COMPUTER NETWORK

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Unit-2

ONE SHOT + 3 PYQ SOLUTIONS

Topics :-

→ Data Link layer → Services

→ Framing and its type

→ Error Detection & Correction.

→ Error Detection method — 2022-23

→ FLOW CONTROL

→ STOP N WAIT → 10 marks (2021-22, 18-19)

→ Slinding window protocol.

→ Channel Allocation.

→ Multiple Access protocols. → (2021-22, 22-23)

→ LAN Standards.

→ Bridging & Spanning Tree Algo.

Data Link Layer

→ It is second layer of OSI Layered Model.

→ Data Link layer is responsible for converting data stream to signals bit by bit and to send that over the underlying hardware.

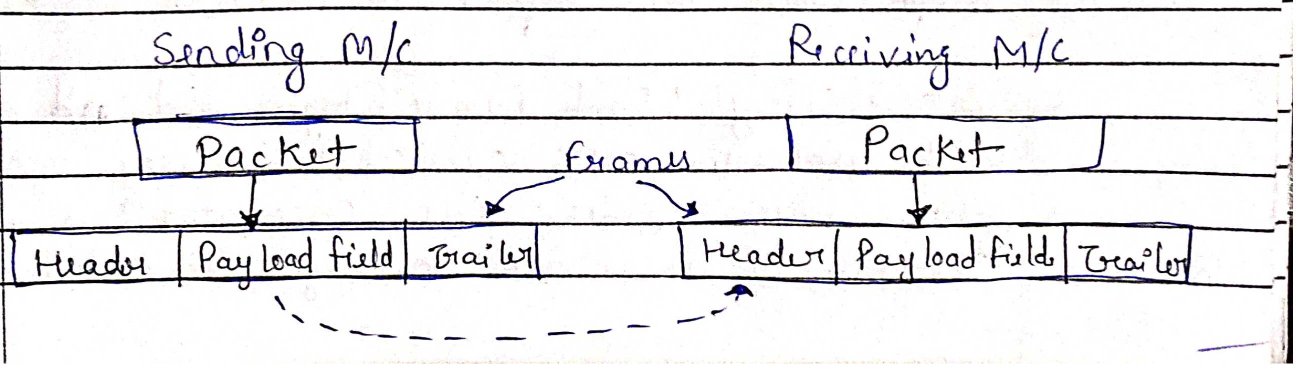
Services of Data Link Layer

→ Framing & Link access
→ Reliable Delivery
→ Flow Control
→ Error Detection
→ Error Correction
→ Half - Duplex & Full - Duplex

Framing

→ Data link layer takes the packets from the Network Layer and encapsulates them into frames. If the frame size becomes too large, then the packet may be divided into small sized frames.

→ Smaller sized frames makes flow control and error control more efficient. At receiver's end, data link layer picks up signals from hardware and assembles them into frames.



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Parts of a Frame:

- Frame Header : It contains the source and the destination addresses of the frame.
- Payload field : It contains the message to be delivered.
- Trailer : It contains the error detection & error correction bits.
- Flag - It marks the begining and end of the frame.

Flag	Header	Payload Field	Trailer	Flag

- **Types of framing**

1. Fixed size
2. Variable size → Length fixed
   → End Delimiter

Character Oriented Framing (Byte) (8bit)

Bit Oriented Framing. (1bit).

A. Byte stuffing ⇒ Sender's DLL Insert Special escape (ESC) Just before 'Accidential data.(Byte).

B. Bit stuffing ⇒ Each frame begin and ~~end~~ end with pattern (01111110) that is flag byte.

→ when ever sender's DLL encounter's five consecutive is in the message it automatically stuff '0' bit into outgoing bit stream.

Error Detection and Correction [2022-23] - 10 marks

Errors are introducted into binary data transmitted from the sender to the receiver due to noise during transmission.

Error Detection : methods are used to check whether the receiver has received correct data or corrupted data.

Error Correction : It is used to correct the detected errors during the transmission of data from sender to receiver.

Types of Errors.

1. Single bit Error → | 1 | 0 | 1 | 1 | → | 1 | 1 | 1 | 1 |

   Sent → Received.

2. Multiple bit Error → | 1 | 0 | 1 | 1 | → | 0 | 0 | 1 | 0 |

   Sent → Received

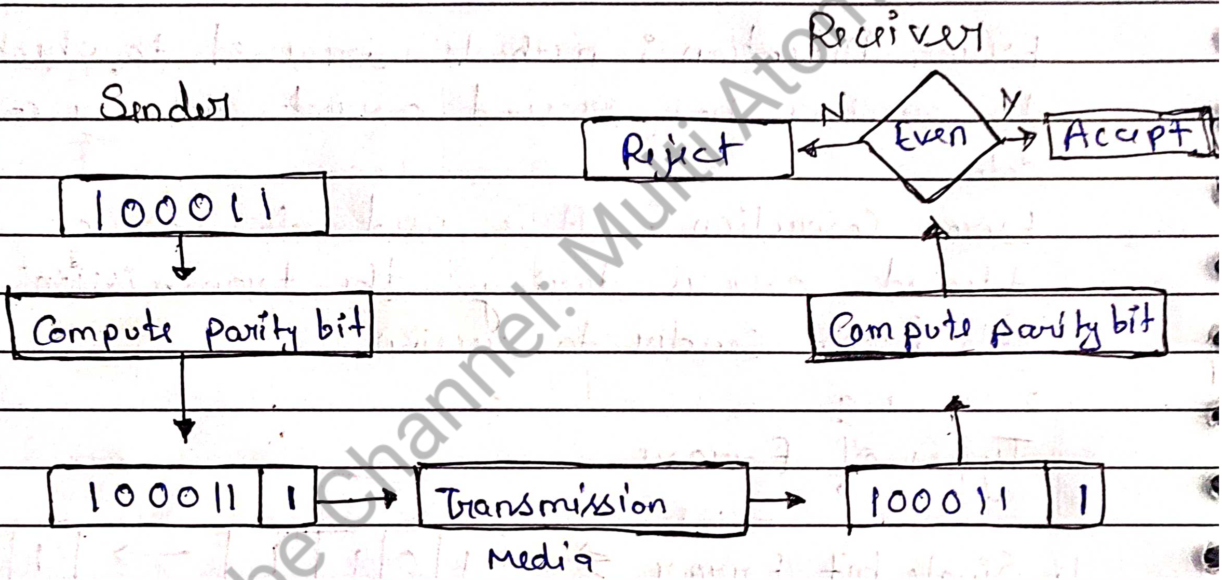
3. Burst Error → | 1 | 0 | 1 | 0 | → | 0 | 1 | 0 | 1 |

Error Detection Method	Error Correction
	Type ↓
→ ~~Single~~ simple Parity Check	→ Backward EC
→ 2-Dimensional parity check	→ Forward EC.
→ CheckSum	Techniques ↓
→ Cyclic Redundancy check.	1. Hamming Code
	2. Determing Parity bit

* Even parity → 1011 → 10111
  → 1010 → 10100

* Odd Parity → 1011 → 10110
  → 1010 → 10101

1. ~~Single~~ simple Parity Check



2. Two-Dimensional Parity Check

Data = 10011001 | 11100010 | 00100100 | 10000100

10011001	0	← row
11100010	0	
00100100	0	
10000100	0	
11011011	0	

col ↓

→ 100110010 | 111000100 | 001001000 | 100001000 | 110110110

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3. Checksum

10011001	11100010	00100100	10000100
1	2	3	4

Sender

1→ 10011001
2→ 11100010

1 01111011
→ 1

01111100
3→ 00100100

10100000
4→ 10000100

1 00100100
→ 1

Sum: 00100101
checksum: 11011010

Receiver

Same as Sender

Sum: 00100101
checksum: 11011010

11111111

Complement = 00000000

Conclusion: Accept Data.

4. Cyclic Redundancy check (CRC):

→ equ → $x^3 + x^2 + 1$ = 01101 $\boxed{x^4\ x^3\ x^2\ x^1\ x^0}$

$x^4 + x^2 + x^0$ = 10101

→ Frame = 101 0000

→ Generator = $x^3 + 1$ → $\boxed{1001}$ 4 bit.

→ if CRC generator is of n bit, then append (n-1) Zeros in the end of original message.

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$\boxed{X \longrightarrow XOR}$

Sender

```
1001 ) 101 0000 000
       X 1001
         0011 000000
          X 1001
            01010000
            X1001
             0011000
              X1001
               01010
               X1001
                0011   ← Remainder
```

→ Message to be transmitted ⇒ 1010000 000
+ 011
$\boxed{1010000011}$

Receiver

```
1001 ) 1010000011
       X1001
        0011000011
         X1001
          01010011
          X1001
           0011011
            X1001
             01001
             X1001
              0000 ← Zero means data
                     is accepted.
```

AKTU - 2022-23 [10 marks]

Q. A bit stream 10011101 is transmitted using x^3+1 generator polynomial. Generate the CRC code word for this message.

→ 1001) 10011101000

  × 1001

  00001101000

  × 1001

  00100000

  × 1001

  000100 ← Remainder.

  ~~× 1001~~

→ $\boxed{\text{CRC code} = 10011101100}$

Hamming Code

→ It is a set of error-correction codes that can be used to detect and correct bit errors that can occur when computer data is moved or stored.

→ It uses parity bit.

→ Using more than one parity bit, an error-correction code ~~is the use of extra~~ not only identify a single bit error in the data unit, but also its location in the data unit.

① → It can be applied to data units of any length.

② → no. of parity bit is decided by

$$\boxed{2^r \geq m + r + 1}$$

D3		D2	D1	
	P_2			P_1

r = No. of parity.
m = message bits.

e.g ⇒ $m = 4$ [1010]

$2^3 \geq 4 + 3 + 1$

$8 \geq 8$ ✓

③ → This parity bits are positional parity bit:

$m = 4$ bit
$r := 3$ bit
$4 + 3 = 7$ bit

P_1	P_2	P_3
2^0	2^1	2^2

7	6	5	4	3	2	1
D_4	D_3	D_2	P_3	D_1	P_2	P_1
			2^2		2^1	2^0

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E.g A bit word 1011 is to be transmitted construct the even parity seven bit Hamming code for this data.

→ even parity = No. of 1s will Even. ✓

Sol $m = 4$ bit
$r = 3$ bit

→ $2^r \geq m+r+1$ ✓

step1 ⇒ $r = 0$ $[2^0 \geq 4+0+1]$ ✗
1 $[2^1 \geq 4+1+1]$ ✗
$[2^2 \geq 4+2+1]$ ✗
$[2^3 \geq 4+3+1]$ ✓ $\boxed{r=3}$

P_1	P_2	P_3
2^0	2^1	2^2

→

7	6	5	4	3	2	1
D_4	D_3	D_2	P_3	D_1	P_2	P_1

→

7	6	5	4	3	2	1
1	0	1	P_3	1	P_2	P_1
111	110	101	100	011	010	001

$P = 3$ Data
$P_1 - (3, 5, 7) \rightarrow (1, 1, 1) = 1$
$P_2 - (3, 6, 7) \rightarrow (1, 0, 1) = 0$
$P_3 - (5, 6, 7) \rightarrow (1, 0, 1) = 0$

⇒

1	0	1	0	1	0	1

AKTU - 2022 - 23 [2 marks]

Q. If a 7-bit hamming code received as 1110101, show that the code word has error. Also, rectify error in this code.

7	6	5	4	3	2	1
1	1	1	0	1	0	1
111	110	101	P_3	011	P_2	P_1
			100		010	001

$P_1 = 1, 3, 5, 7 = (1, 1, 1, 1) = 0$
$P_2 = 2, 3, 6, 7 = (0, 1, 1, 1) = 1$
$P_3 = 4, 5, 6, 7 = (0, 1, 1, 1) = 1$

$110 = 6$

7	6	5	4	3	2	1
1	0	1	0	1	0	1
	↑					

Flow Control

Feedback based
→ sender gets ack. from the user

Rate Based
→ check the rate of flow without ack.

Protocols

for Noiseless Channels
→ Simplex protocol
→ Stop & Wait protocol

for Noisy channels
→ Stop & Wait ARQ
→ Go-Back-N ARQ
→ Selective Repeat ARQ

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① ~~Elemer~~ AKTU - 2022-23 [10 marks]

Q. Explain error control ~~control~~ mechanism in Data Link layer and giving example of each method

Ans ① Elementary Data Link Protocol → simplex $ stop and wait.

② Sliding Window Protocols. → Go-Back-N ARQ
→ Selective Repeat ARQ.

① Simplex Protocol

→ As the name suggests, is the most basic Data Link protocol.

→ data can only be sent in a single direction.

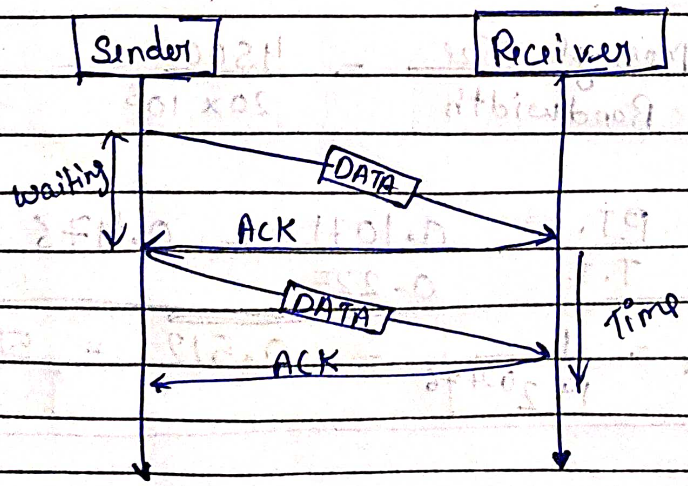
→ the sender/receiver can generate an infinite amount of data.

→ e.g → Keyboard transmitting Keystrokes to a Computer

② Stop and Wait Protocol

→ It is a fundamental data link protocol where the sender transmits a frame and waits for an ack. from the receiver before sending the next frame.

→



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AKTU - 2018-19 [10 marks]

Q. A channel has a bit rate of 20Kbps. The stop and wait protocol with frame size 4500 bit is used. The delay for error detection and sending ACK by the receiver in 0.25 seconds because of a fault. Find the maximum efficiency of the channel if destination is 30000 Km away and the speed of the propagation of the signal is 2.8×10^8 m/s. Find the decrease in efficiency due to the fault.

Sol Bandwidth = 20×10^3 bps

delay because of fault = 0.25 sec.

Size = 4500 bit

distance = $30{,}000 \times 10^3$ m

propagation speed = 2.8×10^8 m/s.

decrease in efficiency = ? & Max efficiency = ?

→ $\eta_{max} = \dfrac{1}{1+2a}$ $\quad a = \dfrac{\text{Propagation Time}}{\text{Transmission Time}}$

→ $P.T = \dfrac{\text{Distance}}{\text{Propagation Speed}} = \dfrac{30{,}000 \times 10^3}{2.8 \times 10^8 \text{ m/s}} = 0.1071$

$T.T = \dfrac{\text{Message size}}{\text{Bandwidth}} = \dfrac{4500}{20 \times 10^3} = 0.225$

$a = \dfrac{P.T.}{T.T.} = \dfrac{0.1071}{0.225} = 0.476$

$\boxed{\eta_{max} = \dfrac{1}{1+2*0.476} = 0.512 = 51.2\%}$

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$$\boxed{\eta_{fault} = \frac{1}{1+2a+\frac{0.25}{T.T}}} = \frac{1}{1+2\times 0.476 \times \frac{0.25}{0.225}}$$

$$\boxed{\eta_{fault} = 0.326 = 32.6\%}$$

→ decrease in η (%) $= \frac{\eta_{max} - \eta_{fault}}{\eta_{max}} \times 100$

$$= \frac{0.512 - 0.326}{0.512} \times 100$$

$$= \boxed{36.3\%}$$

AKTU- 2021-22 [10 marks]

Q. Define the relationship b/w Transmission delay & Propagation delay, if the efficiency is at least 50% in STOP n Wait protocol.

→ $\eta = \frac{1}{1+2a}$, $a = \frac{P.T.}{T.T.}$, $\eta = 0.50 = \frac{1}{2}$

$$\frac{1}{2} = \frac{1}{1+2\times\frac{P.T}{T.T}}$$

$$1 + 2\frac{P.T}{T.T} = 2$$

$$2\times\frac{P.T}{T.T} = 1$$

$$\boxed{2 \text{ Propagation Time} = \text{Transmission Time}}$$

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→ **Sliding window Protocol**

* It is a technique for controlling transmitted multiple data packets b/w two network computers.

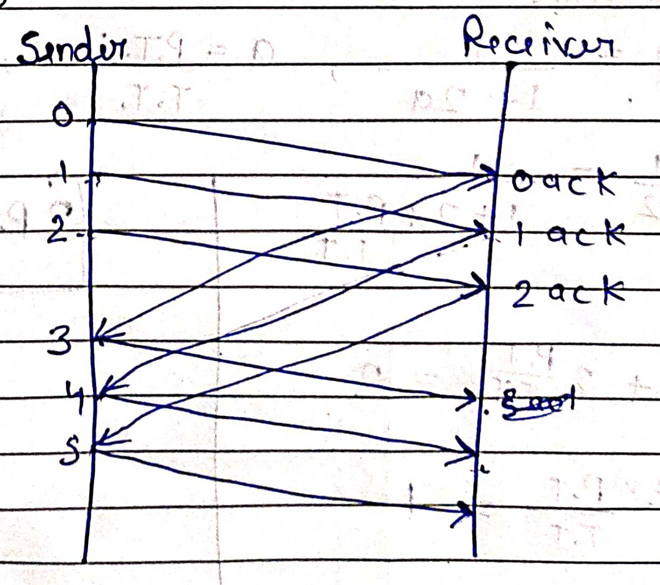
* each data packet includes a unique consecutive Sequence number which is used by Receivers
* to place data in the correct order.
→ avoid duplicate data $ to request missing data.

→ It uses the concept of piggy backing - Instead of sending ack frame on its own, if there is an outgoing data frame in the next short interval, attach the ack to it (using "ack" field in header).

AKTU - 2022-23 [2 mark] - (piggy backing.)

e.g | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | window size = 3

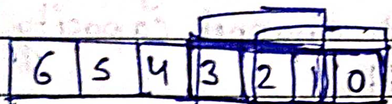
frames = 8



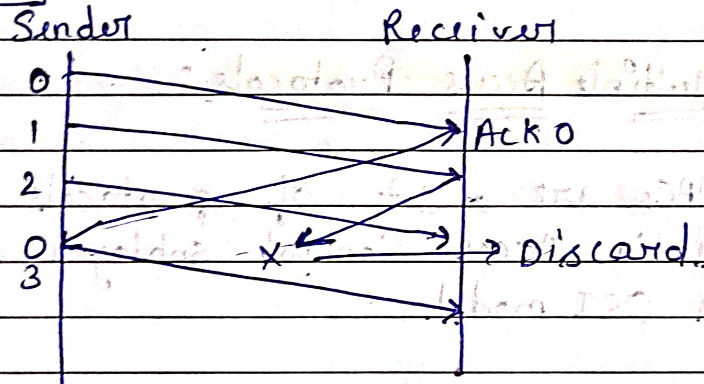
① GO - BACK - N ARQ (Automatic Repeat Request)

→ If one frame is corrupted then all frames have to be sent again. (as respect window size)
→ Number of frames sent depends on window size.

→ The size of the sender window is N and the receiver window size is always 1.

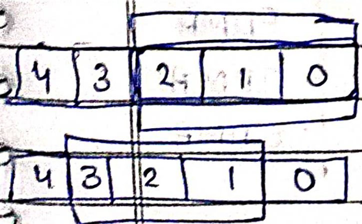


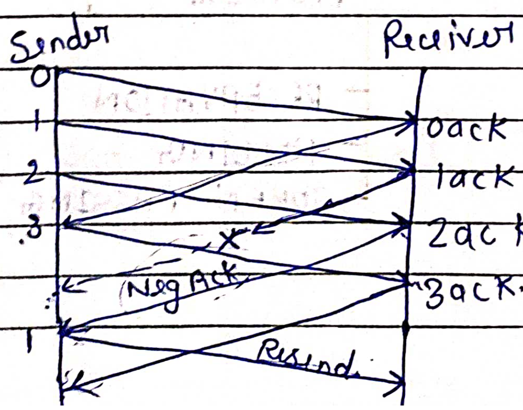
window size = 3



→ Now, Sender have to sent 1, 2, 3 again to Receiver.

② SELECTIVE REPEAT ARQ [Automatic Repeat Request].
→ In this only the frame is sent again, which is lost.
→ size of sender window = size of Receiver window.
→ Size of the sliding window is always greater than 1.
→ when receiver receives corrupt frame. It sends a Neg ACK.





window size = 3

Channel Allocation

→ It is a process in which a single channel is divided and allotted to multiple users in order to carry user specific tasks.

polling → A central controller interrogates each host and allocates channel capacity to those who need it

Multiple Access Protocols:

MACs are a set of protocols operating in the Media Access Control sublayer of Data Link Layer in OSI model.

- MULTIPLE ACCESS PROTOCOLS
  - RANDOM ACCESS PROTOCOL
    - ALOHA
    - CSMA
    - CSMA /CD
    - CSMA /CA
  - CONTROLLED ACCESS PROTOCOL
    - RESERVATION
    - POLLING
    - TOKEN PASSING
  - CHANNELIZATION PROTOCOL
    - FDMA
    - TDMA
    - CDMA

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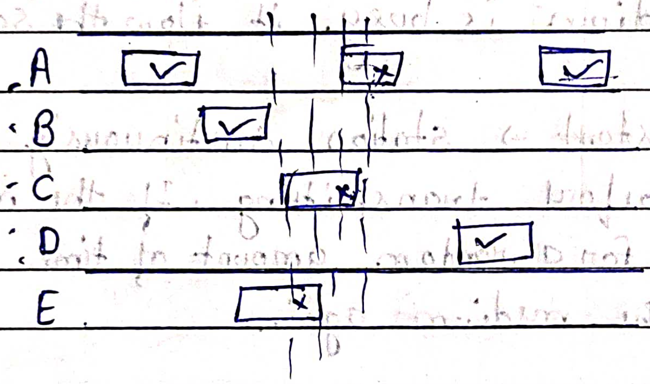
1. Random Access Protocols → Assign Uniform priority to all connected nodes.

→ ALOHA
- Pure ALOHA
- Slotted ALOHA

1. PURE ALOHA ⇒ Devices transmit data whenever they have it, without checking if the channel is busy. Collisions are detected through ack. messages or by the sender if no ack. is received after a certain time.

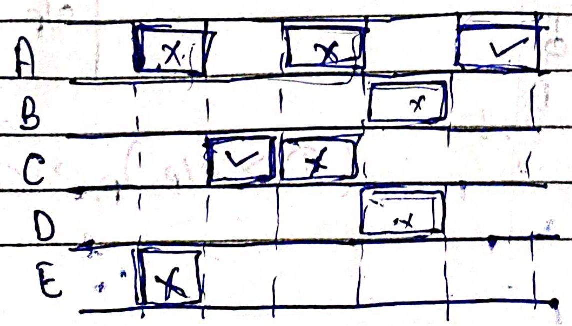
→ The total vulnerable time of pure ALOHA is $2 * T_{fr}$

→ effective maximum channel utilization is 18.4%



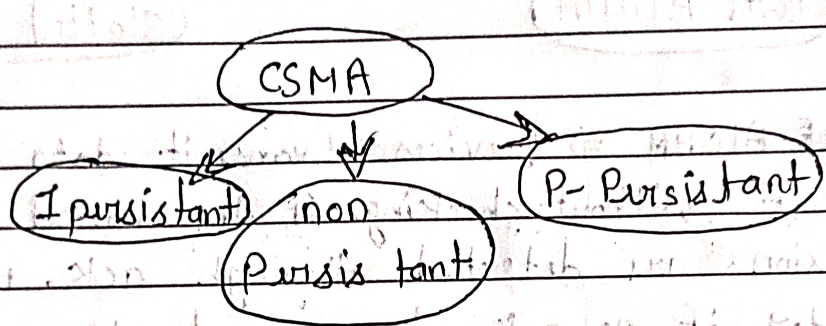
2. Slotted ALOHA ⇒ This variant divides time into discrete slots, and devices are only allowed to transmits at the biggining of each slot. reduces the probability of collisions compared to pure ALOHA. However, collisions can still occur.

→ vulnerable time period is T_{fr} \$ effective max. utilizat. → 36.8%



→ CSMA (Carrier Sense Multiple Access).

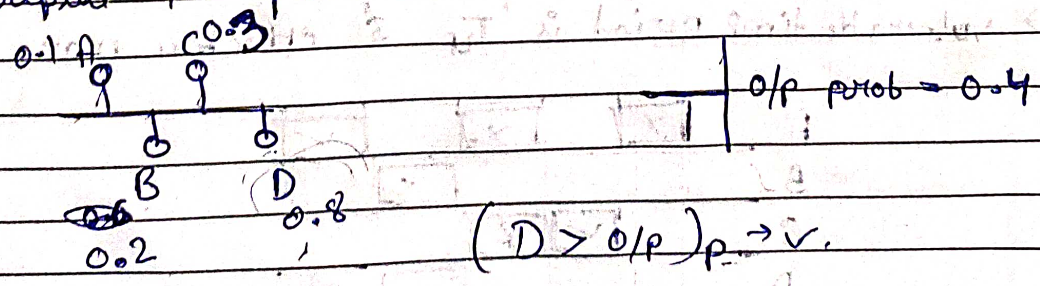
→ devices listen to the communication channel before transmitting. If the channel is Idle, the device can proceed with transmission. and if the channel is busy the device will wait.



1. I-persistant → Continuously senses the medium. If the medium is Idle, it immediately begins transmission if the medium is busy, it flow the same process.

2. Non-persistant → station continuously senses the medium before transmitting. If the medium is busy it waits for a random amount of time and then checks the medium again

3. p- persistant → when a station wants to transmit data, it senses the medium. If the medium is Idle, It check if (device probability > output prob.) it transfer otherwise wait for a slot. and repeat the process.



(D > O/P) p → v.

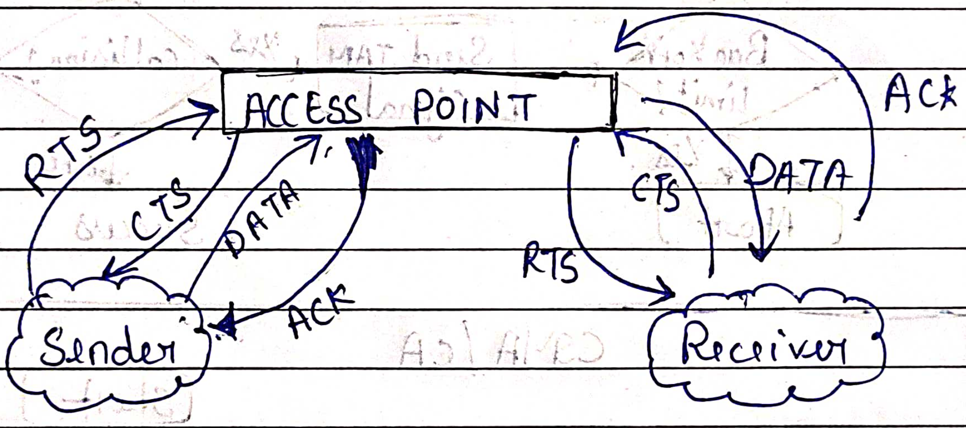
AKTU- 2021-22 + Flowchart.

→ CSMA/CD (Carrier Sense Multiple Access with Collision Detection).

* Commonly used in Ethernet networks, not only listens to the channel before transmitting but also detects collision while transmitting. If a collision is detected, the node stop transmission and send JAM signal to all other nodes and wait's for a random backoff time.

→ CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance)

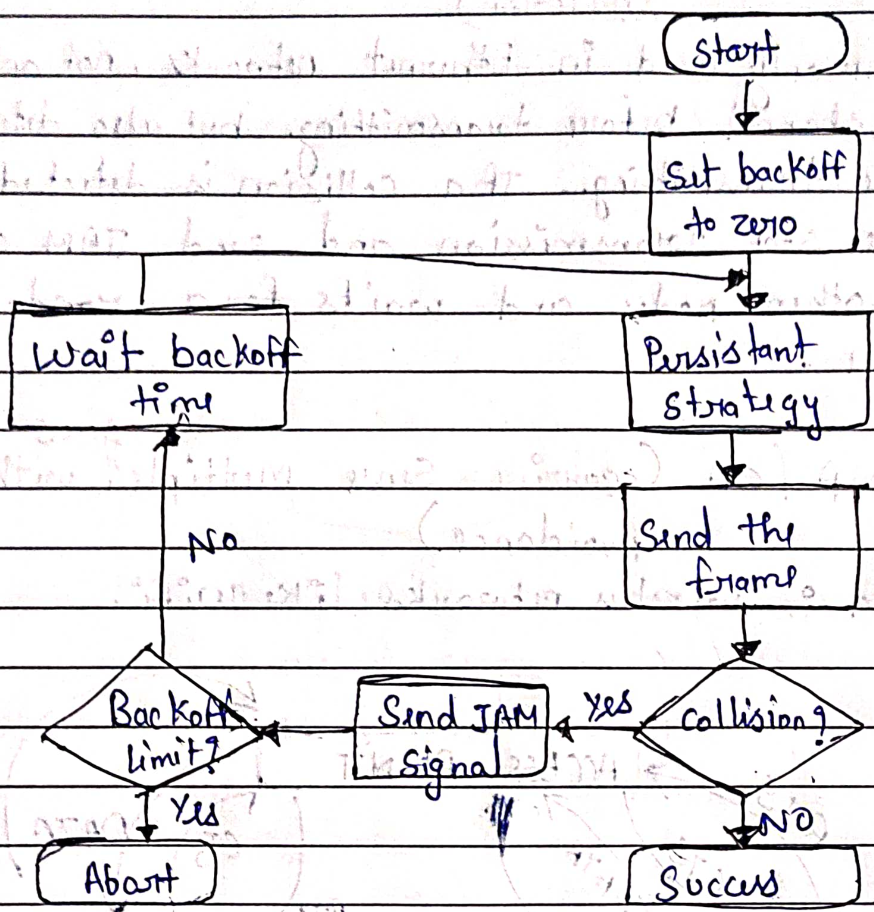
* used in wireless networks like wifi.



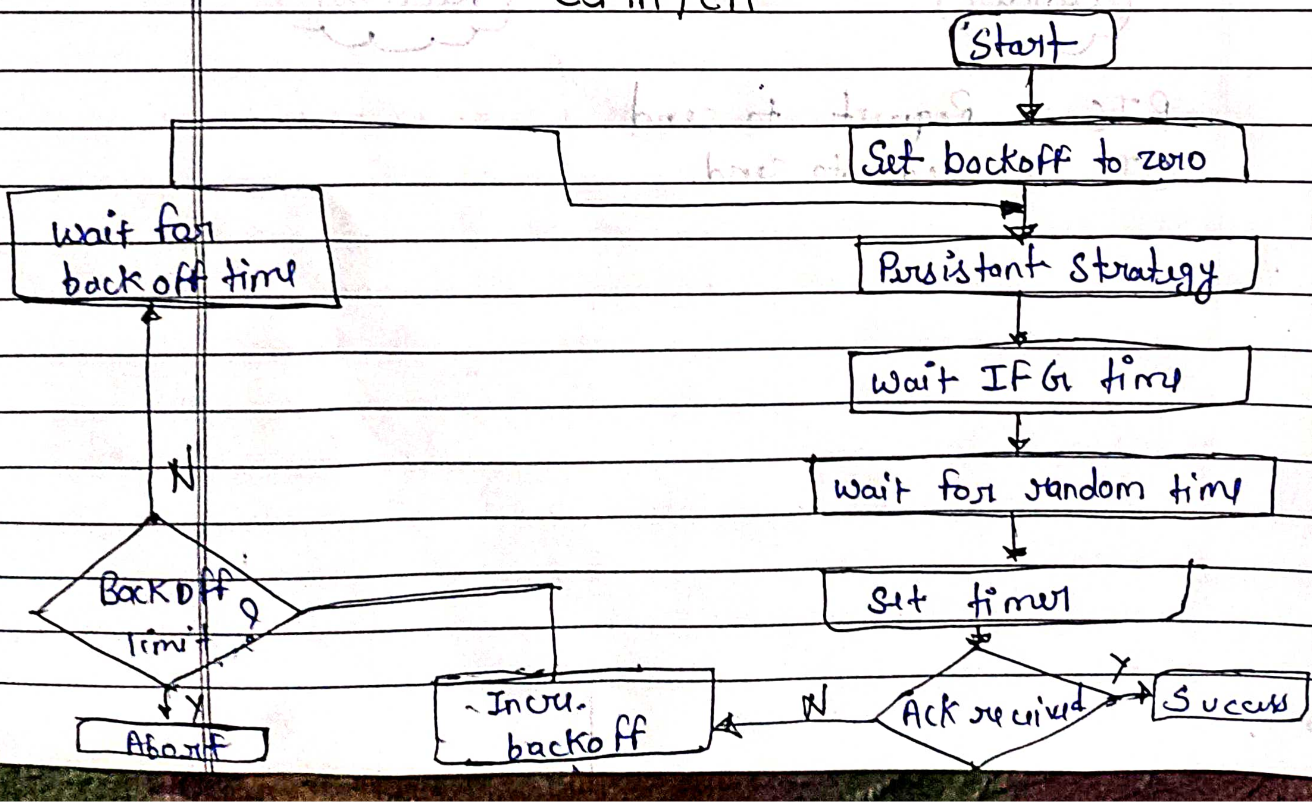
RTS → Request to send
CTS → clear to send.

AKTU - 2022-23 (10 marks)

CSMA / CD



CSMA / CA



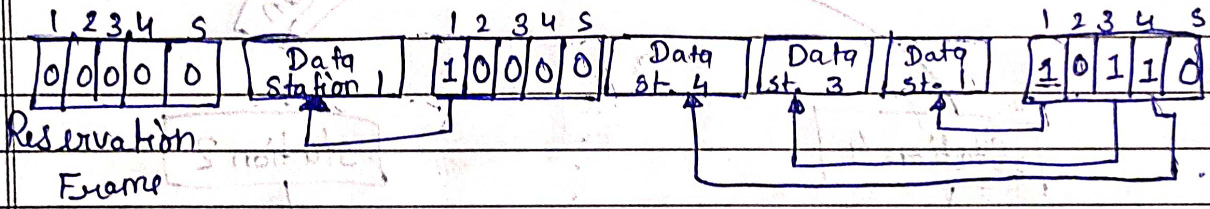
2. Controlled Access Protocol

→ It allows only one node to send at a time, to avoid collision of messages on shared medium.

A. Reservation

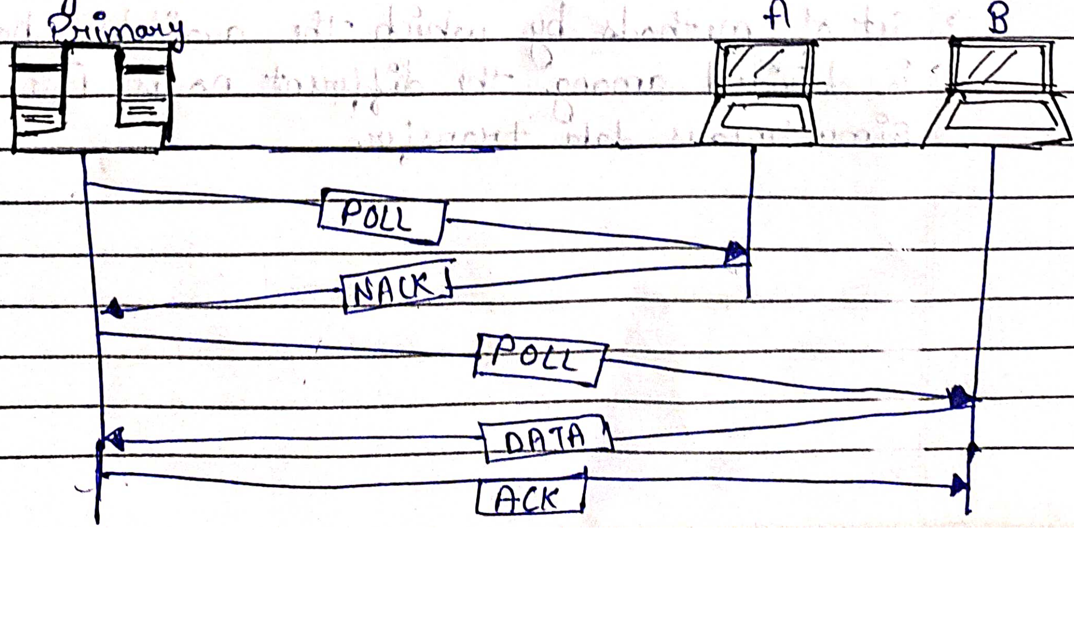
→ A station needs to make a reservation before sending the data

→ whenever a station needs to sends the data frame, then the station makes a reservation in its own minislot.



B. Polling

→ In this, one acts as a controller and the others are secondary stations. All data exchanges must be made through the controller.



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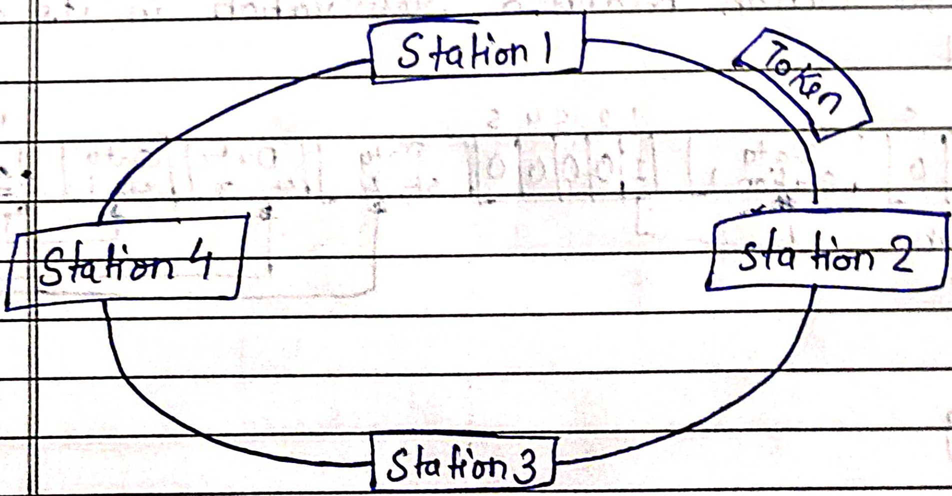
C. Token Passing

→ the stations are connected logically to each other in form of ring and access to stations is governed by tokens. (short message)

→ drawbacks are duplication of token or token is lost or insertion of new station, removal of a station.



3. Channelization Protocol

→ Set of methods by which the available bandwidth is divided among the different nodes for simultaneous data transfer.

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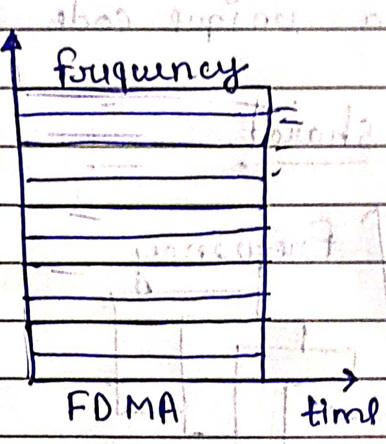
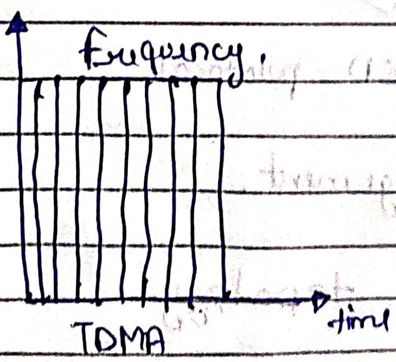
A FDMA (Frequency Division Multiple Access)

→ In this bandwidth is divided into various frequency bands. Each station is allocated with band to send data and that band is reserved for particular station for all the time, which is as follows:



B. Time Division Multiple Access (TDMA)

→ TDMA is the channelization protocol in which bandwidth of channel is divided into various stations on the time basis. There is a time slot given to each station, that station can transmit data during that time slot only which is as follows:



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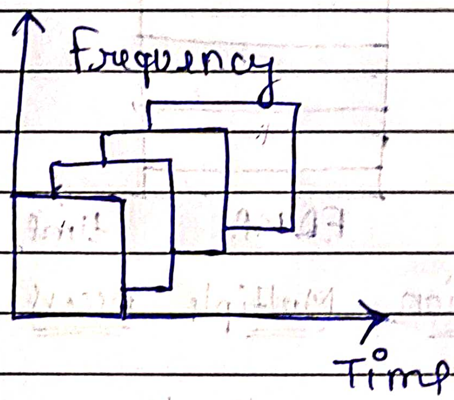
3. Code Division Multiple Access (CDMA):

→ all the stations can transmit data simultaneously. It allows each station to transmit data over the entire frequency all the time. & they are separated by unique code sequence. Each user is assigned with a unique code sequence.

Data + Code → shared.



LAN Standards

* 802.3 frame format.

→ used by LAN
→ use CSMA/CD protocol.

→ No. acknowledgement.

→ Bus and star topology.

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7 byte	1 byte	6 byte	6 byte	2 byte	46 to 1500 byte	4 byte
Preamble	Start Frame Delimiter	Destination Address	Source Address	Length	Data	Frame check Sequence

1. Preamble → 56 bit pattern of 1s or 0s used for Synchronization and timing recovering by the receiving device.

2. SFD → indicating the Start of the frame.

3. D.A → indicating the MAC Address of the receiver device.

4. S.A → indicating the MAC Address of the Sender device.

5. Length → indicating the type of protocol (length of data) (e.g IPv4, ARP

6. Data → Data.

7. FCS → for error detection.

→ Data Link layer Max Data length → 1518 byte. → For 2 marks AKTU

2. 802.5 Format

→ Use for Ring Topology → LAN

→ Access Control Method for token passing.

→ Piggy backing (Data + ACK.)

→ Use Differential Manchester encoding.

[802.5] frame format.

Fiber Distributed Data Interface (FDDI) : frame format.

Start Delimiter	Access Control	Frame Control	Dest Add.	Src Add.	Data	FCS	End Deli.	Frame Status
1 byte	1	1	6	6	>=0 max 4500 byte	4	1	1

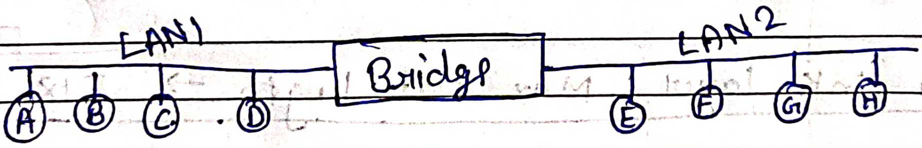
Start Deli.	Access Control	End Deli.
1	1	1

← token format

→ Switching in unit-I

→ **Bridging Concept**

Bridge is used to connect two different LAN's



Bridge works at 'physical layer' as well as at "DLL"

Mapping table for bridge.

$$\begin{array}{l|cccccccc} \text{MAC} & A & B & C & D & E & F & G & H \\ & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ \text{PORT} & \multicolumn{4}{c}{\underbrace{\qquad\qquad\qquad}_{P1}} & \multicolumn{4}{c}{\underbrace{\qquad\qquad\qquad}_{P2}} \end{array}$$

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① Static Bridge : Do ~~mapping~~ Manually Mapping.

② Dynamic / learning / Transparent Bridge :

They will automate learning the entries.

Capabilities of a Bridge :

① Filtering : (S.MAC & D.MAC are on same LAN)

② Forwarding : (S.MAC & D.MAC are on diff. LAN)

③ Flooding : (if any new station will be added)

④ Store & forward : (No collision will occur)

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Spanning Tree Algorithm for Bridging

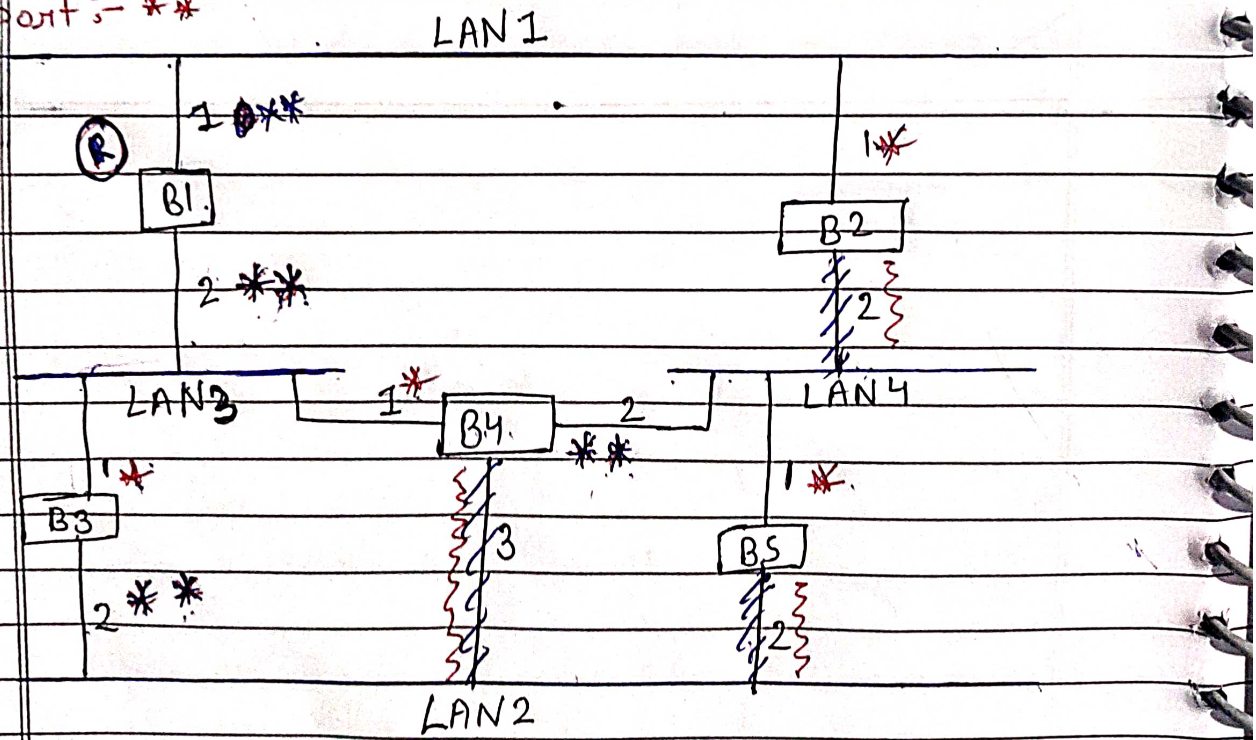
1. Every Bridge is having a built in ID. The one with smallest ID is taken as root bridge.

2. Mark one port of each bridge which is closest to the root bridge as a root port.

3. ~~LAN~~ Every LAN choses a bridge closest to it as a designated bridge for that LAN & make that correspondant port as a designated port.

4. Mark the root port and designated port as forwarding port & block the remaining ~~#~~ port.

(close)
Root Port :- *
Designated port :- **



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