# COMPUTER NETWORKS

COMPUTER NETWORKS

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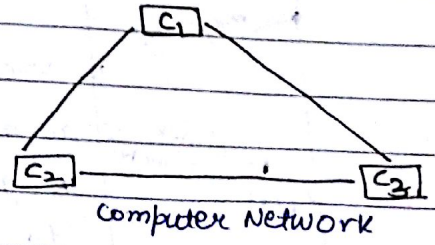
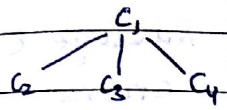
## Introduction

* we use network to communicate
* Components of Communication:
  1. Sender
  2. Medium
  3. Receiver
  4. Message
  5. Protocol - Rules/agreement



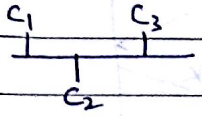
Computer Network

Different topologies for networks:-

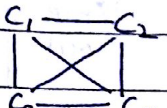


Star topology

Ring topology



Bus



Mesh

environment

S → message → R → message c errors

Two ways to get original message from errorful message -

- Error detection → Retransmission → in ~~long~~ short term → planetary communication → Comm^n
- Error correction → No retransmission → in ~~long~~ short term comm^n → short distance comm^n

Two models of computer/communication Network

(open system interconnection)

OSI

Gives a layout of comm^n

- Application
- Presentation
- Session
- Transport
- Data links
- Physical

layers of OSI model →

TCP/IP

- Appl^n
- Transport
- Network
- Data link → Physical

http is an appl^n layer protocol

email

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NIC card – Network interface card
↳ a device at physical level on system

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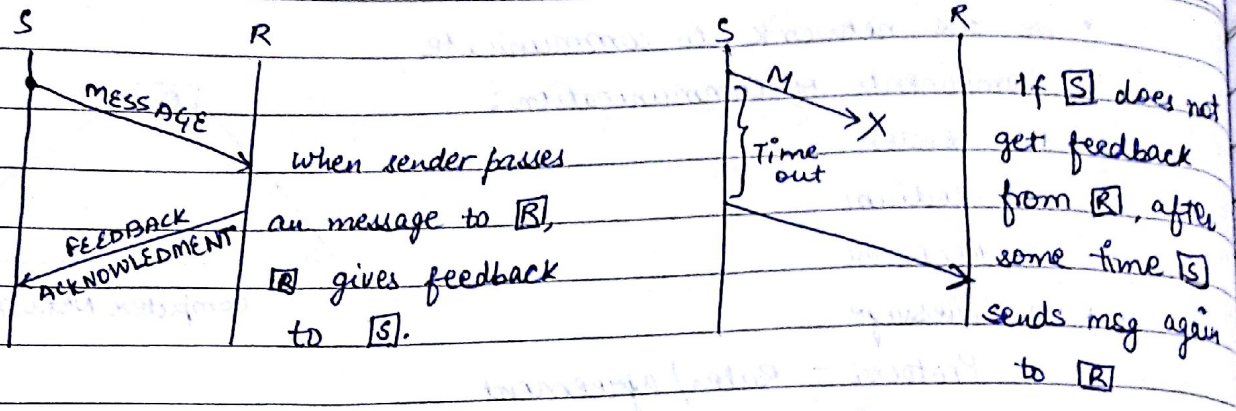
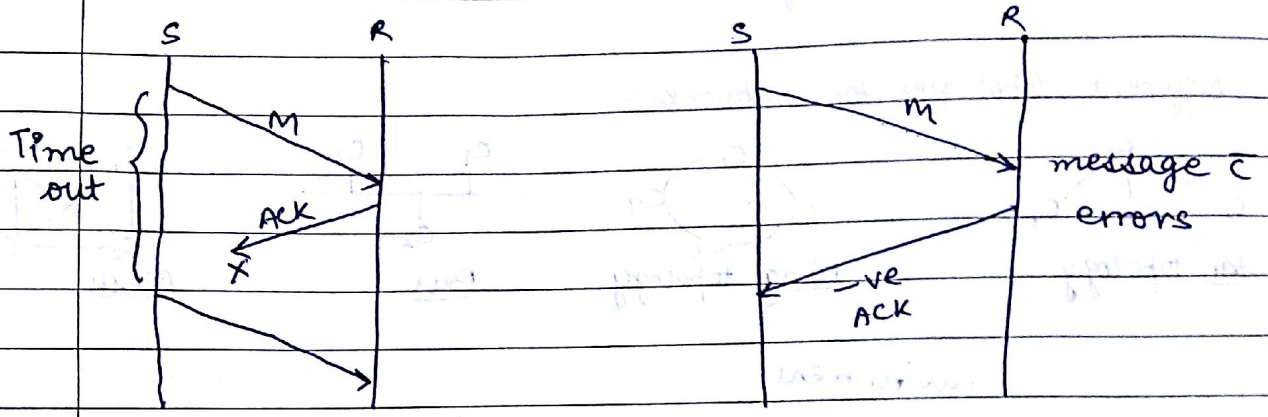
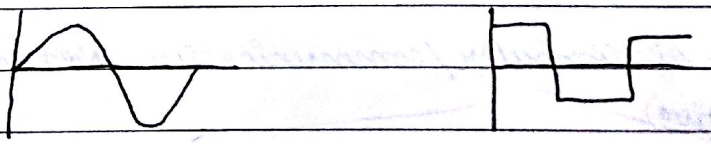



## Signal and data

- Data is a peace of useful information
- Data can analog or digital.
- Analog data means data is continuous.
- Digital data means information in discreate form/state.



Analog  Digital

Signals → Analog
→ Digital

- Analog signal:-
  - It has infinitely many levels of intensity over a period of time.

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- **Digital Signal**
  - It only have limited no. of defined value.
- Both analog & digital signal may be periodic or aperiodic.
- **Periodic Signal**
  - It completes a pattern in a specified time and repeat that pattern over a time.
  - eg :- Sine wave
- **Aperiodic Signal** :- Changes without exhibiting any pattern or cycle that repeated over a time.
  - eg :- Audio wave.

**Sine Wave** –

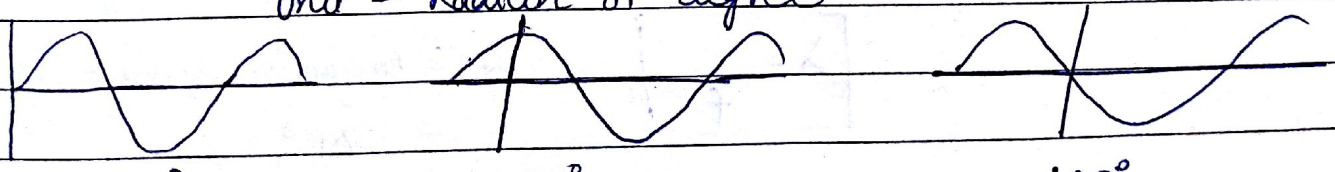

A sine wave can be represented by these component :-

i) **Amplitude** :- absolute value of its highest intensity /value.
[Unit - Volt (V)]

(ii) **Frequency**
- no of cycle per sec  Unit – Hertz. (Hz)

(iii) **Phase**
- Shifting of wave from origin
- describes the position of waveform relative to time 0.

Unit – Radian or degree




**Cycle** :- is a unit periodic signal

1 cycle = 360° phase

1 Radian = $\frac{180}{\pi}$ degree

1 degree = $\frac{\pi}{180}$ radian

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Q) If we shift ⅙ of cycle, how much phase change?

1 cycle – 360°

⅙ cycle = 60° phase

(1 sec.)

- Period :- amount of time to complete one cycle.

$$\therefore \boxed{T = \frac{1}{f}} \qquad f \rightarrow \text{frequency}$$

i.e., period = $\frac{1}{\text{Frequency}}$

Ex :- If T = 100 ms || f = 10 Hz.

| | | | |
|---|---|---|---|
| * | 1 KHz = $10^3$ Hz | 1 ms = $10^{-3}$ s | |
| | 1 MHz = $10^6$ Hz | 1 μs = $10^{-6}$ s | |
| Giga | 1 GHz = $10^9$ Hz | 1 ns = $10^{-9}$ s | (nanosecond) |
| Tera | 1 THz = $10^{12}$ Hz | 1 ps = $10^{-12}$ s | (pico second) |

- Wavelength :-
  - It binds the period or frequency of simple sine wave to propagation speed of medium
  - Frequency is independent of medium but wavelength is dependent on both, frequency and medium
  - Denoted by λ ; unit is 'm'

$$\boxed{\lambda = \frac{c}{f}}$$

c = propagation speed = speed of light = $3 \times 10^8$ m/s

* Hamming distance (H) :- distance b/w codes of same length which ~~are~~ is defined as the sum of change in symbol.

$C_1 = 1\ 0\ 0\ 1\ 0$

$C_2 = 1\ 1\ 1\ 0\ 1$

$1+1+1$

implemented using XOR

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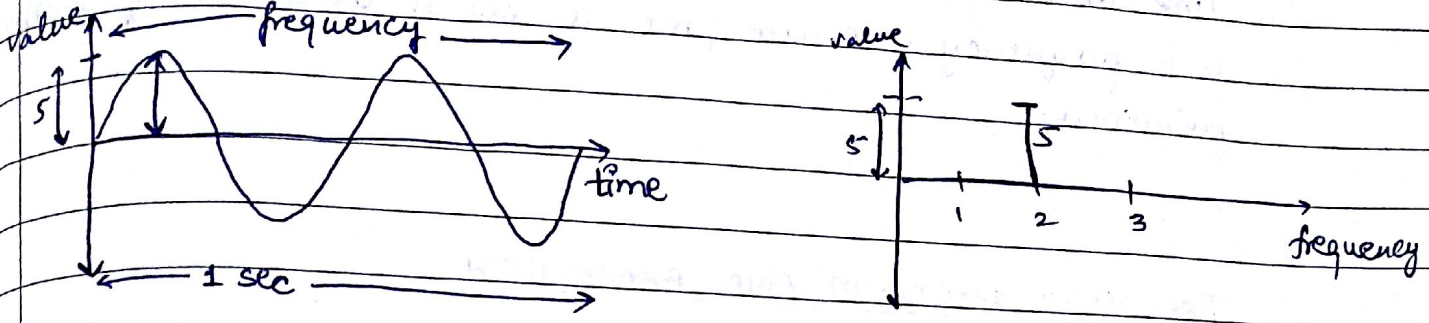
## ① Analog Signal




$f = 2$ Hz

Time-domain plot
(relⁿ b/w time & amplitude)

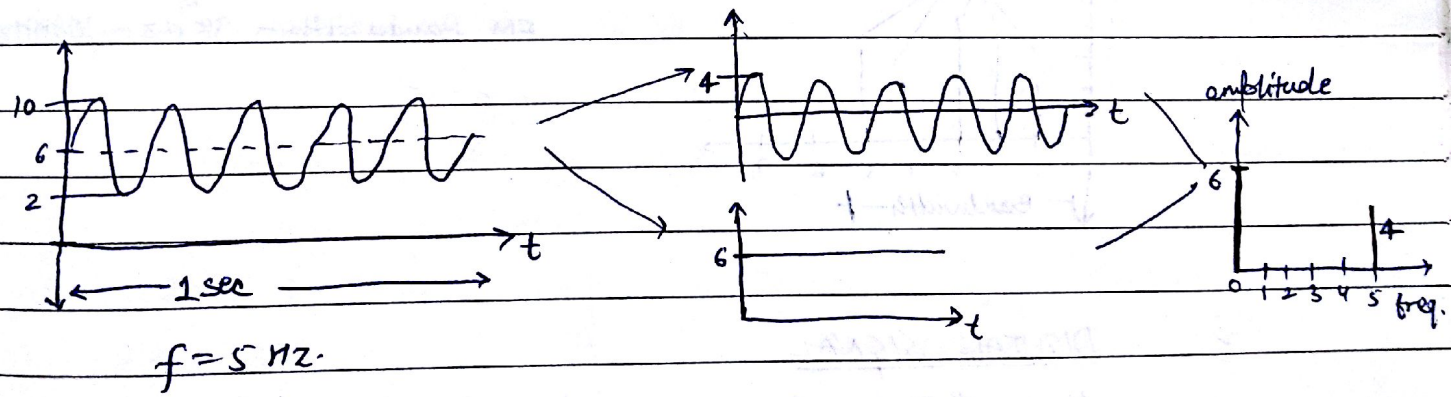
fourier analysis

frequency-domain plot
(relⁿ b/w frequency & amplitude)

### Composite Signals –

→ Any signal made up of different signals is called a Composite signal.

→ Any periodic no matter how complex can be decomposed into a collection of sine waves where each signal can be have a measurable amplitude, frequency and phase.




$f = 5$ Hz.

In time-domain graph, Composite signal is represented as signal entity but in frequency-domain plot, composite signal is represented as series of frequency composite.

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Time-domain plot show the impact of each component but frequency-domain plot a signal as a set of independent frequencies.

## FREQUENCY SPECTRUM AND BANDWIDTH

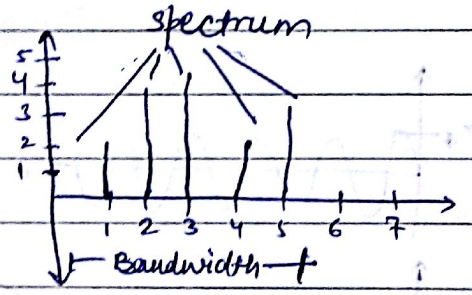
### FREQUENCY SPECTRUM -

- It is a collection of all the components frequencies of a signal contain and it shows using frequency-domain plot.

### BANDWIDTH - (Hz)

- The bandwidth of a signal is width of the frequency spectrum.

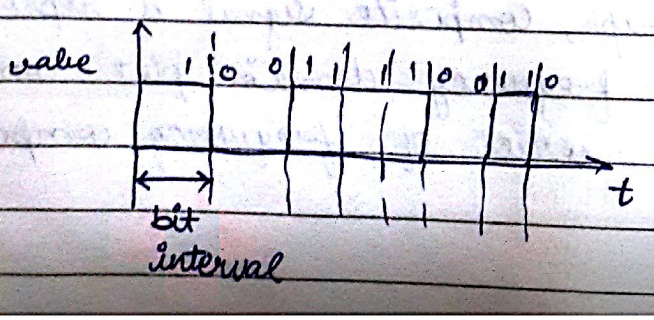
Bandwidth - Range of frequencies
Spectrum - values in the range.




FM Bandwidth - 98 MHz - 108 MHz

(2) DIGITAL SIGNAL

- Most digital signals are aperiodic in nature.
- Thus period or frequency can't be used.



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## Bit Interval and Bit Rate

- Time required to send one Single bit
- Used instead of period
- ~~unit: b~~

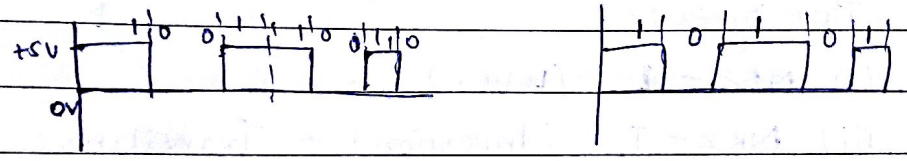
- no. of bits send / second.
- used in place of frequency
- unit: bit per second (bps)

q) If bit rate = 2000 bps duration of 1 bit = ? = $1/2000$ s = 500 μs

q) bit interval = 40 μs (microsecond) bit rate = ? = 25 Kbps

## DIGITAL TO DIGITAL ENCODING

1) Unipolar: Unipolar encoding use only one level of value.




### Problem/Drawback in Unipolar

① DC Component is the average amplitude of the signal.

② Synchronization

DC component: The avg amplitude of a Unipolar signal is non-zero

When a signal contain DC component, it cannot travel through a media that can't handle DC component.

Synchronization: When the signal is unvarying then the receiver can't determine begining & ending of each bit.

For synchronization, we have to change in voltage for each bit.

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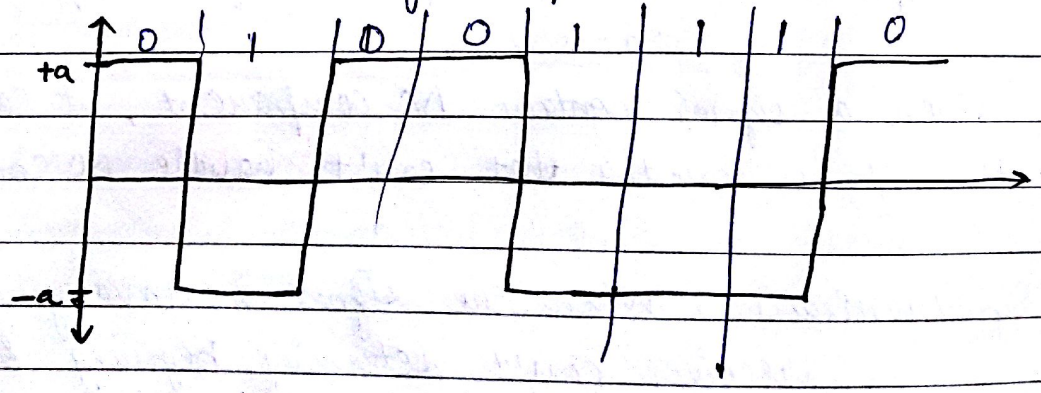
② Polar → NRZ
→ RZ
→ Biphase

- Polar encoding use two voltage level for 1 bit +ve and 0 bit -ve.
- Using both levels in Polar encoding method, the avg voltage level on the line is reduced & the DC component of the Unipolar is solved / reduced.
problem

NRZ (Non-return to zero)
- signal is always +ve or -ve.
- Signal never return to 0 voltage

Two types :-
(i) NRZ-L (level)
(ii) NRZ-I (Inversion) → Transition

NRZ-L : The level of signal depends on the type of bit it represent.
+ve voltage usually represent 0 bit
-ve voltage represents 1-bit




Drawback -
→ The Synchronization for sending consecutive bits can't be solved.

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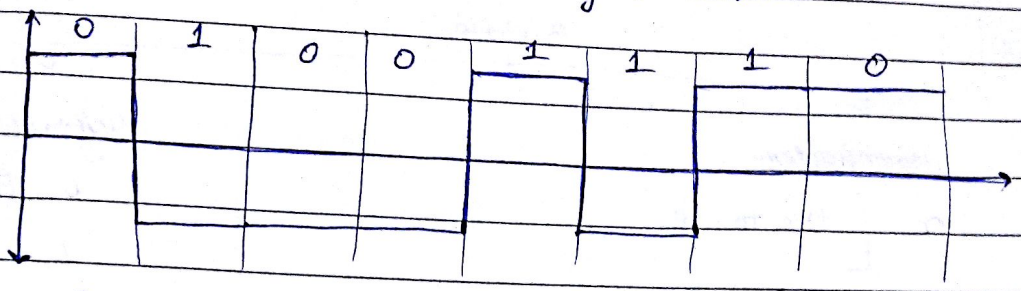
**NRZ – I :-**

In this, the inversion of voltage level represent a 1-bit.

The 0-bit is represented by no transition / no change but 1-bit is represented by transition.



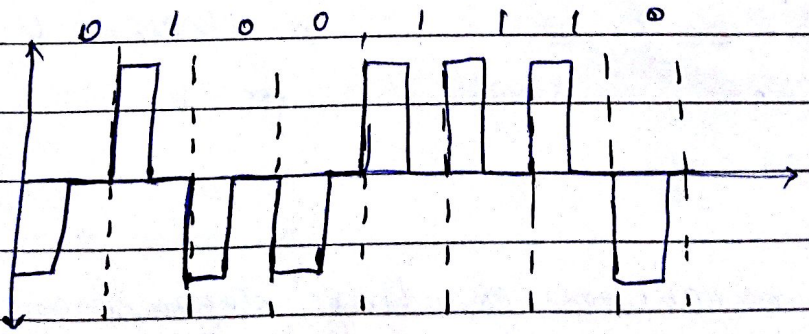

NRZ – I is superior to NRZ-L. due to synchronization provided by the signal change is each time a 1-bit is encountered.

**RZ (Return to zero)**

- to assure a synchronization there must be a signal change for each bit.
- In RZ, the signal change is not b/w bit but during each bit.
- In RZ, the signal changes in halfway of bit period.

1 bit – +ve to zero

0 bit – –ve to zero.




The main disadvantage of RZ encoding is the it requires two signal change to import single bit. And :. occupies more bandwidth.

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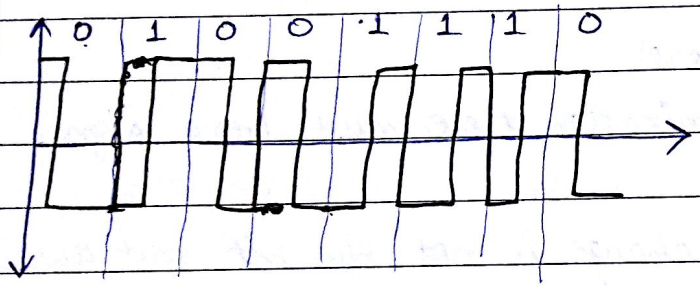
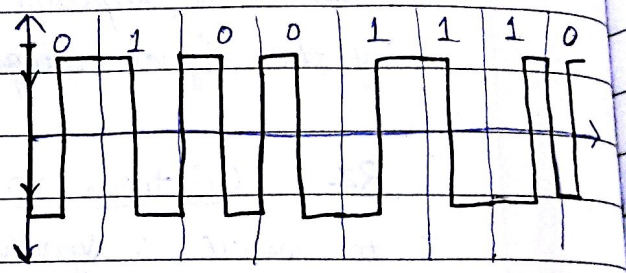
* **Biphase**

In this method, the signal changes at the middle to bit interval but does not return to zero and continue to the opposite of pole.

Biphase

- Manchester
  - 0 ] +ve to -ve
  - 1 ] -ve to +ve
- Differential Manchester
  - 0 – transition
  - 1 – no transition




- achieve same level of synchronization as RZ & two level of amplitude

→ the inversion take place at the middle of bit interval & it useful to synchronization.

→ require two signal change to represent 0 & one change for 1.

→ Differential manchester encoding depends on initial bit representation.

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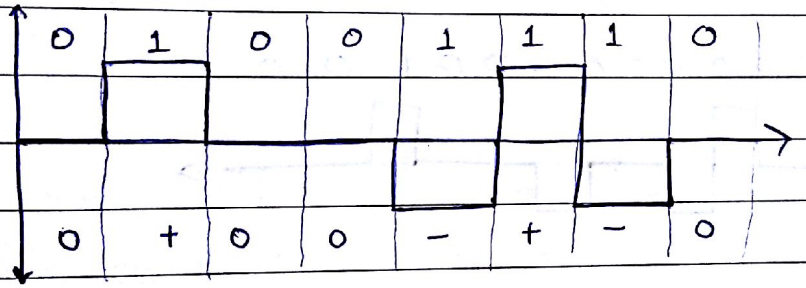
## Bipolar

- It use three voltage levels - zero, +ve, -ve

- **AMI** (Alternective Mark inversion)
- **B8ZS** (Bipolar 8-zero substitution)
  - Developed in North America
- **HDB3** (High Density Bipolar 3)
  - in Europe & Japan.

## AMI

- simplest bipolar encoding in which we perform inversion when we encounter 1 and neutral when 0 is encountered.




- there is a mechanism for synchronization of two consective 1-bits but no mechanism for consective 0-bits.

## B8ZS

- is used to force artificial change in signal called Violation.

```
+ 00000000
↓ ↓ ↓ ↓ ↓ ↓
+ 000+-0-+   ← B8ZS coding

- 00000000
↓ ↓ ↓ ↓ ↓ ↓
- 000-+0+-
```

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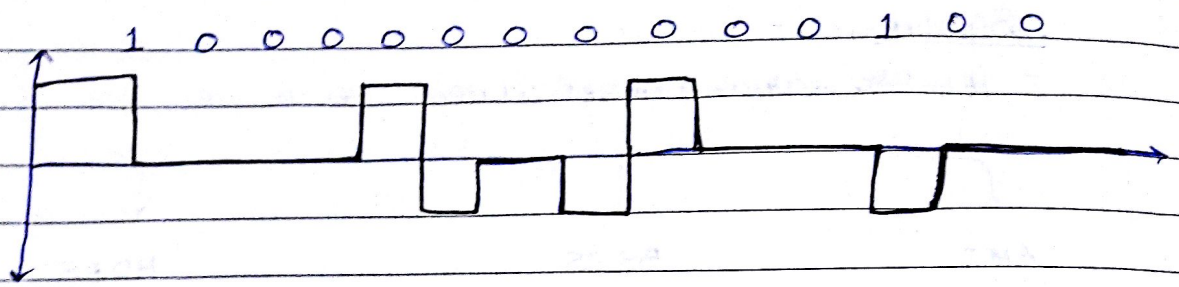


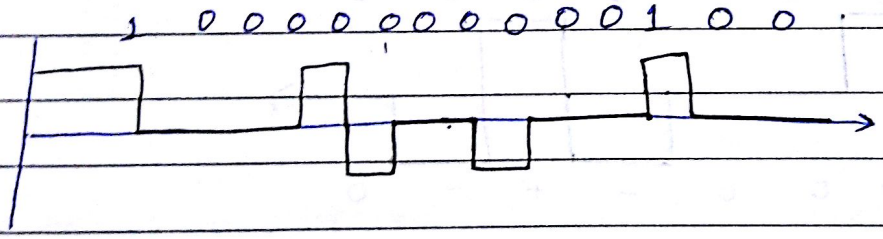

**HDB3**

+0000 −0000 If the no. of 1's since the last substitution is odd

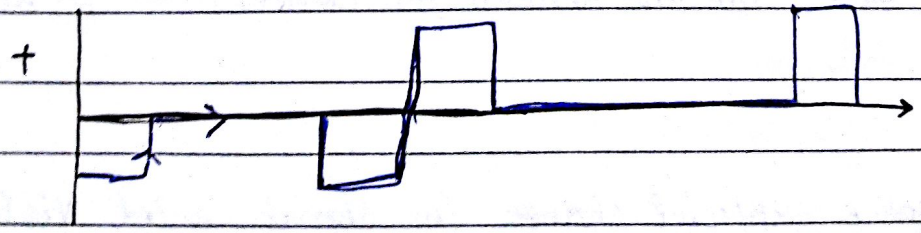
+000+ ← HDB3 coding → −000− last substitution is odd

+0000 −0000 If the no. of 1's since the last

+−00− −+00+ subst$^{n}$ is even.




0 0 0 0 1 0 0 0 0



Pulse → signal which changes instantly

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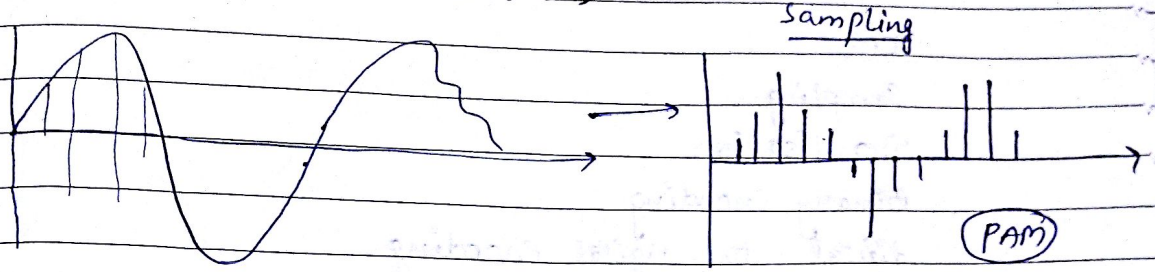
Analog to Digital Conversion

PAM (Pulse Amplitude Modulation)

PCM (Pulse Code Modulation)




Quantisation → Representation.

QUANTIZATION

A method of assigning interval values in a specific range to sample instances.

1) PAM

This technique takes an analog signal sample it and generate a series of pulse based on the result of sampling.

Sampling – Means measuring the amplitude of the signal at the equal interval.

Disadvantages -

→ PAM is not useful in data communication becoz it translate original waveform into a series of pulses but these pulses are still of infinite amplitude. (any).

PCM

To overcome PAM disadvantages, PCM modifies the pulses created by PAM.

→

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after quantisation, binary digits are transformed to digital (signal) form through any of digital-to-digital scheme.

PCM
- Sampling
- Quantisation
- Binary encoding
- digital-to-digital encoding

## Sampling Rate

- no. of samples per unit time.

- The accuracy of any digital system is dependent on no. of samples taken.

## Nyquist Theorem

The sampling rate must be atleast 2 times the highest frequency.

Sampling rate $\geq$ 2* highest frequency of analog signal.

Eg :- $f = 40$ Hz

Sampling rate $\geq$ 80 Hz

$\therefore$ atleast 80 samples/sec.

Q) frequency: 0-4000 Hz  8 bit/sample  bit rate = ?

Sample rate $\geq$ 8000 Hz = 8000 samples/sec.

Bit rate = $8 \times 8000$ = 64000 bps = 64 kbps.

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# Analog-to-analog Conversion

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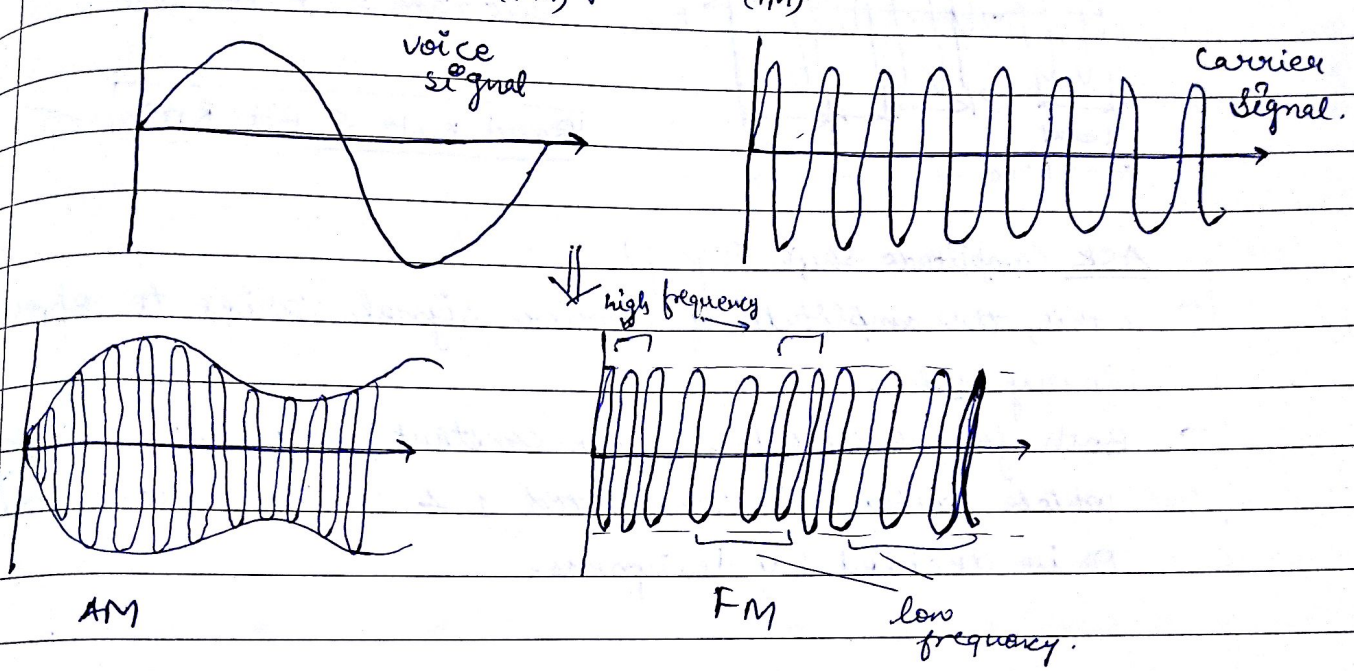
**Modulation :**

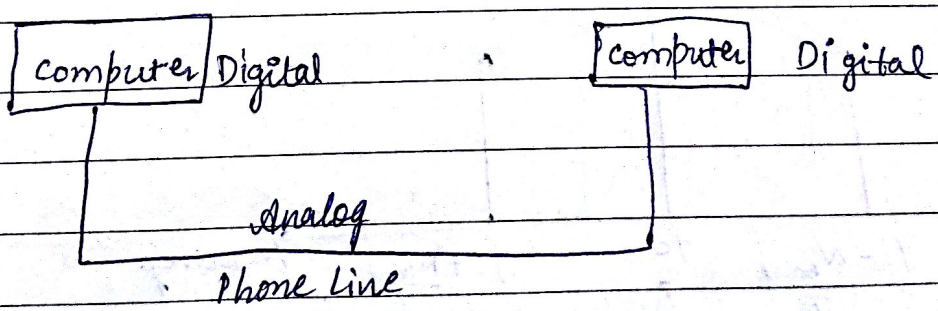
Superimposing of information signal over high frequency carrier signal.

(i) Amplitude (AM) (ii) Frequency (FM) (iii) Phase modulation (PM)




**DIGITAL-TO-ANALOG CONVERSION / Modulation**

- is a process of changing one of characteristics of analog signal based on the information of digital signal.




**Digital-to-analog modulation**

- ASK — Amplitude Shift Keying
- FSK — Frequency
- PSK — Phase

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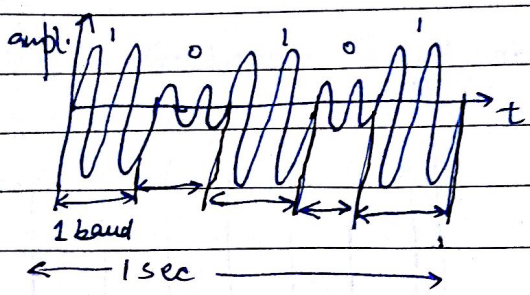
## Baud Rate

or signal unit

Baud rate is the no. of signals per second that are required to represented those bits.




baud rate = 4 baud/sec

bit rate = 4 bit/sec

**Baud Rate ≤ Bit Rate** ✓

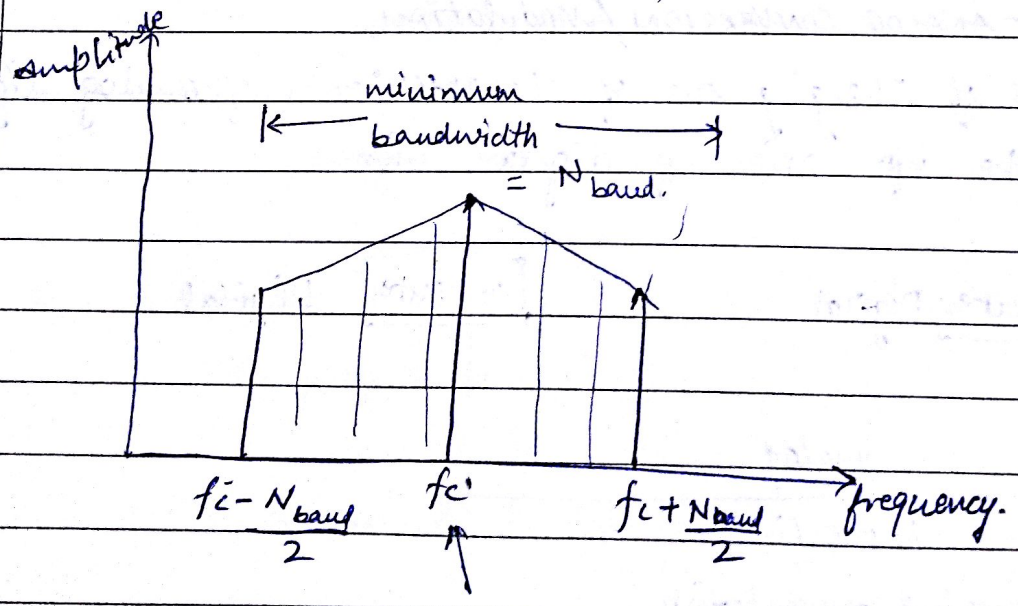
## ASK (Amplitude Shift Keying)

→ In this, the amplitude of carrier signal varies to represent binary 1 & 0.

→ Both frequency & phase are constant, amplitude changes.

→ which voltage is represented 1 & which voltage represent 0 is decided by designers.

## Bandwidth of ASK




$N_{baud}$ = baud rate

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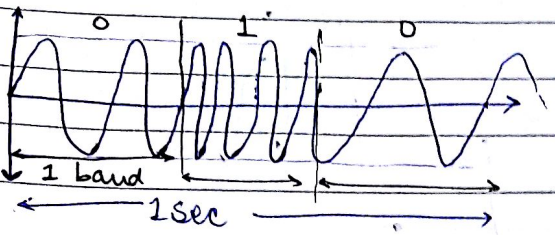
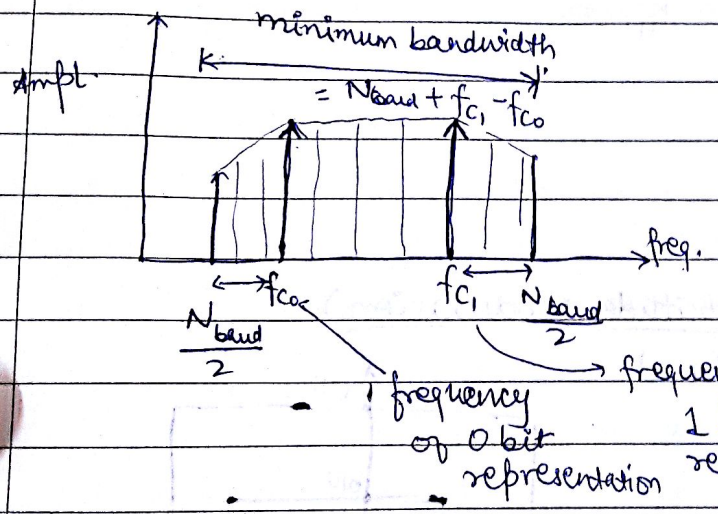
* use less bandwidth.
* ASK is highly susceptible to noise.

## FSK (Frequency Key Shifting)

→ frequency of carrier signal varies to represent 1 & 0's.
→ frequency of signal during each bit is constant and its value depend upon 1 & 0.
→ Both amplitude & phase are constant.




baud rate = 3 baud/sec
bit rate = 3 bps.

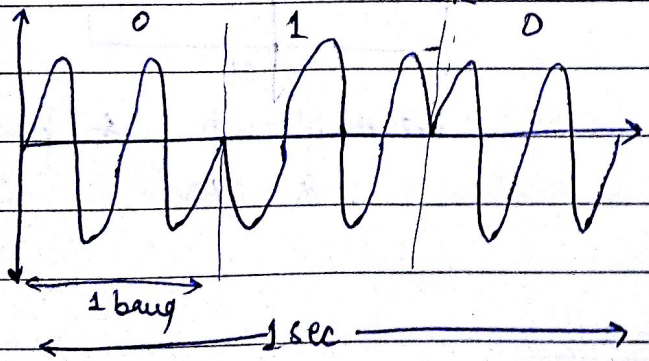



* avoids most of the noise problem of ASK because the
* recieving device is looking for specific freq. change over a given no. of periods. & and ignore voltage spike.
* use large bandwidth.

## Phase key Shifting PSK

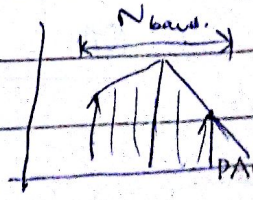
2-PSK

| Bit | Phase |
|---|---|
| 0 | 0° |
| 1 | 180° |




* phase of carrier wave varies to represent 1 or 0.
* Amplitude & freq. constant
*

Bandwidth is ~~as~~ same as ASK.

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QAM = ASK + PSK

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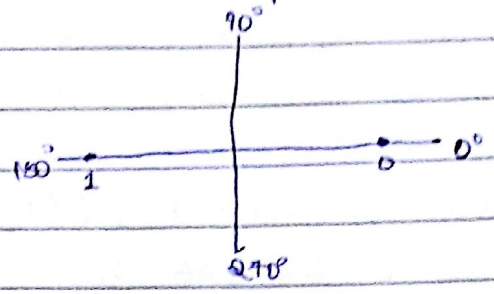
2-PSK / Binary PSK.

Can be represented using



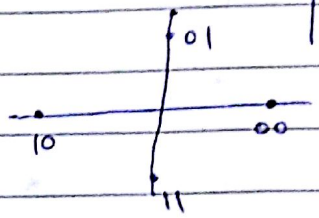

Table

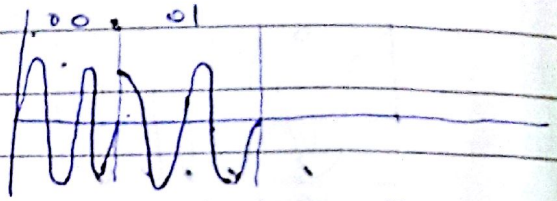
| bit | phase |
|---|---|
| 0 | 0° |
| 1 | 180° |

Constellation diagram / Phase state diagram

4-PSK / Q-PSK

| dibit | Phase |
|---|---|
| 00 | 0 |
| 01 | 90° |
| 10 | 180° |
| 11 | 270° |

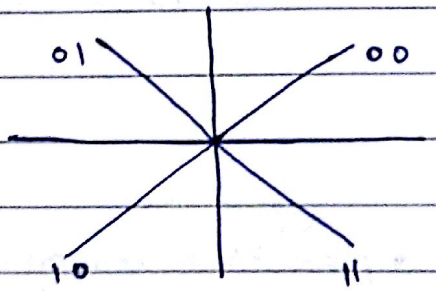



8-PSK

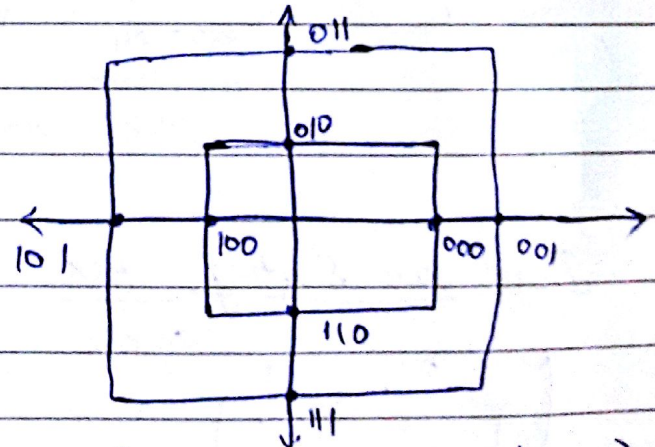
QAM (Quadrature Amplitude Modulation)

(Amplitude + Phase)




4-QAM

(1-Amplitude 4-Phase)




(2-Amplitude 4-phase)

8-QAM.

QAM = ASK + PSK

## DATA RATE LIMIT

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- It depends upon
  - Bandwidth
  - level of signals
  - Quality of channel (level of noise)
    - **Noiseless Channel**
      - Nyquist Rate

Nyquist bit rate = $2 \times B \times \log_2 L$ (Imp.)

$B \rightarrow$ Bandwidth

$L \rightarrow$ Level of signal

Q $B = 3\,KHz$, $L = 4$

$\therefore$ bit rate $= 2 \times 3 \times \log_2 4$

$= 12\,Kbps$

When $L \uparrow$, Reliability of system $\downarrow$.

- **Noisy Channel**

Shannon Capacity

Capacity = Bandwidth $\times \log_2 (1 + SNR)$

SNR $\rightarrow$ Signal-to-noise ratio

→ Independent of level (L)

→ Shannon formula have no identification of signal level which means no matter how many levels we have, we can't achieve a data rate higher than channel capacity.

Q $B = 3\,KHz$ $SNR = 63$

Capacity $= 3 \times \log_2 64 = 18\,Kbps$.

If Signal-to-noise ratio is measured in 'decibels' i.e. $SNR_{dB}$

then, $\boxed{SNR_{dB} = 10 \log_{10} SNR}$

$\log_{10} SNR = \frac{SNR_{dB}}{10}$

$\therefore \boxed{SNR = 10^{(SNR_{dB}/10)}}$

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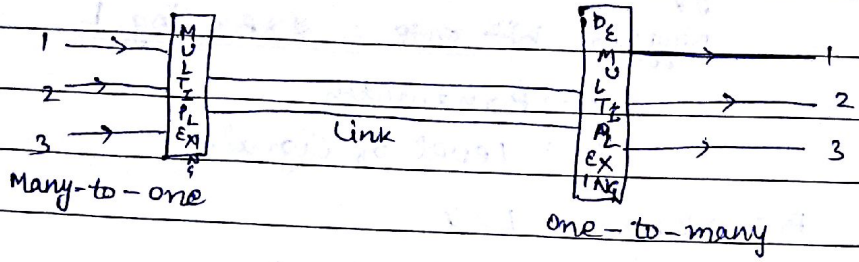
✓ [ Shannon Capacity gives the upper limit of data rate.
Nyquist Rate tell how many signal levels we need.

## Multiplexing

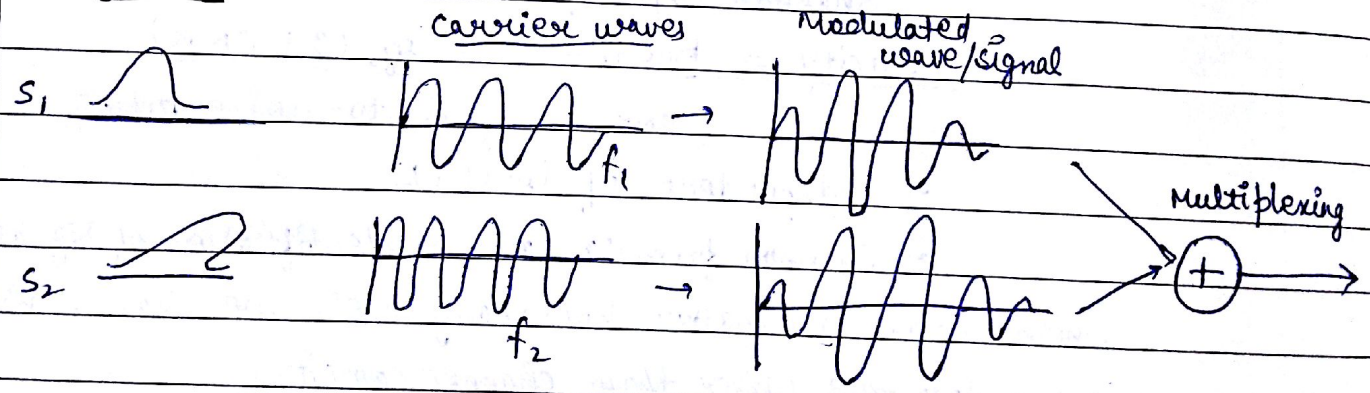
→ a technique that allow simultaneous transmission of multiple signal across a single data link.




3 types of multiplexing :-

(i) FDM (Frequency Division Multi.) Analog Signal
(ii) WDM (Wavelength Division Multi.) Analog
(iii) TDM (Time Division Multi.) Digital Signal.

### i) FDM




Link - physical transmission medium
channel - for particular time being the link / physical medium used to transfer signal
Line - physical transmission medium
Bandwidth - the difference b/w highest & lowest frequency

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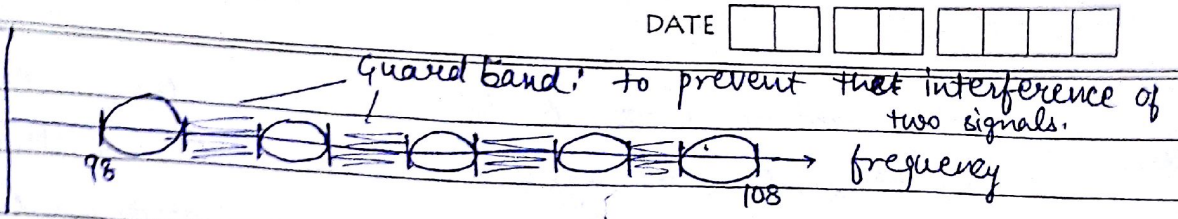


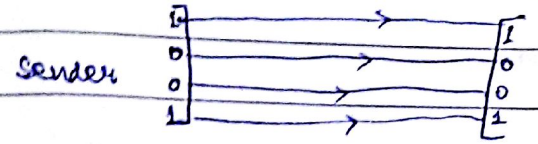

→ no signal/data is transferred from the guardband frequency.

*) Time Division Multiplexing -

TRANSMISSION MODE

Parallel — Serial

Parallel:- all data is transferred simultaneously




(in short distance comm$^n$)

Adv:- • higher speed

Disadv:- • Mismatched data
- costly (more comm$^n$ lines)

Serial:- all data is send bit-by-bit

3 types of serial transmission mode:-

- Synchronous
- ASynchronous
- Isochronous

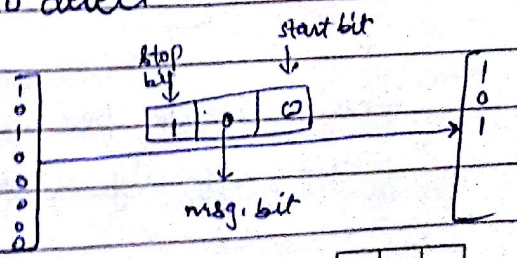
Adv:- • low speed

Disadv:- less comm$^n$ channels required
used in ~~bar~~ long distance comm$^n$.

(i) ASynchronous

- start & stop bits are used to detect.
- data in "Bytes"

8 bit data
1 Stop bit — 1
1 start bit — 0

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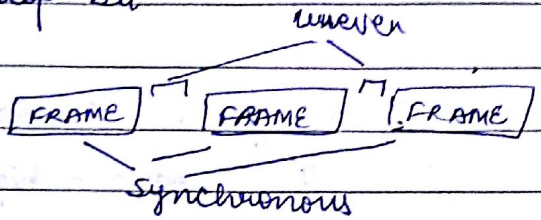
• Asynchronous becoz at the byte level the receiver & sender do not have to ~~sender are not~~ synchronised but within each byte the receiver must be synchronised ~~c~~ the incoming bit stream

Adv:- Cheap  Disadv:- Slower speed.

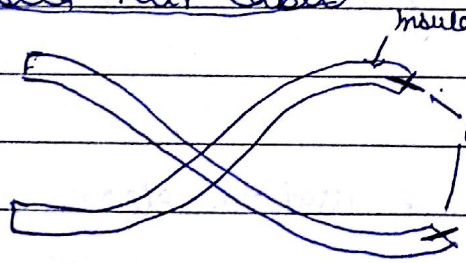
Synchronous
- No start & stop bit
- FRAMES




ISOCHRONOUS
- Real time transmission
- even frame duration
  Audio/Video transmission

→ TRANSMISSION MEDIUM
(i) Guided (wired)
(ii) Unguided (wireless)

GUIDED
→ Twisted Pair Cable




transmission
One wire use for data
other wire – Ground reference
(reduces interference)

– no. of twists per unit area is used to measure quality of cable.

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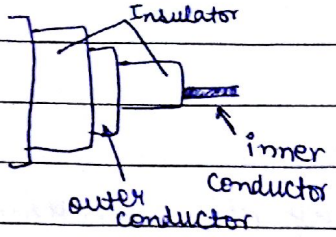
UTP – Unshielded TP

STP – Shielded TP


Twisted pair cable is ~~used~~ connected through RJ-45 (Registered Jack)

→ Coaxial Cable

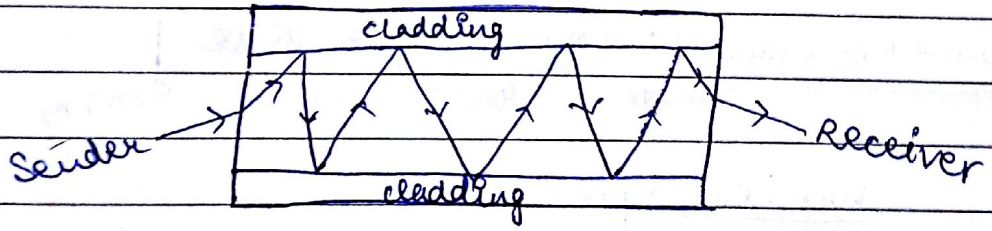



• carries high frequency signals.

| Category | Impedance | use |
|---|---|---|
| RG-59 | 75Ω | cable TV |
| RG-58 | 50Ω | thin ethernet |
| RG-11 | 50Ω | Thick ethernet |

Connector :- BNC (Bayone Neill Concelman)

→ Fibre optics cable




Propagation Mode (in fibre optics)

- Multi-mode
  - Step index
  - Graded index
- Single-Mode (only single wave is send)
  - Higher density at centre

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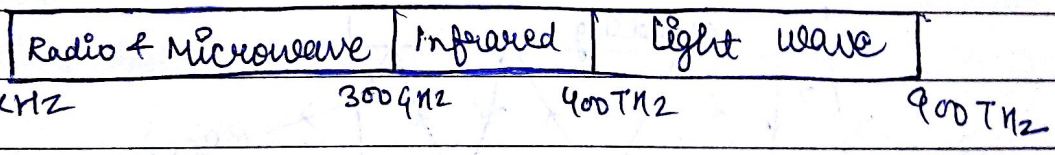
| Step index | Graded index |
|---|---|
| → The density of core remain constant as we move from centre to edge. | → Density gradually decreases as we move from centre to edge. |
| → contain distortion | → less chances of distortion |

Adv:-
- High bandwidth
- less signal attenuation
- Immunity to electromagnetic material
- Resistance to corrosive material
- Light weight
- Greater immunity to tapping

Dis:-
- costly installation & maintinance
- unidirectional light propagation

## Unguided / wireless Media




### Wireless Comm$^n$

**Radio wave**
- Multicasting
Radio/TV

**Microwave**
- Unicasting
Telephone
Stellite

**Infrared**
- Short Range comm$^n$
(Line of sight)

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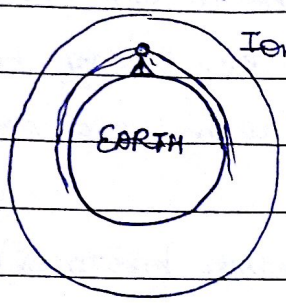
# PROPAGATION METHOD

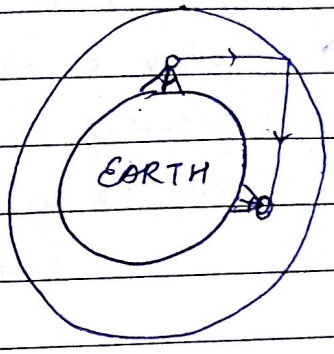
## 1. Ground propagation




(< 2MHz)

- Radio wave travel through the lowest portion of atmosphere.

## 2. Sky Propagation




(2-30 MHz)

- High frequency radio wave
- Greater distance & lower output power.

## 3. Line-of-sight propagation


(> 30MHz)

- very high frequency
- Signal are transmitted into straight line.
- Antenna must be directional, facing each other.

Ch-3 DATA LINK LAYER
(Tanuan)

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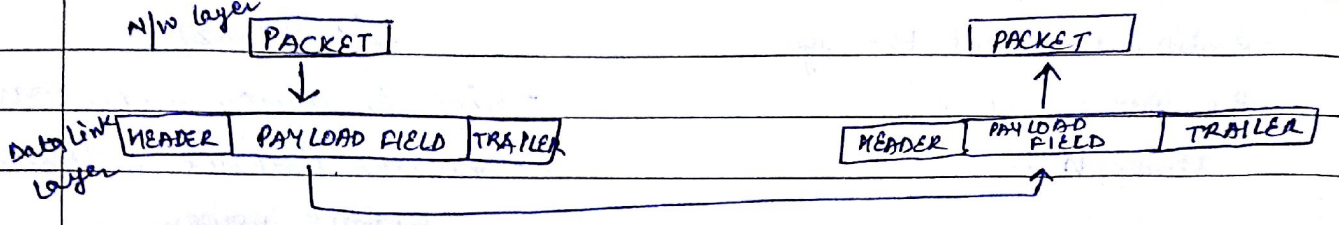
Main functionality of Data Link Layer

→ providing a well-defined services interface to the network layer
→ Dealing ~~c~~ transmission error (CRC, Parity, hamming code)
→ Regulating the flow of data so that slow receivers are not swaped by fast sender
(stop & wait, Sliding window protocol)




① Services provided by Data Link Layer -

•(i) Unacknowledged connectionless service
- No logical connection
- If the frame is lost due to noise, no attempt is made to recover from Data Link Layer.
eg:- Real time transmission/traffic
- appropriate when noise is very low.

(ii) Acknowleged Connectionless Service
- No logical connection.
- each frame sent is individually acknowledged.
- If frame is lost, then sender send it again to the receiver.

PACKET → length of msg Software dependent / User dependent
PAYLOAD → hardware dependent
- Unreliable media (wireless)

(iii) Acknowleged Connection - Oriented Service
- consists of 3 phases

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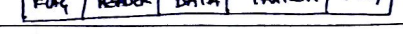
(I) - connection established (variable initialisated, buffer size etc)
(II) - One or more frames is transmitted
(III) - Connection release (variables freed, buffer freed, etc)

~~Item~~ ~~Circuit Switched~~
~~1) Call Setup~~

## FRAMING

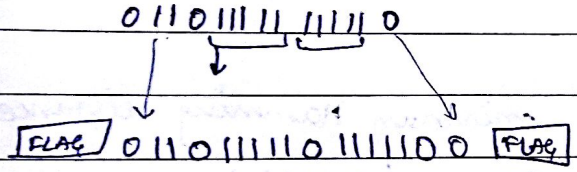
Methods of Framing

1. Character count
2. Flag ~~and~~ bytes with bytes stuffing
3. Starting and ending flag and bit stuffing
4. Physical layer violation




3. flag : 01111110

If encountered five consective 1's then insert 0 after that




## ERROR CONTROL

### ERROR detection & Correction

| • error detection | • error detection + correction |
|---|---|
| ○ Short term Commⁿ | ○ Long term commⁿ |
| • Reliable channel | ○ Unreliable channel |
| eg:- fibre optics | eg:- Wireless |
| • less time | ○ More time |

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## HAMMING DISTANCE

- The no. of bit position in which two code words differs called HAMMING DISTANCE.

XOR

A → 10101

B → 10010

00111 → 3

H(x,y) → Hamming distance of x & y

$$H(x,y) = \sum_{i} x_i \oplus y_i \quad \text{——}$$

$$= \sum_{i} (x_i + y_i) \% 2 \quad \text{——}$$

Properties :-

(i) $H(x,y) \geq 0$

(ii) $H(x,y) = H(y,x)$ Symmetric

(iii) $H(x,x) = 0$

① 00000 11111

② 11111 00000

③ 11111 11111

④ 00000 00000

dcf of code words

minimum Hamming distance

$= \min(H(x,y))$

$= \min(H(1,2), H(1,3), H(1,4), H(2,3), H(2,4), H(3,4))$

H(1,2) = 10 H(2,3) = 5

H(1,3) = 5 H(2,4) = 5 min (H(x,y)) = 5

H(1,4) = 5 H(3,4) = 10

Most imp

# To detect d-error

we need 'd+1' codes

i.e., minimum hamming distance is (d+1).

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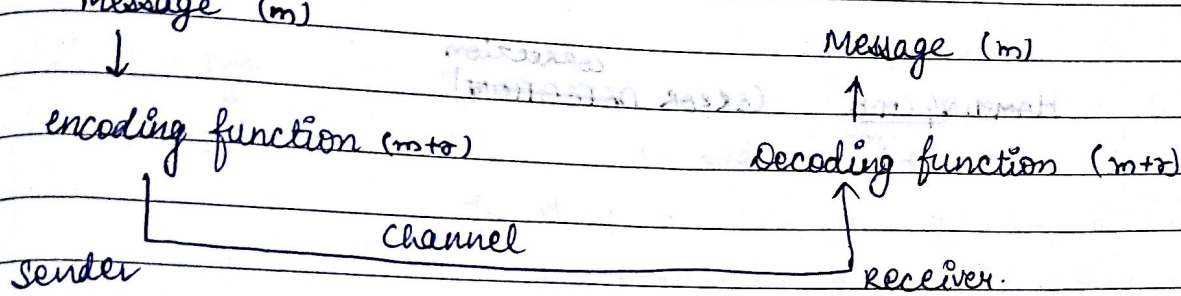
# To correct d-error

we need '2d+1' distance code

ie, minimum hamming distance is (2d+1)

1-bit error detection = 2 hamming distance

1-bit error correction = 3 hamming distance




m : message/data bit

r : check/parity bit

n = m+r : code word to be send

## 2-bit message

$2^2$ = 4 code words

| | | |
|---|---|---|
| 0 0 | encoding function (E) | 0 0 0 |
| 0 1 | | 0 1 1 |
| 1 0 | | 1 0 1 |
| 1 1 | | 1 1 0 |

Parity bit (even parity)

$y = \bigoplus x_i$

minimum hamming distance = 2.

$E : 2^n \longrightarrow 2^{n+1}$

s.t. $E(x_1 x_2 \cdots x_n) = x_1 x_2 \cdots x_n x_{n+1}$

where $x_{n+1} = \bigoplus_{i=1}^{n} x_i$

| | | |
|---|---|---|
| 0 0 0 | Decoding fun$^n$ | 0 0 |
| 0 1 1 | | 0 1 |
| 1 0 1 | | 1 0 |
| 1 1 0 | | 1 1 |

$D : R \to 2^n$

$R \subseteq 2^{n+1}$

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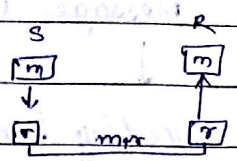
Thus, this system of encoding & decoding can detect only 1-bit error since, $d = 2$ (min. hamming distance)

```
0000011111
1111100000      d = 5
1111111111      4-bit detection
0000000000      2-bit correction.
```

## HAMMING CODE (ERROR ~~DETECTION~~ CORRECTION)




1-bit error correction = 3

m: msg bit  r: parity bit

$n = m + r$ → code word.

$(m + r + 1) \leq 2^r$ to find 'r'

for $m = 7$;

$7 + r + 1 \leq 2^r$

$8 + r \leq 2^r$ ∴ $r \geq 4$

* - Position of power of 2 is reserved for parity bit and other position of data bit.

$m = 1001000$ (7)

$r = 4$

| $2^0$ | $2^1$ | | $2^2$ | | | | $2^3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

Code word :- $P_1$ $P_2$ $D_1$ $P_4$ $D_2$ $D_3$ $D_4$ $P_8$ $D_5$ $D_6$ $D_7$

$D_1 = 1$
$D_2 = 0$
$D_3 = 0$
$D_4 = 1$
$D_5 = 0$
$D_6 = 0$
$D_7 = 0$

Parity bits :- $P_1, P_2, P_4, P_8$

Data bit : $D_1, D_2, D_3, P_4, D_5, D_6, D_7$

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| | $P_8$ | $P_4$ | $P_2$ | $P_1$ |
|---|---|---|---|---|
| 3 | 0 | 0 | 1 | 1 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 1 |

$P_n$ = XOR of data bits at the position where $P_n$ is 1.

$P_1 = 0$

$P_2 = 0$

$P_4 = 1$

$P_8 = 0$

$P_1$ = XOR of ($3^{rd}$, $5^{th}$, $7^{th}$, $9^{th}$, $11^{th}$)

$P_1$ = XOR (1, 0, 1, 0, 0) = 0

$P_2$ = XOR of ($3^{rd}$, $6^{th}$, $7^{th}$, $10^{th}$, $11^{th}$) = XOR (1, 0, 1, 0, 0) = 0

$P_4$ = XOR of ($5^{th}$, $6^{th}$, $7^{th}$) = XOR (0, 0, 1) = 1

$P_8$ = XOR of ($9^{th}$, $10^{th}$, $11^{th}$) = XOR (0, 0, 0) = 0

∴ Code word :- 00110010000

let the error occur at $5^{th}$ position.

∴ Code word received by Receiver is :-

$P_1$ $P_2$ $P_4$ $P_8$

0 0 1 1 1 0 1 0 0 0 0

| | $P_8'$ | $P_4'$ | $P_2'$ | $P_1'$ |
|---|---|---|---|---|
| 3 | 0 | 0 | 1 | 1 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 1 |

$P_1'$ = (3, 5, 7, 9, 11) = (1, 1, 1, 0, 0) = 1

$P_2'$ = (3, 6, 7, 10, 11) = (1, 0, 1, 0, 0) = 0

$P_4'$ = (1, 0, 1) = 0

$P_8'$ = (0, 0, 0) = 0

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| | | |
|---|---|---|
| odd : | $P_8\ P_4\ P_2\ P_1$ | : 0 1 0 0 |
| calculated : | $\oplus\ P_8'\ P_4'\ P_2'\ P_1'$ | : ⊕ 0 0 0 1 |
| | $C_8\ C_4\ C_2\ C_1$ | 0 1 0 1 |
| | | ↳ 5 |

: error at 5th position.

If $C_8 C_4 C_2 C_1 = 0000$ , no error
else error at $C_8 C_4 C_2 C_1$ position.

Q $m = 1101101$ (7) $\quad r = 4$

code word :

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | 1 | 0 | 1 | | 1 | 0 | 1 |
| $P_1$ | $P_2$ | | $P_4$ | | | | $P_8$ | | | |

| | $P_8$ | $P_4$ | $P_2$ | $P_1$ |
|---|---|---|---|---|
| 3 | 0 | 0 | 1 | 1 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 1 |

$P_1 = 0 \quad P_1 = 1$
$P_2 = 0 \quad P_2 = 1$
$P_4 = 1 \quad P_4 = 0$
$P_8 = 0 \quad P_8 = 0$

⇒ CODE WORD : 1 1 1 0 1 0 1 0 1 0 1

Let error occured at position 9th at receiver end
∴ code word (at receiver end)

1 1 1 0 1 0 1 0 0 0 1
X

$P_8\ P_4\ P_2\ P_1$ : 0 0 1 1
$P_8'\ P_4'\ P_2'\ P_1'$ : ⊕ 1 0 1 0
1 0 0 1
↳ 9th position

$P_1' = 0 \quad P_4' = 0$
$P_2' = 1 \quad P_8' = 1$

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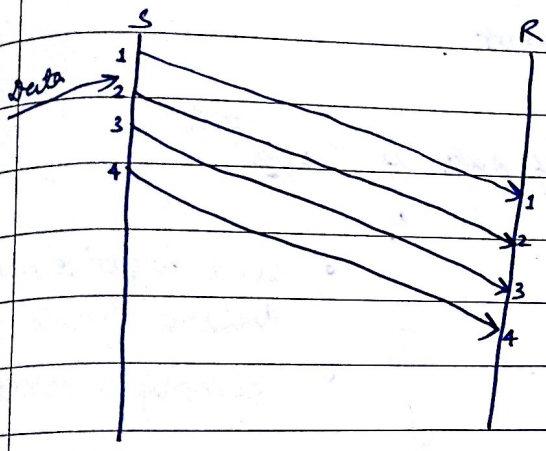
# ERROR CONTROL

- **Noiseless Channel**
  - Simplex Protocol
  - Stop and wait protocol
- **Noisy channel**
  - Stop and wait ARQ
  - GO Back N ARQ
  - Selective Repeat ARQ
  - Sliding window protocol

ARQ: Automatic Repeat Request.

## ① Simplex Protocol:-



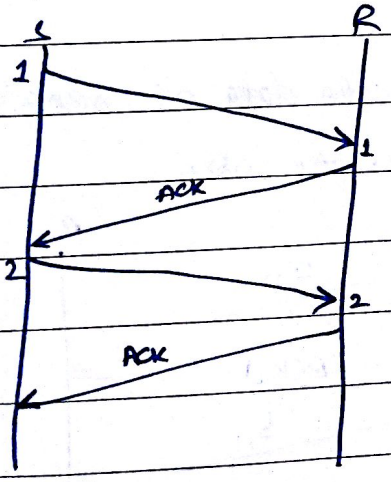

Network layer

Speed of S > Speed of R

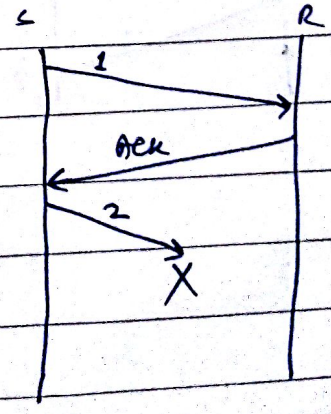
→ No Data loss

→ Data will wait in waiting queue for processing as speed of R is lesser than that of S.

## ② Stop and wait protocol:




R will send Acknowledgement after receiving data from S.




## Noisy Channel

① Stop & wait for noisy channel

Sol$^{n}$:- Retransmission after timeout

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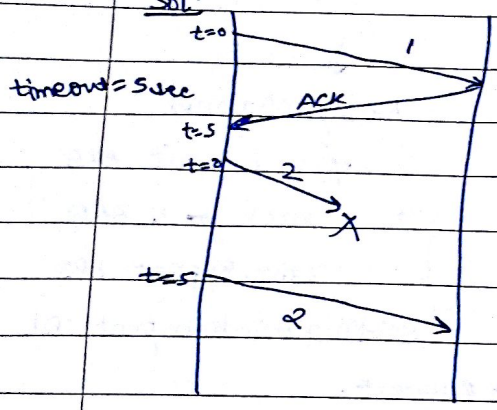
Sol$^n$




RTT :- Round Trip time

We should not take timeout too small or too large. as

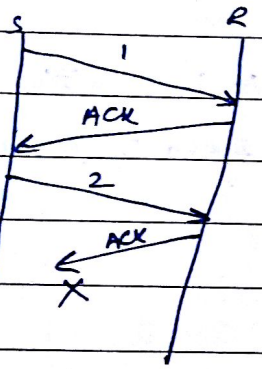
Too Small :- Overflow the receiver & same packet

Too large :- Channel utilization is low.

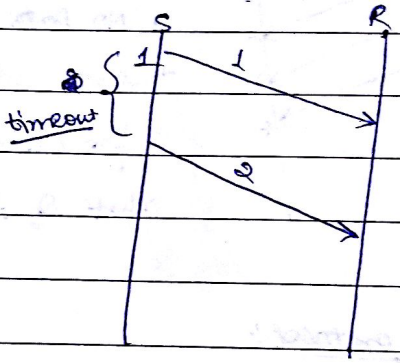
(i) If data is lost

Sol$^n$ :- Retransmission after timeout

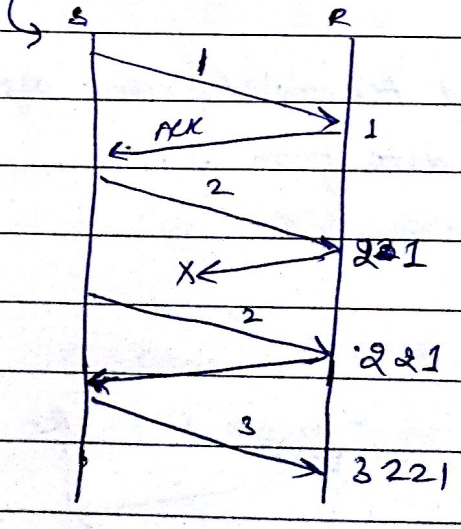
(ii) If Ack is lost




(iii) If data is corruped

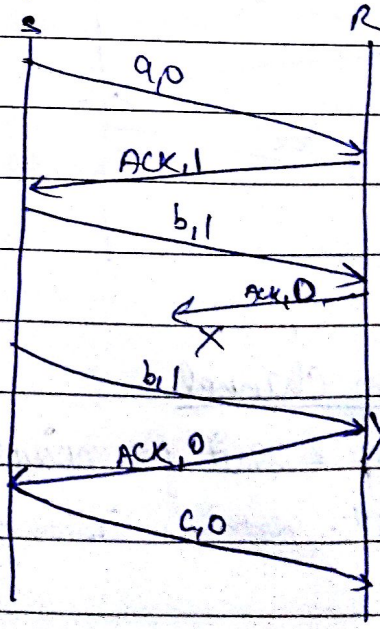



- Send negative Ack and discard frame
- Simply discard.




Dis :- Duplicate data at receiver end

Sol$^n$ :- Sequence no.

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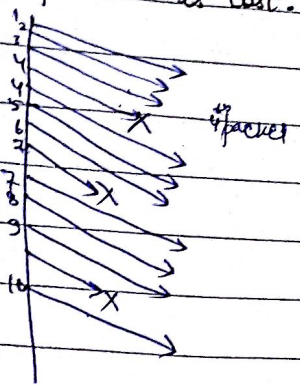
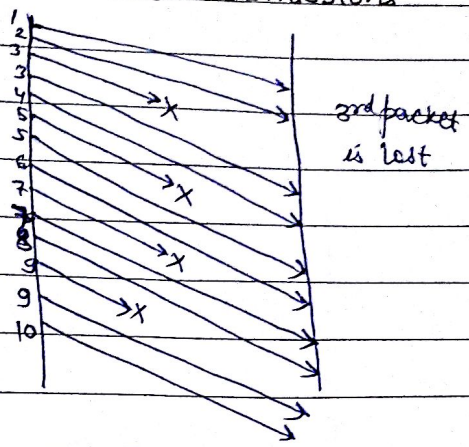
Q If we are using stop and wait protocol. If 10 packets are send and every 3rd packet is lost. Then total transmissions required are?

14 transmissions.
(3rd packet)

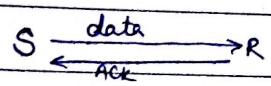
13 transmission
(4th packet lost)

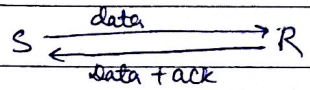



## SLIDING WINDOW PROTOCOL

It is bidirectional.

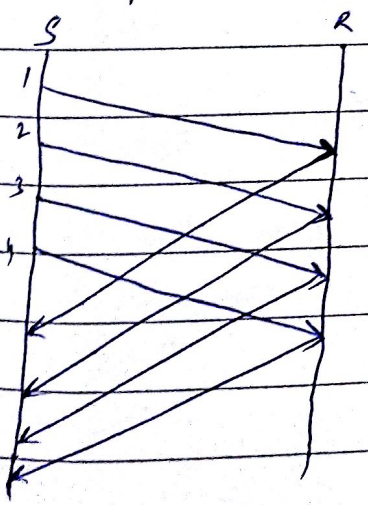


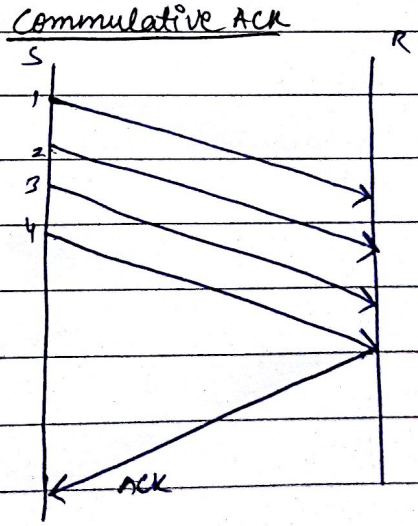

## PIGGYBACKING -

- Sending ~~da~~ ACK ~~c~~ the data

Independent ACK




Commulative ACK




→ The technique of temporary delaying outgoing ACK so that they can be hooked onto the next outgoing data frame is called PIGGYBACKING.

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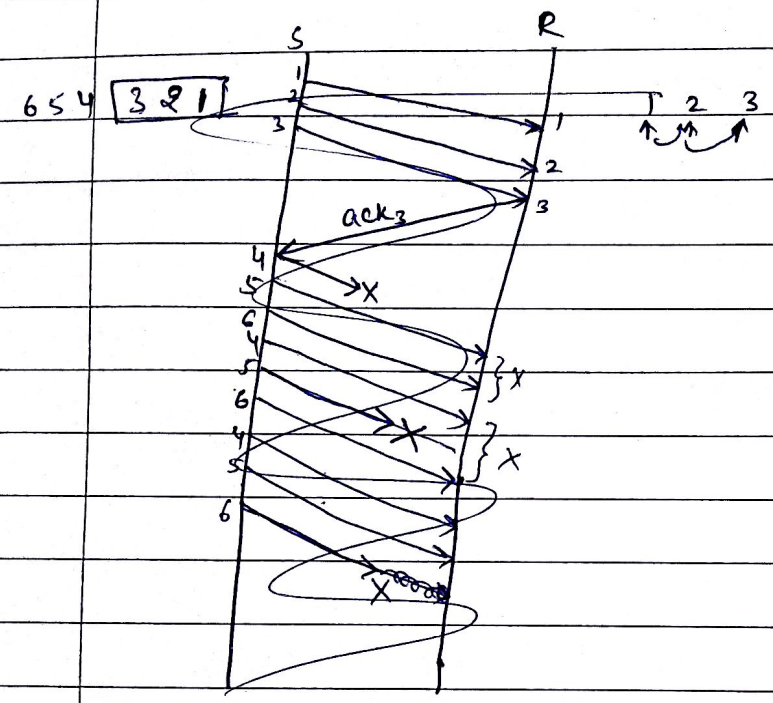
## Go Back N Protocol (in Sliding Window)

1. Commulative acknowledgement
2. Packets arrive at receiver in order

10 Packets every 4th packet is lost

Window = 3




every 5th packet is lost.

1 2 3 4 X5 6

X
5 6 7 8 9 10

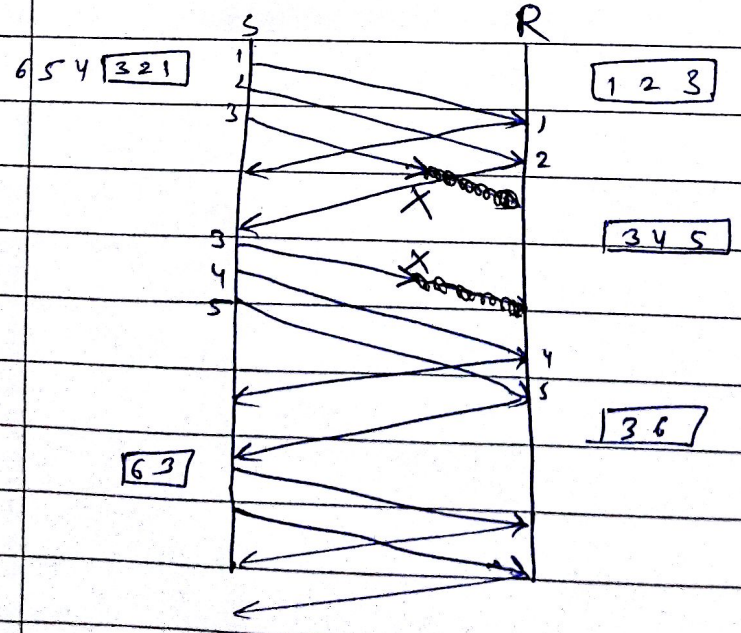
X
8 9 10 10

16 times transmission.

## Selective Repeat

Sender → N

Receiver → N




- Independent Ack
- Packet arrives out of order.

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# COMPUTER NETWORKS

- Railways
- Telephone — wired / wireless

ease of communication

Purpose: Sharing — Data / Information / Resources (Printers)

COMPUTER NETWORKS **Vs** DISTRIBUTED NETWORKS

eg:- Internet

non-linked info.

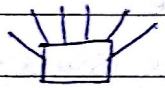
EXPLICIT: sharing info.

eg:- www

shared info.

IMPLICITLY: we are not bothered about the process

(Abstract) Processing is hidden from users




Meta data help:
User Intelligence Machine

it add meta-data

Semantic-web layer / www

Internet & Intranet

- CRITERIA TO CHECK EFFICIENCY AND STANDARDS FOR NETWORKS

1. Performance
   (a) Transit Time - time taken from one node to another
   (b) Response Time - Response time taken by processor
2. Number of users.
3. Type of Media used

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4. Capacity of connected hardware
5. Efficiency of software
6. Reliability : frequency of failure and time taken for recovery (QUALITY)
7. Security unauthorised access from unauthorised user.

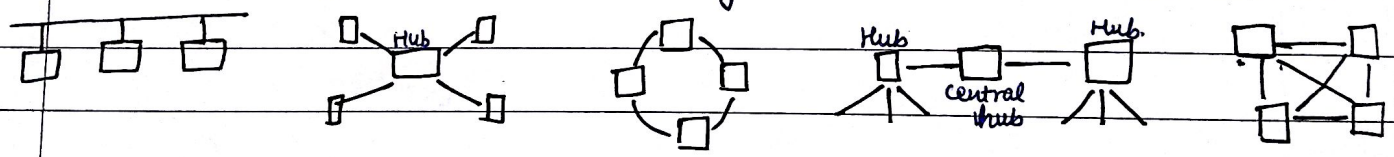
## NETWORK TOPOLOGIES

Uses of network :-

① Organisation/Company → e-marketing, e-business
② People → Personalised newspaper → filters → Recommendation
③ Social Issues → ethical issues, Political issues.

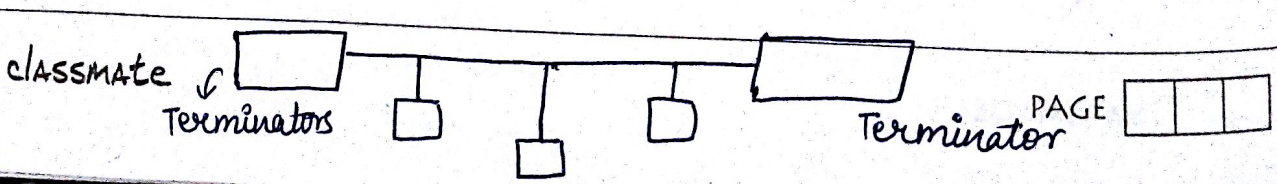
5 topologies

(i) Bus (ii) Star (iii) Ring (iv) Tree (v) Mesh




### (1) BUS TOPOLOGY

i. one or more cables.
ii. use small & simple technology
iii. generally used for temporary installation
iv. if a message is not accepted by any system then, to destroy that message terminators are used. and at the ends of bus.





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v. no active electronics (e.g. repeater) is used to amplify the signals. ∴ Bus is also known as Passive topology
vi. Signal will be sent to all the system but will be accepted by intended receipient.

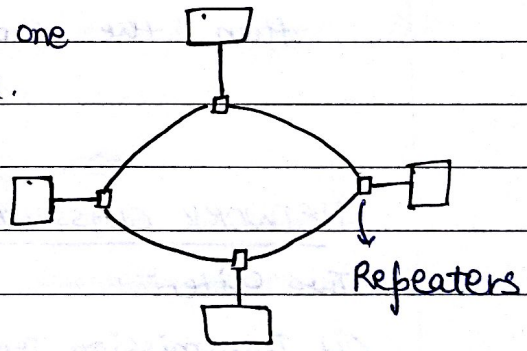
vii. very slow speed
viii. Only 1 system can send message at a time.
ix. Amplifiers can be used for balancing.

Advantages :- • easy to install, simple, cost effective, easy to expand
Disadvantages :- • a break or a loose connector can bring down the whole network.

IEEE 802.4 standard for Bus technology
or Token Bus topology

(2) RING TOPOLOGY

- last system is connected to first one
  ∴ no terminator is used.
- is unidirectional
- active network.
- uses token passing method
- each repeater will regenerate ~~and~~ retransmit each bit




Functions of ring
- data reception
- data insertion
- data removal

Adv :- • each system is given equal access to the token.

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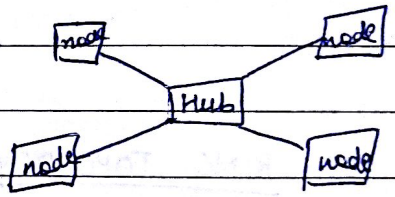
Disadv:- • if cable break then whole system will go down
• it is necessary to remove circulating message becoz of close nature of ring
• can't be expanded easily
• difficult to rectify the problem.

IEEE 802.5 common standard for token ring

One more commonly used standard is
FDDI (Fibre Distributed data interface)
this is a fast fibre optic network based on ring topology.

③ STAR TOPOLOGY

- all nodes are connected to a hub.
- easy to expand.
- If the central hub goes down then, the whole network will die.




NETWORK CLASSIFICATION

Two Criteria:-

(i) Transmission Technology - Point-to-point, Broadcast, Multicast
(ii) Size - PAN, LAN, MAN, WAN

Standard Wired LAN - IEEE 802.3 Ethernet
(Wifi) " Wireless LAN - IEEE 802.11

Communication
↳ Protocols – Rules
↳ Standards – agreed upon rule
↳ key elements → syntax
→ Semantics
→ Timing

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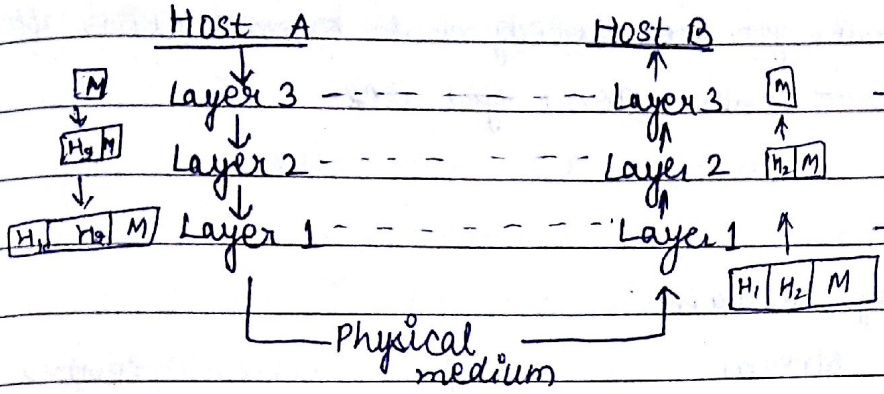
## LAYERED ARCHITECTURE FOR NETWORK COMMUNICATION

→ Network architecture is combination of all the layers and protocols




Lower layer – service provide
Upper layer – Service user

⇒ Every interface have some Service Access ~~Provi~~ Point (SAP) having unique address
→ Services which are provided by lower layers to uppers are termed as Primitives.

Design Issues for the network layers
1. Addressing – For communication destination should be addressed.
2. Direction of transmission : simplex, half-duplex, duplex
3. Error control : msg can be erroreous
4. Avoid loss of sequencing : all packets of msg are properly numbered.
5. Ability of receiving long messages
6. to use Multiplexing and de-multiplexing.
↳ If one channel shared by more than 1 receivers/devices.

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## Two types of services/Connection

(more reliable) i) Connection-oriented services — eg:- Telephone
ii) Connection-less services — eg:- Postal service

## Quality of Services

i. Reliable - sender gets acknowledgment from receiver after receiving msg
ii. Non-reliable - sender don't get ack.

## Types of Services

i. Reliable message stream
ii. Reliable type stream
iii. Unreliable Connection
} connection Oriented Service (COS)

iv. Unreliable datagram service
v. Acknowledgement datagram service
vi. Request-reply kind of service
} connection less service (CLS)

## What is OSI model?

An ISO standard that covers all aspects of network communications is the OSI model. It is not a protocol, it is a model for understanding & designing network architecture that is, flexible, robust & inter-operable.

An Open System is an model that allows any two different System to Communicate regardless of their underlying architecture.

There are 7 layers in OSI model

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## Functions of different layers of OSI model

1) **Physical layer-**
   i) To activate, maintain & deactive the physical connection
   ii) This layer defines Voltage & data rates
   iii) Convert data bits into electrical signals
   iv) decide whether transmission is simplex, half-duplex or full duplex
   v) This layer does not perform
      - detection & correction of error
      - does not decide the medium & modulation

2) **Data Link layer**
   i) Synchronization & error control of the information which is to be transmitted over the physical layer
   ii) This layer assembles outgoing messages into frames.
   iii) to enable error detection, this layer add error detection bits to ~~this~~ the data which are to be transmitted. ~~It~~ Encoded data is then passed to physical layer. These error detection bits are used by the data link layer on the other side to detect and correct errors.
   iv) Correct operation of data link layer ensure reliable transmission of each message.

Few example
HDLC (High level Data link control)
SDLC (
X.25

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Synchronous

3) Network layer -

# This layer routes the signal through various channels to other end.

# This layer acts as a network controller by deciding which route data should take.

# Divides the outgoing msg into packets and the incoming packets into message for the higher layer.

# Congestion Control

4) Transport layer -

# this layer decides that the data transmission should take place on single path or parallel paths.

# It does the functions such as, multiplexing, splitting or segmenting the data.

# Breaks the data groups into smaller units so that they are handled more efficiently by the network layer (Segmentation & re-assembling).

5) Session layer

# This layer manages & synchronises conversations b/w two diff. appl$^{n}$

This is the level at which the user will establish session-to-session connection.

# Controls logging on & logging OFF, User identification billing & session management.

# In the transmission of data from one system to other, at session layer streams of data are marked & re-synchronised properly so that the ends of msg's are not cut pre-maturely and data loss is avoided.

6) Presentation Layer

# This layer makes it sure that the information is delivered in such a form that the receiving system will understand and use it.

# The form & syntax of the two communicating system can different.

eg :- The one system is using ASCII code for data transfer and the other system is using EBCDIC code. Under such condⁿ the presentation layer provides the translation from ASCII to EBCDIC & vice-versa

7) Application Layer

# Provides services such as manipulation of information in various ways, transferring the files or information, distributing the result etc. to the user sitting above this layer.

# The funⁿs such as Log In & Password Checking are also performed by applⁿ layer.

subnet :- communication channels + switches / Routers.

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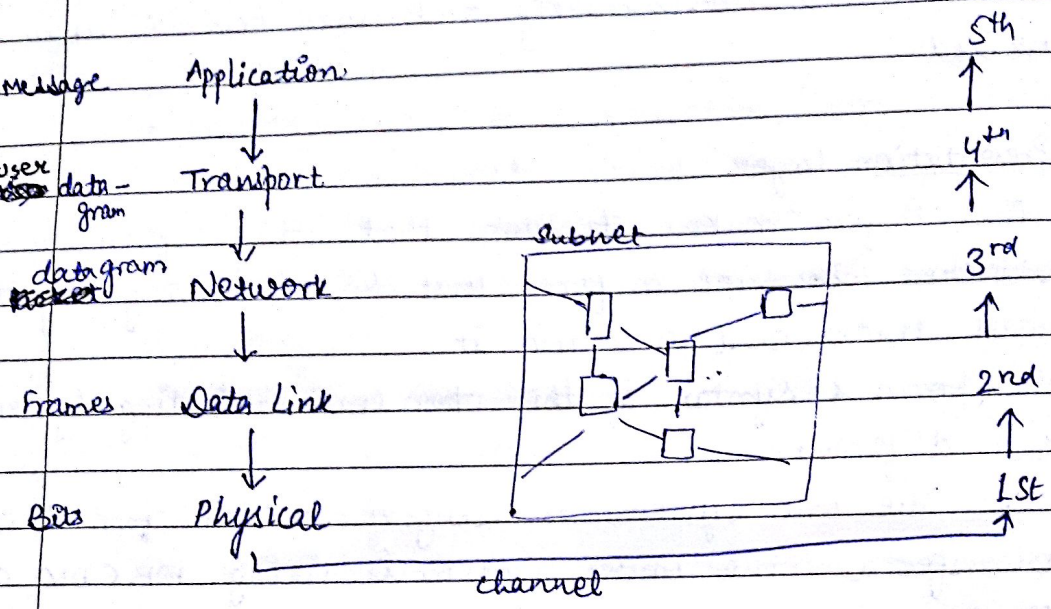
## TCP/IP Protocol Suite

↳ 5 layer

↳ internet is based on TCP/IP




- This is a 5 layered model.
- Duty of upper 3 layers is end-to-end.
- Domain of duty of these layer is internet

- Duty of lower 2 layers is hop-to-hop. where hop is a router/host. Domain of duty of these layer is link.

### 1. Physical Layer

- Carry bits is a frame across the link.
- makes logical ~~connection~~ communication becoz there is a hidden layer i.e., the transmission media, under the physical layer.
- Several protocols can be used that transform a bit into a signal.

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2. Data Link Layer

- Takes the data-gram and moves it across the link where link can be wired LAN, wireless LAN, wired WAN or wireless WAN.
- Error detection and/or error correction.
- Data link layer takes a datagram and encapsulates it in a packet called frame.

3. Network Layer

- Creating connection b/w source & destination system.
- Communication is host-to-host.
- Routes the packets through possible routers.
- In internet it includes IP Protocol.
  It defines the format of packets called Datagrams.
  (IP)
- It also defines format and structure of addresses used in this layer.
- IP routes packets from source to destination.
- IP is a connectionless Protocol. therefore, it provides no flow control, no error protocol & no congestion control services.
  For these services, appl" should relay on Transport layer services.
- Protocols that help IP in delivering and routing task are :-
  i. ICMP - Internet Control message Protocol
     - helps IP to report some problems when routing a packet
  ii. IGMP - Internet Group Management Protocol
     - helps IP in multitasking.
  iii. DHCP - Dynamic Host Configuration Protocol
     - helps IP to get network layer address for a host.

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iv. ARP - Address Resolution Protocol
- helps IP to find a link layer address of a host or a router when its network layer address is given.

4) Transport Layer
→ takes msg from Appl" layer, encapsulates it in segments and send it through the logical imaginary connection to the transport layer at destination host.
→ main protocols of transport layer are -
(i) TCP : Transmission Control protocol
(ii) UDP : User datagram protocol
(iii) SCTP : Stream Control Transmission protocol.

TCP :- • connection-oriented protocol
• provides flow control (data rate), error control and congestion control.

UDP :- • connection-less protocol.
• transmits datagram without first creating logical connection.
• each datagram is independent of previous or next datagram.
• does not provide flow, error & congestion control.
• it can't afford to retransmit the packet if it is lost or corrupted.

SCTP :- • designed to respond to new appl"s that are emerging in the multi-media.

Application Layer
→ communication is b/w processes or two programs running at this layer.

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Protocols are :

i) HTTP : Hyper Text Transfer protocol
use for accessing web.

ii) SMTP : Simple Mail Transfer protocol.
used for e-mails.

iii) FTP : File Transfer protocol. (transferring file)

iv) Telnet : Terminal Network

v) SSH : Secure shell.
→ used for accessing a site remotely

vi) SNMP : Simple Network Management Protocol.
used by Administrators

vii) DNS : Domain Name System
- used by other protocol to find the network layer address of a computer

viii) IGMP - Internet grp Management Protocol.
- used to collect membership in a grp.

## SWITCHING

→ at 4 layers -

Physical, DataLink, Network, Application.

(Circuit Switching) (Packet S.) (Packet S.) (2 types) (Message S.)

(Datagram S.) (Virtual S.)

**Problem**

→ is how to make one-to-one comm$^n$ possible b/w networked devices

**Solution** is switching.

→ ~~Sw~~ switched networks consists of series of interlinked switches or nodes

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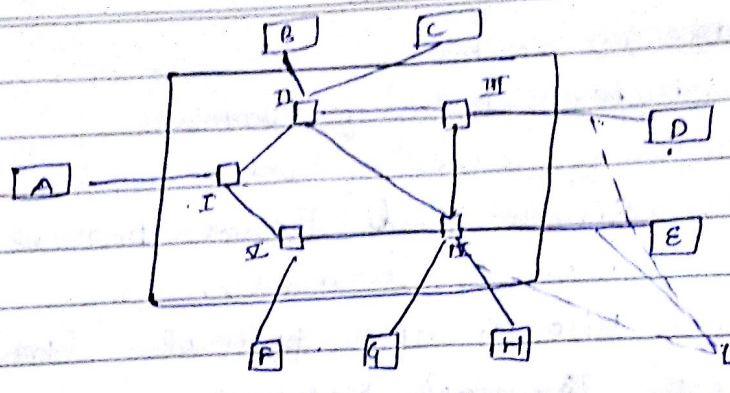



I, II, ... are switches

A, B, ... are connecting devices

- Each switches is connected to multiple Links
- Switches are capable of creating temporary connection b/w two or more devices linked to the switches
- Switching & different TCP/IP layers
  - switching can happen at several layer of TCP/IP protocol suite.

(i) Switching at PHYSICAL LAYER

As there are no packets at physical layer, only circuit switching is possible allowing signals to travel in one path or another.

(ii) Switching at DATALINK layer

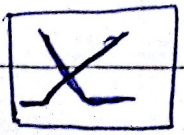
At this layer, packet switching is possible which is normally done using virtual circuit approach.

(iii) Switching at NETWORK LAYER

At this layer, packet switching is possible.

(iv) Switching at Appln Layer

This layer allows only message switching.

Switch → 

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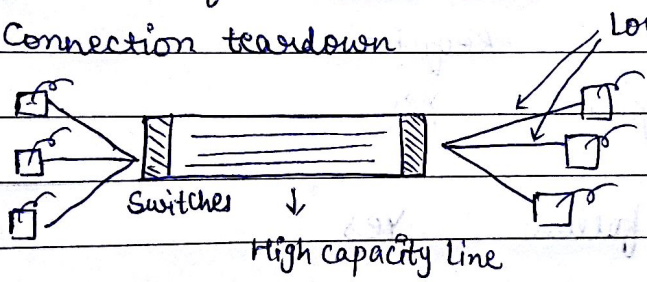
## CIRCUIT SWITCHED NETWORK

- Consists of series of switches connected via physical layers.
- establishes dedicated links / path
- each link is divided into n channels using TDM or FDM.

A will send request to communicated to E, The request will be accepted by all switches in-b/w and by E itself. This is called SETUP PHASE.

- dedicated path ~~wastes~~ wastes bandwidth if not used completely.
- it allows continuous flow from source to destination
- end-to-end addressing is used during the setup phase.
- not very efficient
- delay is minimised.
- actual comm^n requires 3 phases -
  a) Connection Setup
  b) Data transfer
  c) Connection teardown




- switches can only forward the msg and has no storage capacity
- switches are less fault tolerant
- allows high quality telephone calls.

→ Switches can only be active or inactive in this switching

## PACKET SWITCHED NETWORK

In computer Network, the comm^n b/w two ends is done in blocks of data called PACKETS. PACKETS can be of same size or different sizes. Switches fun^ for both storing and forwading becoz a packet is an independent entity that can be stored & sent later.

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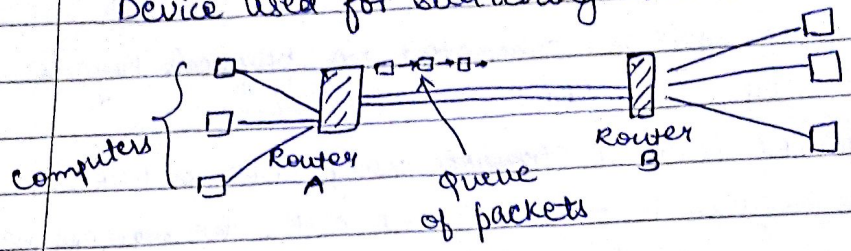
Device used for switching here is ROUTER.




- Packet switched network is more efficient than a circuit switched network but packets may encounter some delays.
- Resources are allocated for packets to be transferred on-demage on FIRST COME FIRST SERVE basis.
- This network is more fault ~~tored~~ tolerant.
- more simple & efficient for computer networks
-

| Item | Circuit Switched Network | Packet Switched Network |
|---|---|---|
| 1) Call Setup | Required | |
| 2) Dedicated physical path | Yes | NO |
| 3) each packet follow same route | Yes | NO |
| 4) packet arrives in order | Yes | NO |
| 5) Is switch crash fatal? | Yes | NO |
| 6) Bandwidth Available | Fixed | Dynamic |
| 7) Time of possible Congestion | At setup time | On every packet, when packet are send. |
| 8) Potentially wasted bandwidth | Yes (if no traffic on reserved bandwidth) | NO |

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| | | |
|---|---|---|
| 9) Store and forward Transmission | NO | Yes |
| 10) Charging (payement) | per minute | per packet |
| 11) Queuing Delay | NO | Yes. (Bcoz no bandwidth is reserved ∴ packet may have to wait to be forward) |
| 12) Trade-off | Guaranteed Service & wasting recources | No guaranteed Service & No resource wasting |
| Ex:- | Telephone Network ∵ high quality calls | Computer Network having simplicity & efficiency |

PACKET SWITCHED NETWORK

Fixed size OR Variable length

**DATAGRAM (connectionless)**

- each packet is treated individually independent of all others. and called as DATAGRAMS.
- Done at Network layer
- Connectionless network
- packets can be reordered or lost.
- each switch has a routing table which is dynamic & having destination address stored in packet headers.

**VIRTUAL CIRCUIT (Connection-Oriented)**

Circuit switched network + packet switched (Data-gram)

- implemented at Data Link Layer
- Data is PACKATIZED.
- all packets follow the same path as in Circuit switched networks.

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- efficiency is better than Circuit switched network because resources are allocated when packets are to be transferred.
- delay is data-gram is more than Virtual Circuit network.

3rd sept, 16

Virtual Circuit Network

→ • Like Circuit switched network, it has setup & tear-down phase in addition to the data transfer phase.
• Resources can be allocated during the setup phase as in Circuit switch network or on-demand as in Datagram network.
◦ As in Circuit switched network, all packets follow the same path established during the connection.
◦ As in Datagram network, data is packetised and each packet carries an address in the header.
However, address has local juridiction (It defines what the next switch should be and the channel on which packet is being arrived) not end-to-end juridiction

◦ In Virtual Circuit network two types of addressing is involved :- global addressing and local addressing

In Global addressing, address is unique in the scope of whole network
and in local addressing, a small number (Virtual Circuit Identifier, VCI) that has only switch scope, it is used by a frame between two switches. When

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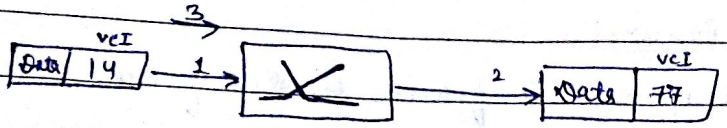
a frame arrives at a switch, it has a VCI but when it leave it has ~~some~~ different VCI




- Like circuit switching, in ~~VCN~~ VCN three phase are required -
  i) Setup ii) Data transfer iii) Tear-down

- Setup phase comprises of two setup :-
  (i) Setup Request (ii) Acknowledgement
  In setup phase, the source and destination use their global address to help switches make table entry for the connection.

- In teardown phase, source and destination informs the switches to delete the entries.

| Incoming VCI | | outgoing VCI | |
|---|---|---|---|
| 1 | 14 | 2 | 77 |
| 3 | | | |

- To transfer a frame from source to destination all switches need to have table entries for its virtual ~~entries~~ circuit.

Each switch changes the VCI and routes the frame. The data transfer phase is active until sources sends all the frames to its destination

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**Setup phase :-**

In setup phase switches creates entries for a virtual circuit -

(a) **Setup Request**

- Setup Request frame is send from source to destination

(b) **Setup Acknowledgement**

A special frame called Acknowledgement frames completes the entries in switching table

**Teardown phase -**

In this phase source A after sending all the frame to destination B sends a special frame called a Teardown request. Destination B responds ~~c~~ a Teardown Confirmation frame. All switches then delete corresponding entries from table.

| | Issue | DATAGRAM | VIRTUAL CIRCUIT (VC) |
|---|---|---|---|
| 1. | Circuit setup | Not required | Required |
| 2. | Addressing | Each packet contains a full source & destination address. | Each packet contains a short VCI. |
| 3. | State Information | Routers do not hold state information about connections | Each VC requires a router table space per connection. |
| 4. | Routing | Each packet is routed independently | Route is chosen when VC is setup & all packets follows it. |
| 5. | Affect of router failure | None | All VC that passes through that failed router are terminated. |

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| | | |
|---|---|---|
| Quality of service | Difficult | Easy if enough of resources can be allocated in advance for each VC. |
| Congestion control | Difficult | Easy in case enough resources can be allocated in advances. |

# MUTLIPLE ACCESS PROTOCOL & NETWORKS

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Links → Point-to-point
→ Broadcast

LAN → wired (802.3 ethernet) — IEEE
→ wireless (802.11 wifi)

Broadcast : Multi Access Channel OR RANDOM ACCESS CHANNEL

(Sender) Station ——— carrier ——— Station (Reciever)

Algorithm/Protocols :- 1) ALOHA
2) Slotted ALOHA

These protocol works on MAC (Medium Access control)
3) CSMA (carrier Sense Multiple Access)
4) CSMA/CD → collision Detection

# In case of broadcasting, key issue is who gets next on a multi-Access Channel when there is competition for it.

Data link layer → MAC (Multiple Access Control)
→ LLC (Logical Link control)
(Sublayers of Data Link)

CHANNEL ALLOCATION → Static — FM (inefficient for large no. of channels)
→ Dynamic — efficient but has 5 issues

## Assumption/Issues of Dynamic Chanel Allocation

1). Independent Traffic
~~2)~~ Call stations r independent to generate & transmit their msg

2) Single channel for all Communications.
3) Observable collisions
(when signal is garbled)
4) Continuous and slotted Time
(In slotted time, there are discrete interval of time)
5) Carrier Sense or No carrier sense

* 1-persistent :- It sends msg ☆ full probability
- optimistic algorithm
- it works as a stalker

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CSMA
- P-Persistent
- 1-Persistent [greedy algorithm: keeps on checking the channel]
- N-persistent [not greedy] randomly.

Aims of CSMA
1. * to improve efficiency
2. * to minimize collisions on the channel.

## What is CSMA?

It is a network access method which belong to MAC, sublayer of Data link layer. It is used on shared network topologies to control access of the network.

Carrier Sense means devices attached to the network cable listen before transmitting. Multiple access means many devices can connect to and share the same network and attempt many times until successful.

## 1- Persistent CSMA / PERSISTENT CSMA

There 1 is the probability with which station transmits the message when it finds channel idle.

CASE I:- CHANNEL IS IDLE - station sends the data

CASE II:- If channel is busy - station sense continuously and waits until it become idle.

CASE III:- If Collision occurs - station waits a random amount of time and starts all over again.

Collision occurs because 2 stations are waiting for channel to become free and as soon as the channel becomes free both begin ~~to~~ transmitting, resulting in a collision if were not impatient then there will be less collision.

* Propagation delay has important affect of collision.

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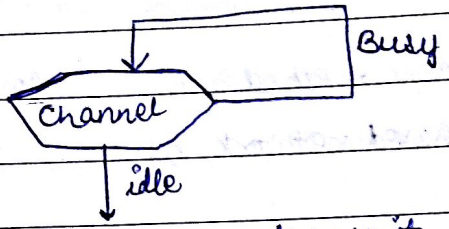
Bandwidth delay product also plays important role in collision. Bandwidth delay product is no. of frames that fit on the channel. If only a tiny portion of frame fits on the channel propagation delay is small and chances of collision happening is also Small.

The larger the bandwidth delay product, the worse the performance of the protocol will be.




Non-Persistent CSMA

In this protocol, concious attempt is made to be less greedy than the previous one (1-persistent).

CASE I: If the channel is idle/Free - station sends the frame

CASE II: If the channel is already in use

- the channel/station does not continually sense it for the purpose of ceasing it immediately upon detecting the end of the previous transmission.

It reduces chances of collision becoz the station waits a random amount of time; therefore it is unlikely that both the station transmit at the same time.

DISADVANTAGE

It reduces the efficiency network because the channel remain idle when there may be stations with frames to

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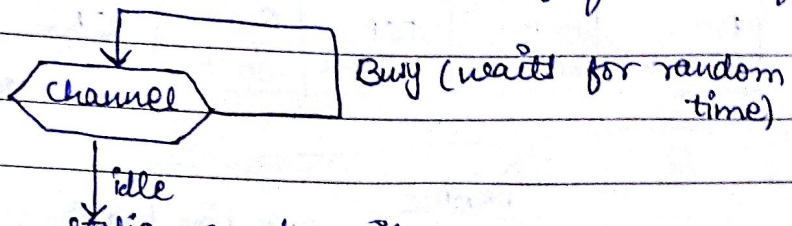
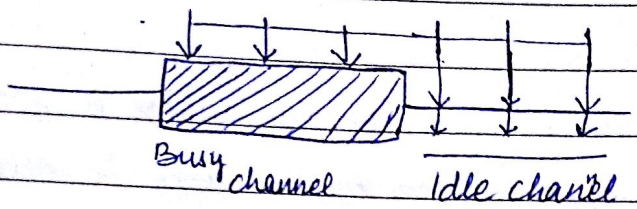
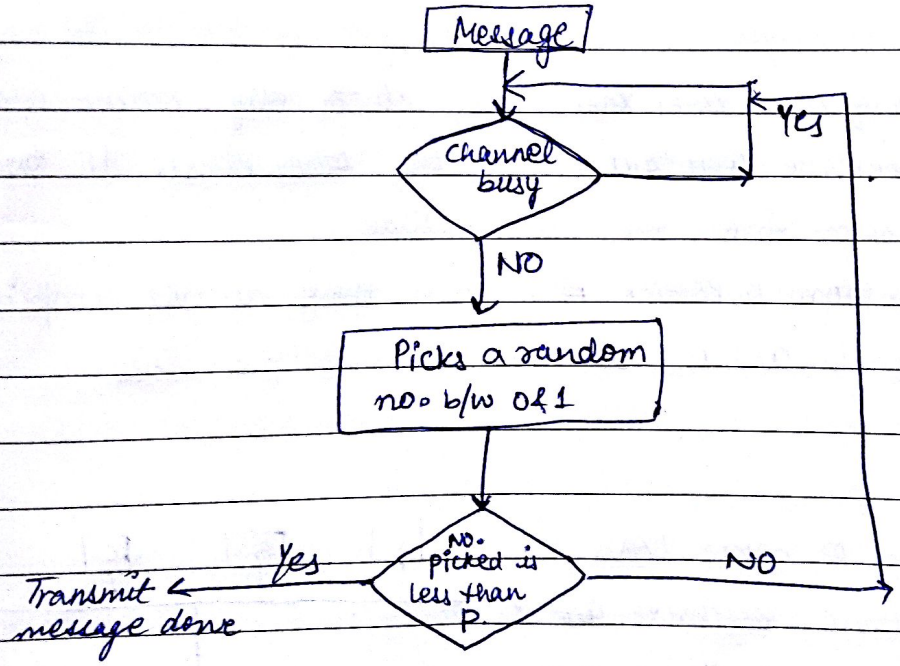
Send becoz station waits a random amount of time after collision.




ADVANTAGE

It reduces the chances of collisions and improves the efficiency of network.




→ Connecting Devices

Repeaters, Hubs – PHYSICAL LAYER

Bridges / Switches – DATA LINK LAYER

Routers – NETWORK LAYER

Gateway → transport Gateway – TRANSPORT LAYER

→ Appl" Gateway – APPLICATION LAYER

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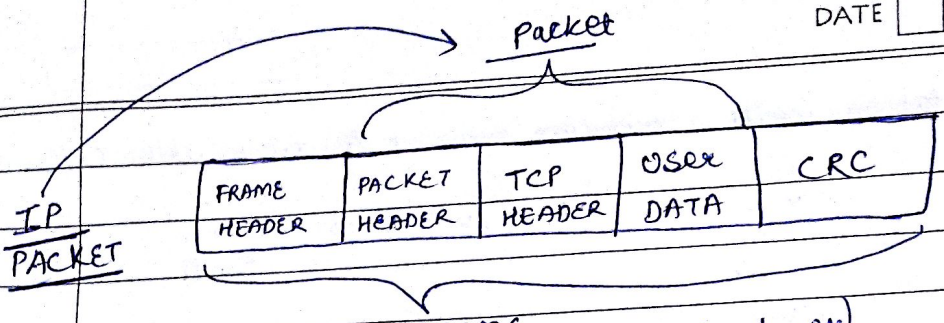


(1) REPEATERS

→ analog devices that works on signals on the cables to which they are connected. A signal appearing on the cable is cleaned up and amplified and put out on another cable.

Repeaters do not understand frame, packets or headers. They understand symbols that encodes bits as volts.

(2) HUB

→ it has number of input lines that it joins electrically. Frame arriving on any of the lines are sent out on all the other lines. If two frame arrive at the same times, they will collide.

HUBS differs from REPEATER in that they do not amplify the incoming signals and are designed for multiple lines.

(3) BRIDGE

→ connects two or more LANs

When a frame arrives, software in the bridge extracts the destination address from header and looks it up in a table to see where to send a frame.

For ethernet, this address is 48-bit destination address.

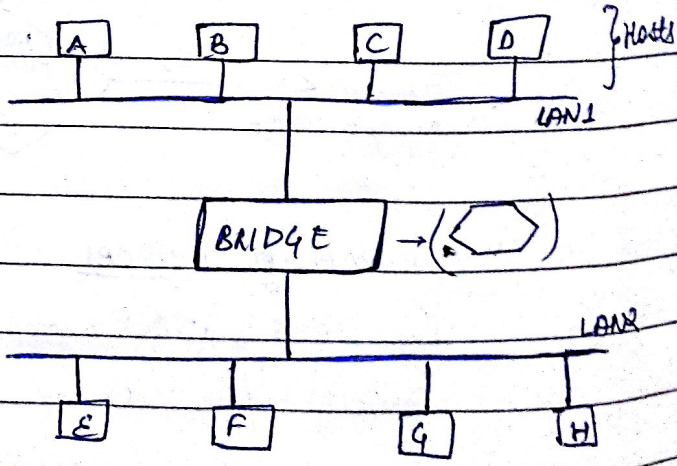


FIG-A

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4) SWITCHES

→ are similar to bridges in that they both routes on frame address.

Main difference is that the SWITCH is most often used to connect individual computers.

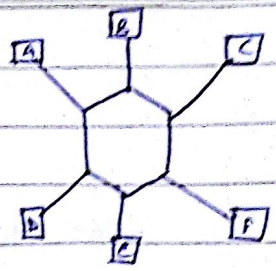

FIG-B

When in FIG-A, host A want to send a frame a to host B, the bridge will get the frame and just discard it. In contrast, the switches will actively forward the frame becoz there is no other way for the frame to get there.

5) ROUTER

when a packet comes to a router, the frame header and trailer are removed and the packet located in the frame's payload field is passed to the routing software. This software uses the packet header to choose an output line. For an IP packet header will contain a 32-bit (IP V4) and 128-bits (IP V-6) addresses.

32-bit address scheme allows $2^{32}$ addresses. Every device that connects to internet requires an address.

IP V4 address are in Decimels, IP V6 are in hexademical.

6) TRANSPORT GATEWAYS

→ connects two computers that use different connection-oriented transport protocols. These protocols may be connection-oriented protocols and connection-oriented ATM protocols.

7) APPLICATION GATEWAY

→ This understand the formats and contents of the data and translate msg from one format to another.

Ex:- An E-Mail gateway could translate internet msgs into SMS msgs for mobile phones.

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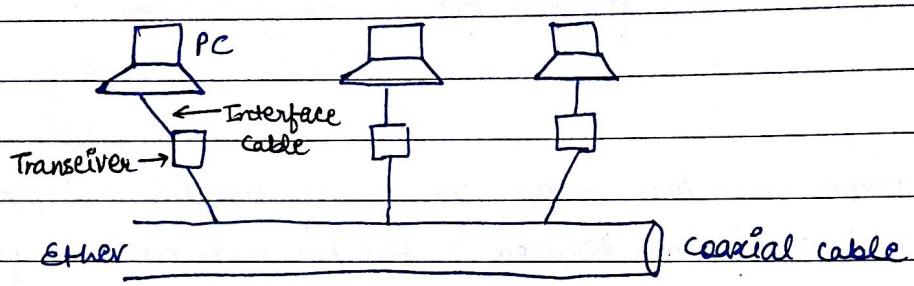
# Ethernet LAN

IEEE 802.11 - Wireless

802.15 - Bluetooth

802.16 - Wireless MAN

## Architecture of original ethernet




Transeiver is a device comprising both a transmitter and receiver (e.g:- walkitalkie and modem)
Transeiver are called medium attachement units (MAU) and were widely used in 10Base2 and 10Base5 ethernet networks.

Ether - The ether referred to as the single coaxial cable used to connect the personal workstations. As far as the origin of term is concerned just as once ether was believed to carry Electromagnetic waves through space, the cable carried data to workstations connected to it.

In chemistry, ether is a pleasent smelling colourless volatile liquid that is highly flammable. And in literature, ether is upper layer of air (region) beyond clouds

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## Ethernet Cabling –

Most common types of ethernet cabling options are :-

| | Name | Cable | Max. Segment Strength | Nodes/segment | Advantages | Popularly known as |
|---|---|---|---|---|---|---|
| 1. | 10 Base 5 | Thick Coaxial | 500 m | 100 | Original cable; now obsolete | Thick ethernet |
| 2. | 10 Base 2 | Thin Coaxial | 185 m | 30 | No hub needed | Thin ethernet |
| 3 | 10 Base T | Twisted pair | 100 m | 1024 | Cheapest System | — |
| 4. | 10 Base F | Fibre optics | 2000m | 1024 | Best b/w buildings | — |

- **10 Base 5**

In this, 10 specifies speed in Mbps.
This uses Baseband signaling. It supports segments of upto 500 m.

**Baseband v/s Broadband**

In the fourier domain, a baseband signal is a signal that occupies a frequency range from 0Hz upto a certain cutoff. It is called Baseband becoz it occupies the base or lowest range of the spectrum.

Broadband signal occupies higher range 1MHz – 3MHz.