CHAPTER 2

Physical Layer and Network Media

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Physical Layer

- It is the bottom layer of OSI Model.
- It is responsible for the actual physical connection between the devices. Such physical connection may be made by using twisted pair cable.
- It is concerned with transmitting bits over a communication channel

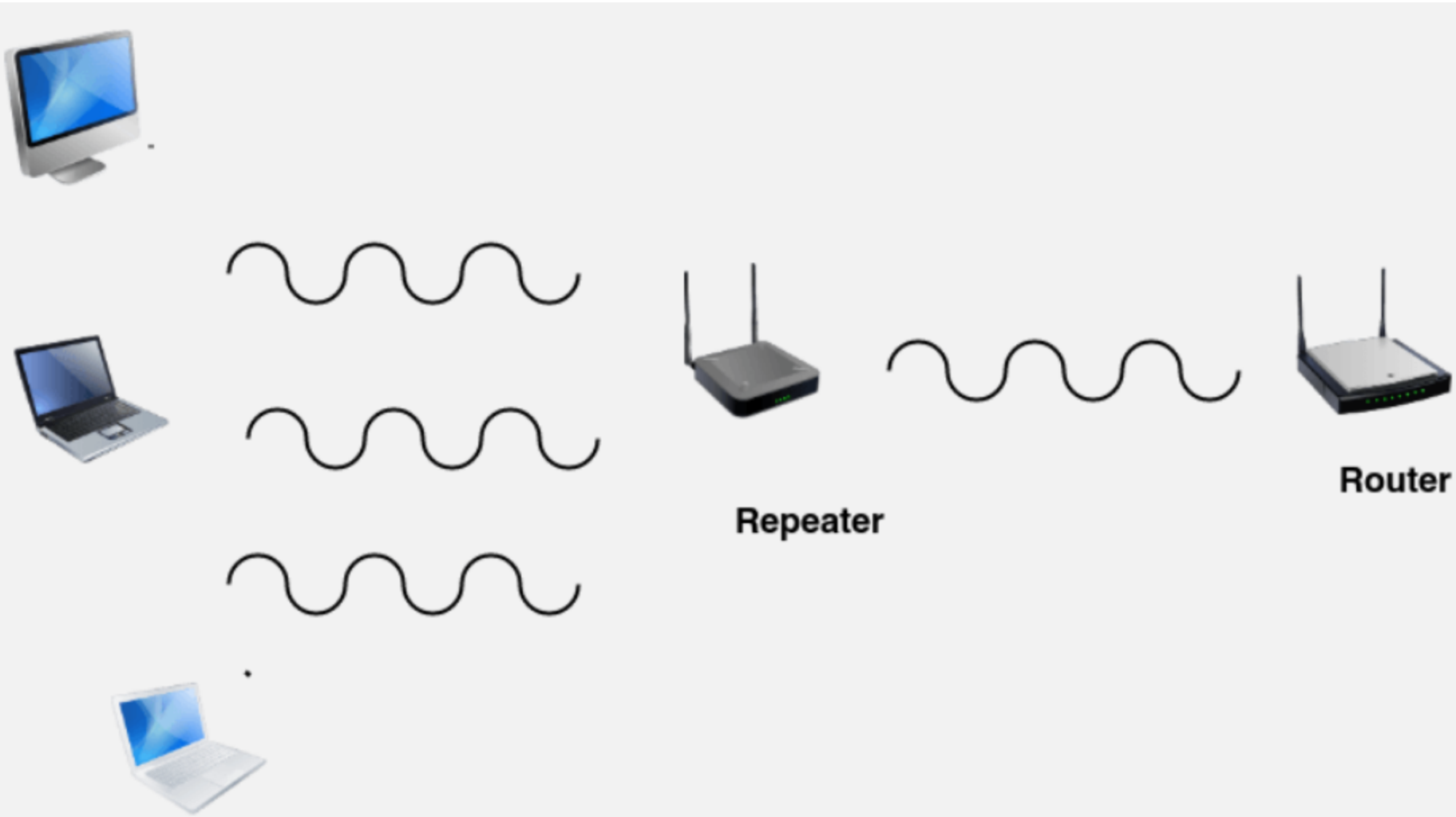
Functions of Physical Layers

- Transforming bits into signals
- Provides synchronization of bits by a clock.
- Physical layer manages the way a device connects to network media.
- It defines the transmission rate.
- It defines the way in which the devices are connected to the medium.
- It provides physical topologies
- It can use different techniques of multiplexing

2.1 Network Devices

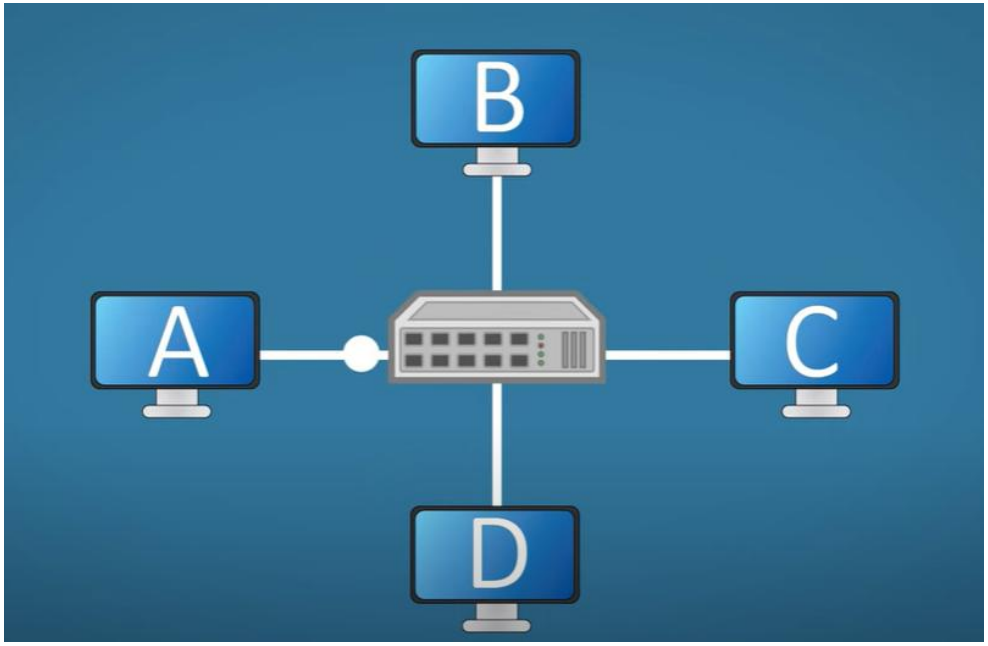
1. Repeater

- A repeater operates at the physical layer.
- Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.
- An important point to be noted about repeaters is that they do not amplify the signal. When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength.
- It is a 2 port device.


Repeater
Router

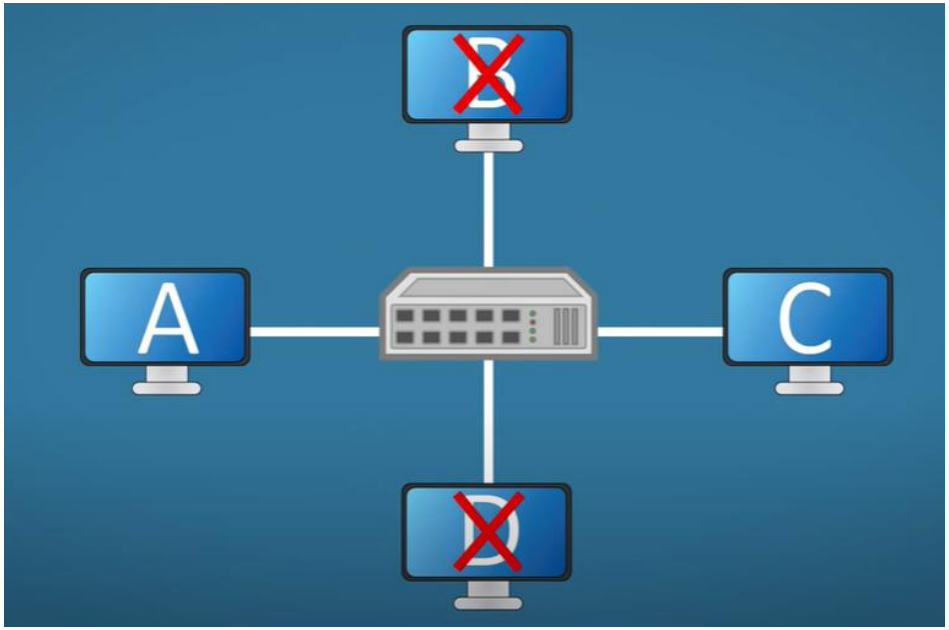
2. HUB

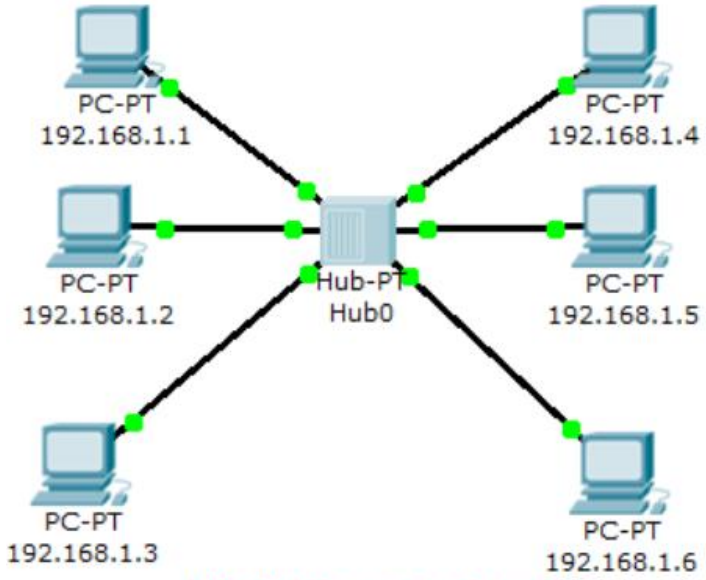
- A hub is basically a multiport repeater.
- A hub connects multiple wires coming from different branches, for example, the connector in star topology which connects different stations.
- Hubs cannot filter data, so data packets are sent to all connected devices.
- In other words, the collision domain of all hosts connected through Hub remains one. Also, they do not have the intelligence to find out the best path for data packets which leads to inefficiencies and wastage.
- Half Duplex Communication
- Wasted of Bandwidth and security risks



❑When HUB receives data from A, it sends data to Node B, Node C and Node D without filtering

❑Only Node C receives the data while Node B, and Node D rejects the data.





192.168.1.0 range configuration

Types of HUB

- **Active Hub:-** These are the hubs that have their own power supply and can clean, boost, and relay the signal along with the network. It serves both as a repeater as well as a wiring center. These are used to extend the maximum distance between nodes.

- **Passive Hub :-** These are the hubs that collect wiring from nodes and power supply from the active hub. These hubs relay signals onto the network without cleaning and boosting them and can't be used to extend the distance between nodes.

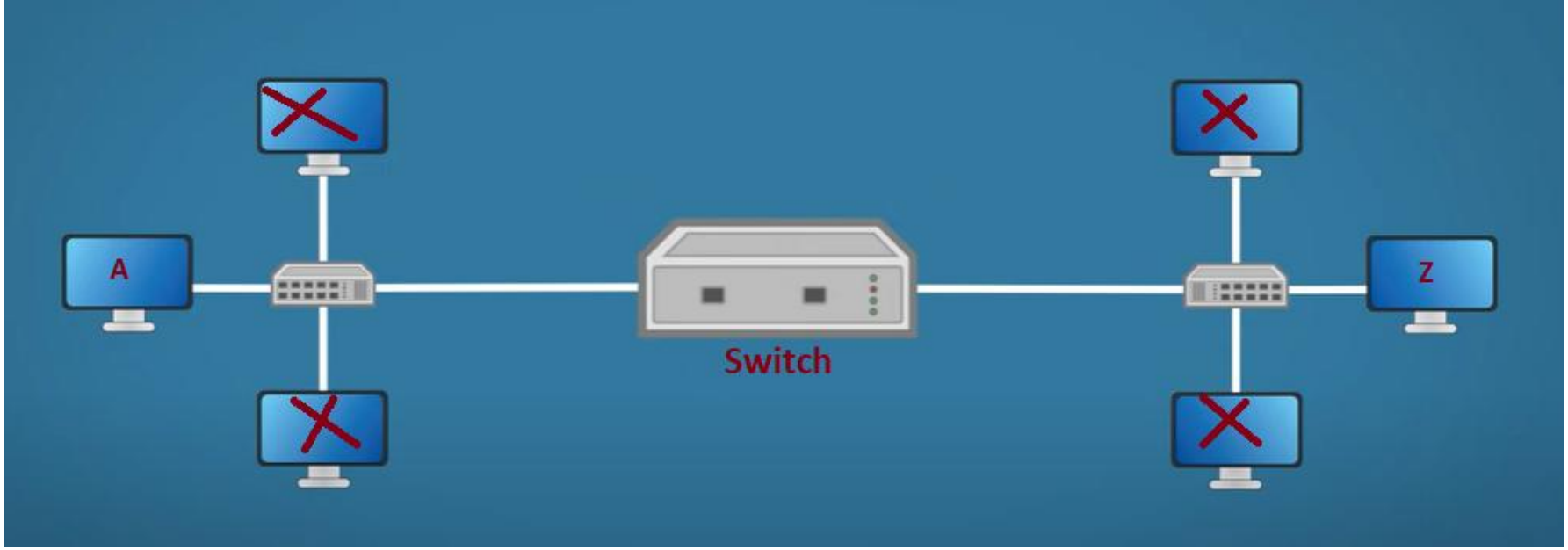
- **Intelligent Hub :-** It works like active hubs and includes remote management capabilities. They also provide flexible data rates to network devices. It also enables an administrator to monitor the traffic passing through the hub and to configure each port in the hub.

3.Switch

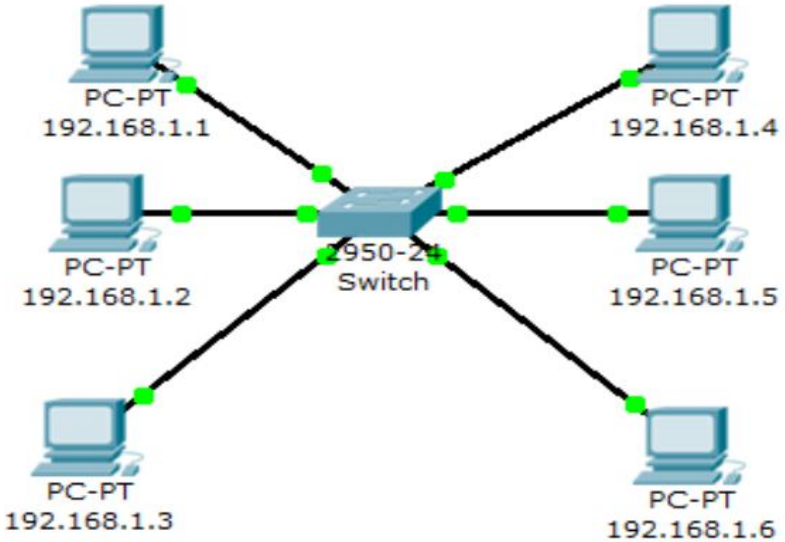
- Works on Layer 2
- Works based on MAC address, Used to connect computers in Network (LAN), Only same range of IP

- Have MAC address table to store information about ports and MAC address of computer connected in port
- Broadcasting only done initially after that unicasting
- Broadcasting only before learning the mac address of the systems connected
- Switch automatically will learn the MAC Address of the system connected in the port and stores in MAC table

- After learning the address only unicasting is used for data transmission
- It can operate in simple, half duplex and full duplex mode



When Computer A sends data to Computer Z, It works on the basis of MAC address ,thus all other computers rejects the data while computer Z received the data.

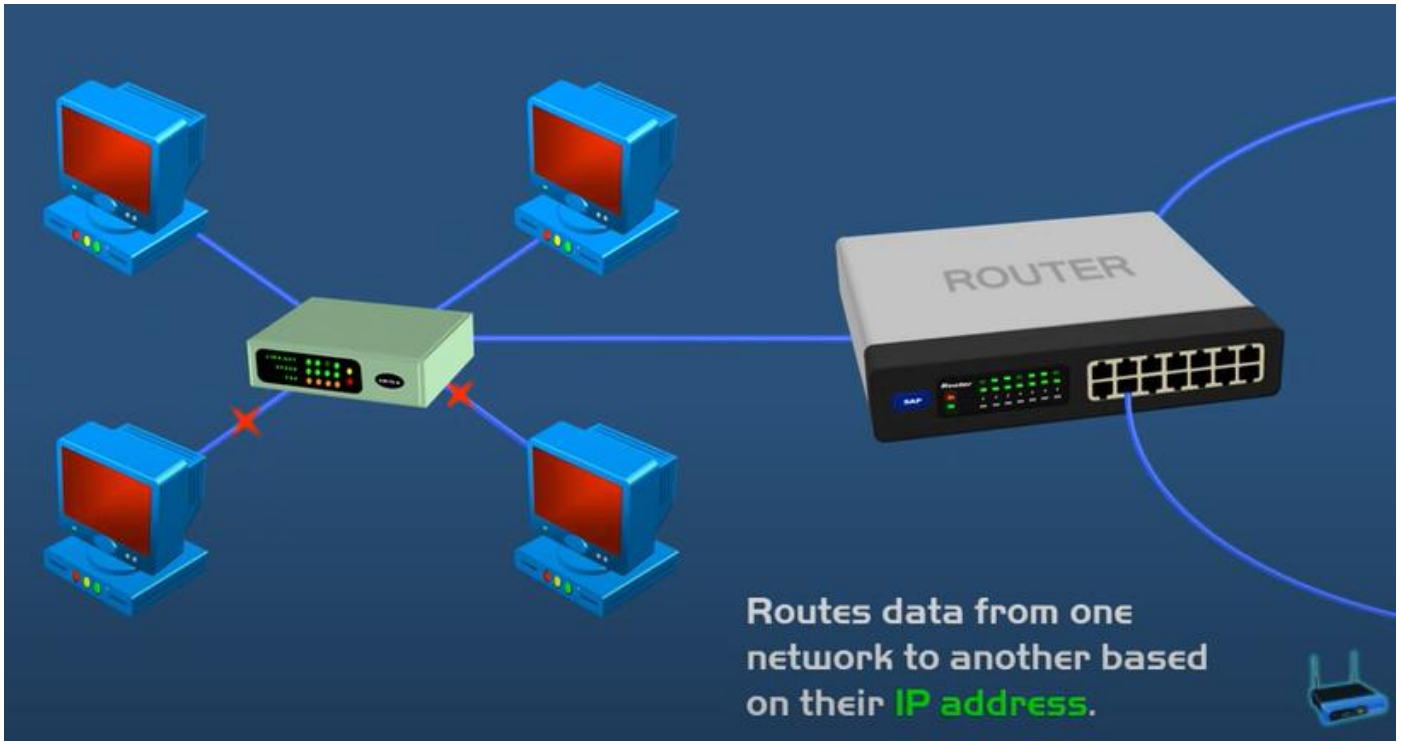


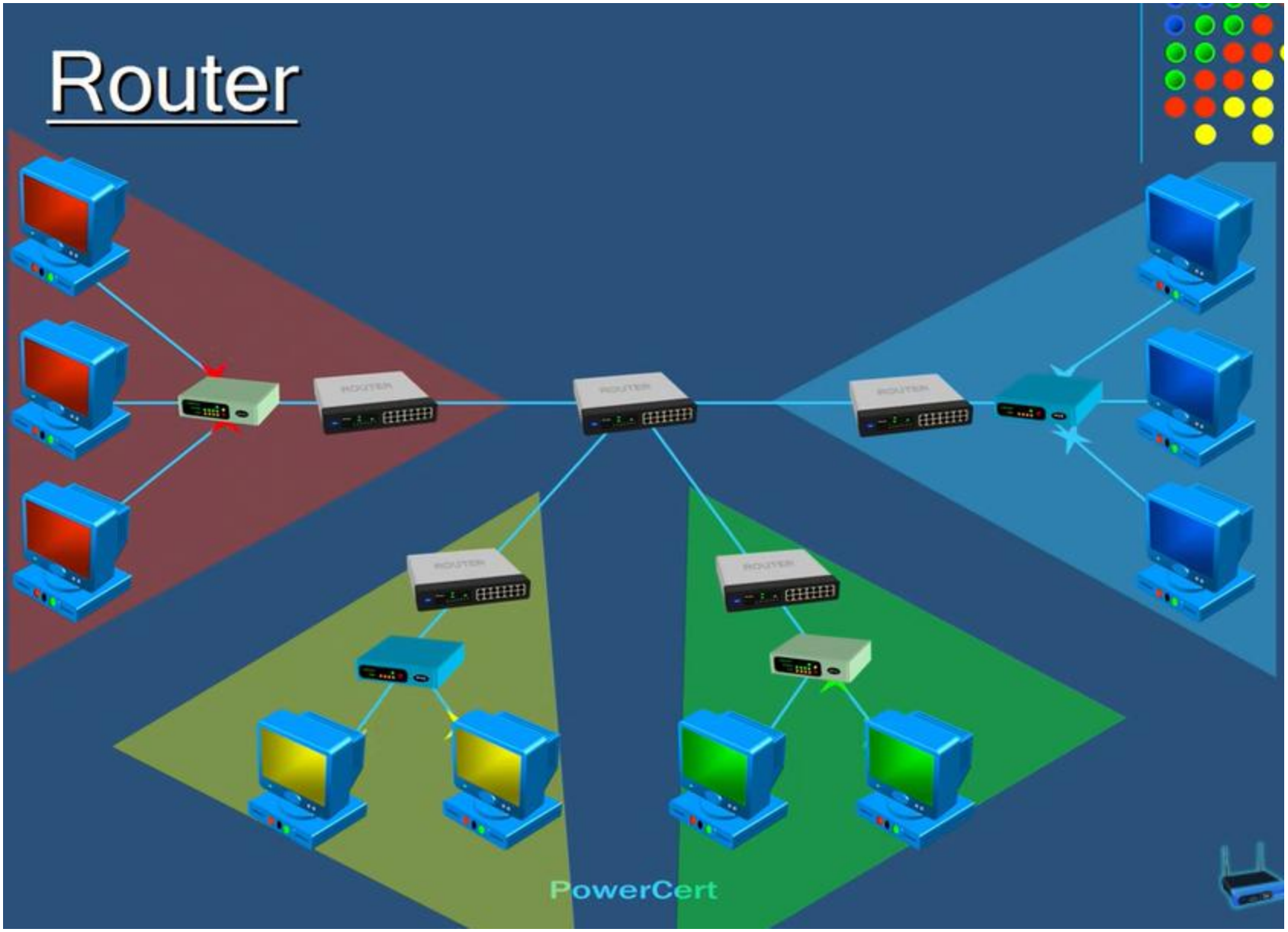
4.Router

- Router works on Network layer(Layer 3)
- It work based on IP address
- It helps in finding route ,best path in Networks
- 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 each other

Two types of routers –

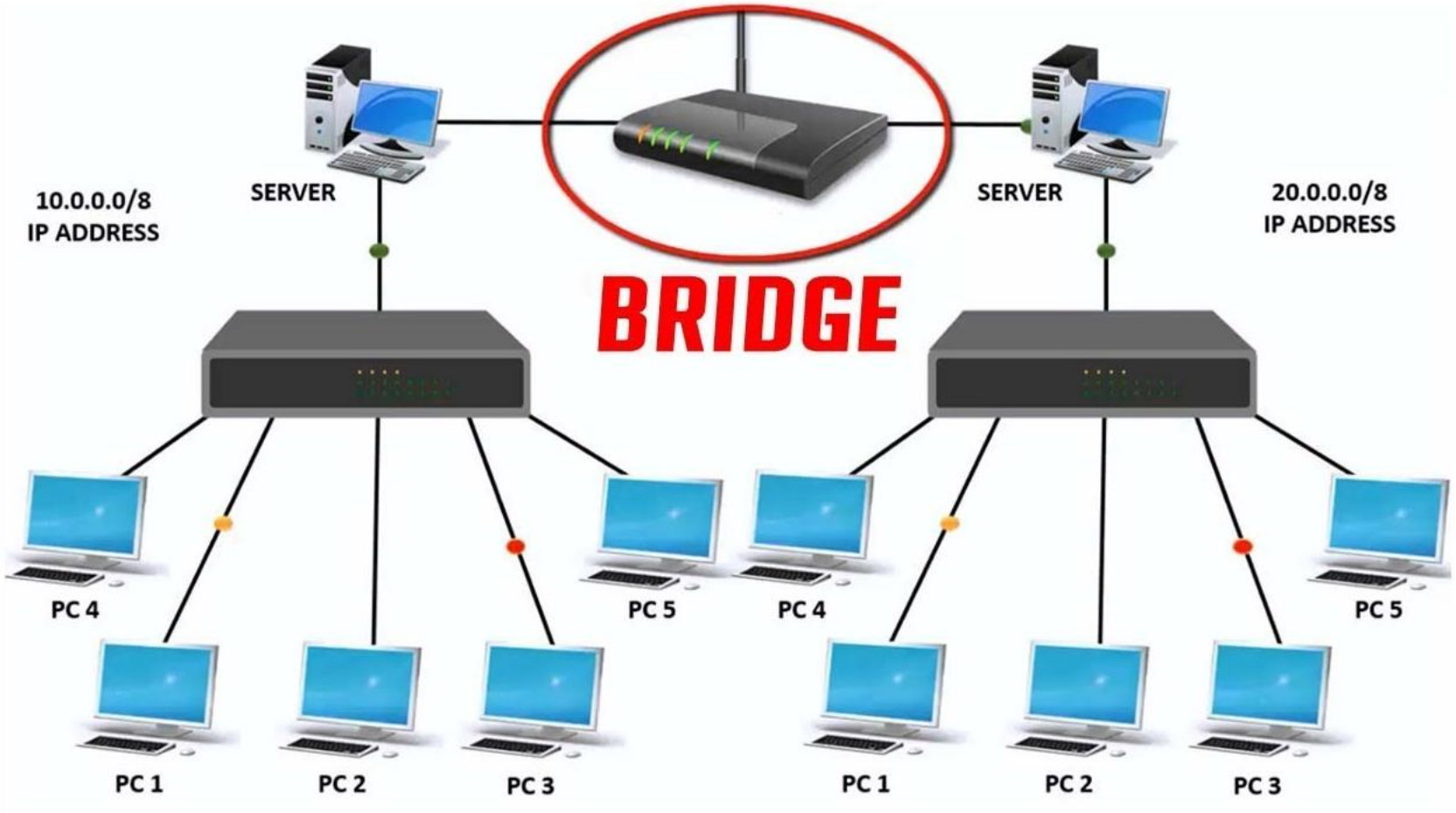
- **Static routers** – Static routers are configured manually and route data packets based on the information in a router table.
- **Dynamic routers** – Dynamic routers use adaptive routing which is a process where a router can forward data by a different route.



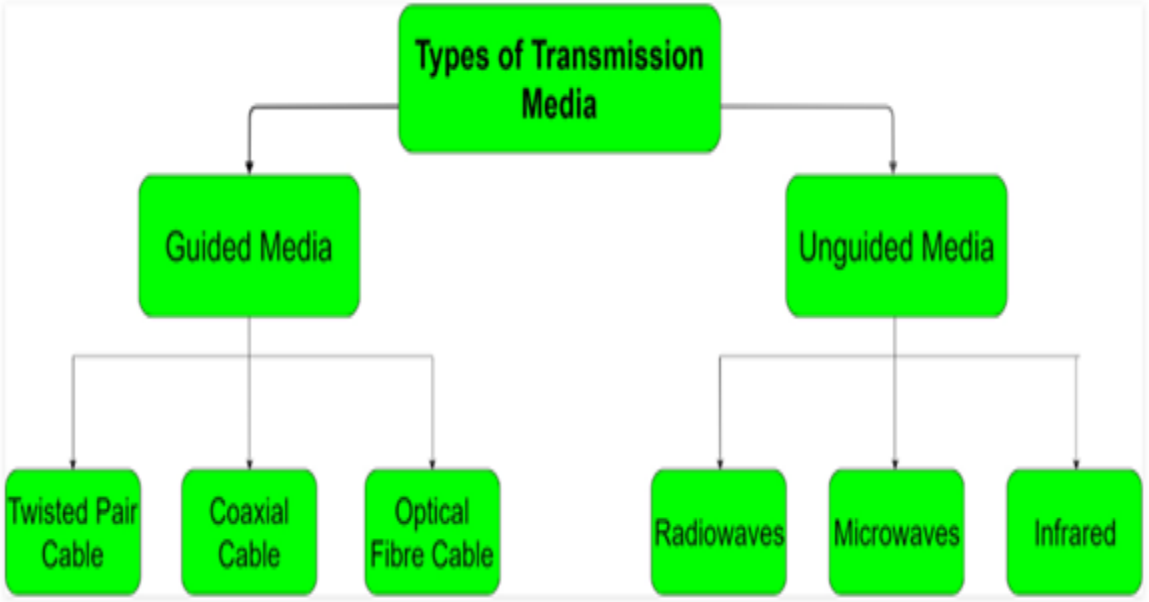

Router
PowerCert

5. Bridge

- Bridge connect 2 segments of same network
- Bridge works on same principle of switch(Layer 2 , MAC table)
- Bridges are used when hub is used in LAN
- HUB have higher no of collision when more devices are the in network
- To avoid the no of collision in network connected using hub
- Network is divided into smaller segments connected using bridge


10.0.0.0/8
IP ADDRESS
SERVER
BRIDGE
SERVER
20.0.0.0/8
IP ADDRESS
PC 4
PC 5
PC 1
PC 2
PC 3
PC 4
PC 5
PC 1
PC 2
PC 3

2.2 Transmission Media



- A transmission medium can be broadly defined as anything that can **carry information** from a **source** to **destination**
- Transmission medium is usually **free space, metallic cable, or fibber-optic cable**
- Information :- Signal that is the result of a conversion of data from another form

Guided Media

• Also called Bounded media/ Wired Media

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

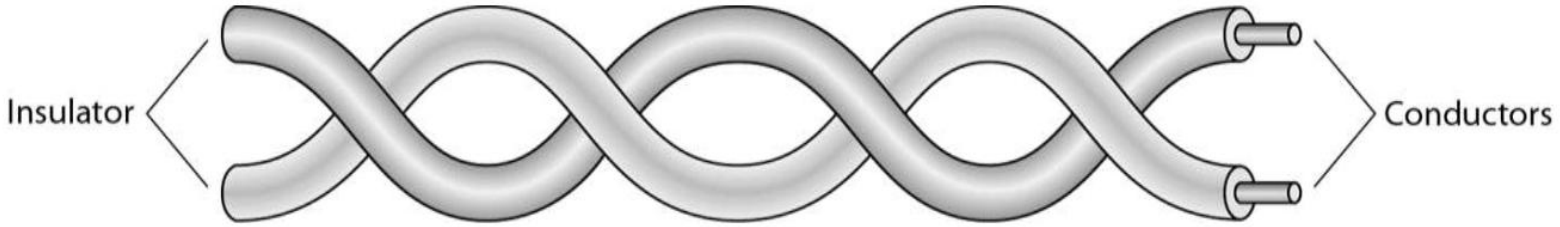
1. **Twisted-pair cable**
2. **Coaxial cable**
3. **Fibber-optic cable**

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

• Twisted-pair and coaxial cable -- Metallic (copper) conductors -- **signals in the form of electric current**

• Optical fibber -- **transports signals in the form of light**

1. Twisted Pair



- The wires are twisted together in a helical form.

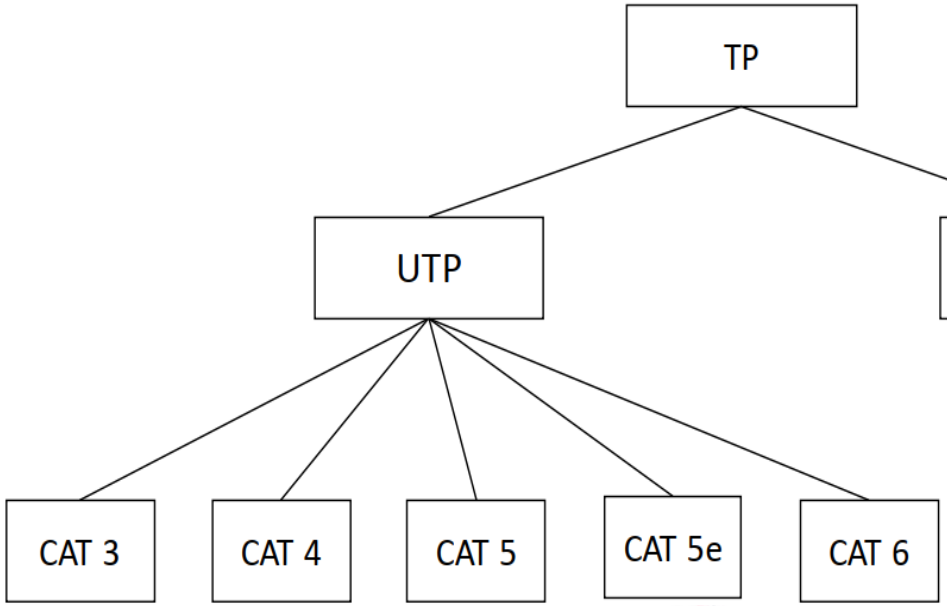
  • A twisted pair consists of two insulated copper wires twisted together regular spiral pattern

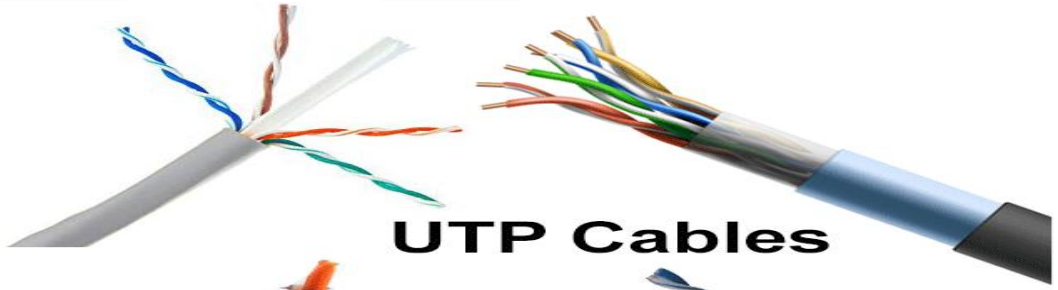
  • Twisting tends to decrease the crosstalk

  • Crosstalk is the interference due to the magnetic filed of 2 wires nearby

  • Used to transmit both analog and digital transmission

- Twisted pair is limited in distance, bandwidth, and data rate.
- The attenuation for twisted pair is a very strong function of frequency

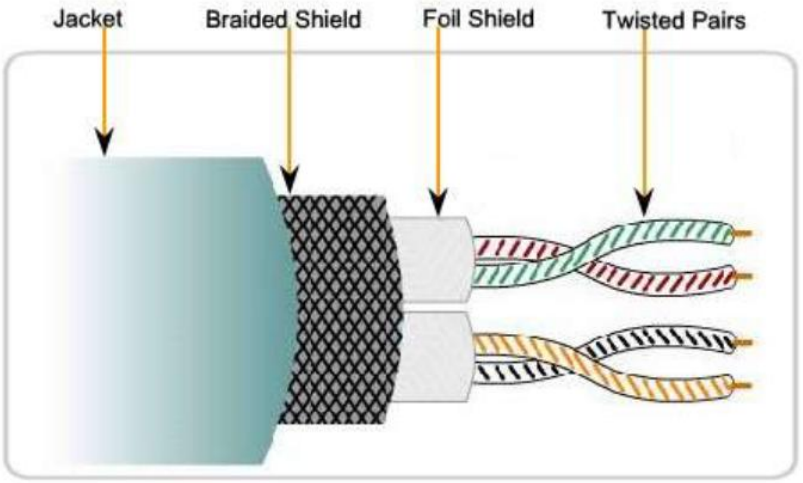




Shielded Twisted Pair(STP)

- STP uses two or more pairs of wires that are wrapped in an overall metallic braid or foil.
- Shields the entire bundle of wires within the cable as well as the individual wire pairs
- Provides better noise protection
- Higher price

Figure STP Cable



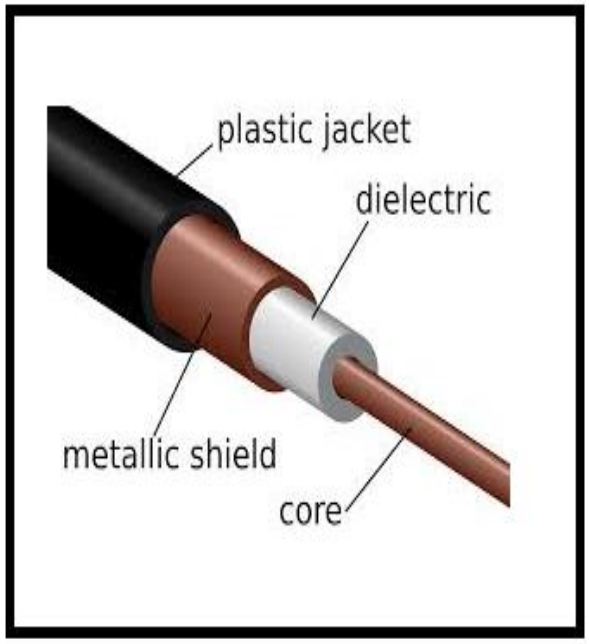
- More expensive
- Easiest to install
- Harder to handle (thick, heavy)
- Data Rate : 10- 100 Mbps
- Max Cable Length – 100M

Unshielded Twisted Pair(UTP)

- Flexible and cheap cable.
- Category rating based on number of twists per inch and the material used
- CAT 3, CAT 4, CAT 5, Enhanced CAT 5 and now CAT 6.

2. Coaxial Cables

- The coaxial cables have a central copper conductor, surrounded by an insulating layer, a conducting shield, and the outermost plastic sheath.
- Thus, there are three insulation layers for the inner copper cable.
- There are two basic modes of data transmission in coaxial cables: baseband mode that has dedicated bandwidth, and broadband mode that has distributed cable bandwidth.

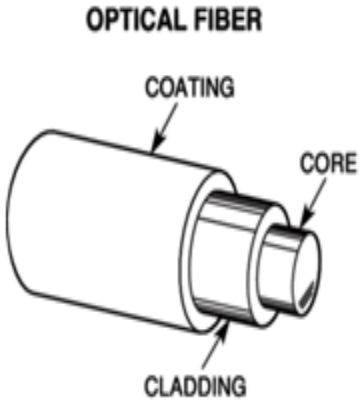


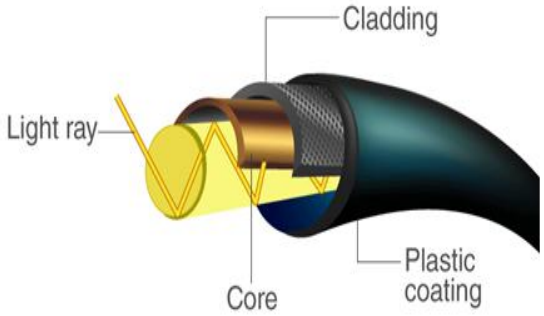
Characteristics

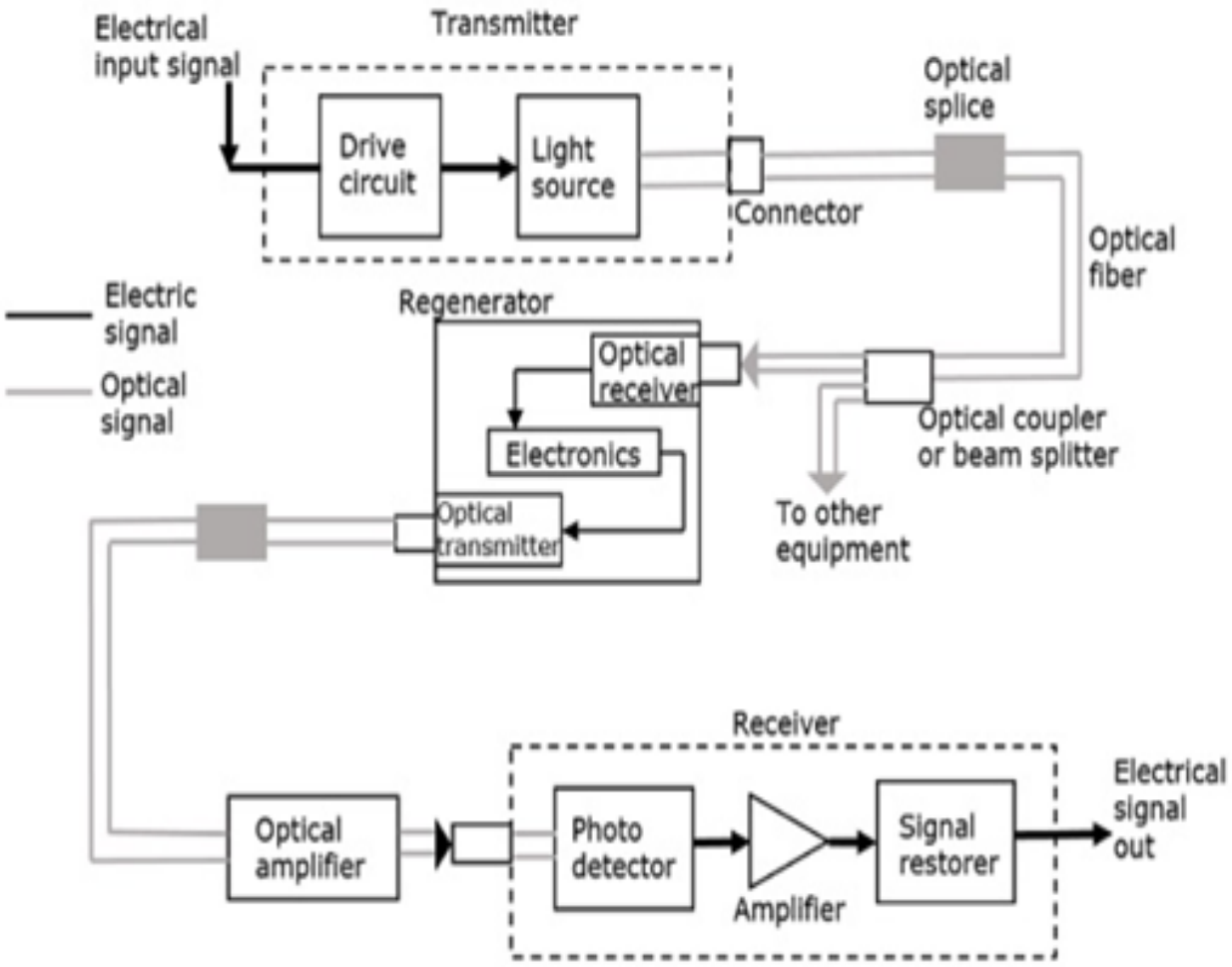
- It is comparatively inexpensive
- Its installation us comparatively simple
- It must be grounded properly in a network connection
- Its bandwidth capacity is around 10 Mbps
- It suffers from data attenuation

3. Optical Fibers

Optical fibers use light waves for transmission. Crosstalk, EMI, and attenuation aren't issues with optical fibers.







Block Diagram of Optical Fibre Communication

Advantages of Optical Fiber

1. The transmission bandwidth of the fiber optic cables is higher than the metal cables
2. The power loss is very low and hence helpful in long-distance transmissions.
3. Fiber optic cables provide high security and cannot be tapped.
4. Fiber optic cables are immune to electromagnetic interference.
5. These are not affected by electrical noise
6. The capacity of these cables is much higher than copper wire cables.
7. Though the capacity is higher, the size of the cable doesn't increase like it does in copper wire cabling system.
8. The space occupied by these cables is much less.
9. The weight of these FOC cables is much lighter than the copper ones.
10. Since these cables are di-electric, no spark hazards are present.
11. These cables are more corrosion resistant than copper cables, as they are bent easily and are flexible.
12. The raw material for the manufacture of fiber optic cables is glass, which is cheaper than copper Fiber optic cables last longer than copper cables

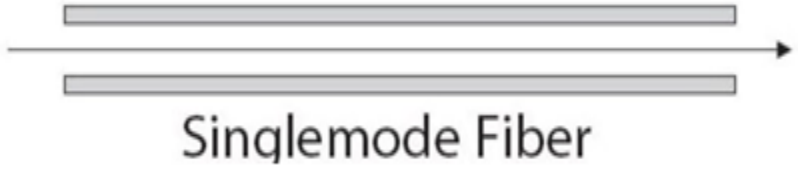
Applications of Fiber Optics

The optical fibers have many applications. Some of them are as follows –

- Used in telephone systems
- Used in sub-marine cable networks
- Used in data link for computer networks, CATV Systems
- Used in CCTV surveillance cameras
- Used for connecting fire, police, and other emergency services.
- Used in hospitals, schools, and traffic management systems.
- They have many industrial uses and also used for in heavy duty constructions.

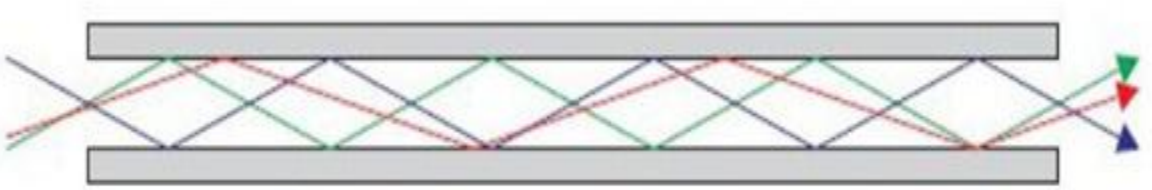
1. Single Mode Optical fiber

- As the name suggests, this type of optical fiber transmits only one mode of light. To put it another way, it can carry only one wavelength of light across its length.
- This wavelength is usually 1310nm or 1550nm.



- These cables can carry only one mode, physically, by having a tiny core. That is to say that the diameter of the core is essentially of the same order as the wavelength of the light passing through it.
- Only lasers are used as a light source. To point out, the lights used in single-mode fibers are not in the visible spectrum.
- Since the light travels in a straight direction, there are fewer losses, and it can be used in applications requiring longer distance connections.
- A distinct disadvantage of single-mode fiber is that they are hard to couple.

2. Multimode



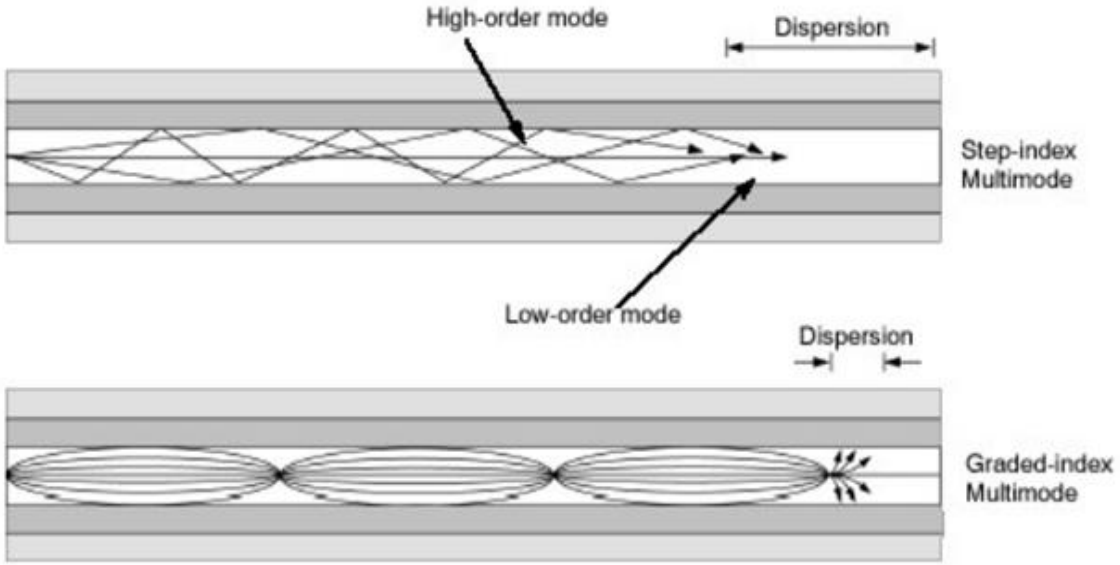
· As the name implies, these types of optical fibers allow multiple modes of light to travel along their axis.

· To explain physically, they can do this by having a thicker core diameter.

· The wavelengths of light waves in multimode fibers are in the visible spectrum ranging from 850 to 1300 nm.

· The reflection of the waves inside the multimode fiber occurs at different angles for every mode. Consequently, based on these angles, the *number* of reflections can vary.

- Since the basis of optical fiber, communication is a total internal reflection, all modes with incident angles that do not cause total internal reflection get absorbed by the cladding. As a result, losses are created.
- We can have higher-order modes, waves that are highly transverse to the axis of the waveguide can reflect many times. In fact, due to increased reflections at unusual angles, higher-order modes can get completely lost inside the cable.



Step index multimode fiber

In step index fiber, the refractive index suddenly changes at the interphase between core and cladding. The refractive index of the core is slightly greater than that of cladding thus confining the light to the core by the principle of total internal refraction,

Graded index multimode fiber

In graded index multimode fiber, the refractive index changes gradually from the core to the cladding. These fibers collect light better than small core single mode fibers and have broader bandwidth than step index multimode fiber.

TABLE 3.3 Typical fiber characteristics [STER93].

Fiber type	Core diameter (μm)	Cladding diameter (μm)	Attenuation (dB/km) (Max) 850 nm	1300 nm	1500 nm	Bandwidth (MHz/km) (Max)
Single Mode	5.0	85 or 125	2.3			5000 @ 850 nm
	8.1	125		0.5	0.25	
Graded-index	50	125	2.4	0.6	0.5	600 @ 850 nm 1500 @ 1300 nm
	62.5	125	3.0	0.7	0.3	200 @ 850 nm 1000 @ 1300 nm
	100	140	3.5	1.5	0.9	300 @ 850 nm 500 @ 1300 nm
Step-index	200 or 300	380 or 440	6.0			6

Characteristics	Twisted Pair Cables	Coaxial Cables	Fiber Optic Cables
Bandwidth	10– 100 Mbps	10 Mbps	100 Mbps - 1 Gbps
Maximum cable segment	100 meters	200 – 500 meters	2 k.m. – 100 k.m.
Interference rating	Poor	Better than twisted pair wires	Very good as compared to any other cable
Installation cost	Cheap	Costly than twisted pair wires	Most costly to install
Security	Low	Low	High

Unbounded Media(Wireless Media)

- Very useful in difficult terrain where cable laying is not possible
- Provides mobility to communication nodes
- Right of way and cable laying costs can be reduced
- Antenna radiates electromagnetic energy into the medium(air)
- Antenna picks up electromagnetic waves from the surrounding
medium

Disadvantages

- Susceptible to rain, atmospheric variations

- Objects in transmission path will reduce the signal strength

Advantages

- Greater Bandwidth
- Low Power Loss
- Less Interference
- Scalable Size
- Safety
- Security
- Flexibility

Frequency Bands

Band	Range	Propagation	Application
VLF	3–30 KHz	Ground	Long-range radio navigation
LF	30–300 KHz	Ground	Radio beacons and navigational locators
MF	300 KHz–3 MHz	Sky	AM radio
HF	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF	3–30 GHz	Line-of-sight	Satellite communication
EHF	30–300 GHz	Line-of-sight	Long-range radio navigation

Wireless Technology

wireless technology	transmission distance
Bluetooth	33 feet (10 meters)
WLAN 802.11a	300 feet (90 meters)
WLAN 802.11b	375 feet (112 meters)
Satellite	Worldwide
Fixed broadband	35 miles (56 kilometers)
WAP (cell phones)	Nationwide

Transmission

- Radio Waves 3 KHz to 1 GHz
- Micro Waves 1 GHz to 300 GHz
- Infrared 300 GHz to 400 THz

Infra Red

- Infrared signals have frequencies between 300 GHz to 400 THz.

- They are used for short-range communication.

- Infrared signals have high frequencies and cannot penetrate walls.

- Line of Sight is needed.

- Infrared is used in devices such as the mouse, wireless keyboard and printers.

- Due to its short-range communication system, the use of an infrared communication system in ONE ROOM will not be affected by the use of another system in the next room

Radio Waves

- Radio waves are normally Omni directional.

- When an antenna transmits radio waves, they are propagated in all directions

- Sending and receiving antennas do not have to be aligned.

- The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers.

- Our AM and FM radio stations, cordless phones and televisions are examples of multicasting.

- Bluetooth ,Wi-Fi, GSM, CDMA

Bluetooth

- Bluetooth is a wireless technology standard for exchanging data over short distances

- Using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz

- Used from fixed and mobile devices, and building personal area networks (PANs)

- It can connect several devices, overcoming problems of synchronization

- Physical range :Typically less than 10 m, upto 100 m

Wi-Fi (Wireless LAN)

• Wi – Fi (Wireless Fidelity) is a standard that certifies that wireless
devices (Wireless LAN) can work together.

• Supports IEEE802.11b or IEEE802.11g or IEEE802.11b/g standard

• Wi - Fi high-speed wireless Internet technology is commonly used in the world.

• Uses radio signals to transmit high speed data over the wireless network with the installation of the Access Pc
device, Such as mobile phones, PDAs and note

• Range appx 100M

• Mainly uses 2.4GHz radio waves

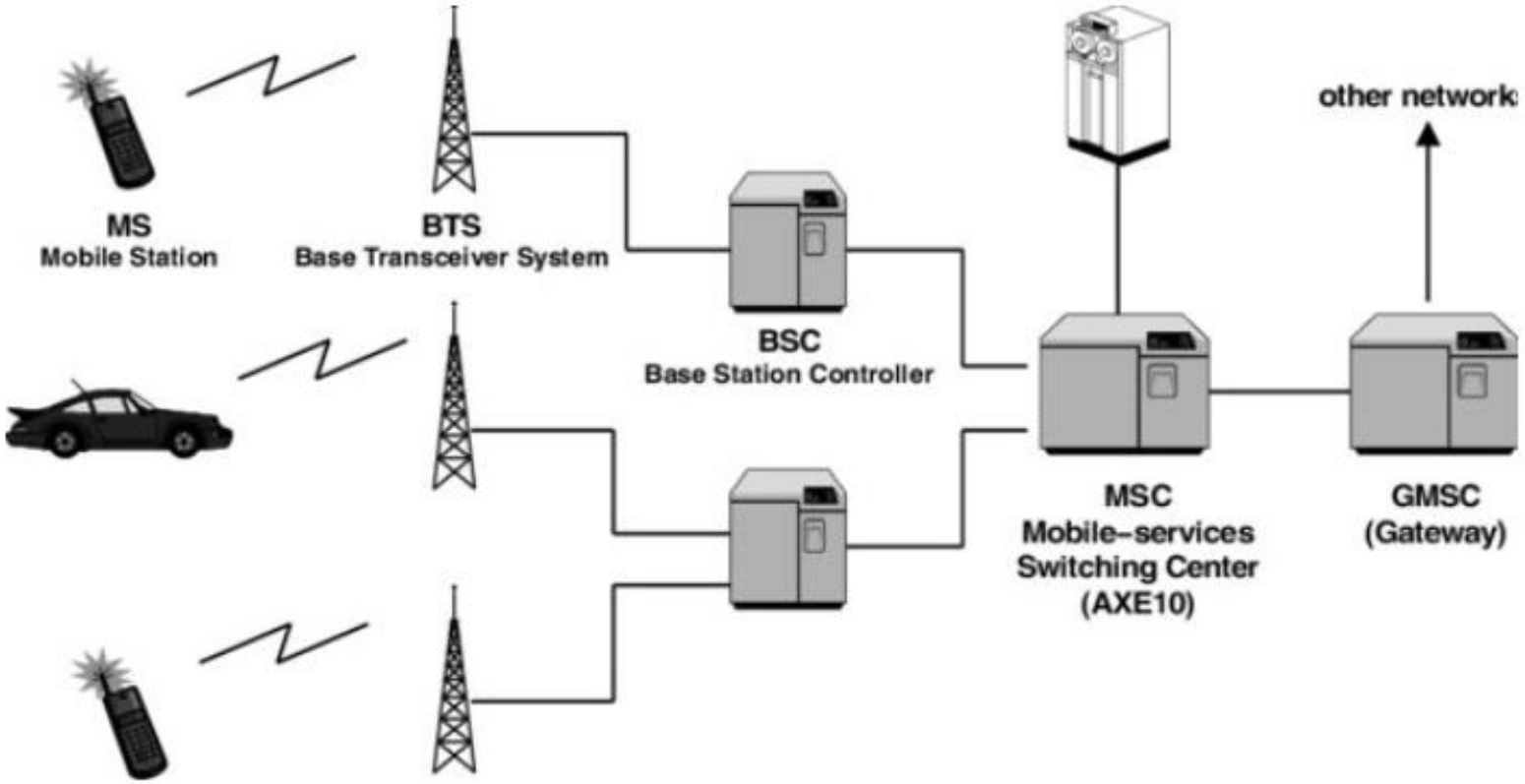
GSM

• GSM (Global System for Mobile Communications, originally **Group Special M**obile)

• Standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks

• GSM networks operate in a number of different carrier frequency ranges (separated into GSM frequency ranges for 2G and UMTS frequency bands for 3G),

• Most 2G GSM networks operating in the 900 MHz or 1800 MHz bands


MS
Mobile Station
BTS
Base Transceiver System
BSC
Base Station Controller
MSC
Mobile-services
Switching Center
(AXE10)
GMSC
(Gateway)
other network

Micro Waves

- Electronic waves with frequencies between 1 GHz to 300 GHz are normally called microwaves.

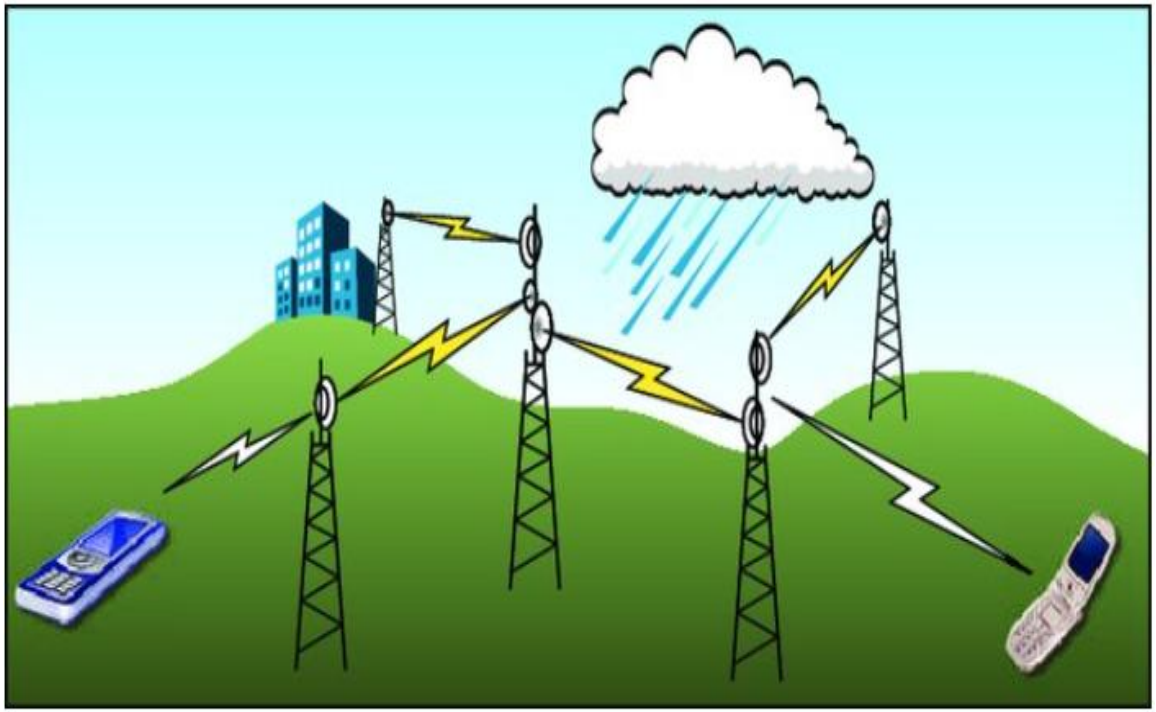
- Microwaves are unidirectional, in which the sending and receiving antennas need to be aligned.

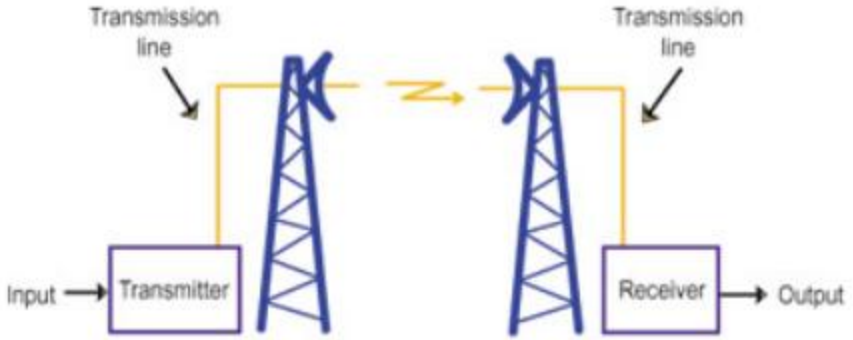
- Microwaves propagation is line-of-sight therefore towers with mounted antennas need to be in direct sight of each other

.

- Due to the unidirectional property of microwaves, a pair of antennas can be placed aligned together without interfering with another pair of antennas using the same frequency.

- High-frequency microwaves cannot penetrate walls. This is why receiving antennas cannot be placed inside buildings.




Transmission line
Transmission line
Input
Transmitter
Receiver
Output

Satellite Communication

• Because **microwave** restrictions on the landscape that affect obscure wave, satellite is introduced

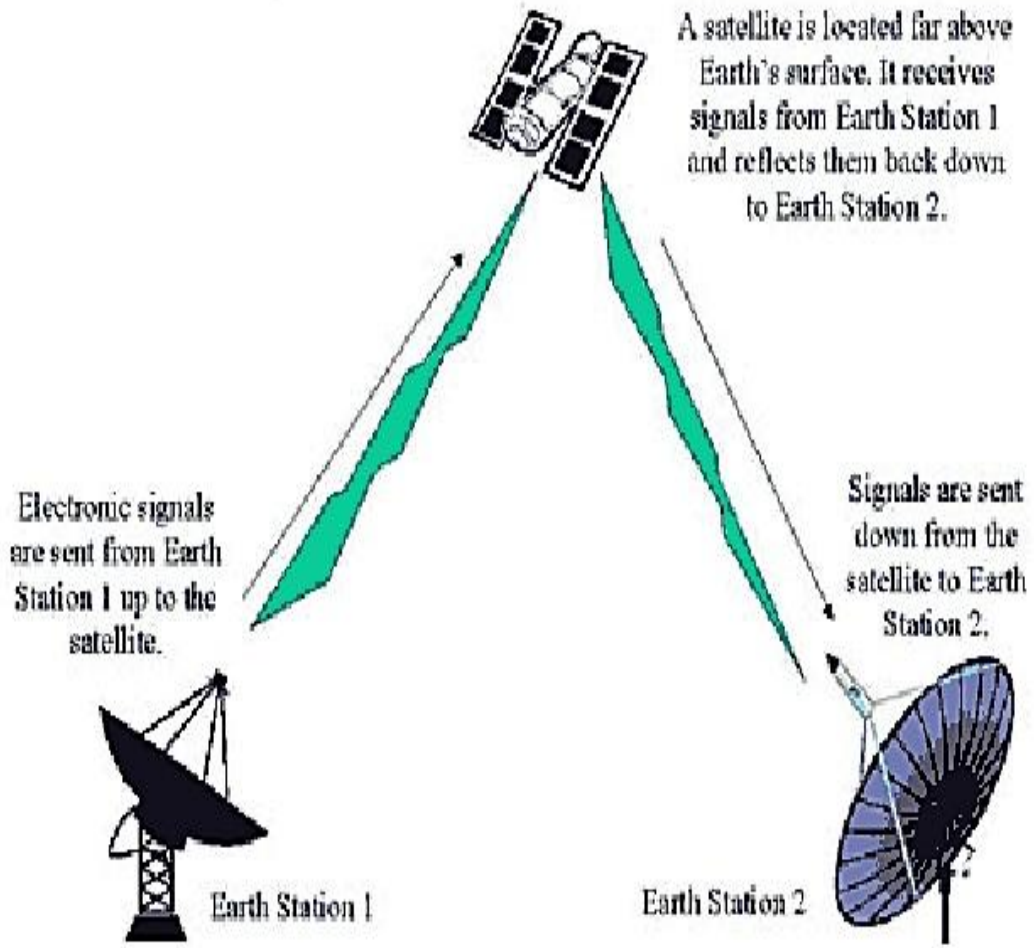
• A communication satellite is, In fact, Satellite is a microwave station.

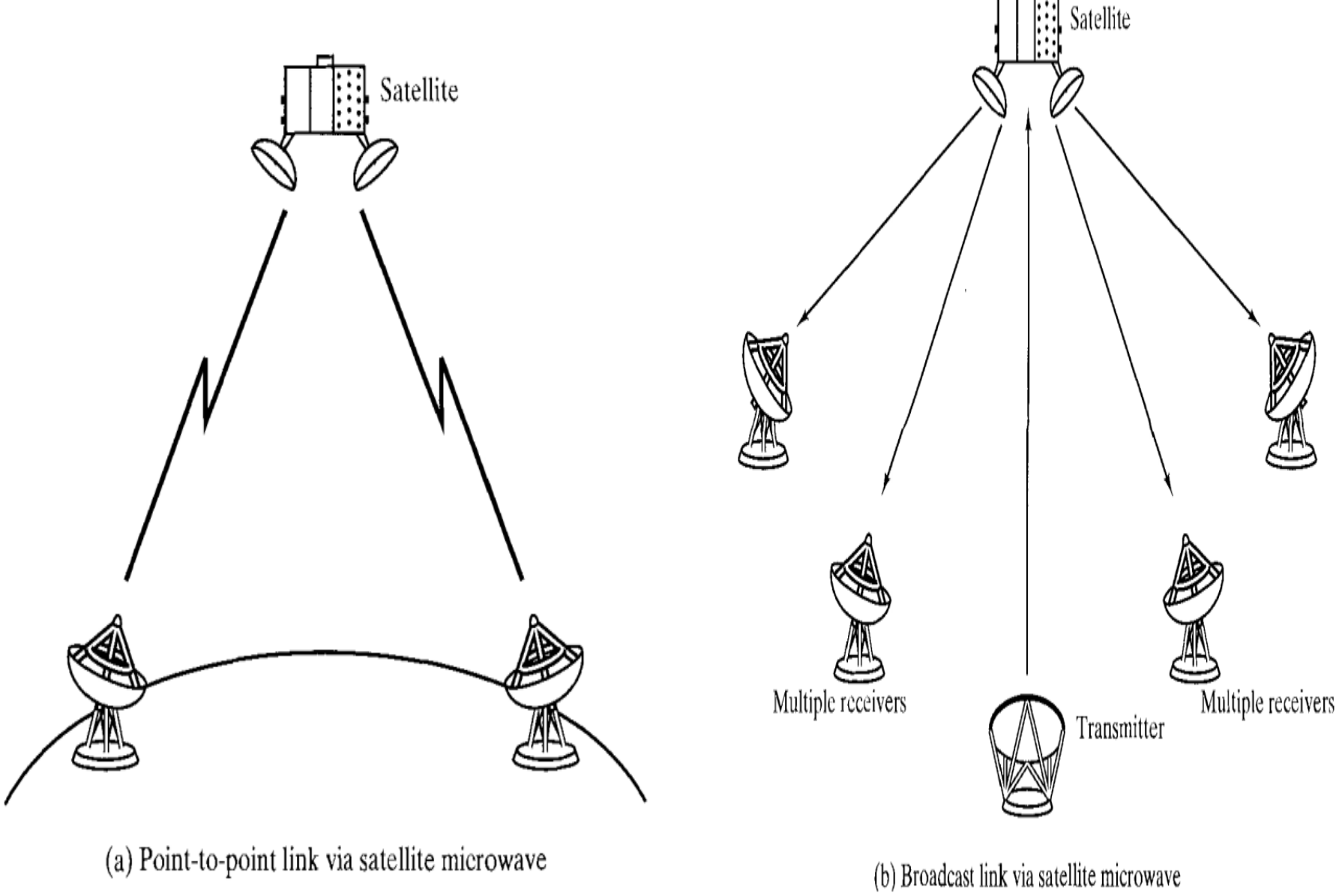
• It is used to link two or more ground-based microwave transmitter /receivers, known as earth stations, or ground stations

• Implementing such satellite to orbit above the Earth's surface, only three satellites, it can be cover to communicate to all the world

• The satellite receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink)

What is the path of the satellite signal?





(a) Point-to-point link via satellite microwave

(b) Broadcast link via satellite microwave

Satellite communications configurations.

Switching Technologies

• Switching is process to forward packets coming in from one node to a another leading towards the destination

• Communication system may include number of switches and nodes.

• At broad level, switching can be divided into two major categories:

1. **Connection Oriented:** Pre-establish circuit along the path between both endpoints eg. **Circuit switching**
2. **Connectionless:** No previous handshaking is required and acknowledgements are optional.eg. **Message switching,Packet switching**

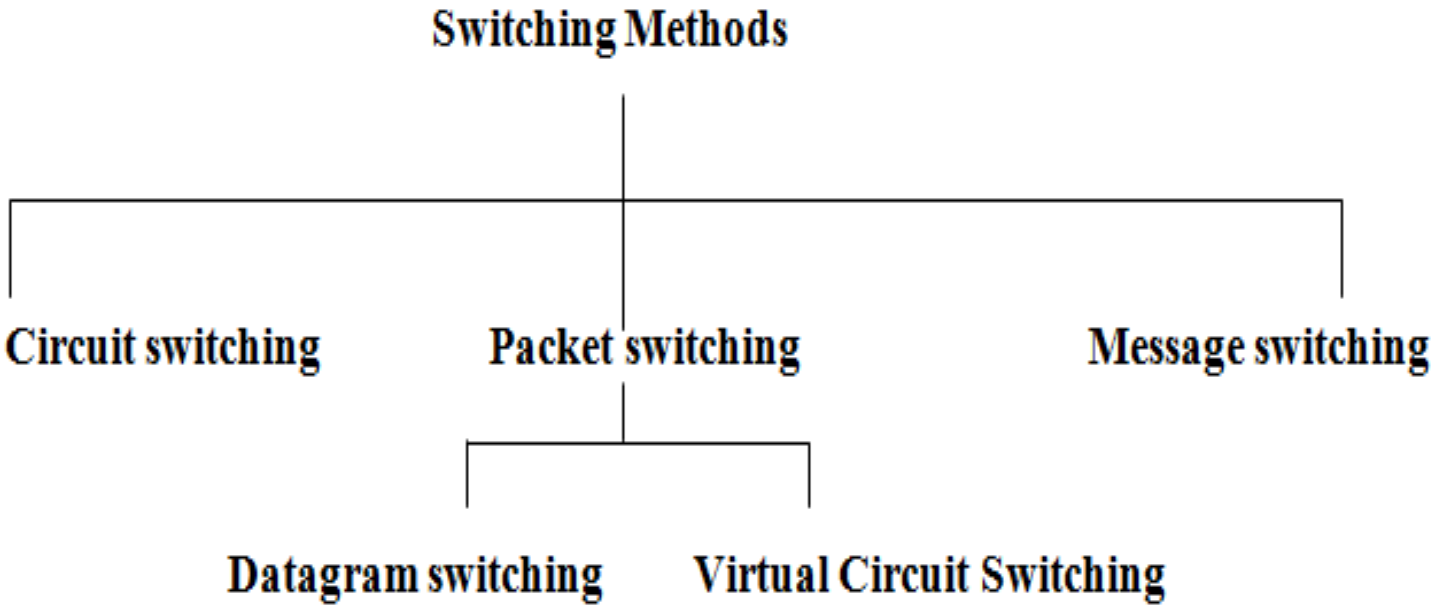


Fig- Types of switching methods

1. Circuit Switching

- Circuit- Switching is the real time connection oriented system
- In circuit switching a dedicated channel (circuit) Is set up for a single connection between the sender and recipient during the communication session.
- In telephone communication system, the normal voice call is the example of circuit switching(i.e. unbroken link)
- Circuit switching is pass through three phases, that are circuit establishment, data transfer and circuit disconnect.

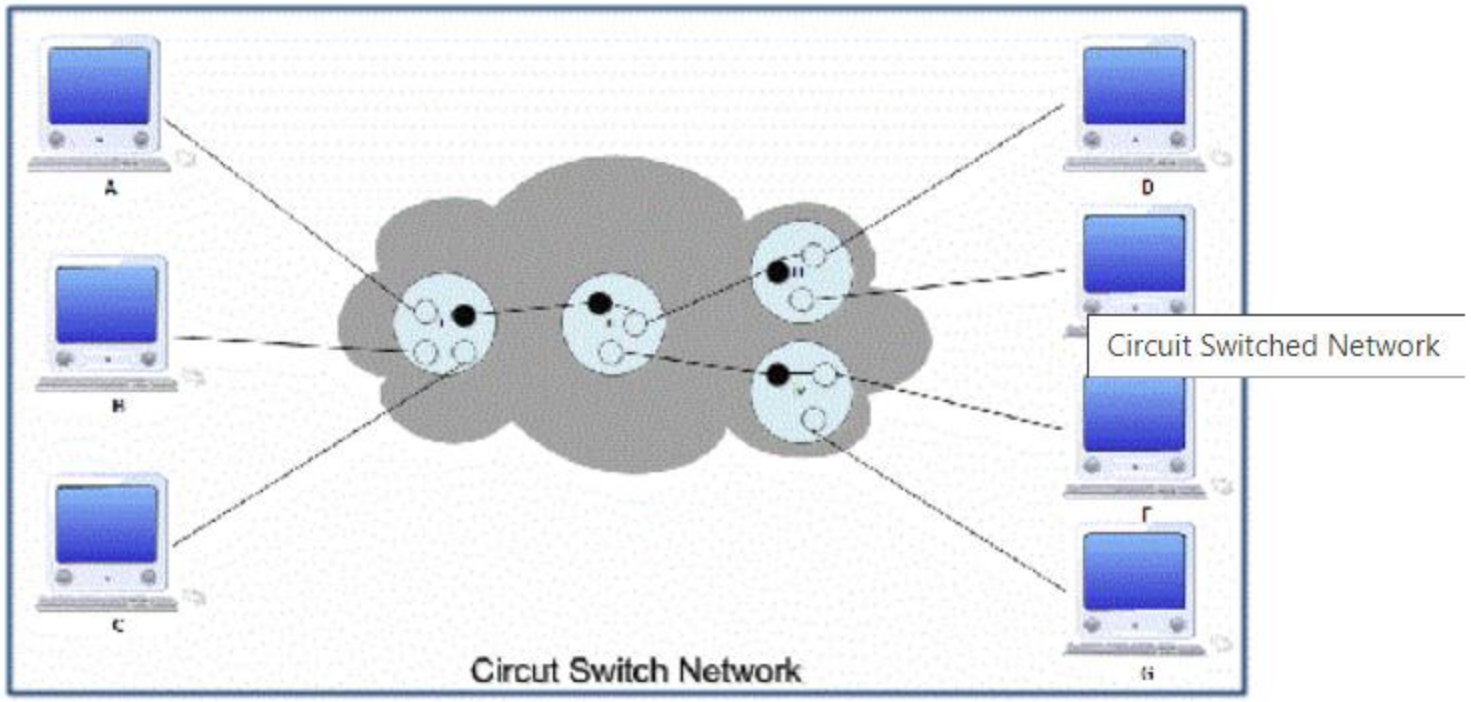


Figure shows a circuit switched network in which computer A, B and C are connected to computer D, E, F and G via four switches. If these computers are to be connected with a point-to-point connections, 12 dedicated lines are required which will incur high line cost.

2.Message Switching

- Message Switching was a technique developed as an alternate to circuit switching, before packet switching was introduced.

- In message switching, end users communicate by sending and receiving messages that included the entire data to be shared.

- Two Characteristics
  - Store and forward
  - Message delivery

1. **Store and forward:**

- Intermediate nodes have the responsibility of transferring the entire message to the next node.
- Hence each node must have storage capacity
- A message will only be delivered if the next hop and the link connecting it are both available, otherwise it will be stored indefinitely

2. **Message delivery**

Each message must have a header that contains the message routing information, including the source and destination.

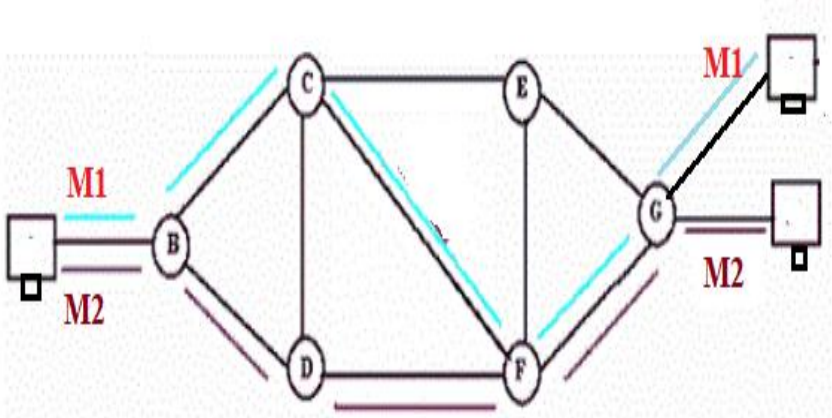
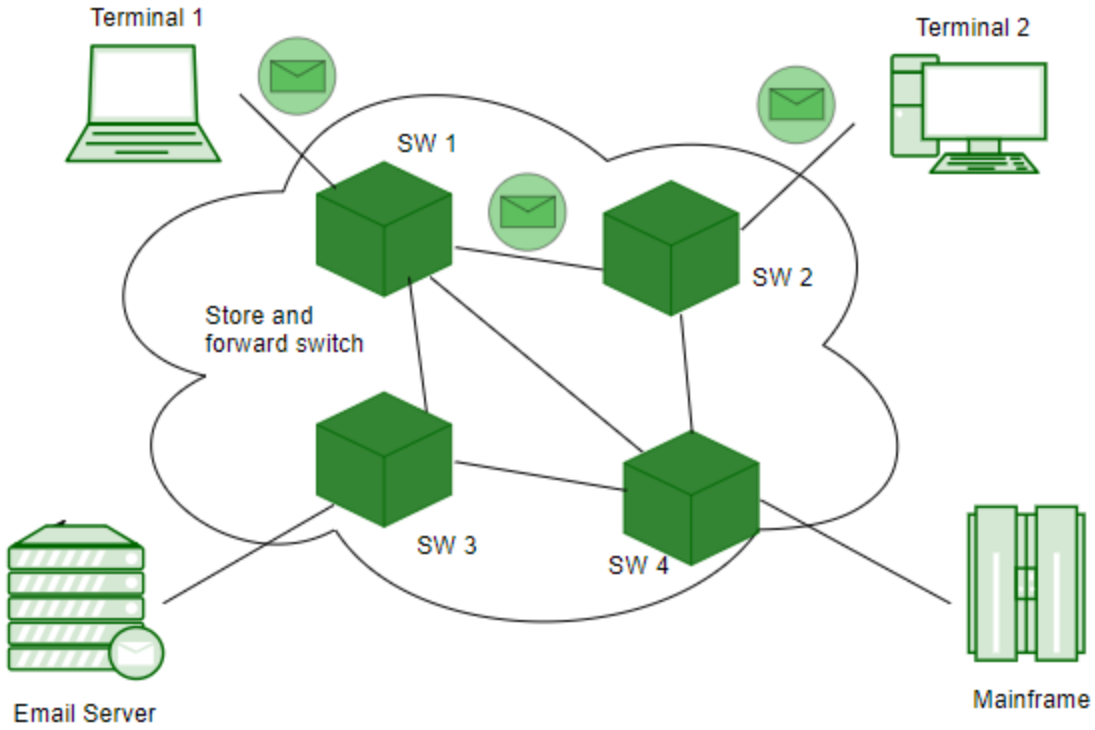


Fig- Message Switching



- **Advantages**

1. Channel efficiency can be greater compared to circuit-switched systems, because more devices are sharing the channel.
2. Traffic congestion can be reduced, because messages may be temporarily stored in route.
3. Message priorities can be established due to store-and-forward technique.

- **Disadvantages**

1. Every switch in transit path needs enough storage to accommodate entire message
2. Because of store-and-forward technique and waits included until resources are available, message switching is very slow
3. Message switching was not a solution for streaming media and real time applications

3. Packet Switching

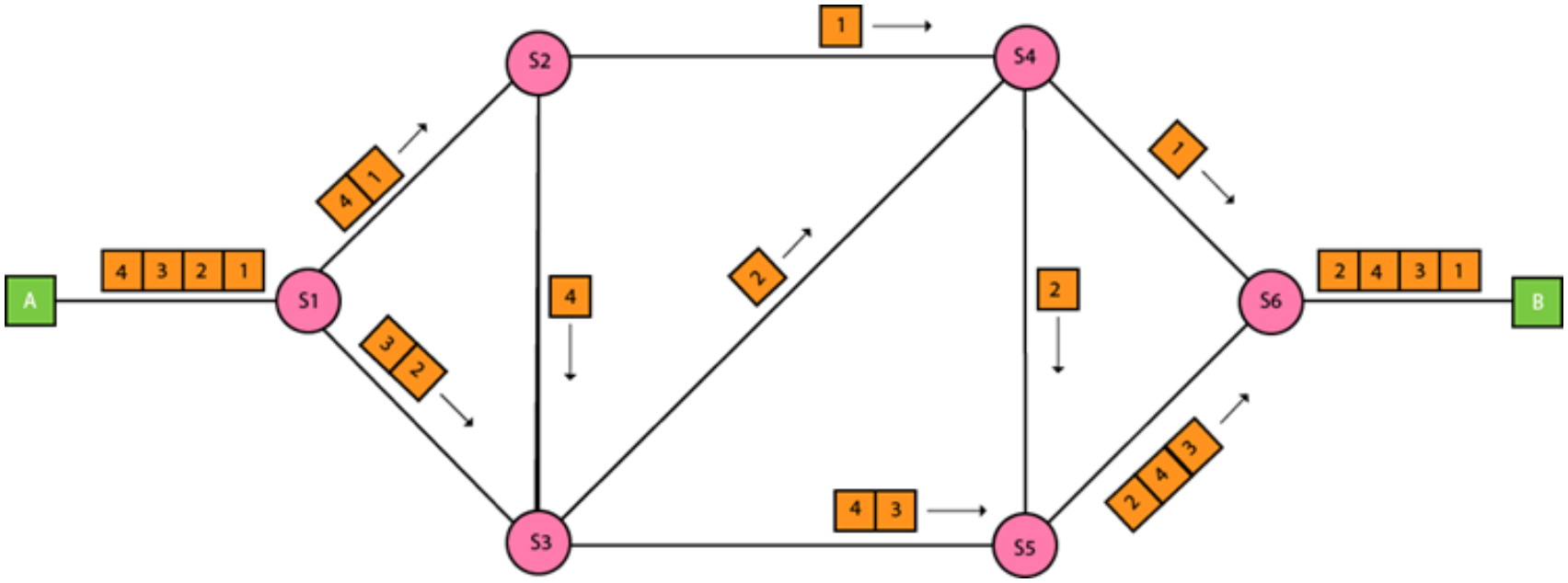
- The packet switching is a switching technique in which the message is sent in one go, but it is divided into smaller pieces, and they are sent individually.

- The message splits into smaller pieces known as packets and packets are given a unique number to identify their order at the receiving end.

- Every packet contains some information in its headers such as source address, destination address and sequence number.

- Packets will travel across the network, taking the shortest path as possible.

- All the packets are reassembled at the receiving end in correct order.
- If any packet is missing or corrupted, then the message will be sent to resend the message.
- If the correct order of the packets is reached, then the acknowledgment message will be sent.



Advantages:

- Packet switching is cost effective.
- Offers improved delay characteristics.
- Packet can be rerouted if any problem occurs.

Disadvantages:

- Packet switching protocols are typically more complex.
- If packet gets lost sender needs to resend the data.

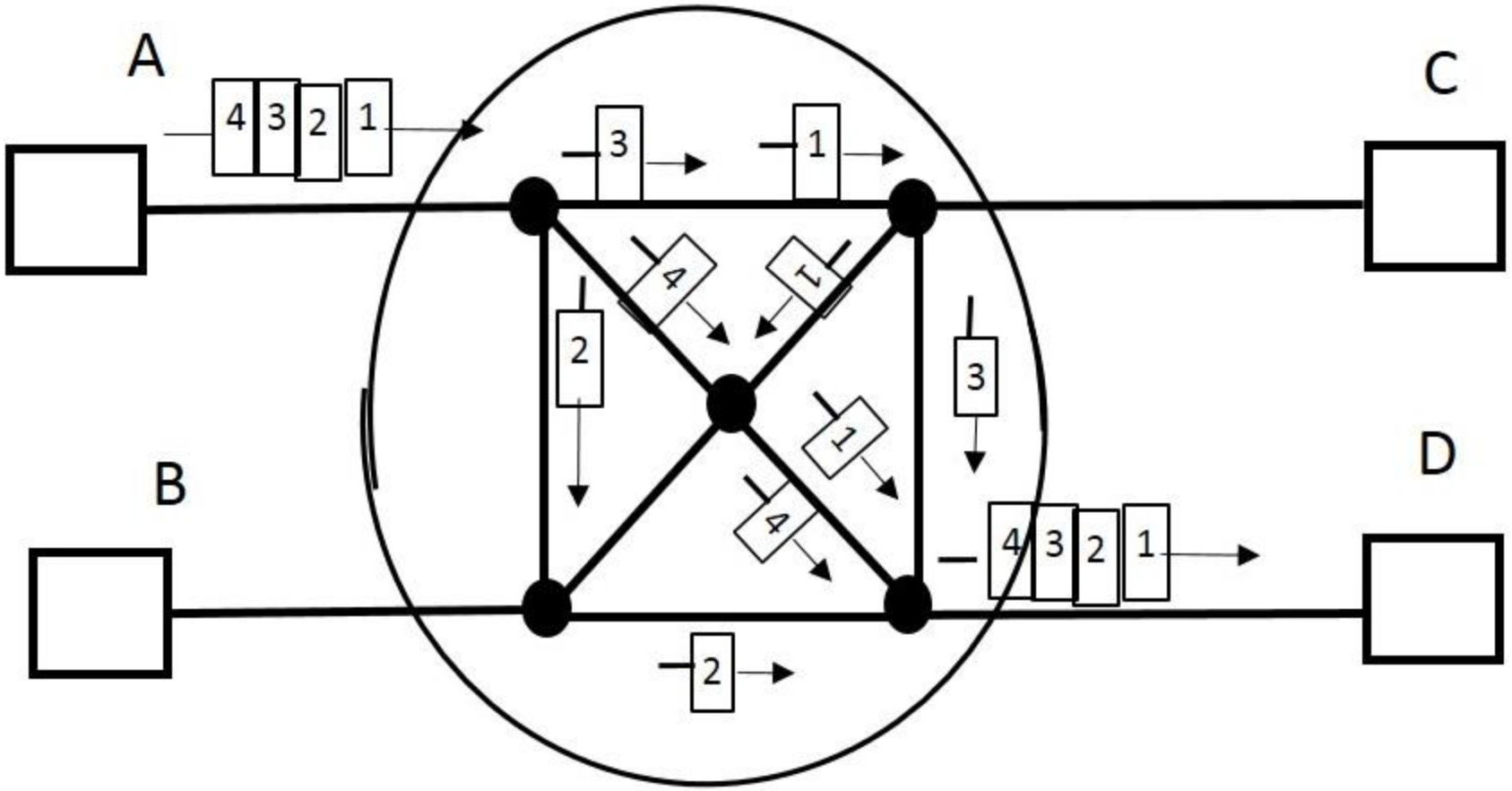
Circuit Switching	Packet Switching
Connection Oriented	Connection Less
Entire Message Have to follow same route during transmission	Entire Message can be divided and routed Independently
Implemented at Physical Layer	Implemented at Network Layer
Waste of bandwidth if Idle	No Waste of bandwidth if Idle
Initially designed for Voice Transmission	Initially designed for Data Transmission

Packet switching: Virtual

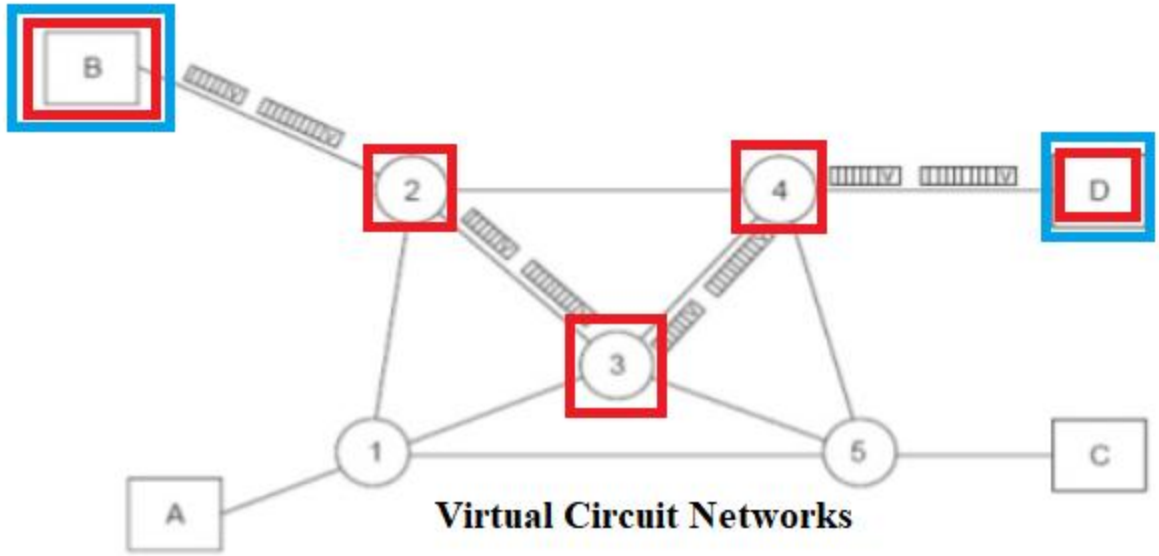
- In this type of switching a preplanned route is established before the packets are sent.
- Sender sends a **"call request packet"** to establish a logical connection and receiver sends back an acknowledgement packet **"packet accepted"**.
- It is a cross between circuit switching network and packet switching network.
- Used by the telephone calls, ATM (Asynchronous Transfer Mode).
- Demerit : - It takes link set up time
  -No dynamic switching in case of link failure

Packet switching: Datagram

- Datagram packet switching is a packet switching technology by which each packet is treated as a separate entity and are called as datagram.
- Packets have their own complete addressing information attached.
- Each packet follows different routes to reach the destination.
- So, the packets may arrive at different times, and may be in a disturbed order. In this case reordering is done.



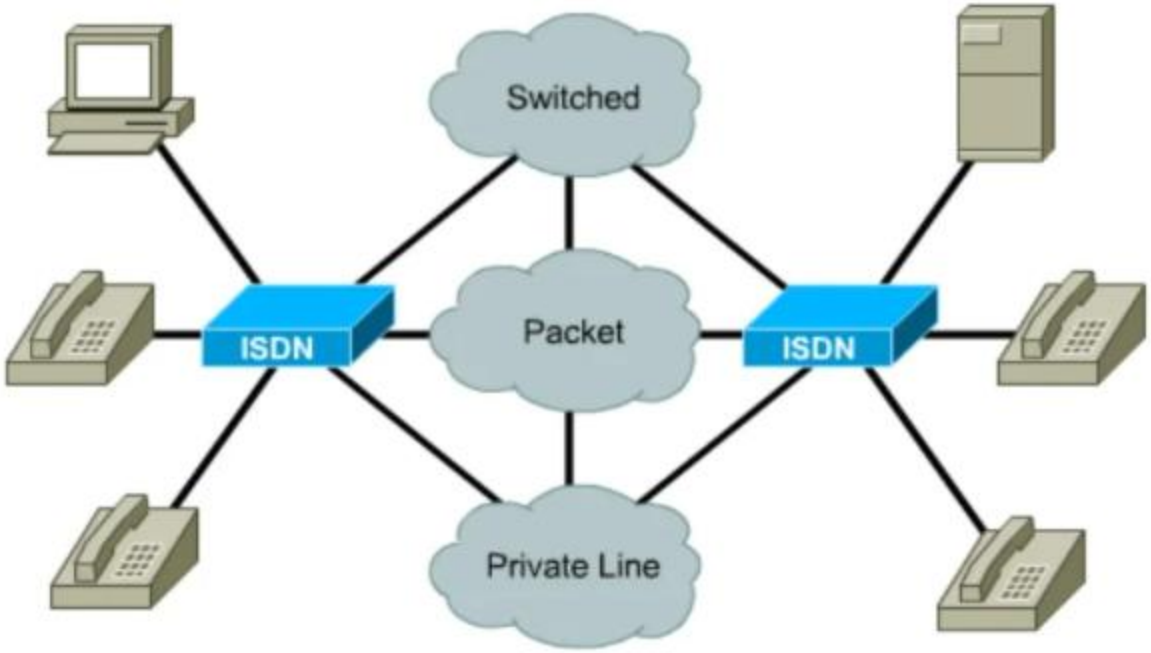
Datagram Networks



Virtual Circuit Networks

ISDN (Integrated Services Digital Network)

- The Public Switched Telephone network(PSTN) is still analogue from
- The need has arisen to extend the digital network out to subscribers and to provide a single standardized interface to all different users of public networks
- Integrated -> Both transmission and Switching
- Telephone services -> Telecommunication services
- Used for voice, image and data
- In Practice there are multiple networks providing the service nationally , user however sees a single network



ISDN CHANNELS

The Digital pipe is made up of channels - one of three types

1. B channel
2. D channel
3. H channel

Channels are grouped and offered as a package(Interfaces) to users

ASSIGNMENT

Thank You