Physical Layer and Network Media

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- Ethernet Cable standards
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- ISDN

Network Device

- **Computer networking devices**, are physical devices which are required for communication and interaction between devices on a computer network.
- Specifically, they mediate data in a computer network.
- Units which are the last receiver or generate data are called hosts or data terminal equipment

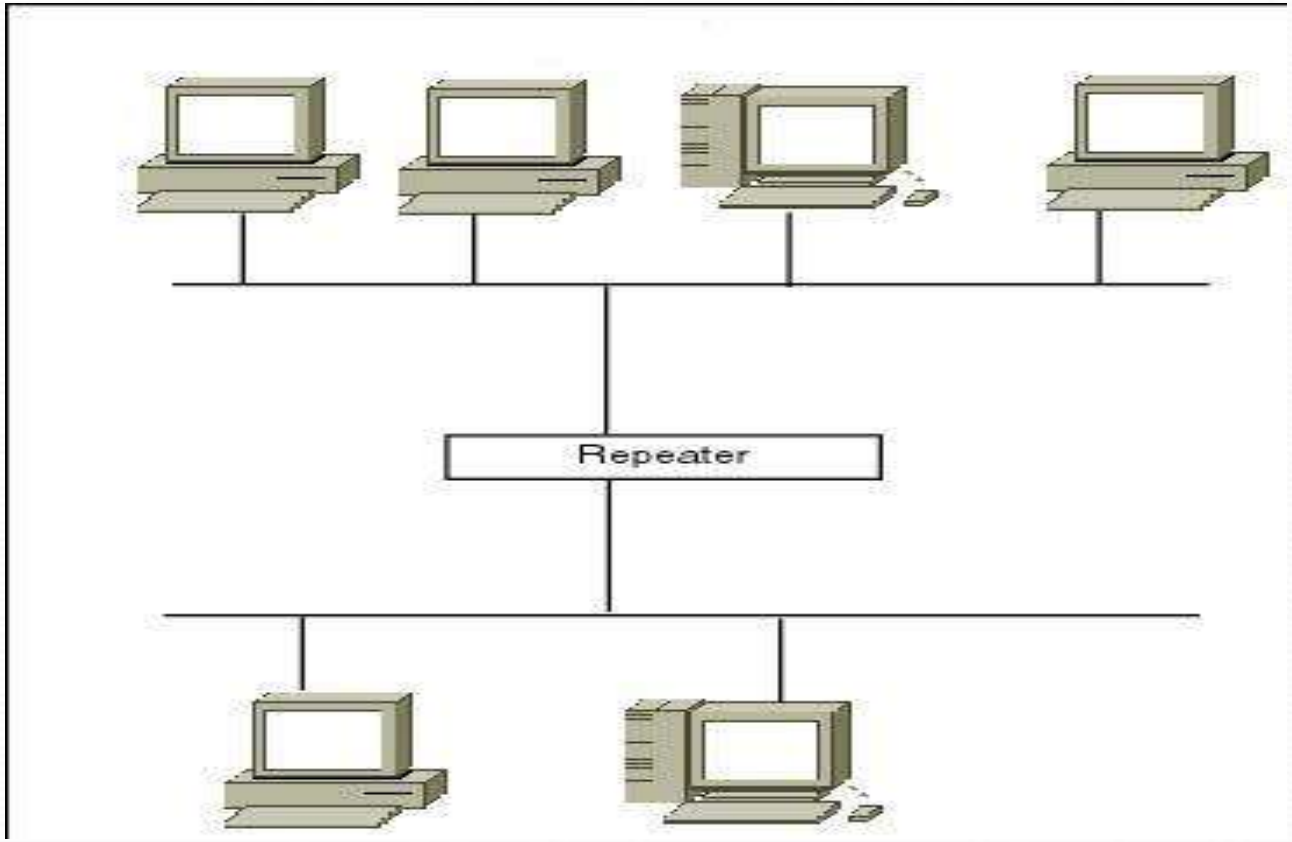
Main Networking Devices are:

- Repeater
- Switch
- Hub
- Router
- Bridge
- Gateway

Repeater

- A repeater operates at the physical layer.
- A **repeater** is an electronic device that receives a signal and retransmits it
- 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.
- Repeaters don't not amplify the signal. When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength.
- Repeaters are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction
- Using a repeater between two or more LAN cables segment requires that the same physical layer protocol be used to send signal over all the cable segments.
- The purpose of a repeater is to extend the LAN segment beyond its physical limits (e.g. Ethernet is 500m for 10Base5).

Repeater



Advantages :

- Simple to connect
- Cost effective
- Ability to strengthen signal

Disadvantages:

- Repeaters provide no method for isolating traffic generated on one cable segment from traffic generated by the other cable segment
- If numerous collisions are occurring in one part of the network, they will be forwarded to other parts of the network.

Hubs

- A hub is used as a central point of connection among media segments.
- Cables from network devices plug in to the ports on the hub.
- Types of HUBS :
  - A **passive hub** is just a connector. It connects the wires coming from different branches.
  - The signal pass through a passive hub without regeneration or amplification.
  - Connect several networking cables together
  - **Active hubs or Multiport repeaters-** They regenerate or amplify the signal before they are retransmitted.

Contd..

- A hub is a repeater with multiple ports, and can be thought of as being the centre point of a star topology network. It is often known as a multi-port repeater (or as a concentrator in Ethernet).
- Hubs can be active (where they repeat signal sent through them) or passive (where they do not repeat, but merely split, signals sent through them).
- When a hub receives a packet of data (an Ethernet frame) at one of its ports from a network device, it transmits (repeats) the packet to all of its ports to all of the other network devices. If two network devices on the same network try to send packets at the same time a collision is said to occur.
- Hubs are considered to operate at Physical Layer (Layer 1) of OSI model.

Hub generally:

- Amplify signals.
- Propagate the signal through the network.
- Do not filter traffic. This is a major disadvantage with hubs and repeaters as data arriving at any of the ports is automatically transmitted to all the other ports connected to the hub.
- Do not determine path.
- Centralize the connection to the network.

Advantages of Hub:

It can extend total distance of the network.
It does not affect performance of the network seriously.
It is cheaper.
It can connect different media type

Disadvantages of Hub:

It does not have mechanisms such as collision detection and retransmission of packets.
It does not operate in full duplex mode.
It can not connect different network architectures such as token ring and ethernet etc.
It can not filter information i.e. it passes packets to all the connected segments.
It does not have mechanism to reduce the network traffic.

Switch

- It is an intelligence device and operates at Layer-2 of OSI layer
- When any host on the network or a switch sends a message to another host on the same network or same switch, the switch receives and decodes the frames to read the physical (MAC) address portion of the message.
- It checks the destination address to route the packet appropriately.
- Following are features of the network switches.
  - It is available in various configurations and as per data transfer speeds such as 10/100/1000 Mbps or 10/100 Gbps.
  - Operates in full duplex mode
  - Packet collision is avoided due to port to port data transmission.

Switch

Advantages of Switches:

- They increase the available bandwidth of the network.
- They help in reducing workload on individual host PCs.
- They increase the performance of the network.
- Networks which use switches will have less frame collisions. This is due to the fact that switches create collision domains for each connection.
- Switches can be connected directly to workstations

Disadvantages of Switches

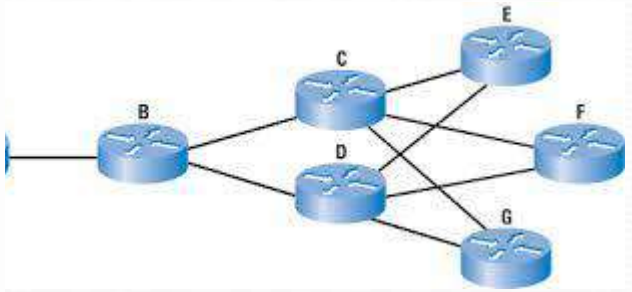
- They are more expensive compare to network bridges/hubs.
- Network connectivity issues are difficult to be traced through the network switch.
- Broadcast traffic may be troublesome.
- Proper design and configuration is needed in order to handle multicast packets.
- While limiting broadcasts, they are not as good as routers.

Router

- A router is a device that determines the next network point to which a packet should be forwarded toward its destination
- Allow different networks to communicate with each other
- A router creates and maintain a table of the available routes and their conditions and uses this information to determine the best route for a given packet.
- A packet will travel through a number of network points with routers before arriving at its destination.
- There can be multiple routes defined. The route with a lower weight/metric will be tried first.

Routers

Network Routers



Advantages of Router:

- It provides connection between different network architectures such as ethernet & token ring etc.
- It can choose best path across the internetwork using dynamic routing algorithms.
- It can reduce network traffic by creating collision domains and also by creating broadcast domains.
- It provides sophisticated routing, flow control and traffic isolation.
- They are configurable which allows network manager to make policy based on routing decisions.

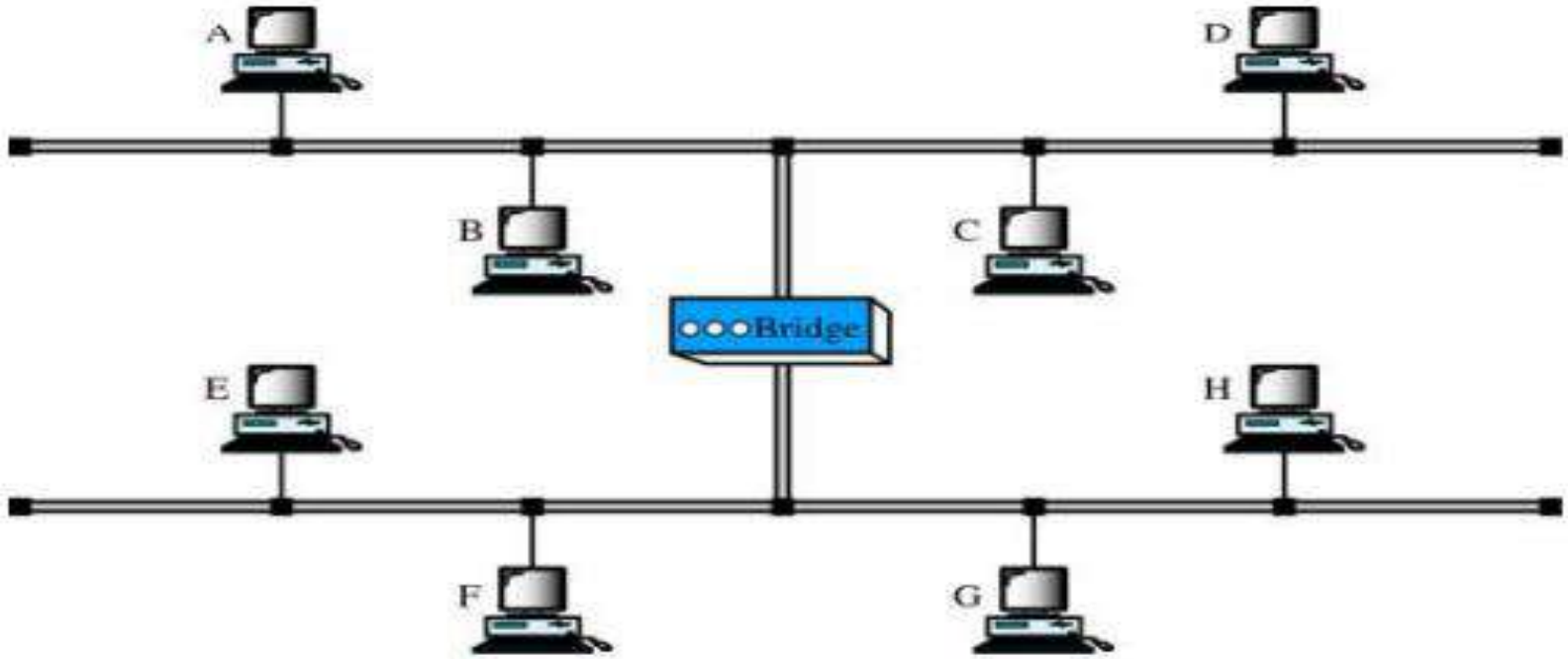
Disadvantages of Router:

- They operate based on routable network protocols.
- They are expensive compare to other network devices.
- Dynamic router communications can cause additional network overhead.
- This results into less bandwidth for user data.
- They are slower as they need to analyze data from layer-1 through layer-3.
- They require considerable amount of initial configurations.
- They are protocol dependent devices which must understand the protocol they are forwarding.

Bridge

- A **network bridge** connects multiple network segments at the data link layer (Layer 2) of the OSI model.
- In other words, it is normally used to connect two networks at the data link layer.
- Useful when the networks have different data link layers but the same network layer.
- For ex. A connection between ethernet and token bus would normally be a bridge.
  - The frames from the ethernet arrive at the bridge in ethernet form and are copied to the token bus in token bus form and vice versa.
- Are smart, full of software; can be programmed to copy frames selectively.
- This networking device uses bridge table or forwarding database to transmit frames across various network segments. It broadcasts traffic from one network segment to the other as well as manages them unlike hub which simply broadcasts.

• a bridge can divide a large network into smaller segments, or relay Frames between 2 originally unconnected LANs:



• unlike a repeater, a bridge contains logic which allows it to keep traffic for each segment separate ⇒ ***bridge can filter traffic***

• helps in controlling traffic congestion, isolating problems, security…

Advantages:

- It helps in extension of physical network.
- It reduces network traffic with minor segmentation.
- It creates separate collision domains. Hence it increases available bandwidth to individual nodes as fewer nodes share a collision domain.
- It reduces collisions.
- Some bridges connect networks having different architectures and media types.

Disadvantages:

- It is slower compare to repeaters due to filtering
- It does not filter broadcasts.
- It is more expensive compare to repeaters.

Gateway

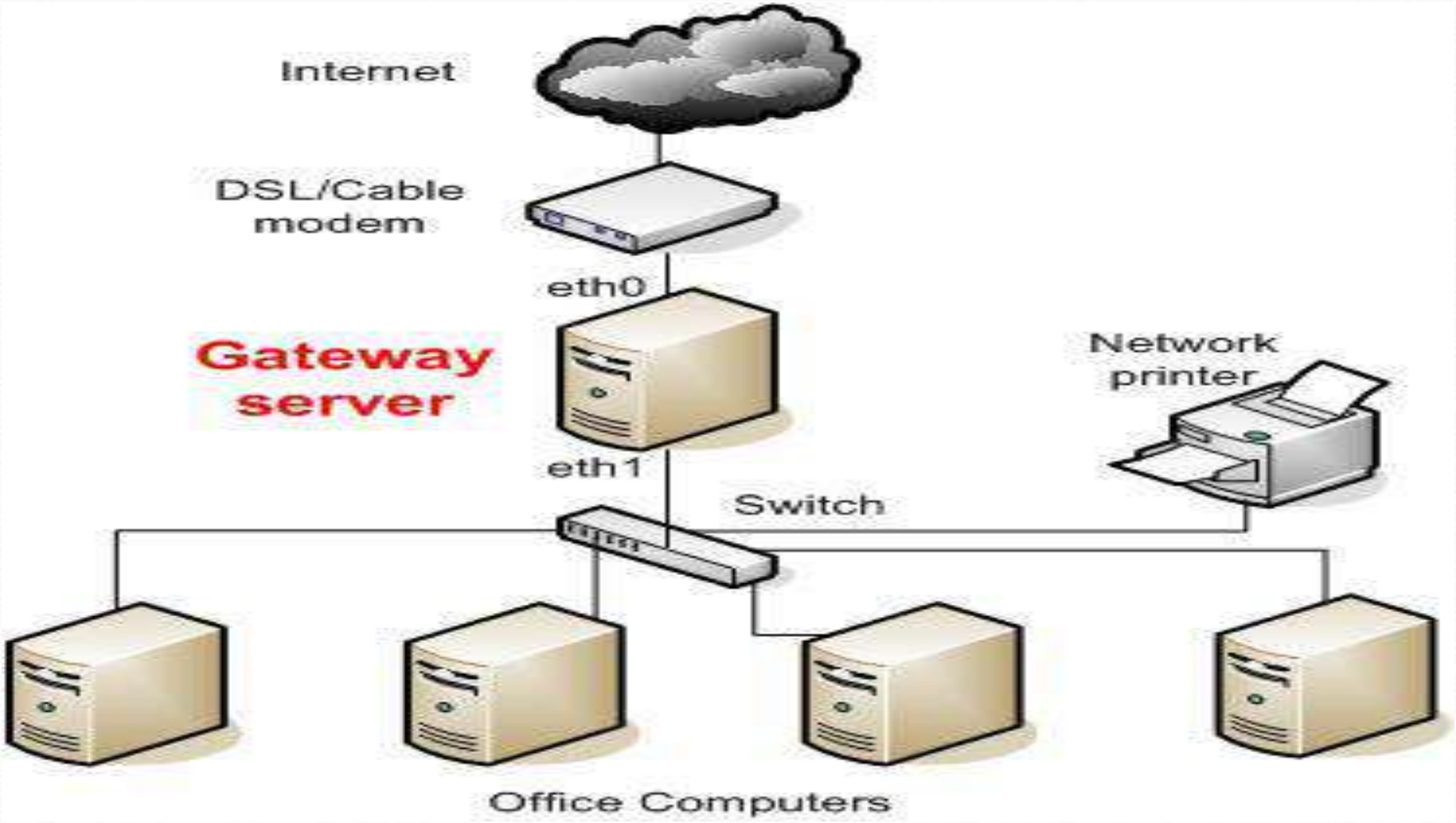
- Gateways are multi-purpose connection devices.
- They are able to convert the format of data in one computing environment to a format that is usable in another computer environment (for example, AppleTalk and DECnet).
- The term gateway is sometimes used when referring to a router.
- Gateways are devices that link different network types and protocols. For example, gateways translate different electronic mail protocols and convey email across the Internet

Gateways can operate at all layers of the OSI model since they:

•Can provide a physical link between networks.

•Create junctions between dissimilar networks.

•Translate different network protocols and/ or applications (for example, electronic mail between the Internet and a commercial online service with its own mail protocol).


Internet
DSL/Cable
modem
eth0
Gateway
server
Network
printer
eth1
Switch
Office Computers

Transmission Media

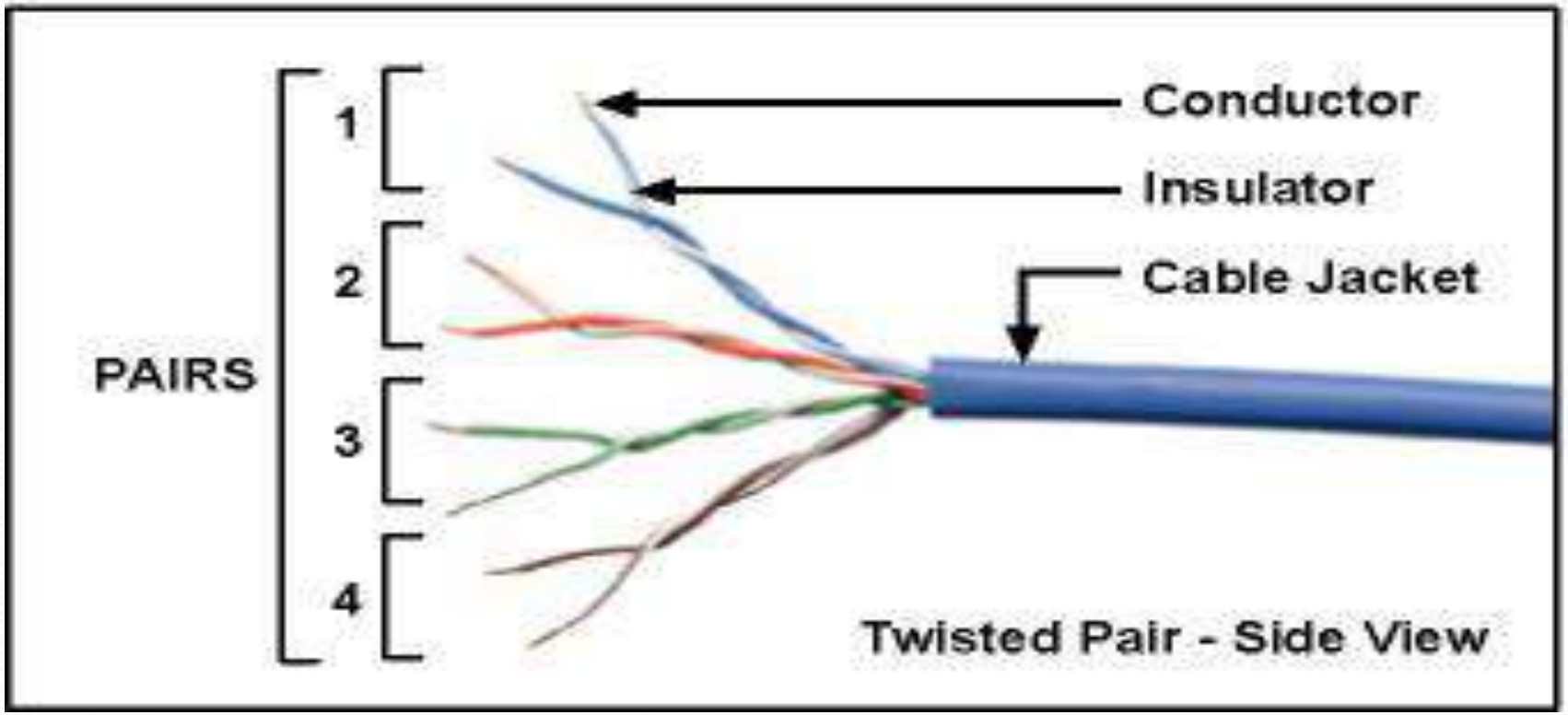
- The means through which data is transformed from one place to another is called transmission or communication media.
- Transmission media is a pathway through which data are transmitted in Communication Networks.
- There are two **types of transmission media:**
- **Guided Media**: use a conductor such as a wire or a fiber optic cable to move the signal from sender to receiver. Transmission capacity depends on the distance and on whether the medium is point-to-point or multipoint
- **Unguided Media**: The unguided media is the wireless media. It simply transports electromagnetic waves without using any physical conductor. Signals are normally broadcast through the air and thus are available to anyone who has the device capable of receiving them. Unguided signals can be travelled from source to the destination in several ways. These ways include ground propagation, sky propagation and line of sight propagation.

Guided Media	Unguided Media
The signal energy propagates within the guided media ..i.e. through wires.	The signal energy propagates through air.
It is mainly suited for point to point line configurations.	It is mainly used for broadcasting purpose.
The signal propagates in the form of voltage, current or photons.	The signal propagates in the form of electromagnetic waves.
Examples of guided media are:- =>Twisted Pair Cable =>Co-axial Cable =>Optical Fiber Cable	Examples are:- =>Microwave or Radio Links =>Infrared

Twisted Pair Cable

- A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in fig. below
- One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.
- In addition to the signal sent by the sender on one of the wires, interference (noise)and crosstalk may affect both wires and create unwanted signals.
- If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources(e,g., one is closer and the other is farther). This results in a difference at the receiver.
- By twisting the pairs, a balance is maintained. For example, suppose in one twist, one wire is closer to the noise source and the other is farther; in the next twist, the reverse is true.
- Twisting makes it probable that both wires are equally affected by external influences(noise or crosstalk). This means that the receiver, which calculates the difference between the two, receives no unwanted signals. The unwanted signals are mostly canceled out.
- The number of twists per unit of length(e.g., inch) has some effect on the quality of the cable.
- Types: UTP and STP

Twisted Pair Cable



Unshielded Twisted Pair

- Unshielded Twisted Pair (UTP) is the most common type of twisted pair cable used in Computer networks.
- The UTP consists of two copper conductors, each having their own insulating material (e.g. plastic), intertwined with each other to cancel induced current.
- The reason for placing twist in the pair of wires is to minimize the vulnerability of the twisted pair cable to external electrical noise.
- Its frequency range is suitable for data transmission as well as voice transmission (100 Hz-5 MHz).
- The Electronic Industries Association (EIA) has developed five standards or categories for UTP :

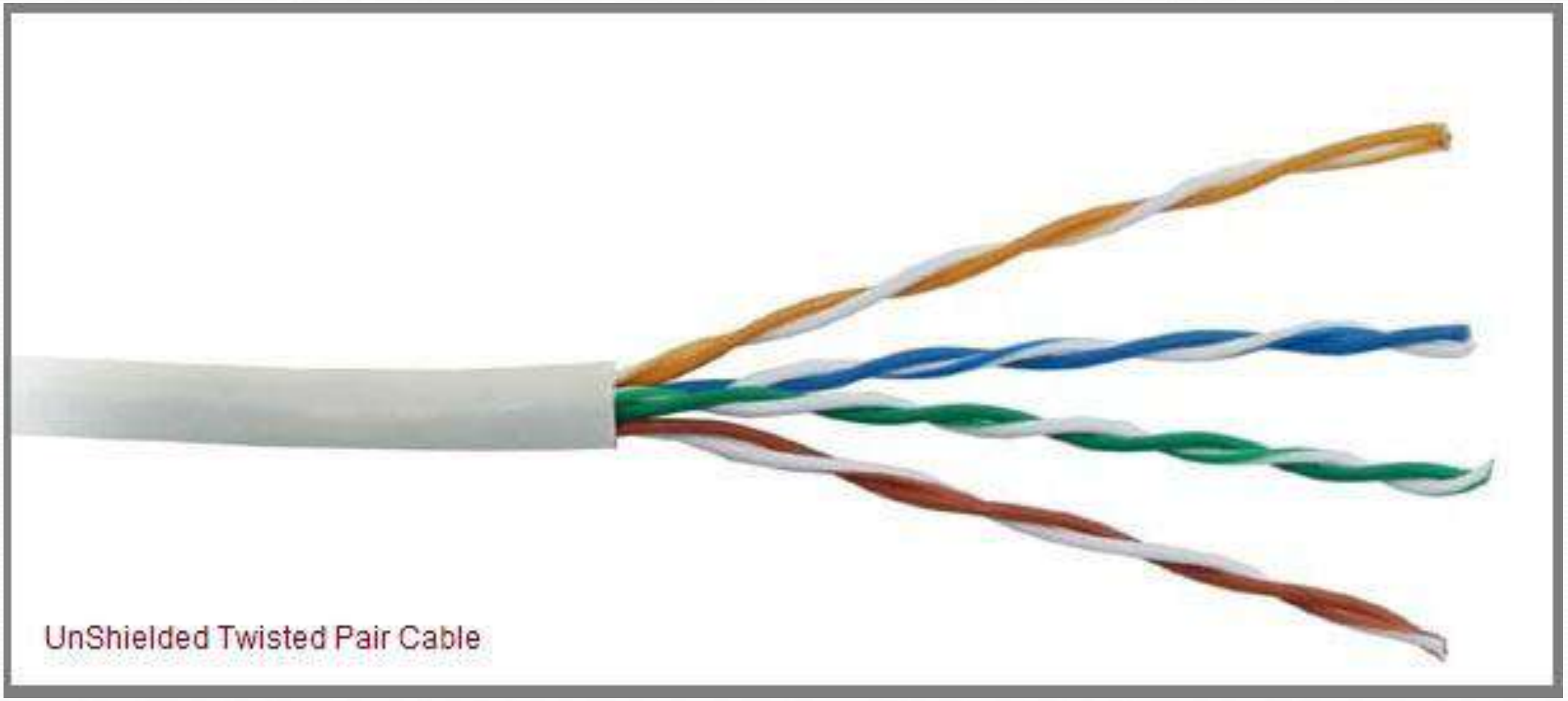

UnShielded Twisted Pair Cable

TABLE 1-2

Different UTP Category Cabling

UTP Category	Purpose	Transfer Rate
Category 1	Voice only	
Category 2	Data	4 Mbps
Category 3	Data	10 Mbps
Category 4	Data	16 Mbps
Category 5	Data	100 Mbps
Category 5e	Data	1 Gbps (1000 Mbps)
Category 6	Data	10 Gbps

Unshielded Twisted Pair Cable

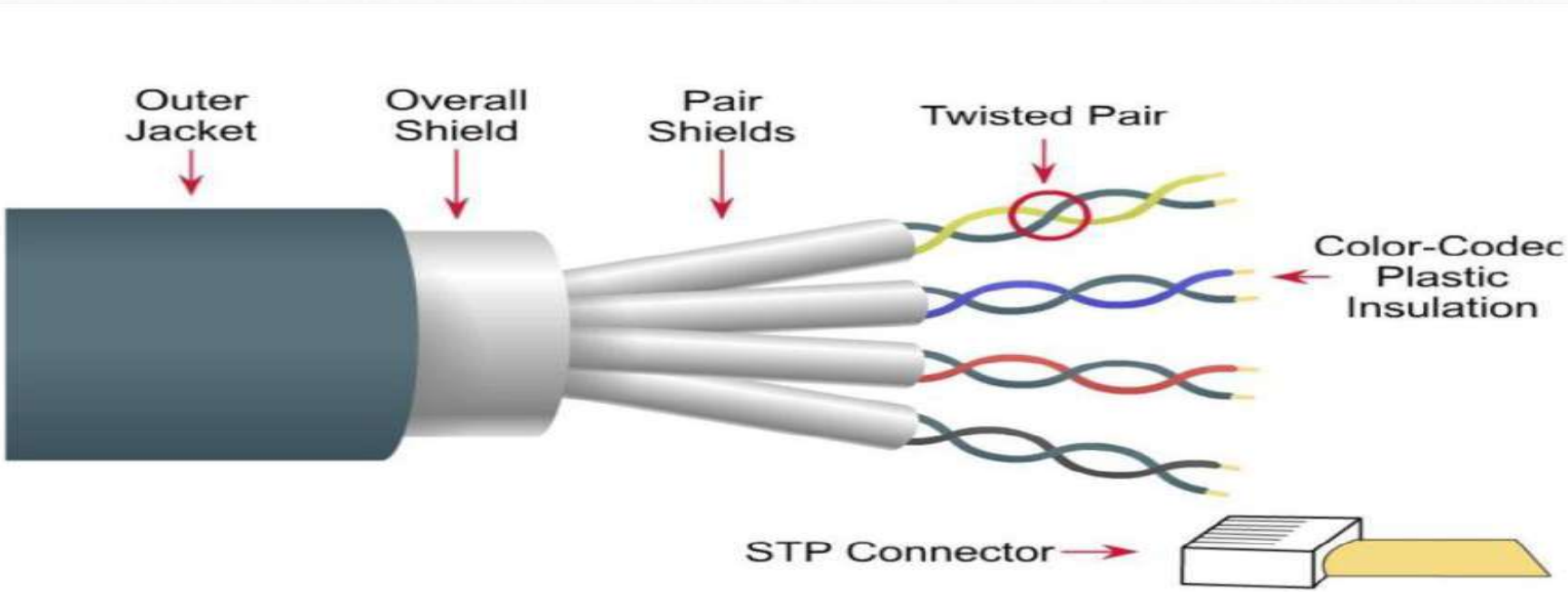
Advantages:

- The advantages of UTP are its low cost,
- It is easy to installation procedure.
- It is basically used in LAN implementations

Disadvantages:

- Bandwidth is low when compared with Coaxial Cable
- Provides less protection from interference

Shielded Twisted Pair Cable



- This cable has a metal foil or braided-mesh covering which encases each pair of insulated conductors.
- Electromagnetic noise penetration is prevented by metal casing. Shielding also eliminates crosstalk .
- It has same attenuation as unshielded twisted pair. It is faster than unshielded and coaxial cable. It is more expensive than coaxial and unshielded twisted pair.

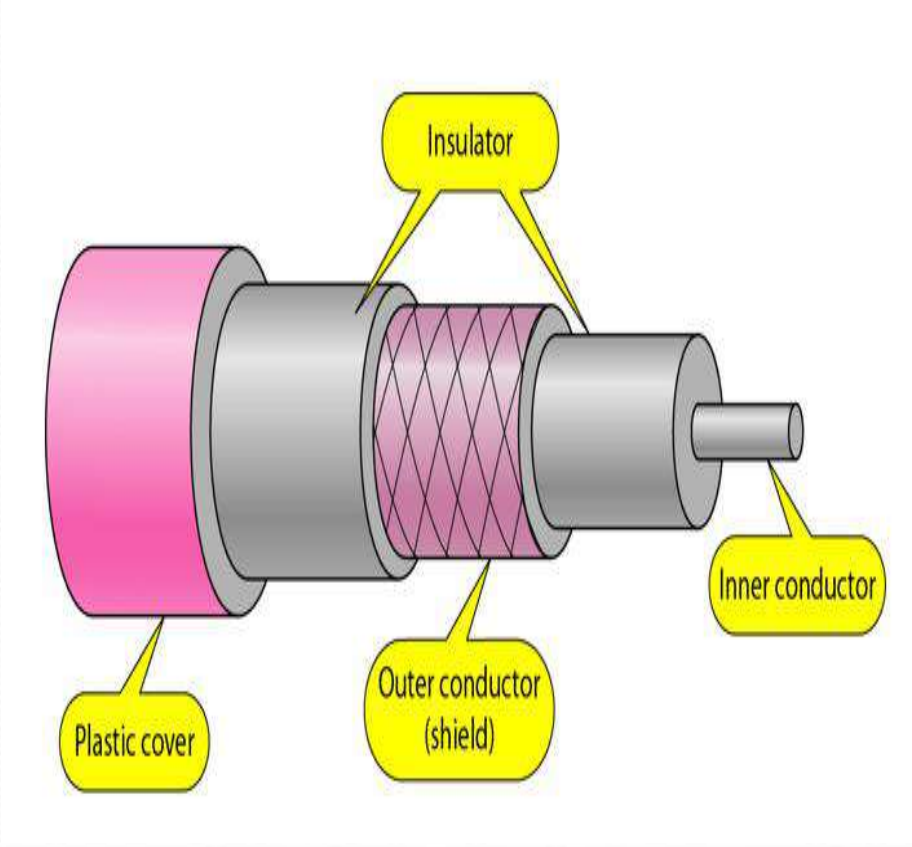
Advantages:

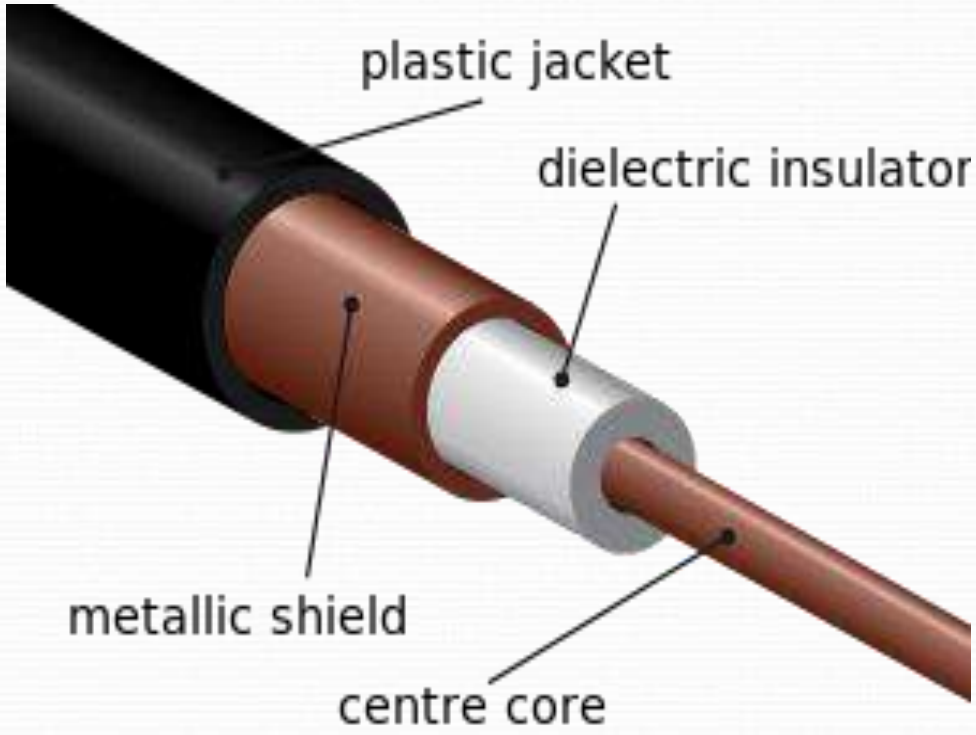
- Easy to install
- Performance is adequate
- Can be used for Analog or Digital transmission
- Increases the signalling rate
- Higher capacity than unshielded twisted pair
- Eliminates crosstalk

Disadvantages:

- Difficult to manufacture
- Heavy

Coaxial Cable





Coaxial Cable

- A coaxial cable is a specific type of cable that consists of four layers of material. There is an inner conductor, a dielectric insulating layer, another conductive layer, and an insulating layer.
- The cable is called coaxial because both the inner and outer conductive layers are on the same geometric axis.
- A cable consisting of an electrically conductive wire surrounded by a layer of insulating material, a layer of shielding material, and an outer layer of insulating material, usually plastic or rubber.
- The purpose of the shielding layer is to reduce external electrical interference. Coaxial cables are used for transmission of high-frequency audio, video, computer network and other signals.
- Used in Cable TV and Computer Network

Common Coaxial Standards

- 50-Ohm RG-7 or RG-11 : used with thick Ethernet.
- 50-Ohm RG-58 : used with thin Ethernet
- 75-Ohm RG-59 : used with cable television
- 93-Ohm RG-62 : used with ARCNET.

Types:

Thinnet

Thicknet

Thinnet:

- **Thinnet** is a flexible coaxial cable about ¼ inch thick. Thinnet is used for short-distance.
- Thinnet connects directly to a workstation's network adapter card using a British Naval Connector (BNC).
- The maximum length of thinnet is 185 meters.

Thicket:

- **Thicknet** coaxial is thicker cable than thinnet.
- Thicknet cable is about ½ inch thick and can support data transfer over longer distances than thinnet.
- Thicknet has a maximum cable length of 500 meters and usually is used as a backbone to connect several smaller thinnet-based networks.

Advantages and Disadvanntages

Advantages:

- It has better shield against electromagnetic interference than twisted pair cable, so it can span longer distance at higher data bits per second (bps).
- It can be used for both analog and digital data transmissions. For analog data transmission, 75-ohm broadband coaxial is used and for digital transmission, 50 – ohm baseband cable is used.
- It is inexpensive as compared to twisted pair wires and STP cables but easy to handle.
- Bandwidth is high
- Used in long distance communication

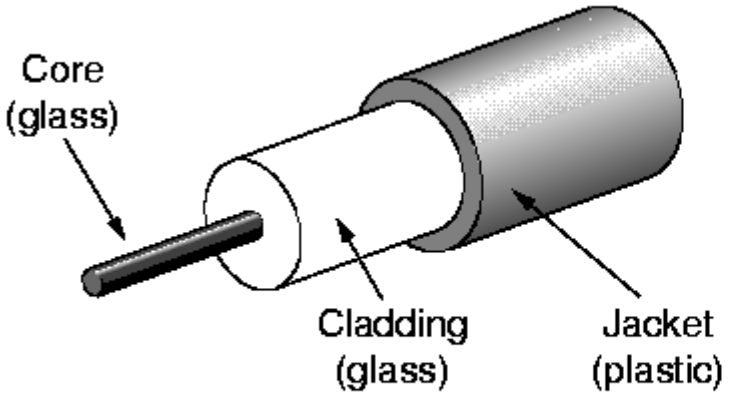
Disadvantages:

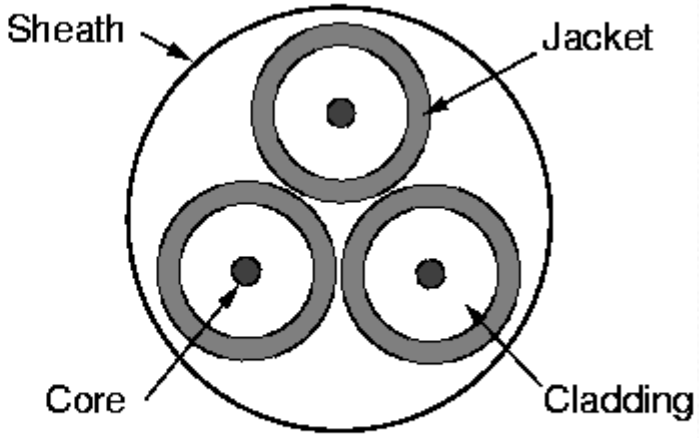
- Single cable failure can fail the entire network
- More expensive to install compare to twisted pair cable.
- The thicker the cable, the more difficult to work with.

Fiber Optic Cable

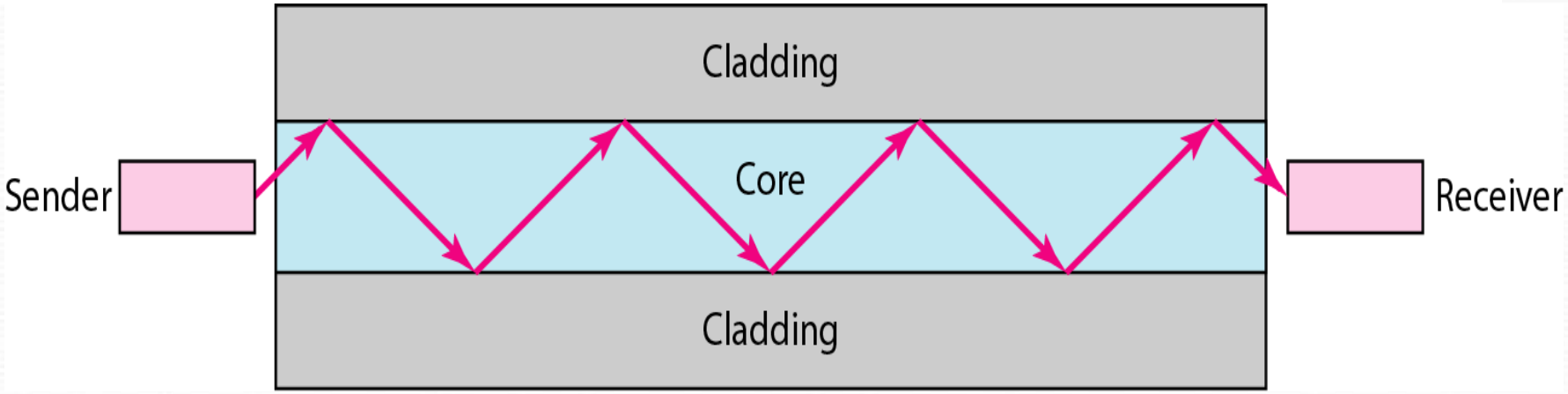
- A fibre-optic cable is made of glass or plastic and transmits signals in the form of light.
- Optical fibres use reflection to guide light through a channel.
- A glass or plastic core is surrounded by a cladding of less dense glass or plastic. The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.

Fiber Optic

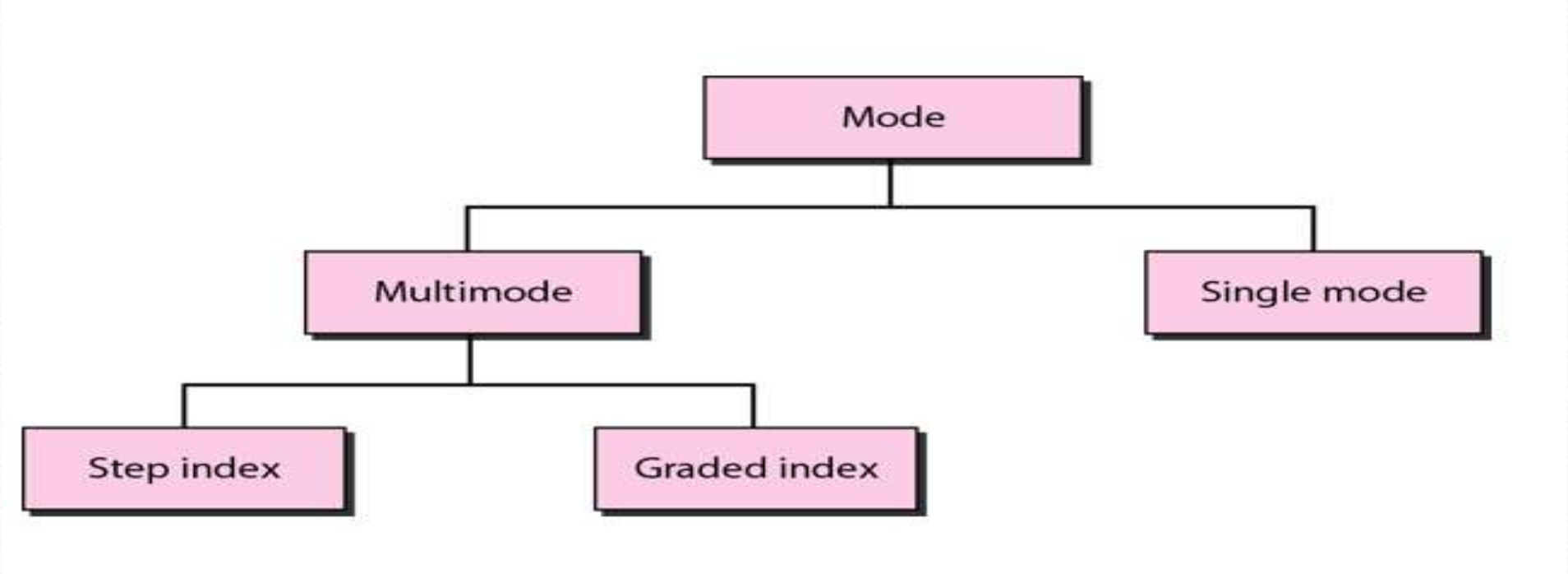


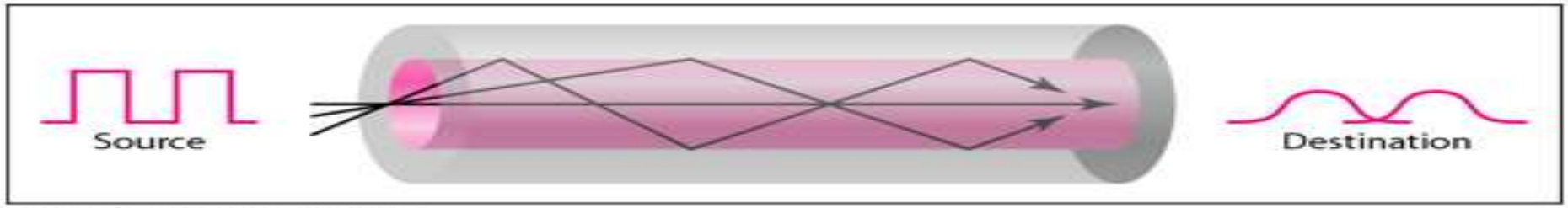


(a) (b)

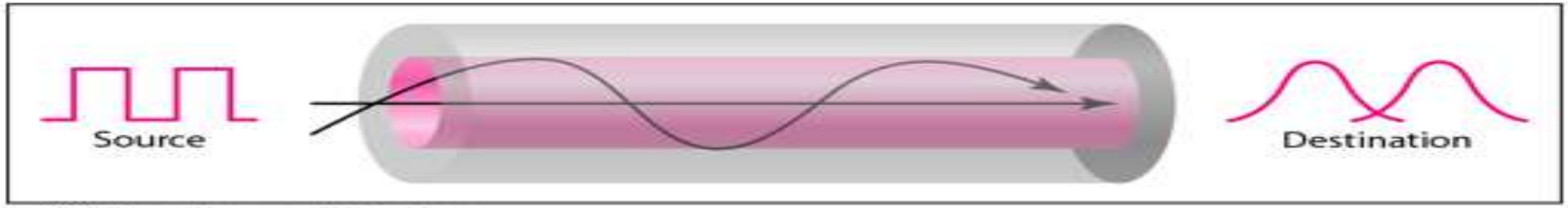


Propagation Modes of Fiber Optic Cable





a. Multimode, step index



b. Multimode, graded index

c. Single mode

Multimode Fiber

- Multimode is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.
- In **multimode step-index fibre**, the density of the core remains constant from the centre to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
  The term step-index refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fibre.
- In **multimode graded-index fibre**, this distortion gets decreases through the cable. The word index here refers to the index of refraction. This index of refraction is related to the density. A graded-index fibre, therefore, is one with varying densities. Density is highest at the centre of the core and decreases gradually to its lowest at the edge.

Single Mode Fiber

- Single-mode uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal.
- The single-mode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density .
- The decrease in density results in critical angle that is close enough to 90 degree to make the propagation of beams almost horizontal. In this case, propagation of different beams is almost identical, and delays are negligible.
- All the beams arrive at the destination "together" and can be recombined with little distortion to the signal.

Advantages:

- Higher bandwidth
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials
- Light weight
- Greater immunity to tapping

Disadvantages:

- Difficult to Installation and maintenance
- Unidirectional light propagation
- High Cost

Unguided Media:Infrared

- Electromagnetic waves having frequencies from 300 GHz to 400 THz.
- They are used for short range communication and use line of sight propagation.
- Infrared waves cannot pass through solid objects like walls (disadvantage).
- IR waves offer very large bandwidth for use.
- An infrared communication provides better security with minimum interference.
- Infrared communication is unreliable outside the building because the sun rays will interfere with the infrared waves.
- For e.g. Remote controls used for TV, DVD players, Communication between keyboard, mouse, printers.

Radio Wave

- Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.
- Radio waves are omnidirectional, i.e., the signals are propagated in all the directions.
- The range in frequencies of radio waves is from 3KHz to 300GHz.
- In the case of radio waves, the sending and receiving antenna are not aligned, i.e., the wave sent by the sending antenna can be received by any receiving antenna.
- An example of the radio wave is **FM radio**.

Applications Of Radio waves:

- A Radio wave is useful for multicasting when there is one sender and many receivers.
- An FM radio, television, cordless phones are examples of a radio wave.

Advantages Of Radio transmission:

- Radio transmission is mainly used for wide area networks and mobile cellular phones.
- Radio waves cover a large area, and they can penetrate the walls.
- Radio transmission provides a higher transmission rate.

Microwave

Microwaves are radio waves that are used to provide high-speed transmission. Both voice and data can be transmitted through microwave. Data is transmitted through the air form one microwave station to other similar to radio signals

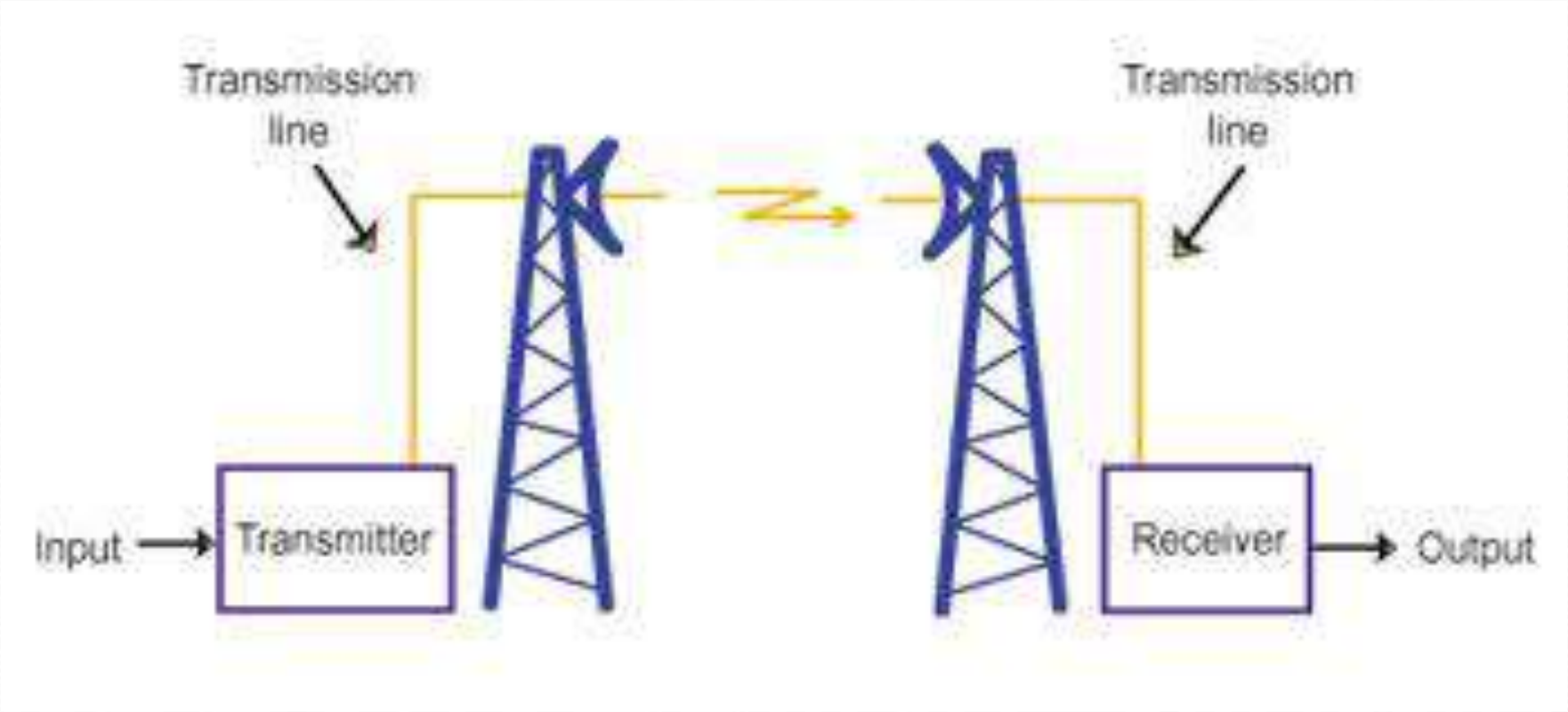
Microwaves are of two types:

- Terrestrial microwave
- Satellite microwave communication.

Terrestrial Microwave Transmission

- Terrestrial Microwave transmission is a technology that transmits the focused beam of a radio signal from one ground-based microwave transmission antenna to another.
- Microwaves are the electromagnetic waves having the frequency in the range from 1GHz to 1000 GHz.
- Microwaves are unidirectional as the sending and receiving antenna is to be aligned, i.e., the waves sent by the sending antenna are narrowly focussed.
- In this case, antennas are mounted on the towers to send a beam to another antenna which is km away.
- It works on the line of sight transmission, i.e., the antennas mounted on the towers are the direct sight of each other

Microwave


Transmission line
Transmission line
Input
Transmitter
Receiver
Output

- **Characteristics of Microwave:**
- **Frequency range:** The frequency range of terrestrial microwave is from 4-6 GHz to 21-23 GHz.
- **Bandwidth:** It supports the bandwidth from 1 to 10 Gbps.
- **Short distance:** It is inexpensive for short distance.
- **Long distance:** It is expensive as it requires a higher tower for a longer distance.
- **Attenuation:** Attenuation means loss of signal. It is affected by environmental conditions and antenna size.

Advantages and disadvantages

Advantages:

- Microwave transmission is cheaper than using cables.
- It is free from land acquisition as it does not require any land for the installation of cables.
- Microwave transmission provides an easy communication in terrains as the installation of cable in terrain is quite a difficult task.
- Communication over oceans can be achieved by using microwave transmission.

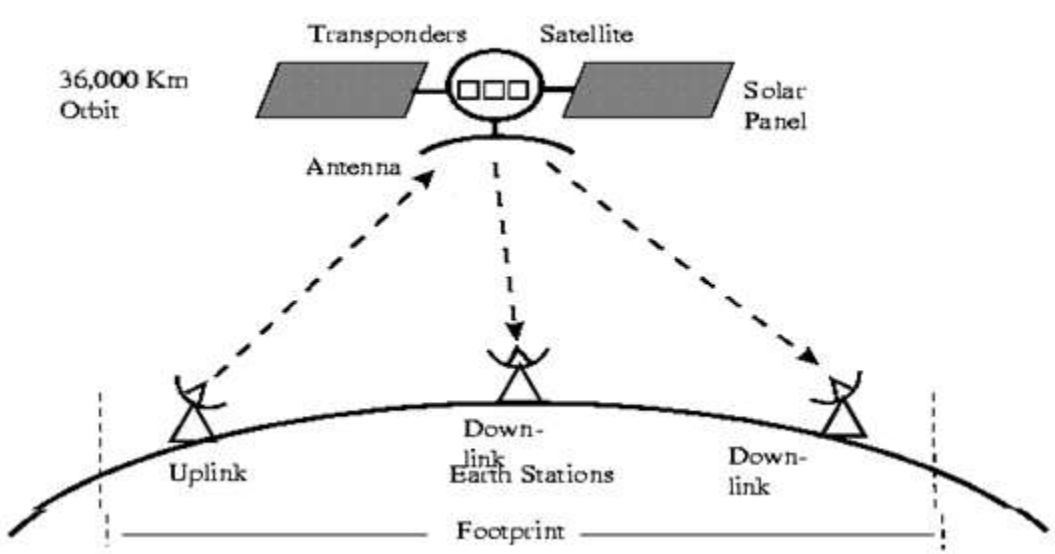
Disadvantages:

- **Eavesdropping:** An eavesdropping creates insecure communication. Any malicious user can catch the signal in the air by using its own antenna.
- **Out of phase signal:** A signal can be moved out of phase by using microwave transmission.
- **Susceptible to weather condition:** A microwave transmission is susceptible to weather condition. This means that any environmental change such as rain, wind can distort the signal.
- **Bandwidth limited:** Allocation of bandwidth is limited in the case of microwave transmission.

Satellite Microwave communication

- A satellite is a physical object that revolves around the earth at a known height.
- Satellite communication is more reliable nowadays as it offers more flexibility than cable and fibre optic systems.
- We can communicate with any point on the globe by using satellite communication.
- **How Does Satellite work?**
- The satellite accepts the signal that is transmitted from the earth station, and it amplifies the signal. The amplified signal is retransmitted to another earth station.

Satellite


Transponders
Satellite
36,000 Km
Orbit
Solar
Panel
Antenna
Down-
link
Uplink
Earth Stations
Down-
link
Footprint

Advantages:

- The coverage area of a satellite microwave is more than the terrestrial microwave.
- The transmission cost of the satellite is independent of the distance from the centre of the coverage area.
- Satellite communication is used in mobile and wireless communication applications.
- It is used in a wide variety of applications such as weather forecasting, radio/TV signal broadcasting, mobile communication, etc.

Disadvantages :

- Satellite designing and development requires more time and higher cost.
- The Satellite needs to be monitored and controlled on regular periods so that it remains in orbit.
- The life of the satellite is about 12-15 years. Due to this reason, another launch of the satellite has to be planned before it becomes non-functional.

Ethernet Standards

- **Ethernet** is the most widely used local area network (LAN) technology, that defines wiring and signaling **standards** for the physical layer of TCP/IP.
- IEEE 802.3 is the signaling standards for Ethernet, and IEEE 802.11 is the standards for Wi-Fi.
- **Ethernet** was originally standardized as IEEE 802.3 with a data transmission rate of 10 Mb/s.
- Newer versions of Ethernet were introduced lately to offer higher data rates.
- Fast Ethernet and Gigabit Ethernet support data rates of 100 Mbps and 1 Gbps (1000 Mbps) respectively. An Ethernet LAN may use coaxial cable (10Base2), unshielded twisted pair wiring (10BaseT, 100BaseT and 1000BaseT), or fiber optic cable.
- Ethernet devices compete for access to the network using a protocol called Carrier Sense Multiple Access with Collision Detection (CSMA/CD).
- With the prosperity of Internet, Wi-Fi, the wireless LAN technology standardized by IEEE 802.11, is used in hybrid with Ethernet LAN to offer portability.

UTP Categories - Copper Cable

UTP Category	Data Rate	Max. Length	Cable Type	Application
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Rink & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

Optical Fiber standards

- There are two main groups that cover international standards: IEC and ITU.

IEC – International Electrotechnical Commission

- IEC is a global organization and it makes international standards that covers all electrical, electronic, and related technologies. These international standards serve as a basis for national standardization.
- IEC is composed of many technical committees. Each committee prepares technical documents on specific subjects. For example, TC86 committee focuses on fiber optics, and its subcommittees SC86A, SC86B, and SC86C focus on one corresponding particular subject.
- SC86A – Fibers and Cables
- SC86B – Fiber Optic Interconnecting Devices and Passive Components
- SC86C – Fiber Optic Systems and Active Devices

ITU – International Telecommunication Union

- ITU is an international organization. They define guidelines, technical characteristics, and specifications for telecom systems, networks, and services. They also cover optical fiber performance and test & measurement applications.
- ITU is composed of three different sectors.
- Radiocommunication Sector (ITU-R)
- Telecommunication Standardization Sector (ITU-T)
- Telecommunication Development Sector (ITU-D)

Switching Techniques

In large networks there might be multiple paths linking sender and receiver

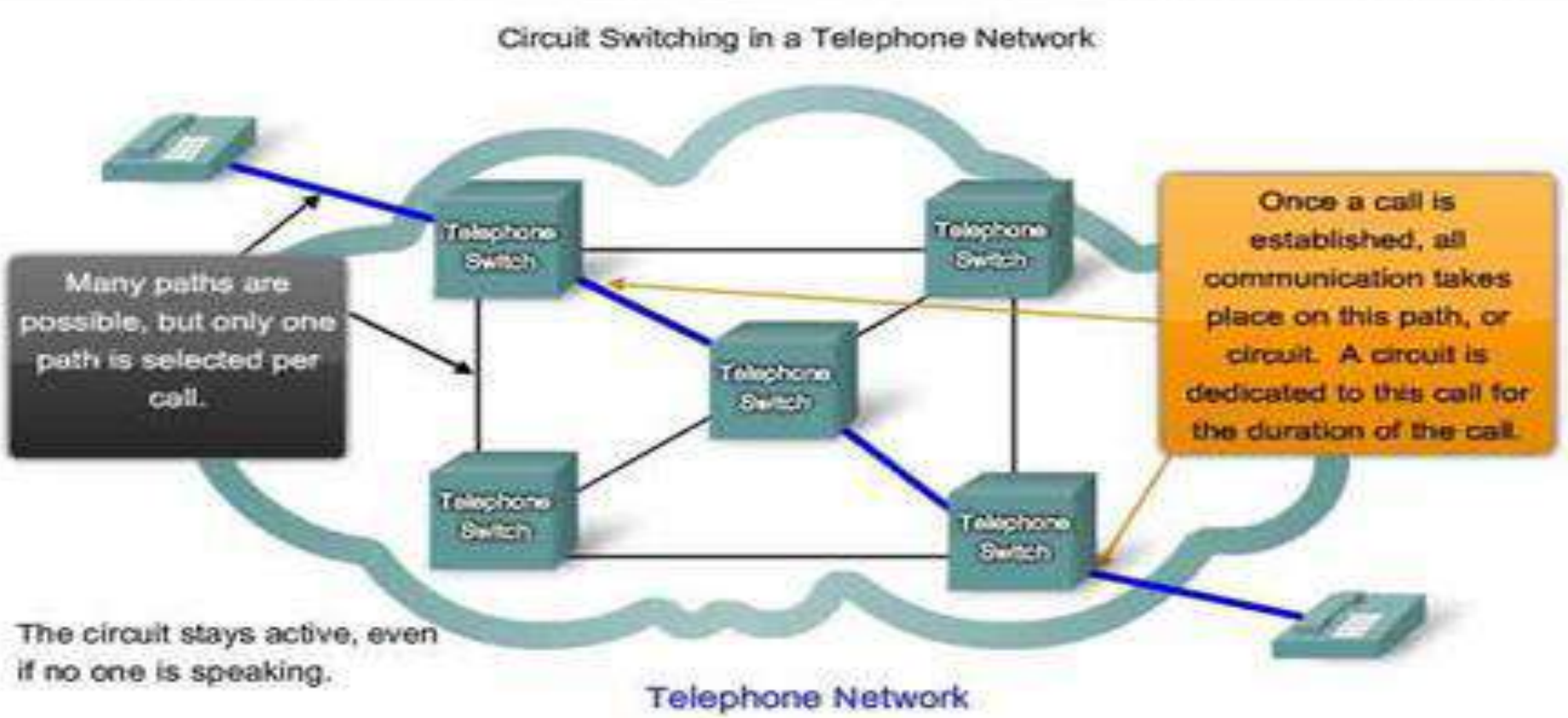
Information may be switched as it travels through various communication channels.

There are three typical switching techniques available for digital traffic.

- Circuit Switching
- Message Switching
- Packet Switching

Circuit Switching

- **Circuit switching** is a technique that directly connects the sender and the receiver in an unbroken path.
- Circuit switching was designed in 1878 in order to send telephone calls down a dedicated channel.
- This channel remains open and in use throughout the whole call and cannot be used by any other data or phone calls
- There are three phases in circuit switching:
  - Establish
  - Transfer
  - Disconnect
- Telephone switching equipment, for example, establishes a path that connects the caller's telephone to the receiver's telephone by making a physical connection.
- With this type of switching technique, once a connection is established, a dedicated path exists between both ends until the connection is terminated.
- Routing decisions must be made when the circuit is first established, but there are no decisions made after that time.


Circuit Switching in a Telephone Network
Many paths are possible, but only one path is selected per call.
Telephone Switch
Telephone Switch
Telephone Switch
Telephone Switch
Telephone Switch
Once a call is established, all communication takes place on this path, or circuit. A circuit is dedicated to this call for the duration of the call.
The circuit stays active, even if no one is speaking.
Telephone Network

Circuit Switching

- **Circuit switching** in a network operates almost the same way as the telephone system works.
- A complete end-to-end path must exist before communication can take place.
- The computer initiating the data transfer must ask for a connection to the destination.
- Once the connection has been initiated and completed to the destination device, the destination device must acknowledge that it is ready and willing to carry on a transfer.

Circuit switching

Advantages:

- The communication channel (once established) is dedicated
- Guaranteed the full bandwidth for the duration of the call
- Guaranteed quality of service

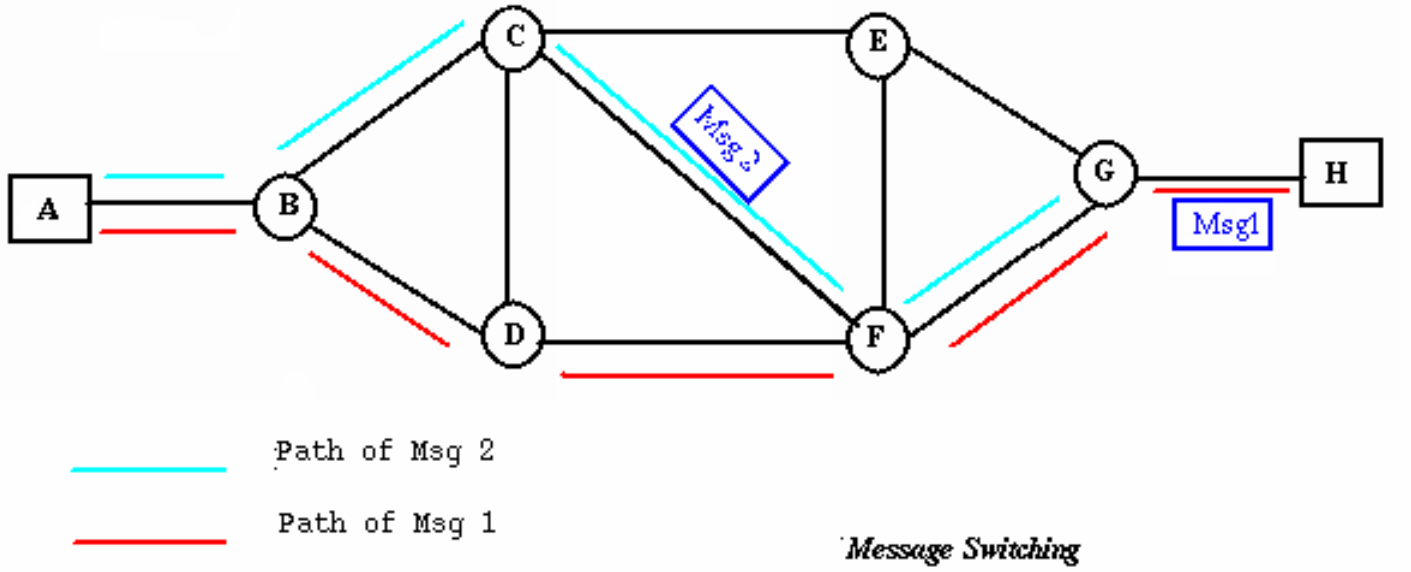
Disadvantages:

- Possible long wait to establish a connection, (10 seconds, more on long- distance or international calls.) during which no data can be transmitted.
- More expensive than any other switching techniques, because a dedicated path is required for each connection.
- Inefficient use of the communication channel, because the channel is not used when the connected systems are not using it.

Message Switching

- With message switching there is no need to establish a dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network, in its entirety, from node to node.
- Each node receives the entire message, stores it in its entirety on disk, and then transmits the message to the next node.
- This type of network is called a store-and-forward network.

Message Switching



A message-switching node is typically a general-purpose computer. The device needs sufficient secondary-storage capacity to store the incoming messages, which could be long. A time delay is introduced using this type of scheme due to store-and-forward time, plus the time required to find the next node in the transmission path.

Message Switching

Advantages:

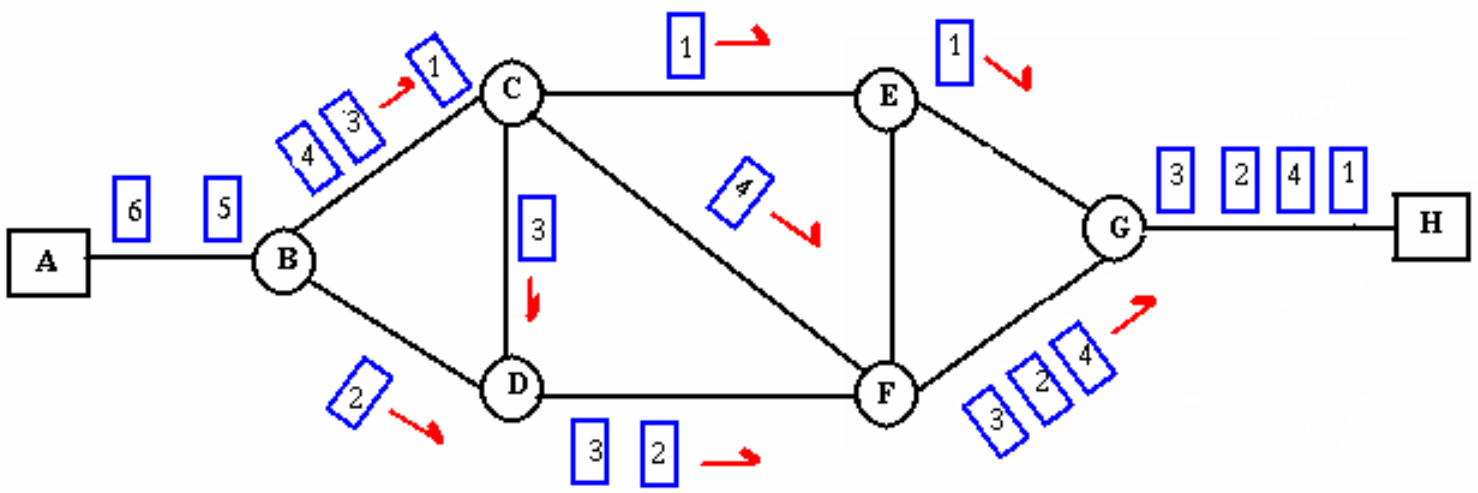
- Channel efficiency can be greater compared to circuit-switched systems, because more devices are sharing the channel.
- Traffic congestion can be reduced, because messages may be temporarily stored in route.
- Message priorities can be established due to store-and-forward technique.
- Message broadcasting can be achieved with the use of broadcast address appended in the message.

Disadvantages

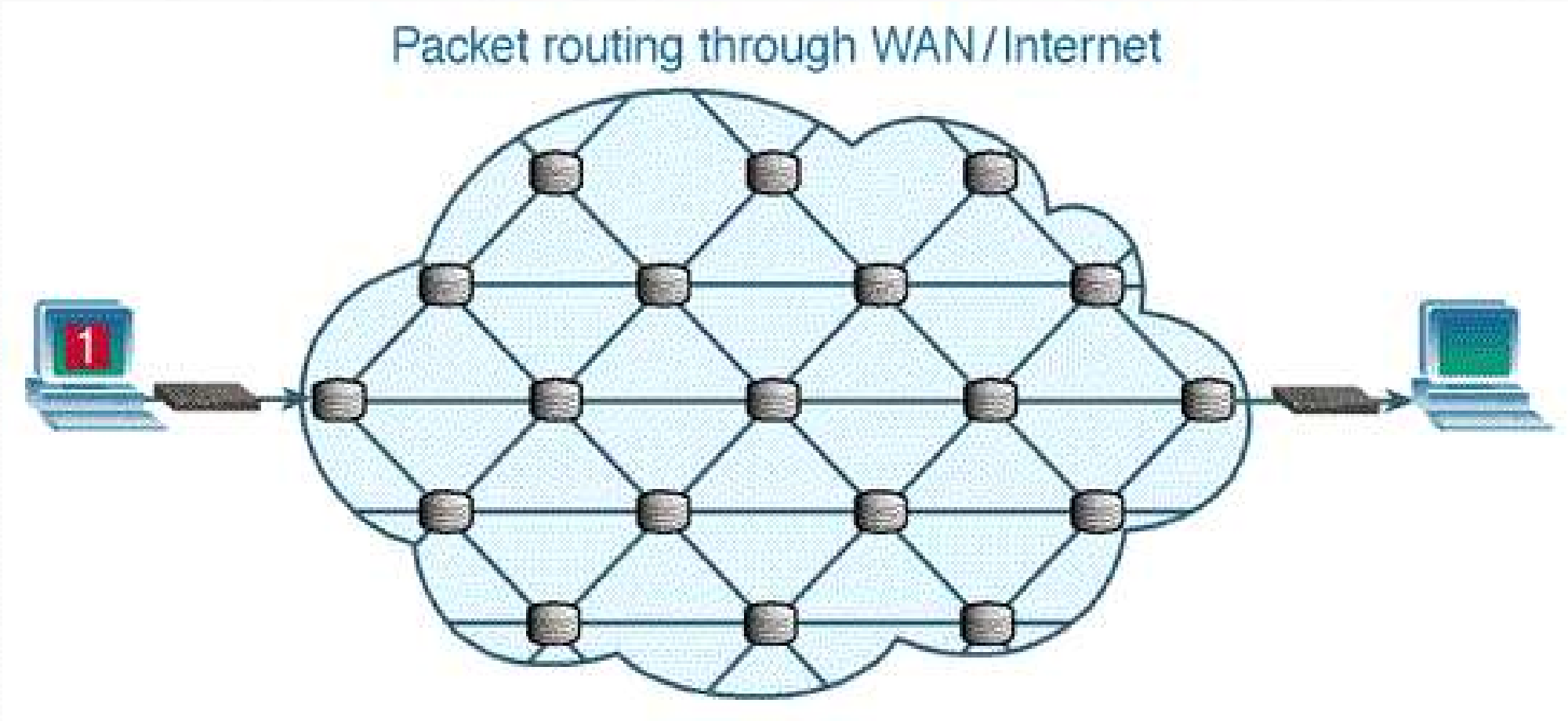
- Message switching is not compatible with interactive applications.
- Store-and-forward devices are expensive, because they must have large disks to hold potentially long messages.

Packet Switching

- *Packet switching* can be seen as a solution that tries to combine the advantages of message and circuit switching and to minimize the disadvantages of both.
- There are two methods of packet switching: Datagram and virtual circuit.



Packet Switching


Packet routing through WAN / Internet
1

Packet Switching

- In both packet switching methods, a message is broken into small parts, called packets.
- Each packet is tagged with appropriate source and destination addresses.
- Since packets have a strictly defined maximum length, they can be stored in main memory instead of disk, therefore access delay and cost are minimized.
- Also the transmission speeds, between nodes, are optimized.
- With current technology, packets are generally accepted onto the network on a first-come, first-served basis. If the network becomes overloaded, packets are delayed or discarded (``dropped'').

Packet Switching: Datagram

- Datagram packet switching is similar to message switching in that each packet is a self-contained unit with complete addressing information attached.
- This fact allows packets to take a variety of possible paths through the network.
- So the packets, each with the same destination address, do not follow the same route, and they may arrive out of sequence at the exit point node (or the destination).
- Reordering is done at the destination point based on the sequence number of the packets.
- It is possible for a packet to be destroyed if one of the nodes on its way is crashed momentarily. Thus all its queued packets may be lost.

Packet Switching:Virtual Circuit

- In the virtual circuit approach, a preplanned route is established before any data packets are sent.
- A logical connection is established when
  - a sender send a "call request packet" to the receiver and
  - the receiver send back an acknowledge packet "call accepted packet" to the sender if the receiver agrees on conversational parameters.
- The conversational parameters can be maximum packet sizes, path to be taken, and other variables necessary to establish and maintain the conversation.
- Virtual circuits imply acknowledgements, flow control, and

Packet Switching:Virtual Circuit

- In virtual circuit, the route between stations does not mean that this is a dedicated path, as in circuit switching.
- A packet is still buffered at each node and queued for output over a line.
- The difference between virtual circuit and datagram approaches:

  - With virtual circuit, the node does not need to make a routing decision for each packet.
  - It is made only once for all packets using that virtual circuit.

Packet Switching: Virtual Circuit

VC's offer guarantees that

- the packets sent arrive in the order sent
- with no duplicates or omissions
- with no errors (with high probability)

regardless of how they are implemented internally.

Advantages of packet switching

Advantages:

- Packet switching is cost effective, because switching devices do not need massive amount of secondary storage.
- Packet switching offers improved delay characteristics, because there are no long messages in the queue (maximum packet size is fixed).
- Packet can be rerouted if there is any problem, such as, busy or disabled links.
- The advantage of packet switching is that many network users can share the same channel at the same time. Packet switching can maximize link efficiency by making optimal use of link bandwidth.

Disadvantages of packet switching

Disadvantages:

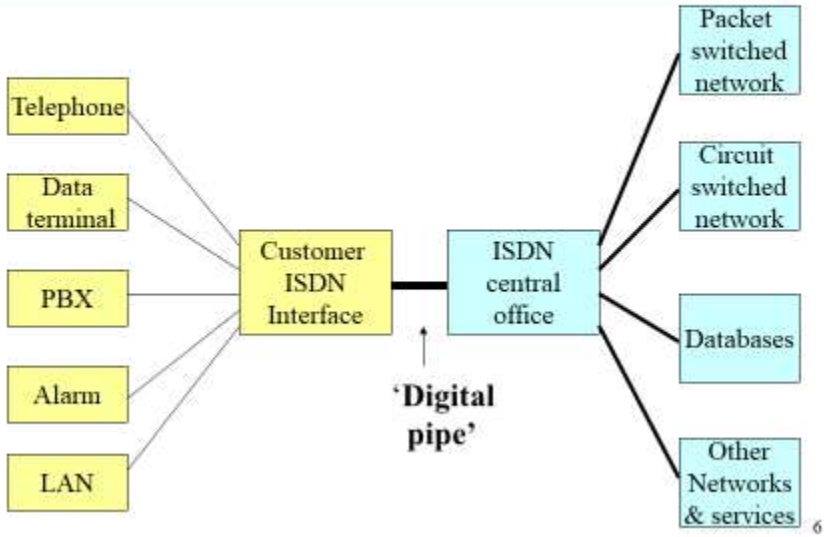
- Protocols for packet switching are typically more complex.
- It can add some initial costs in implementation.
- If packet is lost, sender needs to retransmit the data.
- Another disadvantage is that packet-switched systems still can't deliver the same quality as dedicated circuits in applications requiring very little delay - like voice conversations or moving images.

Circuit Switching	Datagram Packet	Virtual Circuit Packet
Dedicated path	No dedicated path	No dedicated path
Path established for entire conversation	Route established for each packet	Route established for entire conversation
Call set up delay	Packet transmission delay	Call set up delay, Packet transmission delay
Overload may block call set up	Overload increases packet delay	Overload may block call set up and increases packet delay
No speed or code conversion	Speed or code conversion	Speed or code conversio
Fixed bandwidth	Dynamic bandwidth	Dynamic bandwidth
No overhead bits after call set up	Overhead bits in each packet	Overhead bits in each packet

ISDN

- Integrated Services Digital Network in concept is the integration of both analog or voice data together with digital data over the same network.
- Although the ISDN integrates these on a medium designed for analog transmission, broadband ISDN (BISDN) will extend the integration of both services throughout the rest of the end-to-end path using fiber optic and radio media.
- Integrated Services Digital Network is a telephone system network. It is a wide area network becoming widely available.
- Prior to the ISDN, the phone system was viewed as a way to transport voice, with some special services available for data.
- The key feature of the ISDN is that it integrates speech and data on the same lines, adding features that were not available in the classic telephone system.
- ISDN is a circuit -switched telephone network system, that also provides access to packet switched networks, designed to allow digital transmission of voice and data over ordinary telephone copper wires, resulting in better voice quality than· an analog phone.

Integrated Services Digital Network



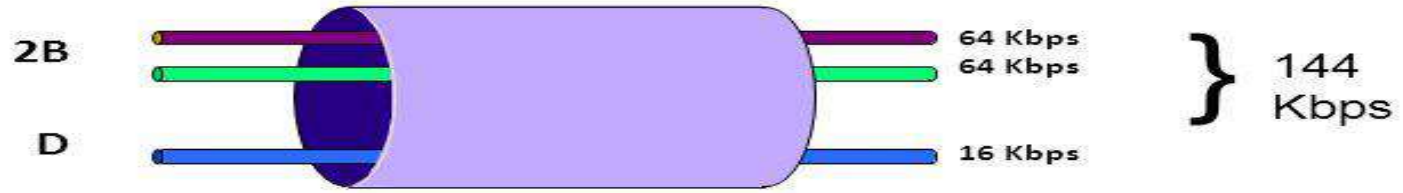
ISDN Interfaces

- There are various kinds of interfaces defined by ISDN such as Basic Rate Interface (BRI), Primary Rate Interface (PRI), and Broadband (B-ISDN).
- **Basic Rate Interface (BRI)**
- Basic Rate Interface of ISDN contains two 64-B channel and one D- channel for broadcasting control information. In some circumstances it refers to as 2B+D.
- **Primary Rate Interface (PRI)**
- ISDN Primary Rate Interface (PRI) contains 23 B-channel and one D-channel in US and in Europe it contains 30 B-channel and one D-channel.
- Primary Rate Interface is very well-liked all over the world particularly for PSTN circuits to PBXs. Many networks all through the world use the term ISDN to refer low bandwidth circuits.

- **Broadband (B-ISDN)**
- An additional version of ISDN is called B-ISDN (Broadband ISDN) make use of broadband communications. Broadband is capable to carry broadcasting rate of 1.5 Mbps.
- B-ISDN (Broadband ISDN) mainly have need of fiber optic cables.
- To get access it is compulsory to subscribe the ISDN phone line and consumer should required special devices for it such as terminal adapter which is used for communication with the telephone company switch or other ISDN devices.
- Most broadband channel carries 64 kbit/s signals

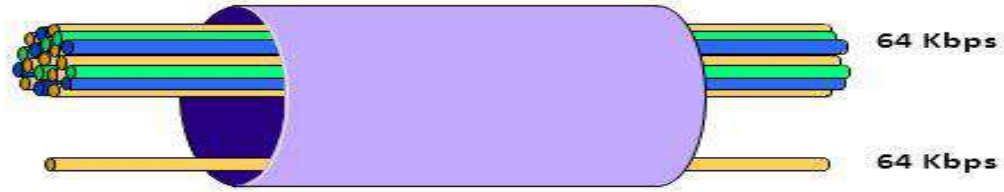
ISDN Interfaces

Basic Rate Interface (BRI)



144 Kbps

Primary Rate Interface (PRI)



1.544 Mbps in U.S.

2.048 Mbps in Europe

FRANKLIN UNIVERSITY

Sevices of ISDN

ISDN provides a fully integrated digital service to users.

These services fall into 3 categories- bearer services, teleservices and supplementary services.

Bearer Services –

- Transfer of information (voice, data and video) between users without the network manipulating the content of that information is provided by the bearer network.
- There is no need for the network to process the information and therefore does not change the content. Bearer services belong to the first three layers of the OSI model.
- They are well defined in the ISDN standard. They can be provided using circuit-switched, packet-switched, frame-switched, or cell-switched networks.

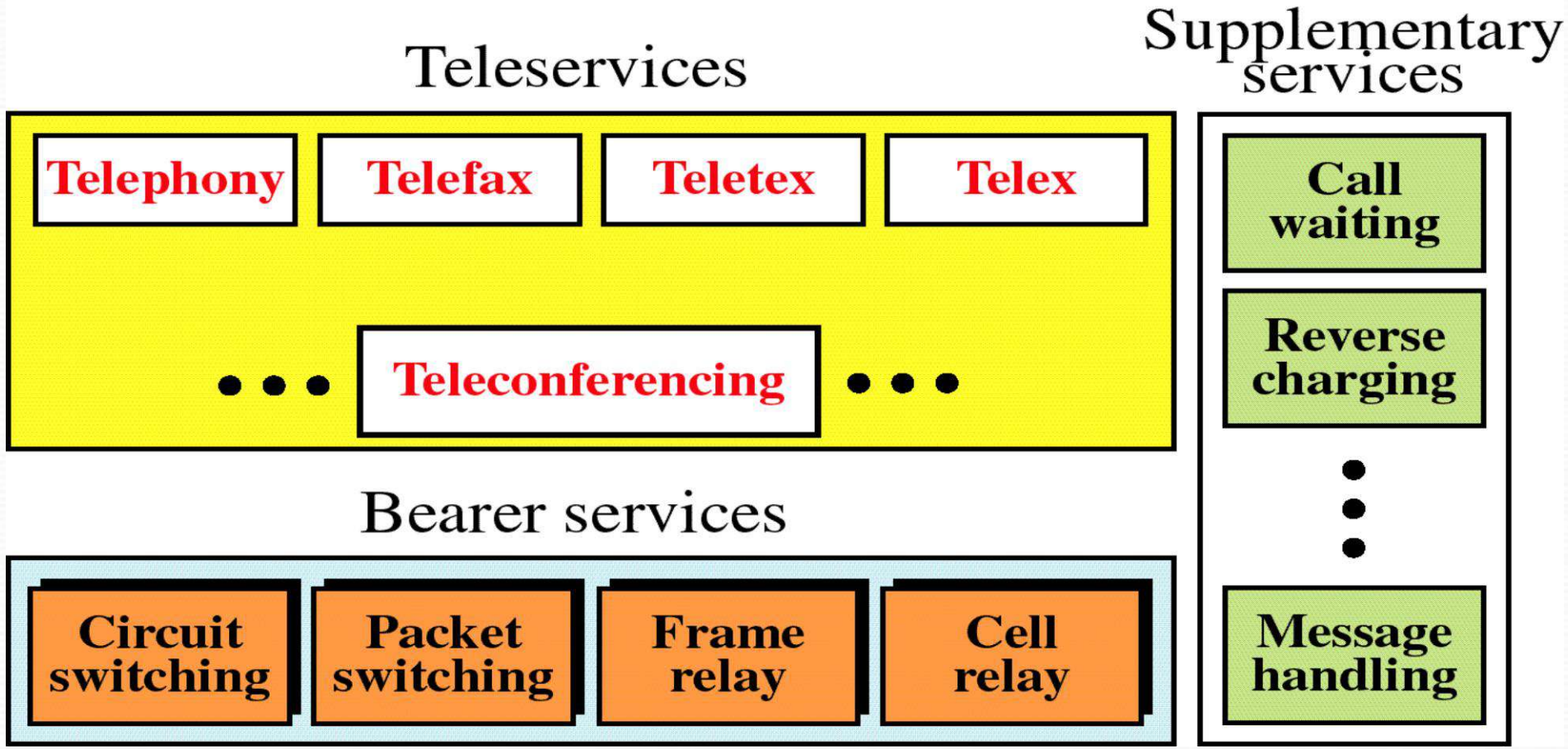
Teleservices –

- In this the network may change or process the contents of the data. These services corresponds to layers 4-7 of the OSI model.
- Teleservices include telephony, teletex, telefax, videotex, telex and teleconferencing. Though the ISDN defines these services by name yet they have not yet become standards.

Supplementary Service –

- Additional functionality to the bearer services and teleservices are provided by supplementary services. Reverse charging, call waiting, and message handling are examples of supplementary services which are all familiar with today's telephone company services.

ISDN Services



ISDN Channels and their Applications

B Channel (64 kbps)	**D Channel (16/64 kbps)**	**H Channel (384/1536 kbps)**
Digital voice	Signalling (using SS#7)	High-speed trunk
High-speed data (e.g. packet and circuit switched data)	Low- speed data, (e.g. packet, terminal, videotex)	Very high speed data
Other (e.g. fax, slow video)	Other (e.g. telemetry)	Other (e.g. fast fax. Video)

Advantages

- The basic advantage of ISDN is to facilitate the user with multiple digital channels. These channels can operate concurrently through the same one copper wire pair.
- The digital signals broadcasting transversely the telephone lines.
- ISDN provides high data rate because of digital scheme which is 56kbps.
- ISDN network lines are able to switch manifold devices on the single line such as faxes, computers, cash registers credit cards readers, and many other devices. These all devices can work together and directly be connected to a single line.

Disadvantages

- The disadvantage of ISDN lines is that it is very costly than the other typical telephone system.
- ISDN requires specialized digital devices just like Telephone Company.

ISDN Standards

- ISDN works based on the standards defined by ITU-T (formerly CCITT).
- The Telecommunication Standardization Sector (ITU-T) coordinates standards for telecommunications on behalf of the International Telecommunication Union (ITU) and is based in Geneva, Switzerland.
- The various principles of ISDN as per ITU-T recommendation are:
- To support switched and non-switched applications
- To support voice and non-voice applications
- Reliance on 64-kbps connections
- Intelligence in the network
- Layered protocol architecture
- Variety of configurations