

# Chapter 3

## Physical Layer

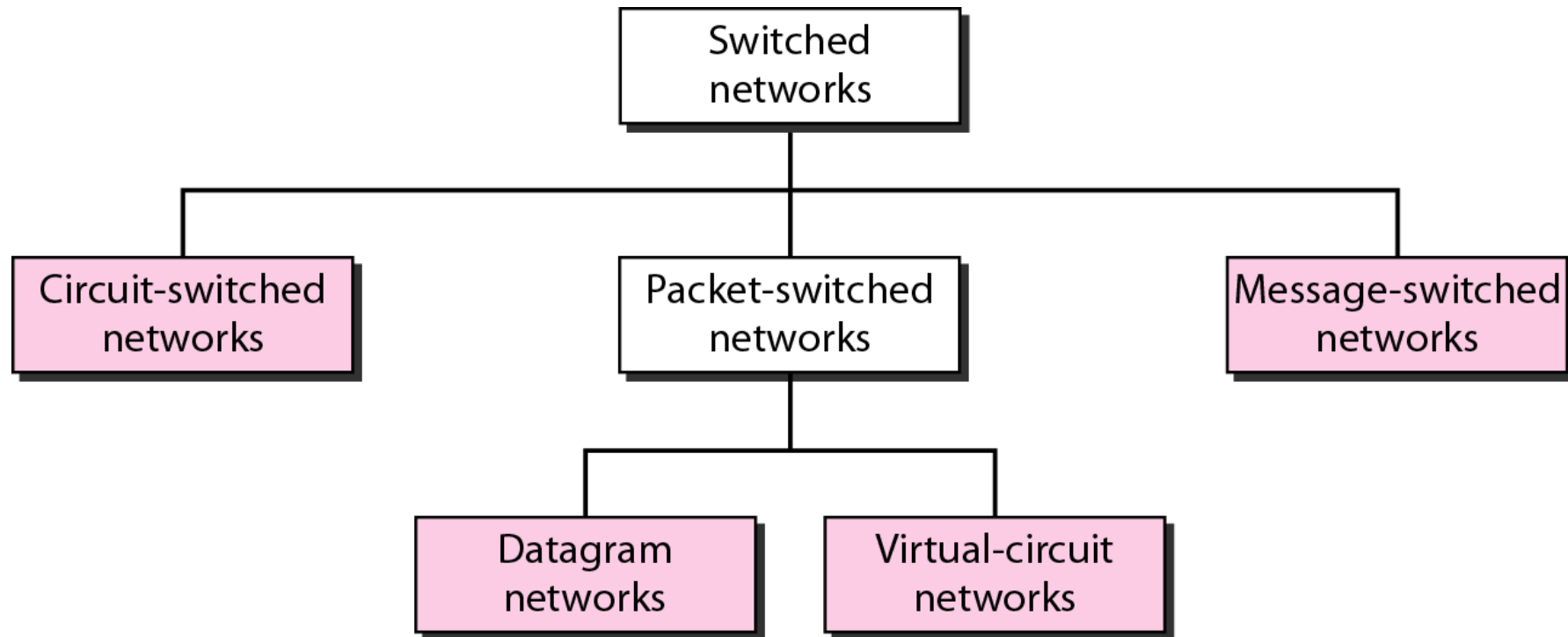
# Contents

- Circuit/Packet/Message switching
- Network performance
- ISDN signaling
- Guided Media: Copper, Fiber Cabling
- Unguided Media

# Circuit Switching

- For one to one communication in the large network, point to point communication between each pair of devices or between a central device and every other device are impracticable and wasteful
- For this switching is a better solution
- A switched network consists of a series of interlinked nodes called switches
- Switches are hardware or software devices capable of creating temporary connections between two or more devices linked to the switch but not to each other.

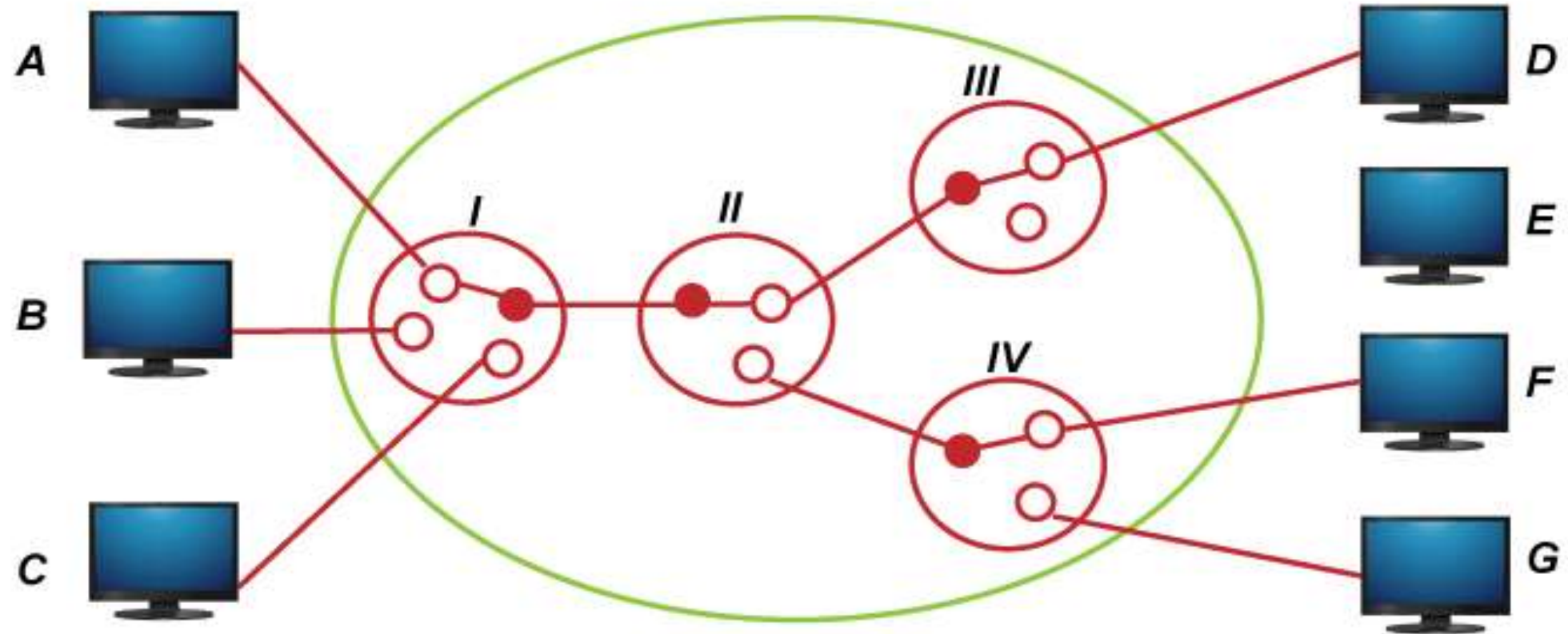
# Circuit Switching



# Circuit Switching

- In circuit switching, the system establishes a dedicated communication channel between the devices such as phone or computers before any data is transmitted
- It is widely used in public switched telephone network
- A circuit switch is a device with  $n$  inputs and  $m$  outputs that creates a temporary connection between an input link and an output link. The number of inputs don't have to match the number of outputs

# Circuit Switching



*Circuit Switched Network*

# Circuit Switching

- In fact the circuit switching was designed for voice communication. It creates temporary (dialed) or permanent (leased) dedicated links that are well suited to this type of communication
- It is less well suited for data and other non voice communication.
- Similarly there is inflexibility and weakness of single data rate for both devices.

# Packet Switching

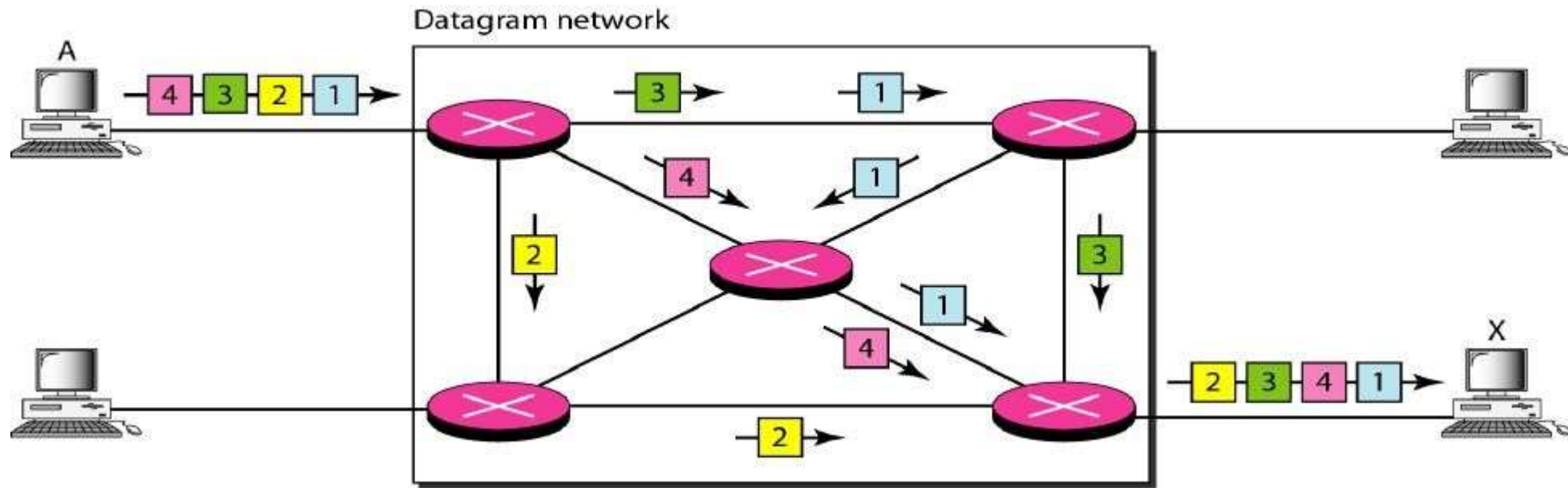
- In packet switched network, computers divide their data into small discrete units of potentially variable block length called packets. The maximum length of the packet is established by the network itself
- Most LAN technologies such as ethernet, token ring, fiber distributed data interface (FDDI) uses packet switching
- Longer transmission are broken up into multiple packets. Each packets contains not only data but also a header with control information (such as priority codes, source and destination address)



# Packet Switching

- The packets are sent over the network node to node. At each node, the packet is stored briefly then routed accordingly to the information in its header.
- Segmenting the data in this way is necessary because the computers in a LAN share a single cable and a computer transmitting a single unbroken stream of data would monopolize the network for too long.
- Two popular approaches to packet switching network are:
  - Datagram Approach
  - Virtual Circuit Approach
    - Switched virtual circuit
    - Permanent virtual circuit

# Packet Switching – Datagram Approach



# Packet Switching – Datagram Approach

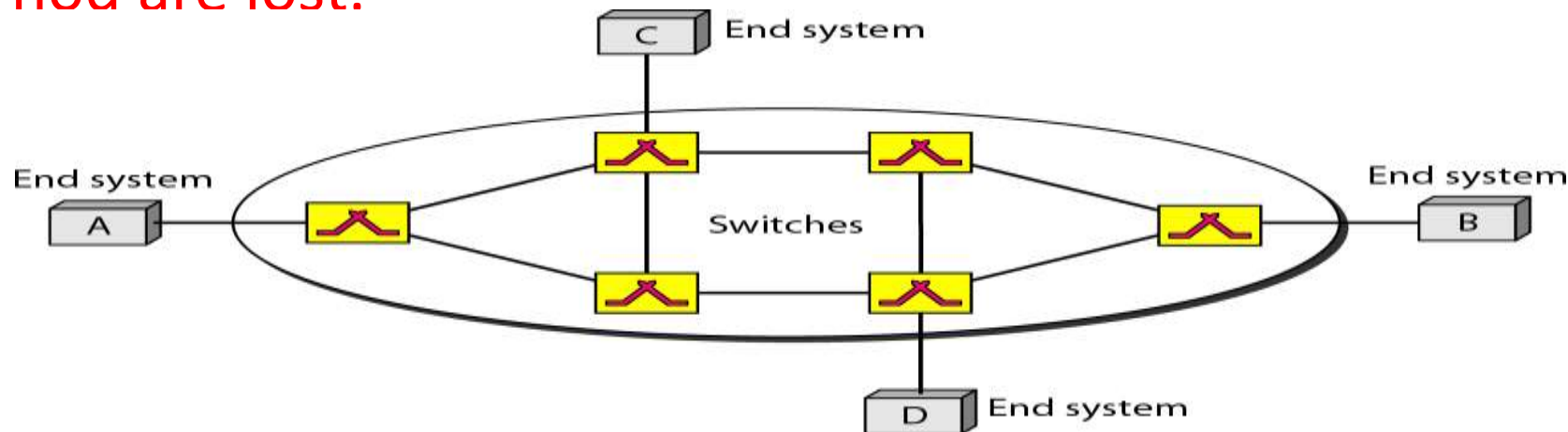
- On major advantage of datagram approach is that the call set up phase is avoided. Thus if a station wishes to send only on or few packets, datagram delivery will be quicker.
- In datagram approach to packet switching, each packet is treated independently from all others and that independent packet can follow/take any independent route
- Packets in this technology are referred to as datagrams

# Packet Switching – Switched Virtual Circuit

- A switched virtual circuit (SVC) is a temporary connection that's set up on demand to transmit data in a packet-switched network.
- SVCs are established and maintained only for the duration of a data transfer session, and are then disconnected when the session ends
- Process involved
  - Connection established
  - Data transfer
  - Connection release

# Packet Switching – Permanent Virtual Circuit

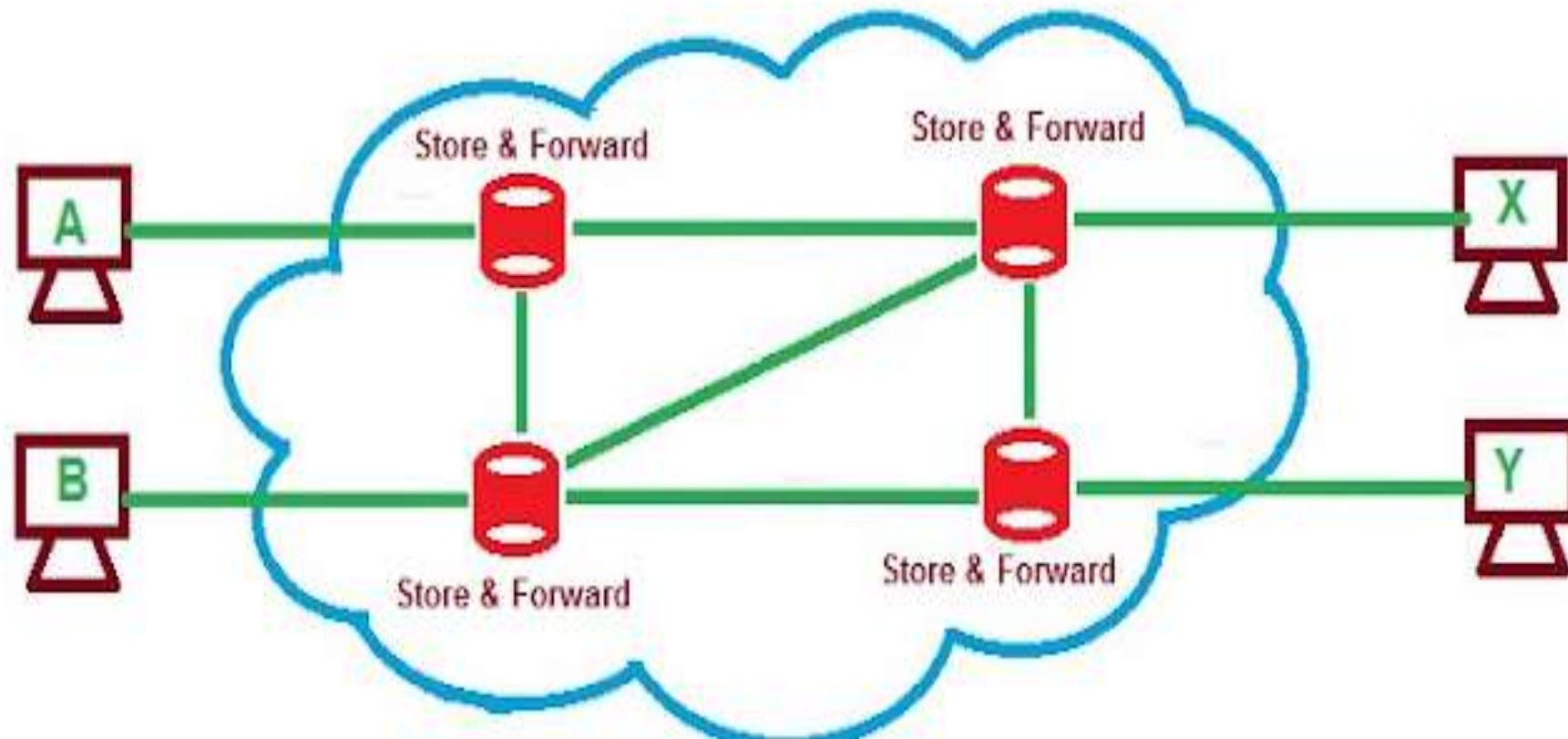
- A permanent virtual circuit (PVC) is a virtual circuit established for repeated/continuous use between the same DTE.
- In a PVC, the long-term association is identical to the data transfer phase of a virtual call
- With virtual circuit, if a node fails, all virtual circuits that pass through that node are lost.



# Message Switching

- Message switching is best known by the descriptive term store and forward.
- In this mechanism, a node (usually a special computer with a number of disks) receives a message, stores it until the appropriate route is free, then sends it along.
- Store and forward concept is considered a switching technique because there is no direct link between the sender and receiver of a transmission.
- Email delivery is the perfect example of message switching.

# Message Switching



# Path versus Route

- Path versus Route
- Dedicated versus Sharing

In a permanent virtual circuit, **the links that makes the path** are dedicated; they cannot be used by another connection

Whereas, in a virtual circuit connection the **link that make a route** can be shared by other connection



# Network performance

- Bandwidth
- Throughput
- Latency
- Bandwidth Delay Product
- Jitter

# Bandwidth

- Maximum amount of data that can be transmitted per second
- Bandwidth of a network is given by the number of bits that can be transmitted over the network in certain period of time
- In Guided media (wired network) we have cables in BW of bits/sec
- In Unguided media (wireless network) we are dealing with frequency so the BW is in Hertz

# Throughput

- Informal - actual amount of data that passes through the medium
- Formal – the throughput is the measure of how fast we can actually send data through the network
- A link may have a BW of 8 bps, but we can only send 'T' bps, through the link i.e.  $T < B$

# Latency

- The latency or delay defines how long it takes for an entire message to completely arrive at the destination from the time the first bit is sent out of the source
- Categories of delay
  - Transmission delay
  - Propagation delay
  - Queuing delay
  - Processing delay

Summation of all these delay comprises latency

# Bandwidth-Delay Product

- Bandwidth delay product is calculated as the product of the link capacity of the channel and the round – trip delay time of transmission.
- The link capacity of a channel is the number of bits transmitted per second. Hence, its unit is bps, i.e. bits per second.
- The round – trip delay time or RTT is the duration measured in milliseconds, from when a browser sends a request to when it receives a response from a server
- The unit of bandwidth delay product is bits or bytes.

# Bandwidth-Delay Product

- Consider that the link capacity of a channel is 512 Kbps and round – trip delay time is 1000ms
  - The bandwidth delay product  $= 512 \times 10^3 \text{ bits/sec} \times 1000 \times 10^{-3} \text{ sec}$   
 $= 512,000 \text{ bits} = 64,000 \text{ bytes} = 62.5 \text{ KB}$

# Jitter

- In internet protocol (IP) , jitter is the variation in the latency on a packet flow between two systems when some packets take longer to travel from one system to another
- So when packets arrive at unexpected time, calls can be interrupted
  - online games players graphics will be disturbed etc.

# ISDN signaling

- Developed by ITU-T in 1986
- It is a set of protocols that combine digital telephony and data transport services
- ISDN is circuit switching service because it creates a temporary point-to-point circuit between two sites
- Most ISDN service agreements include a per minute charge as well as installation fees and monthly subscriber fees. Unlike a leased line, one can disconnect and ISDN WAN link during off hours
- The goal of ISDN is to form a wide area network that provides universal end to end connectivity over digital media



# ISDN signaling and architecture - Services

- The purpose of ISDN is to provide a fully integrated service to users
  - 1) Bearer Service
  - 2) Tele service
  - 3) Supplementary Service

# Subscriber access to the ISDN

- Digital pipes are organized into multiple channels of different sizes
- It defines three channel types
  - a) B channel (Bearer Channel)
  - b) D channel (Data Channel)
  - c) H channel (Hybrid Channel)

# Subscriber access to the ISDN

## a) B channel (Bearer Channel)

- B channel (bearer) is a telecommunications term which refers to the ISDN channel in which the primary data or voice communication is carried.
- It has a bit rate of 64 kbit/s in full duplex

# Subscriber access to the ISDN

## b) D channel (Data Channel)

- D channel (delta channel) is a telecommunications term which refers to the ISDN channel in which the control and signalling information is carried.
- The bit rate of the D channel of a basic rate interface is 16 kbit/s, whereas it amounts to 64 kbit/s on a primary rate interface.

# Subscriber access to the ISDN

## c) H channel (Hybrid Channel)

- A hybrid channel in Integrated Services Digital Network (ISDN) is a channel with a data rate of 384 Kbps (H0), 1536 Kbps (H11), or 1920 Kbps (H12).
- These data rates make hybrid channels suitable for high data rate applications like video and teleconferencing.

# Subscriber access to the ISDN

Channel Name	Speed	Comments
B (Bearer)	64 Kbps	Carries voice and data
D	16 Kbps or 64 Kbps	Speed depends on the type of service; carries signaling information and other conversation control information
HO	384 Kbps	Aggregate of 6 B channels
H10	1472 Kbps	Aggregate of 23 B channels

# User interface

- Digital Subscriber loops are of two types
  - a) Basic Rate Interface (BRI)
  - b) Primary Rate Interface (PRI)

# User interface

## a) Basic Rate Interface (BRI)

- An Integrated Services Digital Network (ISDN) line that delivers two Bearer Channels (B-Channels) and one 16 kbps Data Channel (D-Channel) over an ordinary telephone line.
- The BRI is intended primarily for home and small business use, while larger networks are usually supported using a Primary Rate Interface (PRI)



# User interface

## b) Primary Rate Interface (PRI)

- Specifies a digital pipe upto 23B channels and one 64 kbps D channel.
- It uses 8 kbps overhead

# Broadband ISDN

- To provide the needs of the next generation of technology, an extension of ISDN is called broadband ISDN
- BISDN provides subscribers to the network with data rates in the range of 600 Mbps, almost 400 times faster than the PRI
- BISDN is based on a change from metal cable to fiber optic cable at levels of telecommunication
- The goal of BISDN is to achieve complete integration of services ranging from low-bit-rate bursty traffic to high-bit-rate continuous real-time signals

# Ethernet

- When you say ethernet, it generally reminds us of a computer network
- When ethernet was developed it did not use any type of cable at all
- In mid 1990's, Xerox Corporation developed ethernet network on basis of research at University of Hawaii
- An ALOHA network was established using radio broadcast to connect different sites on the island.
- As this network was connecting different sites wirelessly and transmission medium was ether, this type of network was termed as ethernet.

# What is ether transmission?

- Ether also spelled as aether also called luminiferous ether, in physics is a theoretical substance believed during the 19<sup>th</sup> century to act as the medium for transmission of electromagnetic waves
  - e.g. Light and X rays, much as sound waves are transmitted by elastic media such as air

# Ethernet

- Initially Xerox system went very successful. Soon, it was applied to connect various office equipment like printers, computers, scanners etc.
- In 1983, IEEE published IEEE 802.3 standard based on ethernet specification

Ethernet is a set of technologies commonly used in LAN/MAN/WAN” for controlling access to a shared network medium

# Ethernet

- Ethernet surpassed its competitors due to the following advantages
  - Simple to install and manage
  - Flexible and scalable
  - Inexpensive
  - Easy interoperation between vendors, since all manufacturers are providing support for ethernet cables by making their devices ethernet complaint

# Ethernet

- Initially ethernet network used ether as a medium but now ethernet medium uses
  - Twisted pair cable
  - Co-axial cable
  - Optical fiber cable

RJ45 cable is the most widely used connecting medium for ethernet networks and has become the representative of ethernet networks

# Network Cabling

- Cabling specifications
  - Bandwidth measures cable speed
    - Typically measured in Mbps
  - Maximum cable length
  - Connector describes the type of plug



# Network Cabling

- Ethernet
  - Very popular cabling technology
  - 10 Base T, 10Base2, 10Base5
  - Maximum bandwidth 10 Mbps
  - Maximum distances 100 to 500 meters



IEEE standard	Physical Standard	Cable Type	Maximum Speed	Maximum Cable Length
802.3	10baseT	Twisted Pair	10 Mbps	100m
802.3	10baseF	Optical Fiber	10 Mbps	200m

# Network Cabling

- Fast Ethernet
  - Newer version of Ethernet
  - Bandwidth is 100 Mbps
  - Uses Cat5 or greater cable
    - Sometimes called 100Base T
  - Requires a switch

# Network Cabling

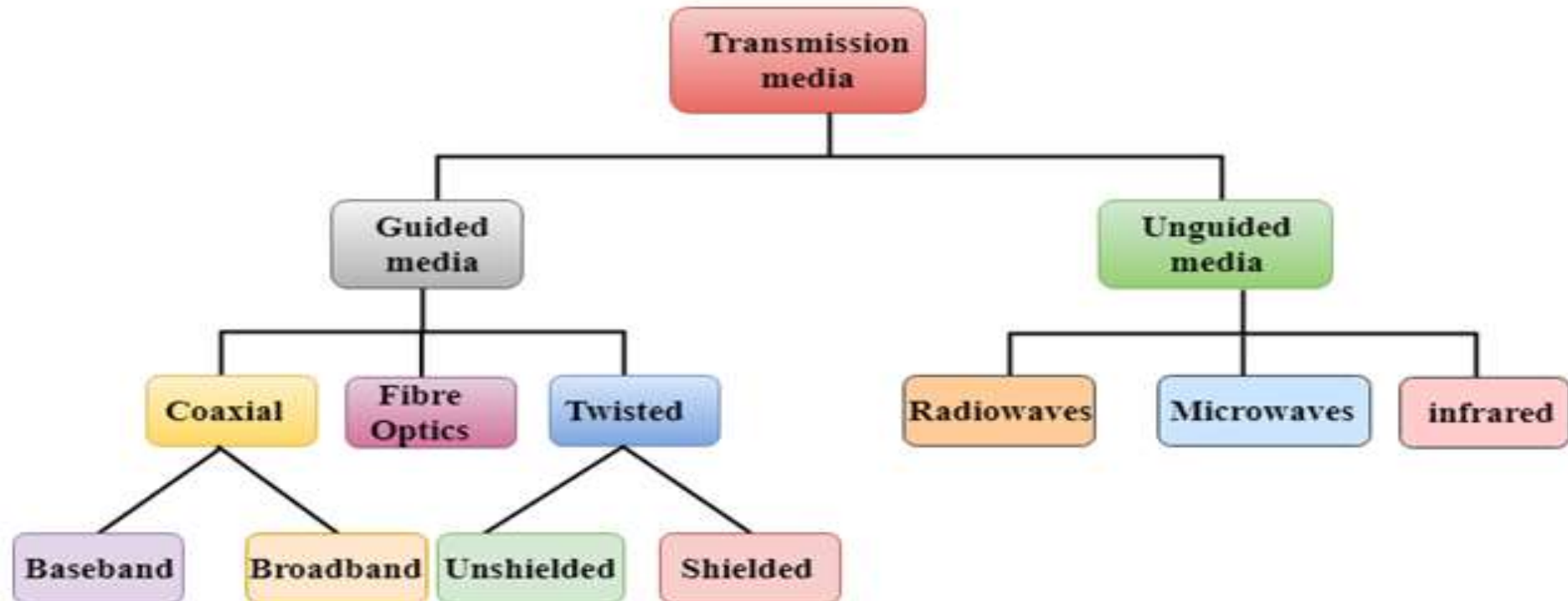
- Gigabit Ethernet
  - High bandwidth version of Ethernet
  - 1 to 10 Gbps
  - Cat 5 or fiber optic cable
  - Video applications

# Network Cabling

- Token ring
  - Uses shielded twisted pair cabling
  - Bandwidth between 10 and 25 Mbps
  - Uses a multiple access unit (MAU)
  - Popular in manufacturing and finance

# Transmission Media

- Transmission media is a communication channel that carries the information from the sender to the receiver. Data is transmitted through the electromagnetic signals.

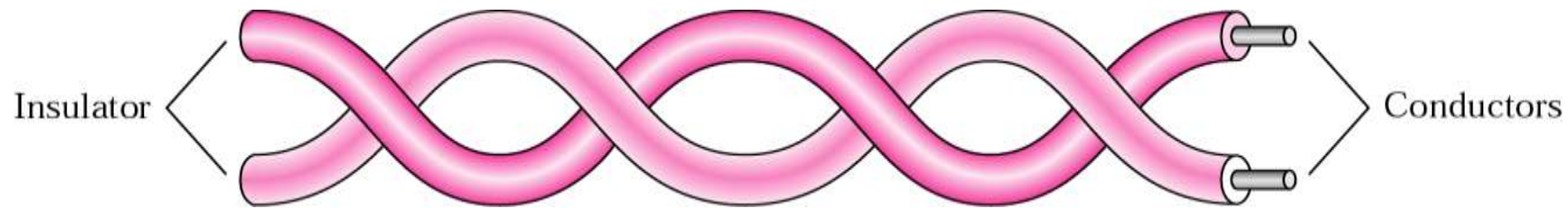


# Guided Media

- It provides conduction from one device to another via twisted pair cable, coaxial cable and fiber optic cable.
- Twisted pair cable and coaxial cable use metallic conductors that accept and transport signals in the form of electrical current whereas
- Optical fiber is a glass or plastic cable that accepts and transports signals in the form of light

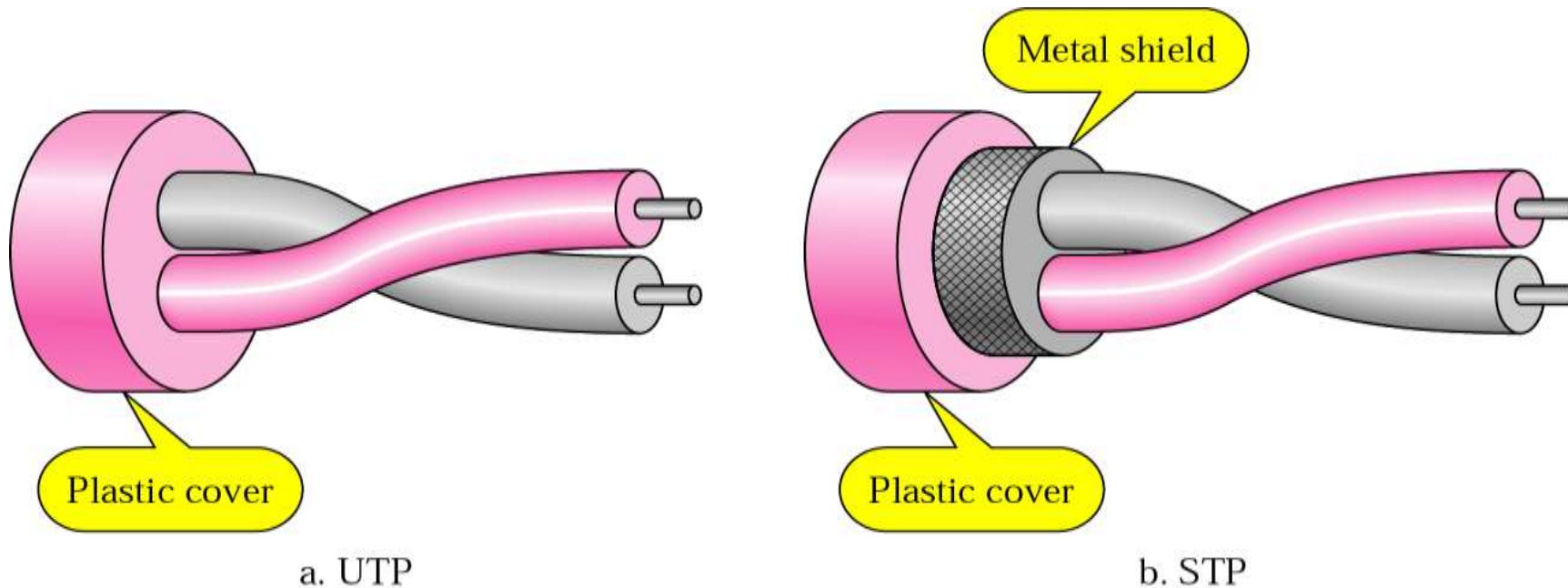
# Guided Media – twisted pair cable

- It consists of two insulated copper wires typically about 1mm thick. The wires are twisted together in a helical form, just like a DNA molecule
- The purpose of twisted pair wires is to reduce electrical interference from similar pairs close by
- Twisted pair cable run several kilometers without amplification, but for longer distances repeaters are used



# Twisted pair cable – UTP and STP

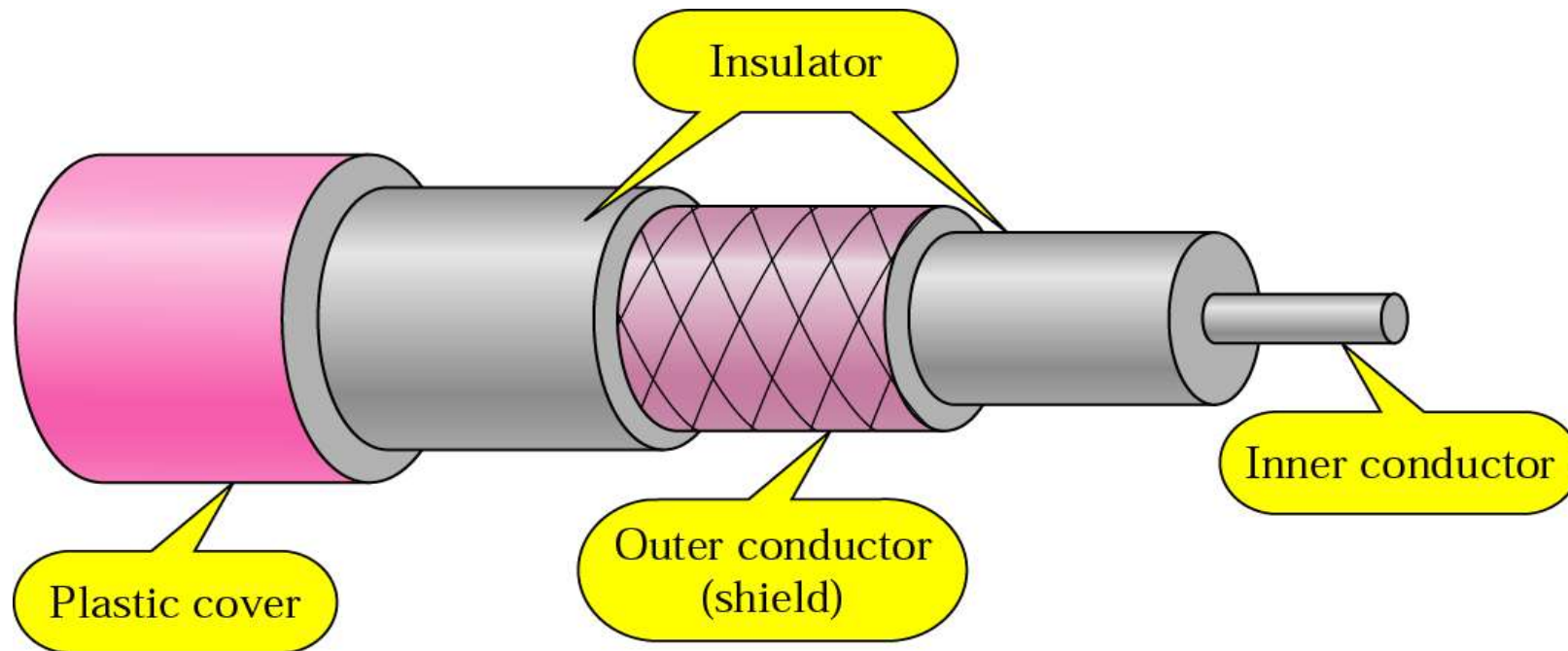
- UTP – unshielded twisted pair – cheap flexible and easy to install
- STP – shielded twisted pair
  - less susceptible to noise, used for highly sophisticated networks such as research lab, almost zero interference exists for such cable





# Guided Media – coaxial cable

- Instead of have two wires, coaxial cable has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath which is, in turn, enclosed in an outer conductor of metallic foil.



# Coaxial Cable : Baseband Cable

- ❑ Carries Single Signal at a Fixed Frequency.
- ❑ It is used for Digital Transmission.
- ❑ Uses Digital Signaling Technique.
- ❑ It is used for Small Area.
- ❑ 10 Base 5 Cable => Distance up to 500m.
- ❑ Repeaters Can be used to deal with attenuation.

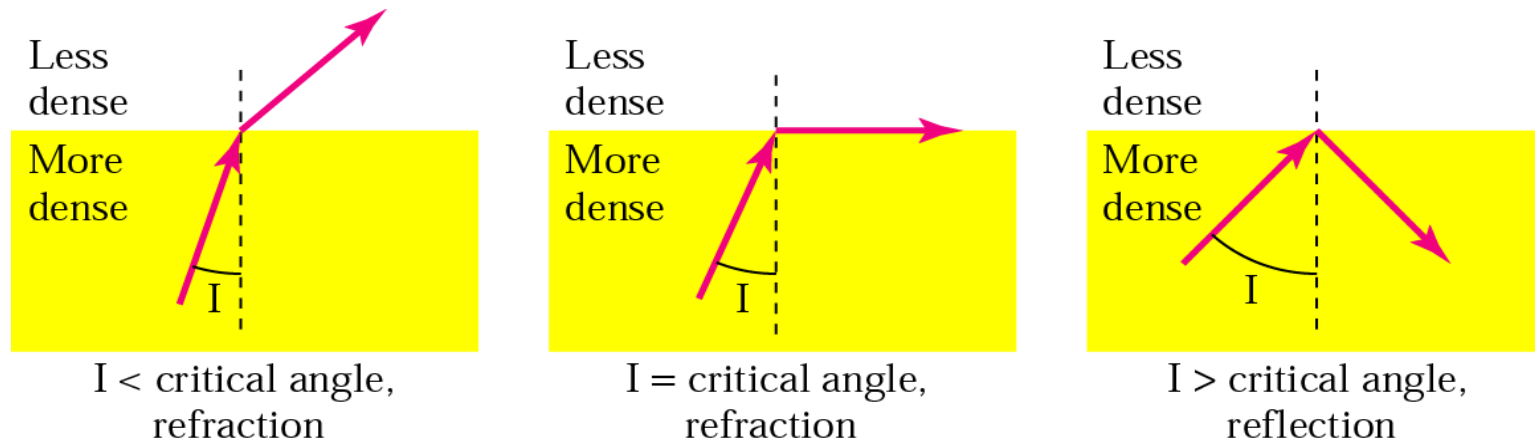
# Coaxial Cable : Broadband Cable

- ❑ Carries Multiple Signals => Multiplexing.
- ❑ It is used for Analog Transmission.
- ❑ Uses Analog Signaling Technique.
- ❑ It is used for Large Area => Cable Television
- ❑ Amplifiers Can be used to deal with attenuation.

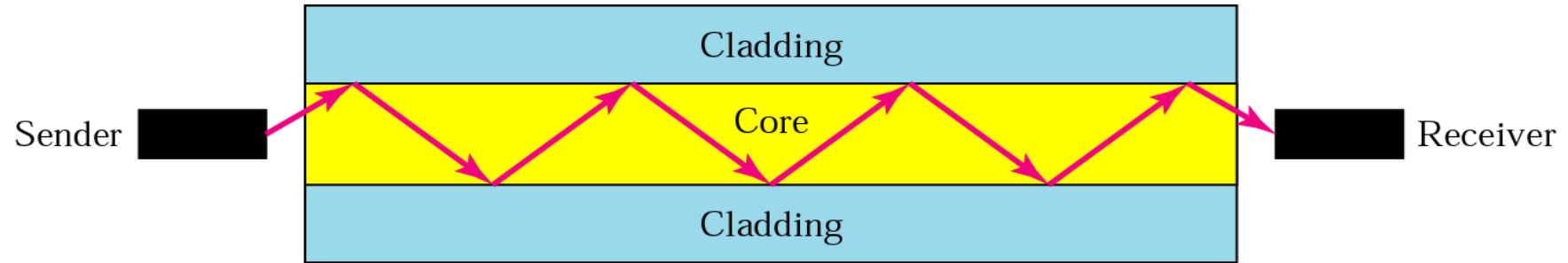
# Guided Media – optical fiber cable

- Optical fiber is a glass or plastic cable that accepts and transports signal in the form of light
- The lowest losses have been obtained by using fibers of ultra pure fused silica
- Optical fiber has a cylindrical shape and consists of three concentric sections: the core, the cladding and the jacket
- Refractive index of core is always greater than the refractive index of the cladding
- The outermost covering is known as jacket. This jacket is composed of plastic and other materials layered to protect against moisture, crushing and other environmental damages
- Optical fiber uses the total internal reflection feature.

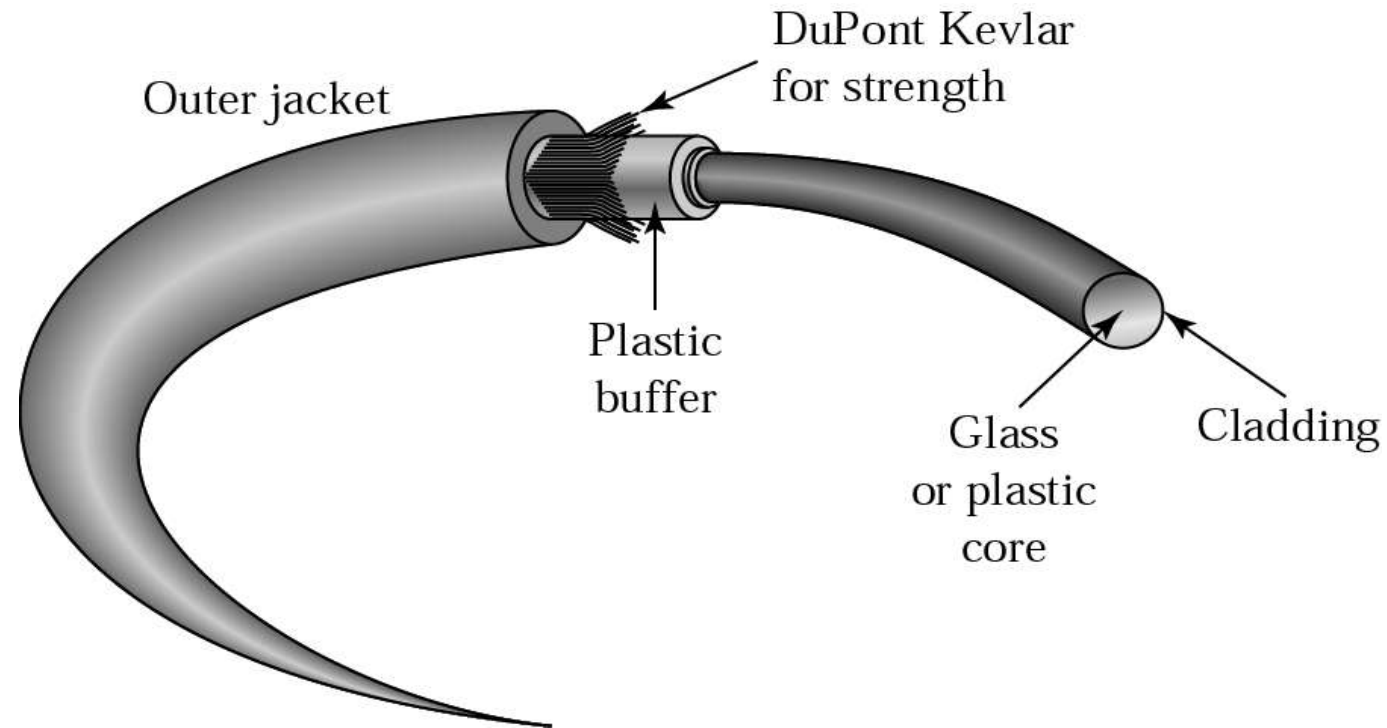
# Optical Fiber : Bending of Light Ray



# Optical Fiber : Structure ?



# Fiber Construction

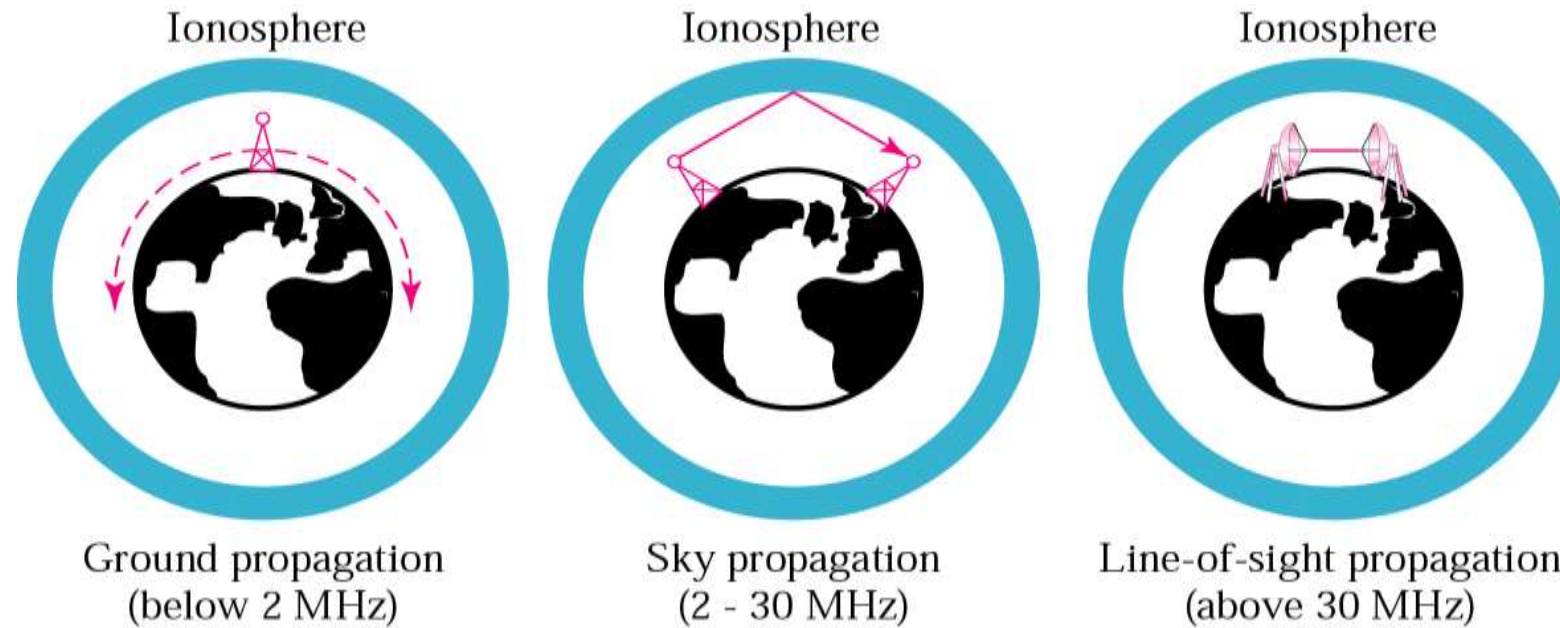


# Optical Fiber : Benefits

- Supports Higher Data Rate => data rate is 2 Gbps over tens of sub km
- Smaller Size and Lighter Weight.
- Lower Attenuation
- Electromagnetic Isolation
- Greater Repeater Spacing

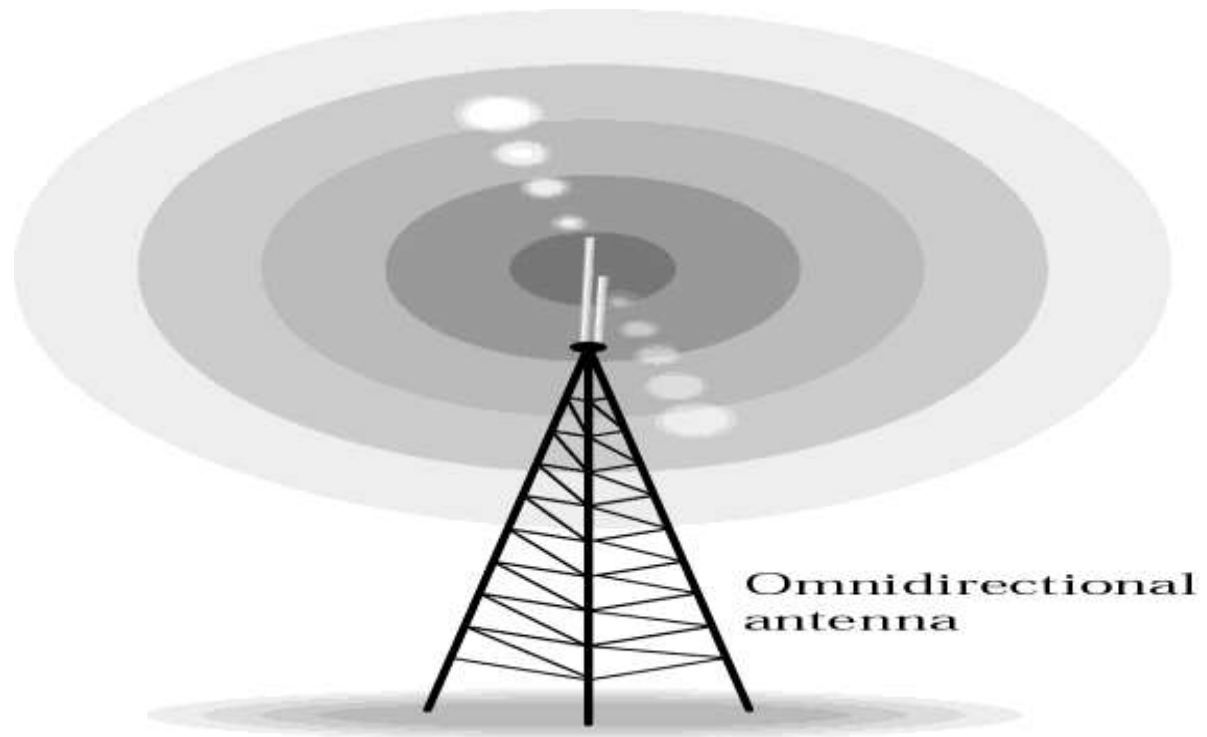


# Propagation Methods



# Antennas : Omnidirectional

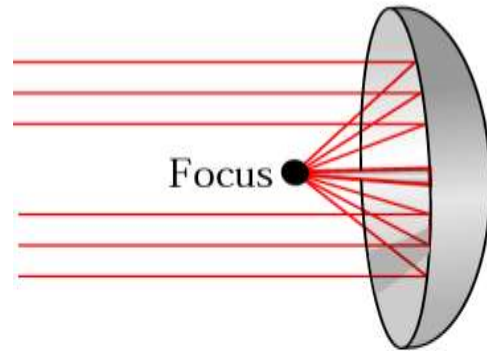
- An antenna is metallic device (a rod or a wire) for radiating or receiving radio waves.
- In other words, antenna is transducer that converts photons to electrons and vice versa



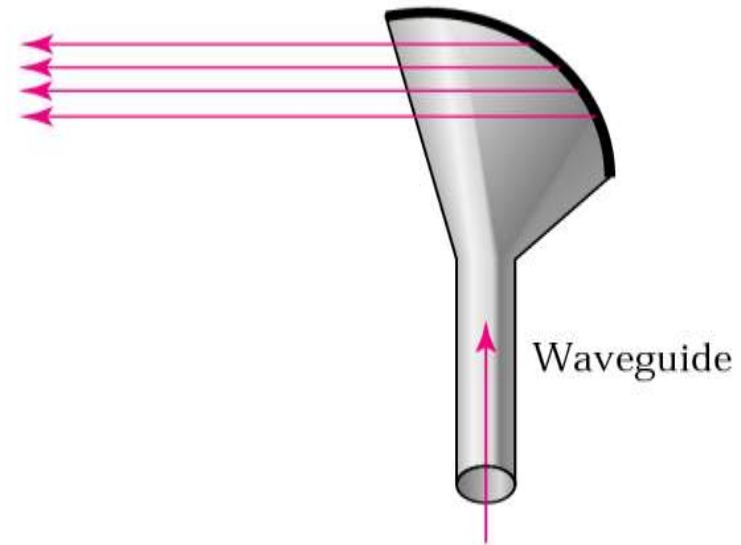
# Antenna

In radio engineering, an antenna (or, aerial) is the interface between radio wave propagating through space and electric current moving in metal conductors, used with a transmitter or receiver

# Antennas : Unidirectional



a. Dish antenna

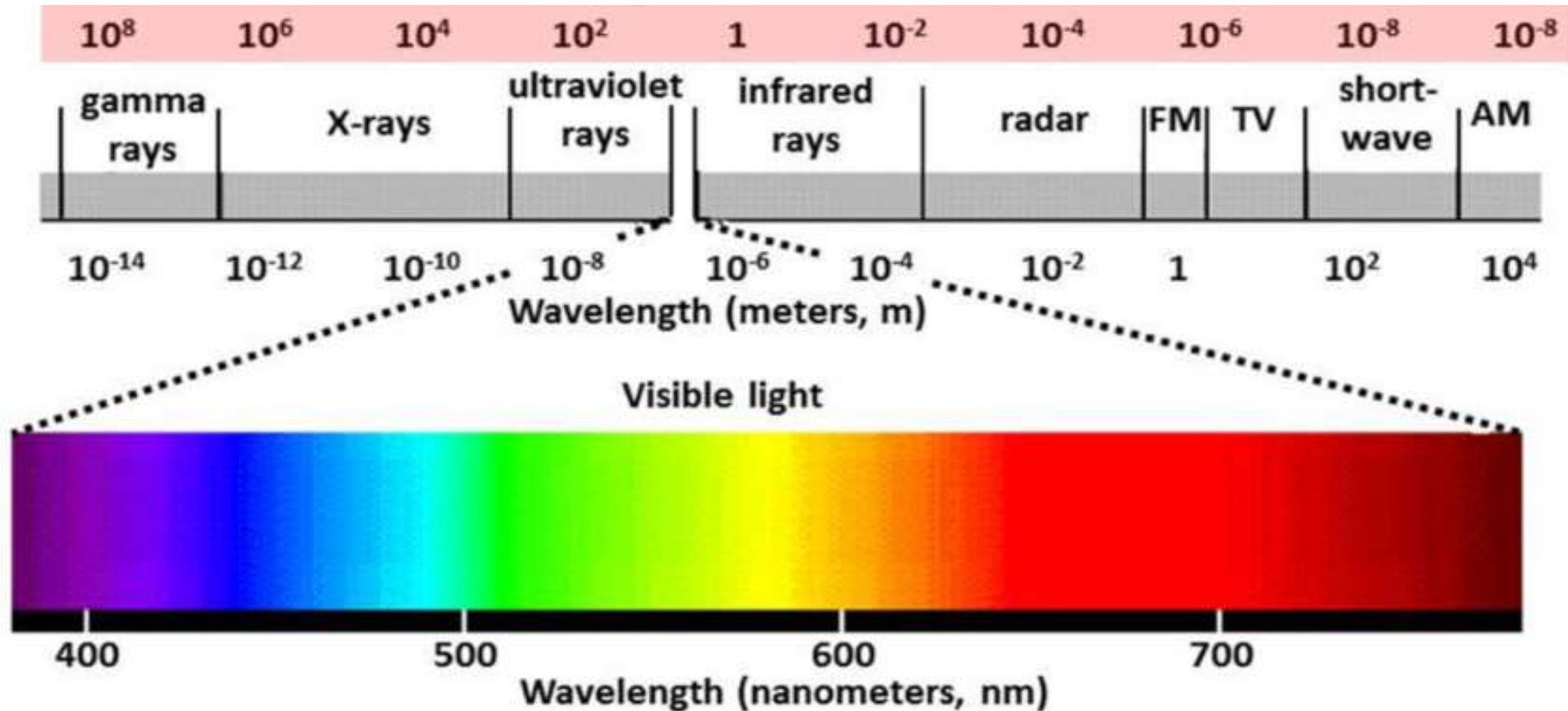


b. Horn antenna

# Electromagnetic Spectrum

- Process of production of electromagnetic energy
  - Accelerated motion of charges in conducting wires
  - Nuclear reaction
  - Metal bombarded with high energy electrons

# Electromagnetic Spectrum



# Radio waves

- Radio waves are easy to generate, can travel long distances and penetrate buildings easily, so they are widely used for communication both indoor and outdoor. They are omnidirectional
- At low frequency, radio waves pass through obstacles well, but the power falls off sharply with distance from the source.

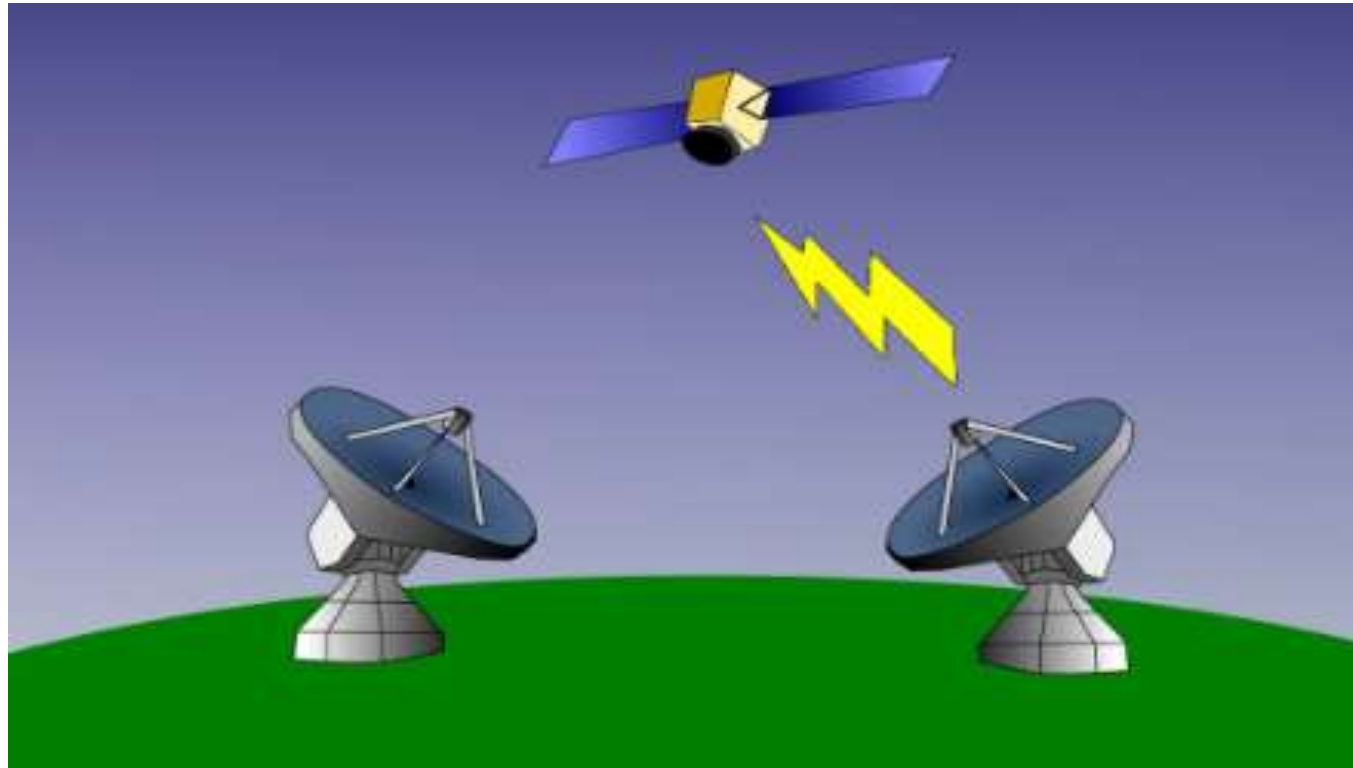
# Micro waves

- Micro waves travel in a straight path and therefore can be narrowly focused. It gives much higher signal to noise ratio, but the transmitting and receiving antennas must be accurately aligned with each other.
- Since microwaves travel in a straight line, if they are too far apart, repeaters are needed periodically. Generally 100 m of tower has the spacing of 80 km



# Unguided Media – Satellite Communication

- Satellite is a distant microwave repeater



# Satellite Communication

- Generally 6 GHz is used for uplink connection and 4 GHz is used for downlink connection. So we got to use the frequency translator in addition to a normal repeater
- In other words, the satellite receives transmission on one frequency band (uplink), amplifies or repeats the signal and transmits it on another frequency (downlink)
- Reason for employing two frequencies
  - If same frequency is used, amplifiers used result in oscillations and interference between the uplink and downlink takes place
- Half circuit
  - It implies the communication between the earth station via a satellite
- Full Circuit
  - It is the communication between the two stations via a satellite

# Satellite Communication

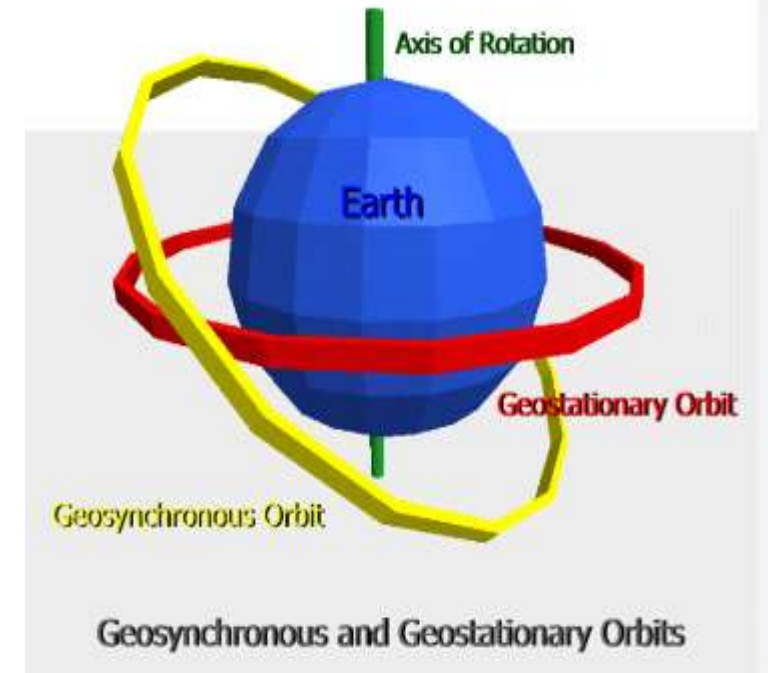
- The most desired frequency band for satellite communication system is 6 GHz on the uplink (Earth to Satellite transmission) & 4 GHz on the downlink (Satellite to Earth transmission)

i.e.  $C = 6/4$  GHz

- In this frequency range, the equipment is relatively inexpensive, the cosmic noise is small and the frequency is low enough that rainfall does not appreciably attenuate the signal.

# Satellite Communication

- The fundamental advantage of a satellite is its ability to obtain a global look of large portion of the Earth's surface



# Satellite Communication

- A system of three satellites in geosynchronous orbit can cover almost all of the earth's surface. This has led to the application of satellites in several areas such as communication in mobile satellites, photography for meteorology and earth's resources, navigation for aircraft and ships etc.
- Some of the services provided by the satellites are:
  - Fixed satellite service
  - Broadcasting satellite service
  - Mobile satellite service
  - Navigational satellite service
  - Meteorological satellite service

## **Tutorial 3**

### **Computer Network**

#### **Deadline of submission:**

1. What is guided media? Compare and contrast between co-axial cable and fiber cable.
2. Explain different types of unguided media in detail.
3. Compare twisted pair cable, coaxial cable and optical fiber cable on the basis of cost, speed, attenuation, crosstalk and implementation.
4. Why telephony company developed ISDN? Explain the working principle of ISDN with its interface and functional group.
5. Explain various network performance that exists in communication devices.
6. Compare and contrast between circuit switching, packet switching and message switching.
7. What is satellite communication? Explain its necessity for a topographically diverse country like Nepal.
8. Write short notes on
  - a. Bluetooth
  - b. Wi-Fi
  - c. Microwaves
  - d. Radio waves