THE PHYSICAL LAYER

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- Physical Layer operations
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- Physical Layer Principals
- Physical Media and Types
- Media Connectors
- Transmission Impairment
- Circuit and Packet Switching
- The pubic switch telephone Network
- Cable Television

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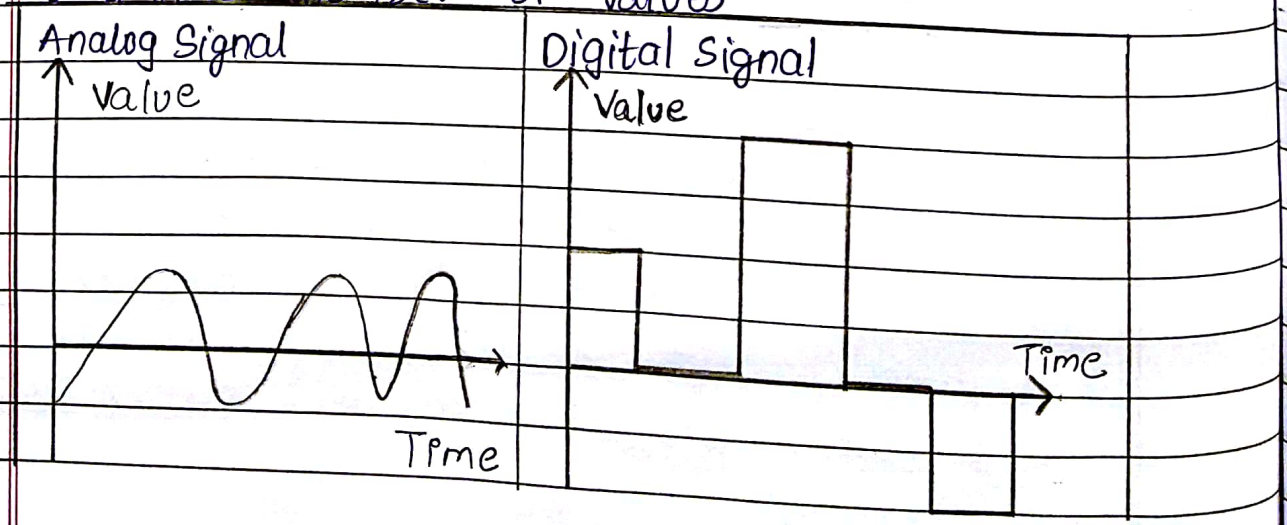
COMMUNICATION SIGNALS

To be transmitted, data must be transformed to electromagnetic signals

ELECTROMAGNETIC SIGNALS

ANALOG | DIGITAL

- The term analog data refers to the information that is continuous, digital data refers to information that has discrete states.
- Analog data take on continuous values. Digital data take on discrete values.
- Analog signals can have an infinite number of values in a range; digital signals can have only a limited number of values.



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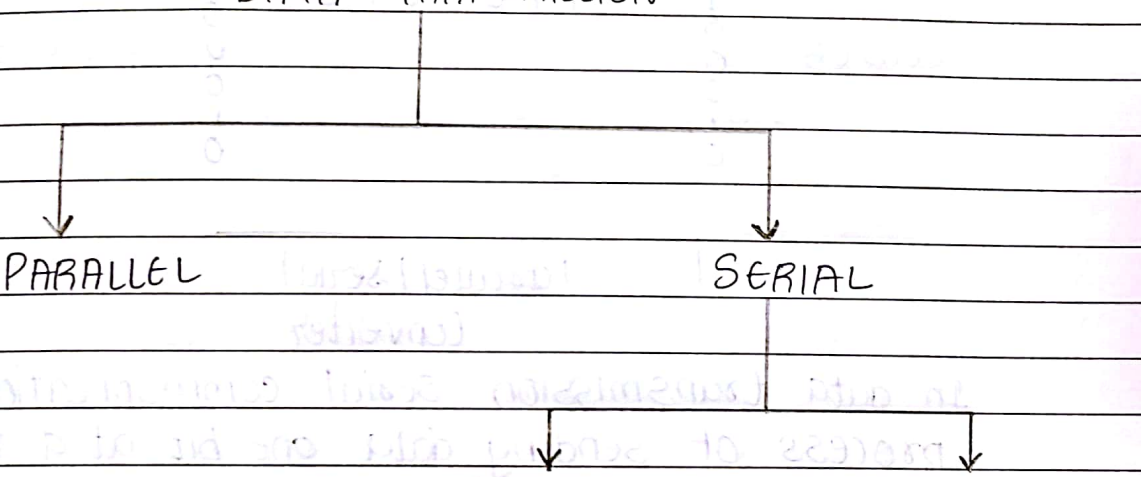
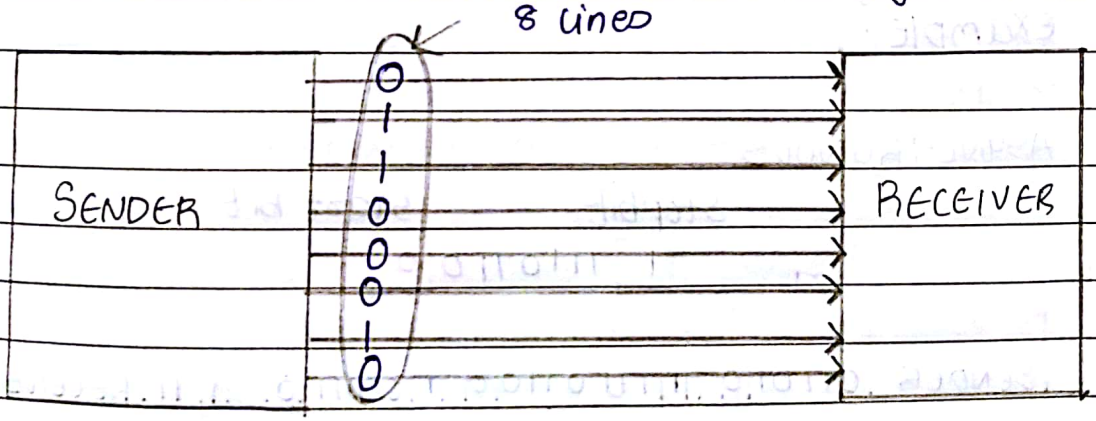
TYPES OF DATA TRANSMISSION



1] PARALLEL



- In data transmission, parallel communication is a method of conveying multiple binary digits (bits) simultaneously
- Parallel communication is and always has been widely used within integrated circuits, in peripheral buses, and in memory devices such as RAM.

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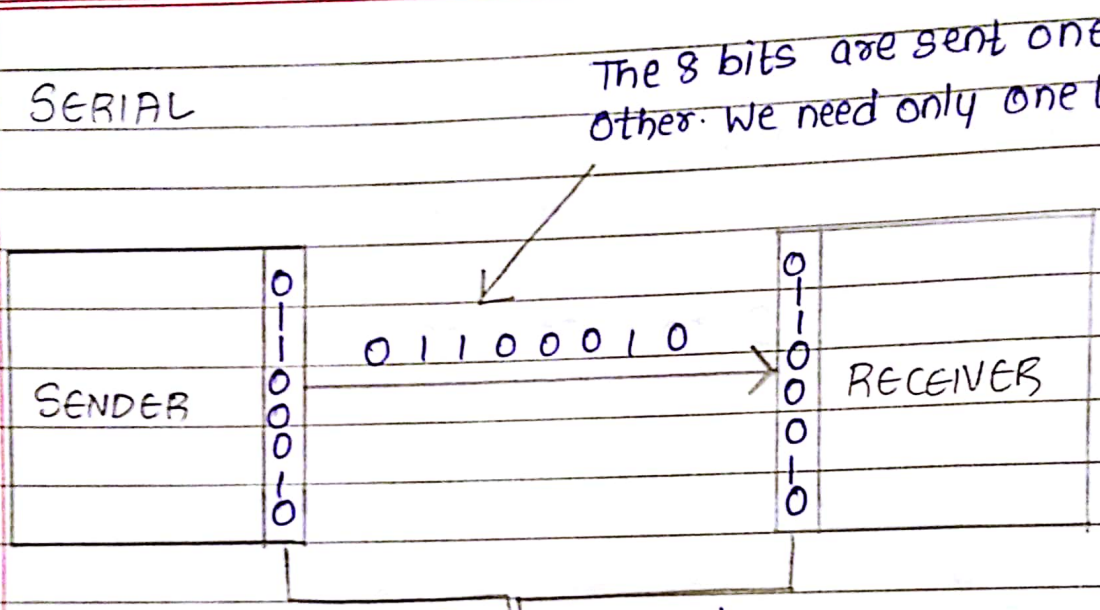
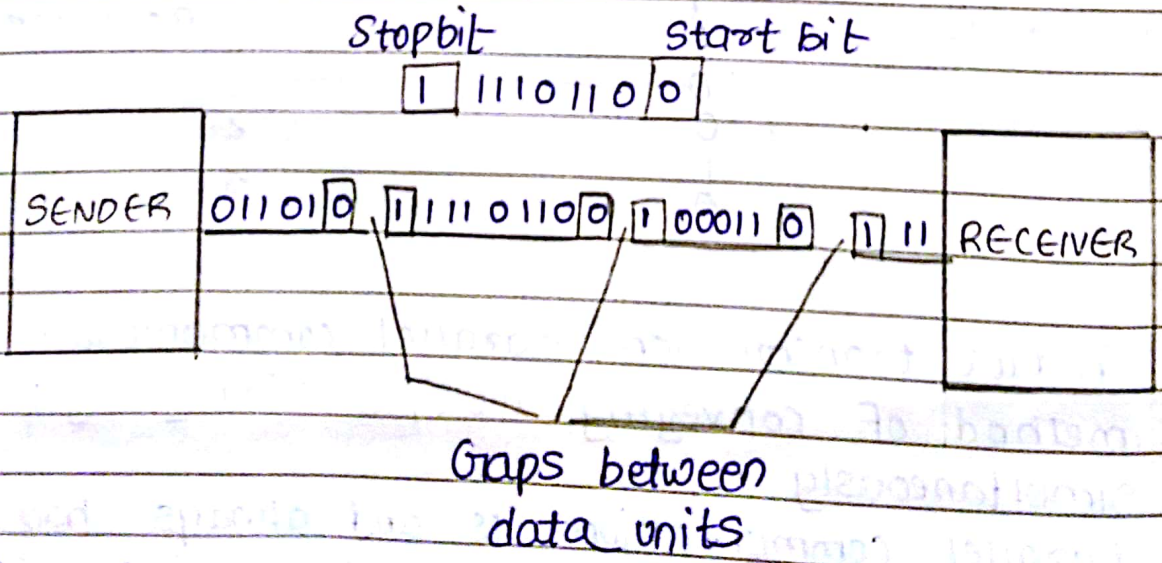
2.] SERIAL



- In data transmission, serial communication is the process of sending data one bit at a time, sequentially, over a communication channel or computer bus.
- The migration from PCI to PCI express is an example.

2.1] ASYNCHRONOUS



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- Asynchronous transmission works in spurts and must insert a start bit before each data character and a stop bit at its termination to inform the receiver where it begins and ends.

2.2] SYNCHRONOUS

Direction of flow →

SENDER	10100011	11111011	00010000 110	RECEIVER

- Synchronous data transmission is a data transfer method in which a continous stream of data signal is accompained by timing signals to ensure that the transmitter and the en receiver are in step (synchronized) with one another.

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PURPOSE OF PHYSICAL LAYER

- The OSI Physical Layer provides the means to transport across the network media the bits that make up a Data Link Layer frame.
- This layer accepts a complete frame from the Data Link Layer and encodes it as a series of signals that are transmitted onto the local media
- The encoded bits that comprise a frame are received by either an end device or an intermidate device
- The device can be a router that will forward the frame or the destination device
- The delivery of frames across the local media requires the following Physical layer elements.
- The physical media and the associated connectors
- A representation of bits on the media
- Encoding of data control information
- Transmitter and receiver circuitry on the network devices.

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PHYSICAL LAYER OPERATION

- Each medium has unique signaling used to represent the bits in the data-link frames, but because IP is media independent, the frames remain unchanged as they cross the next device.
The below table lists the key media types and signal type used for each

MEDIA	SIGNAL TYPE
Copper Cable	Patterns of electrical pulses
Fiber-optic Cable	Pattern of light pulses
Wireless	Pattern of radio transmission

- When the physical layer puts a frame out onto media, it generates a set patterns of bits, or signal pattern, that can be understood by the receiving device.
- They are organized so that the device will be able to understood when a frame begins and when it ends.

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PHYSICAL LAYER - STANDARDS

- The Physical Layer consists of hardware, developed by engineers, in the form of electronic circuitry, media and connectors
- Therefore, it is appropriate that the Standards governing this hardware are defined by the relevant electrical and communications engineering organizations

The Physical layer Technology are defined by organization as:

- The International organization for Standardization (ISO)
- The Institute of Electrical and Electronic Engineers (IEEE)
- The American National Standards Institute (ANSI)
- The International Telecommunication Union (ITU)
- The Electronics Industry Alliance / Telecommunication Industry Association (EIA/TIA)

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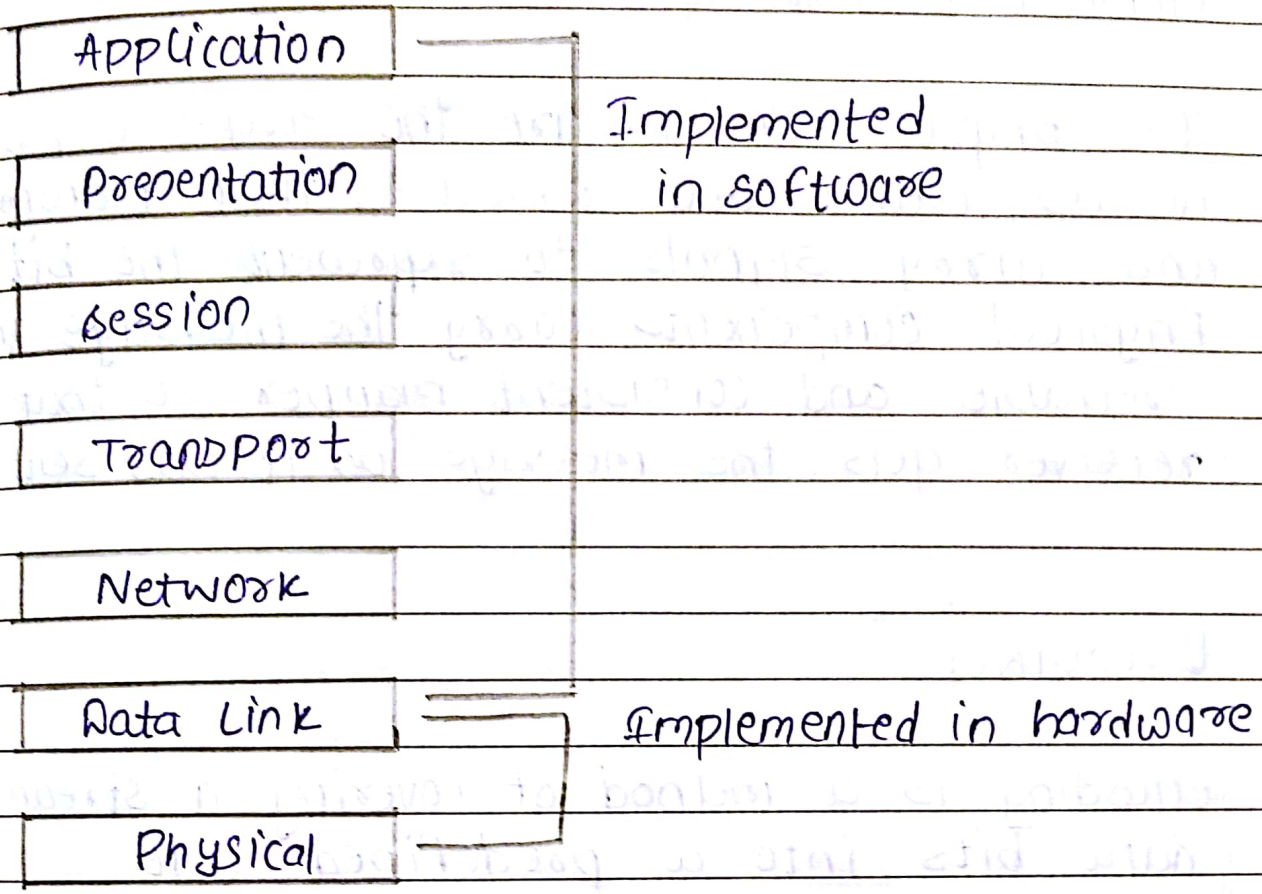

PHYSICAL LAYER PRINCIPLES

- Communication at the physical layer is a process involving physical components that carry encoded data sent out as a signal appropriate to the medium
- The following three components of Layer1 communication are key to understanding how the physical layer functions.

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PHYSICAL COMPONENTS

- The physical elements are the electronic hardware devices, media and connectors that transmit and carry signals to represent the bits
- Physical components carry the message in a reliable and consistent manner so that the receiver gets the message as it was sent.

ENCODING

- Encoding is a method of covering a stream of data bits into a predefined code
- Codes are grouping of bits used to provide a predictable pattern that can be recognized by both the sender and receiver
- Using predictable pattern helps to distinguish data bits from control bits and provide better media error detection.
- In addition to creating codes for data, encoding methods at the Physical layer may also provide codes for control purposes such as identifying beginning and end of a frame.

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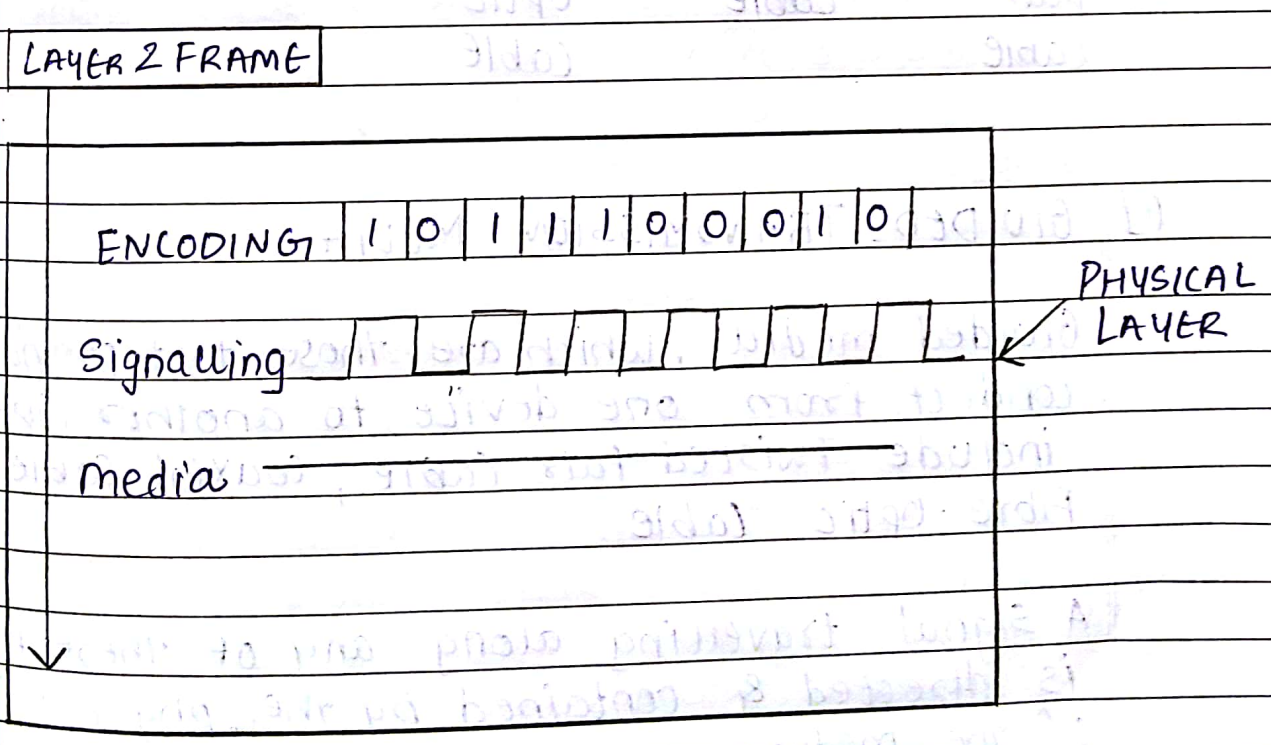
SIGNALLING

- The Physical layer must generate the electrical, optical or wireless signals that represents the "1" and "0" on the media
- The method of representing bits is called signaling method
- The Physical Layer standards must define what type of signal represent a "1" and a "0"
- This can be as simple as change in the level of electric signal or optical pluse or a more complex signaling method



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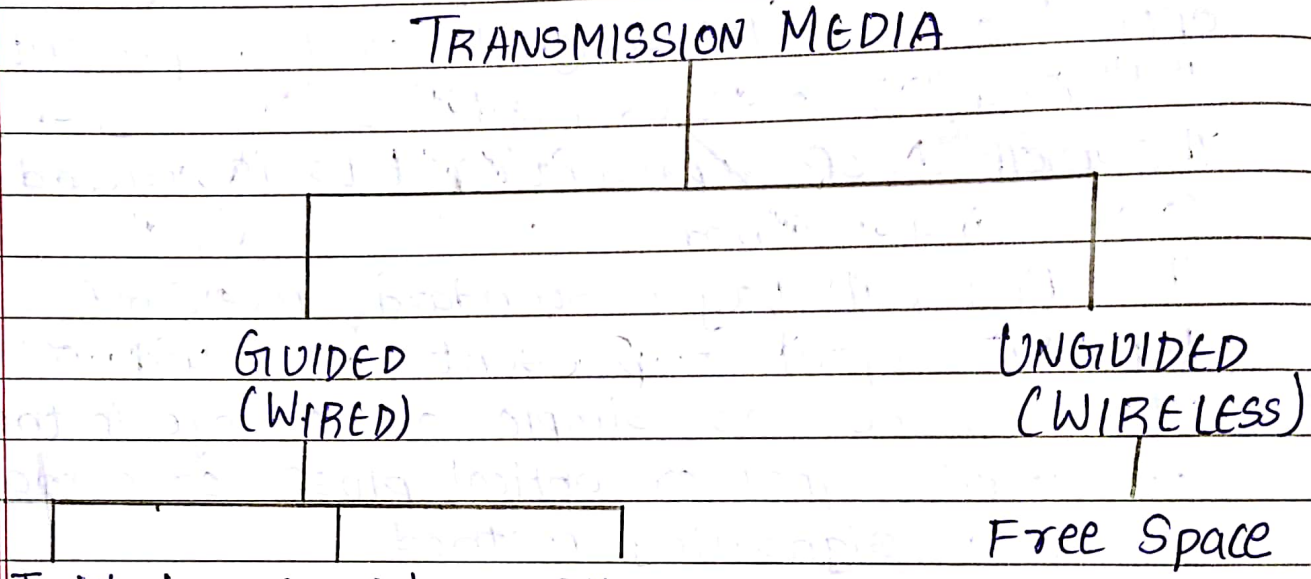
TYPES OF TRANSMISSION MEDIA



1.] GUIDED TRANSMISSION MEDIA

Guided media, which are those that provide a conduct from one device to another, inside include Twisted-Pair Cable, coaxial Cable & Fibre-optic Cable

A signal travelling along any of these media is directed & contained by the physical limits of the medium

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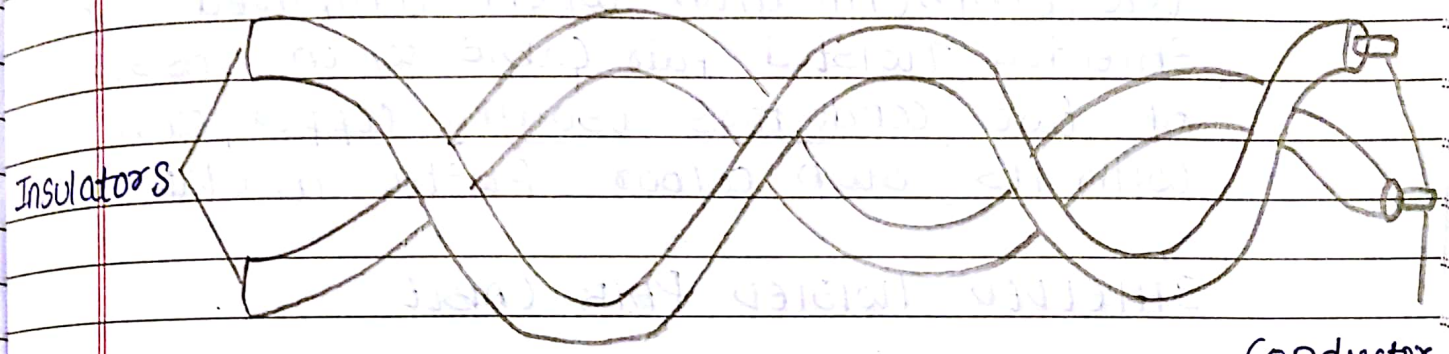
10] Twisted Pair Cable



- A twisted pair consists of two insulated copper wires arranged in a regular spiral pattern
- The twisting tends to decrease the crosstalk interference between adjacent pair in a cable
- Twisted pair may be used to transmit both analog and digital transmission
- Twisted pair is limited in distance, bandwith and datarate
- The attenuation for twisted pair is a strong function of freavency

TWISTED PAIR CABLE

UNSHIELDED | SHIELDED

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UNSHIELDED TWISTED PAIR CABLE

It is the most common type of telecommunication when compared with Shielded Twisted Pair Cable which consists of two conductors usually copper, each with its own colour Plastic insulator.

SHIELDED TWISTED PAIR CABLE

This cable has a metail foil or which encases each pair of insulated conductors Electromagnetic noise penetration is prevented by metal casing. Shielding also eliminates cross talk.

* COAXIAL CABLE

- Coaxial cable consists the following layers in its construction
  - The copper conductor
  - Insulation layer of plastic foam
  - Second conductor or sheild of wire mesh tube or metalic foil
  - outer jacket of tough plastic
- Coaxial cable can be used over long distances and support more stations on a shared line than twisted pair
- Coaxial cable is a versatile transmission medium, used in a wide variety of applicati

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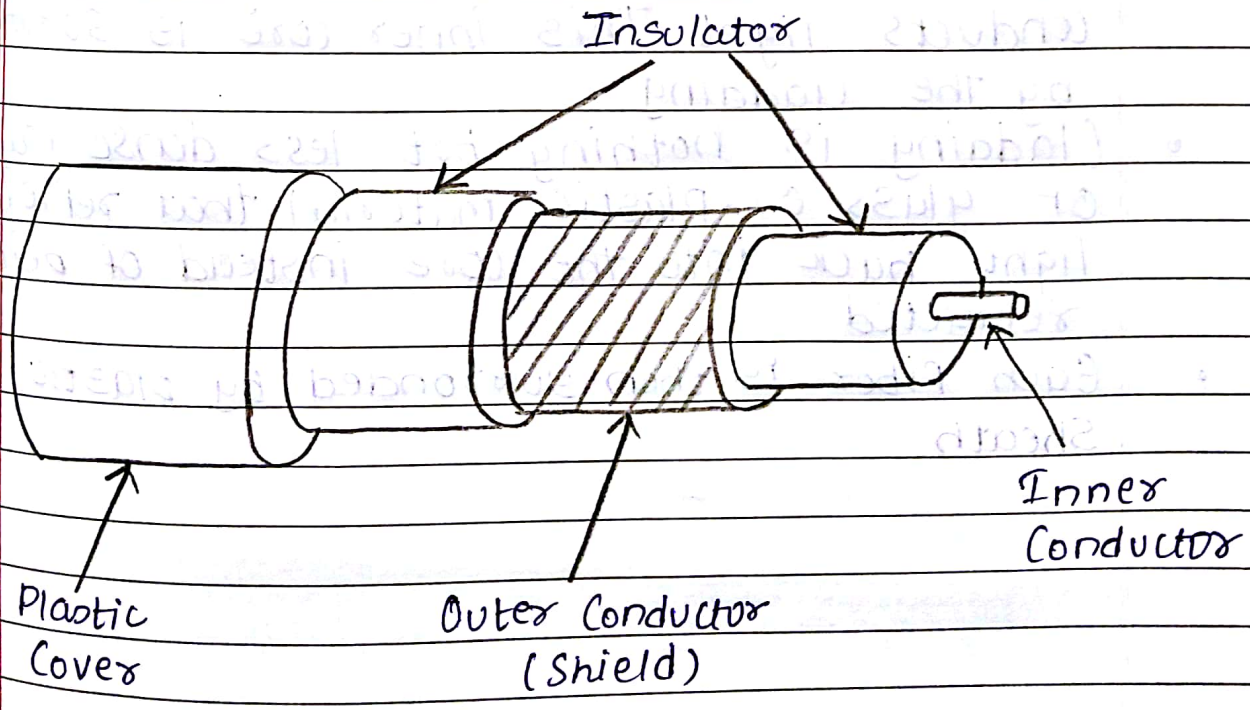
ions, including : Television distribution - Serial to TV systems

Characteristics

- It is comparatively inexpensive
- Its installation is comparatively simple
- It must be grounded properly in a network connection
- Its bandwidth capacity is around 10Mbps
- It is thin Ethernet connection maximum 30 nodes and in thick Ethernet connection maximom 100 nodes can be successfully interlinked with its cable connection
- It suffer from data attenuation



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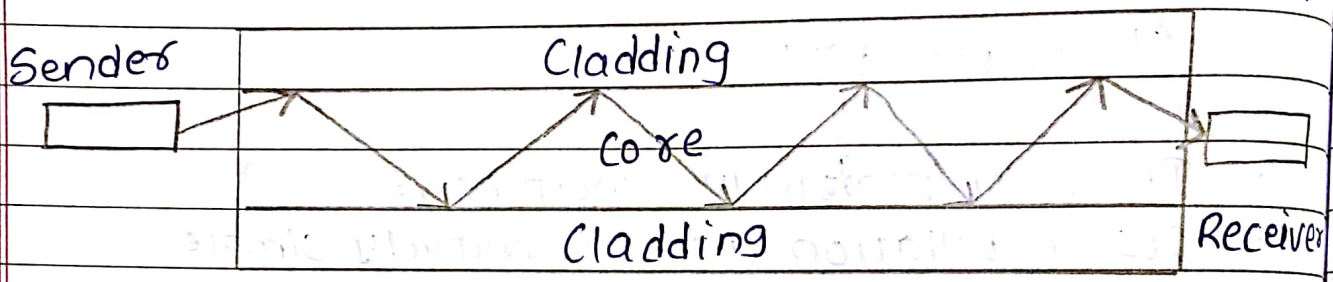
OPTICAL FIBER



- Fiber optic cable is known as most sophisticated cables used in long distance network connections
- Through this cable data transmission is done through light ray signal transmission, rather than electric signal transmission
- It has inner core of the glass that conducts light. This inner core is surronded by the cladding
- Cladding is nothing but less dense layer of glass or plastic material that reflects light back into the core instead of being refracted
- Each fiber is then surronded by plastic sheath

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BENEFITS

- Greater capacity or High Bandwidth
  - data rates of hundred of Gbps.
- Smaller size & Weight
- less signal attenuation
- Isolation from Electromagnetic Interference.

DEMERITS

- Installation & maintaience
- Unidirectional light propagation
- Cost

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UNGUIDED MEDIA

- Unguided media transport electromagnetic waves without using a physical conductor
- This type of communication is often referred to as wireless communication

Examples of unguided media

- RADIO WAVE
- MICRO WAVE
- INFRA RED
- Wi-Fi
- BLUETOOTH
- LASERS

WIRELESS TRANSMISSION FREQUENCY

2GHz to 40GHz
- microwave
- highly directional
- Point to point
- statellite

30MHz to 1GHz
- Omni directional
- broadcast radio

3X1011 to 2X1014
- infrared
- local

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BLUETOOTH

- Bluetooth is a low-cost, low-power, short range wireless communication technology used in networking, mobile phones and other portable devices
- Bluetooth wireless technology also enables devices to communicated with each other as soon as they come within range; no need to connect, plug into, install, enable or configure anything

Wi-Fi

- WiFi or Wireless Fidelity refers to the technology surrounding the radio transmission of internet protocol data from an internet connection wirelessly to a host computer
- Most often the internet connection is a higher speed one such as via satellite, DSL or cable rather than slower dial-up connections.

SATELLITE

- Satellite is a relay station
- Receives on one frequency, amplifies or repeats signal and transmit on another frequency
  Eg:- Uplink 5.925 - 6.425 ghz & downlink 3.7 - 4.2 ghz
- Typical uses

Television	Private business networks
long distance telephone	
Global poistioning	

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INFRARED

- Infrared technology allows computing device to communicate via short-range wireless signals
- With infrared, computer can transfer files & other data bidirectionally
- The infrared transmission technology used in computers is similar to that used in consumer product remote control units.

INSTALLATION AND USAGE

- Computer infrared network adapters both transmit and receive data through ports on the rear or side of a device.
- Infrared adp adapters are installed in many laptops and handled personal devices.

RANGE

Infrared communication span very short distances.

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- Place two infrared devices within a few feet (not more than 5 meters) of each other when networking them
- Unlike WiFi and Bluetooth technologies, infrared network signal cannot penetrate walls or other obstructions and work only in the direct "line of sight".

ADVANTAGES

- Low power requirements
- Low circuitry costs
- Simple circuitry
- Higher security
- Portable

DISADVANTAGES

- Line of sight
- Blocked by common materials
- Short Range
- Light, weather sensitive
- Speed

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RADIO WAVE

- Radio waves are used for multicast communications, such as radio and television, and paging system
- They can penetrate through walls
- Highly regulated.
- Use omni directional antennas

MICROWAVE

- microwaves are used for unicast communication such as cellular telephones, satellite networks and wireless LANs
- Higher frequency ranges. Cannot penetrate walls
- Use directional antennas - point to point. Line of sight communications.

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MEDIA CONNECTORS

Common Copper Media Connectors

- Different Physical Layer standards specify the use of different connectors
- These standards specify the mechanical dimensions of the connectors and the acceptable electrical properties of each type for the different implementations in which they are employed.
- Although some connectors may look the same, they may be wired differently according to the Physical Layer specification for which they are designed.

CORRECT CONNECTOR TERMINATION

- Each time copper cabling is terminated, there is the possibility of signal loss and introduction of noise to communication circuit.
- It is essential that all copper media transmissions be of high quality to ensure optimum performance with current & future network topologies.

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COMMON OPTICAL FIBER CONNECTORS

1] Straight-Tip (ST) - a very common bayonet style connector widely used with multimode fiber

2] SUBSCRIBER CONNECTOR (SC) - a connector that uses a push-pull mechanism to ensure positive insertion. This connector type is widely used with single-mode fiber

3.] Lucent Connector (LC) - A small connector becoming popular for use with single-mode fiber and also supports multi-mode fiber.

Three common types of fiber-optic termination and splicing errors are:

1] Misalignment - the fiber-optic media are not precisely aligned to one another when joined

2.] END GAP - the media do not completely touch at the splice or connection

3.] END Finish - the media ends are not well poished or dirst is present at the termination.

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TRANSMISSION IMPAIRMENT

- Signal travels through transmission media, which are not perfect. The imperfection causes signal impairment
- This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium
- What is sent is not what is received.

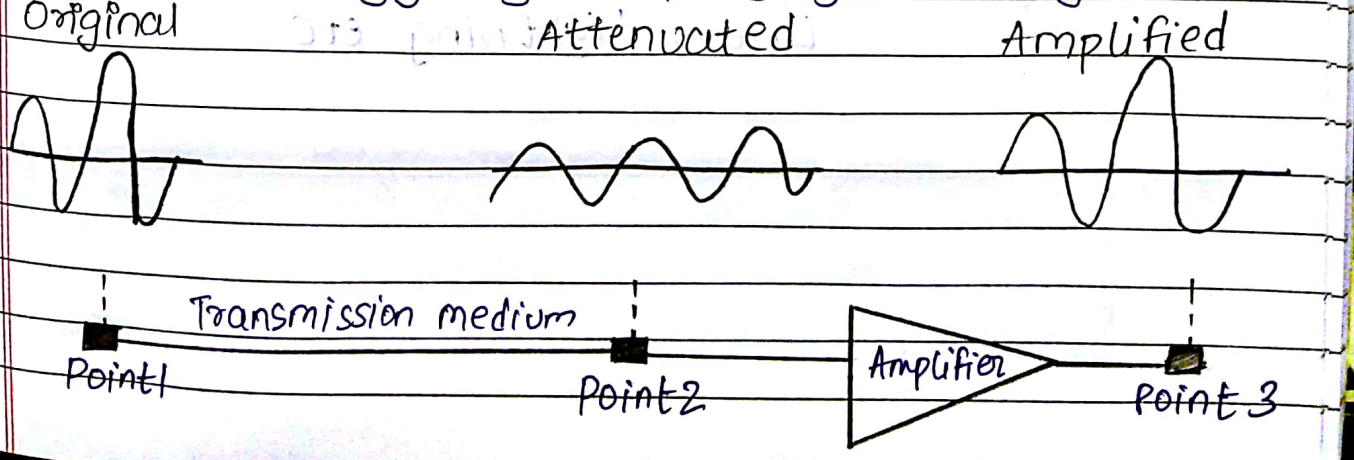
Three

IMPAIRMENT CAUSES

ATTENUATION | DISTORTION | NOISE

[1] ATTENUATION

- means loss of energy → weaker signal
- When a signal travels through a medium it losses energy overcoming the resistance of the medium
- Amplifiers are used to compensate for this loss of energy by amplifying the signal.



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DISTORTION

- Means that the signal changes its form or shape
- Distortion occurs in composite signals
- Each frequency components has its own propogation speed travelling through a medium
- The diff components therefore arrive with different delays at the receiver

NOISE

1. THERMAL - random noise of electrons in the wire creates an extra signal.
2. INDUCED - from motors and appliances, devices as transmitter antenna
3. CROSSTALK - Same as above, but between two wires
4. Impulse - Spikes that result from power lines, lightning etc.

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SIGNAL TO NOISE RATIO

- To measure the quality of a system the SNR is often used. It indicates the strength of the signal wrt the noise power in the system
- It is the ratio between two powers
- It is usually given in dB and referred to as SNRdB

WIRELESS CHANNELS

- Are subject to a lot more errors than guided media channels
- Interference is one cause for errors, can be circumvented with high SNR
- The higher the SNR the less capacity is available for transmission due to the broadcast nature of the channel.

DATA RATE LIMITS

- A very important consideration in data communications is how fast we can send data, in bits per second, over a channel. Data rate depends on three factors
  1. The bandwidth available
  2. The level of the signal we use
  3. The quality of the channel (the level of noise)

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PERFORMANCE

Generally we measure the performance on the foll basis

- Bandwidth
- Throughput
- Latency
- Bandwidth-Delay Product

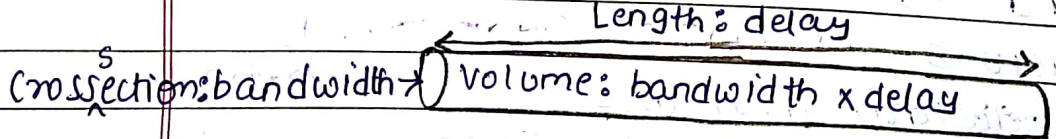
For eg refer ppt

we can think about the link between 2 points as a pipe

The cross section of the pipe represents the bandwidth, and the length of the pipe represents the delay

we can say the volume of the pipes defines the bandwidth-delay product, as shown in fig

The bandwidth-delay product defines the number of bits that can fill the link



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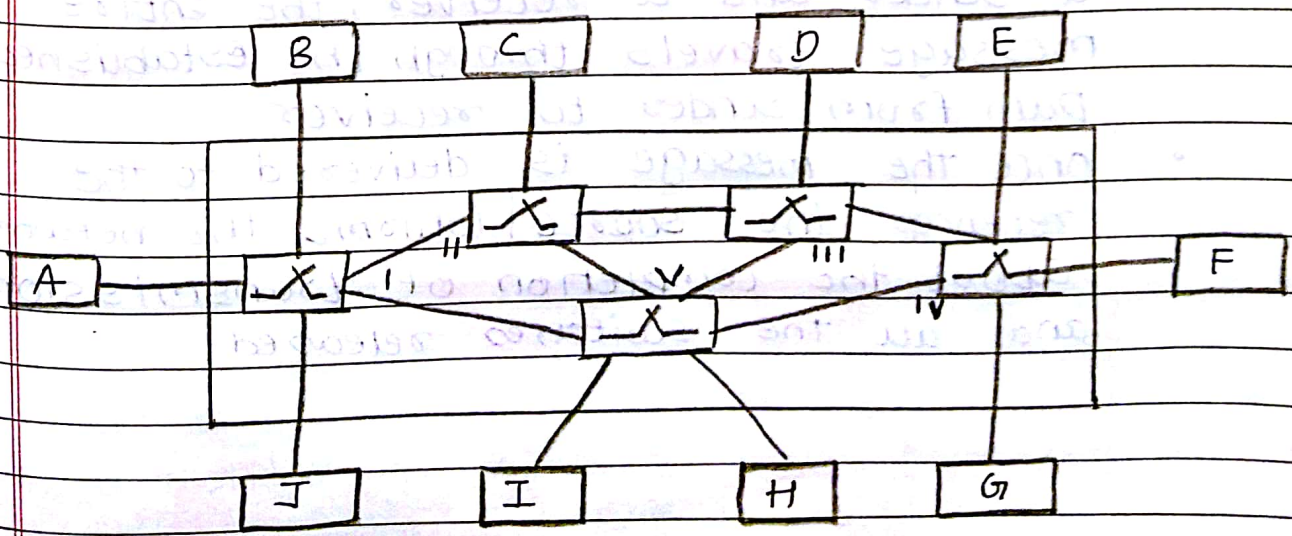
SWITCHING

- If we have multiple devices, we have the problem of how to connect them to make one-to-one communication possible
- One solution is to make a point-to-point connection between each pair of devices (mesh topology) or between a central device and every other device (a star topology)
- These methods however, are impratical and wasteful when talking about large networks.
- A better solution is switching. A switched network consists of a series of interlinked nodes, called switches
- Switches are devices capable of creating temporary connections between two or more devices linked to ~~each other~~ switch
- The end systems (communicating devices) are labeled A, B, C, D and so on, and the switches are labeled I, II, III, IV & V. Each switch is connected with multiple links



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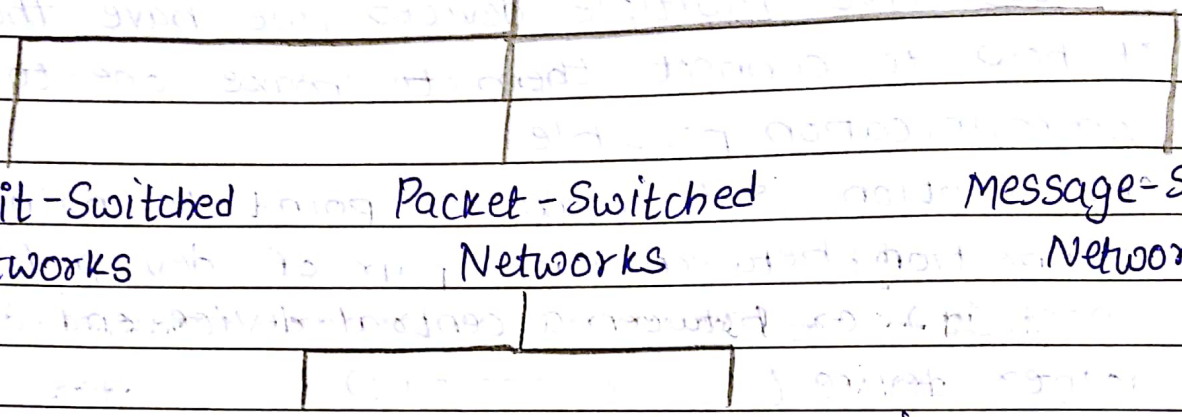
SWITCHED NETWORKS



CIRCUIT-SWITCHED NETWORKS

- A circuit-switched network consists of a set of switches connected by physical links
- A connection between two stations is a dedicated path made of 1 / more links
- when a connection is established between a sender and a receiver, the entire message travels through the established path from sender to receiver
- once the message is delivered to the receiver, the source informs the network about the completion of transmission and all the switches released.

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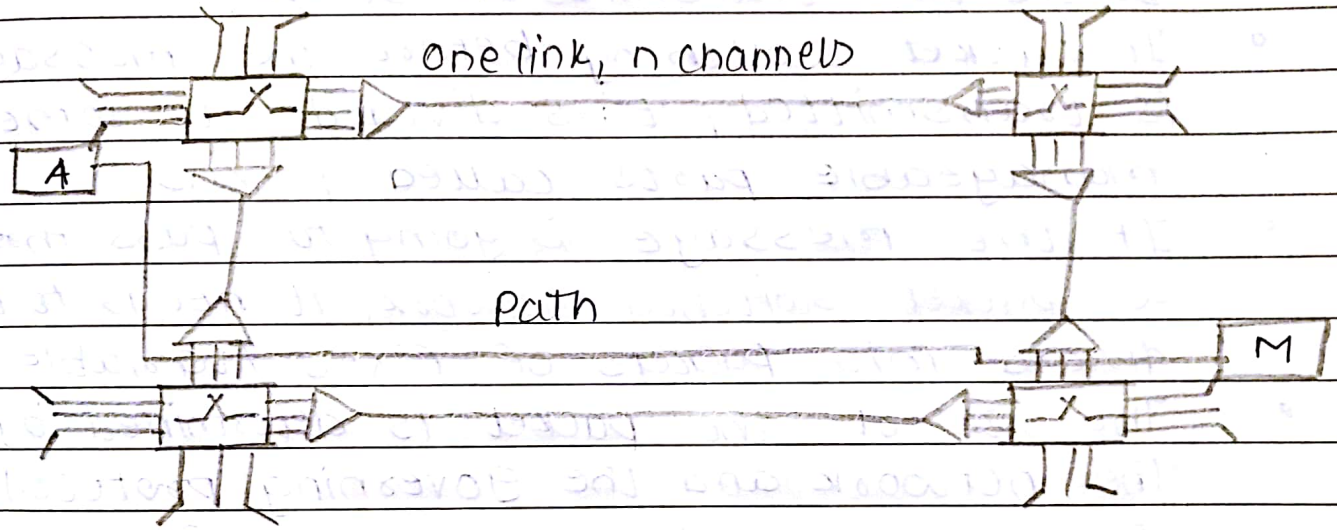
- Each link is normally divided into n channels by using
  FDM (Frequency Division Multiplexing) or
  TDM (Time Division Multiplexing)
- CS is always implemented at the Physical Layer



- In circuit switching, the resources need to be reserved during the setup phase; the resources remain dedicated for the entire duration of data transfer until the teardown phase
- Example:
  In a telephone conversation, once a connection is established, between a caller and the receiver, it remains connected, till the whole conversation is finished and both caller and receiver hang up the phone.
- Bandwidth is wasted.

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PACKET-SWITCHED NETWORKS

- Packet switching is connectionless as it doesn't establish any physical connection before the transmission starts
- In packet switching before the message is transmitted, it is divided into some manageable parts called packets
- If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed / variable size
- The size of the packet is determined by the network and the governing protocol
- Packets are routed one by one from source to destination
- Each packet may follow a different route to reach the destination
- Packets arrived at the destination are out of order but, they are assembled in order before the destination forward it to upper layer
- There is no resource allocation for a packet
- This means there is no reserved bandwidth on the links, and there is no scheduled processing time for each packet.
- Resources are allocated on demand. The allocation is done on a first come, first served basis.

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- When a switch receives a packet, no matter what the source or destination is, the packet must wait if there are other packets being processed.
- Packet switching is always implemented at the network Layer

DATAGRAM NETWORKS

- In a datagram network, each packet is treated independently of all others
- Even if a packet is a part of a multi packet transmission, the network treats it as though it existed alone. Packets in this approach are referred to as Datagrams
- In Datagram approach each packet is independent of other though they belong to the same message and may also choose a different path to reach the destination
- The datagram networks are sometimes referred to as connectionless network.
- The connectionless here means that the switches (packet switch) does not information about the packet state
- A switch in a datagram network uses a routing table that is based on the destination address
- The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.

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VIRTUAL-CIRCUIT NETWORKS

- A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both
- In a virtual-circuit switching, all packets belonging to the same source and destination travel the same path; but the packets may arrive at the destination with different delays if resource allocation is on demand
- The relationship between the packets that belong to the same message is preserved as the packet are not independent of each other, and all the packets that belong to a particular message follow the same route to travel to the destination
- Switching at the data-link layer in a switched WAN is normally implemented by using virtual circuit networks.

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CIRCUIT SWITCHING	PACKET SWITCHING
• connection oriented	• connectionless
• Intially designed for voice communication	• Intially designed for Data Transmission
• Inflexible, because once a path is set all parts of transmission follows the same path	• Flexible because a route is created for each packet to travel to the destination
• Message is received in order sent from source	• Packets of messages are received out of order assembled at the destination
• Circuit switching can be achieved using two techno logyies, either Space Division Switching or Time-Division Switching	• Packet switching has two approaches Datagram Approach and Virtual Circuit approach
• Circuit switching is implemented at physical layer	• Packet switching is implemented at the Network Layer.

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TELEPHONE NETWORK

- Telephone network use circuit switching. The telephone had its beginnings in late 1800s
- The entire network, which is referred to as the plain old telephone system (POTS), was originally an analog system using analog signals to transmit voice
- one component of the telephone network is the LocalLoop, a twisted-pair cable that connects the subscriber telephone to the nearest end office or local central office
- TRUNKS are transmission media that handle the communication between office. Transmission is usually through optical fiber or satellite links
- To avoid having permanent physical link between any two subscriber, the telephone company has switches located in the switching office. A switch connects several local loops or trunks and allow a connection between different subscriber

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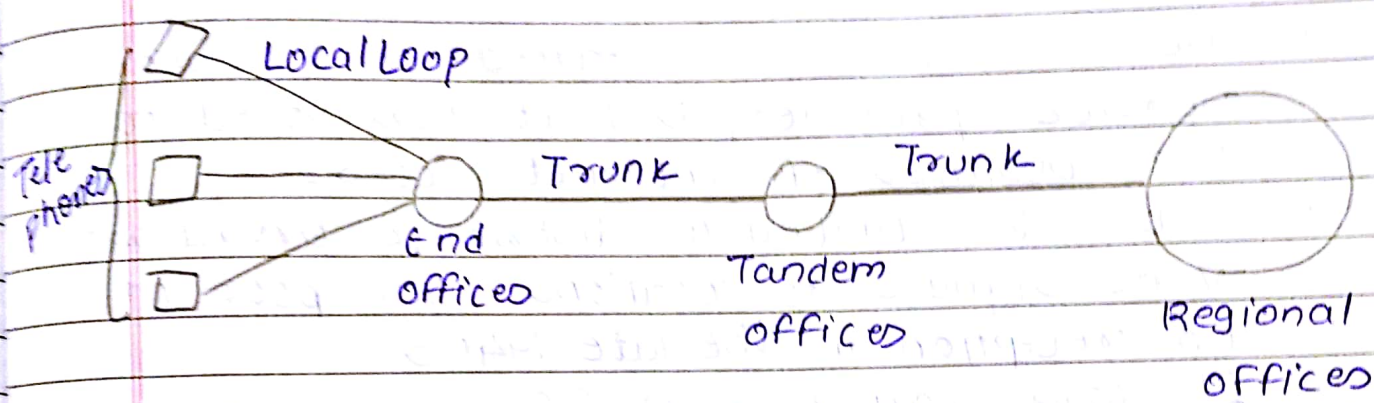

DIAL-UP MODEMS

- Traditional telephone lines can carry frequencies between 300 and 3300 Hz, giving them a bandwidth of 3000 Hz
- All this range is used for transmitting voice, where a great deal of interference and distortion can be accepted without loss of intelligibility
- Data signals require higher degree of accuracy to ensure integrity. Signal bandwidth must be smaller than cable bandwidth
- The effective bandwidth of a telephone line being used for data transmission is 2400 Hz, covering the range from 600 to 3000 Hz
- Basically modem has two functions:
  - Signal modulator
  - Signal demodulator

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CABLE TV NETWORKS

- The cable TV network started as a video service provider, but it has moved to the business of Internet access
- Cable TV started to distribute broadcast video signals to locations with poor or no reception in the late 1940s
- It was called CATV (Community Antenna TV) because an antenna at the top of a tall hill or building received the signal from the TV stations and distributed them, via coxial cables to the community
- The cable TV office, called the head end
- Communication in the traditional cable TV network is unidirectional.
- The second generation of cable networks is called a HFC (Hybrid fiber coaxial) network.
- Communication in HFC can be bidirectional
- The theoretical downstream data rate is 30 Mbps
- The theoretical upstream data rate is 12 Mbps

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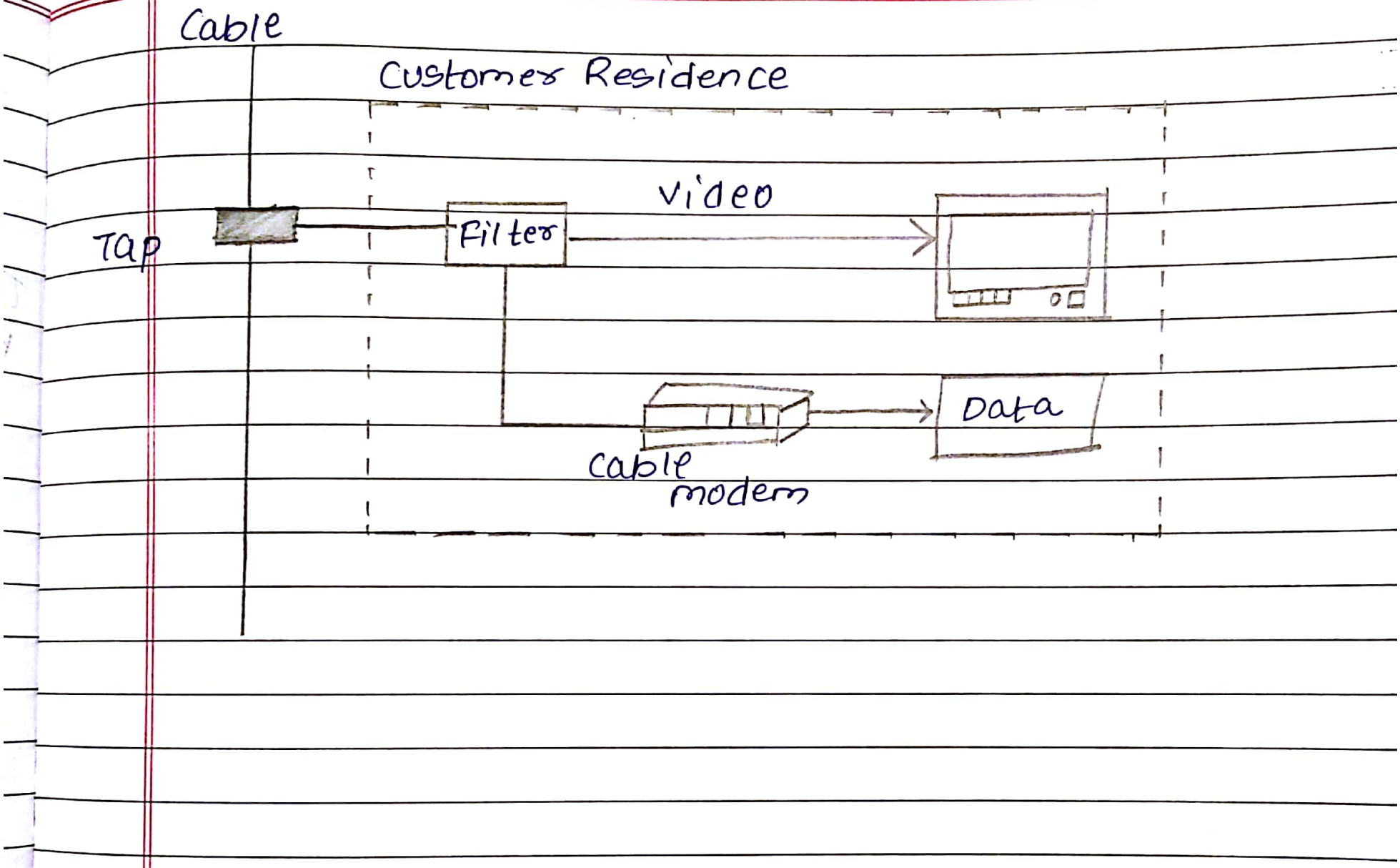

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