BACHELOR OF COMPUTER APPLICATIONS

SEMESTER 3

DCA2104

BASICS OF DATA COMMUNICATION

Unit 6

Transmission Media

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1. INTRODUCTION

This unit introduces the concept of transmission media. Transmission media is a medium which carry information from a source to a destination. Transmission media are directly controlled by the physical layer and are located below the physical layer. In data communication, the transmission medium is usually a free space, metallic cable or fiber optic cable. In telecommunication, transmission media can be divided into guided and unguided transmission media. Guided media include twisted-pair cable, coaxial cable and fiber-optic cable. Unguided medium is free space.

In this unit, we are going to discuss transmission media and its types. We will discuss guided transmission media such as twisted pair cable, coaxial cable, fiber optic cable. Then we will discuss wireless transmission methods such as radio waves, microwaves and infrared. In the last session, we will discuss line of sight transmission.

1.1 Objectives

After studying this unit, you should be able to:

- *Describe transmission media*
- *Explain guided transmission*
- *Describe wireless transmission*
- *Explain line of sight transmission*

2. GUIDED TRANSMISSION MEDIA

In guided media, computers are connected through a system of conduits. This include twisted-pair cable, coaxial cable and fiber optic cable. Signal travelling through any of these media is directed and restricted by the physical limits of the medium. Twisted pair and coaxial cable use metallic 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.

2.1 Twisted-Pair Cable

A twisted pair consists of two copper conductors each with its own plastic insulation, twisted together. Figure 6.1 shows a twisted pair cable.

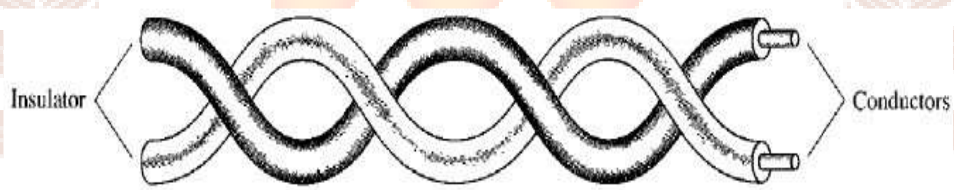


Figure 6.1: Twisted-pair cable

In twisted pair cable, one of the wires is used to carry signals to the receiver and the other is used only as a ground reference. The receiver uses the difference between the two. In addition to the signal sent by the sender on one of the wires, interference and crosstalk may affect both wires and create unwanted signals. If both wires are parallel, the effect of these unwanted signal is not the same in both wires and this results in a difference at receiver. By twisting the wires, a balance is maintained. Twisting makes it probable that both wires are equally affected by external influences. This means that the receiver which calculate the difference between two receives no unwanted signals. The unwanted signals are mostly canceled out. This means, 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). Another version of twisted pair cable produced by IBM is called shielded twisted pair (STP). STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors. This metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, but it is bulkier and more expensive. We discuss more about UTP because STP is not used outside of IBM.

The Electronic Industries Association (EIA) has developed standards to classify unshielded twisted-pair cable into seven categories. Categories are determined by cable quality, with 1 as the lowest and 7 as the highest. Each EIA category is suitable for specific use. Table 6.1 shows these categories.

Table 6.1: Categories of unshielded twisted-pair cables

Category	Specification	Data Rate (Mbps)	Use
1	Unshielded twisted-pair used in telephone	<0.1	ephone
2	Unshielded twisted-pair originally usedin T-lines	2	T- 1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in token ringnetworks	20	LANs
5	Cable wire is normally 24 AWG with ajacket and outside sheath	100	LANs
5E	An extension to category 5 that includesextra 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 testedat a 200-Mbps data rate	200	LANs
7	Sometimes called SSTP (shieldedscreen twisted-pair). Each pair is individually wrapped in a helical metallicfoil 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

The most common UTP connector is RJ45 (RJ stands for registered jack), which is shown in figure 6.2. The RJ45 is a keyed connector (that is, connector can be inserted in only one way).

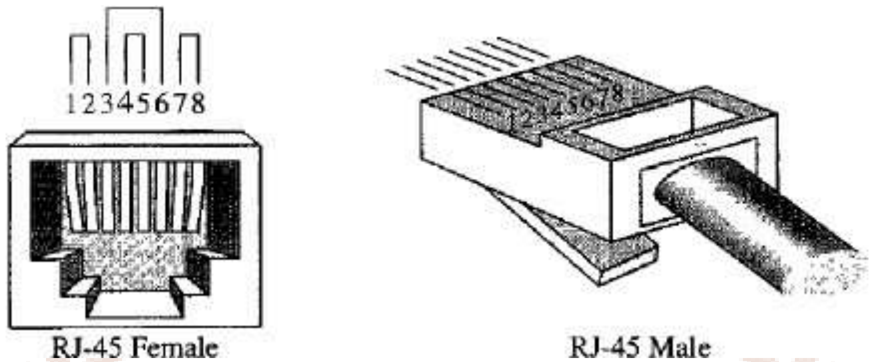


Figure 6.2: UTP connector

Applications

Twisted pair cables are used in telephone lines to provide voice and data channels. The lines that connects subscribers to the central telephone office, commonly consists of unshielded twisted-pair cables. The Digital Subscriber Lines (DSL) 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 10BaseT and 100BaseT also use twisted pair cables.

2.2 Coaxial Cable

Coaxial cable carries signals of higher frequency ranges than those in twisted pair cable, because the two media are constructed quite differently. In coaxial cable, there is a central core conductor of solid or stranded wire enclosed in an insulating sheath, which in turn encased in an outer conductor of metal foil. The outer metallic wrapping act as a shield against noise and as the second conductor, which completes the circuit. Outer conductor is enclosed in an insulating sheath and the whole cable is protected by a plastic cover. Figure 6.3 shows a coaxial cable.

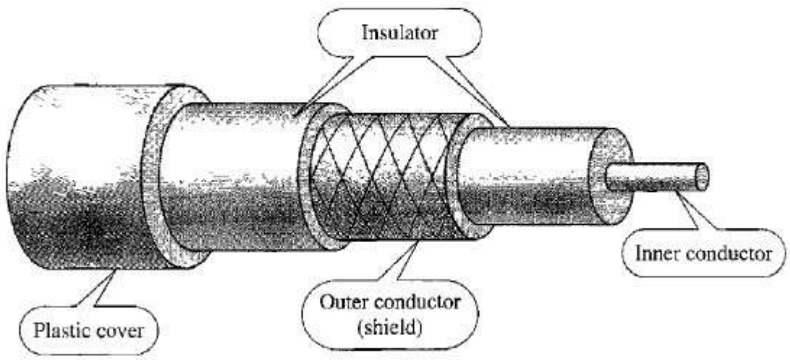


Figure 6.3: Coaxial cable

Coaxial cables are categorized by its Radio Government (RG) ratings. Each RG number denotes a unique set of physical specification which include the wire gauge of the inner conductor, thickness and type of inner insulator, construction of the shield and size and type of the outer casing. Each cable defined by an RG rating is adapted for a specialized function. Different categories of coaxial cables are RG-59 (uses in cable TV), RG-58(thin ethernet) and RG-11(thick ethernet).

We need coaxial connectors to connect coaxial cable to devices. The most common type of connector used today is the Bayone-Neill-Concelman (BNC) connector. Figure 6.4 shows three popular coaxial connectors: the BNC connector, the BNC T connector and the BNC terminator.

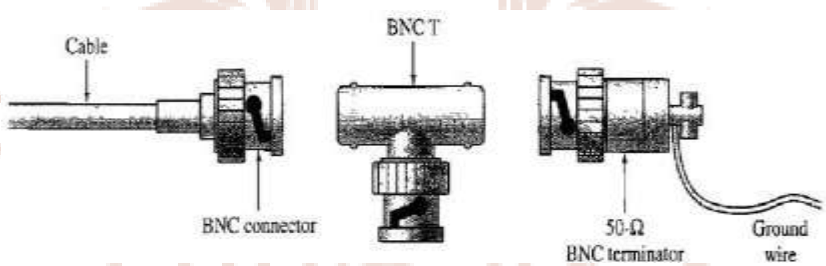


Figure 6.4: BNC connectors

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.

Attenuation is higher in coaxial cables than in twisted pair cable. So even if coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.

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. Today, coaxial cable in telephone networks has largely been replaced with fiber optic cable. Traditional Cable TV networks also used coaxial cables. Nowadays it is replaced with fiber optic cable and this hybrid network use coaxial cable at the network boundaries, near consumer premises. Cable TV uses RG-59 coaxial cable.

Another common application of coaxial cable is in traditional ethernet LANs. Because of its high bandwidth and high data rate, coaxial cable was chosen for digital transmission in early Ethernet LANs. The thin ethernet (10Base2) uses RG-58 coaxial cable with BNC connectors to transmit data at 10 Mbps with a range of 185 m. The thick ethernet (10Base5) uses RG-11 (thick coaxial cable) to transmit 10 Mbps with a range of 5000m. Thick ethernet has specialized connectors.

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 into another substance (of different density), the ray changes its direction. Figure 6.5 shows the bending of light ray when going from a denser to a less dense substance.

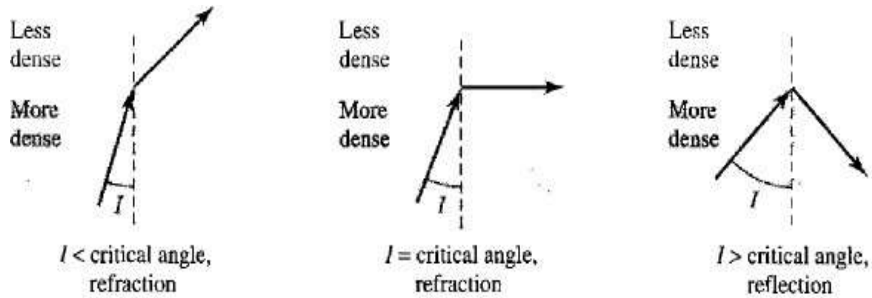


Figure 6.5: Bending of light ray

As figure 6.5 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 *critical angle*, the ray refracts and move 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. Value of critical angle differs from one substance to another. Figure 6.6 shows an optical fiber structure.

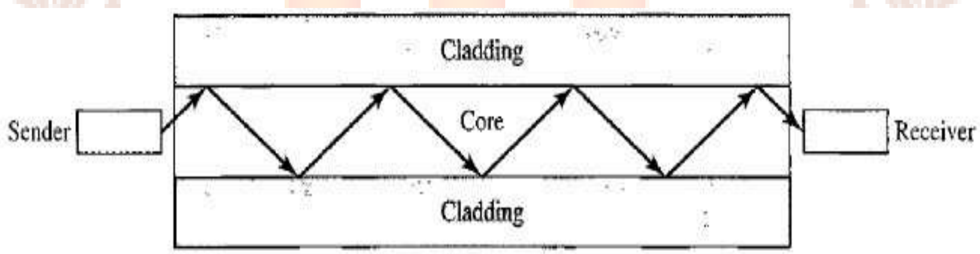


Figure 6.6: optical fiber

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.

Propagation Modes

There are two modes known as *multimode* and *single mode*, for propagating light along optical channels. Each mode requires fiber with different physical characteristics. Multimode can be implemented in two forms: they are step- index or graded-index. Figure 6.7 shows different propagation modes.

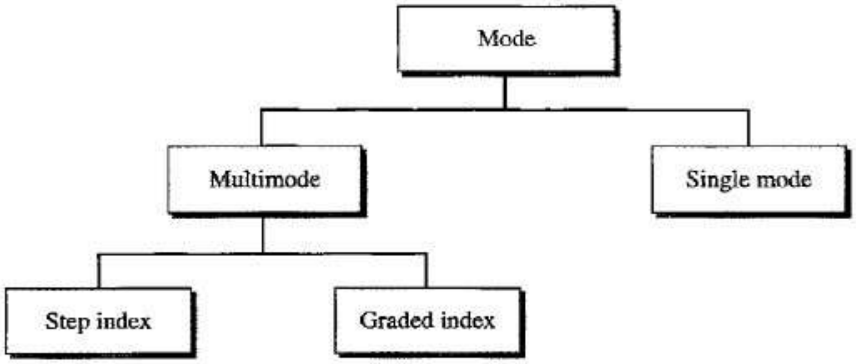


Figure 6.7: Propagation modes

In multimode propagation, 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 cladding. At the interface, there is a sudden 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 contribute to the distortion of the signal as it passes through the fiber.

Multimode graded index fiber decreases distortion of the signal through the cable. Index refers to the index of refraction. Index of refraction is related to density. A graded index fiber is the one with varying densities. Density is highest at the center of the core and decreases gradually to its lowest at the edge. Figure 6.8 shows the impact of this variable density on the propagation of light beams.

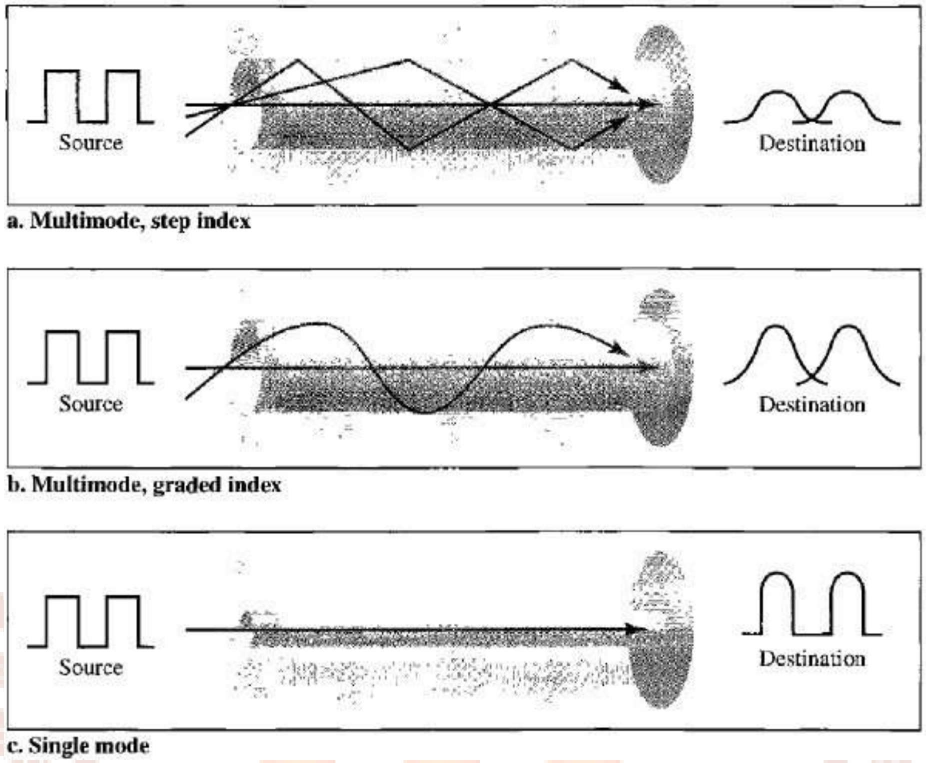


Figure 6.8: Modes

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 horizontal. The single mode fiber is manufactured with a much smaller diameter than that of multimode fiber and with lower density. The decrease in density results in a critical angle that is close enough to 90o to make the propagation of beams almost horizontal. In single mode, 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.

Applications

Since its wide bandwidth is cost effective, fiber optic cable is often found in backbone networks. Few cable TV companies use a combination of optical fiber and coaxial cable and thus creating a hybrid network. Optical fiber provides the backbone structure while coaxial cable provides the connection to the user premises. 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 of Optical Fiber

Fiber optic cable has several advantages over metallic cable.

- Fiber optic cable can support higher bandwidth than twisted pair or coaxial cable. Currently, data rates and bandwidth utilization over fiber optic cable are limited not by the medium but by signal generation and reception technology available.
- Fiber optic transmission distance is greater than that of guided media. That means, it has less signal attenuation. A signal can run for 50km without requiring regeneration. But in coaxial or twisted pair, we need repeaters every 5 km.
- Fiber optic cable has immunity to electromagnetic interference.
- It has resistance to corrosive materials. As we know, glass is more resistant to corrosive materials than copper.
- Fiber optic cables are much lighter than copper cables
- It has 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

There are some disadvantages in the use of optical fiber.

- Fiber optic cable's installation and maintenance require expertise that is not available everywhere
- In fiber optic, propagation of light is unidirectional therefore, if we need bidirectional communication, two fibers are needed.
- Fiber optic cable and the interfaces are relatively more expensive than any other guided media.

Self-Assessment Questions -1

1. Which layer directly control transmission media?
   a) Physical layer
   b) Datalink layer
   c) Network layer
   d) Transport layer
2. 'Unguided medium is free space'. State true or false.

   (a) True (b) False

3. Optical fiber is a cable that accepts and transports signals in the form of ___________ .
4. Twisted pair and coaxial cable accept and transport signals in the form of_________ .
5. ______________carries signals of higher frequency ranges than those in twisted pair cable.
6. The most common type of coaxial connector used today is_________________.
7. If *the angle of incidence is less* than the ray refracts and move closer to the surface.
8. There are two modes for propagating light along optical channels. They are ___________ and_____________.

3. WIRELESS TRANSMISSION

Unguided transmission media transport electromagnetic waves without using a physical conductor or medium. This type of communication is also known as wireless communication. In this communication, signals are broadcast through free space and thus are available to anyone who has a device capable of receiving them. Figure 6.9 illustrates electromagnetic spectrum, ranging from 3 kHz to 900THz, used for wireless communication.

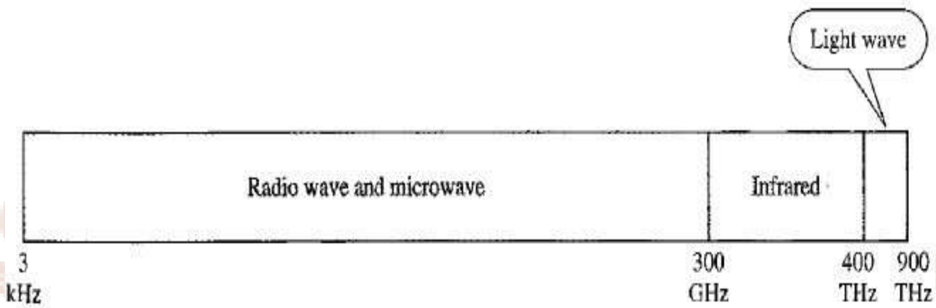


Figure 6.9: Electromagnetic spectrum for wireless communication

In wireless communication, unguided signals can travel from the source to destination in several ways. Different ways are ground propagation, sky propagation and line of sight propagation.

In ground propagation, radio waves travel through the lowest portion of the atmosphere, touching the earth. These low frequency signals flow out 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 atmospheric layer 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. Figure 6.10 shows different propagation methods.

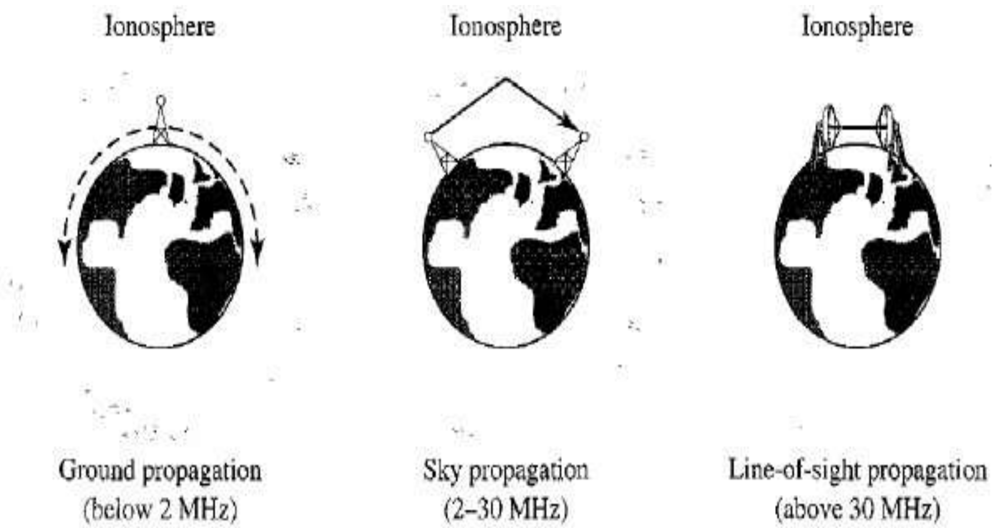


Figure 6.10: Propagation methods

The part of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges called bands. Each of these bands are regulated by government authorities. These are rated from very low frequency (VLF) to extremely high frequency (EHF). Table 6.2 lists these bands, their ranges, propagation methods and some applications.

Table 6.2: Bands

Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3-30 kHz	Ground	Long-range radionavigation
LF (low frequency)	30-300kHz	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 lineof 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

We can divide wireless transmission into three broad groups. They are radio waves, micro waves and infrared waves. Figure 6.11 shows wireless transmission waves.

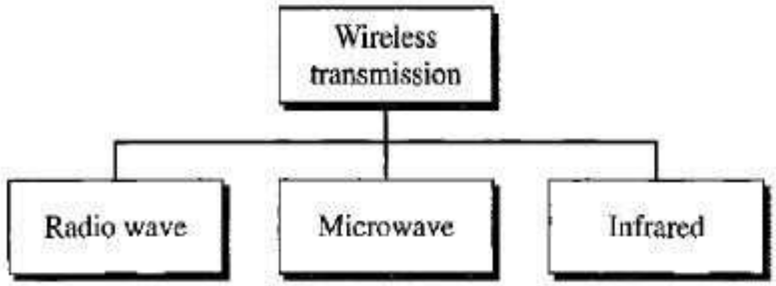


Figure 6.11: Wireless transmission waves

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. The behavior of the waves, rather than the frequencies is a better criteria for classification. Radio waves are omnidirectional that means, when an antenna transmits radio waves, they are propagated in all directions. 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. Drawback of omnidirectional property is that the radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using same frequency or band.

Radio waves, especially those propagate in sky mode can travel long distances. This makes radio waves good for long distance broadcasting such as AM radio. Radio waves of low and medium frequencies can penetrate walls. This can be an advantage and a drawback as well. It is an advantage because, for instance, 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. Compared to microwave band, radio wave band 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. Almost the entire band is regulated by authorities. In order to use any portion of the band, we need permission from authorities.

Radio waves use omnidirectional antennas that send out signals in all directions. Based on the wavelength, strength and purpose of transmission, we can use several types of antennas. Figure 6.12 shows an omnidirectional antenna.

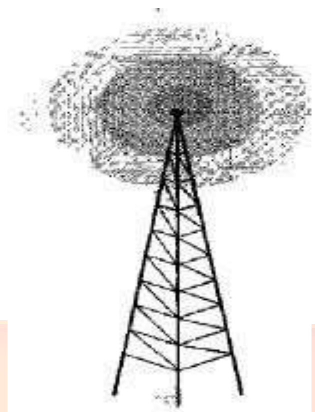


Figure 6.12: Omnidirectional antenna

Applications

Omnidirectional characteristics makes radio waves useful for multicasting in which there is one sender and many receivers. AM and FM radio, television, maritime radio, cordless phones and paging are examples of multicasting.

3.2 Microwaves

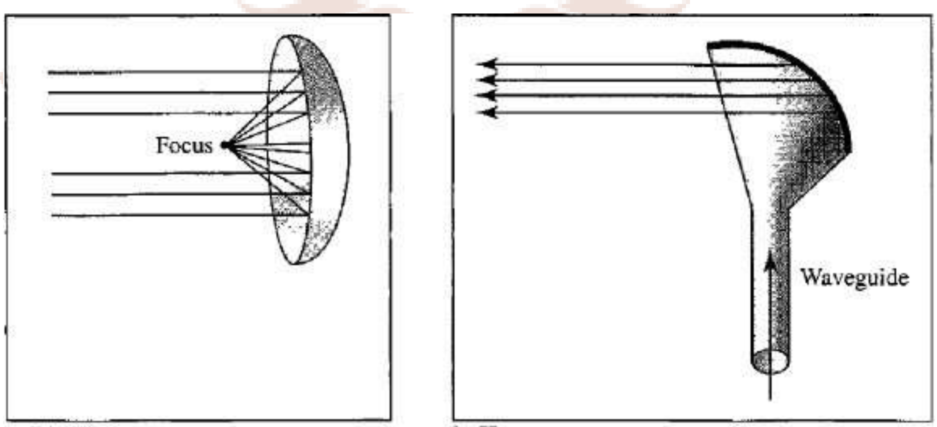
Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves. Microwaves are unidirectional. Sending and receiving antennas need to be aligned properly when an antenna transmits microwave waves because they can be narrowly focused. The advantage of unidirectional property is that we can align a pair of antennas without interfering with another pair of aligned antennas. Some characteristics of microwave propagation are:

- Microwave propagation is line of sight. Towers that are far apart should be very tall as the towers with mounted antennas need to be in direct sight of each other. Due to the curvature of the earth and other blocking obstacles, two short towers cannot communicate by using microwaves. Repeaters are often needed for long distance communication.

- Very high frequency microwaves cannot penetrate walls. These characteristics can be a disadvantage if receivers are inside buildings.
- The microwave band is relatively wide, approximately 299 GHz. Therefore, wider subbands can be assigned and high data rate is possible.
- We need permission from authorities to use certain portion of the band.

Unidirectional Antennas

Microwaves need unidirectional antennas that send out signals in one direction. Two types of antennas are used for microwave communication. They are, the *parabolic dish* and the *horn*. A parabolic dish antenna is based on the geometry of a parabola. Each line parallel to the line of symmetry 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. In this way, more of the signal is recovered than would be possible with a single point receiver. Outgoing transmissions are broadcast through a horn aimed at the dish. The microwaves hit the dish and are turned outward in a reversal of the receipt path. A horn antenna looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem and deflected outward in a series of narrow parallel beams by the curve head. Received transmissions are collected by the scooped shape of the horn, in a way similar to the parabolic dish and are deflected down into the stem. Unidirectional antennas are depicted in figure 6.13.



a. Dish antenna b. Horn antenna

Figure 6.13: Unidirectional antennas

Applications

Due to their unidirectional properties, microwaves are very useful when unicast (one to one) communication is needed between the sender and receiver. Microwaves are used for unicast communications such as cellular phones, satellite networks and wireless LANs.

3.3 Infrared

Infrared waves having frequencies between 300 GHz to 400 THz can be used for short range communication. Infrared waves having high frequencies cannot penetrate walls, this characteristic of infrared waves 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. For example, when we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. But this property makes infrared signals useless for long range communication. Also, 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, approximately 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 instance, some manufacturers provide a special port called IrDA port that allows a wireless keyboard to communicate with a PC.

Earlier, the standard 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 can be used for short range communication in a closed area using line of sight propagation. 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.

Self-Assessment Questions - 2

9. In___________ , signals are broadcast through free space and thus are available to anyone who has a device capable of receiving them.
10. The part of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges called ___________ .
11. Wireless transmission can be categorized into three groups such as_____________, ___________ and _________ .
12. Electromagnetic waves having frequencies between 1 and 300 GHz are called _____________ .
13. Two types of antennas used in microwave communication are __________ and___________ .
14. _______________waves can be used for short range communication.

4. LINE OF SIGHT TRANSMISSION

Line of sight is a type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other without any obstacles between them. FM radio, microwave and satellite transmission are examples of line of sight communication. In this section, we will discuss some of the impairments specific to wireless line of sight transmission.

Free space loss

In all wireless communication, the signal disperses with distance. So, an antenna with a fixed area will receive less signal power the farther it is from the transmitting antenna. For satellite communication, this is the primary mode of signal loss. Even if no other sources of attenuation or impairment are assumed, a transmitted signal attenuates over distance because the signal is being spread over a larger and larger area. This form of attenuation is known as free space loss.

Atmospheric absorption

An additional loss between transmitting and receiving antennas is atmospheric absorption. Oxygen and water vapor in the atmosphere cause attenuation (weakening in force or intensity). A peak attenuation occurs in the locality of 22 GHz due to water vapor. Attenuation is less at frequencies below 15 GHz. Presence of oxygen results in an absorption peak in the area of 60 GHz but contributes less at frequencies below 30 GHz. Rain and fog results in the scattering of radio waves that also results in attenuation. Scattering means, production of waves of changes direction or frequency when radio waves encounter matter. This can be a major cause of signal loss. In order to avoid this, either path lengths have to be kept short or lower frequency bands should be used.

Multipath

For wireless facilities, antennas can be placed in such a way that there should not any nearby interfering obstacles. That is, there is a direct line-of- sight path from transmitter to receiver. For many satellite facilities and for point-to-point microwave, this allocation is used. In other case such as mobile telephony, there are many obstacles. The signal can be reflected by such obstacles so that multiple copies of the signal with varying delays can be received. In fact, in extreme cases, there may be no direct signal. Based on the differences in the path lengths of the direct and reflected waves, the composite signal can be either larger or smaller than the direct signal. Reinforcement and cancellation of this type of multipath signal can be controlled for communication between fixed antennas and between satellites and fixed ground stations. Multipath consideration can be predominant in case of mobile telephony and communication to antennas that are not well sited.

Figure 6.14 shows examples of multipath interference. For fixed microwave, in addition to the direct line of sight, the signal may follow a curved path through the atmosphere due to refraction and the signal may also reflect from the ground. For mobile communications, structures and topographic features provide reflection surfaces.

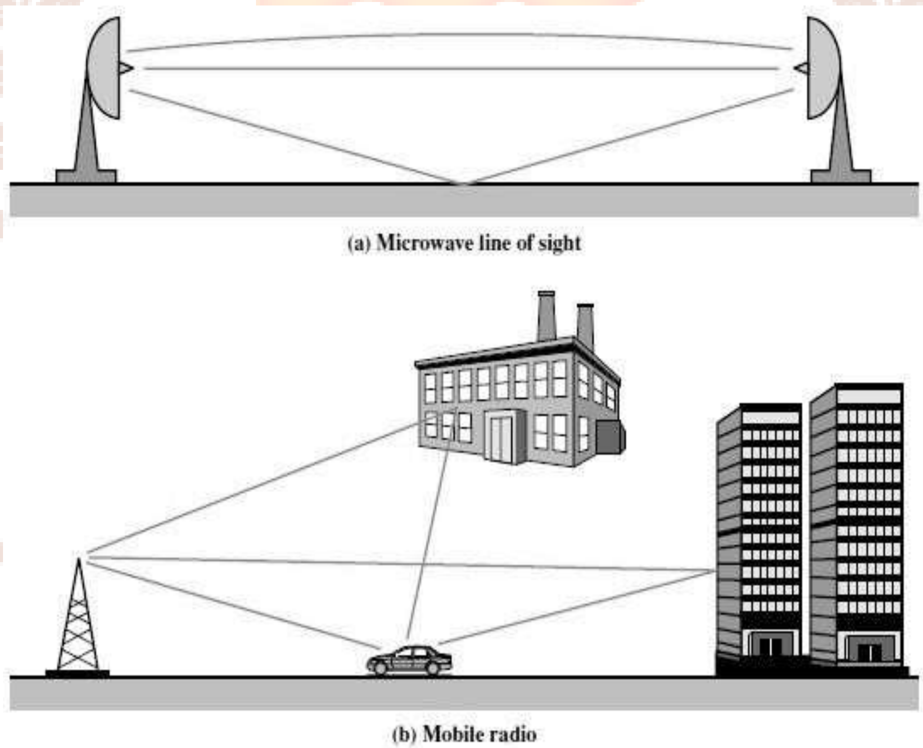


Figure 6.14: Examples of multipath interference

Refraction

Radio waves are refracted (or bent) when they propagate through the atmosphere. The refraction is caused by changes in the speed of the signal with altitude or by other spatial changes in the atmospheric conditions. The speed of the signal increases with altitude and as a result, radio waves bend downward. Sometimes weather conditions also may also lead to variations in speed with height that differ significantly from the typical variations. This may cause a situation in which only a part or no fraction of the line-of-sight wave reaches the receiving antenna.

Self-Assessment Questions - 3

15. ______________is a type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other.
16. The speed of the signal increases with altitude and as a result, radio waves bend downward. State true or false.
    (a) True (b) False
17. The ______________ is caused by changes in the speed of the signal with altitude or by other spatial changes in the atmospheric conditions.

5. SUMMARY

Let us recapitulate the important concepts discussed in this unit:

- Transmission media is a medium which carry information from a source to a destination.
- Transmission media can be divided into guided and unguided transmission media.
- In guided media, computers are connected through a system of conduits. This include twisted-pair cable, coaxial cable and fiber optic cable.
- The most common twisted pair cable used in communications is referred to as unshielded twisted-pair (UTP). Another version of twisted pair cable produced by IBM is called shielded twisted pair (STP).
- There are two modes known as *multimode* and *single mode*, for propagating light along optical channels.
- Unguided transmission media transport electromagnetic waves without using a physical conductor or medium. This type of communication is also known as wireless communication.
- In wireless communication, unguided signals can travel from the source to destination in different ways such as: ground propagation, sky propagation and line of sight propagation.
- 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.
- Two types of antennas are used for microwave communication, they are: the *parabolic dish* and the *horn*.
- Infrared signals can be used for short range communication in a closed area using line of sight propagation.

6. TERMINAL QUESTIONS

1. Explain guided transmission media.
2. Differentiate between guided and unguided transmission.
3. Differentiate between radio waves and microwaves.
4. Write short note on infrared waves
5. Describe line of sight transmission.

7. ANSWERS

Self-Assessment Questions

1. Physical layer
2. (a) True
3. Light
4. Electric current
5. Coaxial cable
6. Bayone-Neill- Concelman (BNC) connector
7. Critical angle
8. Single mode, multimode
9. Wireless transmission
10. Bands
11. Radio waves, micro waves and infrared waves
12. Microwaves
13. Parabolic dish, horn
14. Infrared
15. Line of sight
16. (a) true
17. Refraction

Terminal Questions

1. In guided media, computers are connected through a system of conduits. This include twisted-pair cable, coaxial cable and fiber optic cable. Signal travelling through any of

these media is directed and restricted by the physical limits of the medium. (Refer section 2 for detail).

2. Transmission media can be divided into guided and unguided transmission media. Guided media include twisted-pair cable, coaxial cable and fiber-optic cable. Unguided medium is free space. (Refer section 2 and 3 for detail).
3. 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. (Refer section 3.1 and 3.2 for detail).
4. Infrared waves having frequencies between 300 GHz to 400 THz can be used for short range communication. Infrared waves having high frequencies cannot penetrate walls. This advantageous characteristics prevents interference between one system and another. (Refer section 3.3 for detail).
5. Line of sight is a type of propagation that can transmit and receive data only where transmit and receive stations are in view of each other without any obstacles between them. (Refer section 4 for detail)

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