Unit - 2

Data Link Layer

Framing: In data link layer framing separate message from another message the source to destination. By adding header & trailer framing distinguish the starting of the frame & ending of frame. It is of two type

(i) Fixed size framing
(ii) Variable size framing.

Fixed size framing: In this size of the frame are fixed for fixed size frame there is no problems

Variable size framing: In this we have to declare the beginning & ending of frame In VSF the flag is used to define the boundary of the frame. VSF is categories into 2 type

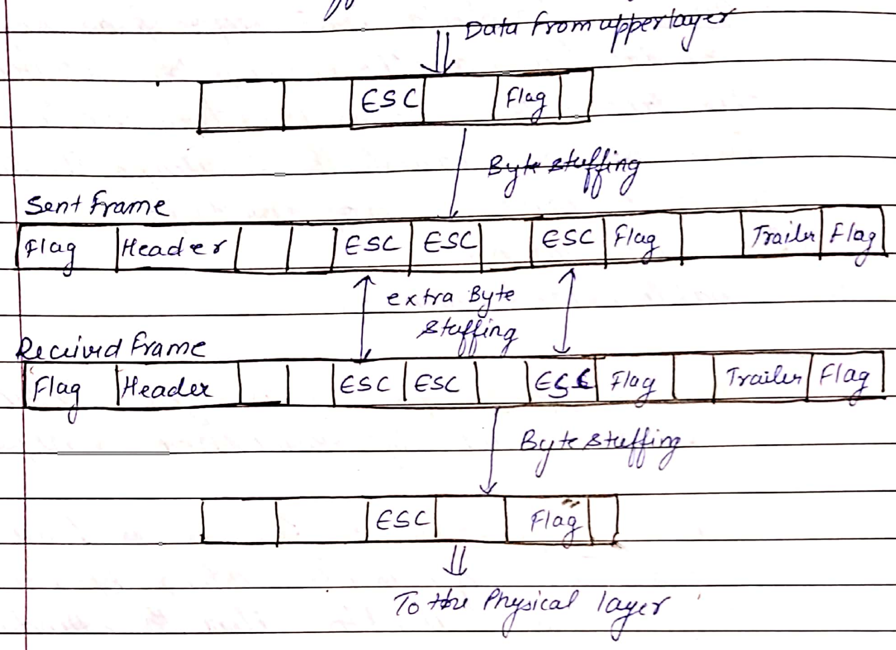
(a) Byte oriented or character oriented
(b) Bit Oriented

Byte Oriented Protocol

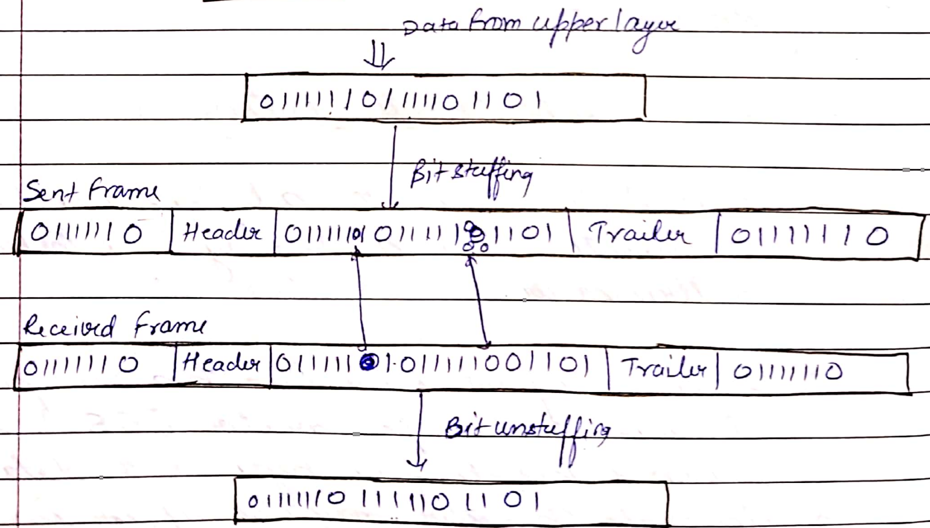
→ Uses Byte stuffing to made the frame 1 byte or character is chosen as flag for the boundary determination

→ If flag is the part of the Data then one special character as escape character [ESC] is stumb before the flag byte in the data
→ The Escape character may also appear in the Data source again stuff one Escape character before the ESC byte.

→ At the receiver end byte unstuffing will be done to unstuff the extra byte.



Bit Oriented Protocol:



It used 01111110 as flag if this 8 bit pattern for flag is also the part of the data then we will add one extra bit 0 whenever 5 consecutive 1s followed by a 0 this is called bit stuffing. At the receiver end bit unstuffing is done in the same manner i.e extra 0s will be removed

Error Control

Error : When a data changes from 0 to 1 or 1 to 0 than it is called error there are two types of error.

(i) Single bit error (ii) Burst error

Single bit error : If only one bit changes during the transmission i.e 0 to 1 or 1 to 0 is called single bit error.

Sent - $\boxed{10101110}$

Received - $\boxed{10001110}$

Burst error : In this more than one bit can be change during the transmission

Sent $\boxed{10101110010110001}$

Received. $\boxed{10001010110010001}$

Burst length

(no. of bit b/w the left most corrupted bit & rightmost corrupted bit)

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Error Control: It is of two type error ~~correct~~ detection & error correction.

→ Error correction is more difficult than error detection.

→ Error detection only involves the detection of error i.e to find the answer of the question is there any error in the data, which could be simply "yes" or "no".

→ Error Correction involves error detection as well as position of bits which are change due to error. And after that correct that errors.

Redudancy: They are the extra bits to check the error it is not the part of data to detect or correct errors we need to send some extra bits which is called redundancy.

Hamming Distance: It is distance b/w same length of code word is no. of change b/w corresponding bit of both codewords. It is denoted as d(x,y) to find hamming distance Performer XOR operation bit by bit & calculate no. of 1s of resultant bits minimum hamming distance it is denoted by dmin: Minimum hamming distance is smallest hamming distance b/w all possible pairs in the set of codewords.

Dataword	Codeword
00	000
01	011
10	~~0~~01
11	110

d(000, 011) = 2
d(000, 101) = 2
d(000, 110) = 2
d(011, 101) = 2
d(101, 110) = 2
d(011, 110) = 2

$d_{min} = 2$

	Codeword
00	00000
01	010~~0~~1
10	10101
11	11110

d(00000, 01011) = 3
d(00000, 10101) = 3
d(00000, 11110) = 4
d(01011, 10101) = 4
d(01011, 11110) = 3
d(10101, 11110) = 3

$d_{min} = 3$

Role of dmin :

(i) detect upto 's' error — $d_{min} \geq s+1$

(ii) Correct upto 't' error — $d_{min} \geq 2t+1$

(iii) Detect upto 's' error & correct upto 't' errors — $d_{min} \geq s+t+1$

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Coding: Redundancy is achieved by various coding techniques

n = data bit
r = redundancy bit
c = codeword bits

total dataward = 2^n $\qquad c = n + r$
total codeward = 2^c or 2^{n+r}

2^n codwards out of 2^c are valid
& $2^c - 2^n$ codwards will be invalid.

NOTE: an error detecting code can detect only the type of error for which it is designed other types of error may remain undetected

Error detection

(i) Parity checking (ii) Checksum (iii) CRC (Cyclic Redundancy check)

Parity checking: In Parity checking 1 extra bit is added in MSB

MSB LSB

0	1	0	1	1	0	1	0

The receiver detects the presence of error if the no. of errors is odd the no. of even errors remain undetected.

Write ASCII code for the word HOLE using. assume even parity.

H	72	0	1	0	0	1	0	0	0
O	79	1	1	0	0	1	1	1	1
L	76	1	1	0	0	1	1	0	0
E	69	1	1	0	0	0	1	0	1

2D Parity Checking: when a large no. of binary words are being transmitted in succession, the resulting collection of bit is considered as block of data with rows and column.

The Parity Bits are Produced for each row & column. So 2 set of parity bits are generated and known as LRC (longitudinal redundancy check) VRC (Vertical redundancy check)

COMPUTER

	67	79	77	80	85	84	69	82	
	C	O	M	P	U	T	E	R	LRC bit
	1	1	1	1	1	1	1	1	0
	0	0	0	0	0	0	0	0	0
	0	0	0	1	1	1	0	1	0
	0	1	1	0	0	0	0	0	0
	0	1	1	0	1	1	1	0	1
	1	1	0	0	0	0	0	1	1
	1	1	1	0	1	0	1	0	1
VRC→	1	1	0	0	0	1	1	1	1

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Checksum : As each word is transmitted it is added to the previously send words & sum is written at the transmitter & the final carry is ignored.

Each successive word is added in this manner to the previous sum at end of transmission the sum is called checksum upto that time

The checksum byte is regenerated at the receiver seperately by adding the received bytes. The regenerated checksum byte is than compare with the transmitted one if both are identical then there is no error otherwise there is error. Sometimes 2's complement of checksum is transmitted

Q Find Checksum of following
~~10110001101010110011~~
10110001 10101011 00110101 10100001

```
  10110001        01011100        10010001
+ 10101011      + 00110101      + 10100001
(1) 01011100     10010001      (1) 00110010
```

Checksum : 00110010

```
   10110001
   10101011
   00110101
   10100001
Ignore (10) 00110010
```

(Transmitter site)
CRC generation   Max common divisor   CRC ~~Rec~~ Checking (Receiver site)

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CRC (Cyclic Redundancy Check)

Polynomial

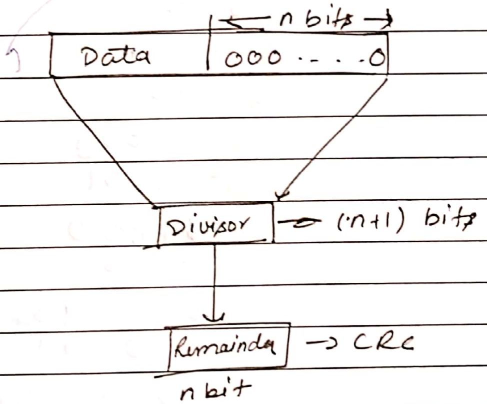
$$x^3 + 1 = x^3 + x^2 + x + 1$$

1   0   0   1

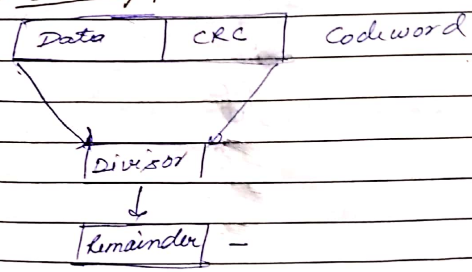
$$x^6 + x^2 + 1 = x^6 + x^5 + x^4 + x^3 + x^2 + x^1 + 1$$

1   0   0   0   1   0   1

CRC Generation



CRC-Checking:



If Remainder = 0 then there is no error.

Q- A fram is 110010101 and generator is $x^4 + x^2 + 1$ what would be the transmitted

10101000

$x^8 + x^7 \quad x^4 + x^2 + 1$

```
             11110111
10101 ) 1100101010000
        ⊕10101
         011000
        ⊕10101
          011011
         ⊕10101
           011100
          ⊕10101
            010011
           ⊕10101
             0011000
            ⊕00000
              011000
             ⊕10101
               011010
              ⊕10101
                011110
               ⊕10101
                 01011
```

Data	CRC
110010101	1011

CRC check

```
          11110111
10101 ) 110010101011011
        10101
        11000
        10101
        011011
         10101
         011100
          10101
          010011
           10101
           0011010
             10101
             011111
              10101
              010101
               10101
               00000
```

$\boxed{00000}$

<u>Error Correction</u>: It is of two types

(i) Forward Error correction
(ii) Automatic Repeat Request / Retransmission

FORWARD <u>ERROR</u> <u>CORRECTION</u>

<u>Hamming Code</u>: It is a linear block code the family of (n, k) hamming code for $m \geq 3$ is defined by the following equations.

(i) Parity bit $m = n - k$
(ii) Minimum Parity by $- n(m-k)$

(ii) $d_{min} \geq 3$

(iii) block length (hamming code length) $n = 2^m - 1$

(iv) ~~Hamming code~~ No. of msg bit $K = 2^m - 1 - m$

Hamming code structure: The seven bit hamming code is used randomly the Parity bit are inserted in b/w data bit.
Parity bit are insert at 2^n position where $n = 0, 1, 2, 3$

D_7	D_6	D_5	P_4	D_3	P_2	P_1

P_1 = 1st parity - 2^0 - 1st Position
P_2 = 2nd Parity - 2^1 - 2nd Position
P_4 = 3rd Parity - 2^2 - 4th Position
P_8 = 4th Parity - 2^3 - 8th Position

Deciding Parity bit

P_1 - Examine 1, 3, 5, 7, 9, 11 - - - position
P_2 - Examine 2, 3, 6, 7, 10, 11, 14, 15 - - position
P_4 - Examine 4, 5, 6, 7, 12, 13, 14, 15 - - - Position
P_8 - Examine 8, 9, 10, 11, 12, 13, 14, 15 - - - - Position

1011

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Construct the even parity 7 bit hamming code for 1011

D7	D6	D5	P4	D3	P2	P1
1	0	1	0	1	0	1

Deciding P_1 parity bit

$P_1 \to 1, 3, 5, 7$
$P_1, P_3\ D_5\ D_7$
since even parity P_1 1 1 1
so $P_1 \to 1$

Deciding P_2 Parity bit

$P_2 \to 2, 3, 6, 7$
$P_2\ D_3\ D_6\ D_7$
P_2 1 0 1
$P_2 \to 0$

Deciding P_4 Parity

$P_4 \to 4, 5, 6, 7$
$P_4\ D_5\ D_6\ D_7$
P_4 1 0 1
$P_4 \to 0$

Correction using Hamming Code

If the seven bit Hamming codeword received by a receiver is 1011011 State whether this codeword is correct or not if wrong locate the bit in the error and correct it

1	0	1	1	0	1	1

Checking P_1 Parity Bit
1, 3, 5, 7
P_1, P_3, D_5, D_7
1 0 1 1
since

Checking P_2 parity bit
2, 3, 6, 7
P_2, P_3, D_6, D_7
1 0 0 1

Checking P_4 Parity Bit
4, 5, 6, 7
D_4, D_5, D_6, D_7
→ 1 ~~1~~ 0 1

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Since Parity is not even $P_1 = 1$	Since Parity is even $P_2 = 0$	Since Parity is odd $P_4 = 1$

error word $\boxed{P_4 \mid P_2 \mid P_1}$

$\boxed{1 \mid 0 \mid 1} = (5)_{10}$

since this code contain error in 5 position from right now the correct code is

$\boxed{1 \mid 0 \mid 0 \mid 1 \mid 1 \mid 0 \mid 1 \mid 1}$

Q- A bit stream 10011101 is transmitted using the standard CRC method the generator pollynom is $x^3 + 1$ show that the actual bit string transmitted.

$x^3 + 1$ 1001

10001100

1001) 10011101000
1001
00001101
1001
01000
1001
000100

10001100 · 1000

10101100100

1011
1001) 100111101100
1001
001011
1001
001001
1001
100

10111011
1001) 10101100100
1001
001111
1001
01100
1001
01010
1001
001110
1001
01110
1001

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Q. A 7 bit hamming code is received as 1110101 what will be the correct code.

D_7	D_6	D_5	P_4	D_3	P_2	P_1
1	1	1	0	1	0	1

Checking P_1 Parity bit	Checking P_2 Parity bit	Parity P_4 Bit
1, 3, 5, 7	2, 3, 6, 7	4, 5, 6, 7
P_1 D_3 D_5 D_7	P_2 D_3 D_6 D_7	P_4 D_5 D_6 D_7
1 1 1 1	0 1 1 1	0 1 1 1
$P_1 = 0$	$P_2 = 1$	$P_4 = 1$

P_4	P_2	P_1
1	1	0

$= (6)_{10}$

So this code contain error at 6 position from right now correct code is

1	0	1	0	1	0	1

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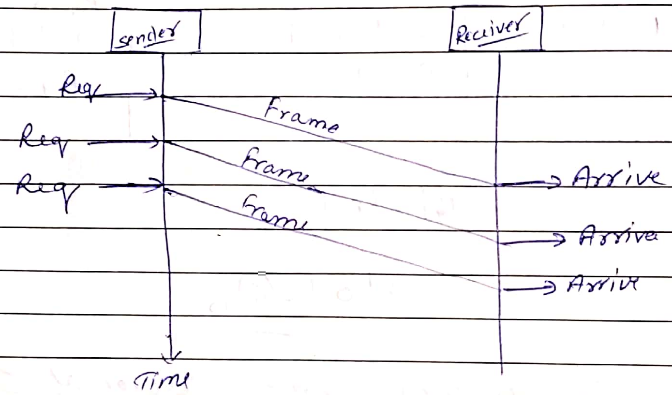
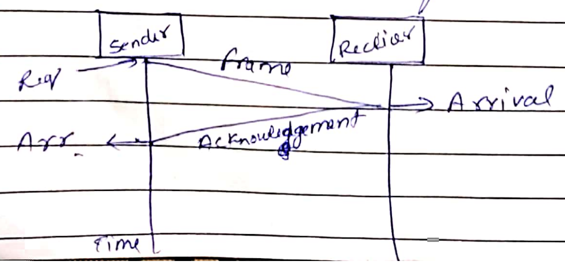
Noiseless Channel (No error control)

Simplest Protocol: In this protocol processing time is zero it dosnot use flow control. When receiver receives the data it immidiately passes the data to upper layer



Stop & Wait Protocol: In this flow control is introduced after sending a frame the sender stops and waits until the acknowledgment of previously sent frame is received. The waiting time = 2Tp (Propagation Time = Tp)

Acknowligment: It is ~~also~~ automatically trigger by receiver whenever a valid frame is received.



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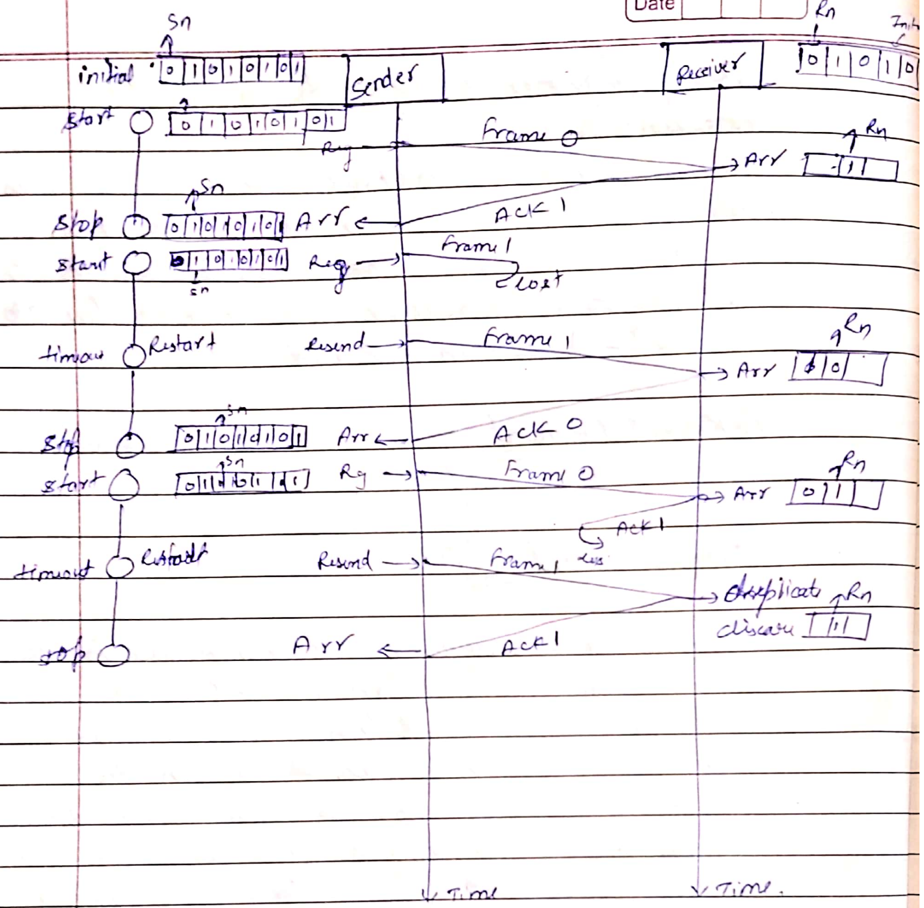
Noisy channel: (Error + flow control):

Sequence No.:
To distinguish b/w frames Protocol nos. the frames which is the sequence no. of frames.
if m bit sequence no. is used to no. the frames then sequence no. ranges b/w ~~0 to~~ 0 to $(2^m - 1)$ & then repeated.

Acknowledgement No.: It always announce next frame expected.

Stop & Wait (ARQ):

(i) In this the sequence no. of frames are based on Module 2 arithmetic i.e (0, 1)
(ii) In this the acknowledgement no. is always announces in modulo 2 arithmetic i.e (0, 1)
(iii) The timer is said to 2Tp. When timer expires it is called timeout. After time out the time will restart & resending of frames will be done.
(iv) Error correction in this is done by keeping a copy ~~same~~ send frame & retransmitting of frame when timer expires
(v) Sender has a control variable Sn which holds the sequence no. of the next frame to be send. The receiver has control variable Rn which holds the sequence no. of next frame expected.
(vi) It is also called single bit ~~stop~~ sliding window



Sliding window Protocol

Go Back - NARQ

Sender sliding window. It is an abstract concept of defining an imaginary window of size $(2^m - 1)$ with three Control variable Sf, Sn & Ssize

The sender window can slide 1 or more slot at a time when a valid acknowledgement is received by the sender or arrived at the sender.

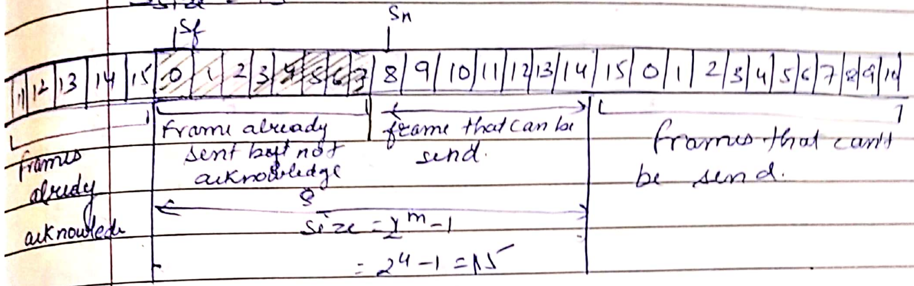
$m = 4$

0 to 15

$S_{size} = 15$

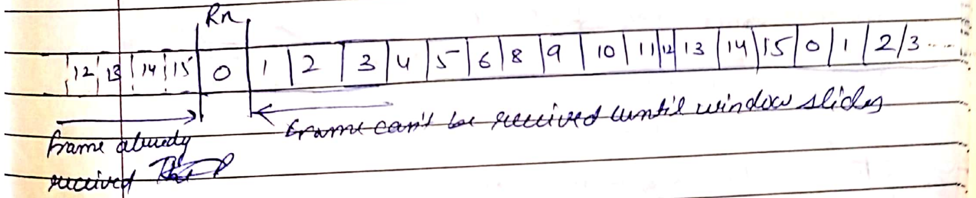
S_f - first outstanding frame

S_n - next frame to be send



Receiver sliding window

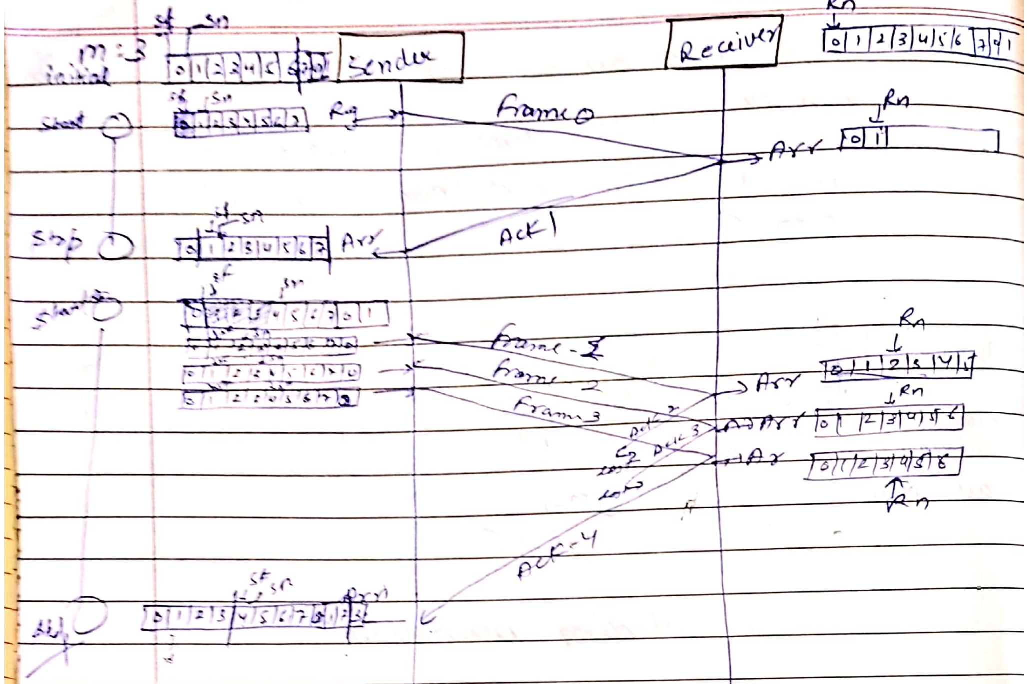
It is an abstract concept of defining an imaginary window of size 1 with a single variable R_n.



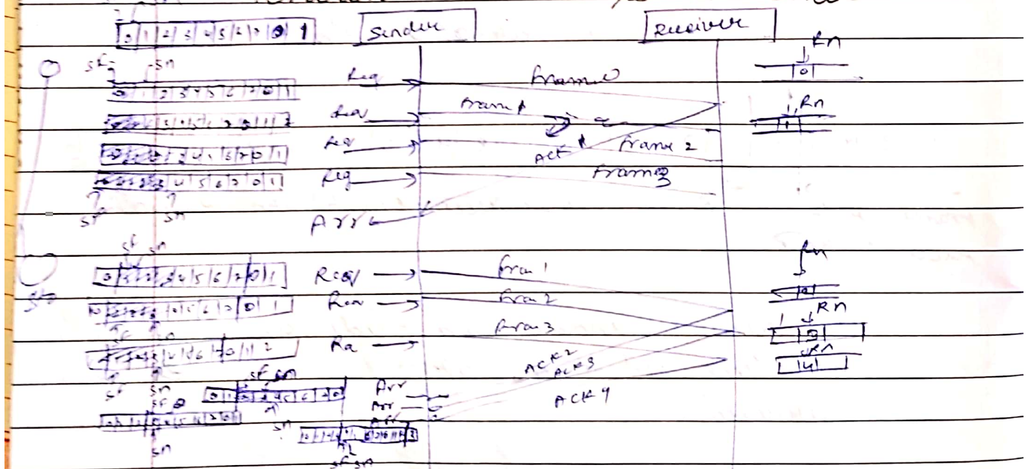
The receiver window can slide only 1 slot at a time. when a correct frame has arrived

Timer: In this protocol we used only one time & assumes that the timer for first outstanding frame always expires first

Backward channel is unreliable

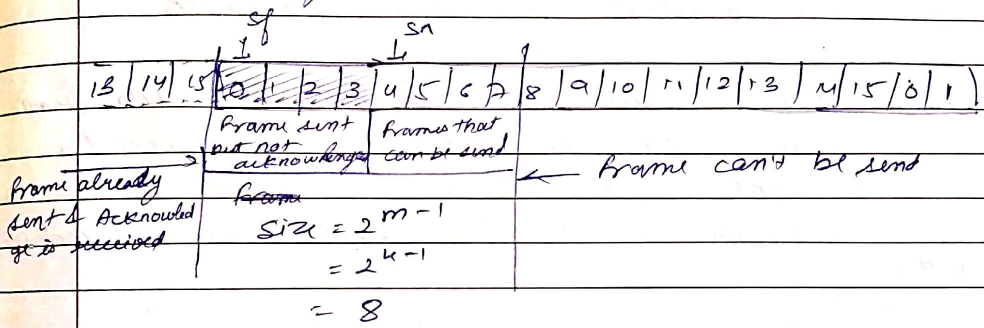


Forward Channel is unreliable.



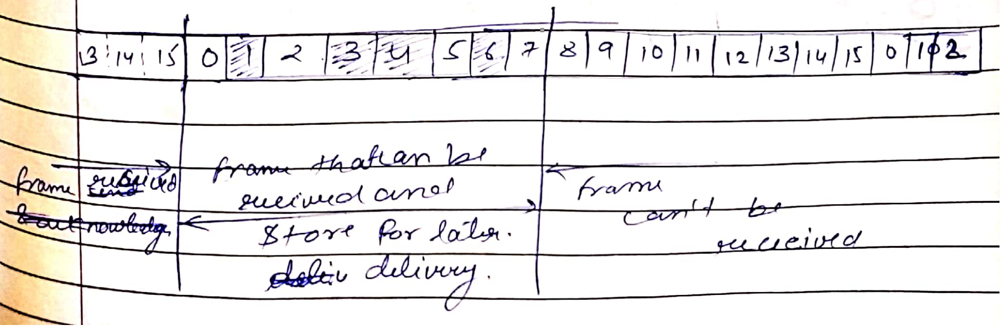
3. Selective Repeat ARQ

Sender window: The sender sliding window is an abstract concept of defining an imaginary window of size ~~$(2^m - 1)$~~ $\left(\frac{2^m}{2}\right)$ or (2^{m-1}) with three control variable S_f, S_n & Ssize



Receiver sliding window

In this ARQ the receive sliding window is equal to the size of sender sliding window i.e 2^{m-1} out of order frame at the receiver site are stored for later delivery it used two control variable r_n & rsize

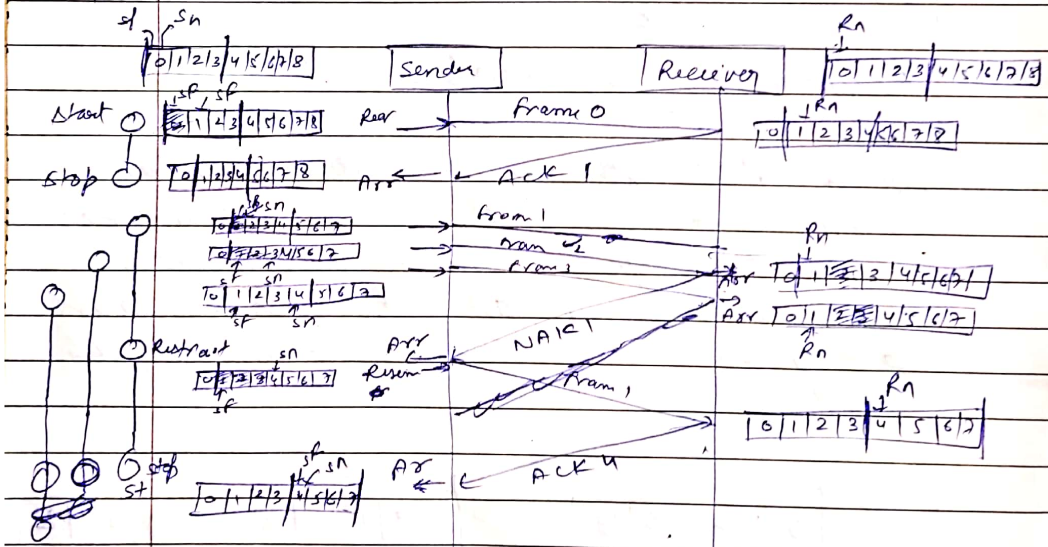


The receiver window can slide one or more than one slot at a time.

Negative Acknowledgement (NAK): Selective repeat ARQ uses the concept of NAK. NAK is the sequence no. of frame which is lost during the transmission & reported by the receiver.

In selective repeat ARQ each frame send or ~~received~~ resend needs a timer which means that the timer needs to ~~be~~ numbered.

m = ~~4~~ 3



Throughput Efficiency (η)

$$\eta = \frac{T_{fr}}{T_{fr} + 2T_p}$$

T_{fr} = Frame transformation time
T_p = propagation time
W = window size

$$\eta = \frac{1}{1 + 2T_p/T_{fr}} = \frac{1}{1+2A} \quad \text{where } A = \frac{T_p}{T_{fr}}$$

$$\eta = \frac{W}{1+2A}$$

Q. A channel has a bit rate of 4Kbps & propagation delay of 20 milisec. for what range of frame size does stop & wait ARQ gives an efficiency of 50%.

Sol $T_p = 2\times10^{-2}$ sec $\quad B = 4$ Kbps $= 4\times10^3$ bps
$\eta = 50\%$

$$\eta = \frac{T_{fr}}{T_{fr} + 2T_p}$$

$$0.5\,T_{fr} + 1T_p = T_{fr}$$

$$0.5\,T_{fr} = 1T_p$$

$$T_{fr} = \frac{2\times10^{-2}}{0.5}$$

$$= 0.4\times10^{-1}$$

$$= 0.04 \text{ sec}$$

$$T_f = \frac{L}{B} \quad = 0.04\times4\times10^3$$

$$= 160 \text{ bits}$$

Frames of 1500 bit are send over a 1 Mbps channel using geostationary satellite acknowledgements are always piggy backed on to data frames 3 bit sequence nos. are used what is the maximum channel utilization for go back N Protocol.

Size(L) = 1500 bit

B = 1 Mbps 1×10^6 bps

m = 3 bit $T_p = 270$ msec

$T_f = \frac{1500}{10^6}$

15×10^{-4}

1.5 msec

for Go back N window size $w = 2^m - 1$

$= 2^3 - 1 = 7$

$$\eta = \frac{w\,T_{fr}}{T_{fr} + 2T_p} = \frac{7 \times 1.5}{1.5 + 540}$$

$$= \frac{10.5}{541.5}$$

0.019339 = 1.939%

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Q. Consider an error free 64 Kbps satellite channel used to send 512 byte ~~word~~ dataframes in one direction with very short acknowledgement coming back the other way. What is max. throughput for window size 7 & 127

$T_p = 270$ msec
$B = 64 \times 10^3$ bps
$L = 512 \times 8 = 4096$ bit

$T_{tr} = 64 \times 10^{-3}$ sec

$A = \frac{T_p}{T_{tr}}$

4.21×10^{3} $\quad 4.21875$

(i) For $w = 7$

$\frac{7}{1+4.21} = \frac{7}{1+8.4375} = 0.7417$

(ii) For $w = 127$

$= \frac{127}{9.47} = 13.4569$

1345.69%

Q A stop & wait protocol uses a 100 Kbps satellite link which employs a round trip propagation delay of 250 msec. Find out the % of time the sender is blocked to wait for a acknowledgement in the frame size 1000 bits

$B = \cancel{100 \times 10^3}$ 10^5 bps $L = 1000$ bits

$T_p = 250 \times 10^{-3}$ sec

$T_f = \cancel{10^2}$ $\cancel{10}$ 10×10^{-3}

waiting time of sender $= 2T_p$ Total time $= T_{fr} + 2T_p$ so

% of time sender is blocked to wait for acknowledgement

$$= \frac{2T_p}{T_{fr} + 2T_p} = \frac{2 \times 250 \times 10^{-3}}{(10 + 2 \times 250)}$$

$= 98.039\%$

Multiple Access: When there is P2P channel or link then there is no problem but if the medium is shared among multiple user then data link layer is subdivided into two sub layers &

(i) LLC sub layer (logical link control) for data link control.

(ii) MAC (Media Access control) for multiple access resolution

So Data link layer is responsible for multiple access

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Datalink control (LLC)

Maduim access resolution (MAC)

Protocol

- Random Access Protocols
  - ALOHA
  - CSMA
  - CSMA/CD
  - CSMA/CA
- Controlled Access Protocols
  - RESERVATION
  - POLLING
  - TOKEN PASSING
- Channelisation
  - FDMA
  - TDMA
  - CDMA

Random Access (Contention Method)

Two feature gives this method its name

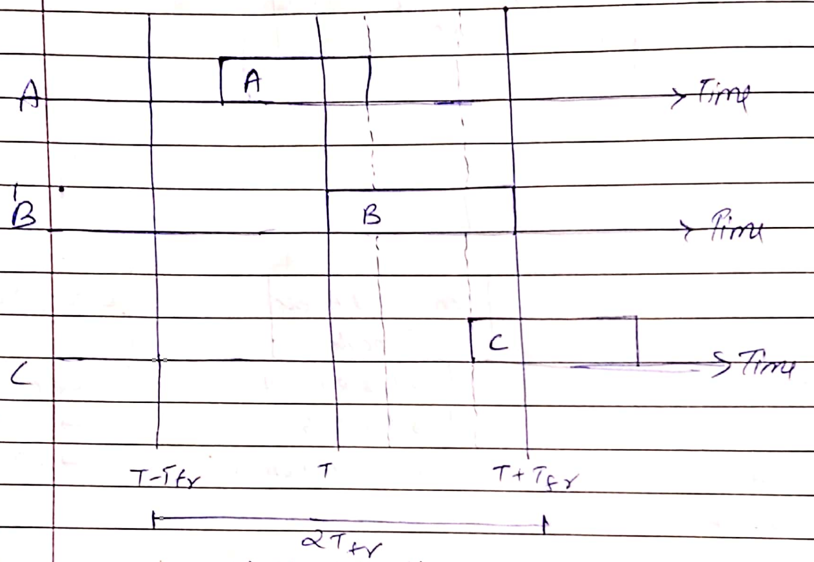
(a) There is no scheduled time for a station to transmit

(b) There is no master slave concept (no one is superior). Transmission random among the users that's why these methods are called radom access method

No rule specify which station should be next station compete to one another to access the medium that's why these methods are also called contention method

ALOHA : (Additive link online Hawaii Area)

Pure ALOHA :



Vulnerable time

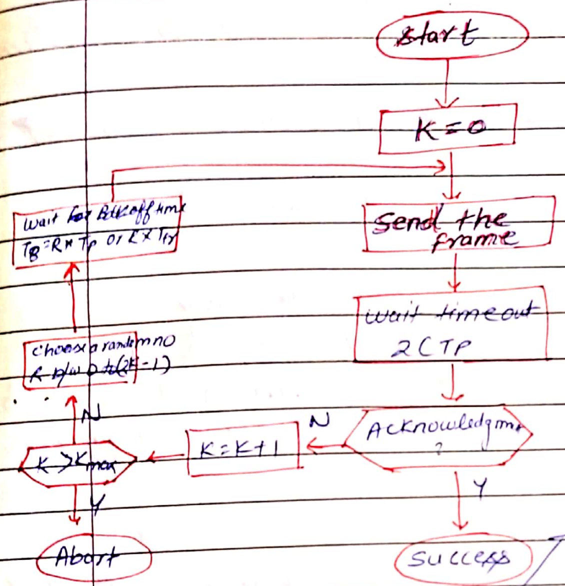
Collision in Pure ALOHA

In pure ALOHA station can send the data frame at any time according to figure A's ending will collide with B's beginning & C's Beginning will collide with B's ending thus all frame will be destroyed

Vulnerable time for pure ALOHA $= 2T_{fr}$

where T_{fr} is one frame transmission time

Procedure for ALOHA (Pure)



- Random access Protocol
- Acknowledgement is there
- LAN Based
- Only transmission time
  No propagation time
- Vulnerable time $= 2T_{fr}$
- Efficiency $= G \times e^{-2G}$
  G = no. of station who want to transmit the data at a particular time slot

Kmax is normally set to 15

Max Efficiency

$$\frac{dn}{dG} = -2G \cdot e^{-2G} + e^{-2G} = 0$$

$$= e^{-2G}(-2G+1)$$

$$-(2G+1) = 0 \quad G = 1/2 \quad e^{-2G} = 0$$

Back off Process

Choose Random No R. b/w 0 to $(2^K - 1)$

K = 1 0, 1

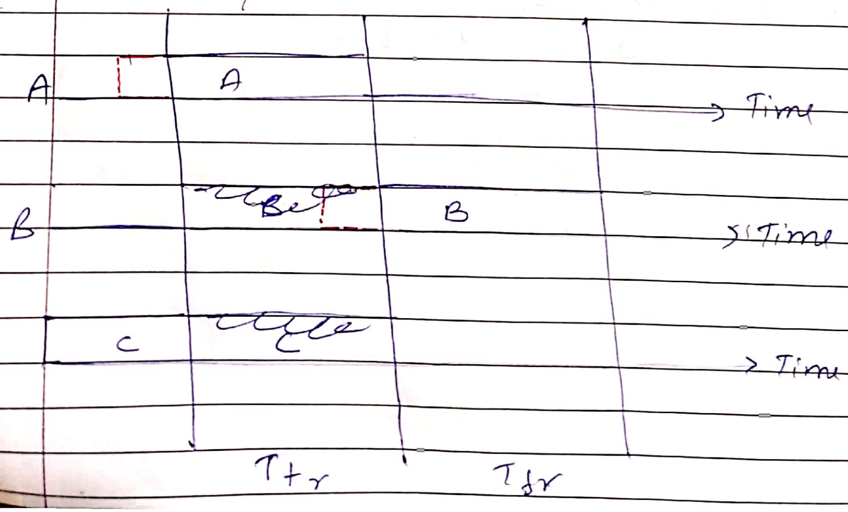
K = 2 0, 1, 2, 3

K = 3 0, 1, 2, 3, 4, 5, 6, 7

(Pure ALOHA)	(Slotted ALOHA)
* Any time transmission	* Any station can transmit ~~bet~~ beggining of slot
* Continuous time system	* Discrete time system.
* Vulnerable time is $2T_{fr}$	* Vulnerable time is T_{fr}
* $\eta = G \times e^{-2G}$	* $\eta = G \times e^{-G}$
* Max Efficiency = 18.4%. occurs at $G = 1/2$	* Max efficiency = 36.8%. occurs at $G = 1$
* It is simple in implementing	* It reduces no. of collisions to half & doubles the efficiency of pure aloha

Slotted ALOHA

In the any one can transmit the data from the starting of slots. In this the slots are divide of same ~~size~~ size assumed that T_{fr} is filled No transmission is possible in the middle of slot



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Vullnerable time is T_{fr}

Efficiency $= G \times e^{-G}$

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

$$= e^{-G}(-G+1) = 0$$

$$= -G+1 = 0$$

$$G = 1$$

max. efficiency $= 1 \times e^{-1}$

$= 1 \times 0.3678$

$= 36.78\%$

Q A group of N stations share 100Kb/s slotted ALOHA channel. Each station output a 500 bits frame on an average of 5000ms even if previous one has not been sent. What is value of N

Sol Throughput of each station = no. of bit sent per sec

$$= \frac{500}{5000 \times 10^{-3} s}$$

$$= 100 bps$$

Throughput of slotted aloha

$\eta \times$ Bandwidth

$0.368 \times 100 Kbps$

36.8 Kbps

Throughput of slotted aloha = Total no. of station * Throughput of each station

36.8 Kbps $= N \times 100$ bps

$$N = \frac{36.8 \times 10^3}{100} = 368$$

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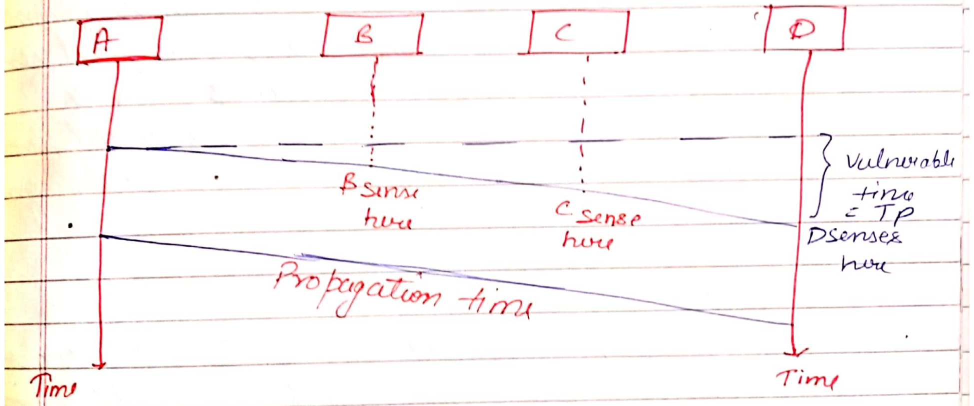
CSMA (Carrier sensor Multiple Access)

This method was developed to decrease the chances of collision when two or more Stations start sending their signals over the datalink layer. Carrier sense multiple access requires that each station first check the state of the medium before sending



Vulnerable time = Propagation Time Tp

<u>1 persistence</u>: It is an aggressive version of CSMA protocol that operates in MAC layer using CSMA protocols more than one users or nodes send & receive data through a shared medium that may be a single cable or optical fibre connecting multiple node or a portion of wireless spectrum

* In this CSMA when a transmitting station has a frame to send and it sense a busy channel it waits for end of transmission & transmit immediately

since it sends with a probablity 1 the name 1 persistent CSMA is given.

0 persistent / Non persistent

It is non aggressive version of CSMA using CSMA Protocol more than one user nodes send & receive data through shared medium.

* In 0 persistent CSMA when a transmitting station has a frame to send & it senses a busy channel it waits for a random period of time without sensing the channel in interim & repeats again.

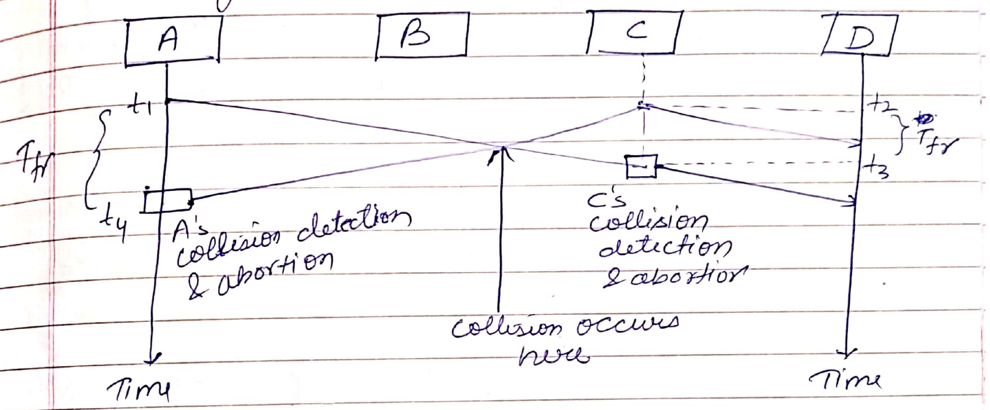
P- persistent

It is an approach of CSMA protocol that combines the advantage of 1-persistent CSMA & nonpersistent CSMA. ~~CSMA~~

* In p persistent CSMA when a transmitting station has a frame to send and it senses a busy channel. it waits for the end of transmission & then transmits with a probablity p. since it sends with a probablity p the name p-persistent CSMA is given

CSMA/CD (Carrier Sense Multiple Access / Collision Detection)

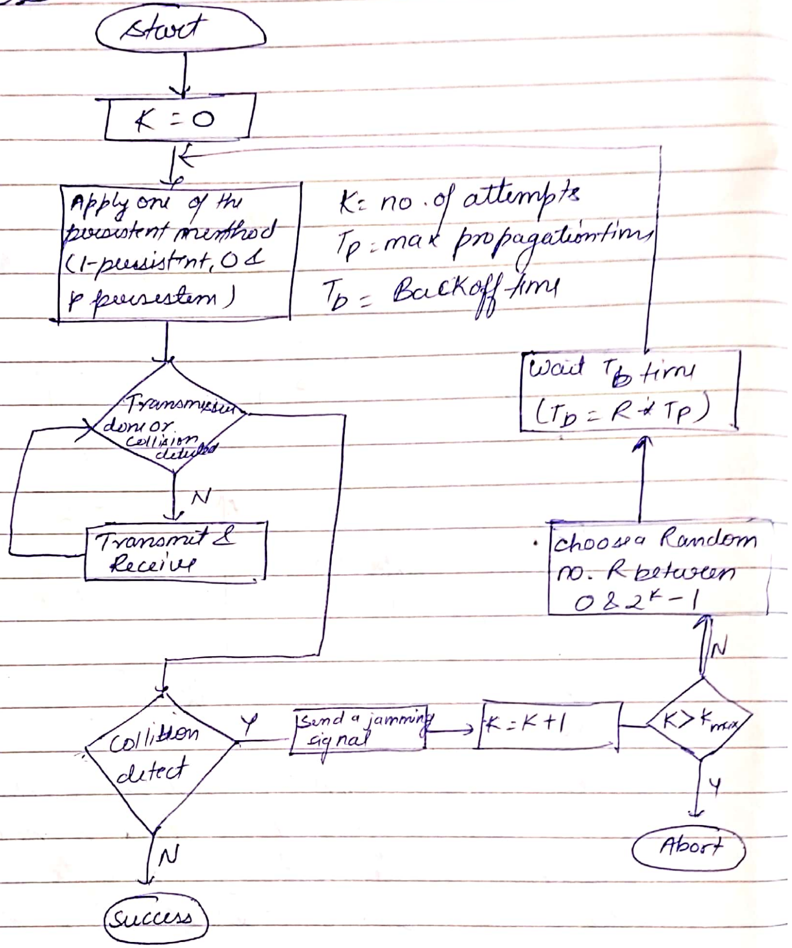
In this method a station monitors the medium after it sends a frame to see if the transmission was successful. If successful the station is finished if not the frame is sent again



In this diagram A starts sends the first bit of its frame at t_1 & since C sees the channel idle at t_2, starts sending its frame at t_2. C detects A's frame at t_3 & aborts transmission. A detects C's frame at t_4 & aborts its transmission.
Transmission time for C's frame is therefore $t_3 - t_2$ & for A's frame is $t_4 - t_1$

So, the T_{fr} should be at least twice the max propagation time (T_p). This can be deduced when the two stations involved in collision are maximum distance apart.

Process



$$\eta = \frac{1}{1 + 6.44a} \qquad a = \frac{T_p}{T_{fr}}$$

Q Consider a CSMA/CD network that transmit data at a rate of 100 Mbps (10^8 bit per second) over 1 Km Cable with no repeater. If the minimum frame size required for this network is 1250 bytes what is ~~so~~ signal speed (Km/sec) in the cable?

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Sol. $TT \geq 2 * PD$

$TT = 2 * PD$

$$\frac{L}{Bandwidth} = 2 * \frac{D}{V}$$

$$\frac{1250 \times 8}{100 \times 10^6} = 2 * \frac{0.1}{V}$$

$$V = \frac{2}{1250 \times 8} \times 100 \times 10^6$$

~~= 160000 Km/sec~~

20000 Km/sec

Q A network has a data transmission bandwidth of 20×10^6 bps. It uses CSMA/CD in MAC layer. The max signal Tp from one node to another node is 40 microsecond. The min. size of a frame in network is _____ byte.

Sol. $TT = 2 * PD$

$L = 2 * 40 \times 10^{-6} \times 20 \times 10^6$

$= 200 \times 10^3$ byte

Q ~~Consider a CSMA/CD n/w that transmit data at a rate of 100 Mbps (10~~

Q Bandwidth = 1 Gbps $\quad D = 1 Km \quad v = 2 \times 10^8 m/sec$

Sol $$\frac{L}{B} = 2 * \frac{D}{V}$$

$$L = \frac{\cancel{2} * 1000 \times 1 \times 10^9}{\cancel{2} \times 10^8} = 10000 \text{ bits}$$

In a wired ~~sing~~ networks, if a collision has occured then the energy of received signal almost doubles & station can sense the possibility of collission

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

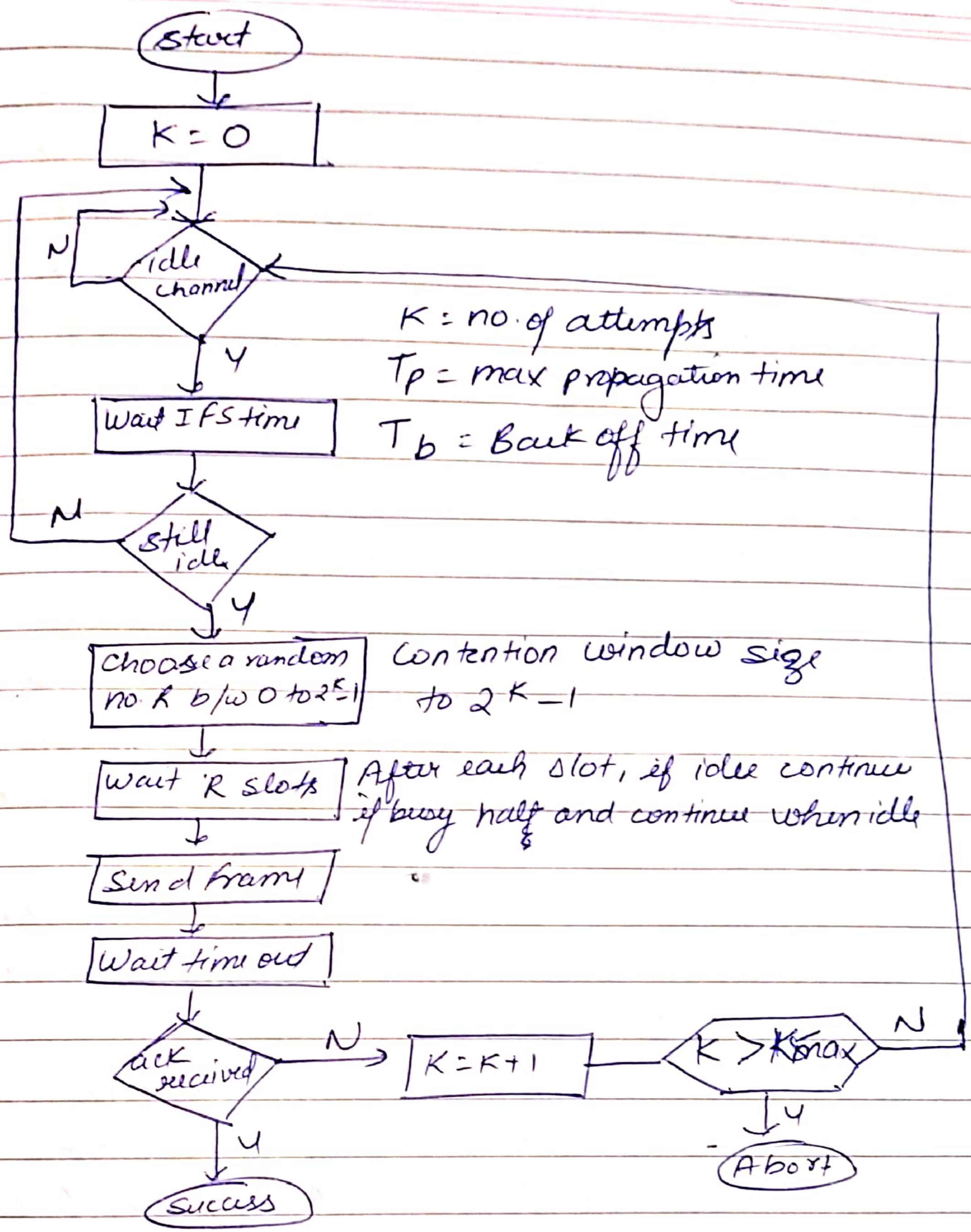
* In a wireless network much of the sent energy is lost in transmission. The received signal has very little energy. Therefore a collision may add 5 to 10 percent additional energy. This is not useful for effective collision detection

It is specially designed for wireless networks.
Collision are avoided using 3 CSMA/CA strategies

Interframe Space (IFS): when a station finds the channel busy it waits for a period of time called IFS time. IFS can also be used to define the priority of a station or a frame. Higher the IFS lower is the priority

Contention Window: It is the amount of time divided into slots. A station which is ready to send frames. Chooses random number of slots as wait time

Acknowledgements: The positive acknowledgements and time out timer can help guarantee a successful transmission of the frame



K : no. of attempts
T_p = max propagation time
T_b = Back off time

Contention window size to $2^K - 1$

After each slot, if idle continue
if busy halt and continue when idle

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Controlled Access Protocol

In this, the stations seek information from one another to find which station has the right to send it allows only one node to send at a time to avoid collision of message on shared medium.

Reservation: In this method station needs to make a reservation before sending data

- The time line has two kinds of periods:

(i) Reservation interval of fixed time length.

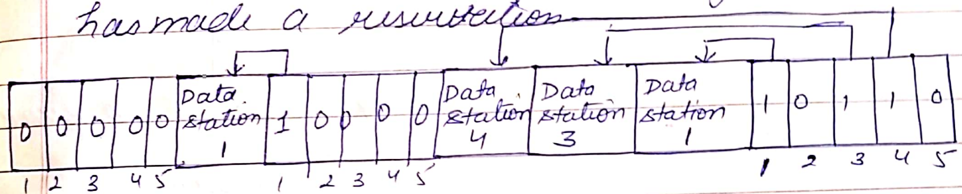
(ii) Data transmission period of variable frames

- If there are M stations, the reservation interval is divided into M slots, and each station has one slot.
- suppose if station 1 has a frame to send it transmits 1 bit during the slot 1. No other station is allowed to transmit during this slot
- ~~In general, ith station may announce that it has been checked, each station knowns which.~~
- In general ith station may announce that it has a frame to send by inserting a 1 bit into ith slot. After all N slots have been checked, each station knows which station wish to transmit

- The station which have reserved their slots transfer their frames in that order.

- After data transmission period, next reservation interval begins.
- since everyone agrees on who goes next there will never be any collision

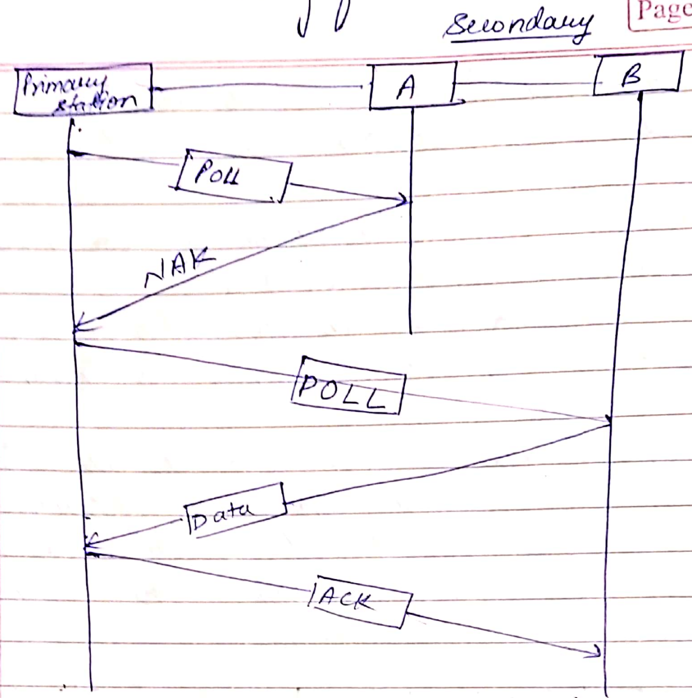
In figure five station and a five slot reservation frame. In first interval only station 1, 3 & 4 have made reservation. In the second interval, only station 1 has made a reservation.



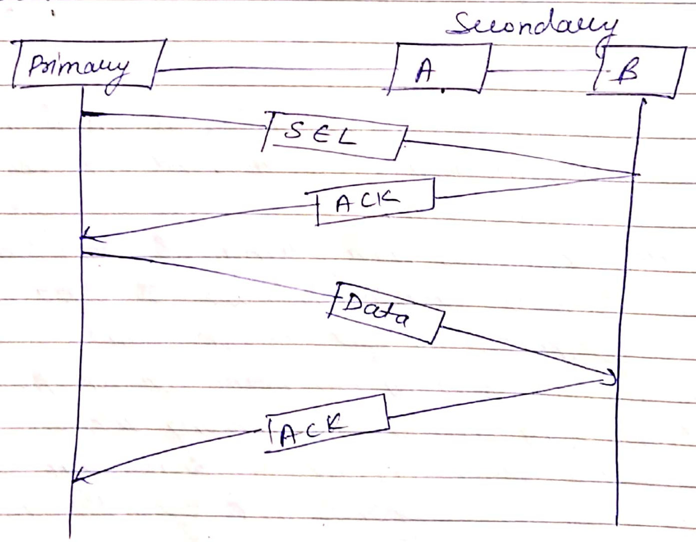
Polling Method.

- It is similar to the roll-call performed in class. Just like teacher, a controller sends a message to each node in turn.
- In this one acts as a primary station (controller) and other are secondary stations. All data exchanges must be made through the controller.
- The message sent by controller contain the address of node being selected for granting access.
- Although all nodes receive the message but the addressed one responds to it & send data, if any. If there is no data usually a "poll reject" (NAK) message is sent back.
- Problems include high overhead of the polling message & high dependence on the reliability of controller

Polling function



It work when primary station ask to receive a data.



Select Function: It is used when primary station wants to send the data.

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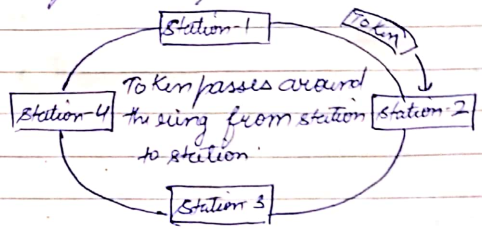
Token Passing Method

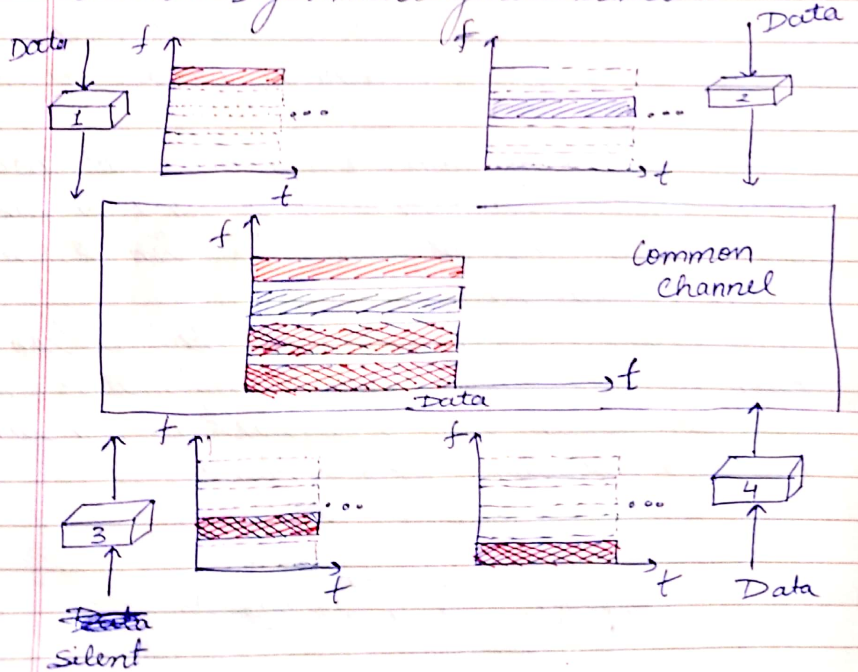
- In this the stations are connected logically to each other in form of ring and access of station is governed by token.
- A token is a special bit pattern or a small message, which circulate from one station to the next in the some predefined order
- In token ring token is passed from one station to another adjacent station in the ring whereas in case of Token bus each station uses the bus to send the token to the next station in some predefined order.
- In both cases token represents permission to send. If a station has a frame queued for transmission when it receives the Token it can send that fram before it passes the token to next station. If it has no queued frame it passes the token simply.
- After sending the frame each station must wait for all N station (including self) to send the token to their neighbour & the other N-1 station to send a frame if they have one.
- There exist a problems like duplication of token is lost or insertion of new station, removal of station; which need to be tackled for correct & reliable operation of this scheme



Channelisation: It is a multiple access method in which the available bandwidth of a link is shared in time, frequency or through code.

FDMA (Frequency-Division Multiple Access)

In this the available bandwidth is divided into frequency bands. Each station is allocated to band to send it its data. In other word each band is reserved for a specific station & it belongs to the station all time. Each station also uses a bandpass filter to confine the transmitter frequencies. To prevent interference the allocated band are seperated from one another by small guard bands.



Difference b/w FDM & FDMA

* FDM is a physical layer technique that combines the loads from low bandwidth channels & transmits them by using a high bandwidth channel. The channels that are combined are low pass. The multiplexer modulates the signals, combines them, & creates a bandpass signal. The bandwidth of each channel is shifted by multiplexer

* FDMA is an access method in data link layer. The data link layer in each station tell its physical layer to make a bandpass signal from data passed to it. The signal must be created in the allocated band. There is no physical multiplexer at the physical layer. The signal created at each station are automatically bandpass-filtered. They are mixed when they are sent to common channel.

TDMA (Time Division Multiple Access)

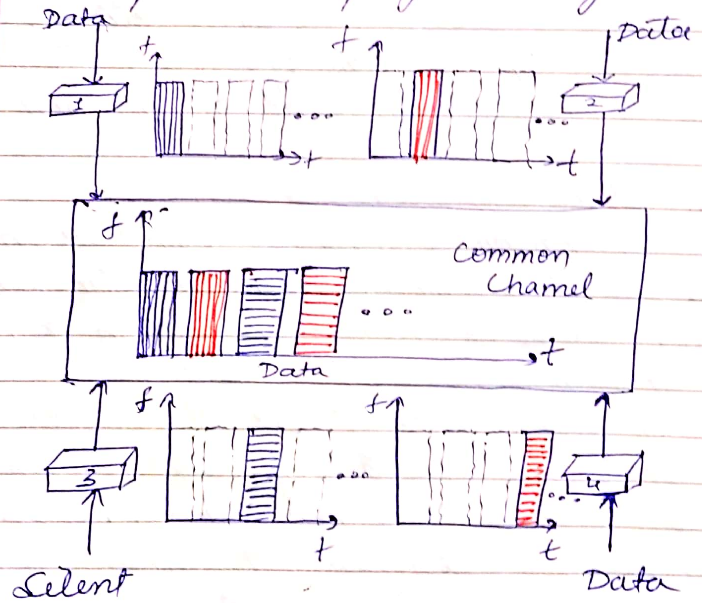
In this the station shares the bandwidth of channel in time. Each station is allocated a time slot during which it can send data. Each station transmits ~~to~~ its dat in is assigned time slot.

The main problem with TDMA lies in achieving synchronization b/w the different station. Each station needs to know the beginning of its slot & the location of its slot. This may be difficult bcz of propagation delays introduced in the system if the station are spread over a large ~~fa~~ area. To compensate for the delays, we can guard times. Synchronization is normally accomplished by having some synchronization bits at the beginning of each slot

Difference B/w TDM & TDMA

- TDM is a physical layer technique that combines the data from slower channels & transmit it ~~into~~ using faster channel. The process uses a physical multiplexer that interleaves data units from each channel.

- TDMA is an access method in data link layer. The data link layer in each station tells its physical layer to use allocated time slot. There is no physical multiplexer at physical layer.



CDMA (code division Multiple Access)

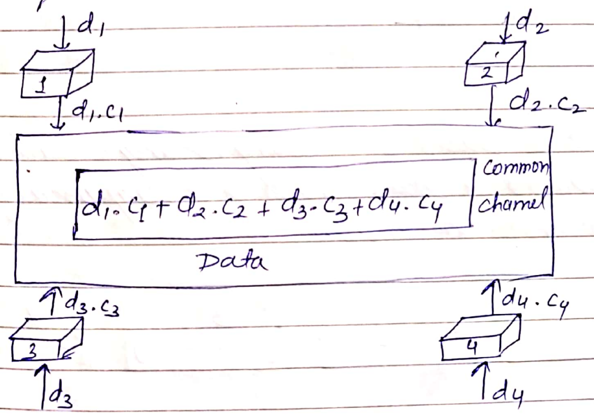
It simply means communication with different codes. CDMA differs from FDMA bcz only one channel occupies the entire bandwidth of link. It differs from TDMA bcz all station can send data simultaneously there is no time sharing.

Implementation:

Let us assume we have four station 1, 2, 3 & 4 connected to same channel. The data from station 1 is d_1, from station 2 are d_2 and so on. The code assigned to first station is c_1, to the second is c_2 & so on. We assume that the assigned code have two properties.

(i) If we multiply each code by another we get 0

(ii) If we multiply each code by itself we get 4 (the no. of station)



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Station 1 multiplies (a special kind of multiplication, as we will see) its data by its code to get $d_1 . c_1$. Station 2 multiplies its data by its code to get $d_2 . c_2$ and so on. The data that go on the channel are the sum of all these terms as shown in box.

Any station that wants to receives data from one to the other then multiplies that data on the channel by the code of sender:

for example:-

station 1 & 2 want to talk to each other.
station 2 wants to hear what station 1 saying. It multiplies the data on channel by C_1 the code of station 1. Bcz $(C_1 . C_1) = 4$ by $(C_2 . C_1)$, $(C_3 . C_1)$ $(C_4 . C_1) = 0$
station 2 divides the result by 4 to get the data from station 1

$$data = (d_1.c_1 + d_2.c_2 + d_3.c_3 + d_4.c_4) . c_1$$
$$= c_1.d_1.c_1 + c_1.d_2.c_2 + c_1.d_3.c_3 + c_1.d_4.c_4$$
$$= 4d_1$$

Chips

CDMA is based on coding theory. Each station is assigned a code, which is a sequence of no. called chips as shown

C_1	C_2	C_3	C_4
[+1 +1 +1 +1]	[+1 −1 +1 −1]	[+1 +1 −1 −1]	[+1 −1 −1 +1]

We need to know that we did not choose the sequences randomly; they were carefully selected. They are called orthogonal sequences

(i) Each sequence is made of N elements, where N is the no. of stations

(ii) If we multiply a sequence by a no. every element in the sequence is multiplied by that element. This is called multiplication of a sequence by a scalar eg

2. [+1 +1 −1 −1] = [+2 +2 −2 −2]

(iii) If we multiply two equal sequences, element by element & add the results we get N where N is no. of elements in each sequence. This is called inner product of two equal sequence.

[+1 .+1 −1.−1].[+1 +1 −1.−1] = 1+1+1+1 = 4

(iv) If we multiply two different sequences, element by element, & add the results we get 0. This is called inner product of two different sequence

[+1 +1 −1 −1].[+1+1+1 +1] = 1+1 −1 −1 = 0

(v) Adding two sequence means adding the corresponding element. The result is another sequence

[+1 +1 −1 −1]+[+1 +1+1 +1] [+2 +2 +0 +0]

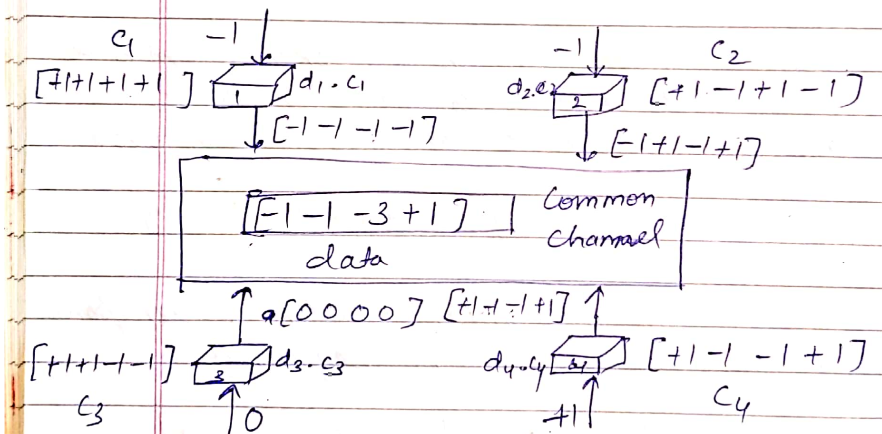
Data Representation

If a station needs to send a 0 bit it encodes it as −1 if it needs to send a 1 bit it encodes it as +1. When station is idle it sends no signal which is interpreted as 0.

Encoding & Decoding

Channel 1 & 2 are sending 0 bit hence -1 and channel 4 is sending 1 bit hence +1 & channel 3 is idle so 0

The data at sender side are translated to -1, -1, 0 & +1 Each station multiples the corresponding no. by its chip which is unique for each station.
The result is a new sequence which is send to the channel. for ~~sp~~ simplicity we assume all ~~them~~ station are sending the sequence at same time



Now imagine station 3 which we said is silent is listening to station 2. Station 3 multiplies the total data on the channel by the code for station 2 which is [+1, -1, +1 -1] to get

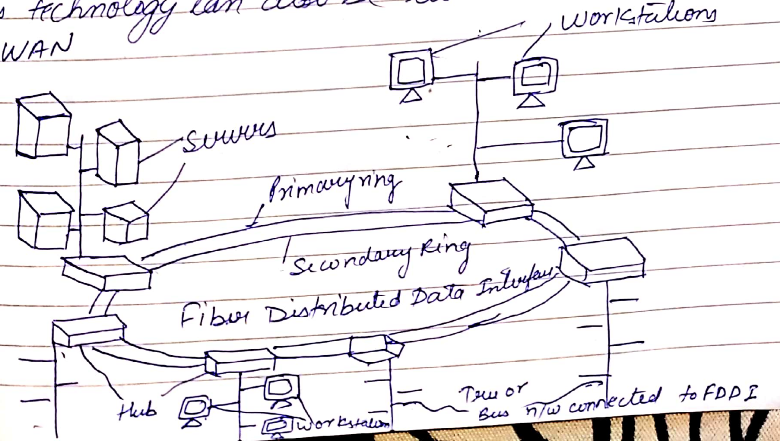
$$[-1 -1 -3 +1]\,[+1 -1 +1 -1] = \frac{-4}{4} = 1 \text{ bit}$$

FDDI (Fiber Distributed Data Interface)

It is a set of ANSI & ISO standard for transmission of data in local area network (LAN) over fiber optics cables. It is applicable in large LANs that can be extend up to 200 Km in diameter.

Features

- It uses optical fiber as its physical medium.
- It operates in physical & medium access control (MAC layer of the open system Interconnection (OSI) network model.
- It provide high data rate of 100 Mbps & can support thousands of users.
- It is used in LANs up to 200 Km & for long distance voice & multimedia communication.
- It uses ring based token passing mechanism & is derived from IEEE 802.4 token bus standard.
- It contains two token rings, a primary ring for data and token transmission & a secondary ring that provides backup if the primary ring fails.
- This technology can also be used as a backbone for WAN



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Frame Format

Preamble	Start Delimiter	Frame Control	Destination Address	Source Address	Payload	Chechsum	End delimiter
for synchronization	mark beginning of frame	specify whether it is data or control frame	address of Destination station	address of source station	Carries data from network layer	check sequence of error detection	mark end of frame.
1 byte	1 byte	1 byte	2-6 byte	2-6 byte	Variable length	4 byte	1 byte