DATA COMMUNICATIONS AND NETWORKING

Transmission Media (continue…)

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Fiber-Optic Cable

- Fiber- Optical is made of glass or plastic. It transmits signals in the form of light
- The Nature of Light
- The speed of light 300,000 Km/sec in a vacuum and Depends on the density of the medium through which it is traveling.
- Other properties of light

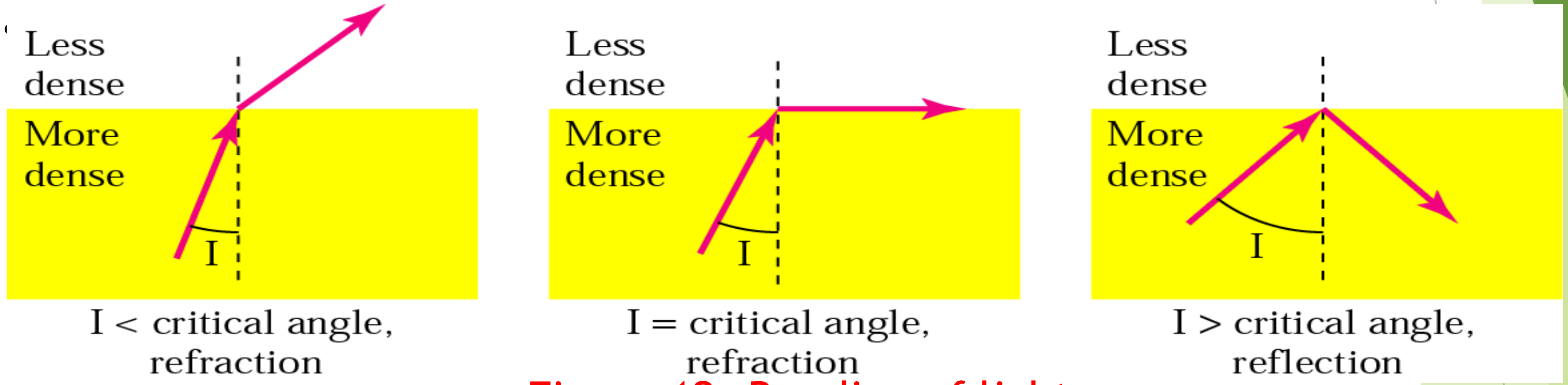

Figure 12. Bending of light ray

- 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.

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- 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, as shown in figures 13 and 14.

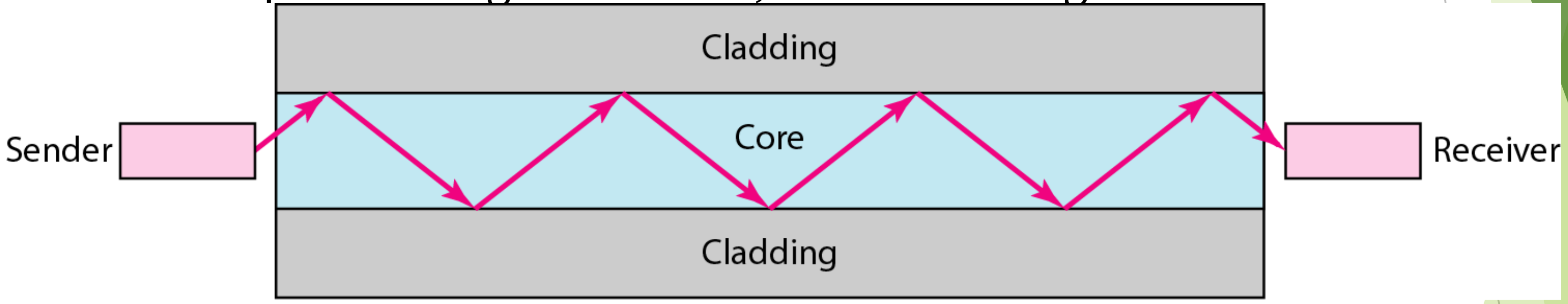

Figure 13. Optical fiber

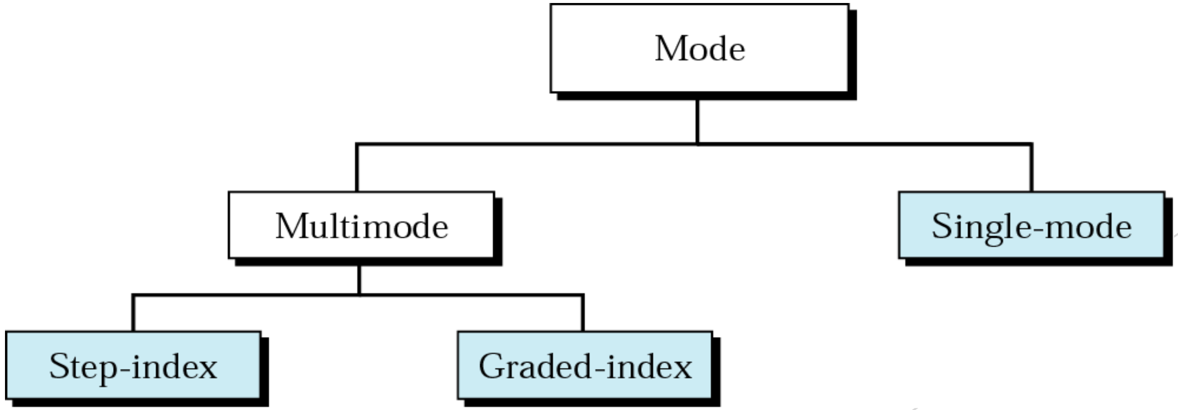

Figure 14. Propagation modes

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- Propagation Modes (continue…)
- Multimode is so named because multiple beams from a light source move through the core in different paths.
- 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.
- 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
- Multimode graded-index fiber, it is the second type of fiber its decreases the distortion of the signal through the cable.
- the index of refraction is related to density. A graded-index fiber, therefore, is one with varying densities.
- Density is highest at the center of the core and decreases gradually to its lowest at the edge.

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- Propagation Modes (continue…)
- 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).
- The decrease in density results in a critical angle that is close enough to 90° to make the propagation of beams almost horizontal. 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.

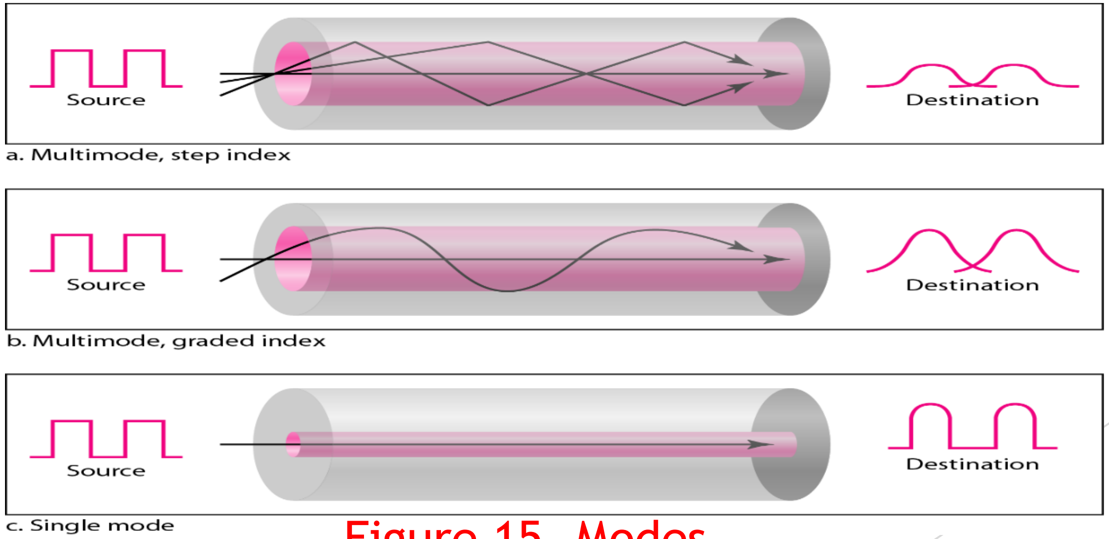

Figure 15. Modes

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- 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.

Table 3. Fiber types

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 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. 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, as show in figure 16.

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- Cable Composition (continue…)

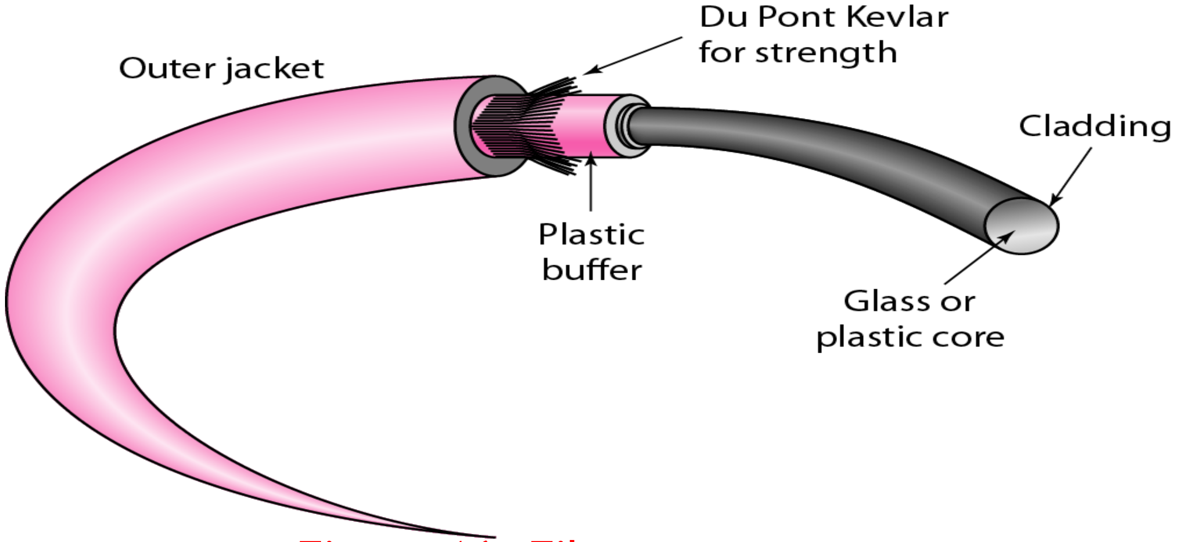

Figure 16. Fiber construction

- Fiber-Optic Cable Connectors
- SC (subscriber channel) connector used for cable TV. It uses push/pull locking system
- ST (straight-tip) connector used for connecting cable to networking device. It uses a reliable bayonet locking system
- MT-RJ is the same size as RJ45, as shown in figure 17.

GUIDED MEDIA (continue…)

- ➢ Fiber-Optic Cable (continue…)
- Cable Composition (continue…)

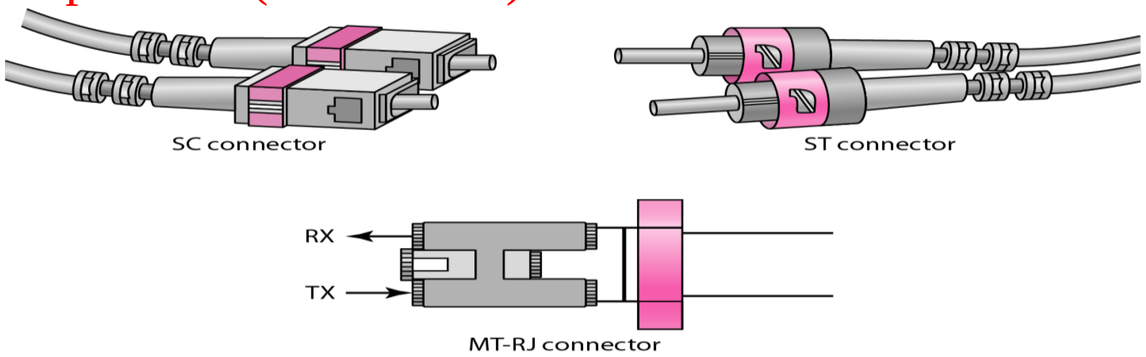

Figure 17. Fiber-optic cable connectors

- Performance
- Attenuation is flatter than in the case of twisted-pair cable and coaxial cable. The performance is such that we need fewer (actually 10 times less) repeaters when we use fiber-optic cable, as shown in figure 18.

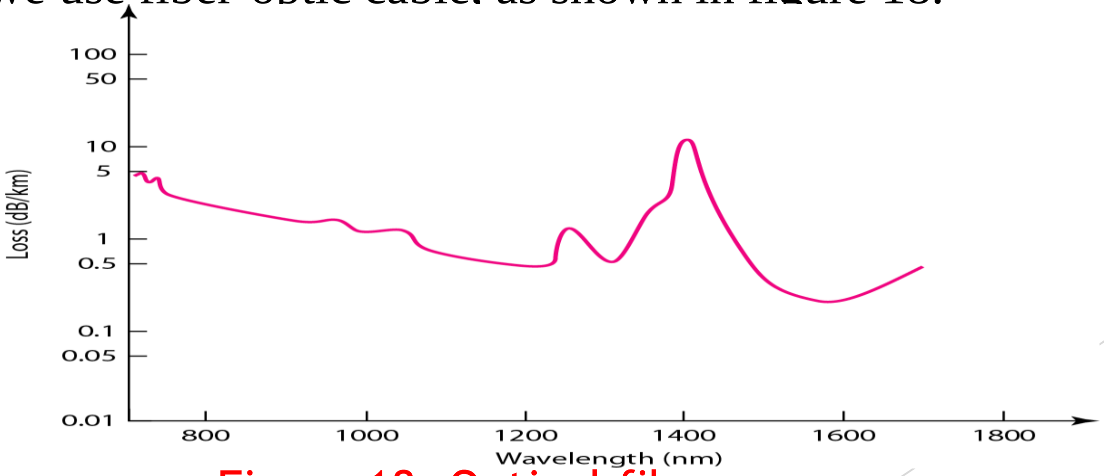

Figure 18. Optical fiber performance

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- Applications
- Fiber-optic cable is often found in backbone networks because its wide bandwidth is cost-effective
- 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.
- Local-area networks such as 100Base-FX network (Fast Ethernet) and 1000Base-X also use fiber-optic cable.

- Advantages/Disadvantages of Optical Fiber
- Advantages of optical fiber.
- Higher bandwidth. Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) 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.

GUIDED MEDIA (continue…)

- Fiber-Optic Cable (continue…)
- Advantages/Disadvantages of Optical Fiber (continue…)
- Advantages of optical fiber. (continue…)
- 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 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 media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.

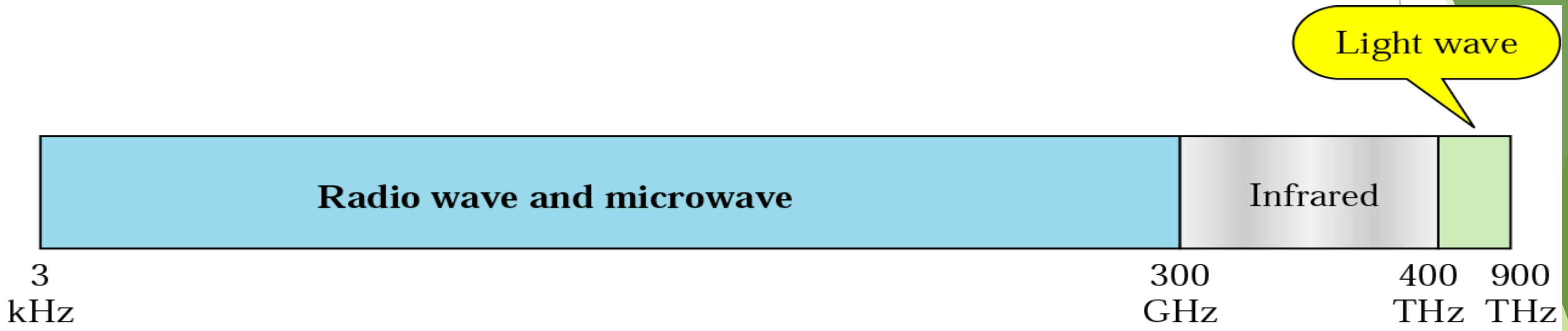

Figure 19. Electromagnetic spectrum for wireless communication

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

UNGUIDED MEDIA:WIRELESS (continue…)

- In line-or-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.

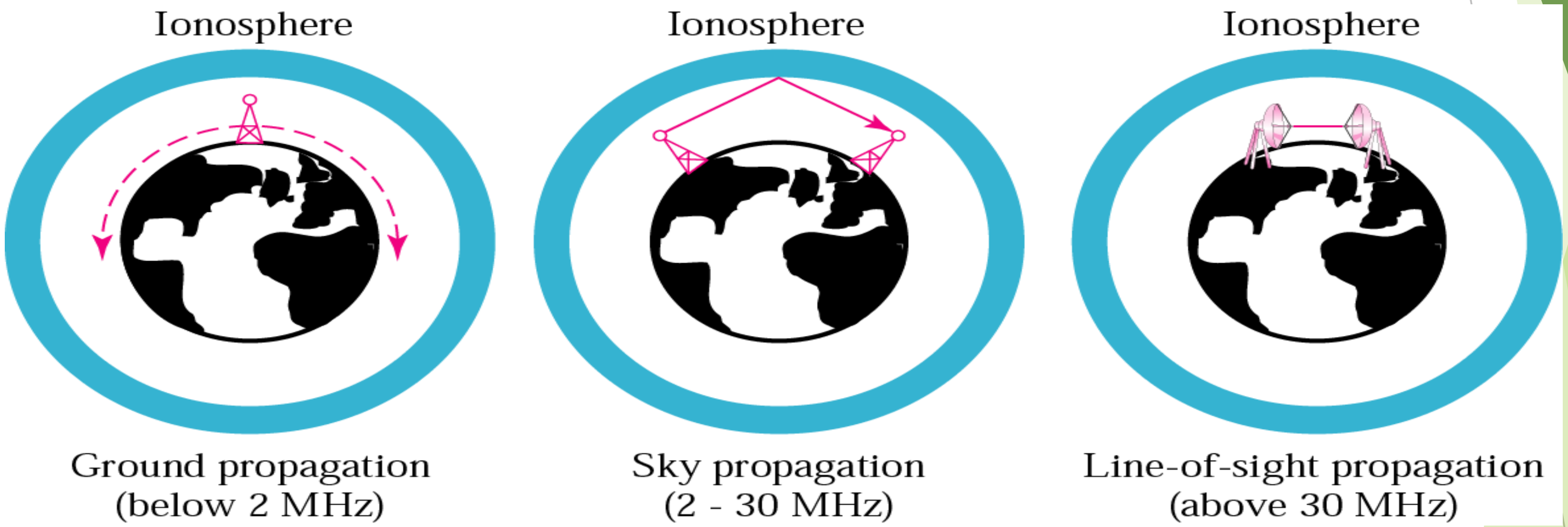

Figure 20. Propagation methods

- The section of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges, called bands, each regulated by government authorities, as shown in figure 21.

UNGUIDED MEDIA:WIRELESS (continue…)

Table 4. Bands

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

The wireless transmission divided into three broad groups: radio waves, microwaves, and infrared waves, as shown in figure 21.

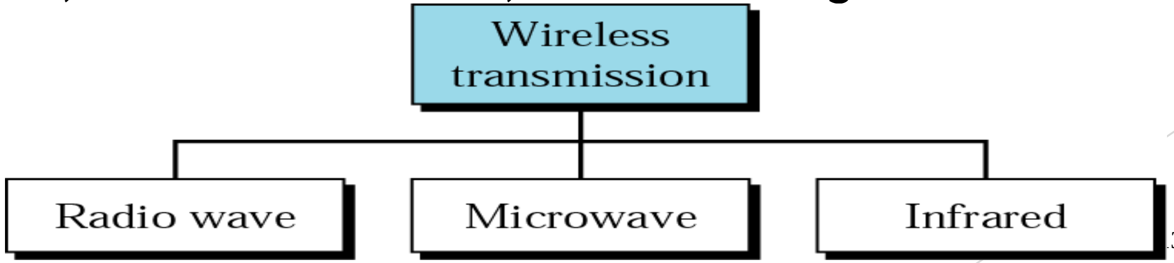

Figure 21. Wireless transmission waves

UNGUIDED MEDIA:WIRELESS (continue…)

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

- 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.

UNGUIDED MEDIA:WIRELESS (continue…)

- Radio Waves (continue…)
- 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.

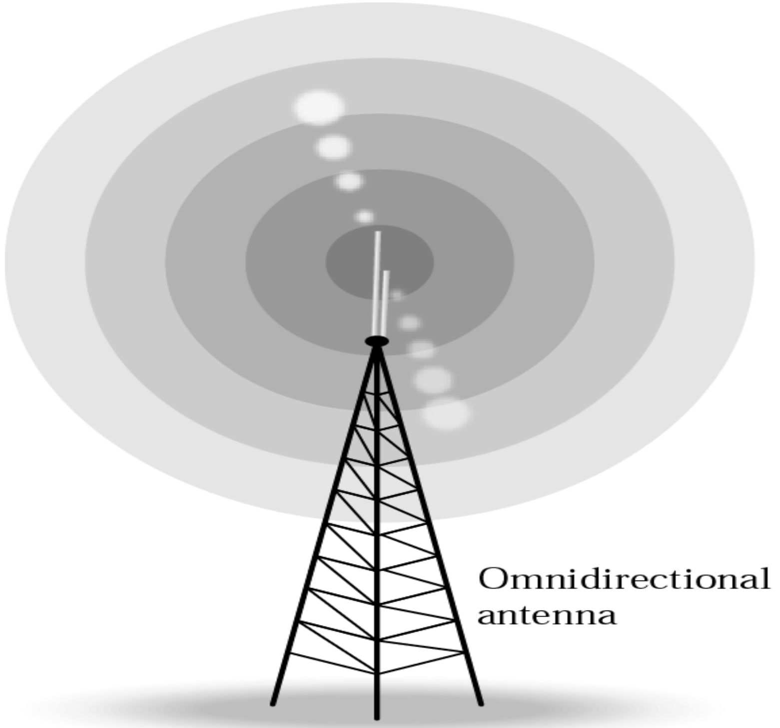

Figure 22. Omnidirectional antenna

UNGUIDED MEDIA:WIRELESS (continue…)

- Microwaves
- Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage.
- 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. 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. 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

UNGUIDED MEDIA:WIRELESS (continue…)

- 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, as shown in figure 23.
- Applications
- Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

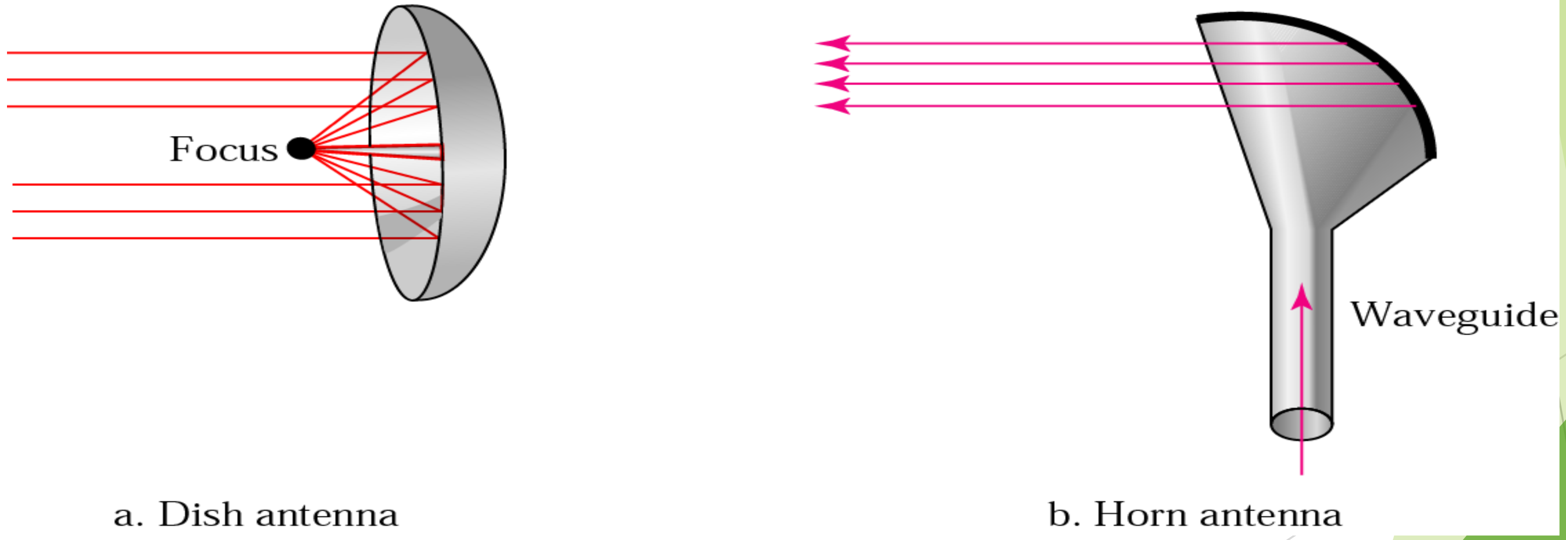

Figure 23. Unidirectional antennas

UNGUIDED MEDIA:WIRELESS (continue…)

- 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. 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
- IrDA (Infrared Data Association) for standards.
- Example: IrDA port for wireless keyboard.

  - Originally defined a data rate of 75 kbps for a distance up to 8 m

Summary

- Transmission media lie below the physical layer.
- A guided medium provides a physical conduit from one device to another. Twisted pair cable, coaxial cable, and optical fiber are most popular types of guided media.
- Twisted-pair cable consists of two insulated copper wires twisted together. Twisted pair cable is used for voice and data communications.
- Coaxial cable consists of a central conductor and a shield. Coaxial cable can carry signals of higher frequency ranges than twisted-pair cable. Coaxial cable is used in cable TV networks and traditional Ethernet LANs.
- Fiber-optic cables are composed of a glass or plastic inner core surrounded by
- cladding, all encased in an outside jacket. Fiber-optic cables carry data signals in the form of light. The signal is propagated along the inner core by reflection. Fiber optic transmission is becoming increasingly popular due to its noise resistance, low attenuation, and high-bandwidth capabilities. Fiber-optic cable is used in backbone networks, cable TV networks, and Fast Ethernet networks.
- 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 radio waves, microwaves, or infrared waves. Radio waves are omnidirectional; microwaves are unidirectional.
- Microwaves are used for cellular phone, satellite, and wireless LAN communications.
- Infrared waves are used for short-range communications such as those between a PC and a peripheral device. It can also be used for indoor LANs.