Computer Network

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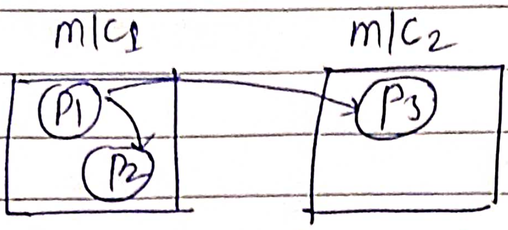

Connection - ~~understandable~~ (e.g. whatsapp)
Communication - understandable
Data transfer

Functionalities

mandatory | optional

Error control | Encryption/decryption
Congestion control

7 layers OSI (open system interconnection)

Application layer
presentation layer
session layer
Transport layer
Network layer
Data link layer — LLC logical link control / MAC Medium access control
physical layer

APSTNDP

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Various devices in Hardware Network

(multiport device)

(I) cables
(II) Hubs
(III) Repeaters

} Hardware
} operates at physical layer

2 port device

mac (IV) Bridges - operates at datalink layer — 2 port device

multiport bridge, mac (V) switches } Hardware + software — datalink layer device

(VI) Routers - Network layer device

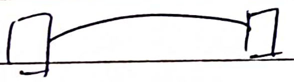
(VII) Gateway (it is not a device it is a functionality)

(VIII) IDS
(IX) Firewall

} security devices

(X) Modem

IP address / mac address



$\boxed{\text{IP address + port No = socket}}$

LAN
MAN - metro politan Network
WAN

DOD (USA)

ARPANET — internet (interNetworking)
→ Advance research project agency

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Cables

→ unshielded or twisted pair cable (electrical signal), coaxial cable
~~and~~ Fiber optics (light signal)

unshielded or twisted pair cable
- electrical signal

10 base T

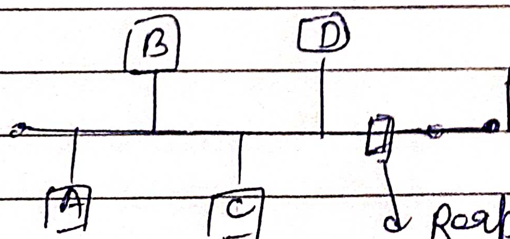
bandwidth — 200 meters (distance)
after this much distance alternation occurs.

Repeater x से x
Amplifier x से 2x, 3x etc

Base band
Broad band

10 band (FX) → 1.99 Km without alternation.

can cable filter?
No



forwarding

Repeater - two port device

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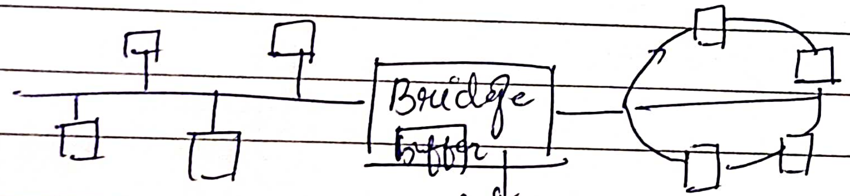
collision domain

- Number of nodes participating in collision.

Repeater vs Hub

Hub identify the problem in the cable.

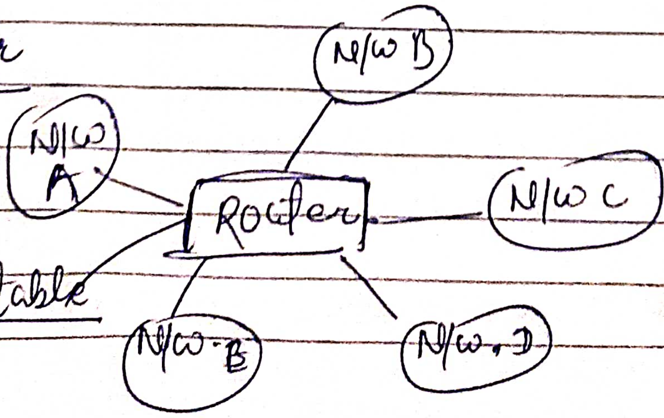


store and forward

static   Dynamic

Hub + functionality → switch

Router



Routing table

Limited broadcast
Direct broadcast

MAC - private Address
IP - public Address

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Flooding used in Router

physical layer

(i) cables and connectors

(ii) physical topology

(iii) Hardware - Hub and Repeaters

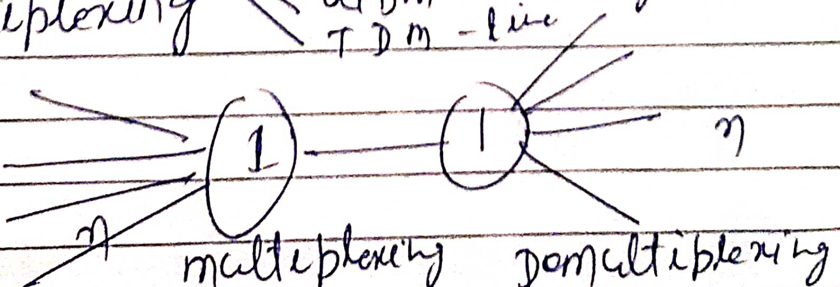
(iv) transmission mode -
- simplex
- Half duplex
- Duplex

(a) simplex - one way (always) communication is possible

(b) Half duplex - one way communication is possible at a time

(c) Half Duplex - Two way communication is possible at a time.

(v) multiplexing
- FDM - Frequency division
- WDM - wavelength
- TDM - time



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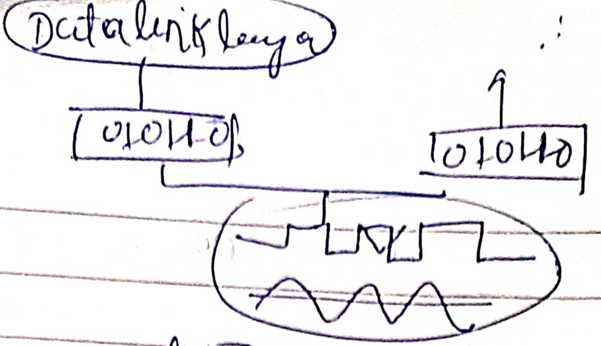


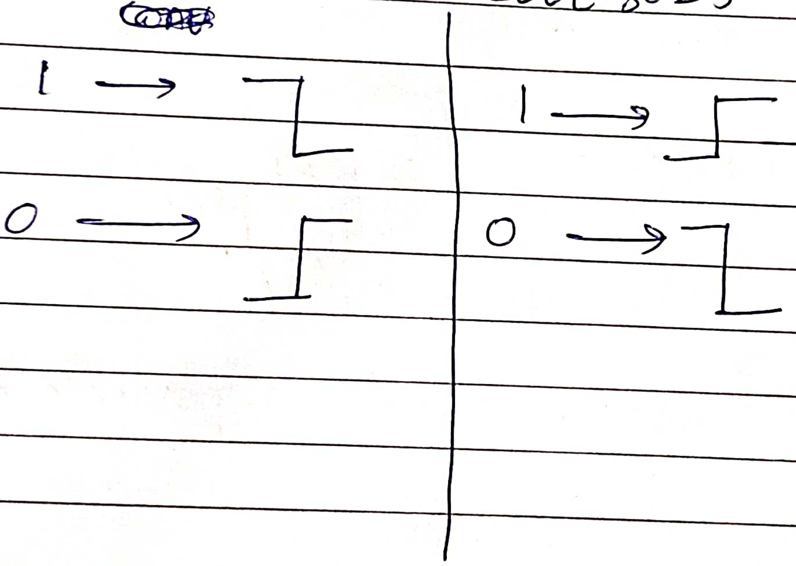
Encoding

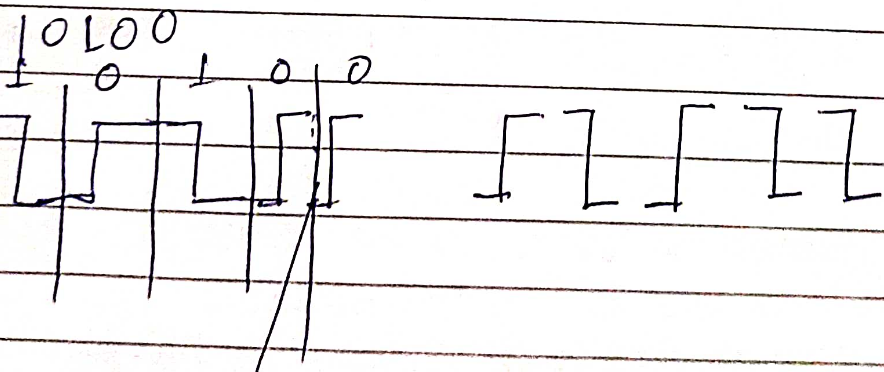
Manchester encoding
Differential encoding

Manchester

Dr Thomas

IEEE 802.3





differential manchester Encoding

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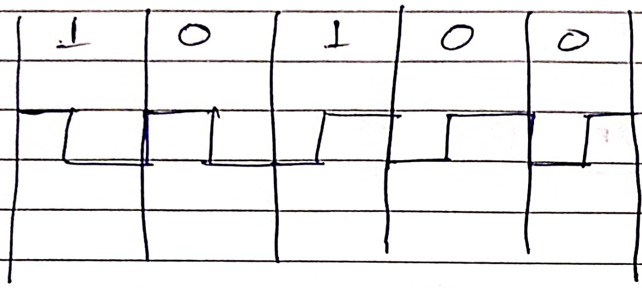
Defferential manchester

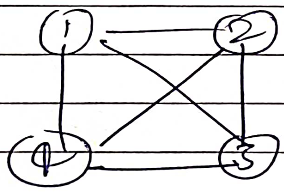
1 → NOT Edge
0 → Edge



Topology

(i) Mesh Topology

every device in a Network is connected to every device directly



No of Cables $= \frac{n(n-1)}{2}$

the No of ports at each device $= n-1$

Total ports in a Network having n device
$= n(n-1)$

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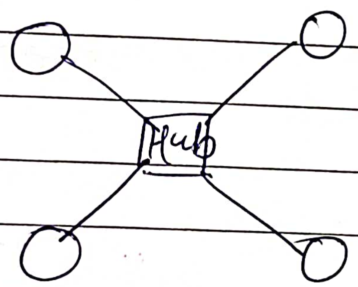
Reliability - do one point failure does not affect whole mesh network

security - more secure.

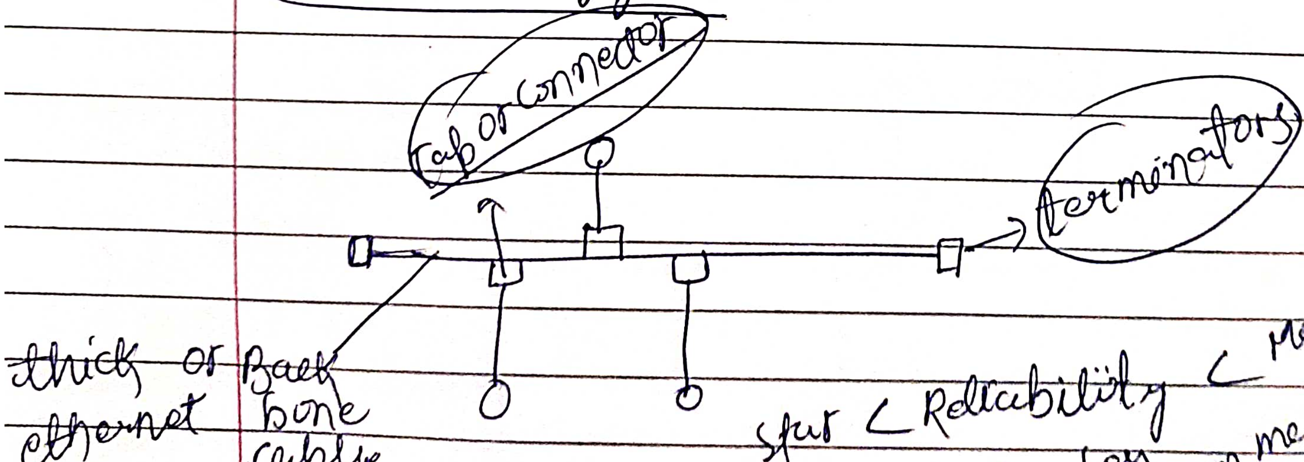
Cost - more

(2) Star/Hub Topology



Reliability ✗
security - very low
Cost - less

(3) Bus Topology



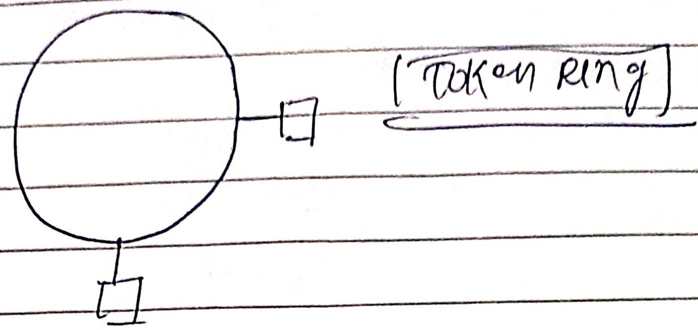
TOKen bus

star < Reliability < mesh

security - low

cost - cheaper than mesh

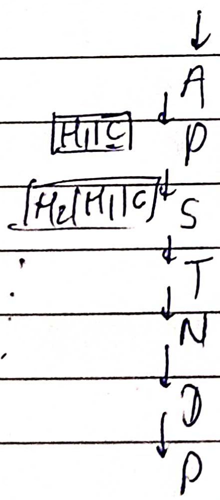
(4) Ring topology



Delays

(1) processing delay

- it is the time to check the packet header and determine where the packet should be directed towards destination.



queuing delay - sometime has to wait in buffer to transmit. the waiting time in the queue before the transmission of packet is queuing delay.

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→ Transmission delay / store and forward delay.
 - Time required to transmit all the bits of the packet over the link.

$$\boxed{TT = \frac{\text{message size}}{\text{bandwidth}}}$$

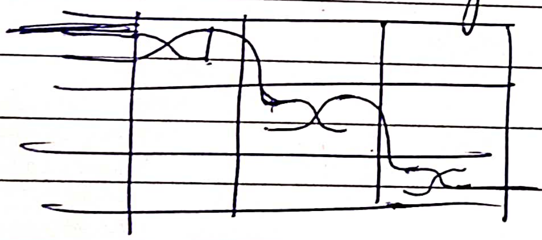
→ propagation delay

$$T = \frac{\text{distance}}{\text{speed}}$$

Switching

(i) circuit switching
(ii) packet ,,
(iii) Message ,,

(I) circuit switching



Reservation of resource
Efficiency ↓
Delay ↑

Delay = setup time + Transmission time + propagation delay + tear-down time

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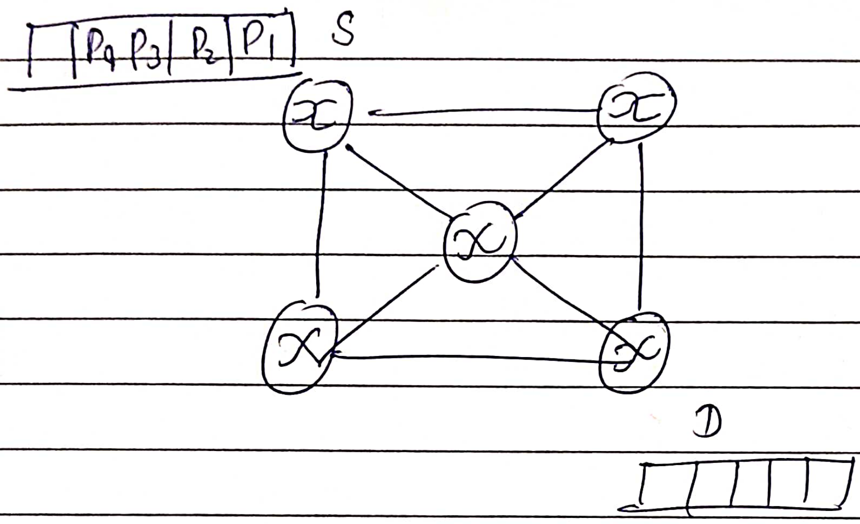
packets switching

Datagram services (work for Network layer)

virtual circuit (work for datalink layer)



Delay = n(Transmission time) + processor delay

n (in between switches)

Datagram	virtual circuit
(I) connection less	Connection oriented
(II) No reservation	Reservation
(III) out of order	same order
(IV) High overhead	less overhead
(V) packet loss more	packet loss less

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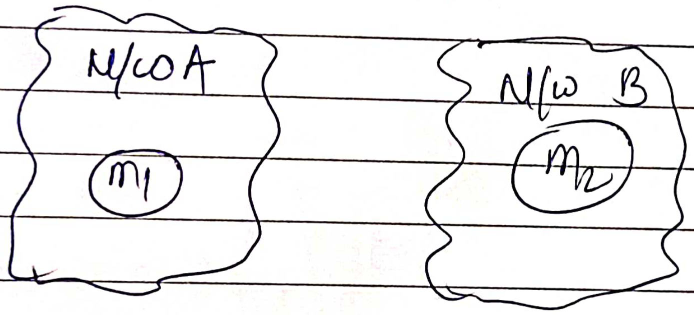
unicast, multicast and Broadcast

unicast – one to one communication
multicast – one to many "
Broadcast – one to All

Limited Directed



~~M1 communicating with~~
M1 broadcasting to all the machines inside Network A is limited

M1 broadcasting to all the machines inside Network B is Directed.

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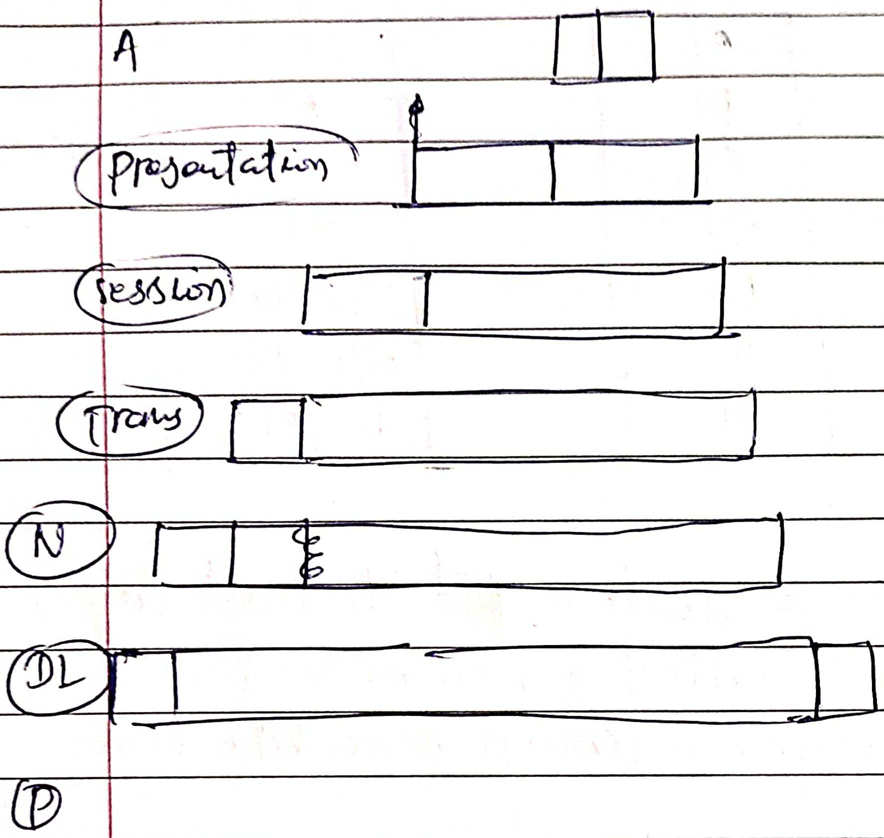
Interleaving

depends on ~~physical clock~~.



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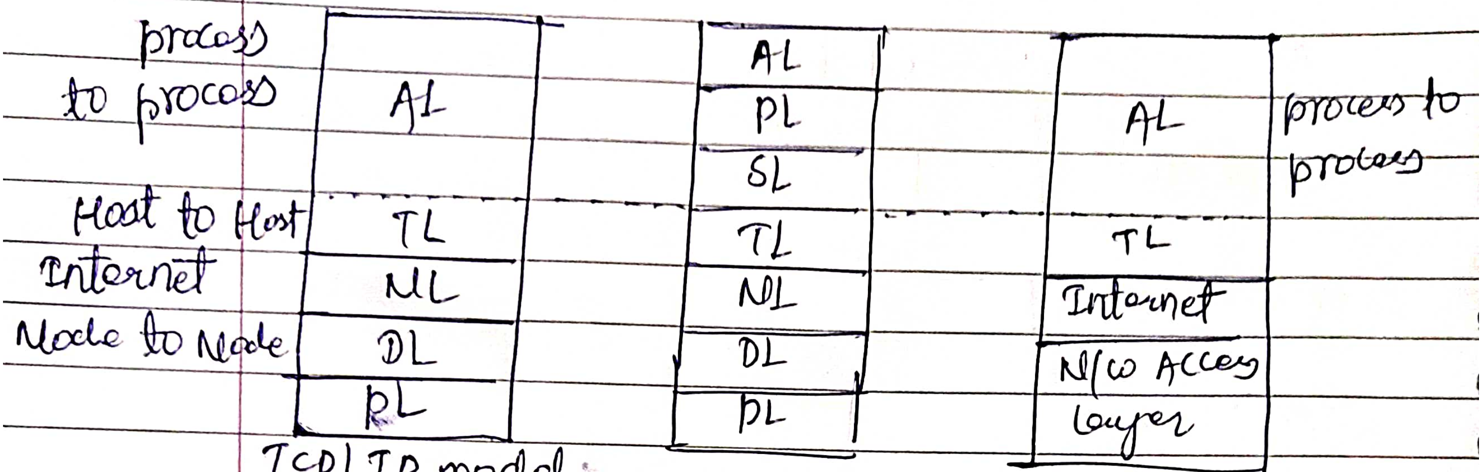
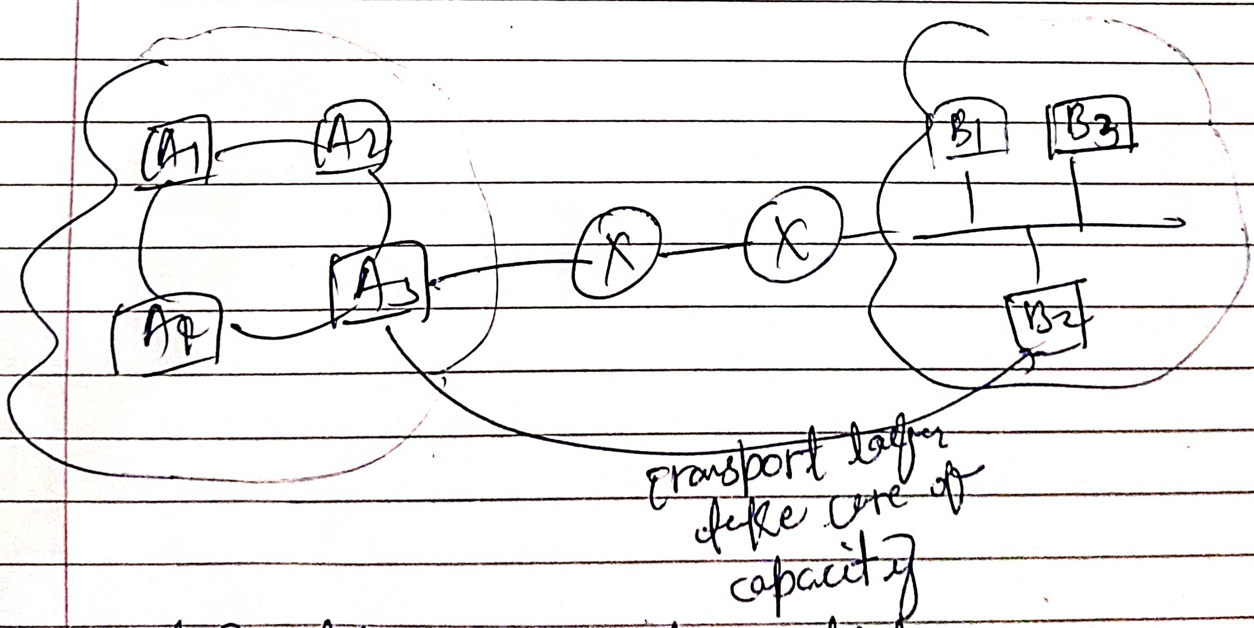
TCP/ IP model - modified form of OSI



TCP/ IP model

→ Transport ~~p~~ layer is called ~~post~~ to Host Layer
→ Network layer is called internet layer
→ Node to Node layer is called Data link layer



DL layer take care of intermediates.
(i) Hop ~~to~~ to Hop delivery
(ii) Error Control (cyclic redundancy check)
(iii) flow Control ← Stop and wait
selective repeat
go back N

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(IV) Access Control
(V) physical Address / MAC Address

Framing

| Flag | H | | T | Flag |

Bit stuffing
Byte stuffing

MAC

- Random Access protocol
  - Aloha
    - pure
    - slotted
  - CSMA
  - → CSMA/CD
  - → CSMA/CA
- Control Access protocol
  - polling
  - Token passing
- channelization protocols
  - ~~time division~~
  - FDMA
  - TDMA
  - CDMA

DMA - Division multiple Acces

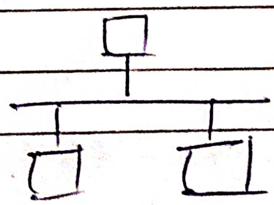
~~carrier~~
→ carrier sense multiple Acces

→ CD - ~~carrier~~ collision detection

→ CA - Collosion Avoidance

point to point - Not require Access Control
Shared media - require Access Control

pure Aloha



$V_T = 2 * T_T$

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pure Aloha

efficiency $\eta = G * e^{-2G}$

$$\frac{d\eta}{dG} = 0$$

$$G = 1/2$$

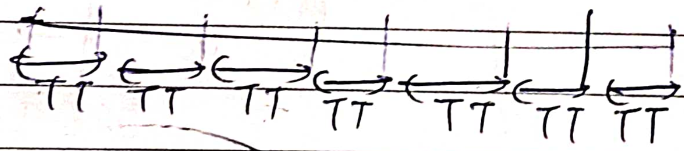
maximum efficiency $= G * e^{-2G}$

$= \frac{1}{2} \times e^{-2(1/2)}$

$= \frac{e}{2} = 0.184$

$= 18\%$

slotted Aloha



$T_T = \frac{ms}{\text{Bandwidth}}$

$V_T = T_T$

$$\eta = G * e^{-G}$$

for max η $G = 1$

$\frac{d\eta}{dG} = e^{-G} - G \cdot e^{-G} = 0$

$G = 1$

$\eta = 1 * e^{-1}$

$= 1/e$

$\eta = 36\%$

collesion detect based on energy signal.

CSMA – carieor sense multiple Access

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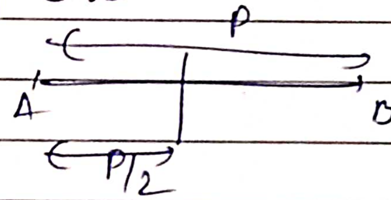
1 - persistent – contenouosly sense the channel untill channel is free
0 - persistent – Not Contenoucus (wait for random amount)
p - persistent – probablity

CSMA / cd – Wired के लिये use करते हैं
Ethernet

backoff time
कोई waiting time होता है

* After sending it stop sensing in traditional CSMA.
* ~~AD~~
कब तक sense करेगा (nearly middle में collesion होता है)

Average case



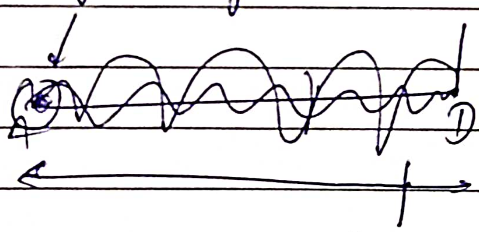
PD = P

Worst case

Jamming signal = signal with High energy

(indicator to all the devices to stop the sending signal in the channel)

PD=P



Vulerable delay = 2P

(Frame का size इतना रखो की 2p time लगे)

transmission में = 2xPD

$$TT = \frac{L}{B} = 2 \cdot PD = \frac{2 \cdot \text{distance}}{\text{speed}}$$

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Consider a CSM/CD network that transmits data at rate ~~of~~ 100mbps = ~~10^5~~ 10^8 bit/s over 1 Km cable with no repeaters if the minimum frame size required for this network is 1250 bytes. what is the signal speed in Km/s in cable

$$= \cancel{2\times 1000} \cancel{\frac{\quad}{10^8}}$$

$$= 2\times L$$

$$\frac{1250\times 8}{10^8} = \frac{2\times L}{S}$$

$$S = \frac{\cancel{2}\times 10^8}{1250\times \cancel{8}\ 4}$$

$$= \frac{\cancel{10^8}\ 10^5}{5000}$$

$$= 20000 \text{ Km/s}$$

Network adminstration for IFS According to your station.

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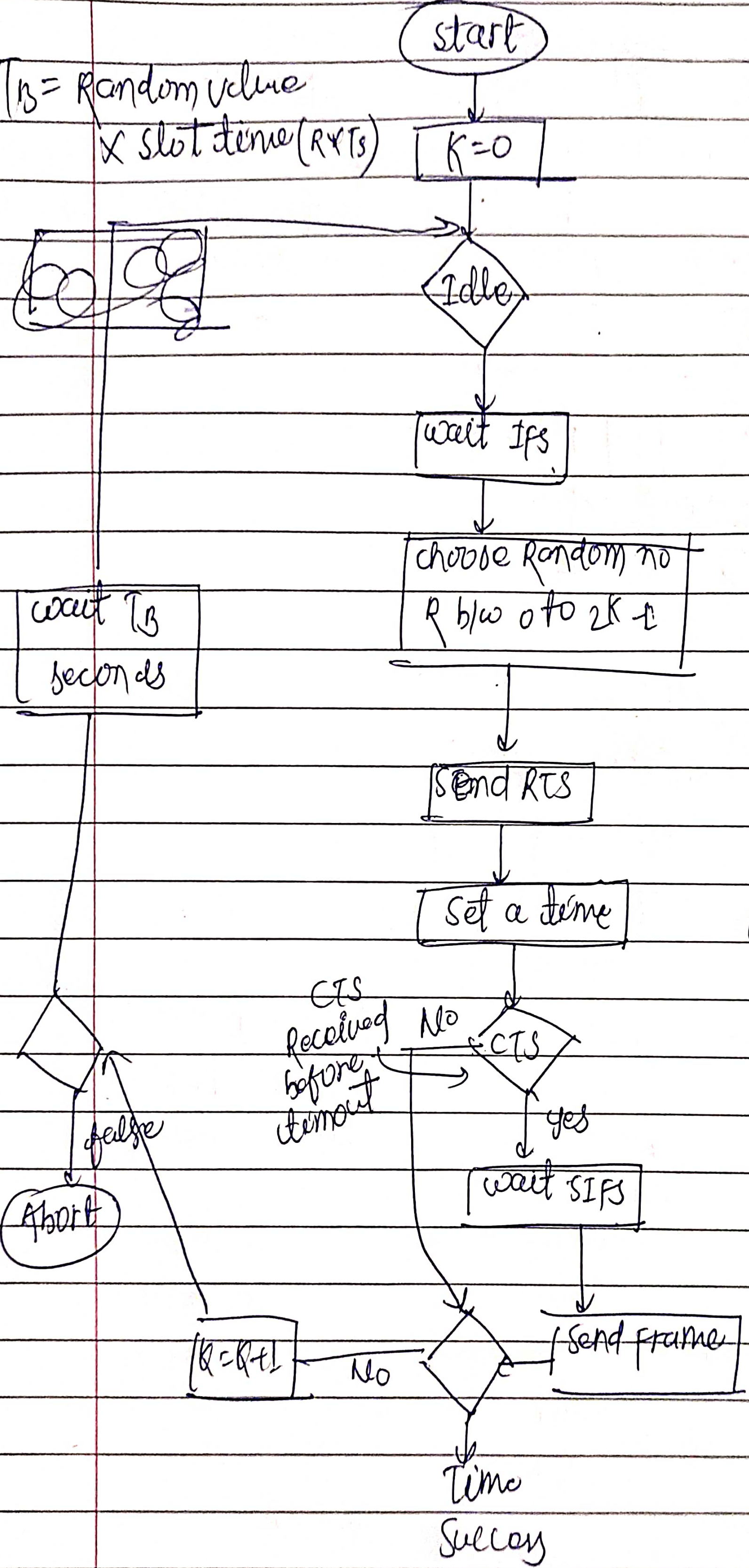
T_B = Random value × slot time ($R \times T_B$)

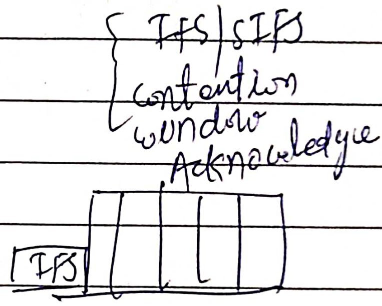


RTS ≡ ready to send

CTS ≡ clear to send

IFS ≡ Interference space.

SIFS ≡ short interference space.



Control packet

Data packet

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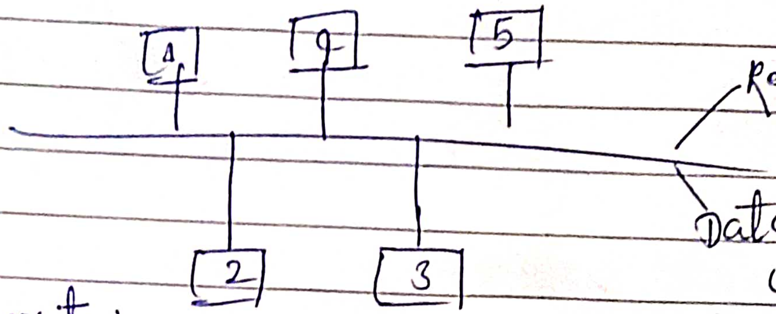
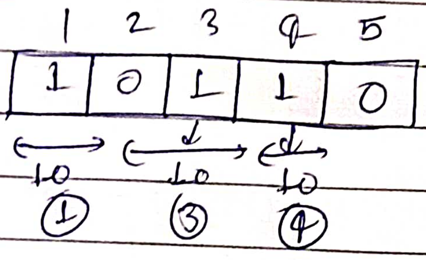


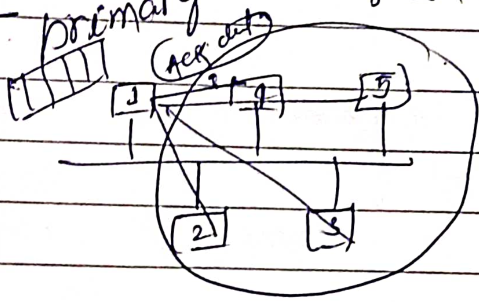
Reservation time

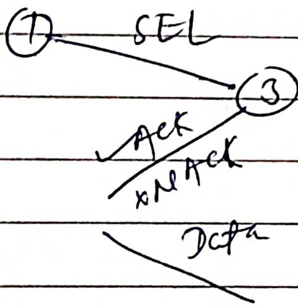
Data transmission time

Reservation



polling

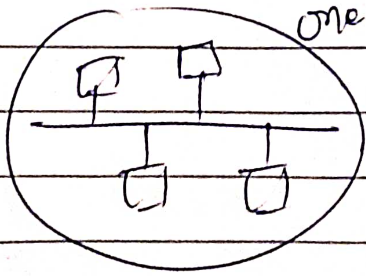




After a periodic time primary polls to all the secondary

Tocken passing

one network



one token

one token acquires

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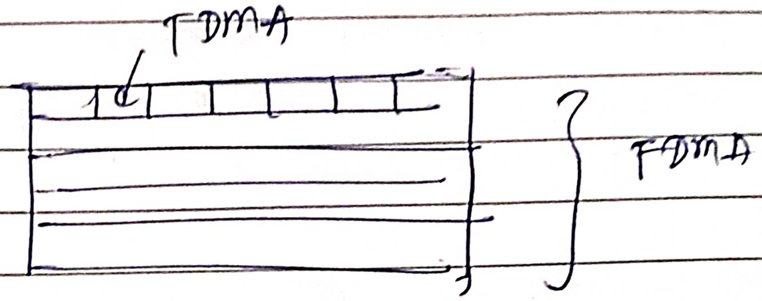
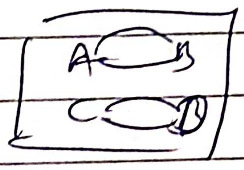
Channelization

(i) FDMA
(ii) TDMA
(iii) CDMA   Code division



CDMA



Error control

send & Received

single bit error   burst error

eg 1101 → 1100   eg 1101 → 0100

S. No.

VRC
LRC
checksum
CRC

Error Handling codes — Error detection (presence/absence of error) — VRC, LRC, checksum, CRC
Error Handling codes — Error Correction (presence + position) — Hamming codes

VRC - vertical redundancy check
LRC - longitudinal redundancy check

(i) Dataword — Blocks of fixed size

(ii) Arrange ~~words~~ blocks line by line
(iii) calculate parity columnwise = Redundantwise

Dataword - 110110110110 Blocksize = 4 (given)

LRC →

0110
1011
1101
0000 even parity
1111 odd parity

checksum

$B_1 \oplus B_2 = S_1$
$S_1 \oplus B_3 = S_2$
$S_2 \oplus B_4 = S_3$
. . . . . .

S_n
Redundant bit $= \overline{S_n}$

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1101101101101 4

1110
0011
R·B = 1100

Codeword = Dataword + Redundant bit
= 1101101101101 + 1100
= 1101101101101 1100

CRC use Data link layer

cyclic redundancy check

(i) divisor of n bits
(ii) Append n-1 zeroes to dataword (dividend)
(iii) perform division ~~at~~ Remainder = n bit then
redundant bit = n-1 bit

eg 1100 = Remainder
100 = R·b

Qurd = 1010001101

$x^5 + x^4 + x^2 + 0x^1 + 1x^0$

$x^5\ x^4\ x^3\ x^2\ x^1\ x^0$
divisor 110101

~~1101010000000~~ = dividend
101000110100000

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1010001101 110 10100000

```
110101 ) 101000110100000
         110101
         0111011
          110101
          00111010
            110101
            00111110
              110101
              00101100
                110101
                0110010
                 110101
                 0001110  Ans
```

R bit, Consecutive	Hamming codes
VRC - 1 bit	R bits are non-consecutive
LRC - 1 block	
Check sum = 1 block	Dataword + R bit = Codeword
CRC = n-1 bits	$R_1 = 2^0 = 1$

$R_2 = 2^1 = 2$

$R_3 = 2^2 = 4$

$R_4 = 2^3 = 8$

1011001010

14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	0	1	1	0	0	R_4	1	0	1	R_3	0	R_2	R_1

17 16 15

R_1	1	0001 ✓
R_2	2	0010
	3	0011
R_3	4	0100
	5	0101
	6	0110
	7	0111
R_4	8	1000
	9	1001
	10	1010
	11	1011
	12	1100
	13	1101
	14	1110

14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	0	1	1	0	0	R_4	1	0	1	R_3	0	R_2	R_1

Except R bit

$R_1 = 3 \oplus 5 \oplus 7 \oplus 9 \oplus 11 \oplus 13$

$= 0 \oplus 1 \oplus 1 \oplus 0 \oplus 1 \oplus 0$

$R_1 = 1$

$R_2 = 3 \oplus 6 \oplus 7 \oplus 10 \oplus 11 \oplus 14$

$= 0 \oplus 0 \oplus 1 \oplus 0 \oplus 1 \oplus 1$

$= 1$

$R_3 = 5 \oplus 6 \oplus 7 \oplus 12 \oplus 13 \oplus 14$

$= 1 \oplus 0 \oplus 1 \oplus 1 \oplus 0 \oplus 1$

$= 0$

$R_4 = 9 \oplus 10 \oplus 11 \oplus 12 \oplus 13 \oplus 14$

$= 0 \oplus 0 \oplus 1 \oplus 1 \oplus 0 \oplus 1$

$= 1$

Hamming Code Work only for 1 bit error in block.

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Complete Code Word

												R_2	R_1
1	0	1	1	0	0	1	1	0	1	0	0	1	1
14	13	12	11	10	9	8	7	6	5	4	3	2	1
						R_4				R_3			

12th bit replaced by 0

Error $R_4 R_3 R_2 R_1$
1100

12th bit Ans

Hamming distance

No of different bits in two Code Word.

or No of 1's after Xor between two Code Word.

MHD = minimum Hamming distance

$d+1 = MHD$ d = error detect

$\boxed{2d+1 = MHD}$ d = error correct

$C_1 = 00000000 \Rightarrow 4$

$C_2 = 00001111 \Rightarrow 4$

$C_3 = 01010101 \Rightarrow 8$

$C_4 = 10101010 \Rightarrow \cancel{4}$

$C_5 = 11110000$

$\Rightarrow 4$

$2d+1 = \cancel{4}\ 3$

$d = 2/2$

$d = 1$

$d = 3$

$d = 1$

Gr. No. ________ Date: ________

c_1 = 00000 3
c_2 = 01011 4
c_3 = 10101 3
c_4 = 11110 4

detection

MHD = p = (2) = 3 error detection 2
q = (1) error correction 1

Flow Control

take care of data wastage that the data which is sending is receiving properly or not.

Stop and wait — ACK / NACK

ARQ
→ Automatic Repeat request.

Go back N	selective repeat
Keep on sending without acknowledgement	
| 5 | 4 | 3 | 2 | 1 |	| 5 | 4 | 3 | 2 | 1 |
N ACK(3)	NACK(3)
out of order X	out of order ✓

Sliding window mechanism

S —————— D

2PD
= 1 RTT (Round trip time)

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Link utilization (U)

$$U \le \frac{W}{1+2a}$$ W = window size of sender

$$a = \frac{PD}{TT}$$

ques Stop and Wait protocol Bandwidth = bit rate

bit rate = 64 KB/s

propagation delay = 20 ms

link utilization = 50%

frame size in bytes

$\frac{2^{15}}{2^{2}}$ 2 15×10^{3}

$$0.5 \le \frac{64 \text{ KB} \times 20}{1 + 2 \cdot \frac{20}{TT}}$$

$$5 \quad \frac{10}{TT} = 64 \times 1000 \times 20$$

$$\frac{10}{TT} = 64$$

ques distance between two Network 8000 km bandwidth 500×10^{6} bits/second propagation speed 4×10^{6} m/s and protocol used is go back N

PD = 2^{3}

PD = 2s Average packet size 10^{7} bits

link utiliz. = 1

minimum size in bits of the sequencing no. =

$$L = \frac{W}{1 + 2 \times \frac{2}{\frac{10^{7}}{500 \times 10^{6}}}}$$

$$W = 1 + \frac{2 \times 2}{10^{7}} \times 500 \times 10^{6}$$

$$W = 201 = 1 + 200$$

$\log(201)$

Sr. No. ______ Date: ______

Frame size = 1kb

= 1.5 mbps

propagation delay = 50 ms

U = .6

$$.6 = \frac{\omega}{1 + 2 \times \frac{50 \times 10^{-3}}{\frac{1}{1.5 \times 1024}}}$$

$\omega = .6(1 + 2 \times 50 \times 1.5 \times 1024)$

$\omega = .6(1 + 150 \times 1024)$

$2^{n-1} = .6(1 + 153600)$

$2^{n-1} = \cancel{92160.6}$

154.6 × 6 = 927.6

75.8

$2^{n-1} = 927.6$

$n-1 = 7$

$2^n = 1855.52$

$n = 8$

1024 × 15 = 5120, 1024, 153600

153601 × .6 = 92160.6

154.6 × .6 = 927.6