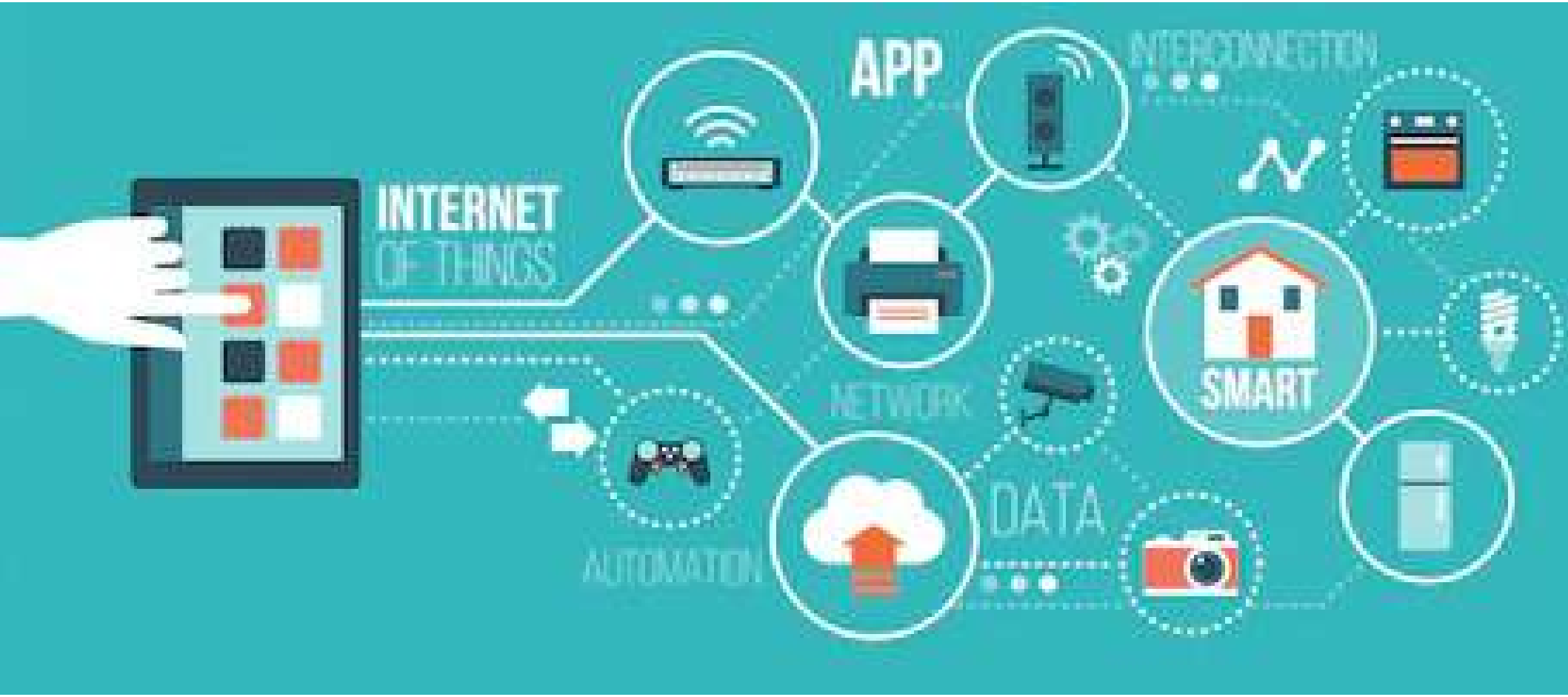
GLS UNIVERSITY

Faculty of Computer Applications & Information Technology



IT Networks & Number Systems

UNIT 4

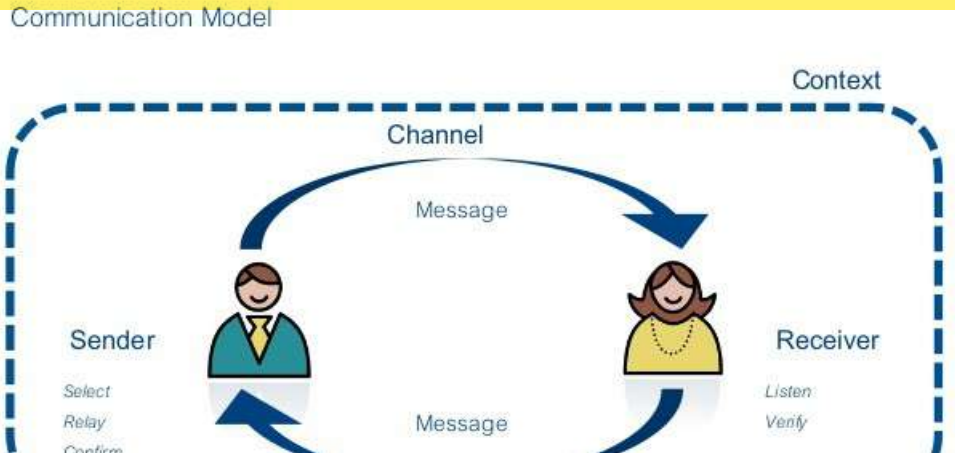
Integrated Msc(IT)

Introduction

- An IT network connects multiple computers and communication devices in a manner to enable meaningful transmission and exchange of data among them.
- It enables sharing of information, processing load and resources (both hardware and software) among the connected computers and communication devices.
- Because most business communications (Telephone, mobile phone, e-mail, messaging, interactions on social media, etc.) and many business transactions (net banking, electronic shopping, e-payment, etc.) happen with the use of IT networks.
- Hence, it is important to have basic knowledge of IT networks.

Communication System

- **Communication** is a process of transferring a message from a sender to a receiver. Example- Telephone system.
- The **sender** creates a message and sends it to the receiver, while the **receiver** receives the message.
- The medium through which the message travels from the sender to the receiver is called the **communication medium** or the **data transmission channel.**
- The maximum amount of data that a communication system can transfer in a given time is known as its **data transmission speed** and is referred to as its **bandwidth**.
- The bandwidth of a communication system is measured in **bits per second (bps).**



Data Transmission Channels

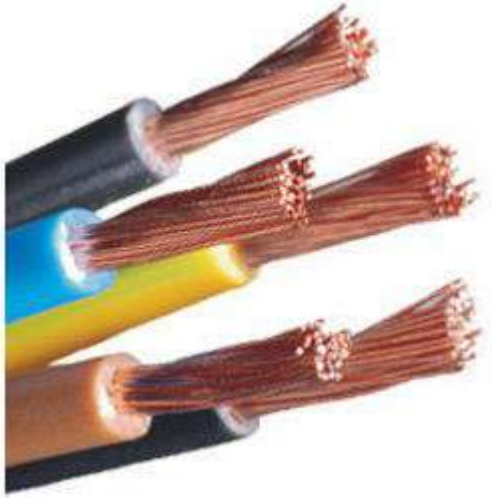
- Data Transmission Channels are also called as communication medium.
- They carry messages from a sender to a receiver.
- There are two categories of communication medium:
    - Wired communication medium
    - Wireless communication medium

Wired Communication System

- Wired communication medium use physical wires (called cables) to connect a sender and a receiver for transmitting messages between them.
- For long distance communication they require laying of cables and the associated construction cost of land digging or placement of poles.
- The two commonly used types of cables for wired medium are:
  - Copper Cables
  - Fibre Optics Cables

Copper Cables

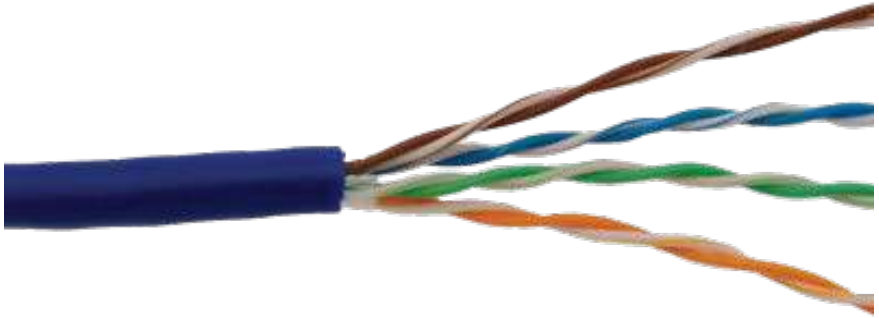
- Copper cable use bunches of thin copper wires.
- Depending on the packaging of the bunches of thin copper wires to create a usable cable, the two commonly used types of copper cables are:
  - UTP Cables
  - Coaxial Cables

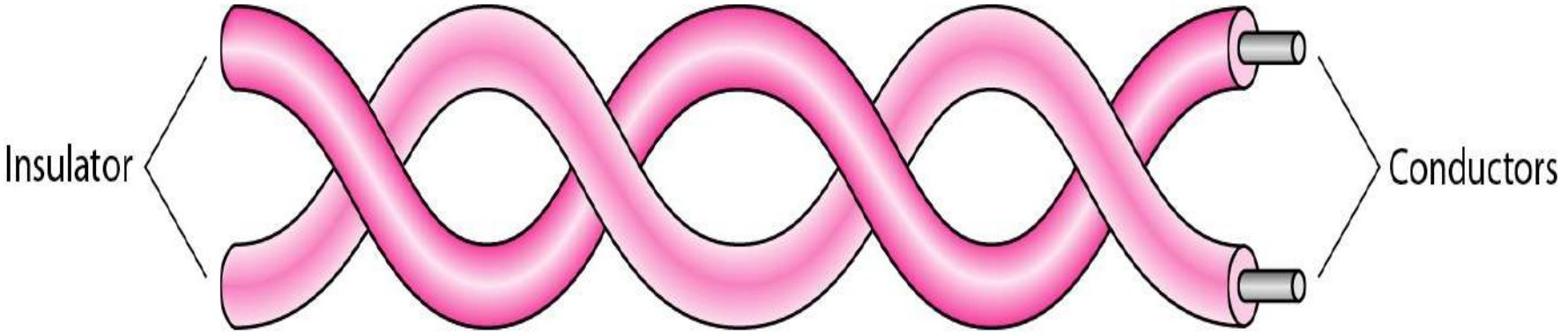


UTP cable

- UTP stands for Unshielded Twisted Pair.
- It consists of two bunches of thin copper wires; each bunch is enclosed separately in a plastic insulation and then twisted around each other to reduce interference by adjacent wires.
- Their maximum transmission speed is of 9600 bps for distances upto 100 meters.
- For longer distance the speed decreases upto 1200 bps.
- UPS are less expensive and easy to install and use.
- However, they are used for shorter distances because they easily pick up noise signals when the cable length is more than 100 metres.

UTP cable

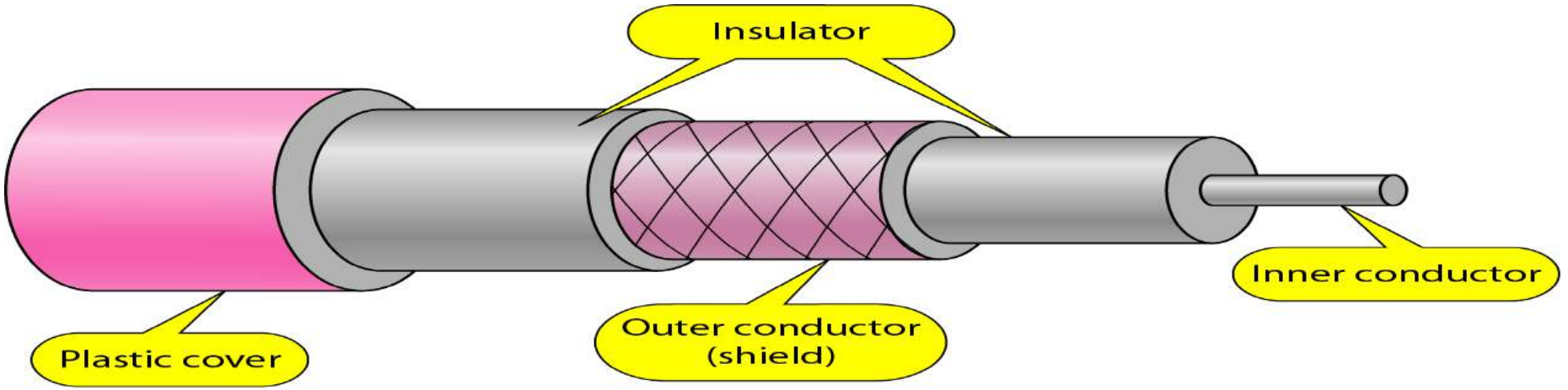




Coaxial cable

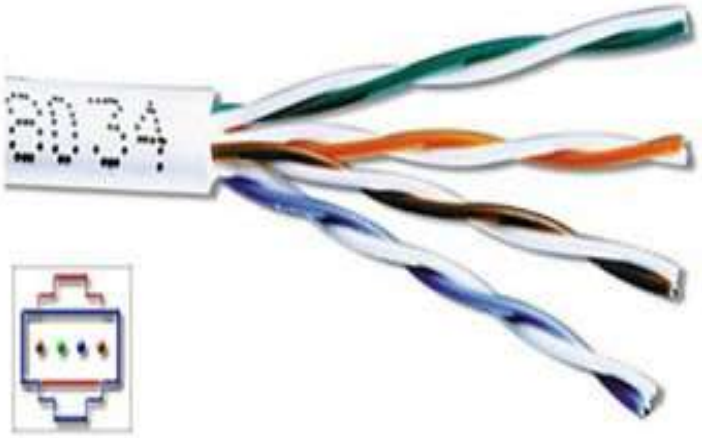
- A coaxial cable consists of a copper wire with two layers of PVC covers and a layer of copper mesh sleeve.
- Signal is transmitted by the copper wire and is electrically shielded against noise by the outer copper mesh sleeve.
- Their transmission speed is upto 10 mega bps.
- They have high noise immunity and can transfer data to long distance with low error rate.
- They are used for long distance telephone lines for both voice and data transmission
- Telephone companies combine several coaxial cable into a large cable and can handle more than 40,000 calls simultaneously.
- They are used to connect the TV with cable operators and to also provide broadband cable internet connection.

Coaxial cable

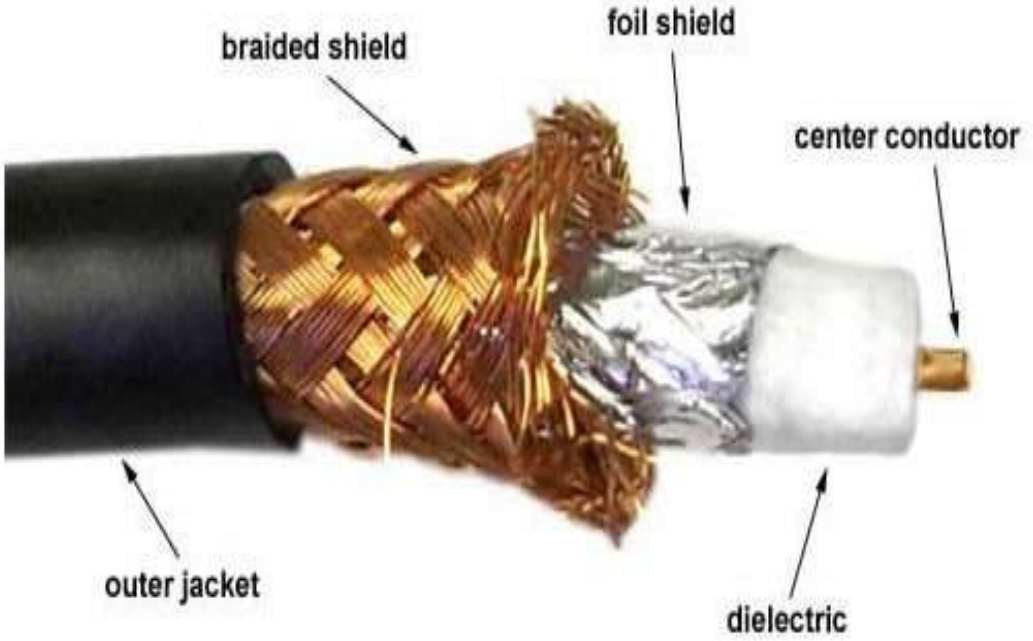


Shielded twisted pair (STP)

Unshielded twisted pair (UTP)



COAXIAL CABLE



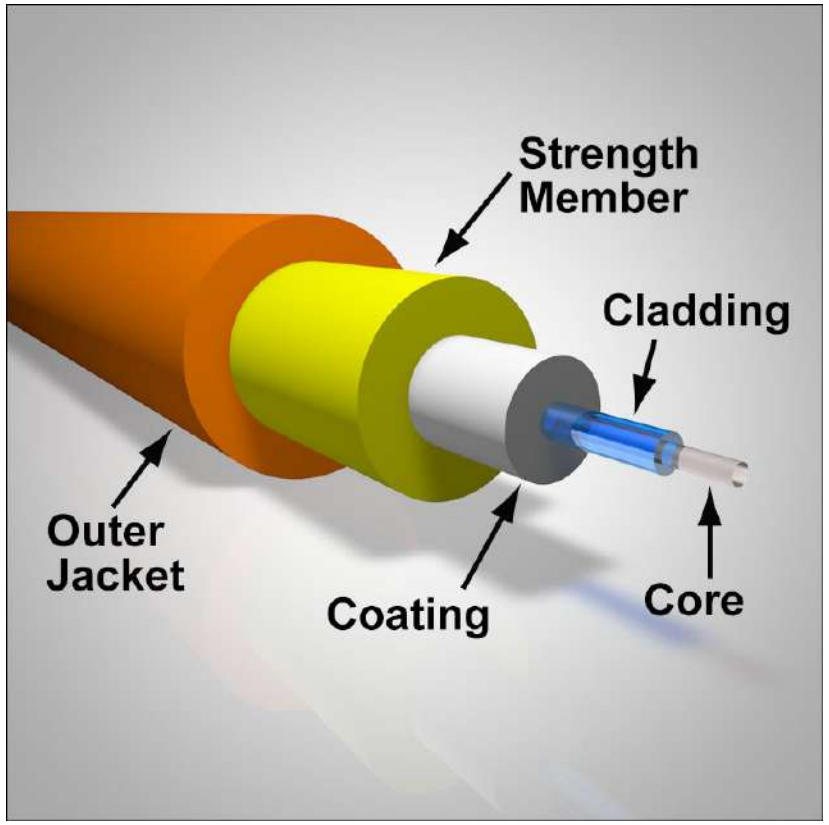
Fibre Optic cable

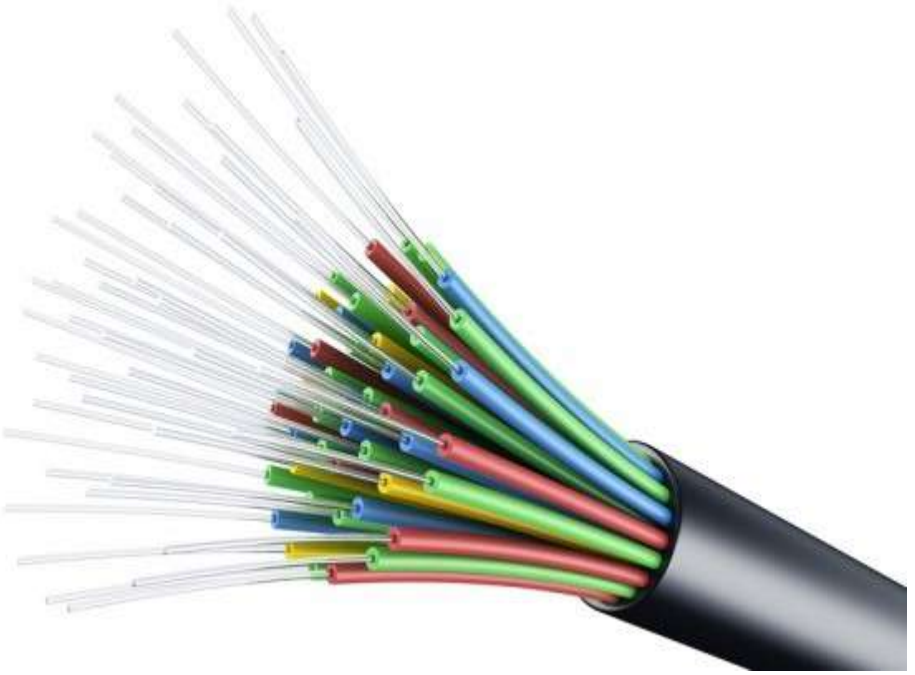
- Optical fibres are hair-thin threads of glass or plastic that can transmit light signals.
- A fibre-optic cable consists of three concentric layers
  - an inner core
  - a cladding around it
  - an outer protective coating.
- The inner core has a diameter of **8 to 200 micrometres** and consists of a bunch of optical fibres.
- The cladding around it is made of plastic or glass.
- The outer protective coating is made of plastic.

Fibre Optic cable

- Copper cables transmit electrical signals while optical fibre transmit light signals.
- Optical fibre can transmit data at more speed compared to copper cables.
- Fibre optic cables are less susceptible than metal cables to interference.
- Fibre optic cables are much thinner and lighter than metal wires.
- The main disadvantage of fibre optics is that the cables are expensive to install.

Fibre Optic cable





Wireless Communication Medium

- Wireless communication medium do not use any physical wire for transmitting messages between a sender and a receiver.
- Devices of wireless communication network communicate by modulating **radio waves** or pulsing **infrared light**.
- The area covered by an individual transceiver's signal is known as a **cell.**
- The cell size may vary like for an infrared – it will cover a small room, a mobile phone transceiver can cover few miles and a satellite beam can cover more than 400 miles in diameter.
- The two commonly used types of wireless communication systems are:
    - Microwave Communication System
    - Satellite Communication System

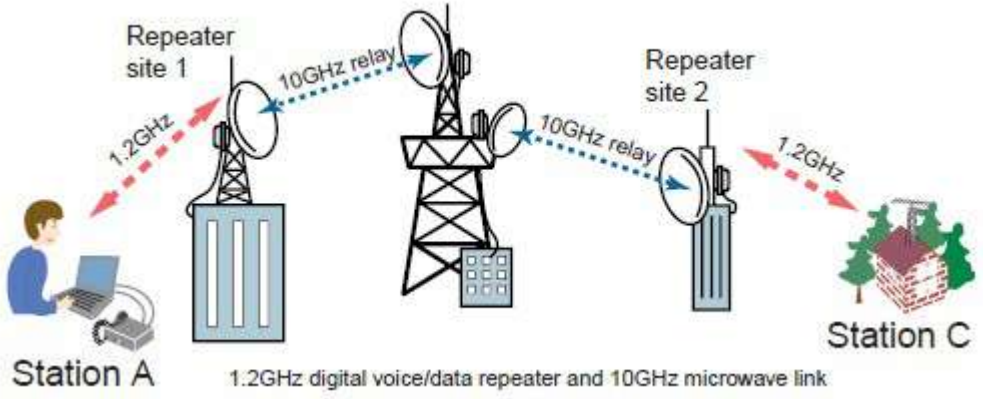
Microwave communication system

- Microwave communication systems use very high frequency radio signals to transmit data through space.
- These signals travel in a straight line and cannot bend to pass over obstacles like tall buildings or hills or the curvature of the earth.
- The signals also become weak after travelling 25 km to 30 km distance and require power amplification.
- The system uses a transmitter and receiver mount on very high towers with in-between repeater stations at intervals of 25-30 km that are also mounted on high towers to be in line-of-sight of each other.

Microwave communication system

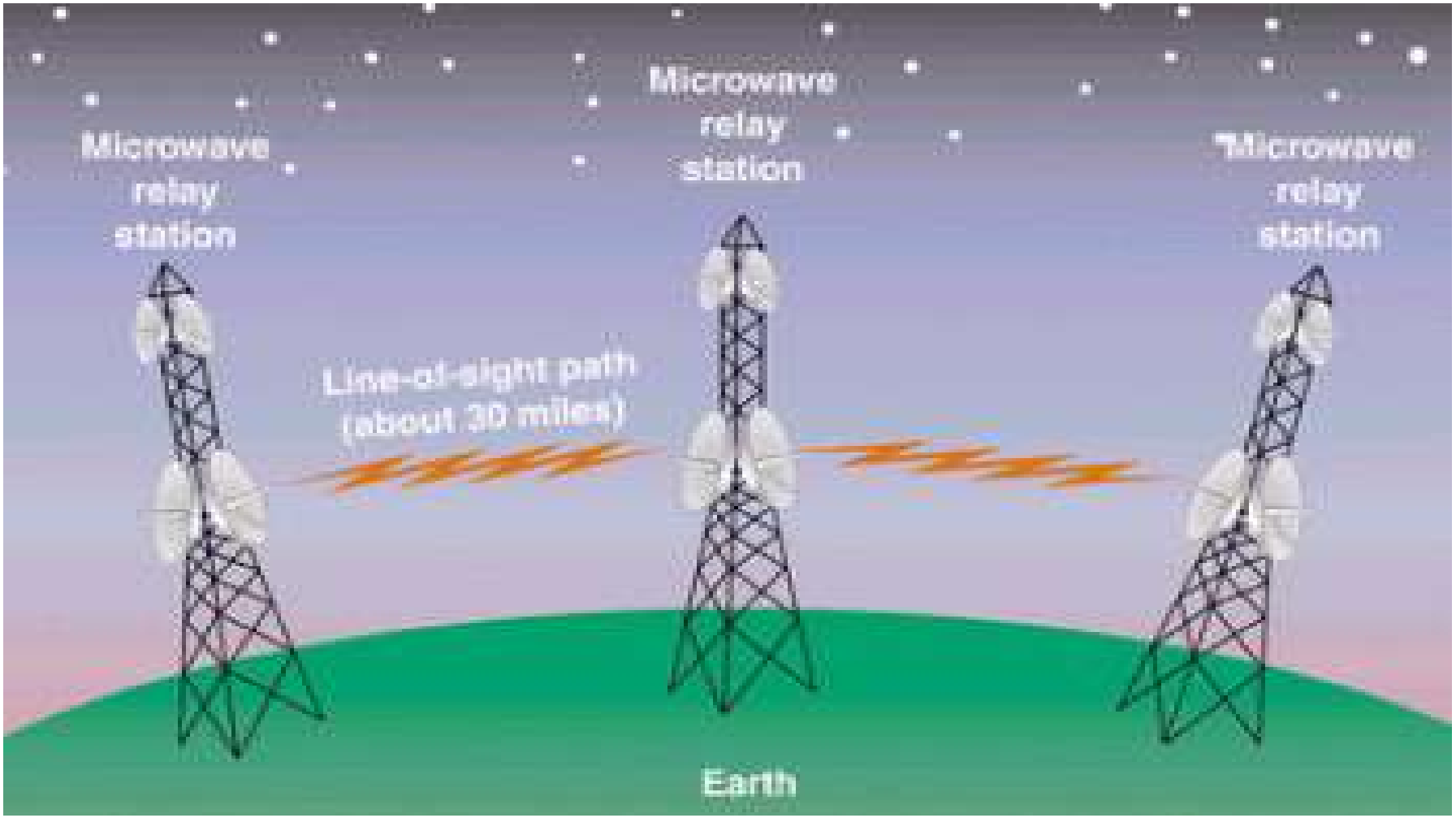
- Each repeater station receives, amplifies and retransmits data signals.
- The bandwidth can be 16 Giga bps.
- Thus, can support approximately 2,50,000 voice channels simultaneously.
- Microwave communication can be used for television broadcasting or by cellular networks.
- The main advantage of microwave communication are
  - No cables required
  - Installation is quicker and easier
  - Capital cost is lower
  - Additional service are provided easily and cheaply

Microwave communication system

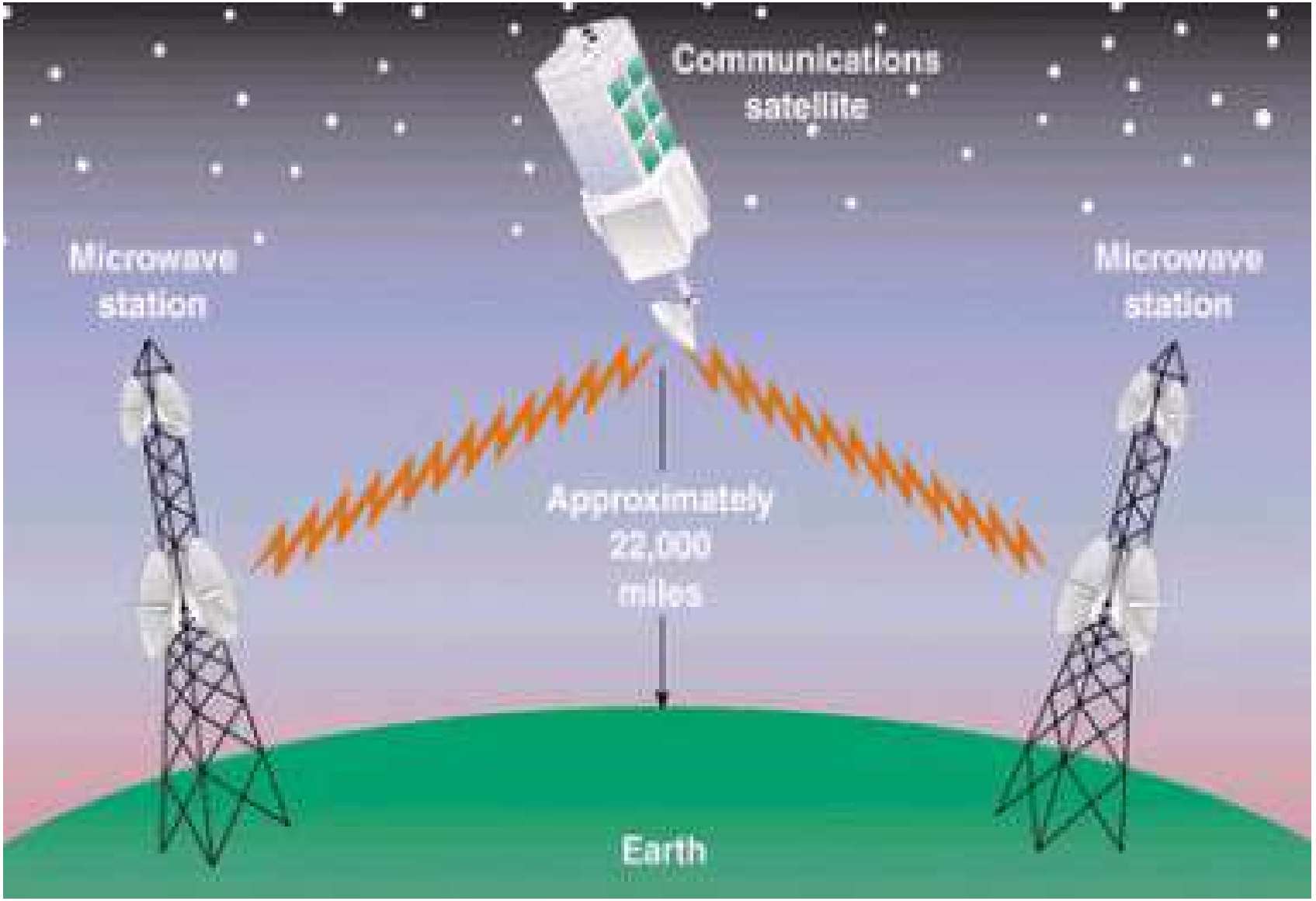


1.2GHz digital voice/data repeater and 10GHz microwave link

Microwave communication system



Satellite communication system



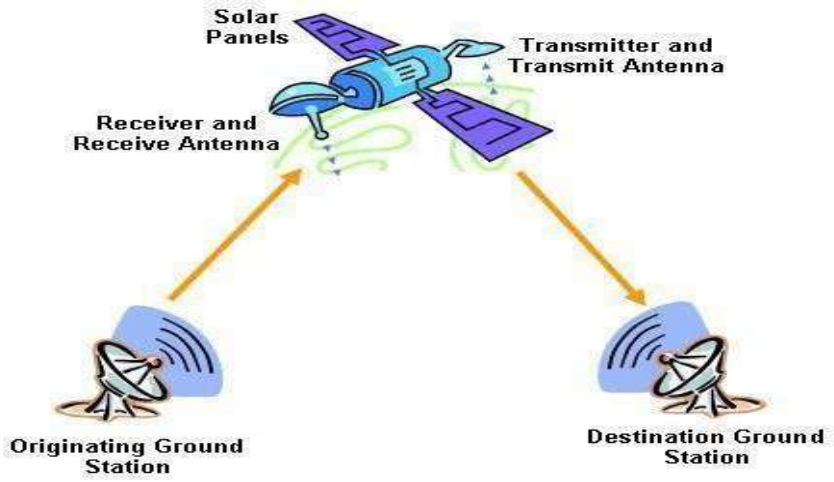
Satellite communication system

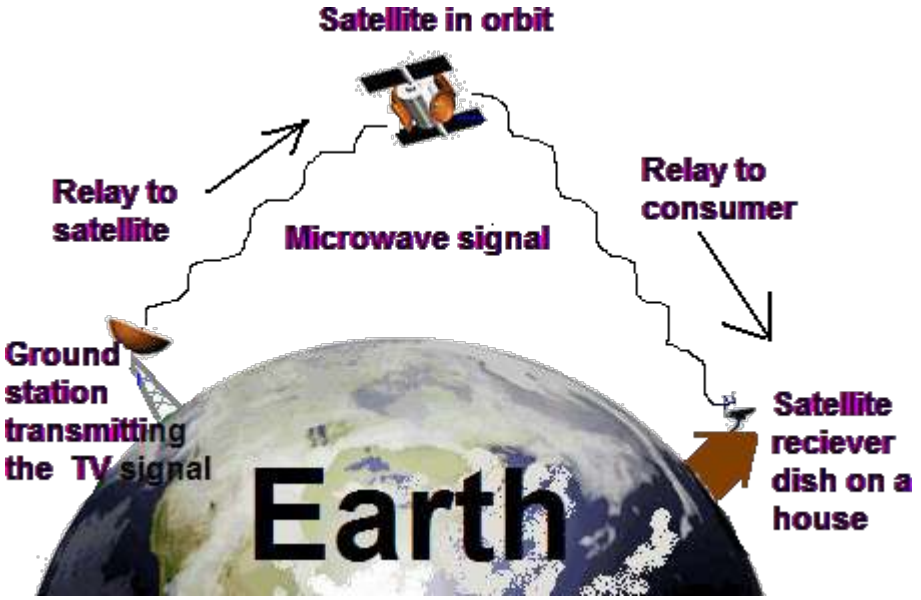
- A satellite is placed in outer space precisely 36,000 km above the equator with an orbit speed exactly matching with the earth’s rotation speed.
- Being in geosynchronous orbit, a satellite is stationary relative to the earth, and always stays over the same point on the ground.
- This allows a ground stations to aim its antenna at a fixed point in the sky.
- To provide data transmission service worldwide, there should be at least three satellites in geosynchronous orbit.
- A satellite has many transponders (transmitters and receivers) mounted on it.
- When a transmitter on earth transmits a microwave signal to a satellite in space, one of these transponder amplifies it, and transmits it back to the earth.
- Receiver on the earth receive the signal and completes the communication process

Satellite communication system

- A single satellite can handle large amount of data.
- The main advantage is that the cost of transmitting data between a sender and receiver is independent of the distance between them.
- However, the initial cost of launching a satellite into space is high and requires high degree of cost.
- Communications satellites are used for television, telephone, radio, internet, and military applications.
- There are over 2,000 communications satellites in Earth’s orbit, used by both private and government organizations.

Satellite communication system





Microwave V/s Satellite communication system

- Microwave communications are used for short-range communications, while satellite communications can be established over long distances. Microwave communications are ideal for television and radio broadcasts, while satellite communications are used for communicating to ships and aircrafts, relaying telephone calls and providing communications to remote areas.
- In Microwave communications receivers are commonly placed on top of high buildings or hilltops and mountain peaks because the higher the receiver is, the farther the signal can be broadcast.
- Satellite communication transfers signal via satellite and, depending on the type of system used, can reach all areas of Earth. They are used for providing satellite telecommunication, links to direct broadcasting, satellite phone service and individual satellite communication links.

Networking Devices

- IT networks use variety of devices for their setup with available communication channels.
- The most commonly used networking devices are as follows:
  - Modem
  - Amplifier
  - Repeater
  - Multiplexer
  - Network Switch
  - Router
  - Network Card

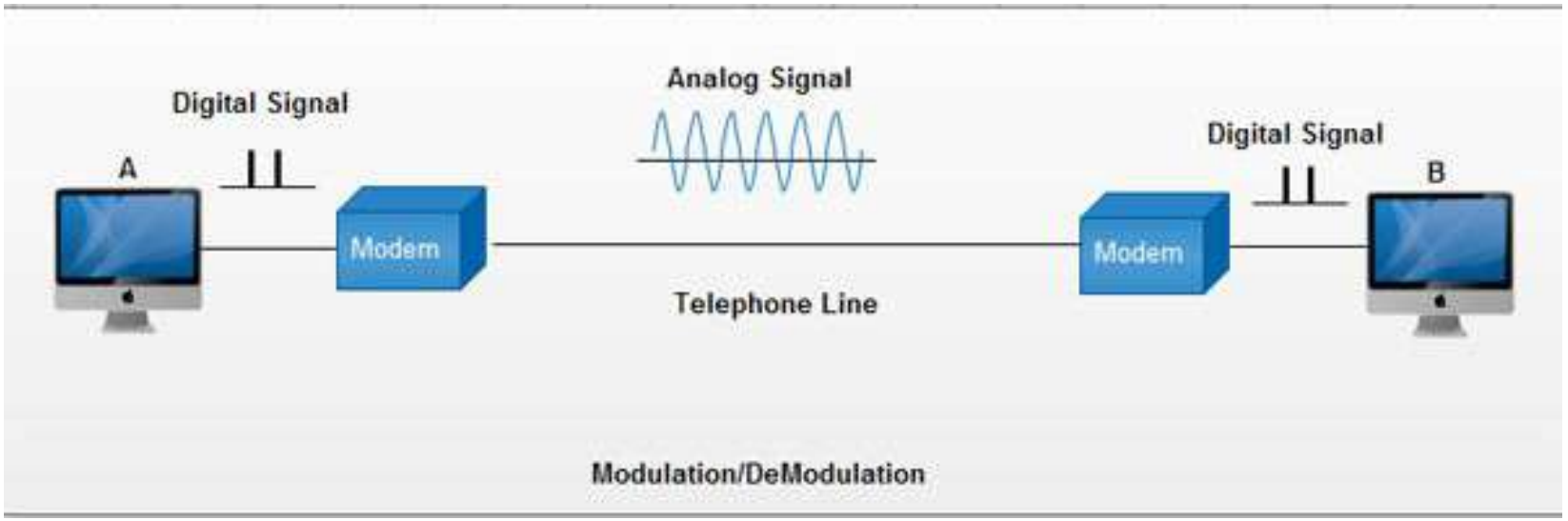
Modem

- The computer generated data is in digital form.
- The telephone lines used for data communication in IT networks has data in analog form.
- When data communication system transmits digital data using a communication channel that carries analog signals, it has to be converted from digital to analog (D to A) at the sender's end and from analog to digital form (A to D) at the receiver's end.
- Modulation is the process of D to A conversion.
- Demodulation is the process of A to D conversion.

Modem

- Modem is a networking devices used for performing modulation and demodulation.
- Hence, when two digital devices (computers) are connected and want to communicate over an analog transmission (telephone line), both devices need a modem.
- Modem is not required when both the digital devices are connected and communicate over a digital transmission channel.
- Note that for transmitting digital data, digital transmission channel is preferred to analog transmission channel because of lower cost of data transmission, higher transmission speeds, and lower error rate. (higher reliability).

Modem


Digital Signal
A
Modem
Analog Signal
Telephone Line
Modem
Digital Signal
B
Modulation/DeModulation

Amplifier

- An amplifier, electronic amplifier is an electronic device that can increase the power of a signal.
- An amplifier functions by taking power from a power supply and controlling the output to match the input signal shape but with a larger amplitude.
- In this sense, an amplifier modulates the output of the power supply based upon the properties of the input signal.
- Analog signals become weak and distorted when they travel long distances.
- Hence, communication systems which transmit analog signals, use amplifiers at periodic intervals of distance along communication channels to amplify (strengthen) weak analog signals.

Amplifier

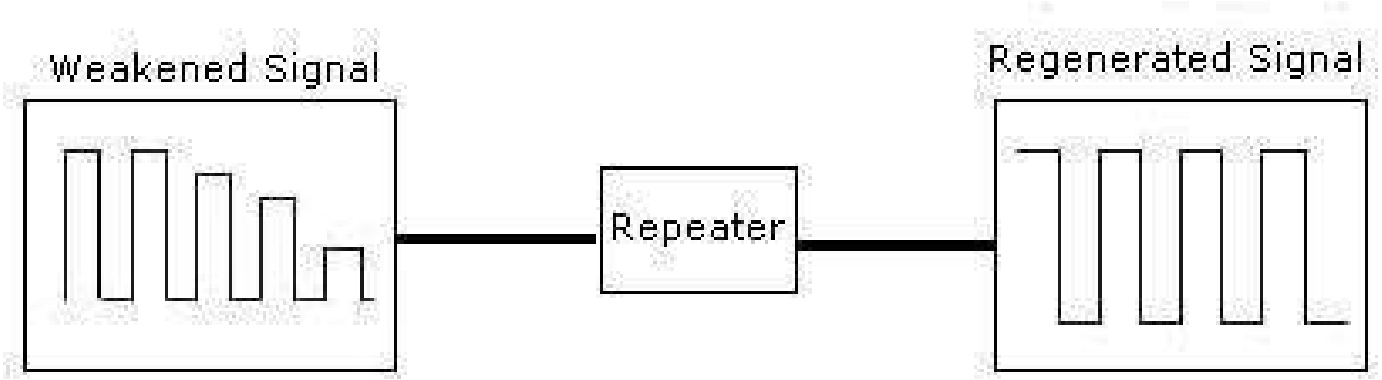

MIC 1
MIC 2
MIC 3
MIC 4
MIC 5/AUX 1
MIC 6/AUX 2
BASS
TREBLE
AUX 3
AUX 4
AUX 5
ZONE 1
ZONE 2
MASTER
0 dB
−6
−12
−18
−24
POWER
ON
OFF
TOA PA AMPLIFIER model A-1706

Repeater

- Even digital signals become weak when they travel long distances.
- In telecommunications, a repeater is an electronic device that receives a signal and retransmits it.
- Repeaters are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction.
- Repeaters amplify the received/input signal to a higher frequency domain so that it is reusable, scalable and available.

Repeater

- Repeaters were introduced in wired data communication networks due to the limitation of a signal in propagating over a longer distance and now are a common installation in wireless networks for expanding cell size.
- Repeaters are also known as **signal boosters.**



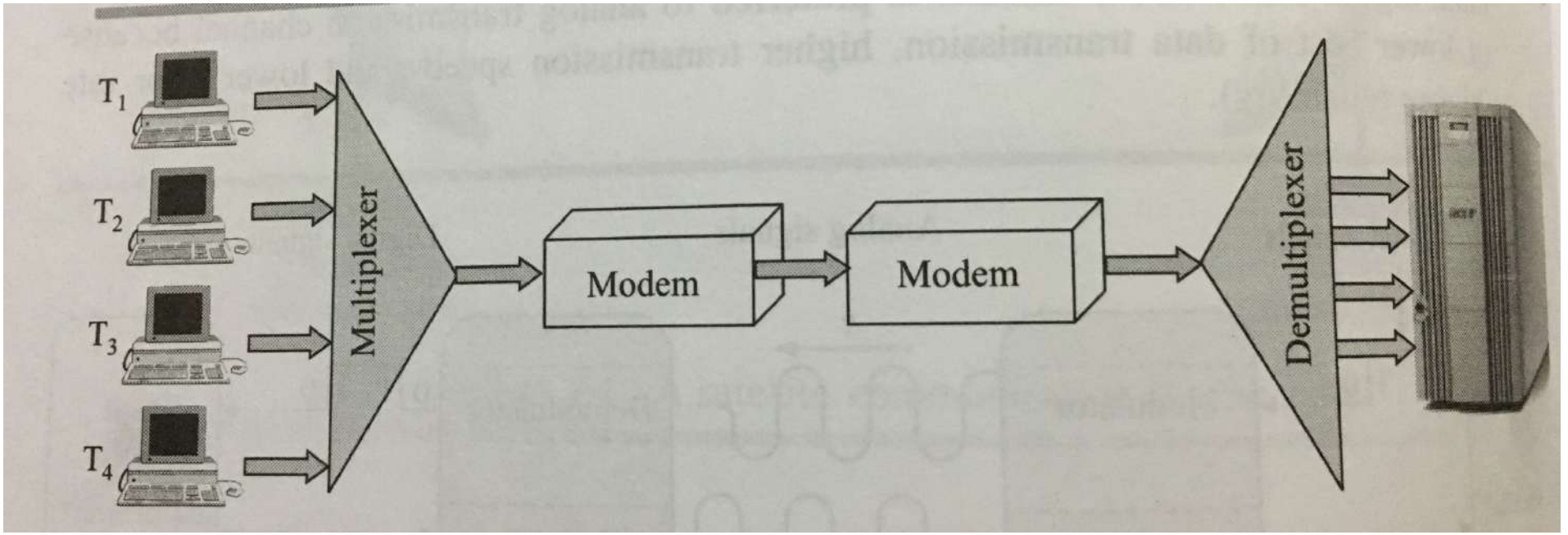
Difference between Amplifier and Repeater

- Amplifier is used to magnify a signal, whereas repeater is used to receive and retransmit a signal with a power gain.
- Repeater has an amplifier as a part of it.
- Sometimes, amplifiers introduce some noise to the signal, whereas repeaters contain noise eliminating parts.
- A repeater is a regenerator; not an amplifier.

Multiplexer

- The bandwidth of a communication channel normally exceeds much beyond the communication requirements of a single user.
- Hence, for optimal utilization, network enable sharing of a communication channel among multiple users by transmitting multiple signals through it.
- The method of dividing a physical communication channel into multiple logical channels is known as **multiplexing.**
- The electronic device that performs this task is known as **multiplexer.**
- A multiplexer converts several data communication lines or signals into one data communication line or signal at the sending end and breaks the single large signal into original signals at the receiving end.

Multiplexer

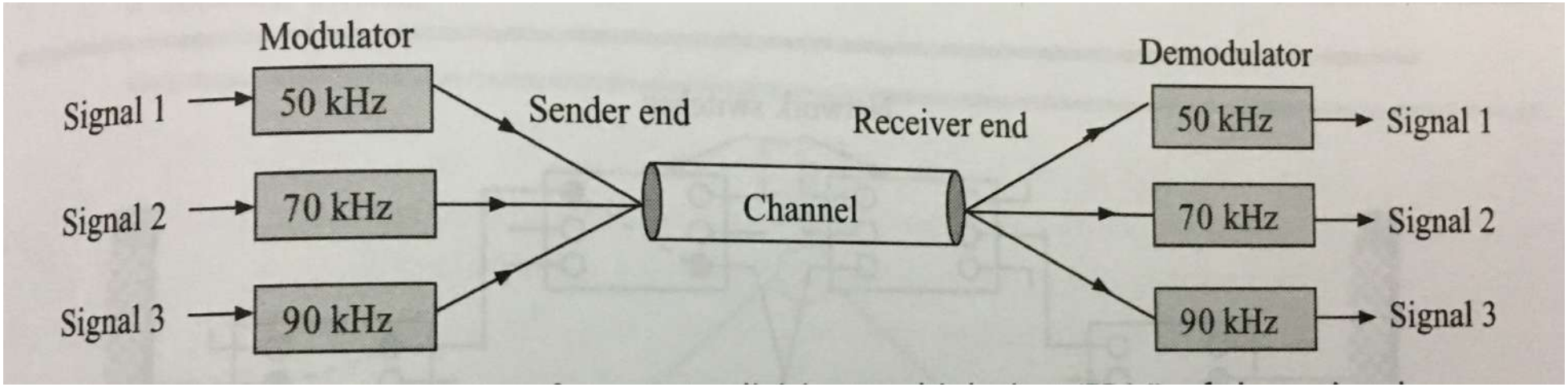


Multiplexer

- The two commonly used methods of multiplexing a communication channel are as follows:
  - Frequency Division Multiplexing (FDM)
  - Time Division Multiplexing (TDM)

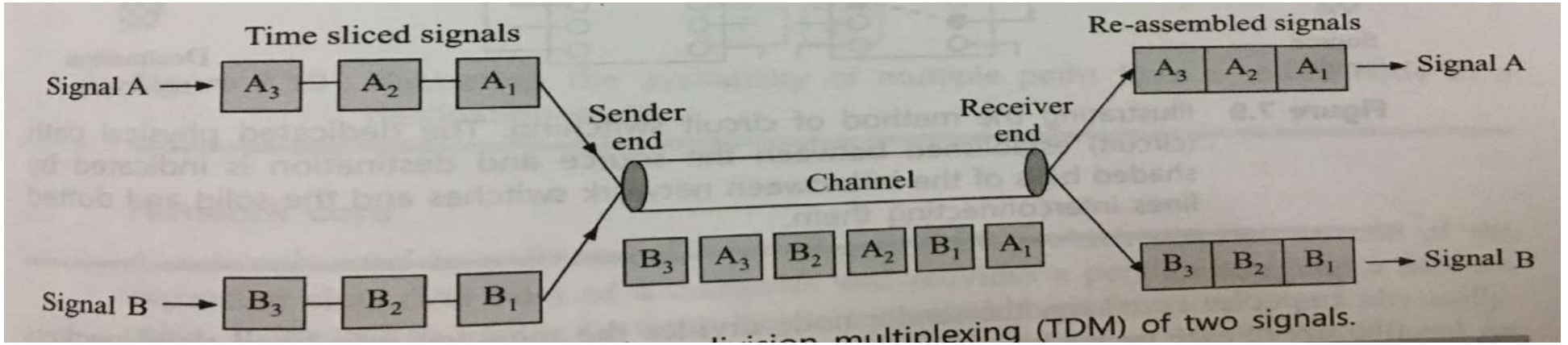
FDM

- In FDM, the available frequency range within the bandwidth of a communication channel is divided intro several smaller, disjoint frequency ranges, and each one is then used as a separate communication channel.
- FDM can handle only analog signals.
- Radio broadcast technology uses FDM to support multiple radio stations simultaneously.



TDM

- In TDM, multiple data streams of different users are interleaved as one data stream at the sender end of the communication channel, and the individual pieces of data of different users are re-assembled into full messages of each user at the receiver end.
- TDM divides the total available time of communication of a communication channel and shares it among multiple users.
- TDM is used for transmission of digital data.
- Internet uses TDM to transmit message packets of multiple users over the same communication channel.



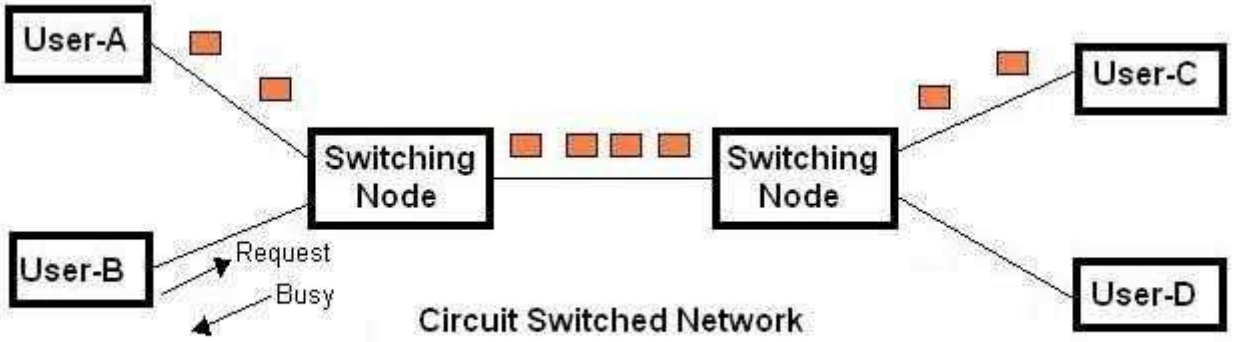
multiplexing (TDM) of two signals.

Network switch

- When a message travels from sender to receiver (from source to destination), it often passes through a network of intermediate nodes.
- This is because direct connectivity between any two nodes is not possible and uneconomical.
- The intermediate nodes are called **network switches** as they provide a switching facility for moving a message from one node to another until it reaches its destination.
- There are two commonly used switching techniques:
  - Circuit switching
  - Packet switching
  - Message switching

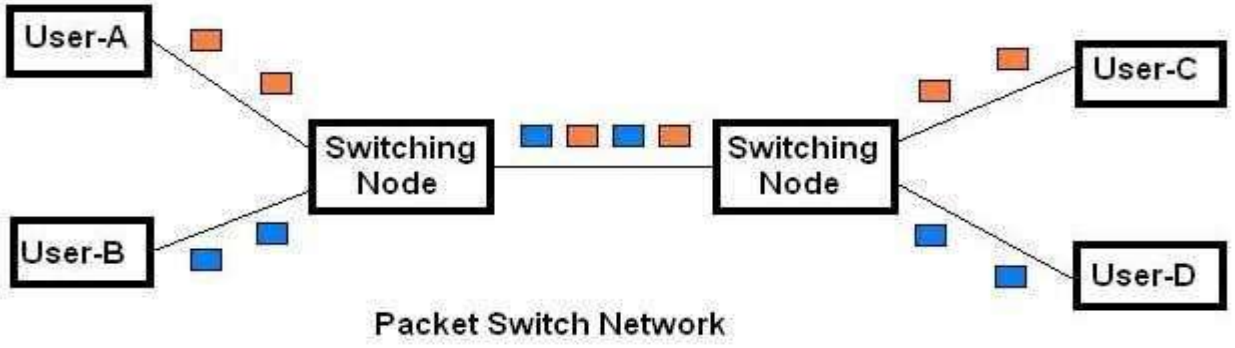
Circuit switching

- A **dedicated physical path called as circuit** is established between the sender and the receiver through the intermediate node of the communication network.
- Once established, the circuit is available exclusively from source to destination.
- PSTN (Public Switched Telephone Network) is the best example of circuit switching.



Packet Switching

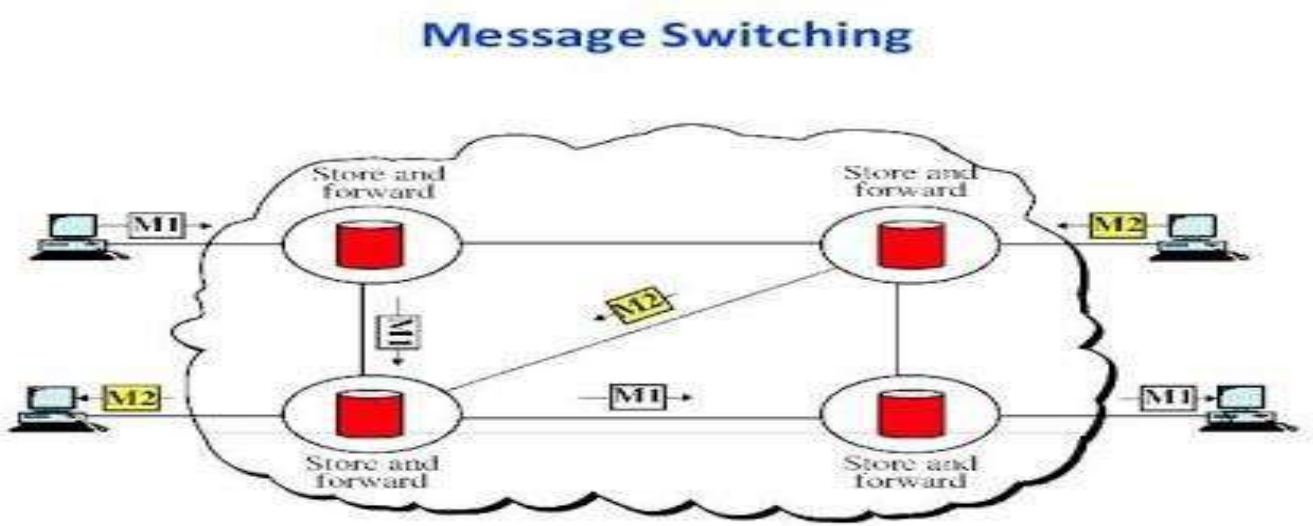
- In packet Switching, the sender node divides the message into fixed size packets.
- It also adds the destination address, the message number, the sequence number of the current packet, the total number of packets to each packet.
- The packet is transmitted on the base of available free channel.
- The destination nodes re-assembles the packets of message in correct sequence to create the original message.
- The path of each packet may differ.
- Internet uses packet switching for data transmission.



Packet Switch Network

Message Switching

- Message switching is works on store and forward technology.
- Message switching is a network switching technique in which data is routed in its entirety from the source node to the destination node, one hope at a time. During message routing, every intermediate switch in the network stores the whole message. If the entire network's resources are engaged or the network becomes blocked, the message-switched network stores and delays the message until ample resources become available for effective transmission of the message.



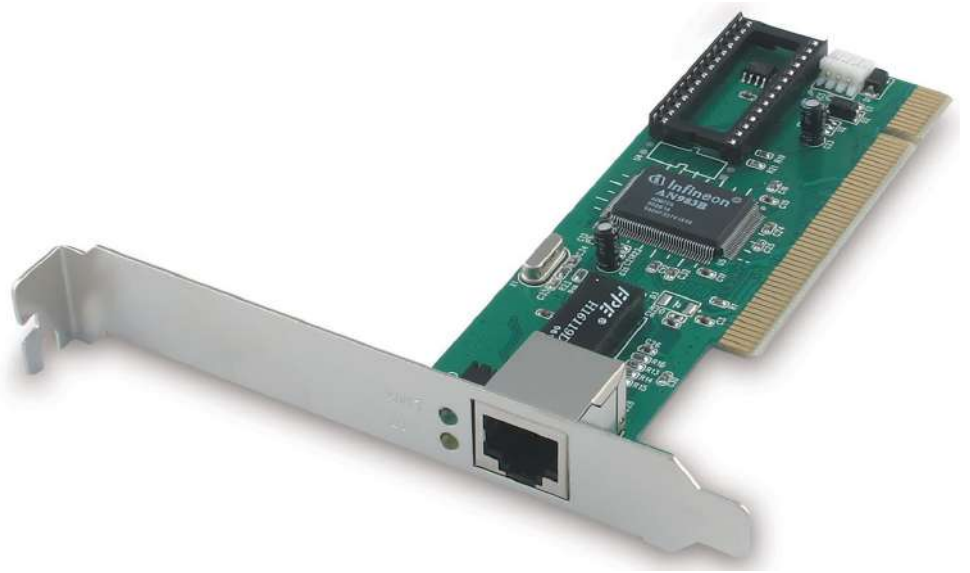
Router

- A router is a device that forwards data packets along networks.
- A router is connected to at least two networks, commonly two LANs or WANs or a LAN and its ISP's network.
- Routers are located at **gateways**, the places where two or more networks connect.
- Routers use **headers and forwarding tables** to determine the best path for forwarding the packets, and they use protocols to communicate with each other and configure the best route between any two hosts.
- These nodes maintain routing tables and execute routing algorithms to take routing decisions.
- When an intermediate node is equipped with the capability to take decisions, it called router instead of switch.

Network Card

- A network card is a **Printer Circuit Board (PCB)** which connects to one of the expansion slots of a computer.
- It provides a port for attaching a network cable.
- It is used to connect a computer to a network.
- Network card is different for different networks.
- Hence a computer needs a Ethernet card, if it is connected to a Ethernet Network.
- It is also called as NIC – Network Interface Card
- The NIC contains the electronic circuitry required to communicate using a wired connection (e.g., **Ethernet**) or a wireless connection (e.g., **WiFi**).
- A network interface card is also known as a network interface controller, network adapter, or **Local Area Network** (**LAN**) adapter.

NIC



Network Types Based on Topology

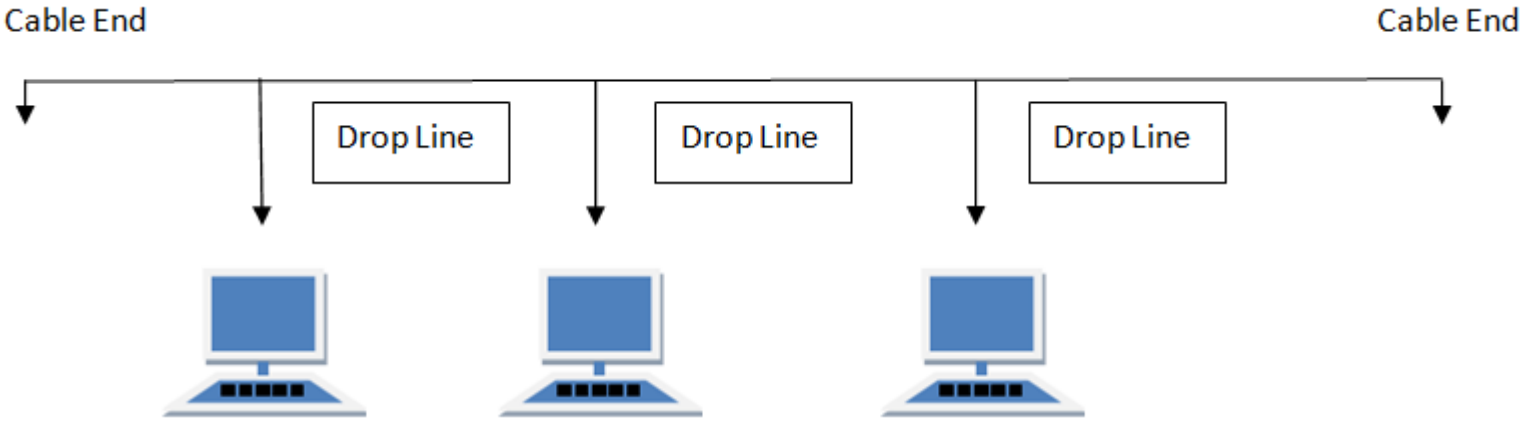
- **Topology** of a network refers to the manner in which the nodes of the network are connected together.
- It determines the various communication paths available between any pair of nodes in the network.
- The topology of a network is decided by its designer based on several factors such as
  - the number of nodes in the network
  - geographical spread of nodes
  - types of communication channels
  - performance, reliability and scalability requirements of the network;
  - the implementation cost of the network.

Types of Network based on Topology

- **Network Topology** is the schematic description of a network arrangement, connecting various nodes(sender and receiver) through lines of connection.
- Following are the types of topology.
  - Bus (Multi-access Bus / Multipoint / Multi Drop)
  - Star
  - Ring
  - Completely-connected
  - Hybrid

Bus Network

- Bus topology is a network type in which every computer and network device is connected to single cable. When it has exactly two endpoints, then it is called **Linear Bus topology**.
- Single communication line shared by all nodes.
- Least expensive
- It transmits data only in one direction.
- Every device is connected to a single cable



Bus Network

Advantages of Bus Topology

- It is cost effective.
- Cable required is least compared to other network topology.
- Used in small networks.
- It is easy to understand.
- Easy to expand joining two cables together.

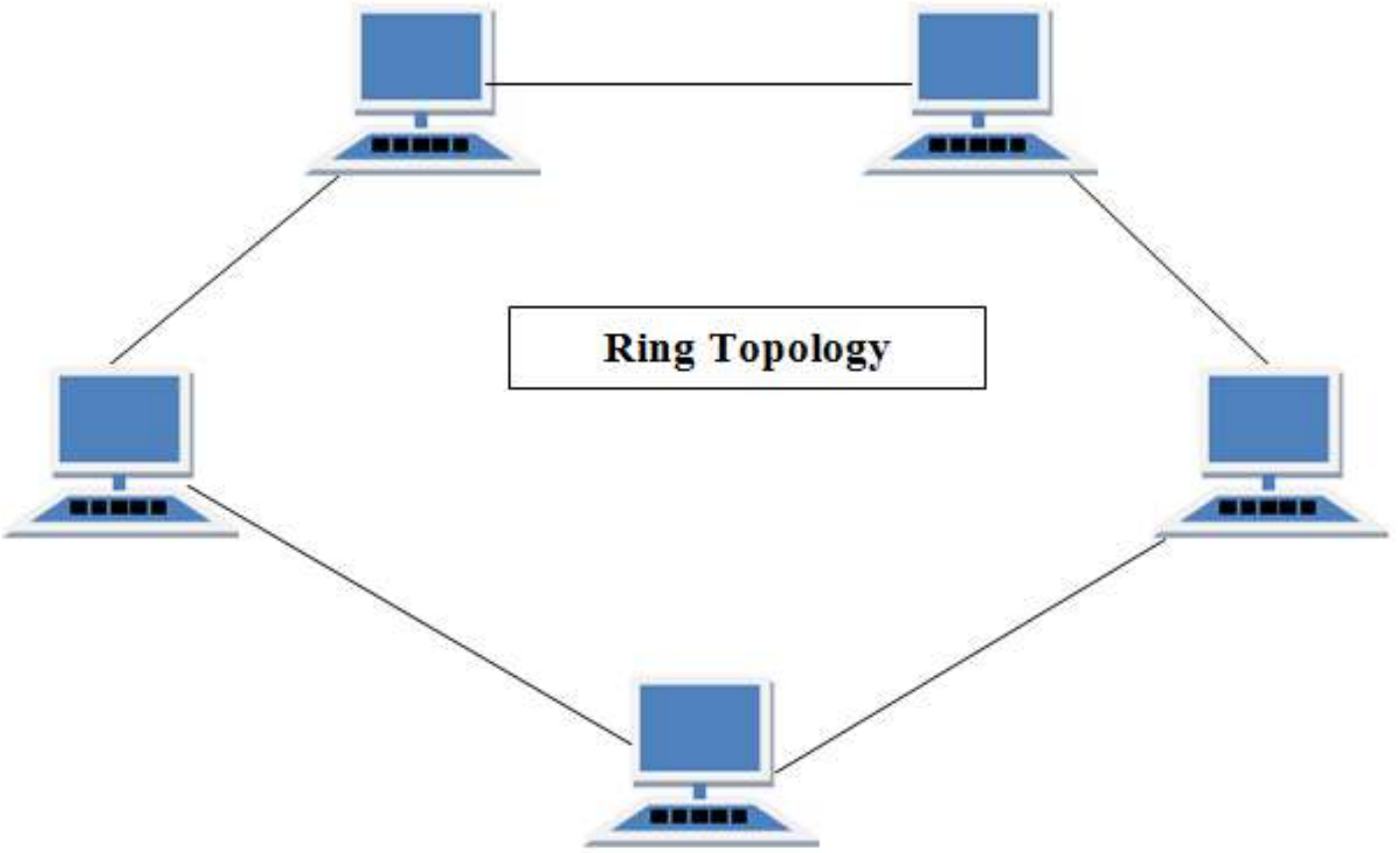
Disadvantages of Bus Topology

- Cables fails then whole network fails.
- If network traffic is heavy or nodes are more the performance of the network decreases.
- Cable has a limited length.
- It is slower than other topology.

Ring Network

- It is called **ring topology** because it forms a ring as each computer is connected to another computer, with the last one connected to the first.
- Exactly two neighbours for each device.
- If n nodes, then need n communication links.
- If one node fails in a network, the communication will continue with the alternate path.
- Data is transferred in a sequential manner that is bit by bit.
- Data transmitted, has to pass through each node of the network, till the destination node.

Ring Network



Ring Network

Advantages of Ring Topology

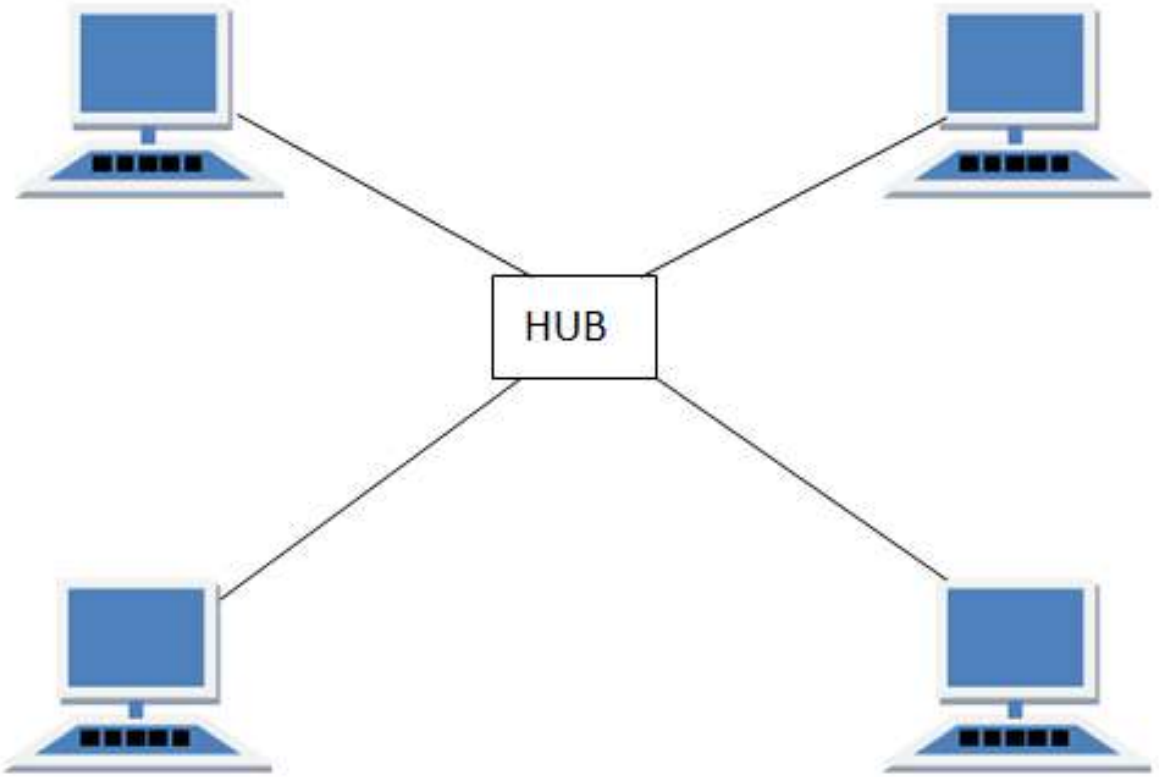
- Transmitting network is not affected by high traffic or by adding more nodes, as only the nodes having tokens can transmit data.
- Cheap to install and expand

Disadvantages of Ring Topology

- Troubleshooting is difficult in ring topology.
- Adding or deleting the computers disturbs the network activity.
- Failure of one computer disturbs the whole network.

Star Network

- In this type of topology all the computers are connected to a single hub (single host) through a cable. This hub is the central node and all others nodes are connected to the central node.
- If n nodes in a network, then needs n-1 communication links
- If any node other than the host node fails, the other nodes in the network can continue to function normally.
- Every node has its own dedicated connection to the hub.
- Hub acts as a repeater for data flow.
- Can be used with twisted pair, Optical Fibre or coaxial cable.


HUB

Advantages of Star Topology

Fast performance with few nodes and low network traffic.

Hub can be upgraded easily.

Easy to troubleshoot.

Easy to setup and modify.

Only that node is affected which has failed, rest of the nodes can work smoothly.

Disadvantages of Star Topology

Cost of installation is high.

Expensive to use.

If the hub fails then the whole network is stopped because all the nodes depend on the hub.

Performance is based on the hub that is it depends on its capacity

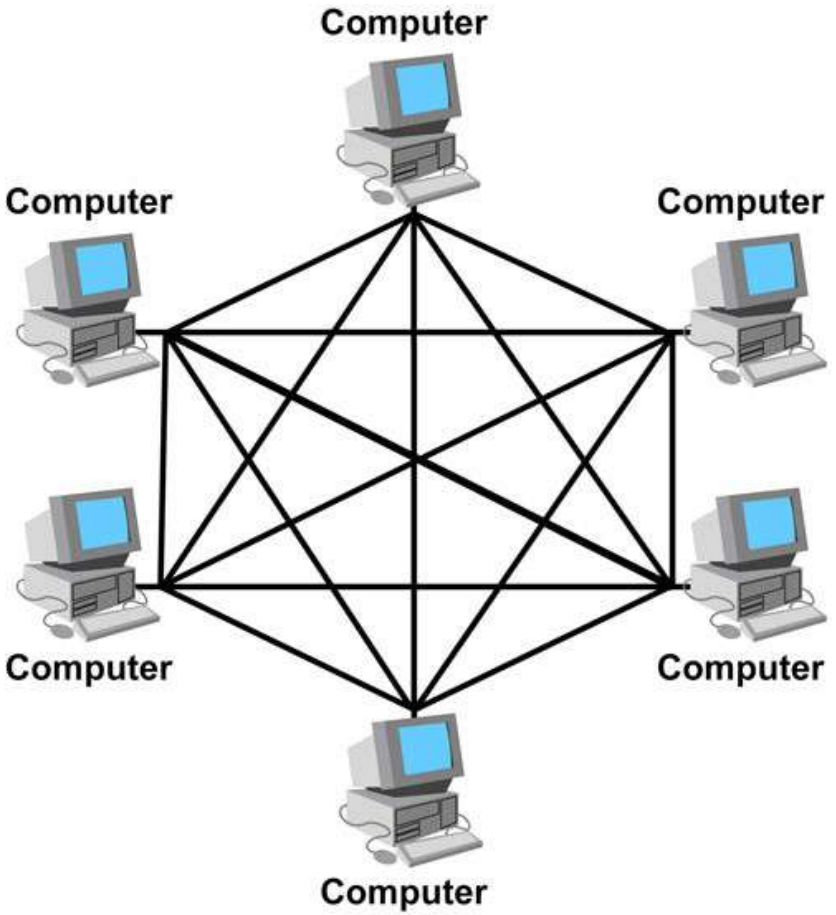
Completely-connected network

In a *fully connected network*, all nodes are interconnected. The simplest fully connected network is a two-node network.

A node can directly communicate with any other node in the network.

If n nodes, then n(n-1)/2 communication links needed.

Most expensive network


Computer
Computer
Computer
Computer
Computer
Computer
Computer

Advantages

Faster communication

More reliability

Only that node is affected which has failed, rest of the nodes can work smoothly

Disadvantages

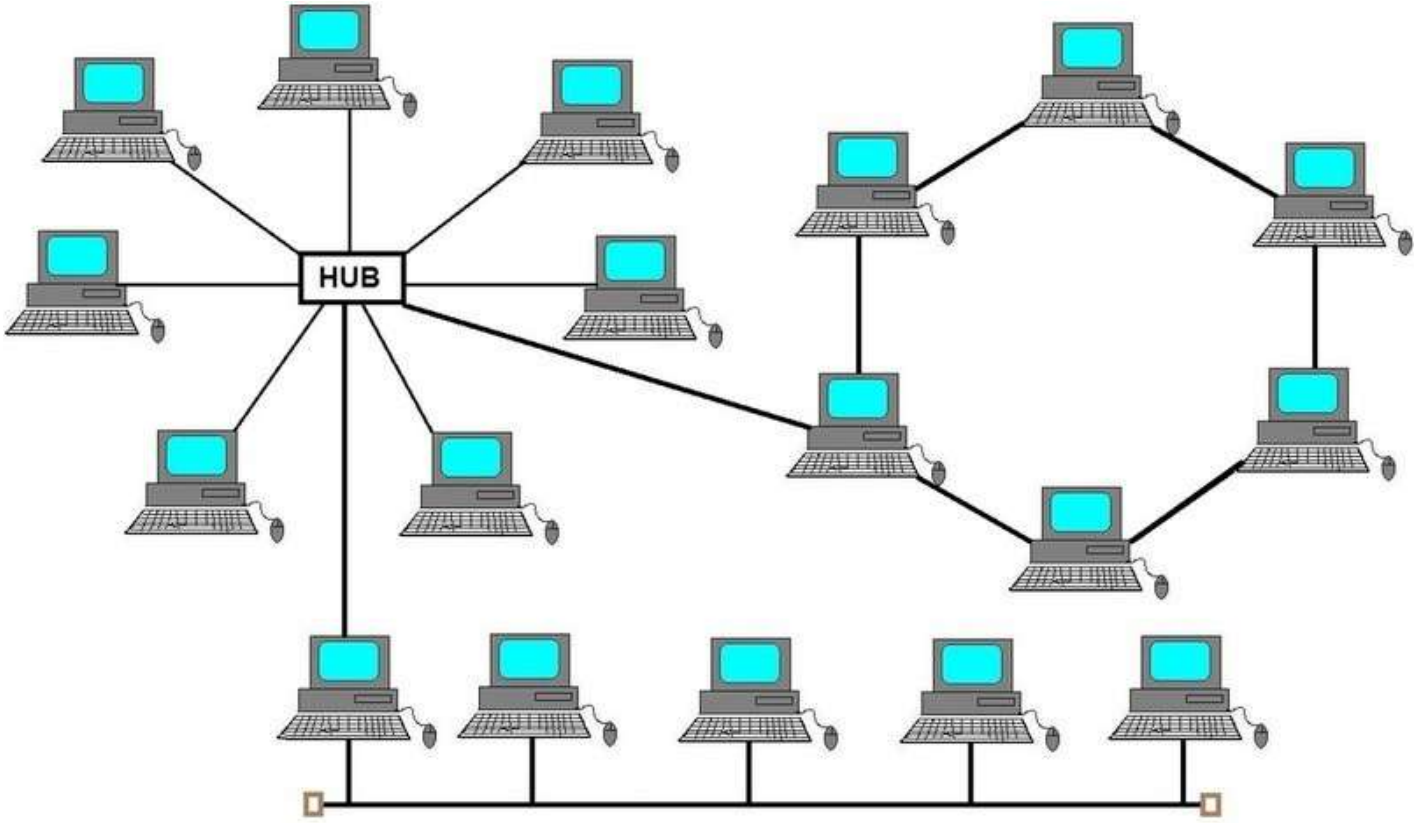
most expensive

Difficult to maintain

Installation cost is high

Hybrid network

- It is two different types of topologies which is a mixture of two or more topologies.
- For example if in an office in one department ring topology is used and in another star topology is used, conne.cting these topologies will result in Hybrid Topology
- It is a combination of two or topologies
- Inherits the advantages and disadvantages of the topologies included.


HUB

Advantages of Hybrid Topology

Reliable as Error detecting and trouble shooting is easy.

Effective.

Scalable as size can be increased easily.

Flexible.

Disadvantages of Hybrid Topology

Complex in design.

Costly.