Transmission Media

Communication Channels/Network Media/ Transmission Media:

- In computer network, media refers to the wires, cables, and other means that are used to connect the networked computers and peripherals, and by which data travels from its source to its destination; i.e., using network media, all nodes and server are connected to each other.

Classification of Transmission Media:

- Every transmission media has its own characteristics. According to their physical composition, transmission media can be classified into two categories: guided and unguided media. In both cases, communication is in the form of electromagnetic wave.

Guided media:

- Guided media, sometimes called wired or cable media, provide a physical path along which the signals are guided or propagated.
- In the case of guided media, the medium itself is more important than the characteristics of the signal in determining the limitations of transmission.
- Three guided media are widely used for data transmission. These include twisted pair cable, coaxial cable, and fiber optic cable.

Unguided media:

- Unguided media, sometimes called aerial media or wireless media, employ an antenna for transmitting signal through air, vacuum, or water.
- The atmosphere and outer space are examples of unguided media, which provide a means of transmitting electromagnetic signals but do not guide them.
- In the case of unguided media, the bandwidth of the signal produced by the transmitting antenna is more important than the medium in determining the limitations of transmission.
- One key property of signals transmitted by antenna is directionality. In general, signals at lower frequencies are omni-directional; that is, the signal propagates in all directions from the antenna. At higher frequencies, it is possible to focus the signal into a directional beam.
- Wireless LAN technology is designed to connect devices without wiring. These devices use radio waves or infrared signals as a transmission medium.

Factors for choosing a transmission media:

- The characteristics and quality of a data transmission are determined both by the characteristics of the medium and the characteristics of the signal. Which media is suitable for your network depends on your purpose. Some prominent factors relating to a particular media that may affect your network are stated below:

Cost:

- Not all media have the same performance. To transmit data at a higher bandwidth, optical fiber cable is better than that of twisted-pair and co-axial cables. But it is 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.

Methods of installation and maintenance:

- Installation system for all transmission media is not the same. Some media like twisted-pair or co-axial cable is easy to install and tap, but to install fiber optic cable, expertise knowledge is required that is not yet available everywhere. Moreover, it is not so easy to join two fiber optic cables together. Unguided media is easily maintained than guided media.

Transmission speed and bandwidth:

- The speed at which data travel over a communication channel is called the data communication rate or the transmission speed. Bandwidth defines how much information can be transmitted through a communication media over a period of time (usually in one second). All other factors remaining constant, the greater the bandwidth of a media, the higher the volume of data that can be transmitted.

Distance:

- If you wish to design network to transmit data within a building, you may use twisted-pair cable. If you further extend your network at a higher distance, you need repeater for signal amplification while using this cable. But if you want to design your network over a wide range e.g. in a campus, you may use optical fiber without using any repeater.

Number of nodes:

- How many nodes you can attach to a cable is an important factor. A guided media can be used to construct a point-to-point link or a shared link with multiple attachments. In the latter case, each attachment introduces some attenuation and distortion on the line, hence limiting the data rate.

Attenuation:

- Attenuation means loss of energy. When a signal travels through a medium, it loses some of its energy in overcoming the resistance of the medium. If the attenuation is too much, the receiver may not be able to detect the signal at all. Lower the attenuation of a media, better the transmission capability of that media. For guided media, twisted-pair cable generally suffers more attenuation than co-axial cable, which in turn suffers more than optical fiber.

Capability of minimizing electromagnetic interference (EMI):

- If two signals are close to each other, then one can affect the other. This is called electromagnetic interference (EMI). Higher the capability to resist EMI, better the quality of that media.

TWISTED-PAIR CABLE

- Twisted pair cable is the most widely used medium for telecommunication and can be utilized for both voice and data transmission.

Twisted-pair cable composition:

- A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern. A wire pair acts as a single communication link. Typically, a number of these pairs (usually four) are bundled together into a cable by wrapping them in a tough protective sheath.
- The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction.

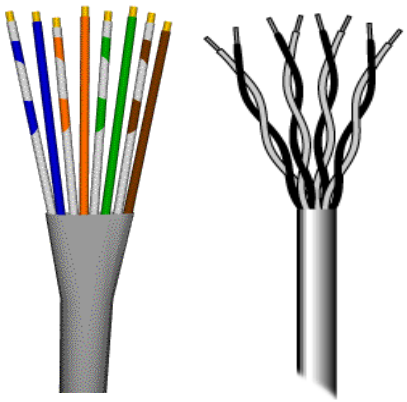

Figure: Twisted-pair cable

Types of twisted-pair cable:

- There are two types of twisted-pair cables:

- **UTP (unshielded twisted-pair) cable:** The most common twisted-pair cable used today in communication is referred to as UTP cable. Except for the plastic coating, nothing shields this type of cable from outside interference. It is lighter, cheaper, easy to work with and easy to install than that of STP cable. This type of twisted pair cable is subject to external electromagnetic interference, including interference from nearby twisted pair and from noise generated in the environment.

- **STP (shielded twisted-pair cable:** This type of twisted-pair cable is further encased in a metal sheath that improves the quality of cable by preventing the penetration of noise or crosstalk. This type of cable provides better performance at higher data rates. However, it is bulkier, more expensive and more difficult to work with than UTP cable. It is seldom used outside IBM (since IBM developed this version of twisted-pair cable for its internal use).

TRANSMISSION CHARACTERISTICS OF TWISTED-PAIR CABLE:

- This cable is widely available in the market.
- It is inexpensive than other guided media.
- It is easier to work with and easy to install.
- It is easy to tap.
- This type of medium is quite susceptible to interference and noise i.e. it has low noise immunity.
- Its bandwidth and data rate are less than that of other guided media. Its transmission speed limits up to 150Mbps (Mega bits per second).
- This cable can accommodate up to 1,000 devices.
- Compared to other guided media, twisted pair cable is limited in distance. It is adequate for network span up to ½ mile. For digital transmission, repeaters are required every ½ mile.
- It is used in telephone and narrowband local networks.

Application of twisted-pair cable:

- By far the most common transmission medium for both analog and digital signals is twisted pair cable.
- In the telephone system, individual residential telephone sets are connected to the local telephone exchange by twisted pair cable to provide voice and data channels. So sometimes it is called telephone wire.
- Local area network, such as 10Base-T and 100Base-T, uses twisted-pair cables.

COAXIAL CABLE

- Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable.
- These cables are used in those communication networks that require many simultaneous communication links. It is widely used in cable TV.
- Coaxial cable can carry more data than older type twisted pair cable and is less susceptible to interference from other wiring.
- This cable is more expensive. Transmission speed ranges from 200Mbps to more than 500Mbps.

Co-axial cable composition:

- This cable is composed of a central core conductor (usually copper) which is enclosed in an insulating sheath that shields the cable from physical damage.
- The insulating sheath along with the central core conductor is further wrapped in a conductive wire mesh. The outer wire mesh shields the cable from physical dangers as well as from electromagnetic interference, thereby minimize interference and distortion.
- This outer wire mesh is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.
- Within the cover, the various cables are shielded from interference with one another.
- A single co-axial cable has a diameter of from 1 to 2.5 cm.

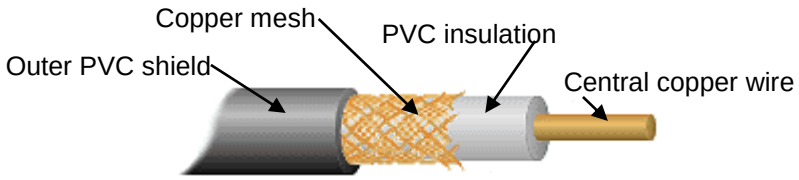

Figure: Coaxial cable

Types of co-axial cable:

- There are two types of coaxial cables:
  - **Baseband co-axial cable:** A baseband coaxial cable transmits a single signal at a time at very high speed. A baseband cable transmit a single stream of data at a very high communication rate (millions of bits per second) but must be amplified every 1000 feet or so. It is mainly used for local area networks.
  - **Broadband co-axial cable:** a broadband coaxial cable can transmit many simultaneous signals using different frequencies. A broadband coaxial cable can carry only an analog signal, so it must be used in conjunction with a modem. It is more complex to use in a network.

CHARACTERISTICS OF COAXIAL CABLE:

- Widely available
- It can be used over longer distances to transmit both analog and digital data than twisted pair cable.
- This cable support more stations on a shared line than twisted pair cable.
- Good noise immunity: This cable is less susceptible to interference and crosstalk from other wiring than twisted pair cable.

- High usable bandwidth: Coaxial cable can carry more data than older type twisted pair cable.
- More difficult to tap than twisted-pair cable
- More expensive than twisted-pair cable
- Transmission speed ranges from 200Mbps to more than 500Mbps.
- Attenuation is much higher in co-axial cables than in twisted-pair cables. That is, although co-axial cable has much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.

Application of Co-axial cable:

- It is widely used for cable television systems, office buildings, and other work-sites for local area networks.
- Coaxial cables are used in those communication networks that require many simultaneous communication links.

OPTICAL FIBER TRANSMISSION

- A fiber-optic or optical fiber cable is a thin strand of glass (each about the diameter of a human hair) wrapped in a protective coating which is capable of guiding an optical ray.
- This type of cable transfers data by means of pulses of light which can travel over extended distances rather than electric frequencies.
- When one end of the strand is exposed to light, the strand carries the light all the way to the other end. Through the use of a laser, data are transmitted from one end of a cable to the other.

Fiber-optic Cable composition:

- An optical fiber cable has a cylindrical shape and consists of three concentric sections: the core, the cladding and the jacket.
- The core is the inner most section and consists of one or more very thin strands or fibers made of glass or plastic. Core has a diameter in the range of 8 to 100 μm.
- Each fiber is surrounded by its own cladding, which is a glass or plastic coating that has different optical properties from that of the core. The interface between core and cladding acts as reflector to confine light that would otherwise escape the core.
- The outer jacket is made of either PVC or Teflon to protect against moisture, abrasion, crushing, and other environmental dangers.
- Figure below shows the composition of a typical fiber optic cable.

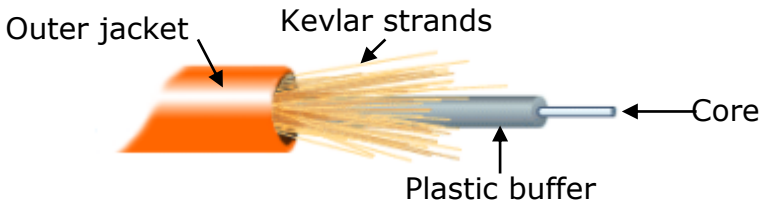

Figure: Fiber optic cable

Advantages of optical fiber

- **Higher bandwidth:**
  Because, light travels at a much higher rate than electrical signal, fiber-optic cable can easily carry great amount of data such as, a billions of bits per second. Its transmission speed is hundreds of times faster than for coaxial cables and thousands of times faster than a twisted-pair cable. This capacity may be further increased by the use of colored light, i.e., light of multiple wavelengths. Instead of carrying one message in a stream of monochromatic light impulses, this technology can carry multiple signals in a single fiber.

- **Immunity to electromagnetic interference:**
  Being optical in nature, fiber-optic cables are not affected by electromagnetic radiation, i.e. electromagnetic noise cannot affect the cables. Hence, it is highly secure.

- **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 amplification. For co-axial or twisted-pair cable, we need repeater in every 5 km.

- **Resistance to corrosive materials:**
  Since optical fiber is made up with glass or plastic materials, it is more resistant to corrosive materials than twisted-pair or co-axial cables that are made up with 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.

Disadvantages of optical fiber

- **Cost:**
  Optical fiber cables and 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.
- **Installation:**
  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 in optical fiber is unidirectional. If we need bidirectional communication, two fibers are needed.

Application of optical fiber:

- Fiber optic cables are widely used in a variety of applications, especially in communication networks. It is likely that they will eventually completely replace copper wire cables for communication applications.
- It is especially used for backbone networks. That is, it provides the backbone structure of a network, while coaxial or twisted-pair 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.
- Some cable TV companies use a combination of optical fiber and co-axial cable, thus creating a hybrid network.
- For high speed local area networks such as 100Base-FX (Fast Ethernet) and 1000Base-X, optical fiber cables are sometimes used.

Cable Connectors

- To transmit data using guided media, devices are connected to each other through the cable with the help of connectors. Different types of connectors are used for different types of cables. Some of them are discussed below.

Twisted-pair cable connectors:

- To connect twisted-pair cable to devices (such as computer, printer etc), we need twisted-pair cable connectors. The most common connector widely used today is RJ-45 connector (Registered Jack connector), as shown in the figure below. This connector can be inserted in only one way.

Figure required: Twisted-pair cable connector
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From Internet

Co-axial cable connectors:

- To connect co-axial cable to devices (such as computer, printer etc), we need co-axial cable connectors. The most common connectors used today is BNC connector (Bayone-Neill-Concelman connector or British Naval Connector). Three types of BNC connectors are:
  - BNC connector: It is used to connect the end of a co-axial cable to a device, such as a TV set.

- BNC T connector: It is looked like the letter T and is used in Ethernet network to branch out to a connection to a computer or other device.
- BNC terminator: It is used at the end of the cable to prevent the reflection of the signal.

Figure required: Co-axial cable connector
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Fiber optic cable connectors:

- To connect fiber-optic cable to devices (such as computer, printer etc), we need fiber-optic cable connectors. Three types of connectors are widely used for fiber-optic cables. These are:
  - SC connector (subscriber channel connector): It is used for cable TV as a push/pull locking system.
  - ST connector (straight-tip connector): It is used for connecting cable to networking devices.
  - MT-RJ connector: This connector is the same size as RJ-45 connector.

Figure required: Fiber optic cable connector
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Unguided Media/ Wireless Technologies

- In wireless transmission media, communication devices communicate with each other and data is communicated through the air or space using broadcast radio signals, microwave signals and infrared signals. This transmission medium is used when it is impossible to install the cables. The data can be transmitted all over the world through this medium. The commonly used wireless transmission media are discussed below.

Broadcast Radio

- It is a wireless transmission medium that is used to communicate information through radio signals in air, over long distance such as between cities and countries. In this medium, a transmitter is required to send messages (signals) and receiver is required to receive them. To receive the broadcast radio signal, the receiver has an antenna that is located in the range of signal. Some networks use a special device called transceiver used to send and to receive messages in the form of radio signals. The data transmission speed of broadcast radio is up to 54Mbps.

Cellular Radio

- Cellular radio is a form of broadcast radio that is used for mobile communications such as cellular telephones and wireless modems. A cellular telephone is a telephone device that uses high frequency radio waves to transmit voice and digital messages. Some mobile users connect their laptop computer or other mobile device to a cellular telephone to access the Web, send and receive e-mail etc. while away from a standard telephone line.

TERRESTRIAL MICROWAVE

- Microwaves are radio waves that provide a high speed data transmission. Terrestrial microwaves use Earth-based transmitter and receiver. Microwave station contains an antenna, transceiver (transmitter & receiver) and other equipments that are required for microwave communication. The equipment looks similar to satellite dishes to transmit data through space. However, at microwave frequencies, the electromagnetic wave cannot bend or pass obstacles like hill. Hence it is necessary that microwave transmission is in a line-of-sight. This may not be possible for long distance transmission. Moreover, the signal becomes weak after traveling a certain distance and requires power amplification. Microwave antennas are usually placed on top of buildings, towers, hills, and mountain peaks. Path between relay stations spaced approx, 48 km (30 miles) apart. Each microwave station receives signals from the previous stations. In this way, data is transmitted from one place to another.

- In order to overcome the problem of line-of-sight and power amplification of weak signals, microwave systems use repeaters at intervals of about 25 to 30 km in between the transmitting and receiving stations. The data signals are received, amplified and retransmitted by each of these repeater stations.

- Microwave system permits data transmission rates of about 16 Gbps.

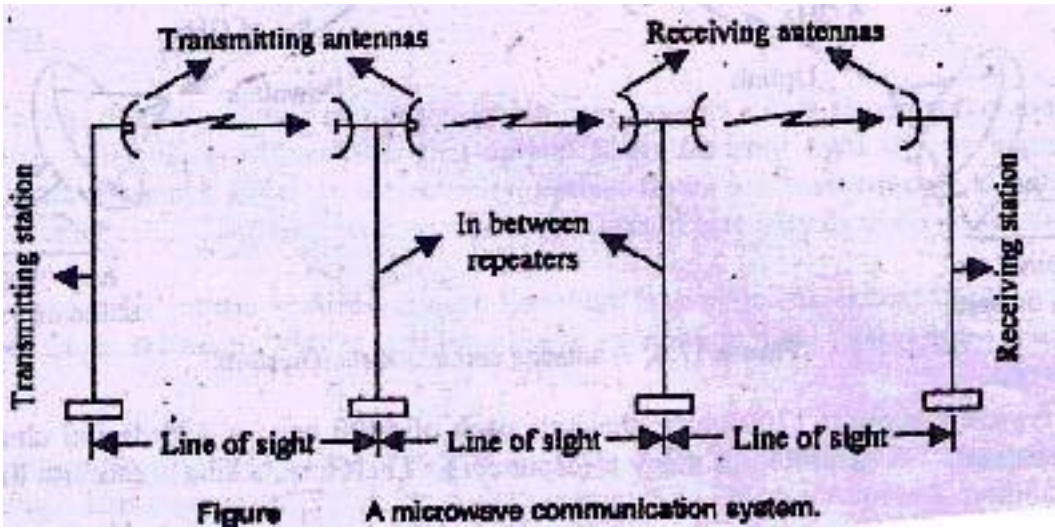

Figure A microwave communication system.

- The data transmission speed of microwave transmission is up to 150 Mbps. Microwave transmission is used in environments where installing physical transmission media is impossible and where line-of-sight transmission is available. It is used in wide-open areas. Today, it is used by telephone companies, cable television providers, universities etc.

COMMUNICATION SATELLITE

- The main problem with the microwave communication is that the curvature of the earth, mountains, and other structures often block the line-of-sight. Due to this reason, several repeater stations are normally required for long distance transmission that increases the cost of data transmission between two points. This problem is overcome by using satellite, which are relatively newer, and more promising data transmission media.
- A communication satellite is basically a microwave relay station placed in outer space that receives microwave signals from earth based microwave station. These satellites are launched either by rockets or by space shuttles and are precisely positioned about 36,000 km above the equator with an orbit speed that exactly matches the earth's rotation speed.
- Since a satellite is positioned in a geosynchronous orbit, it is stationary relative to earth and always stays over the same point on the ground. This allows ground stations to aim its antenna at a fixed point in the sky. These Earth-orbiting systems are capable of receiving and relaying voice, data, and TV signals. Transmitting a signal from ground or earth station to a satellite station in space is called up-linking and the reverse is called the down- linking.

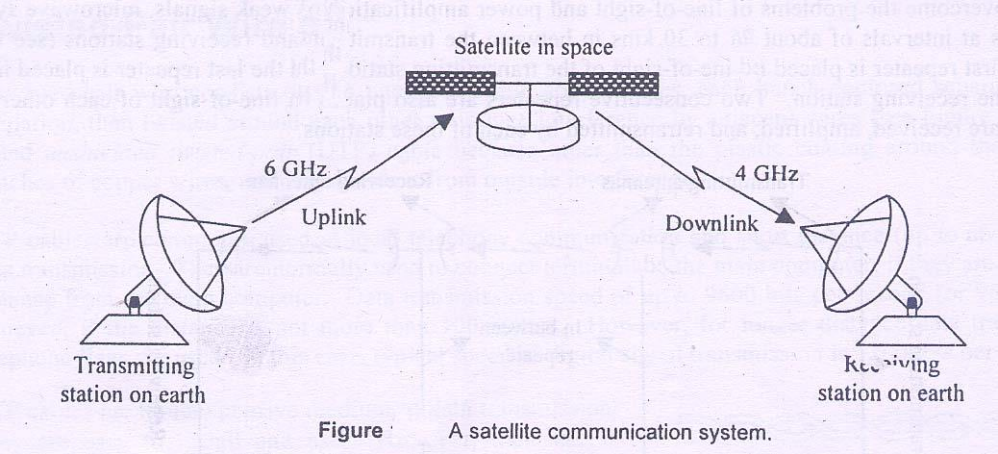

Figure A satellite communication system.

- In satellite communication, microwave signal at 6 GHz is transmitted from a transmitter on the earth to the satellite positioned in space. By this time this signal reaches the satellite and it becomes weak due to 36000 km travel. The satellite amplifies the weak signal and transmits it back to the receiving station on the earth at a frequency of 4 GHz. This entire process takes only a few seconds. [It may be noted that retransmission frequency is different from the transmission frequency in order to avoid the interference of the powerful retransmission signal with the weak incoming signal.

ADVANTAGE OF COMMUNICATION SATELLITE

(i) The data transmission speed of communication satellite is very high such as up to 1 Gbps.
(ii) Satellite communication is single microwave relay station visible from any point of a very large area. Thus transmission and reception can be randomly chosen between any two places in that area.
(iii) Transmission and reception costs are independent of the distance between two points.
(iv) A transmitting station can receive back its own transmission and check whether the satellite has transmitted the information correctly. If an error is detected, the data would be retransmitted.

DRAWBACK OF COMMUNICATION SATELLITE

(i) The high cost of placing the satellite into its orbit
(ii) A signal sent to a satellite is broadcast to all receivers with satellite range. Hence, necessary security measures are to be taken to prevent un-authorized tempering of information.

Infrared communication

- Infrared is a kind of light that is beyond red in the color spectrum. Electromagnetic waves having frequencies between 300 GHz to 400 THz (i.e. wavelength between 1 mm to 770 nm) are called infrared waves that can be used for short-range communication in a closed area using line-of-sight propagation.

- While the light is not visible to the human eye, infrared transmitters and receivers can send and receive infrared signals. Infrared communication can transmit signals between devices within small distances of typically no more than 10 meters, as in the case of TV and DVD remote controls.

Merits:

- Having high frequencies, infrared waves cannot penetrate walls. This is an advantageous characteristic of infrared that 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 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 in short range.
- Infrared communication is low in cost.

Limitations:

- However, this characteristic of infrared has adverse effect also, since it makes infrared signal useless for long-range communication.
- In addition, we cannot use infrared waves outside a building because the ray of the sun contains infrared waves that can interfere with the communication.
- In most cases, line-of-sight propagation is used, which limits the physical positioning of communicating devices.

Application:

- The Infrared Data Association (IrDA), an association for sponsoring the use of infrared waves, has established standards for using these signals to provide point-to-point communication between infrared devices in low cost. For example, to connect computers with devices like keyboard, mouse, printer etc. Many cellular phones are equipped with infrared ports (called IrDA-Infrared Data Association) that allow them to be connected to a computer for dial-up networking connections.