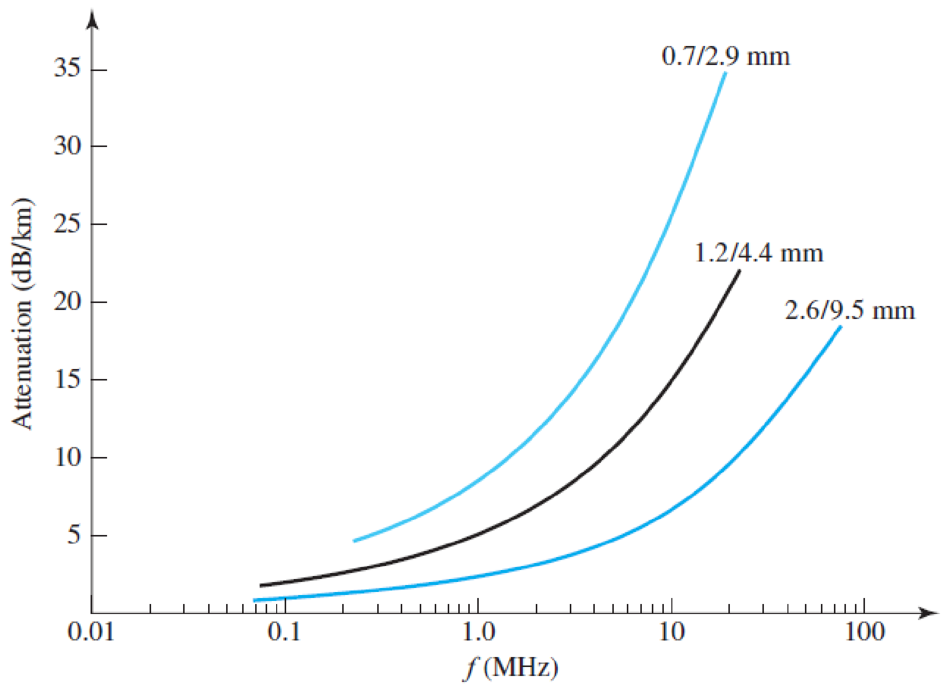
- The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or other device.

- The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

Performance

- The attenuation is much higher in coaxial cable than in twisted-pair cable.

- 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.
- It was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps.
- coaxial cable in telephone networks has largely been replaced today with fiber optic cable.
- Cable TV networks also use coaxial cables.
- In the traditional cable TV network, the entire network used coaxial cable.

Applications

- cable TV providers replaced most of the media with fiber-optic cable;
- hybrid networks use coaxial cable only at the network boundaries, near the consumer premises.
- Cable TV uses RG-59 coaxial cable.
- Another common application of coaxial cable is in traditional Ethernet
- Because of its high bandwidth, and consequently high data rate, coaxial cable was chosen for digital transmission in early Ethernet LANs.

Applications

- 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.
- Thick Ethernet has specialized connectors.

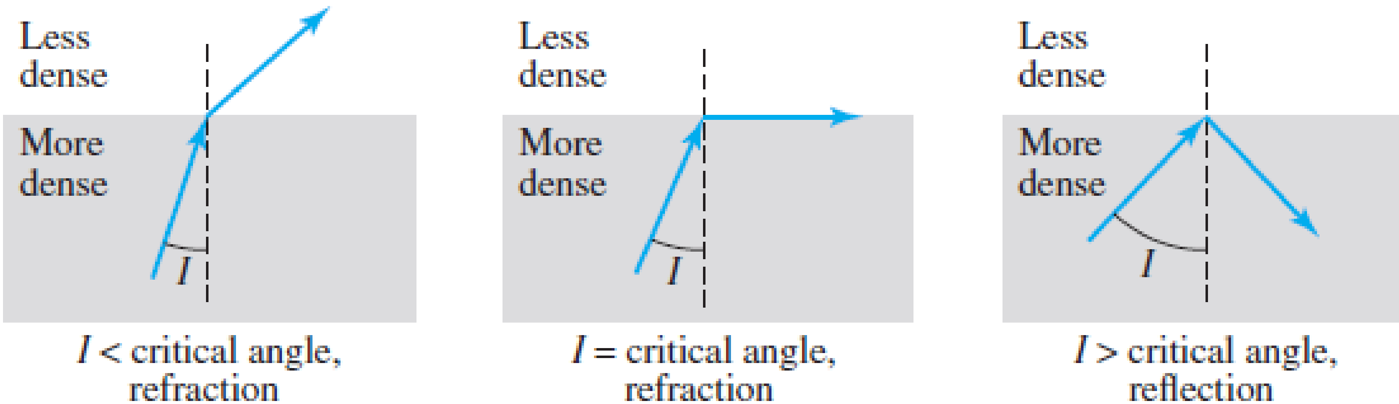
Fiber-Optic Cable

Fiber-Optic Cable

- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
- To understand optical fiber, we first need to explore several aspects of the nature 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.

Fiber-Optic Cable

- Figure shows how a ray of light changes direction when going from a more dense to a less dense substance.



- As the figure shows, 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.

Fiber-Optic Cable

- 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.

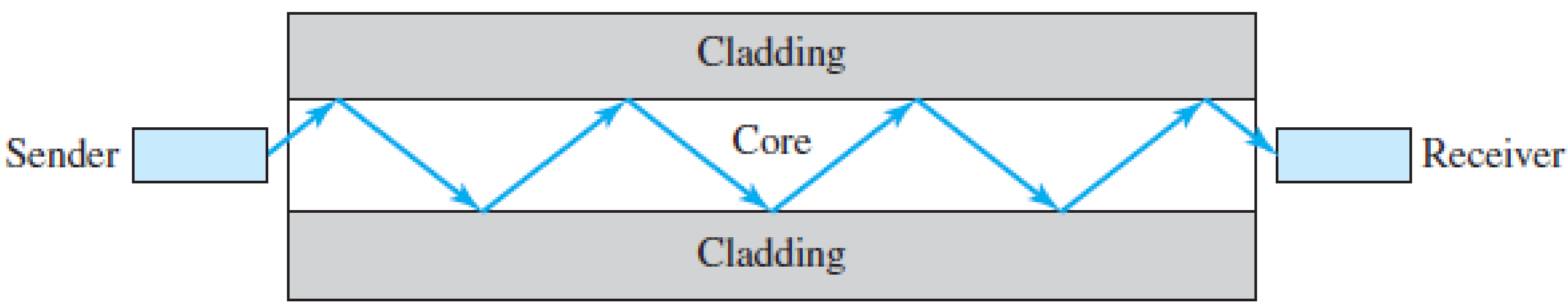
- Note that the critical angle is a property of the substance, and its value differs from one substance to another.

- Optical fibers use reflection to guide light through a channel.

Fiber-Optic Cable

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

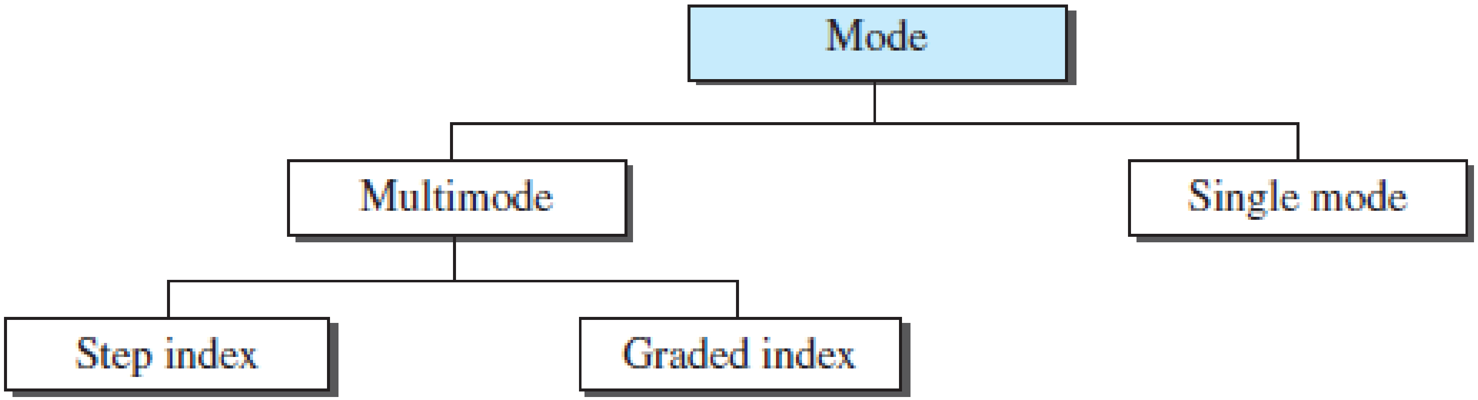
- The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.



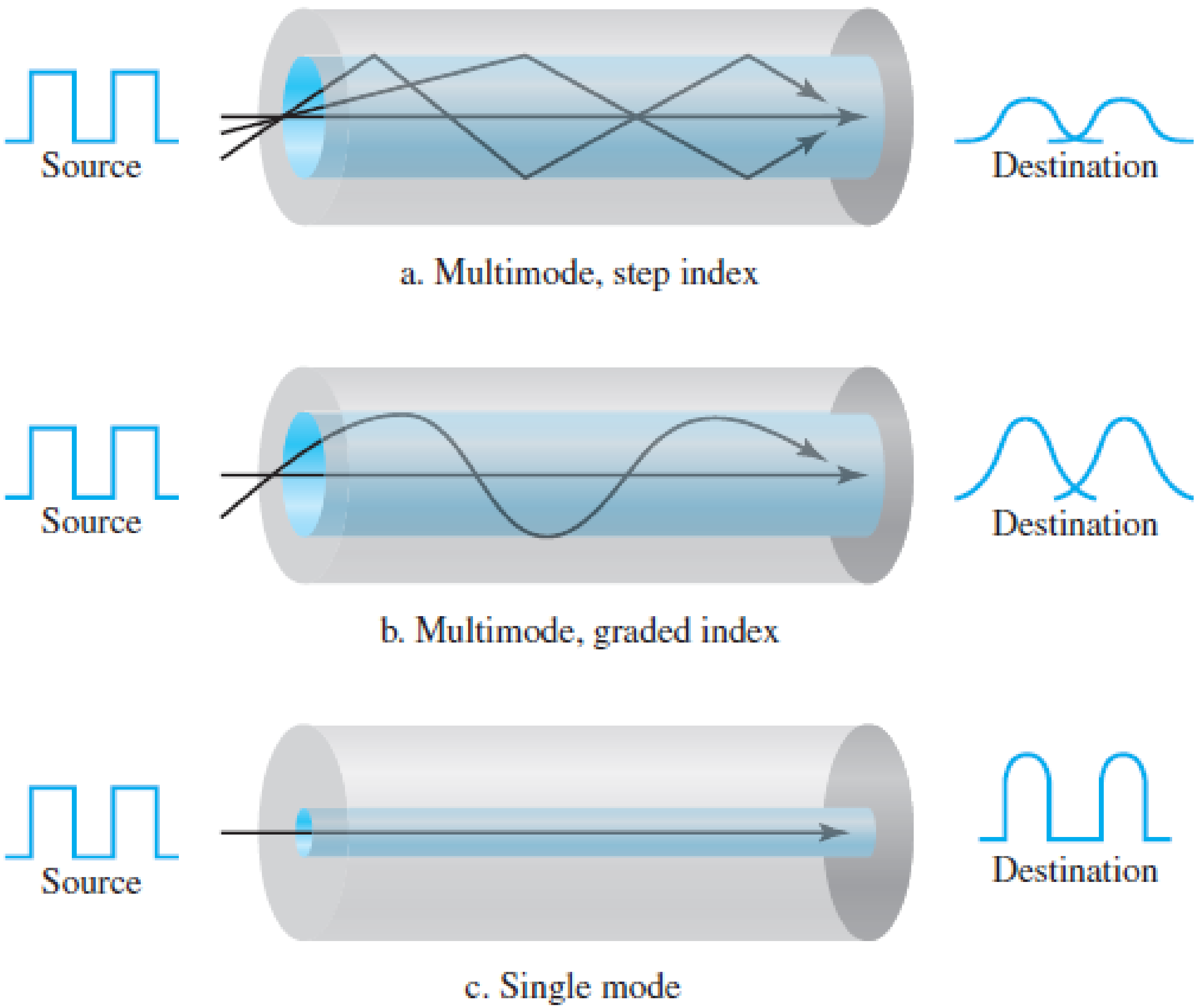
Propagation Modes

- 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



Multimode


Source
Destination
a. Multimode, step index
Source
Destination
b. Multimode, graded index
Source
Destination
c. Single mode

Multimode

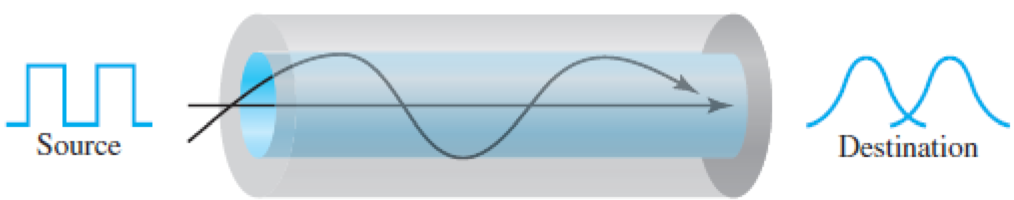
Multimode step-index fiber

1. The density of the core remains constant from the center to the edges.
2. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
3. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion.
4. 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.

Multimode

Multimode graded Index

1. Decreases this distortion of the signal through the cable.
2. The word index here refers to the index of refraction. The index of refraction is related to density.
3. A graded index fiber, therefore, is one with varying densities.
4. Density is highest at the center of the core and decreases gradually to its lowest at the edge.
5. Figure shows the impact of this variable density on the propagation of light beams.



b. Multimode, graded index

Single-Mode

- Uses step-index fiber
- Highly focused source of light that limits beams to a small range of angles, all close to the horizontal.
- 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.

Single-Mode

- In this case, propagation of different beams is almost identical, and delays are negligible.

- All the beams arrive at the destination “together” and can be recombined with little distortion to the signal

Fiber Sizes

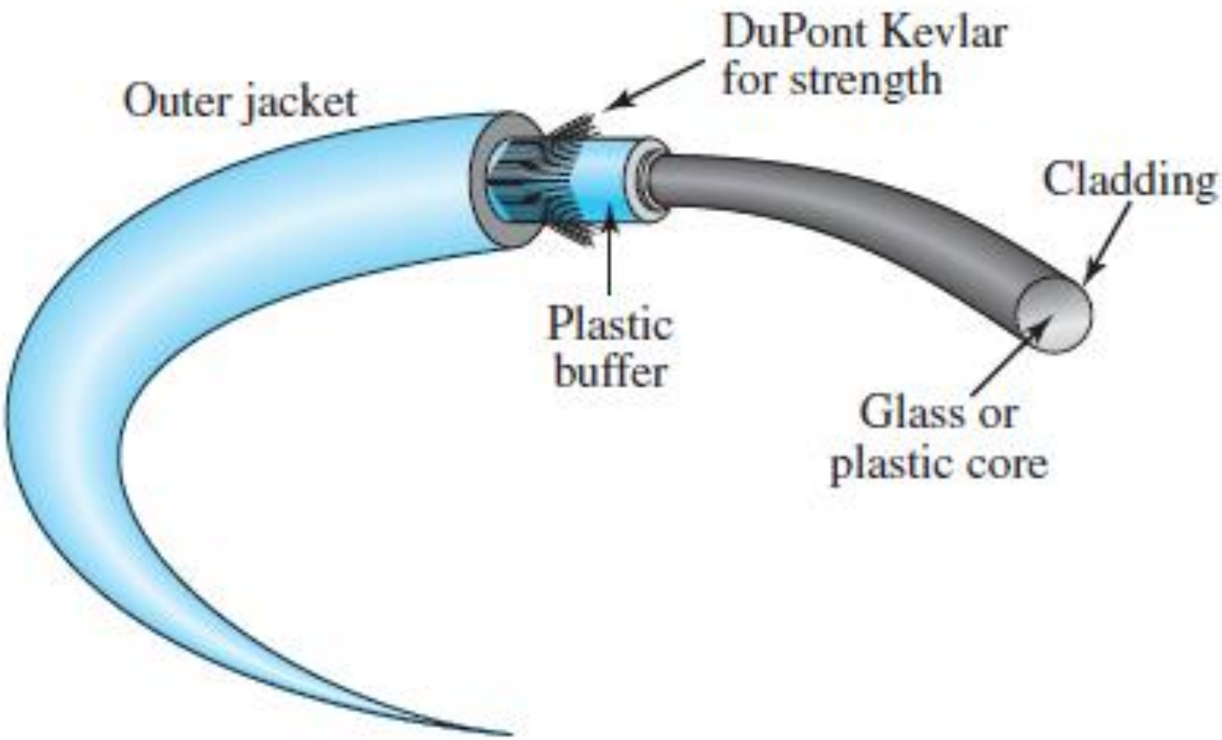
- Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both expressed in micrometers.
- The common sizes are shown in Table.
- The last size listed is for single-mode only.

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

- Figure shows the composition of a typical fiber-optic cable.
- 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.
- 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.

Cable Composition



Fiber-Optic Cable Connectors

- There are three types of connectors for fiber-optic cables, as shown in Figure.

- The subscriber channel (SC) connector is used for cable TV.

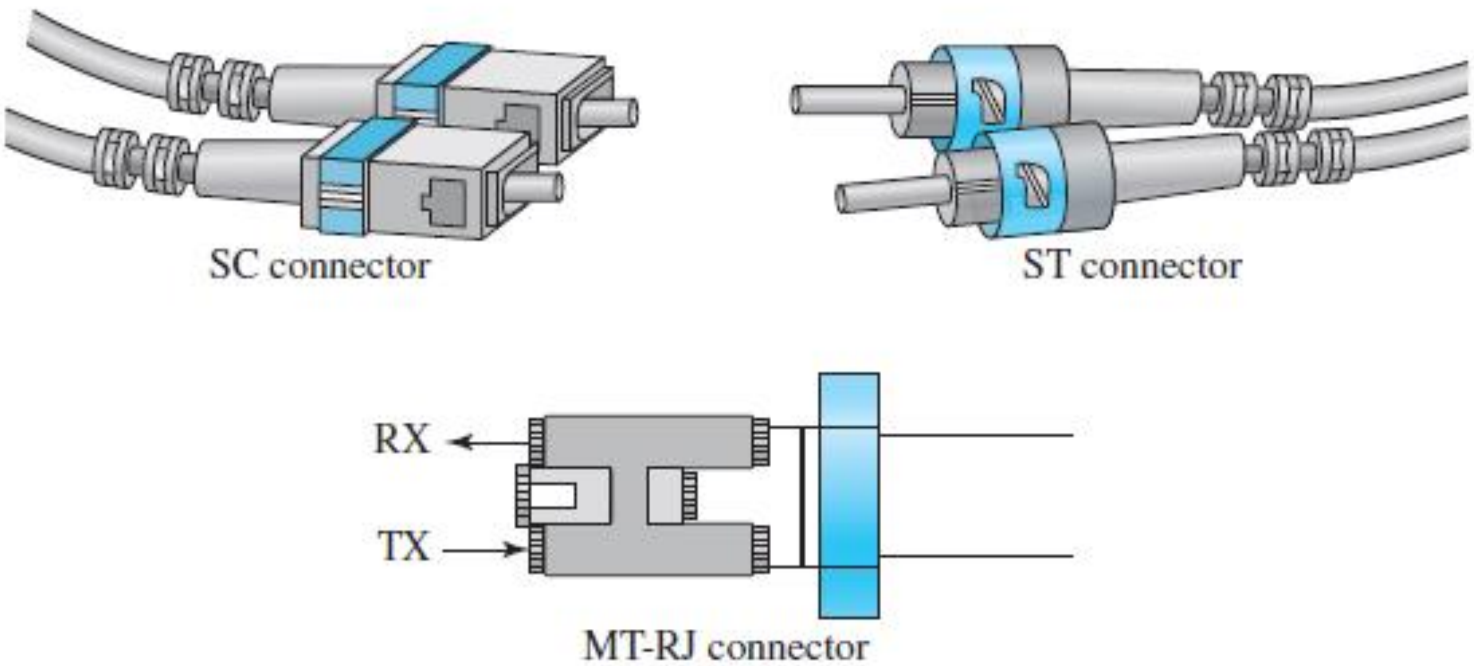
- It uses a push/pull locking system.

- The straight-tip (ST) connector is used for connecting cable to networking devices.

- It uses a bayonet locking system and is more reliable than SC.

Cable Composition

- MT-RJ is a connector that is the same size as RJ45.



Performance

- The plot of attenuation versus wavelength in Figure 7.16 shows a very interesting phenomenon in fiber-optic cable.
- 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

- Fiber-optic cable is often found in backbone networks because its wide bandwidth is cost-effective.
- Today, with wavelength-division multiplexing (WDM), we can transfer data at a rate of 1600 Gbps.
- The SONET network provides such a backbone.
- Some cable TV companies use a combination of optical fiber and coaxial cable, thus creating a hybrid network.
- Optical fiber provides the backbone structure while coaxial cable provides the connection to the user premises.

Applications

- This is a cost-effective configuration since the narrow bandwidth requirement at the user end does not justify the use of optical fiber.

- Local-area networks such as 100Base-FX network (Fast Ethernet) and 1000Base-X also use fiber-optic cable.

Advantages

- Fiber-optic cable has several advantages over metallic cable (twisted-pair or coaxial).

❑ Higher bandwidth. Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable. Currently, data rates and bandwidth utilization over fiber-optic cable are limited not by the medium but by the signal generation and reception technology available.

❑ 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.

Advantages

- 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. Copper cables create antenna effects that can easily be tapped.

Disadvantages

- There are some disadvantages in the use of optical fiber.

❑ 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.

UNGUIDED MEDIA: WIRELESS

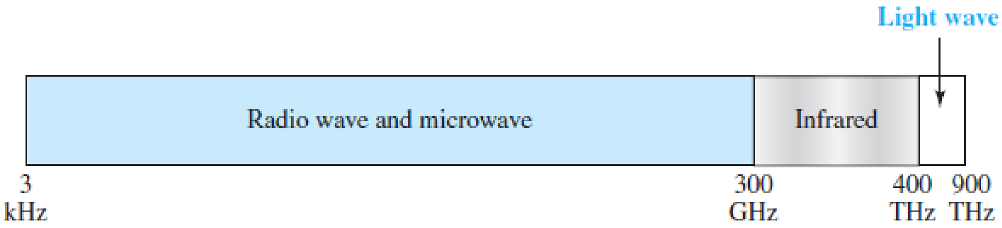
- Unguided medium ***transport electromagnetic waves*** without using a physical conductor.

- This type of communication is often referred to as wireless communication.

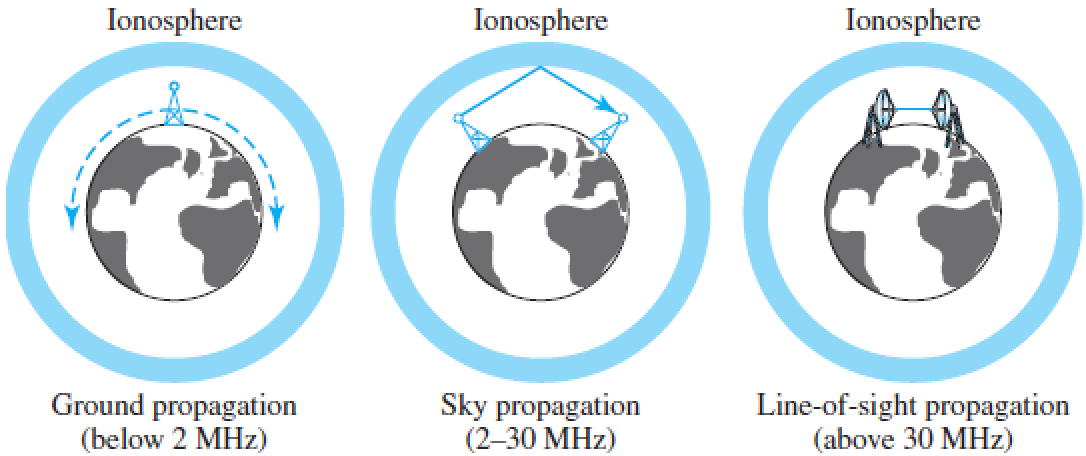
- Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

- Figure shows the part of the electromagnetic spectrum, ranging from 3 kHz to 900 THz, used for wireless communication.

- Unguided signals can travel from the source to the destination in several ways: ground propagation, sky propagation, and line-of-sight propagation.



Electromagnetic spectrum for wireless communication



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.

- 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 ionosphere (the layer of atmosphere where particles exist as ions) 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.

- Line-of sight propagation is tricky because radio transmissions cannot be completely focused.

Band	*Range*	*Propagation*	*Application*
very low frequency (VLF)	3–30 kHz	Ground	Long-range radio navigation
low frequency (LF)	30–300 kHz	Ground	Radio beacons and navigational locators

Band	*Range*	*Propagation*	*Application*
middle frequency (MF)	300 kHz–3 MHz	Sky	AM radio
high frequency (HF)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft
very high frequency (VHF)	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
ultrahigh frequency (UHF)	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
superhigh frequency (SF)	3–30 GHz	Line-of-sight	Satellite
extremely high frequency (EHF)	30–300 GHz	Line-of-sight	Radar, satellite

Radio Waves

- No clear-cut demarcation between radio waves and microwaves

- 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.

- The behavior of the waves, rather than the frequencies, is a better criterion for classification.

- Radio waves, for the most part, are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions.

Radio Waves

- This means that the sending and receiving antennas do not have to be aligned.
- A sending antenna sends waves that can be received by any receiving antenna.
- The omnidirectional property has a disadvantage, too.
- 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

- 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, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage.
- It is an advantage because, for example, an AM radio can receive signals inside a building.

Radio Waves

- It is a disadvantage because we cannot isolate a communication to just inside or outside a building.

- The radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band.

- 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.

- Figure 7.19 shows an 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.

Radio waves are used for multicast communications, such as radio and television, and paging systems.

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.

Microwaves - Characteristics

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. 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.

Microwaves - Characteristics

Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.

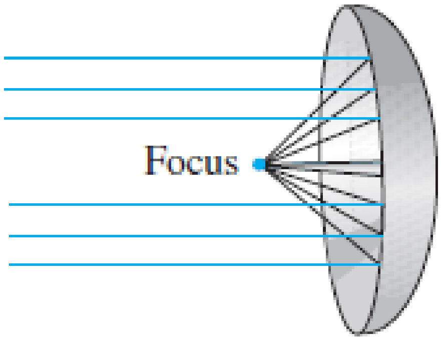
The microwave band is relatively wide, almost 299 GHz. Therefore wider subbands can be assigned, and a high data rate is possible.

Use of certain portions of the band requires permission from authorities.

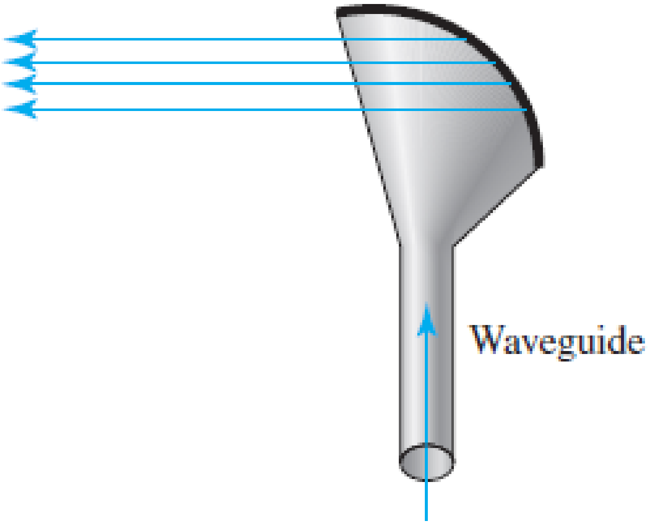
Unidirectional Antenna

- 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



a. Parabolic dish antenna



b. Horn antenna

Unidirectional Antenna

- 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.
- more of the signal is recovered than would be possible with a single-point receiver.

Unidirectional Antenna

- 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 (one to-one) communication is needed between the sender and the receiver.

- They are used in cellular phones, satellite networks, and wireless LANs

Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

Infrared

- Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication.

- Infrared waves, having high frequencies, cannot penetrate walls.

- This advantageous characteristic prevents interference between one system and another; a short-range communication system in one room cannot be affected by another system in the next room.

- When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors.

Infrared

- However, this same characteristic makes infrared signals useless for long-range communication.

- 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, almost 400 THz, has an excellent potential for data transmission.

- Such a wide bandwidth can be used to transmit digital data 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.

- For example, some manufacturers provide a special port called the IrDA port that allows a wireless keyboard to communicate with a PC.

Applications

- 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.

Assignment

- Implementation of Telephone Network
- Implementation of Ethernet Network
- Implementation of Security Camera System
- Implementation of Cable Television
- Implementation of WLAN
- Implementation of Satellite System

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Thank You