Transmission Media

INTRODUCTION

- Transmission media are actually located below the physical layer and are directly controlled by the physical layer. We could say that transmission media belong to layer zero. Figure below shows the position of transmission media in relation to the physical layer.

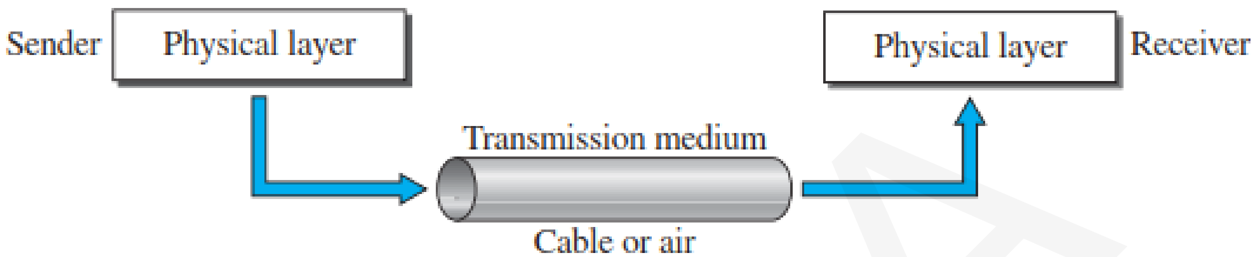


Figure Transmission medium and physical layer

- A transmission medium can be broadly defined as anything that can carry information from a source to a destination.

- In data communications the definition of the information and the transmission medium is more specific. The transmission medium is usually free space, metallic cable, or fiber-optic cable. The information is usually a signal that is the result of a conversion of data from another form.

- 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. Figure below shows this taxonomy.

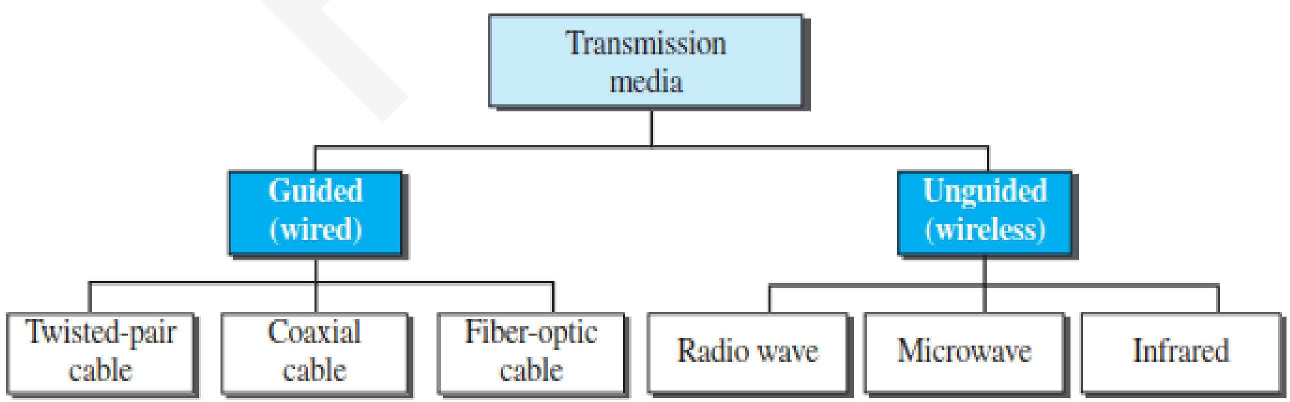


Figure Classes of transmission media

GUIDED MEDIA

-Guided media, which are those that provide a conduit from one device to another,

include twisted-pair cable, coaxial cable, and fiber-optic cable.

- A signal traveling along any of these media is directed and contained by the physical limits of the medium.

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

- Optical fiber is a cable that accepts and transports signals in the form of light.

Twisted-Pair Cable

-A twisted pair consists of two conductors (normally copper), each with its own plastic

insulation, twisted together, as shown in Figure below.

- One of the wires is used to carry signals to the receiver, and the other is used only

as a ground reference.

Unshielded Versus Shielded Twisted-Pair Cable

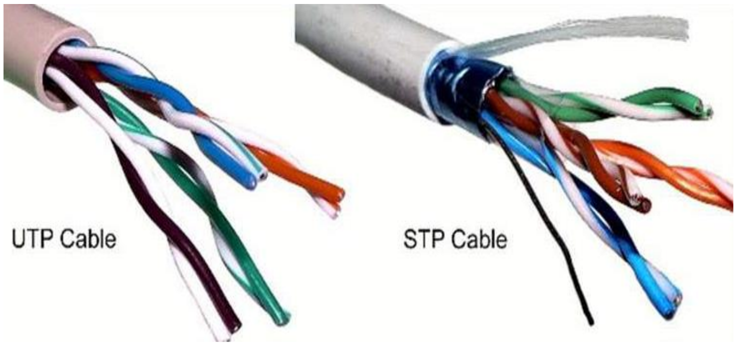
-The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP).

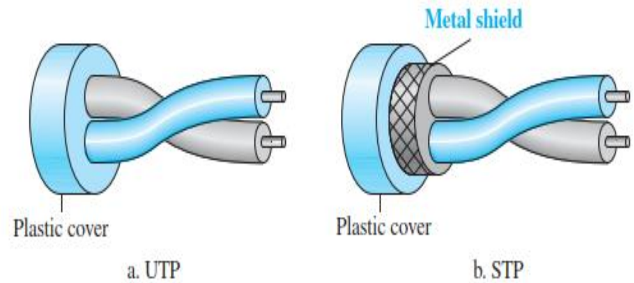
- IBM has also produced a version of twisted-pair cable for its use, called shielded twisted-pair (STP).

- STP cable has a metal foil or braidedmesh covering that encases each pair of insulated conductors.

- Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

- Figure below shows the difference between UTP and STP.





Categories

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 uses. Table below shows these categories.

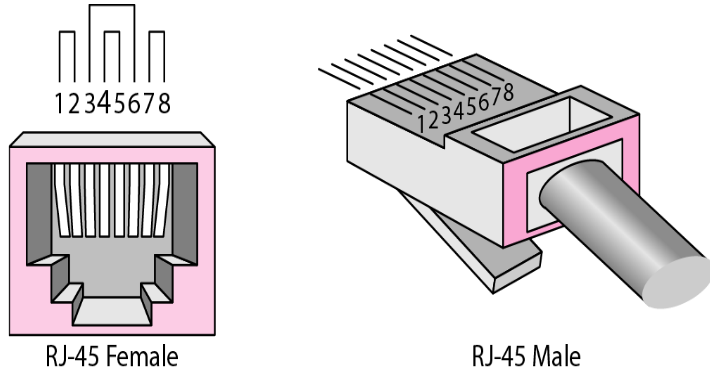
Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T lines	2	T-1 lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with 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), as shown

in Figure below. The RJ45 is a keyed connector, meaning the connector can be inserted in

only one way.



Applications

-Twisted-pair cables are used in telephone lines to provide voice and data channels.

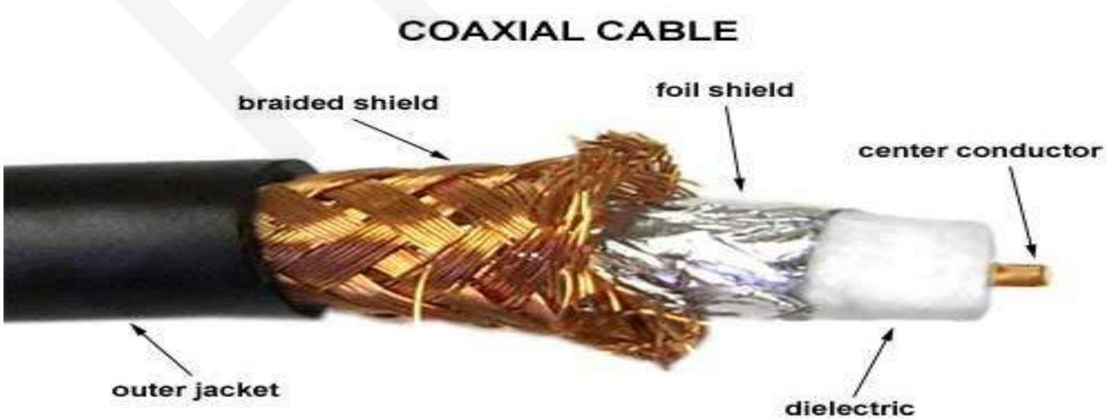
- The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.

- Local-area networks, such as 10Base-T and 100Base-T, also use twisted-pair cables.

Coaxial Cable

- Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable

-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. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover (see Figure below).



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.

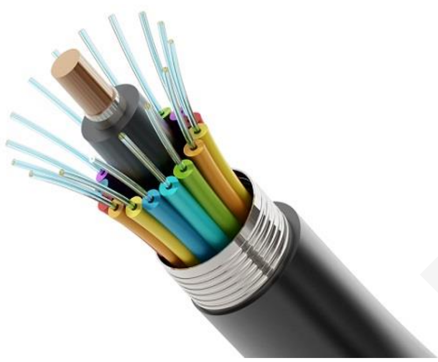
- coaxial cable in telephone networks has largely been replaced today with fiberoptic cable.

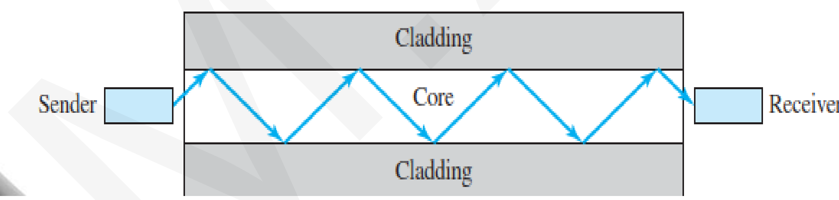
Fiber-Optic Cable

- 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. Figure 7.10 shows how a ray of light changes direction when going from a more dense to a less dense 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. See Figure above.

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.

Advantages and Disadvantages of Optical Fiber

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.
- 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.

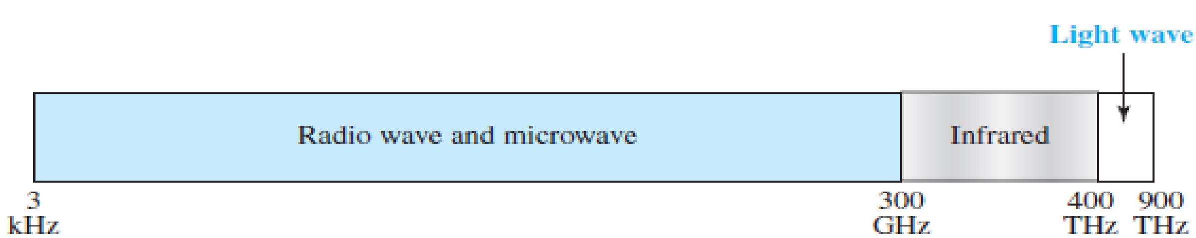
UNGUIDED MEDIA: WIRELESS

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

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

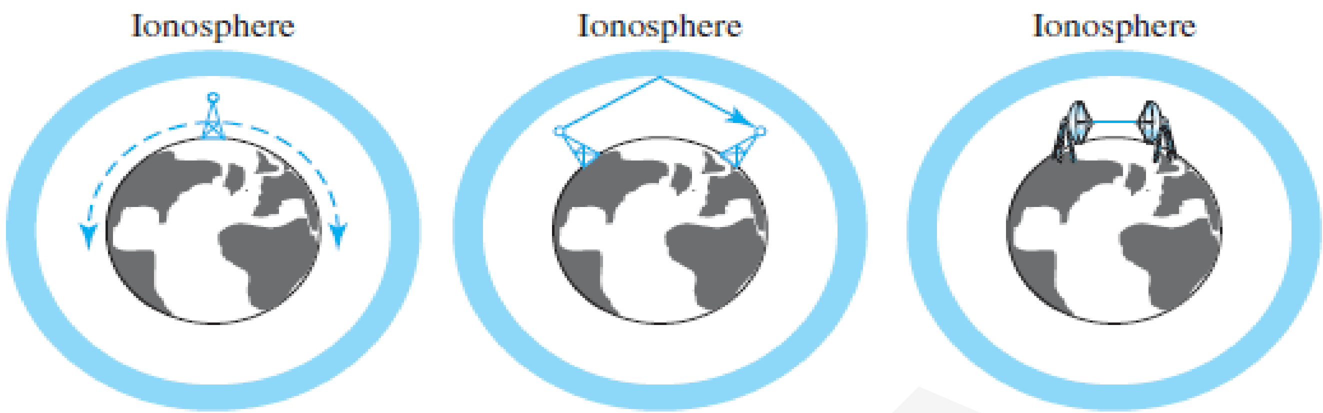
-Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

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



Unguided signals can travel from the source to the destination in several ways:

Propagation methods



Ground propagation (below 2 MHz) | Sky propagation (2–30 MHz) | Line-of-sight propagation (above 30 MHz)

1-ground propagation:

Radio waves travel through the lowest portion of the atmosphere, hugging the earth. Distance depends on the amount of power in the signal: The greater the power, the greater the distance

2-sky propagation:

Higher-frequency radio waves radiate upward into the ionosphere, where they are reflected back to earth. This type of transmission allows for greater distances with lower output power.

3-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

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

Radio Waves

- Although there is 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;

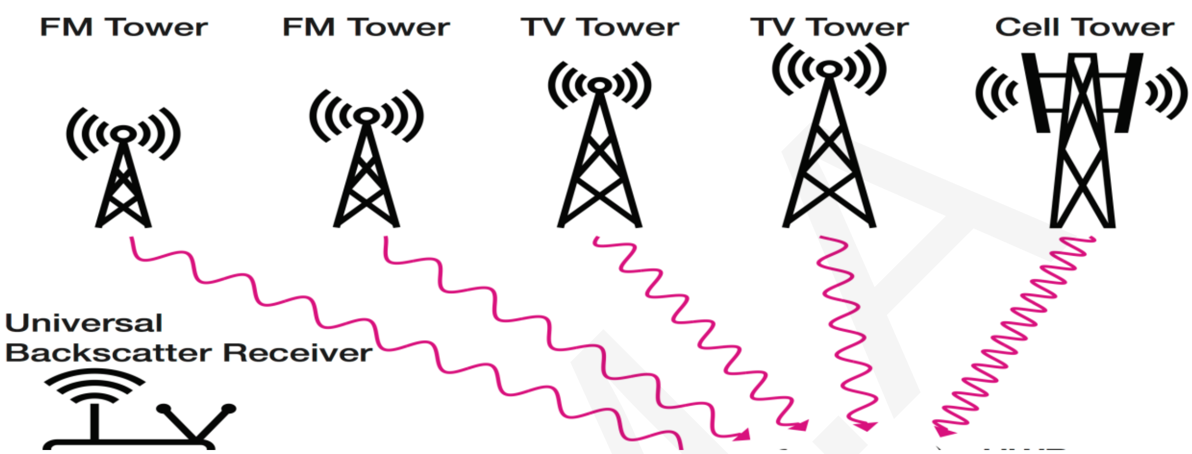
- waves ranging in frequencies between 1 and 300 GHz are called microwaves. However, the behavior of the waves, rather than the frequencies, is a better criterion for classification.

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



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

Radio waves are used for multicast communications(in which there is one sender but many receivers.) , such as radio (AM and FM) 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.

-The following describes some characteristics of microwave propagation:

- Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall. 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 subbands can be assigned, and a high data rate is possible.
- Use of certain portions of the band requires permission from authorities.

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.

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.

-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.

-we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

-Infrared signals defined by IrDA(Infrared Data Association) transmit through line of sight; the IrDA port on the keyboard needs to point to the PC for transmission to occur.

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.