8|08|23

The network of networks that connects devices across the globe. ⟶ Internet.

Intranet → may or may not be connected to the internet.

LAN
MAN
WAN

PAN → Personal Area Network
VPN → Virtual Private Network

→ Message ⟶ Any piece of information sent (transmitted) from sender to receiver.

→ Sender → Any agent which sends the message.

→ Receiver → Any agent which receives the message.

→ Transmission Medium → The physical path on which a message transmits.

→ Two basic categories of transmission medium ① Wired ② Wireless

① Wired → TV Cables, Telephone cables, fibre optics, ethernet cable, etc.

② Wireless media → Wifi, bluetooth, infrared, microwave, etc

→ Protocol → Set of rules that governs/regulates message transmission.

Eg: http
udp
tcp
ftp

IP → Internet Protocol

Routing Protocol

there are three kinds of transmitting modes-

① Simplex:- One device is always the sender, one device is always the receiver.

Eg: Laptop to projector
TV
Radio
mouse to connected device

② Half-Duplex:- Both the devices can be sender/receiver but not at the same time.

Eg: Bluetooth   Whatsapp chats
Email
Pendrive usage

③ Duplex:- Simultaneous sending/receiving

Eg: Video Calling, Audio Calls

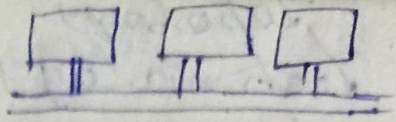
Network → A set of devices connected on a common link for specific purpose.

Various types:-
P2P → Point to Point
MP → Multi Point

Network Topology → The geometrical arrangement of devices & their links on the network.

Kinds of network Topology
Bus   Ring
Star
Mesh

① Bus Topology:-



① Easy to connect & disconnected.

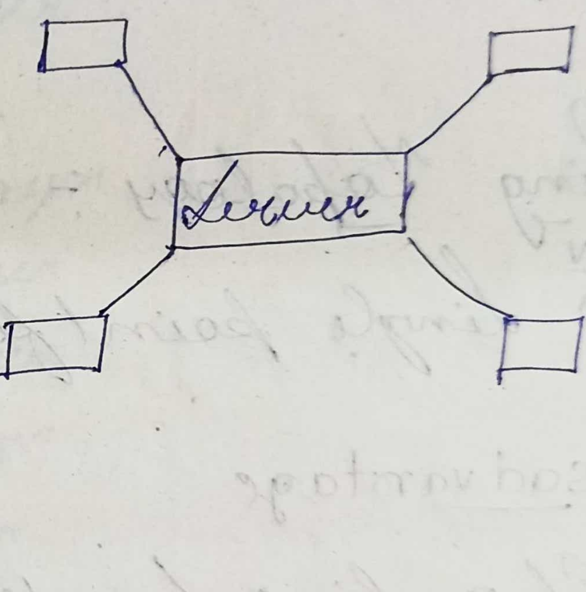
② Less Expensive.

No. of wires required to connect n devices → n + 1
↓
backbone wire

Disadvantage:-

① When the bus breaks, the network breaks.

② Star Topology:-



There is always a central device to which all other devices are connected.

Advantages:-

① Centralized Storage

② Less Expensive → n devices, → n wires

③ faster communication

Dis:-

① If the server fails the entire network fails.

③ Mesh ~~Technology~~ Topology :- Every node is connected to every other node (Fully Connected Graph)

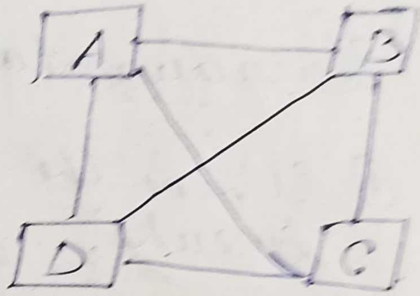
Adv :-

① Less points of failure

Disadvantage :-

① High Expense

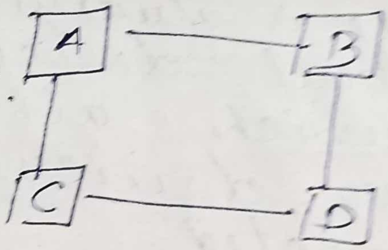
n devices $\rightarrow n(n-1)/2$



④ Ring Topology :-

Adv

① No single point failure.



Disadvantage

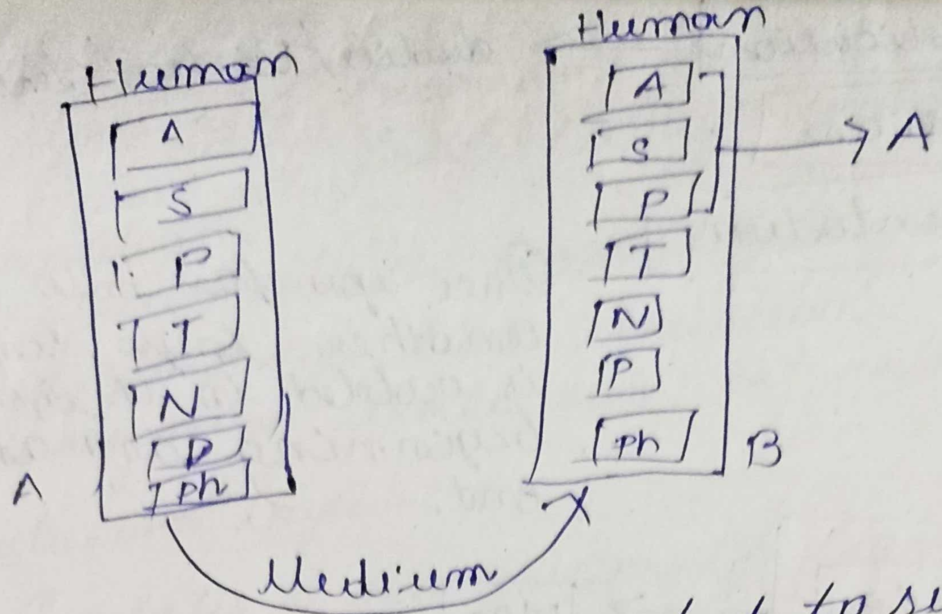
① If a link / node fails longer route.

n - devices $\longrightarrow n$ wires.

Network Model :-

OSI (Open System Interconnection)

Tells about



All the conversion of text to signals occurs through seven layers.

1. Application Layer
2. Session Layer
3. Presentation Layer
4. Transport Layer
5. Network Layer
6. Datalink Layer
7. Physical Layer

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Network Model and its layers

Two models → OSI (7 layers)
→ TCP/IP (5 layers)

Difference:

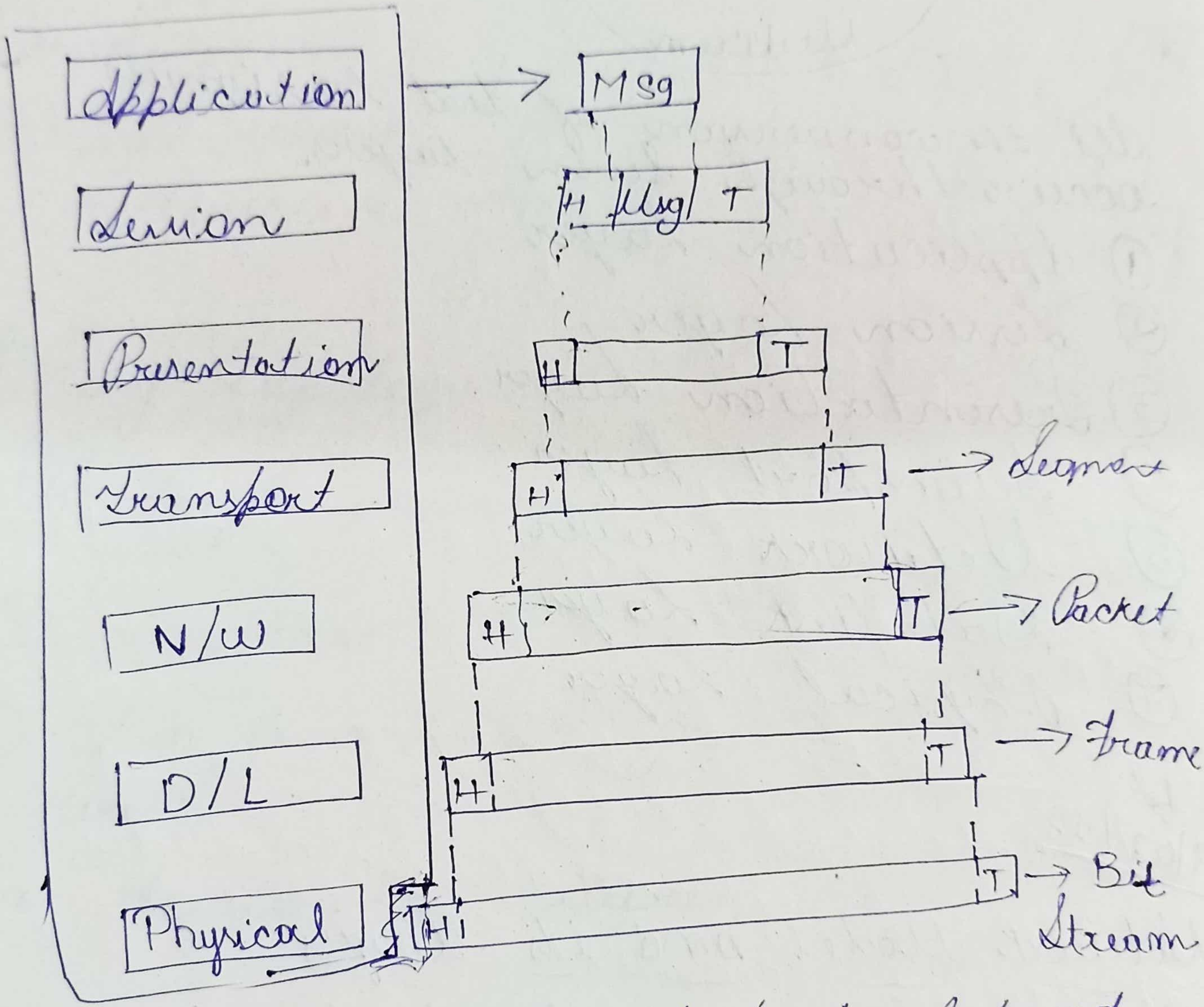
OSI	TCP/IP
Application Session Presentation	Application

Application → Audio/Video/Text(Msg)

Session

Presentation

Once you pass into another layer, something is added to it ~~at~~ the beginning and at the end.



The network model adds protocol based

Functionality of each layer:-

On senders side if layer A is above B than A is a service user which B is a service provider. This reverses in the receivers side.

① Physical layer

(i) Convert & transmit the bits.

(ii) Define the properties of transmission medium.

(iii) Determine the transmission mode.

(iv) Determine link structure.

(v) Determine data rate / bit rate, etc.

② DataLink Layer:-

(i) Regulates transmission of frames.

(ii) ~~Addressing~~ The physical address is added to the packet.

(iii) Error control

(iv) Flow control / governing the data traffic.

(v) Media access control.

③ Network Layer:-

(i) Regulates packet transmission.

(ii) It adds the I/P address to the segment which then becomes a packet.

(iii) Control of packet flow (routing)

(iv) Assembling & disassembling of message.

④ Transport layer:-

(i) Regulates transmission of segments from one process to another.

(ii) It adds port address to message.

(iii) Segmentation & reassembly of message.

(iv) Flow control / error control &

⑤ Presentation layer {How I will present the data to the network}

<i> It converts the machine dependent data from the upper layers into network dependent data for transmission.

⑥ Session layer

<i> Creates transmission check points and regulates authentication & holding of transmission sessions.

⑦ Application layer

<i> Generates various messages and forms new protocols.

I/P addresses:-

Current → IPv4
↓
4 parts of the address

IPv4 — 4 parts × 8 bit = 32 bits

IPv6 - 6 parts × 8 bit = 48 bits

Every IP address has two parts:

<i> Network ID :- Identifies the correct network of the host.

<ii> Host ID :- Identifies the correct host corresponding to the given I/P address.

IPv4 | N.Id | | | |

N.Id ↓ $2^8 = 256$ possible networks can exist

Host ID → $2^{24} \simeq 16$ million

Various classes of IP addresses

Class A :- N.Id = 0___
Class B :- N.Id : 10___
Class C :- N.Id - 110___
Class D :- N.Id 1110 _ } → Military ID usage
Class E :- N.Id : 1111 _ }

Usually for every class of networks, the beginning and the end network IDs are reserved.

131.4.3.1 class B
201.6.5.0 class C

Subnets & Masks

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Signal → physical Quantity varying with time and space.

Terms related to signal :-
1. Amplitude — three key aspects of signal
2. Frequency
3. Wave length
4. phase angle

Time period → The time after which the signal repeats itself.

Frequency → No of cycles of the signal per second; & time period is its reciprocal.

~~time~~

Phase:- Position of the wave from relative to origin.

Band Width

Of a signal:- The difference between the highest and the lowest frequencies of the signal.

Band Width of a periodic signal → 0

Aperiodic or phase wise periodic signals have proper band width.

Low Pass Signal :- ~~which band width~~ Any signal where band width is within from 0 to some low value h.

Band pass signal :- where band width is within ~~certain~~ a positive value h to another positive value. (low to some high value)

Bitrate :- No of bits transmitted per second.

Propagation Speed :- The speed at which a bit is transferred in a channel.

Bit duration :- Time taken b/w bits sending and bits receiving.

Transmission across a low pass signal is called base band signal.

Transmission across a band pass signal is called broad band transmission.

Modulation is conversion of low pass signal to band pass.

Demodulation is conversion of band pass signal to low pass signal.

<i> Noise :-

<ii> Distortion :-

<iii> Attenuation :- The amplitude gets affected.

We need repeaters to boost back the signals because attenuation ~~as~~ affects the signals.

Transmission impairment :-

Causes :-

1> Attenuation :- The decrease in signal amplitude.
↓
measured in decibels (logarithm

2> Distortion :- change in bit form or shape

3) Noise :- Unwanted signals combined with meaningful signals.

↳ Measured as SNR $\frac{\text{Signal power}}{\text{Noise power}}$

(Unitless quantity but usually written in decibals)

SNR also written as $10 \log_{10}(SNR)$

(useful to determine repeaters' statistics)

Two limits to determine data rate channels :-

<i> Noiseless channel :- Given by Nyquist bitrate and is defined as $2 \times BW \times \log_2 L$

$L \rightarrow$ No of signal levels used to represent data.

<ii> Noisy channel :- Defined by Shannon Capacity. Given by $BW \times \log_2 (1 + SNR)$

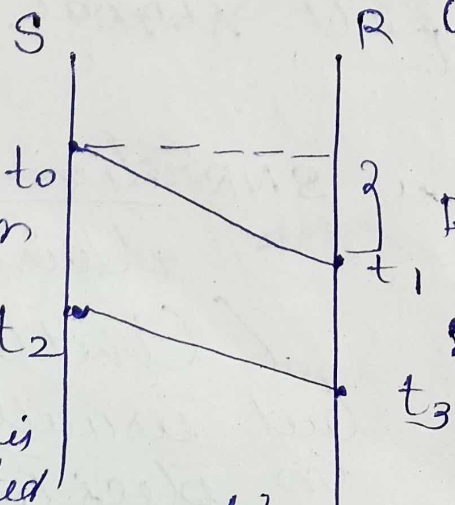
↓

Pure ratio not a decibal.

Performance of transmission medium depends on <i> Band Width

(ii) Throughput

<iii> Latency / Delay



Transmission time {The time in which a message is transmitted

Delay is known as propagation delay. {Time taken b/w sending the 1st bit & receiving the

Total latency = PD + TT {Propagation delay + Transmission Time}
(t_0 to t_2)

Router → Queuing Time (Q) → The time needed for each intermediate or end device to hold the message before it can be processed
+
Proc. Time (P) ← How much time the intermediary nodes take to process the message.

→ $L = PD + TT + n(Q+P)$

Transmission Time (TT) = $\frac{\text{Message size}}{\text{Bandwidth}}$

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Propagation Time = $\frac{\text{Distance}}{\text{Propagation Speed}}$

Physical layer

Que> What is the total latency for a frame of size 5 million bits sent on a link with 10 routers each having a Queuing time of 2 micro second and processing time of 1 micro second, given length of the link is 2000 km speed of light in the link is 2×10^8 m/s and bandwidth is 5 mbps (mega bit per second). Find out the total latency.

Ans) Latency = ~~PD~~ Propagation Delay + Transmission Time + $n(Q+P)$

= PD + TT + $n.(Q+P)$

= 1.01003 sec

PD + TT + 10(2×10^{-6} + $1 \times 10^{\dots}$

= $\frac{1}{10^2} + 1 + 3 \times 10^{-5}$ = PD + TT + 10(3×10^{-6})

= 0.01 + 1 + 0.00003 = $\frac{2000\text{ km}}{2 \times 10^8 \text{ m/s}} + \frac{5}{5} + 3 \times 10^{-5}$

Total latency = PD + TT
(t_0 to t_2) {Propagation delay + Transmission Time}

Router → Queuing Time (Q)
+
Proc. Time (P)

↳ The time needed for each intermediate or end device to hold the message before it can be proceed

How much time the intermediary nodes take to process the message.

↳ $L = PD + TT + n(Q+P)$

Transmission Time (TT) = $\frac{\text{Message size}}{\text{Bandwidth}}$

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Propagation Time = $\frac{\text{Distance}}{\text{Propagation Speed}}$

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= PD + TT + n (Q + P)

= 1.01003 sec

= PD + TT + ~~5~~ $10(2\times10^{-6} + 1\times10^{-6})$

= $\frac{1}{10^2} + 1 + 3\times10^{-5}$

= PD + TT + $10(3\times10^{-6})$

= 0.01 + 1 + 0.00003

= $\frac{2000\ km}{2\times10^8\ m/s} + \frac{5}{5} + 10(3\times10^{-6})$

= $\frac{2\times10^6}{2\times10^8} + 1 + 3\times10^{-5}$

= $\frac{2000\times10^3}{2\times10^8} + 1 + 3\times10^{-5}$

Que> We have a noisy channel with 4 kHz bandwidth, if we want to send data at 100 kbPS (Kilo bit per second) what is the minimum SNR required?

Ans) SNR = $\frac{\text{Signal Power}}{\text{Noise Power}}$ Decibal Conversion $\rightarrow 10\log_{10}(SNR)$

Channel Capacity $\leq$ Shannon Limit

$100 \times 1000 = B C_0$

Shannon Cap $\leq BW \times \log_2(1+SNR)$

$\Rightarrow SNR = 2^{25} - 1$ {Convert into decibals}

Que> A signal has passed through 3 cascaded amplifiers each with is four decibal gain. What is the total gain and by what factor is the signal amplified?

Ans) Total gain = 3×4

$= 12$ decibal gain

Cascaded amplifier $\rightarrow$ NO loss

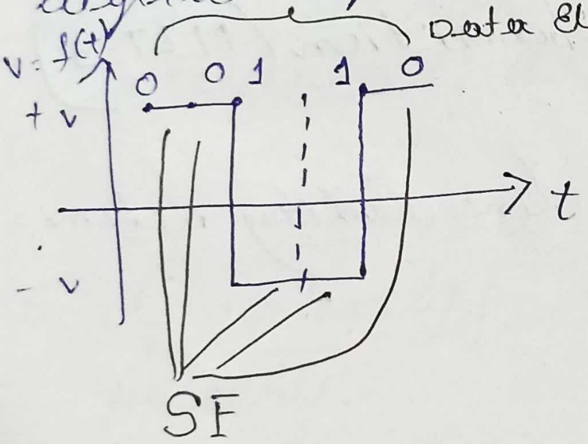
Factor of amplification

$\hookrightarrow 10^{1.2}$

Que 7 We measure the performance of a telephone line having 1KHZ bandwidth. For signal of 10 volts, noise value is 5 millivolt. What is the max datarate supported by the telephone line?

Ans)

Analog Signal → continous amplitude
digital signal → discrete amplitude



→ Digital Signal

Data Element :- The smallest entity that can represent a piece of information.

Signal Element:- The shortest unit of a signal.

One SE can represent 2 bits {DE} {Not necessarily only 1 DE}

$$r = \frac{n(DE)}{n(SE)} = \frac{\text{no of bits}}{\text{no of pulses}}$$

Digital Transmission

- → Line Coding {Generally $r = 1$}
- → Block Coding {Generally K bits, n pulses}
- → Others

Line Coding
- → Unipolar (NRZ)
- → Polar (NRZ-Level, NRZ-inverse, RZ)
- → Bipolar (AMI, Pseudoternary)
- → Multi-Level (2B1Q, 8B6T)
- → Multi Transition (MLT-3)

Characteristics of a good Line Coding Scheme:

1> Base Line wandering

↓

Running avg of received signal power

A drift from a continuous stream of zeros and ones in this signal is called base line wandering.

In a good line coding scheme, base line wandering should not be present.

2> **DC Component** :- For a good scheme, DC component should be absent.

3> Self Synchronization :-

↓ Detection of the bit from the pulse that is received.

↓ Independence of the receiver from the sender.

For a good scheme, Self Synchronization should be present.

4> **Built In Error - Detection** :- Should be present

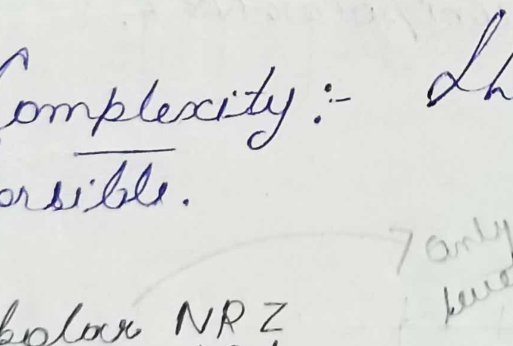
5> Immunity from noise and **interference** :- Should be present

6> **Complexity** :- Should be as simple as possible.

Unipolar NRZ > Only one voltage level other than zero

↓ (+A) or 0

Non Return to Zero ↑ 1 ↑ 0

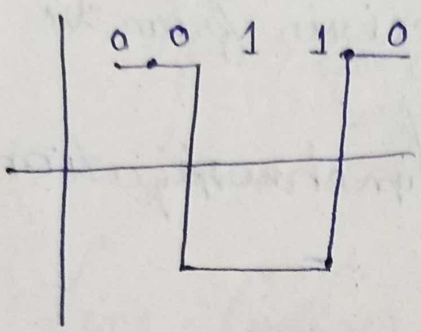


→ { Self Synchronization is not present }

→ Base Line Wandering is present.

→ It is not immune to noise.
→
→ It is simple (not complex).

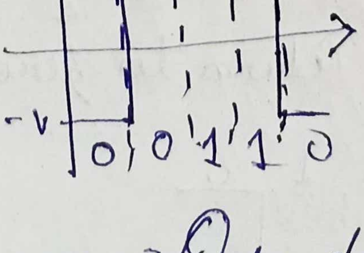
Polar NRZ-Level
Uses two voltage levels other than zero.



→ Base time Wandering is present.
→ DC Component can be present.
→ Self Synchronization absent.
→ Immunity to noise is absent
→
→ More complex than unipolar NRZ.

Polar NRZ-Invert :-

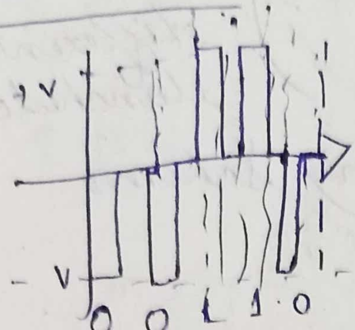
0 - invert
1 - dont invert



Base Line Wandering → Only due to presence of continuous 1's

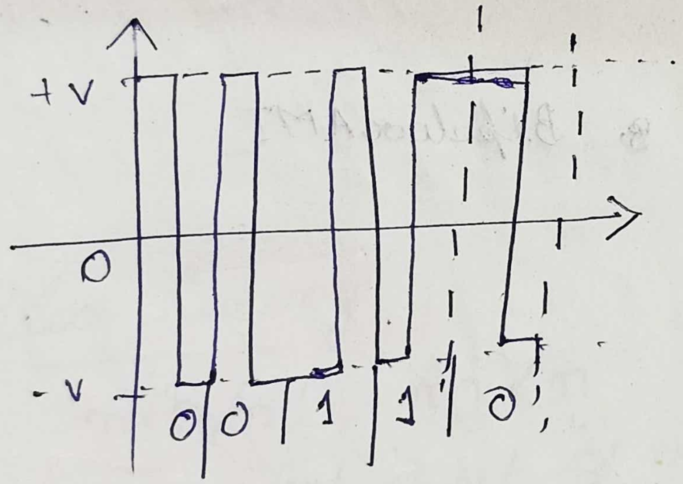
NOTE :- The bandwidth occupied by NRZ is half of the bandwidth occupied by RZ.

Polar RZ

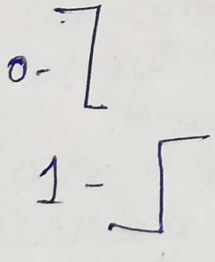


Base Line wandering is present → hence DC component is also present.

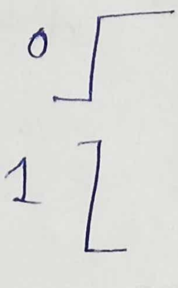
Manchester & Differential Manchester
{Opposite of Manchester}



Manchester



Differential Manchester-



1> Base Line Wandering not present
2> DC component not present
3> Self Synchronization present
4> Error detection present
5>

Both Manchester and differential Manchester

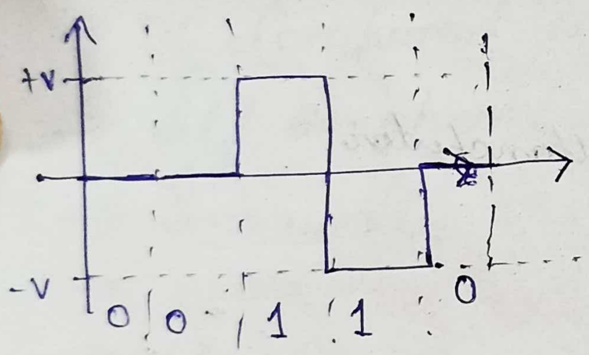
These are effective line coding schemes but not efficiency.

Three voltage levels +ve, -ve & 0

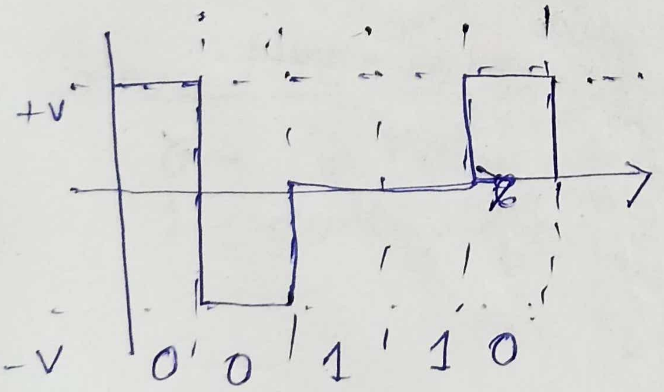
Bipolar AMI & Pseudoternary

Alternate Mark Inversion

Inverse of Bipolar AMI



Bipolar AMI



1> No base li

1>

2>

3> No synchronization

Multilevel line Coding Scheme :-

mBnL

2B1Q {Qutra, Qutri} 4

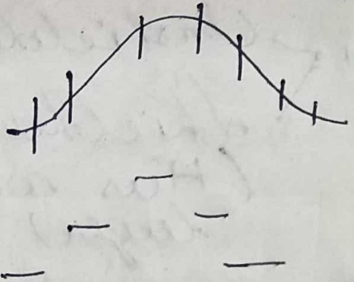
8B6T {Tri} 3

2^m is L^n

2^2 is 4^1

2^8 is 3^6

Quantization → Converting a continous signal into discrete signals.



Block Coding

mB/nB $m < n$

we convert a set of m bits to a set of n bits.

Block Cooding Scheme helps in error checking.

4/5

N → 1.25N $\{\frac{5}{4}N\}$

Bandwidth

{Decrease BW use Block Coding

{Increase Effectivity use Manchester}

Transmission Medium

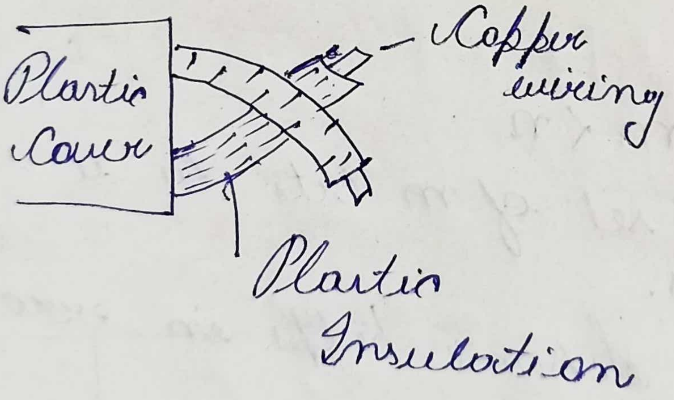
Wire (Guided) {In terms of network}
wireless (~~Guidates~~ Unguided)

Media

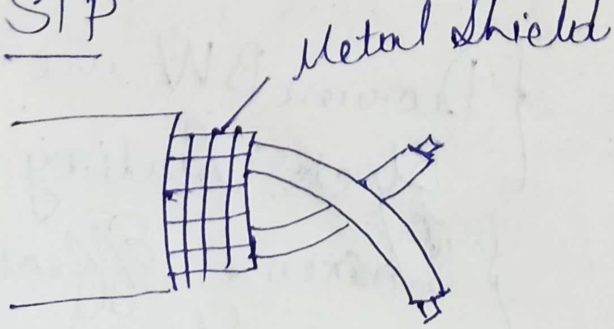
- Guided
  - Twisted Pair
  - Coaxial
  - Optical Fibre
- Unguided
  - Radio
  - Micro
  - IR

Twisted Pair:- Two types
- Unshielded (UTP)
- Shielded (STP) (Has an extra layer)

UTP



STP



~~Switching~~

24/08/23

Switching:-

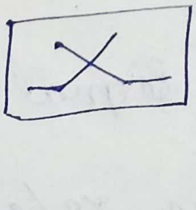
Switch:- A connecting device which creates temporary connections b/w two or more devices linked on a network

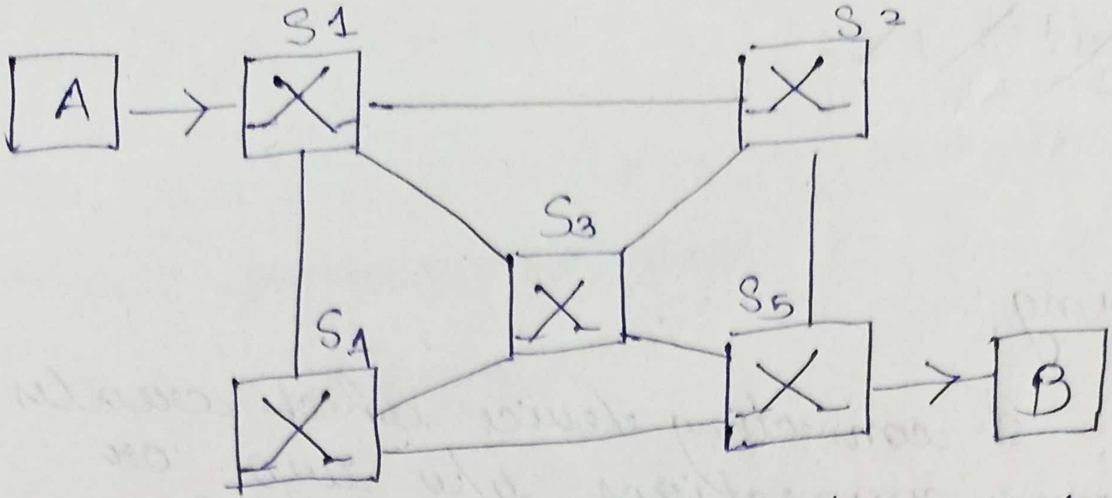
Switching Network:- Series of interconnected switches.

Switching
- → Circuit Switching (Phys. L. Tech)
- → Packet Switching
  - → Virtual Circuit (DL-L-Tech)
  - → Datagram Approach (NW-L-Tech)
- → Message Switching (Appln. L Tech)

Circuit Switching:-

Conventionally, a switch looks like





From A to B

1. 1 → 2 → 5
2. 1 → 3 → 5
3. 1 → 4 → 5
4. 1 → 3 → 2 → 5
5. 1 → 3 → 4 → 5
6. 1 → 2 → 3 → 5
7. 1 → 2 → 3 → 4 → 5
8. 1 → 4 → 3 → 5
9. 1 → 4 → 3 → 2 → 5

Switching Process goes through three phases
- → Path Setup
- → Data Transfer
- → Teardown

Path Setup :- ① A dedicated path is established

② Resource reservation is enforced. { IO ports
Bandwidth
Router processing }

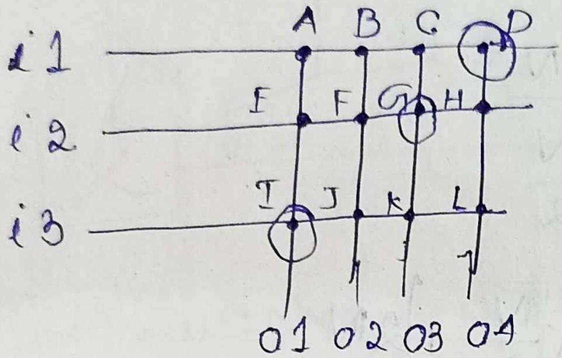
③ A setup request signal (SRS) goes from sender to receiver and acknowledgement signal returns from B to A.

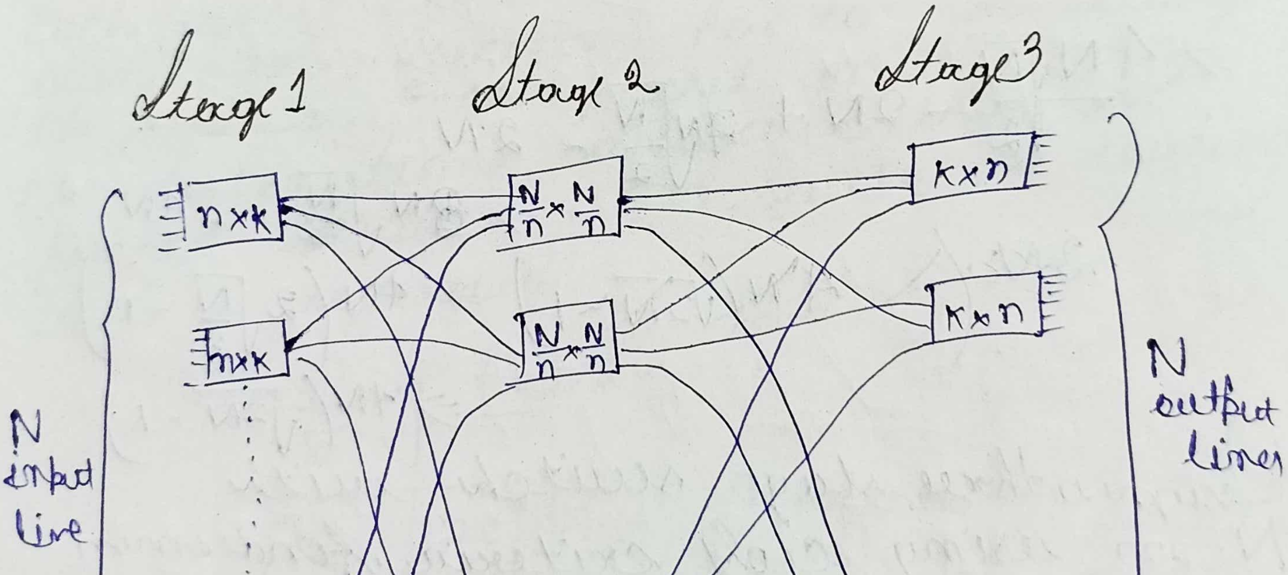
Teardown : ① Teardown signal is sent by A.

There are two kinds of Circuit Switches.

- → Space Division: The switches are distinguished using the geographical location.
- → time Division { Each switch is allocated certain time frame of operation }.

Crossbar Switch:-





N/n K N/n } No of switches

Find out the total no. of crosspoints.

$$\frac{N}{n} \times K + K \times \frac{N}{n} \qquad 2NK + K\frac{N^2}{n^2}$$

$N \to 200$

$n \to 20$ $k \to 40$

$2 \times 200 \times 40 + 40 \times \left(\frac{200}{20}\right)^2$

$16000 + 40 \times 100 = 16000 + 4000 = 20000$

Clos Criteria

$$K \geq 2n - 1$$

$$n = \sqrt{\frac{N}{2}}$$

$$2NK + K\frac{N^2}{n^2}$$

$$\Rightarrow 2N(2n-1) + (2n-1)\frac{N^2}{\frac{N}{2}}$$

$$\Rightarrow 2N\left(2\sqrt{\frac{N}{2}} - 1\right) + \left(2\sqrt{\frac{N}{2}} - 1\right)2N$$

$$\Rightarrow 4N\sqrt{\frac{N}{2}} - 2N + 4N\sqrt{\frac{N}{2}} - 2N$$

$$\Rightarrow 8N\sqrt{\frac{N}{2}} - 4N$$

$$\cancel{2N}\left(\quad 4N(\sqrt{2N} - 1) \Rightarrow 4N\left(2\sqrt{\frac{N}{2}} - 1\right)\right.$$

$$\Rightarrow 4N(\sqrt{2N} - 1)$$

Design a three stage switch with N = 200 using clos criteria, find min no of cross points :- {15200}

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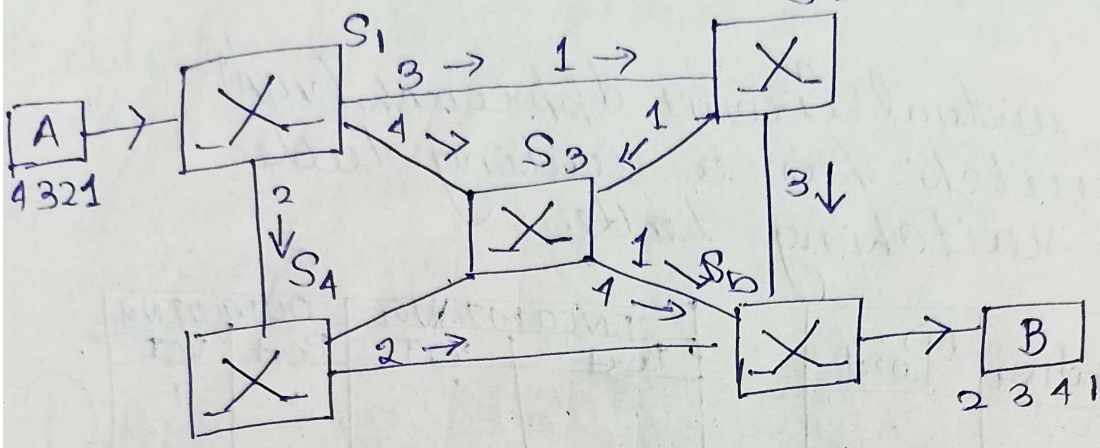
Packet Switching:-

Datagram Approach (N/w layer technology)



B/w two switches multiple packets can go.

Each packet travels independently in its own path. Receiver has to rearrange the packets. Each packet must carry the destination address. When a packet arrives at a switch, a routing table is referred.

Routing table

Destn.	Port	...	...
1237	3		
1235	4		
⋮	⋮		

Destination address is there & corresponding port address is there.

When all ports of a switch are busy and its queue is full then incoming packets get dropped.

Virtual Circuit Approach :-

1> A fixed path is established but it is not dedicated {may change}.

2> Resources are allocated on demand basis.

3> In the virtual Circuit Approach (VCA) each switch has a routing table and a switching table.

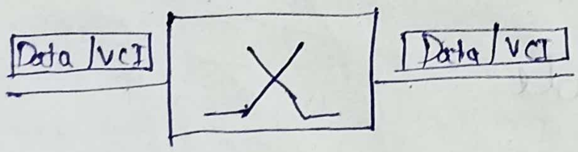
Destination	Port

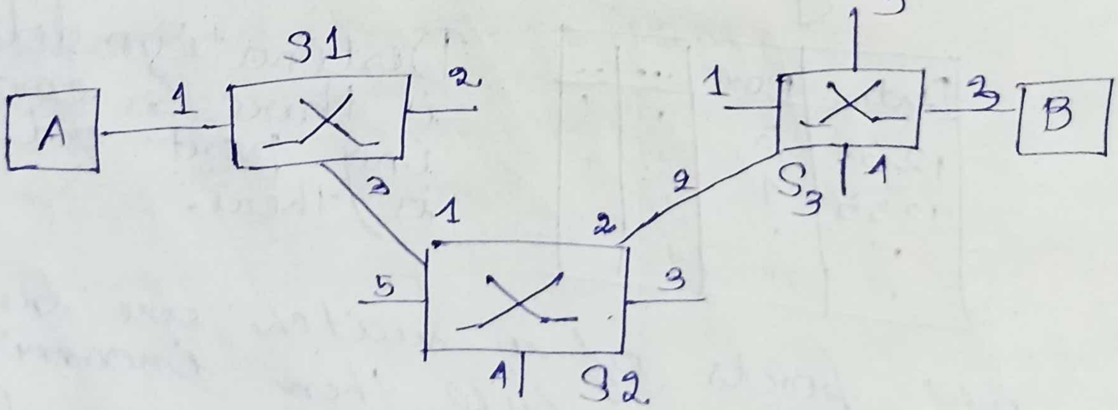
Routing Table

INCOMING		OUTGOING	
Port	VCI	Port	VCI

Switching Table

VCI → Virtual Circuit Identifier
8-bit, switch scope





VCI is a random number. RNG (Random Number Generator) is used here.

1) Set Up Request Frame is sent from Sender to Receiver.

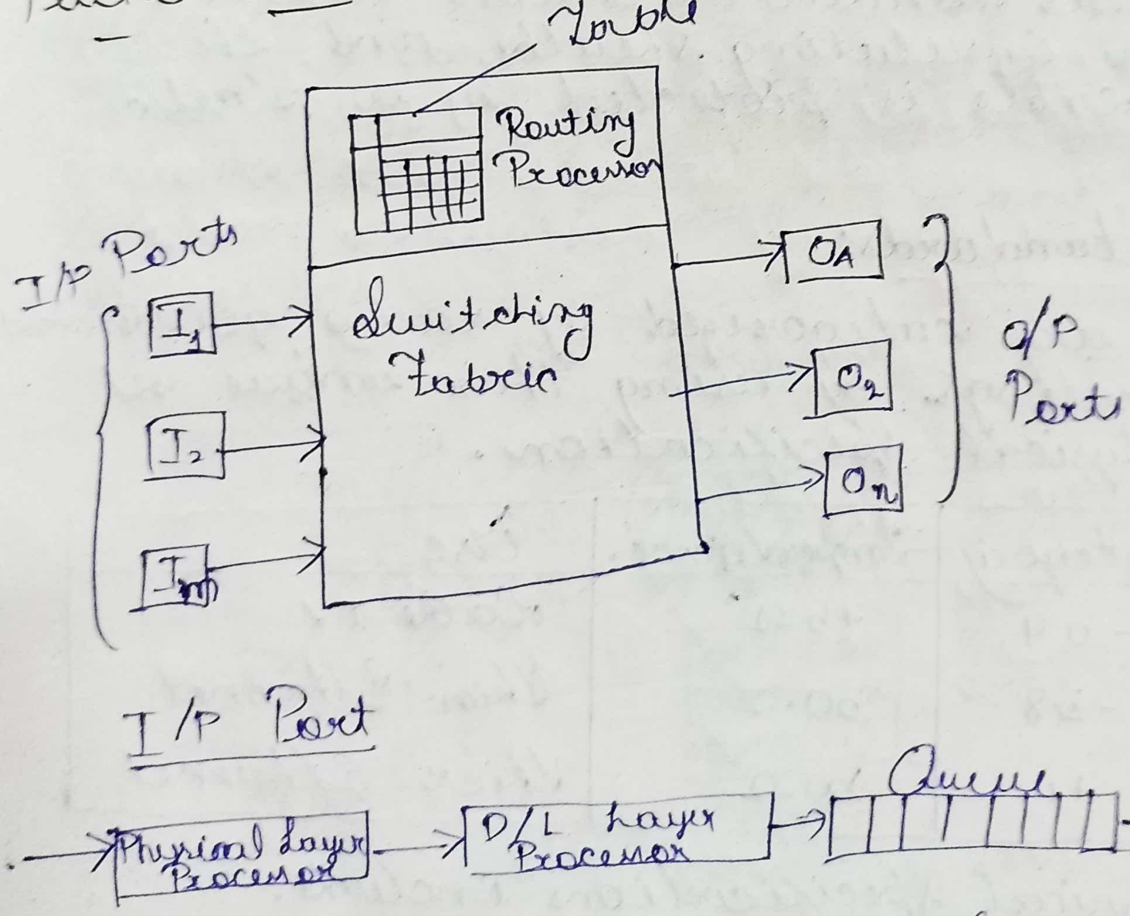
2) Acknowledgement Frame is sent from Receiver to Sender.

3) Switching Table Entries are defined in this phase.

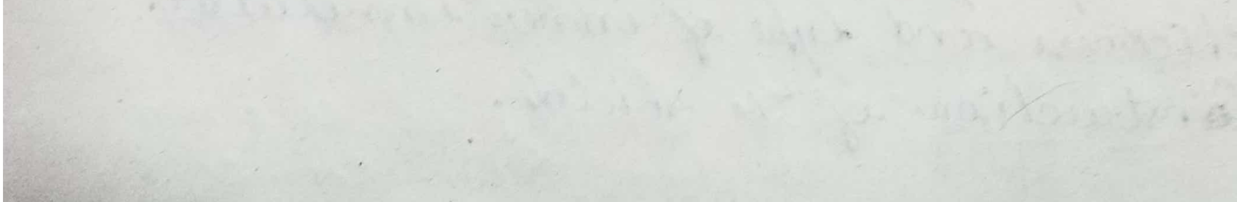
4) A tear down frame is sent across the network and switching table entries are deleted.

Datagram approach is faster than virtual Circuit Approach.

Packet Switch



I/P Port



O/P Port → reverse of i/p port.

Assignment - 01

NAME - Priyambada Onkar
ID - B121040

→ Coaxial Cables (Coax):-

· It carries signals of higher frequencies more than that of twisted pair cables.

· Coax has a central core conductor of solid or stranded wire (usually copper) enclosed in an insulating sheath.

· The central core is encased in an outer conductor of metal foil, braid, or a combination of the two.

· The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.

This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.

Coax Standards:

· Coax are categorized by radio government (RG) ratings by using their unique set of physical specification.

Category	Impedance	Use
RG-59	75Ω	Cable TV
RG-58	50Ω	Thin Ethernet
RG-11	50Ω	Thick Ethernet

The physical specifications include:

1> Wire gauge of inner conductor.

2> Thickness and type of inner insulator.

3> Construction of the shield.

4) Size and type of outer coating.

Connectors:-

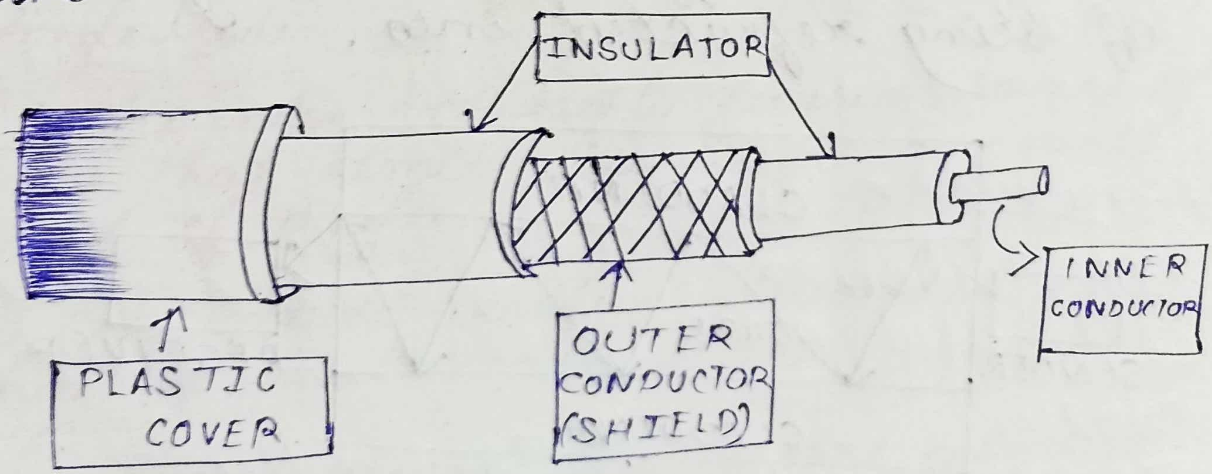
To connect coaxial cable to devices, we need coaxial connectors. The most common type of connector used today is the Bayone-Neill-Concelman (BNC).

Performance:-

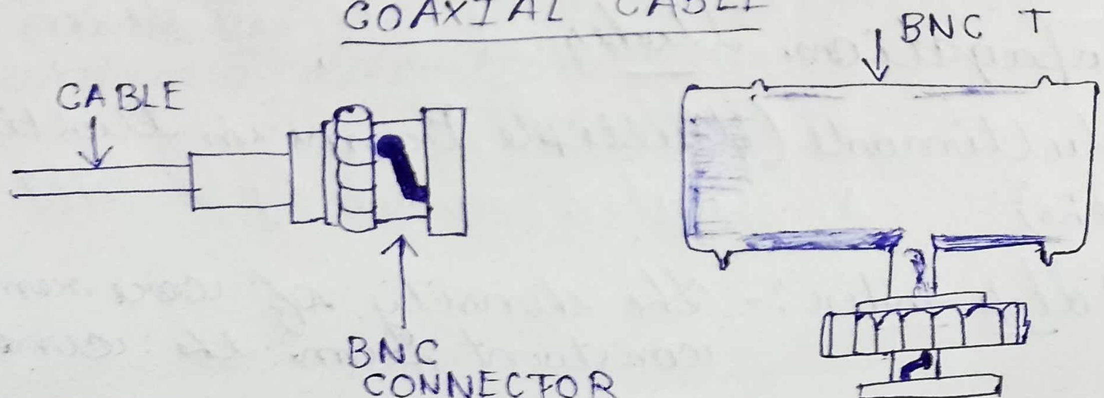
- The attenuation is much higher in coaxial cable than in twisted pair cable.
- Although coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.

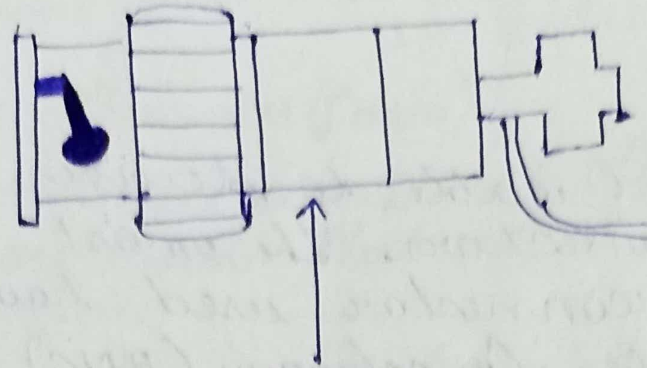
Applications

- It was widely used in analog telephone networks. Later it was used in digital telephone networks, cable TV and traditional Ethernet LAN.



COAXIAL CABLE

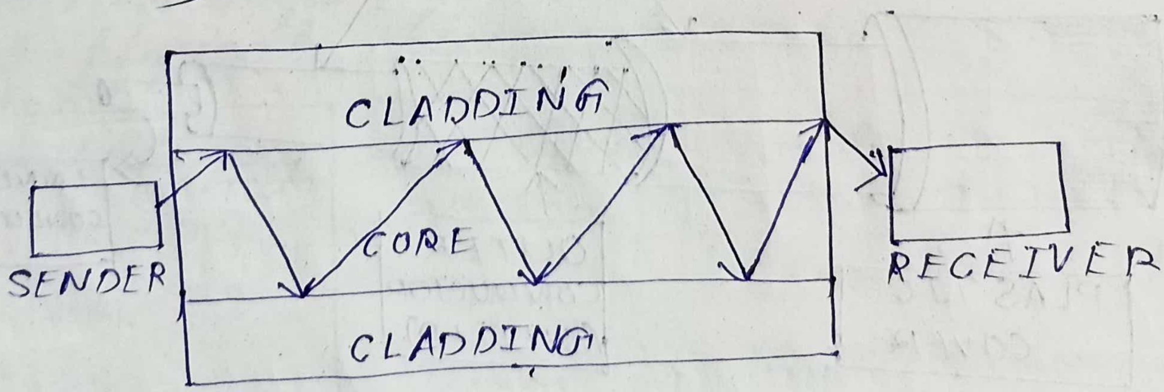




2) Fiber Optic Cable

→ A fiber optic is made up of glass or plastic and transmits signals in the form of light.

→ There use total internal reflection to guide through 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.

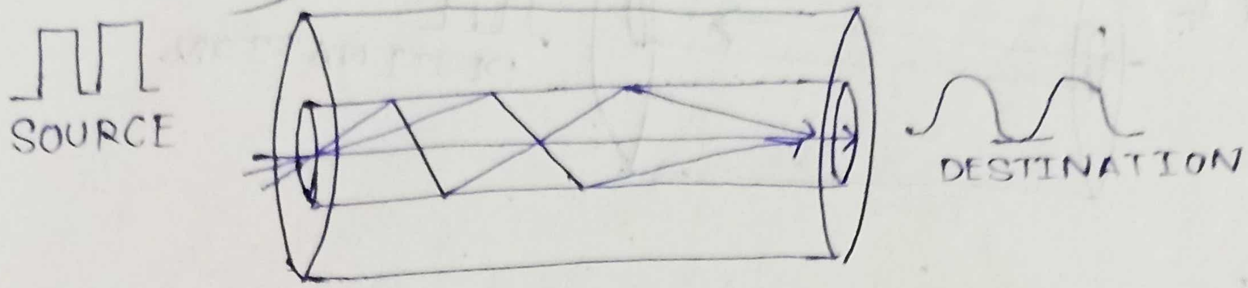


→ Propagation Modes:-

1) Multimode (Multiple Beams in Multiple Paths)

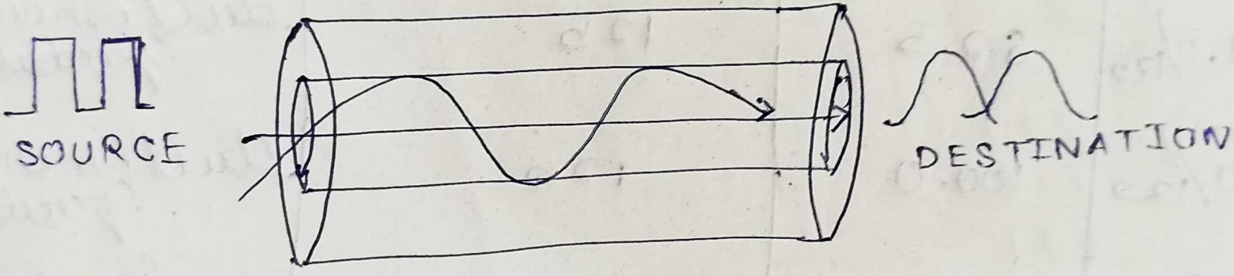
a) Step Index:- The density of core remains constant from the center

- Light waves move in a straight line until it reaches final interface and the cladding.
- The angle of beam changes rapidly on cladding with the interface.



b) Graded-Index Fiber : Decreases distortion of the signal through the cable.

- The index here refer to index of refraction.
- Density is highest at center and decreases gradually at the edges.

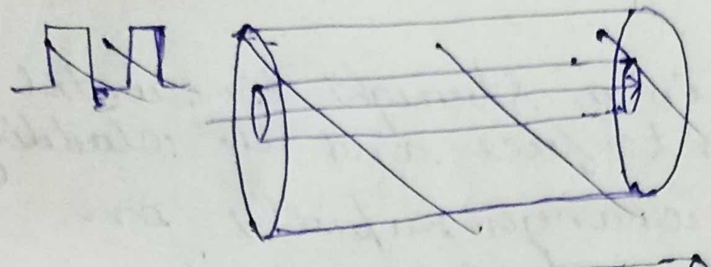


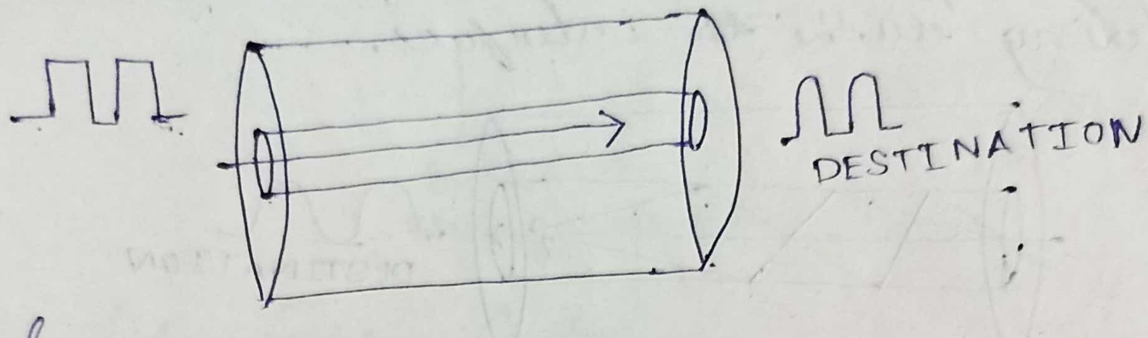
2) Single Mode

→ It step index and highly focused source of light that limits beams to a small range of angles, all close to horizontal.

→ It has much smaller diameter than that of multimode fibre.

→ Propagation of beams are almost identical and no delay in transmission and no distortion.





Sizes:
Defined by the ratio of diameter of their core to the diameter of their cladding.

Type	Core (um)	Cladding (um)	Mode
50/125	50.0	125	Multimode, graded
62.5/125	62.5	125	Multimode, graded
100/125	100.0	125	Multimode, graded
7/125	7.0	125	Single

Performance:-
Attenuation is flatter than in the case of twisted pair cable and coaxial cable.

Advantages:
1. Higher Bandwidth
2. Less Signal attenuation
3. Light Weight
4. Greater Immunity to tapping

Application

1. Cable TV
2. Local Area Networks
3. Fast Ethernet

4/09/23

Block Coding Techniques:-

→ Block Coding:

Dataword $\xrightarrow{+r\ bits}$ codeword

k-bits n-bits

N.O of Possible words $2^k \cdot 2^r = 2^n$

↓

valid $= 2^k$

Invalid $= 2^k(2^r - 1)$

→ Linear Block Coding:-

XOR of any 2 codewords produces another valid codeword.

Eg: 000

011

101

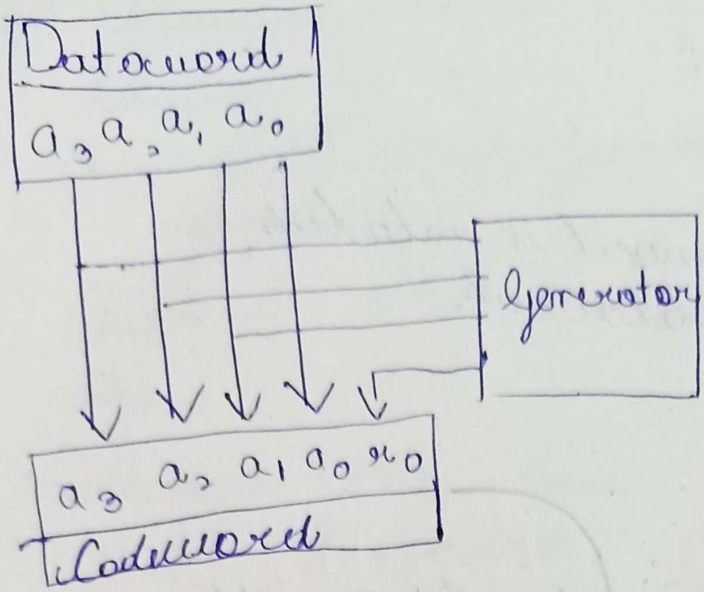
110

000 XOR 011 = 011 000 XOR 101 = 101 000 XOR 110 = 110

011 XOR 101 = 110 011 XOR 110 = 101 101 XOR 110 = 011

→ Parity Bit Check:- {Only a single bit is added in Parity Bit Check for error detection}

$n - k = r = 1$



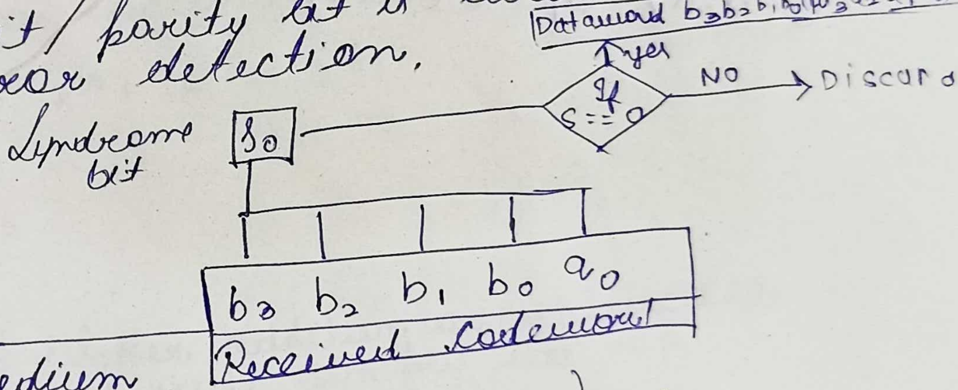
$r_0 = (\sum a_i) \% 2$

1101

Bitwise $r_0 = 1$

Numeric $r_0 = 1$

This modulo bit / parity bit is added to the data for error detection.



Unreliable Transmission Medium

$S_0 = (\sum b_i + r_0) \% 2$

If $S_0 = 0$ then codeword is valid if invalid then should be discarded.

To detect 1 bit error the min hamming distance required would be 2.

2D parity - checks for row parity as well as column parity

→ Cyclic Block Code :

→ Linear Code +

If one codeword is rotated, another is obtained.

000

011   011 = 101

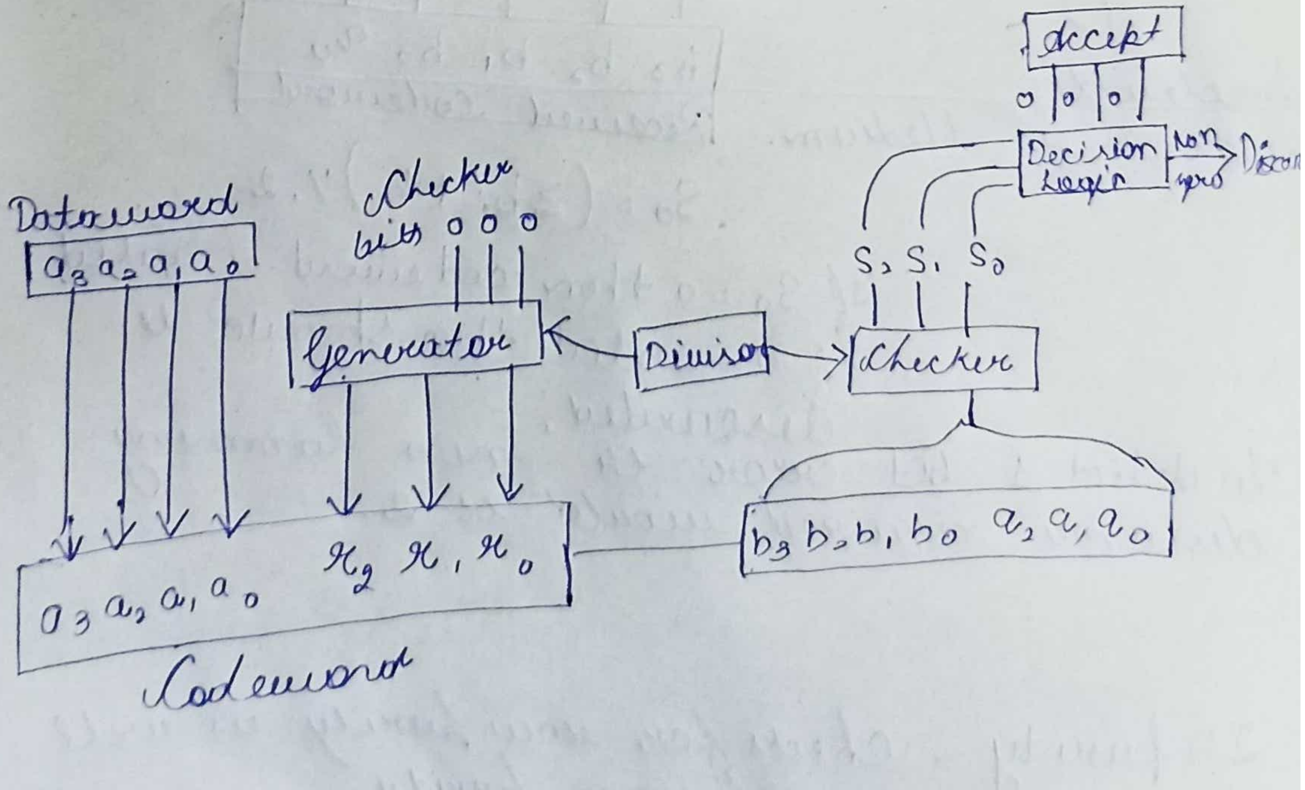
101   101 = 110

110   110 = 011

→ One of the codeword should be all zeros.

→ Cyclic Redundancy Code (CRC)

$C(n, k)$ Eg : $C(7, 4)$



8 4 2 1

Eg: Dataword = 1001   9

Divisor = 1011   11

Find the Quotient, find the remainder

1011 | 1001000

Quotient = 0110

Rem = 110

Codeword = Data + Rem

= 1001110

Codeword = 100110

Divisor = 1011

Syndrome =

→ Representing as polynomials

1001100 = $x^6 + x^3 + x^2$

100 = x^2

110 + 101 } whether addition or subtraction
-      we will simply do XOR

= 110 EXOR 101

= 011

= $x + 1$

Multiplication

$x^2(x^3 + x + 1)$

$= x^5 + x^3 + x^2$ – 101100

$(x^5 + x^3 + x^2 + x)(x^2 + x + 1)$

$= x^7 + x^6 + x^5 + x^5 + x^4 + x^3 + x^4 + x^3 + x^2$

$+ x^3 + x^2 + x$

$= x^7 + x^6 + x^3 + x$

Cyclic Code Analysis

Dataword - $d(x)$
Codeword - $c(x)$
Generator - $g(x)$
Syndrome - $s(x)$
Error - $e(x)$
Received Codeword - $r(x) = c(x) + e(x)$

[illegible]

[illegible]

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