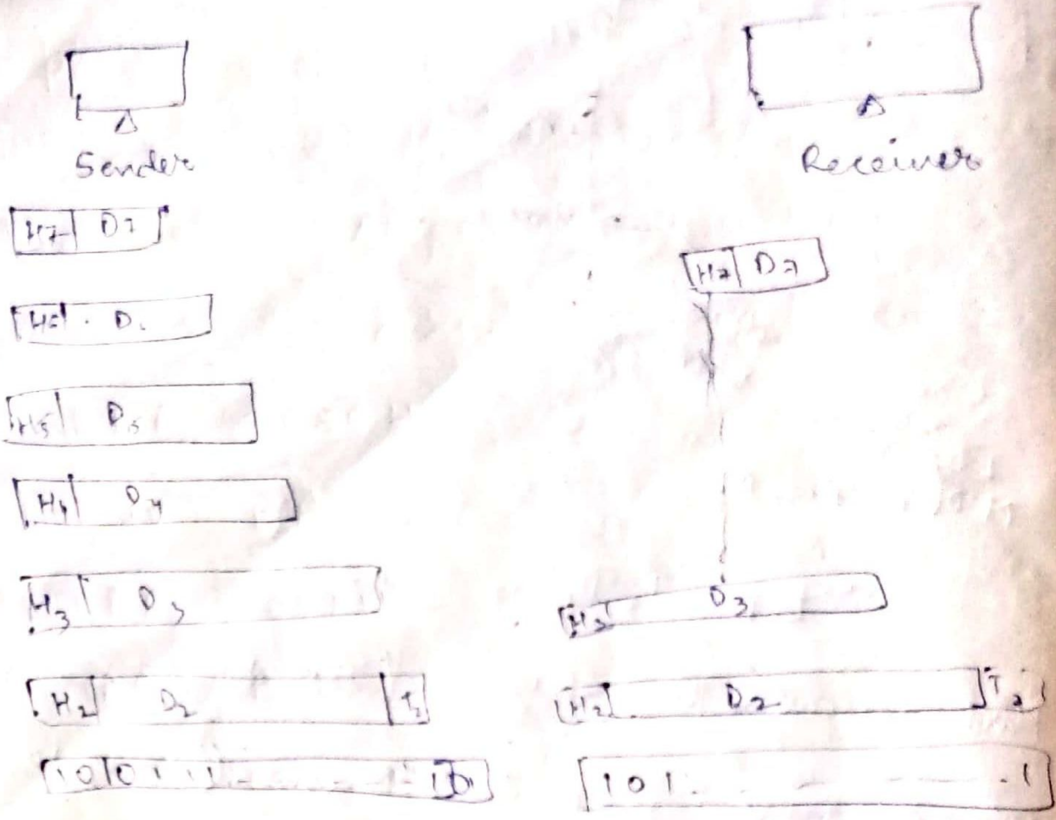
Computer Networks



⇒ Physical Layer

Main resp. ① Transmission of raw bits.

② Physical characteristics of interface and medium.

③ Synchronization of bits

④ Line Configuration

⑤ Physical topology

⑥ Transmission mode.

⑦ Representation of bits

⑧ Data rate.

⇒ Data Link layer.

Main resp. ① It transforms physical layer from being a raw transmission of bits to a reliable ~~code~~ unit.

② Framing.

③ Physical addressing

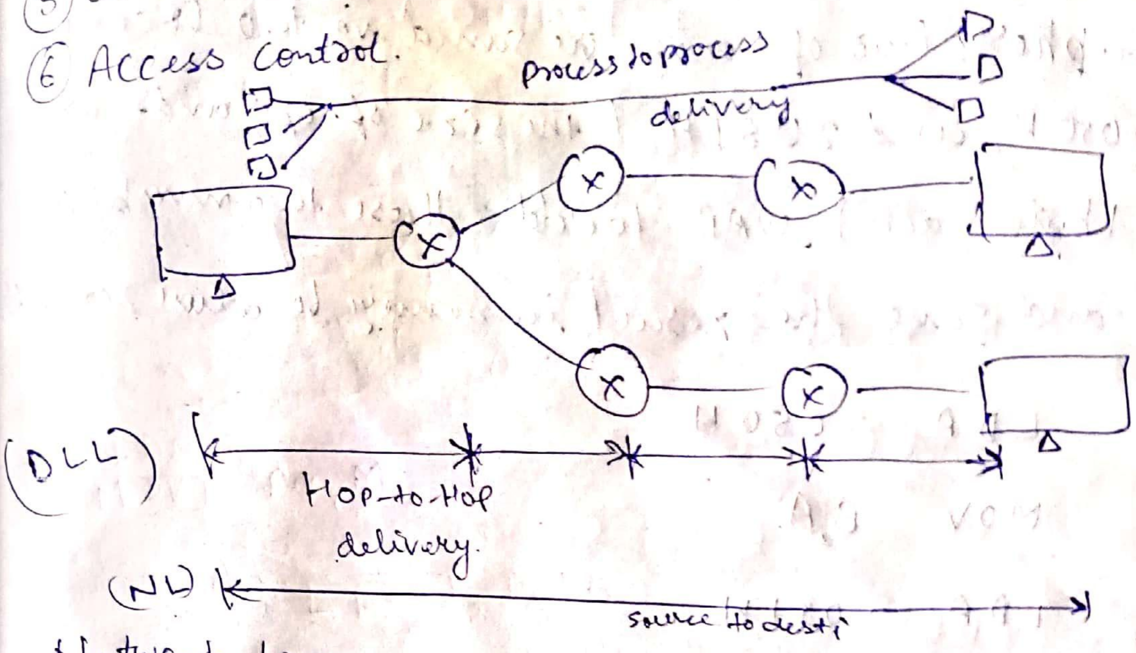
① within the network – add sender + receiver address

② outside the network – address of next node

4) Flow control

5) Error control.

6) Access control.



Network Layer

1) Transmitting the packets from source to destination.

2) Routing

3) Logical addressing.

Transport layer

1) Process to process delivery of segments.

2) Service point addressing (port)

3) Segmentation and Reassembly

4) Connection control

5) Flow control.

6) Error control.

Session layer

1) Dialog control and synchronization.

Presentation layer

1) Translation, Encryption, compression.

Application layer.

1) Provides services to the user.

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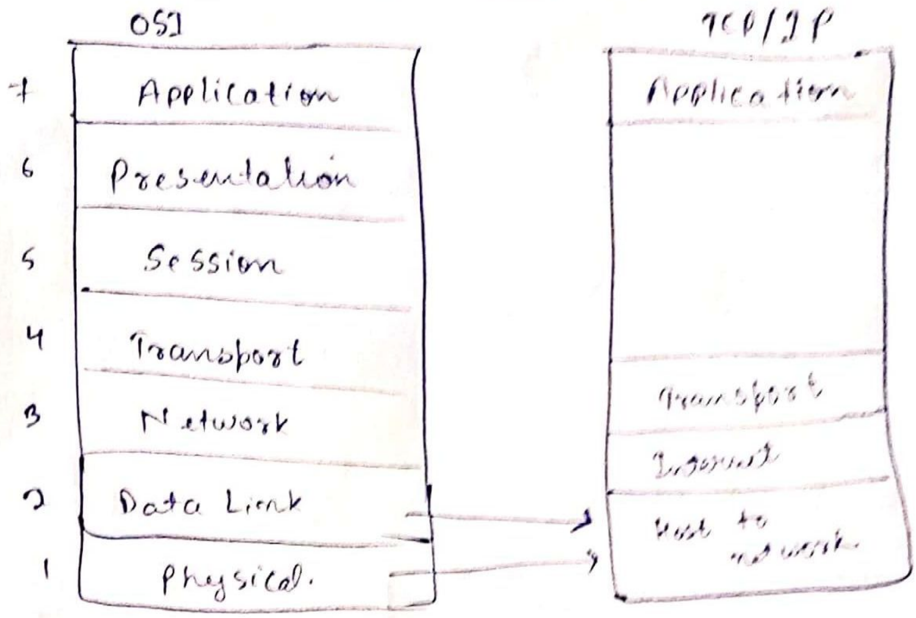
TCP/IP Protocol Suite:-



#1 TCP/IP Vs OSI Model.

1.) Distinction of Services, interface and protocols.

2.) Flexibility to new technology.

3.) Order of protocol and model invention.

4.) Numbers of layers

5.) Way of communication

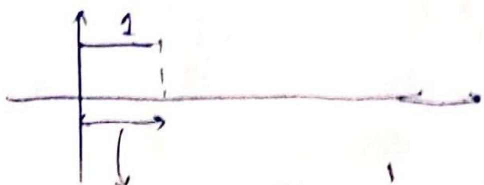
Physical Layer:

+ ~~For~~ L layers can be represented using $\log_2 L$ bits

* Bit rate

* Bit length - The distance one bit occupies on transmission medium

Bit length = Propagation Speed × bit duration



bit duration = $\frac{1}{\text{bandwidth}}$

1) Baseband → low pass filter

2) Broadband → band pass

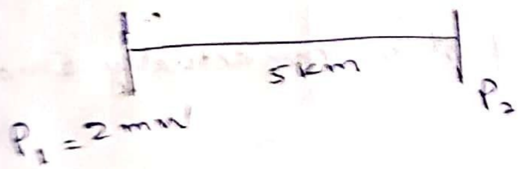
..05-2019

Transmission Impairments

1) Attenuation
2) Distortion
3) Noise

1) Suppose the loss in a cable at beggining is -0.3 dB/km and the signal having power 2mW, what is the power of the signal at 5km.

=>



=> $10\log_{10}\left(\frac{P_2}{2\times10^{-3}}\right) = (-0.3)\times 5$

=> $\log_{10}(P_2\times 500) = -0.15$

=> ~~P_2 = 0.0197 = 1.97 mW~~

=> $P_2 = 0.001415 = 1.415$ mW

= Signal to Noise Ratio

$$SNR_{dB} = 10\log_{10}\left(\frac{S}{N}\right) dB$$

= 1 Noiseless - Nyquist

Max bit rate = $2B\log_2 L$

B → bandwidth
L → no of levels of the signal.

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(2) Noisy → Shannon Capacity

$$\text{Max bit rate} = B \log_2 (1 + SNR)$$

Q) Assume that Signal to noise ratio = 36 dB and channel bandwidth is 2 MHz. Compute the Shannon capacity.

⇒ Max bit rate = $2 \times 10^6 \cancel{\log_2 (1+36)}$

$$SNR = 36 = 10 \log_{10} \left(\frac{S}{N}\right)$$

$$\Rightarrow \frac{S}{N} = 10^{3.6} = 3981.071$$

$$\Rightarrow \text{Max bit rate} = 2 \times 10^6 \log_2 (3982.071)$$

$$= 23.918 \times 10^6 \text{ bits/sec.}$$

Performance Measures :-

1.) Bandwidth

2.) Throughput is a measure of how fast we can actually send data

~~3.)~~ through a network.

3.) latency (Delay)

(I) Propagation time (measures the time required for a bit to travel from source to destination).

~~(II) Transmission time~~

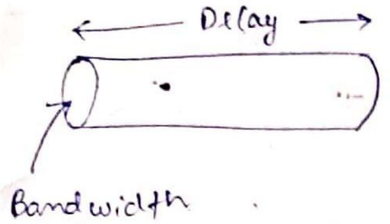
~~(III)~~ { Propagation time = $\frac{\text{Distance}}{\text{Propagation speed}}$.

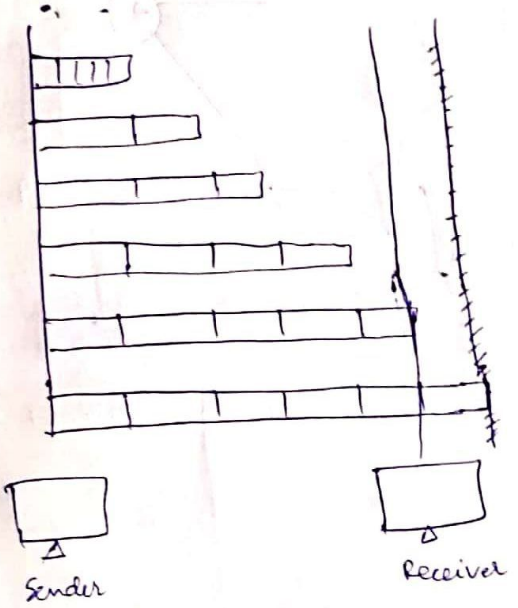
(II) Transmission time = It measures the time required for entire message to leave from the source node.

(III) Queuing time is the time needed for its intermediate or in device before it can be processed.

(IV) Processing time.

4.) Bandwidth Delay Product:





B = 5 bits/sec

delay = 5.

25 bits

Bandwidth Utilization

- Analog
  - Freq. DM
  - Wave. DM
- Digital
  - Time Div. Mul
    - Synchronous TDM
    - Asynchronous T[illegible]

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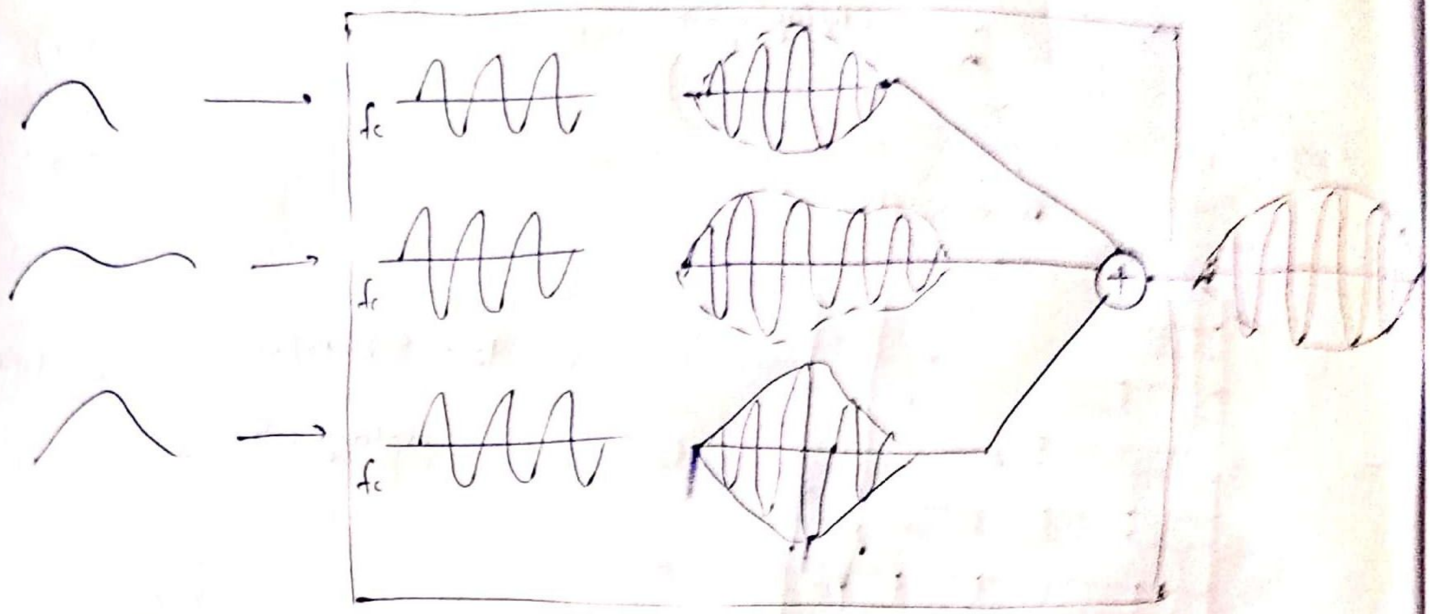
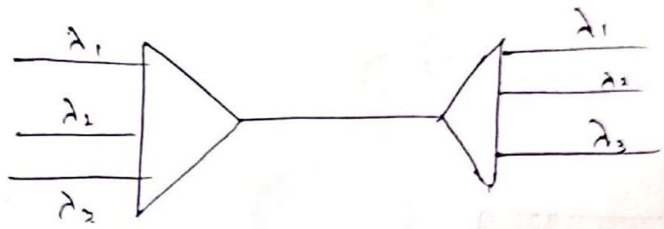
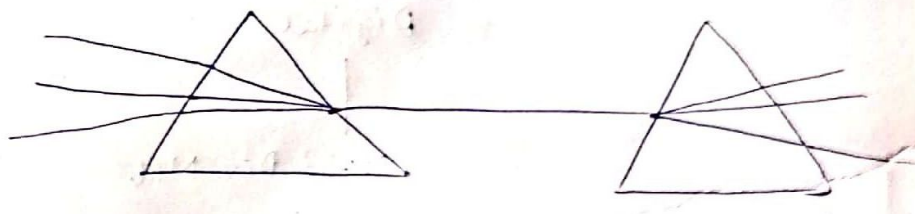
Freq. Div. Mult.



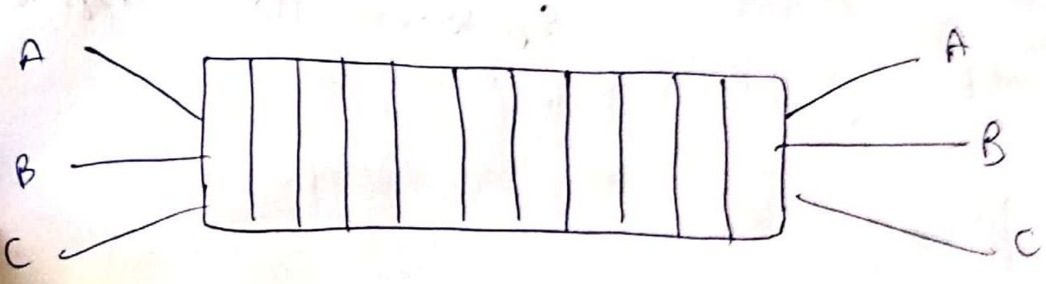
Wavelength Div. Mult.



Ex:



Time Division Mult.



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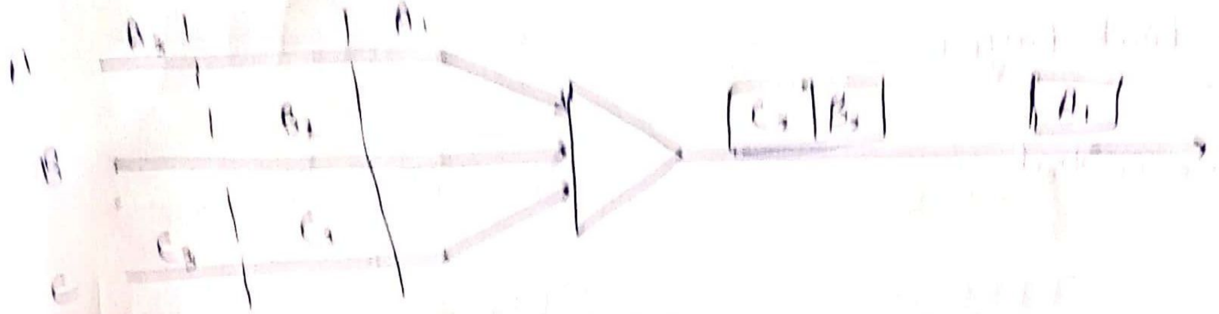
Framing



- Interleaving - Time alloted for each of the individual signal to send the data.

Code Division Multiplexing (CDM)

A 1 0 1 1 1 0 0 1 → + - + + + - - +

B 0 1 1 0 1 1 1 0 → + - - + - - - +

C 1 1 0 0 1 1 0 1 → + + - - + + - +

+3, -1, -1, +1, +1, -1, -3, +3

A → 1, B → 0, C → 1

→ XNOR

⇒ For A: +3, -1, -1, +1, +1, -1, -3, +3

× +1, -1, +1, +1, +1, -1, -1, +1

+3, +1, -1, 1, +1, +1, +3, +3

Adding ⇒ +12

∴ +12 is nearer to +8, hence its a 1 bit signal.

⇒ For B: +3, -1, -1, +1, +1, -1, -3, +3

× -1, +1, +1, -1, +1, +1, +1, -1

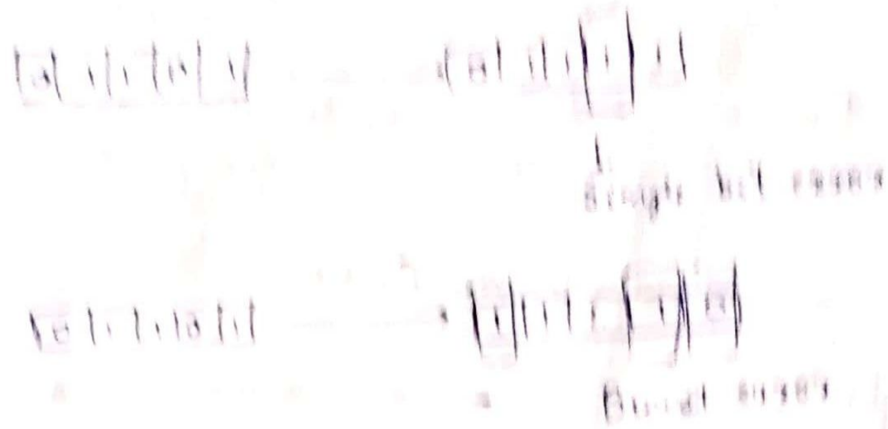
-3, -1, -1, -1, +1, -1, -3, -3

Adding ⇒ -12 ⇒ 0 bit signal (nearer to -8)

* Guided Media # Unguided Media

Data link layer

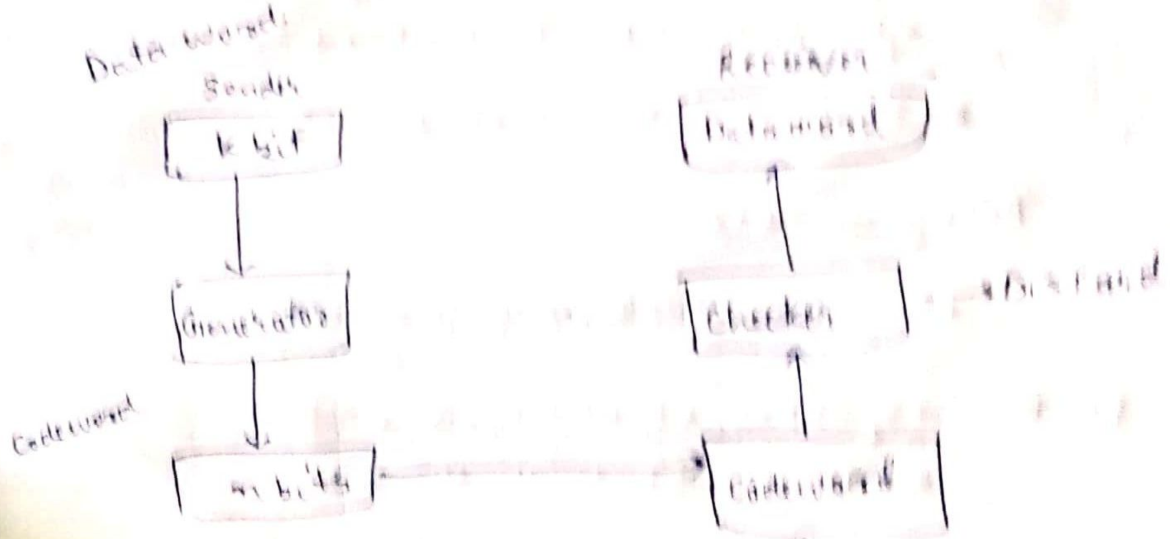
→ Error control



⇒ Error control

- Error detection
- Error correction
  - Forward error correction
  - Retransmission

→ Error detection



· 2B/3B → Can only detect single bit error.

DW	CW
00	000
01	011
10	101
11	110

· 2B/5B

Data word	Codeword.
00	00000
01	01011
10	10101
11	11110

Ex: Ans 01111

Assuming there is only 1 Bit error we can detect the dataword as 01.

Hamming Distance.

Min^m hamming distance -

Modula N- Arithmetic

Add. 0+0 = 0 0+1 = 1 1+0 = 1 1+1 = 0

Sub 0-0 = 0 0-1 = 1 1-0 = 1 1-1 = 0

Linear Block Encoding

00	000
01	011
10	101
11	110

$d_{min} = s+1$, s → no. of error it can detect

$d_{min} = 2t+1$, no of error it can correct.

Parity Checking

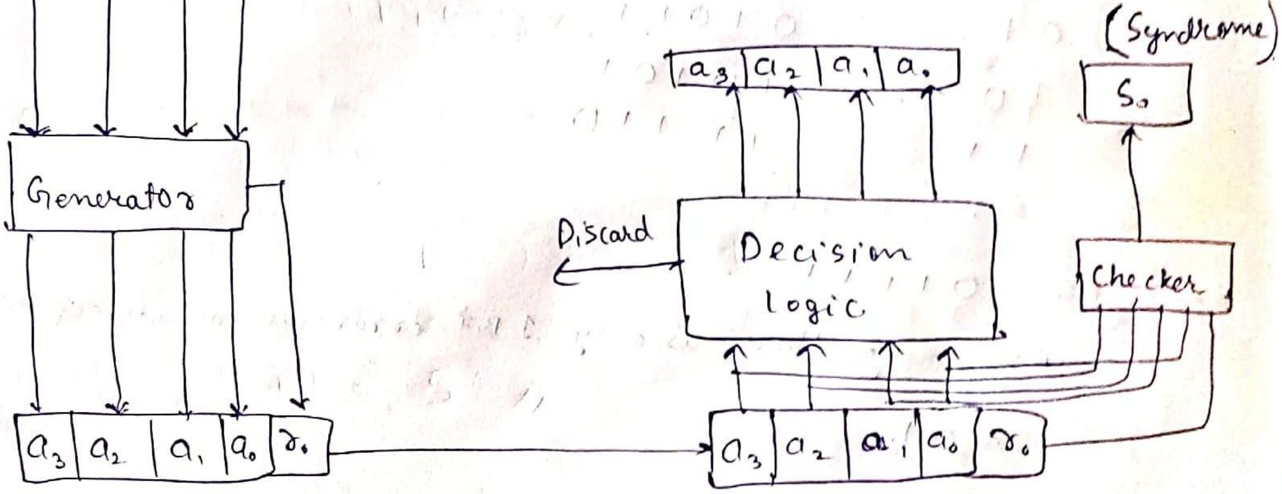
Even parity

Ex:

10100

11101

=>



=> If $S_0 = 0$ → it does not discard the data

If $S_0 = 1$ → it can detect an error in the data

=> ~~If the error is even bit error then~~

=> It can only detect odd no. of bit errors.

Two Dimensional Parity Checking.

1101 1100 1001 0101

1101	1
1100	0
1001	0
0101	0
1101	1

Hamming Code

$2^r \geq k + r + 1$

$r \rightarrow$ no. of redundant bits

$k \rightarrow$ no of bits in dataword

∴ The positions that are power of 2 are considered for parity bit.

1 0 0 1 1 0 1 0

$k = 8$; $r = 4$

P_1	P_2	1	P_4	0	0	1	P_8	1	0	1	0		
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Position 1 : P_1, 1, 5, 7, 9, 11

$P_1 = 0$

Position 2 : P_2, 1, 6, 7, 10, 11

$P_2 = 1$

Position 4 : 4, 5, 6, 7, 12

$P_4 = 1$

Position 8 : 8, 9, 10, 11, 12

$P_8 = 0$.

0	1	1	1	0	0	1	0	1	0	1	0		
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Even parity bits

:) Considering an error.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
0	1	1	1	1 ~~0~~	0	1 ~~0~~	0	1	0	1	1	0	

$P_1 - 1, 3, 5, 7, 9, 11$

$\rightarrow (0+1+\cancel{0}^{1}+1+1+1) \bmod 2 = \cancel{0}\ 1$

$P_2 \rightarrow 2, 3, 6, 7, 10, 11$

$\rightarrow (1+1+0+1+0+1) \% 2 = 0$

$P_4 \rightarrow 4, 5, 6, 7, 12$

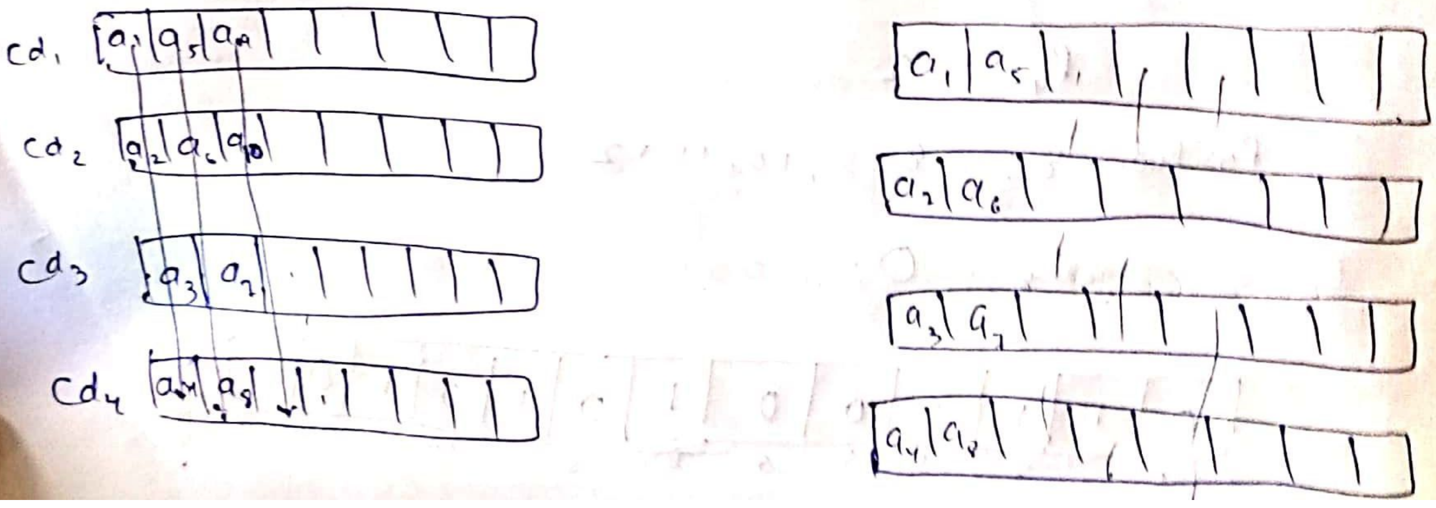
$\rightarrow (1+1+0+1+0) \bmod 2 = 1$

Error at $4+1 = 5$ //

=) It can only detect and correct a single bit error.

For detecting upto 4 bit error.

1101	1110	1010	1011
d_1	d_2	d_3	d_4



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Cycle Redundancy Check (CRC)

⇒ Dataword – 1001

Divisor – 1011

⇒ There are 4 bits in the divisor so we add (4-1) 0 bits to the dataword

```
1011 ) 1001000
       1011
       ------
       001000
         1011
       ------
         00110
```

⇒ 1001000
       110

   1001110 ⟶ Codeword

Receiver side CRC checking

Divisor – 1011

```
1011 ) 1001110 ( 1010
       1011
       -----
       00101
        0000
       -----
         1011
         1011
       -----
         00000
          0000
       -----
           000
```

→ Rem. is zero hence no error.

$x^3 + x^3 = 0$ $x^3 - x^3 = 0$

$x^3 / x^2 = x$ $x^3 \cdot x^2 = x^5$

Ex: $(x^3 + x^2 + x)(x^2 + x + 1) = x^5 + \cancel{x^4} + \cancel{x^3} + \cancel{x^4} + \cancel{x^3} + \cancel{x^2} + x^3 + \cancel{x^2} + x$
$= x^5 + x^3 + x.$

Ex ⇒

Divisor	data
1011	1001 → 1001000
x^3+x+1	$(x^3+1)\,x^3$

⇒

$$
\begin{array}{r|l}
 & x^3 + x \\
\hline
x^3+x+1 & x^6 + x^3 \\
 & x^6 + x^3 + x^4 \\
\hline
 & x^4 \\
 & x^4 + x^2 + x \\
\hline
 & x^2 + x
\end{array}
\rightarrow \cancel{101}\ 110.
$$

⇒ Codeword → $x^6 + x^3 + x^2 + 1$

1001101

Dataword	$d(x)$	
Codeword	$c(x)$	$\dfrac{c(x) + \cancel{g(x)}\, e(x)}{g(x)}$
generator	$g(x)$	
Syndrome	$s(x)$	$= \dfrac{c(x)}{g(x)} + \dfrac{e(x)}{g(x)}$
error	$e(x)$	

⇒ Generator design

→ It should have atleast two terms

The coefficient of x^0 should be 1

It should not divide x^t+1, $t = 2, \dots$ $(n-1)$

It should have factor of $x+1$.

Check Sum

4 bit

Dataword → (7, 11, 12, 0, 6)

Codeword → (7, 11, 12, 0, 6, 36)

⇒ 1's Complement Arithmetic

Wrapping

```
 1|0 1 0 1   → 21
  |   → 1
  |0 1 1 0   → 6
```

Theory:

Sender

```
  7
 11
 12
  0
  6
  0
----
 36 →   10|0100
           → 10
          0110   → wrapping
           ↓
          1001   → 1's complement
           ↘ 9
```

⇒ Codeword → (7, 11, 12, 0, 6, 9)

Receiver:

```
  7
 11
 12
  0
  6
  9
----
 45 →  101101 →   wrapping
                   1101
                     10
                   ----
                   1111 → 1's complement → 0000
```

∴ its 0 ∴ NO error

Framing

Structure of frame

Flag	Address	Control	Information	FCS	Flag

1) Byte stuffing

2) Bit stuffing

Before

After

Bit Stuffing

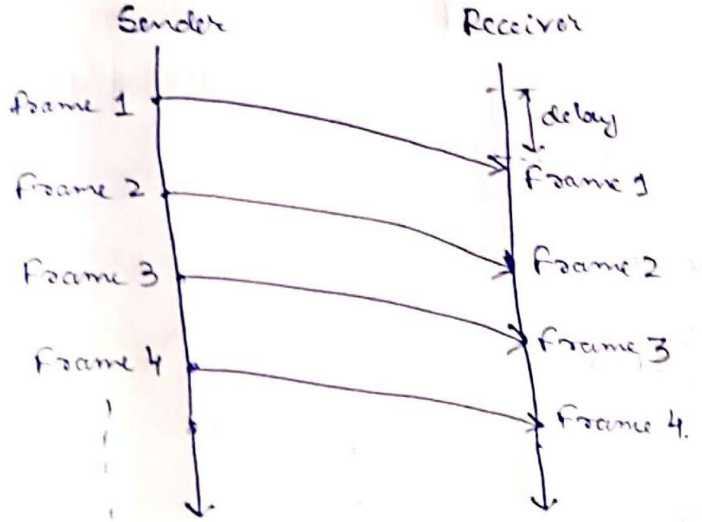
Flag 01111110

5 consecutive 1's stuff 0.

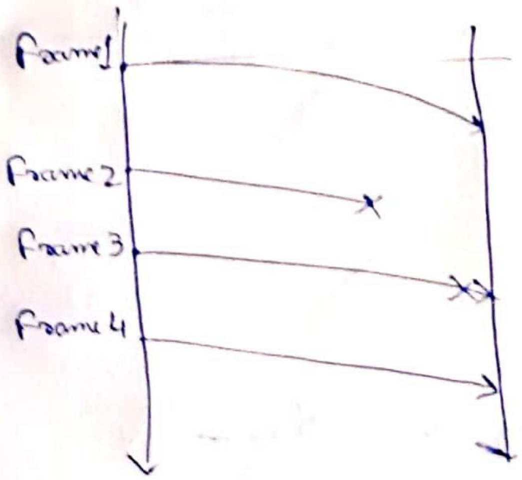
1010 11111 11111 1011

1010 111110111110 1011

d) Flow Control

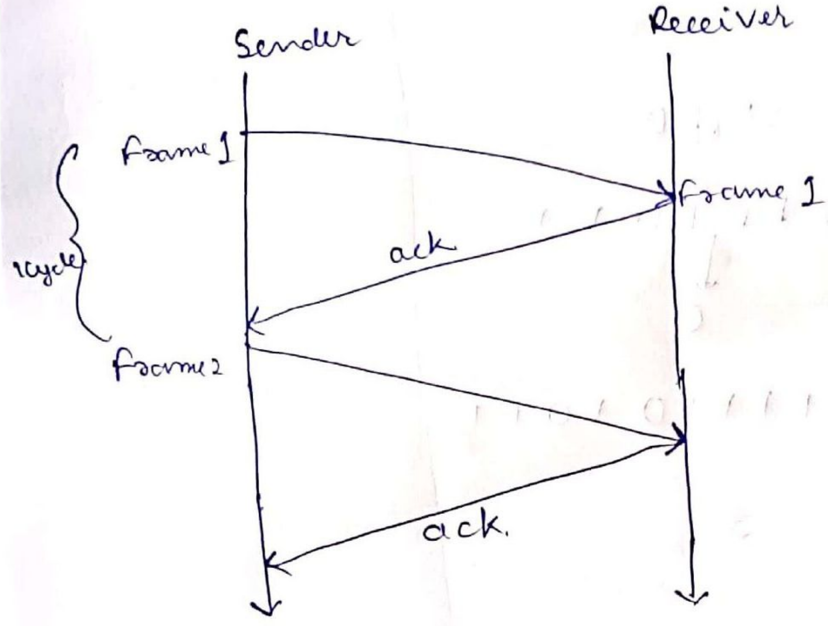


Error free Channel.



noisy channel.

Stop and Wait Flow Control.

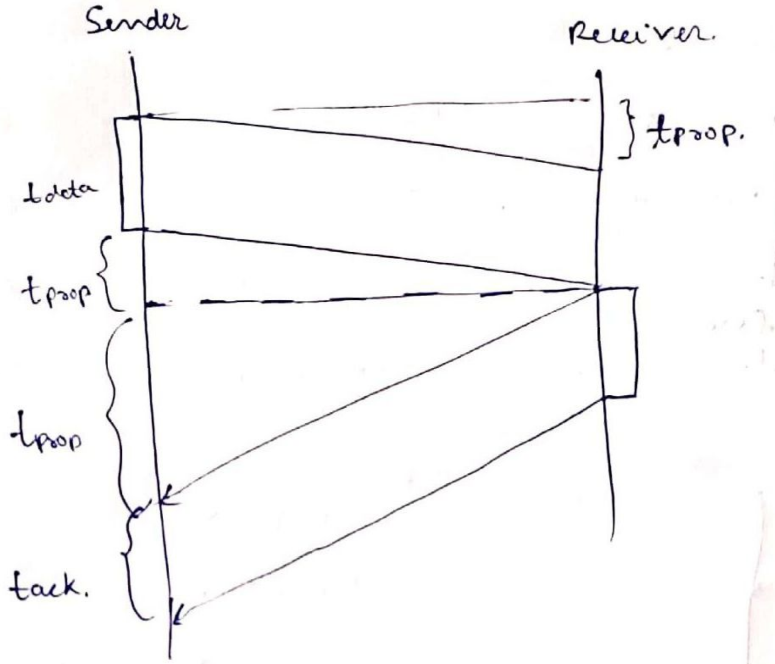


Error free channel.

Ack — aknowledgment

1. Receiver will send an acknowledgment
2. Sender will wait for acknowledgment

⇒



$$1 \text{cycle} = t_{data} + 2t_{prop} + t_{ack}.$$

Sender was busy during 1 cycle $= t_{data}$

* Channel utilization $= \dfrac{t_{data}}{t_{data} + 2t_{prop} + t_{ack}}$; t_{ack} is generally quite less.

i) transmission time = 1 unit

ii) Propagation time = a.

$$CU = \frac{1}{1+2a}\ ; \quad a \geq 1$$

$$CU = \frac{1}{1+2a}\ ; \quad a < 1$$

} remains same.

Sliding Window Flow Control :-

1.) Window of size W.

2.) Sender can transmit W frames without receiving Acknowledgment

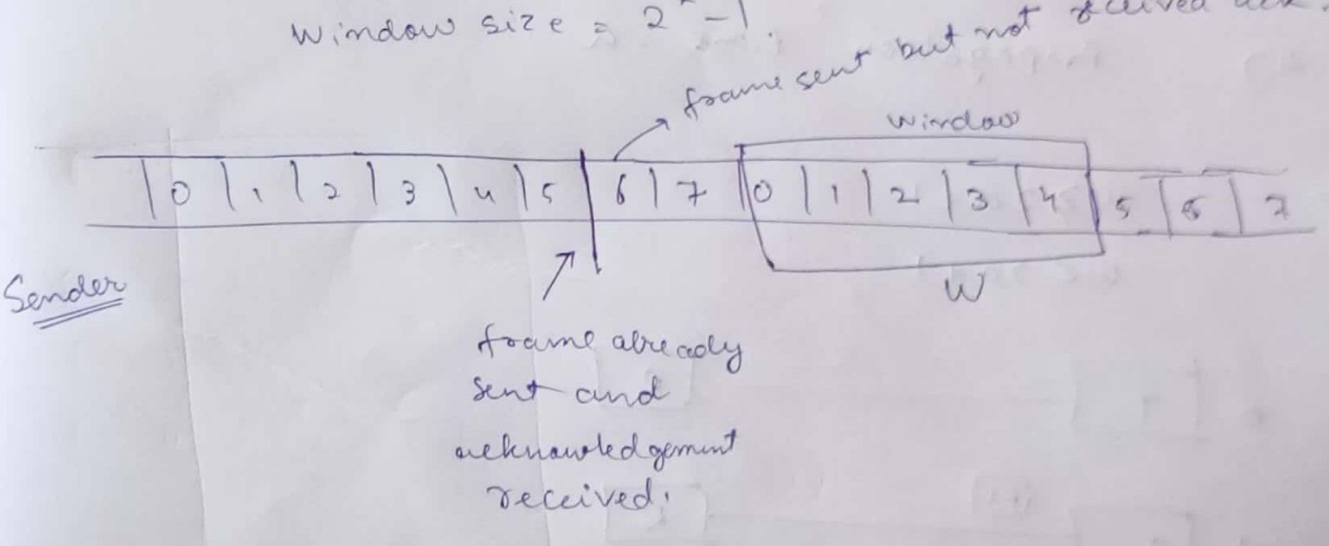
3.) Receiver sends cummulative acknowledgment.

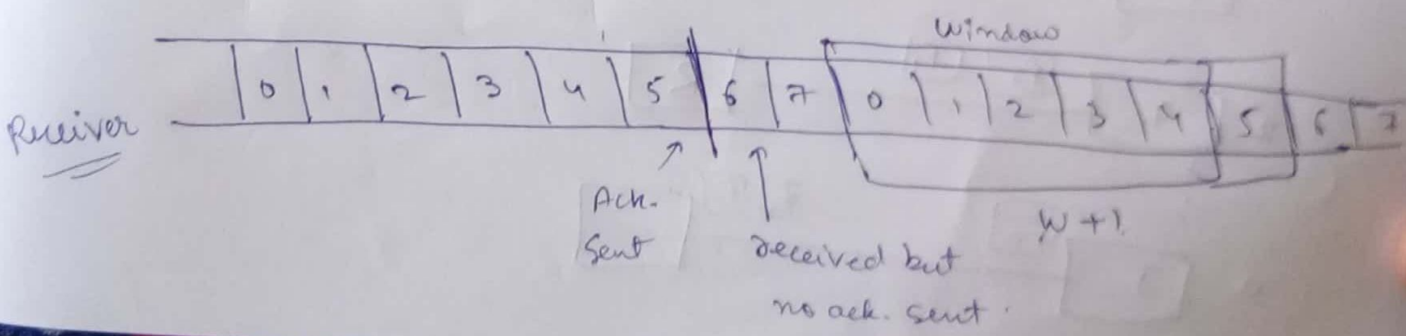
4.) Frame sequence numbers to identify frames

k - bit sequence.

frame will be modulo 2^k.

window size = $2^k - 1$.





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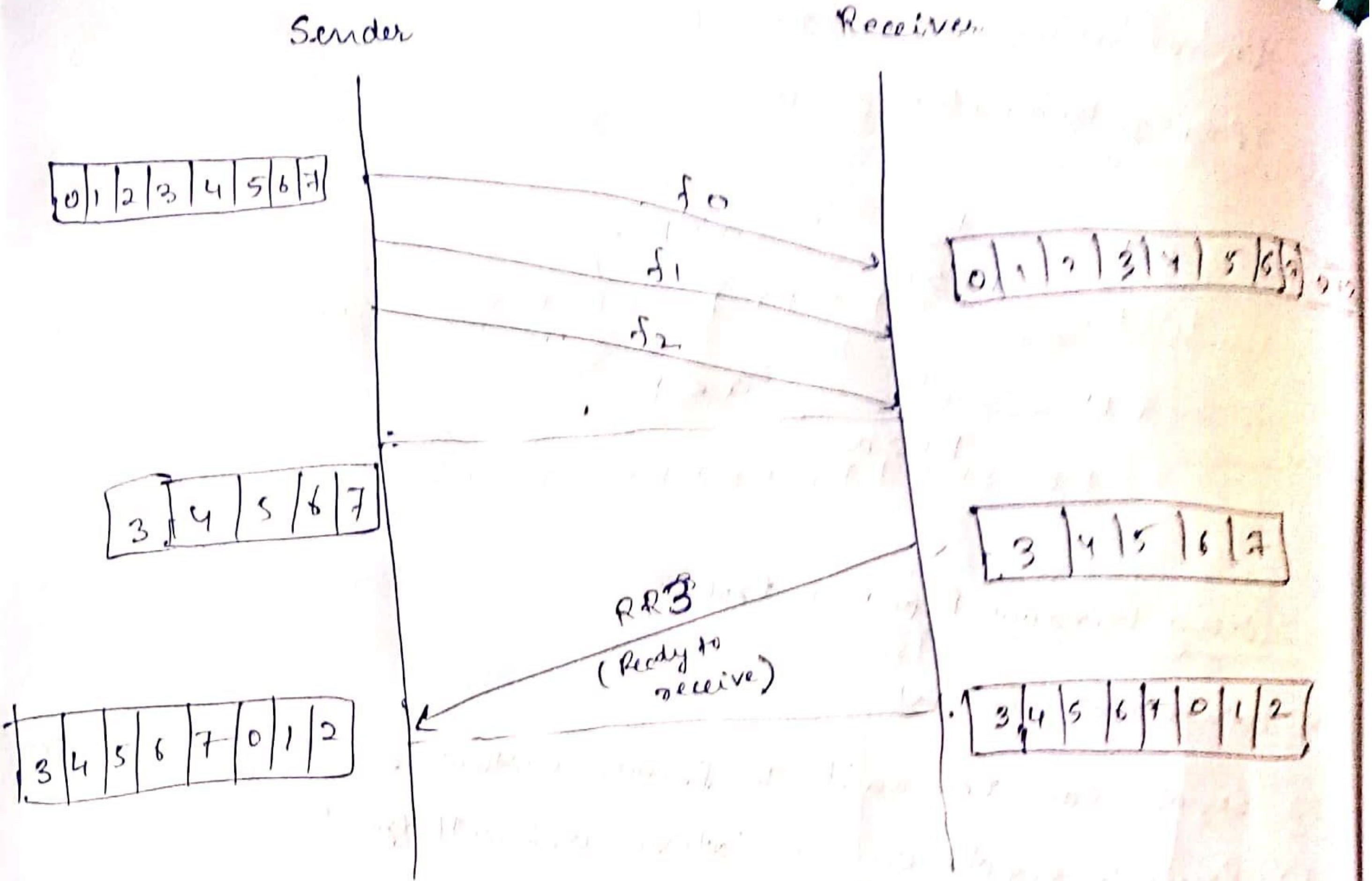


1.) window size - w

2.) transmission time of frame 1

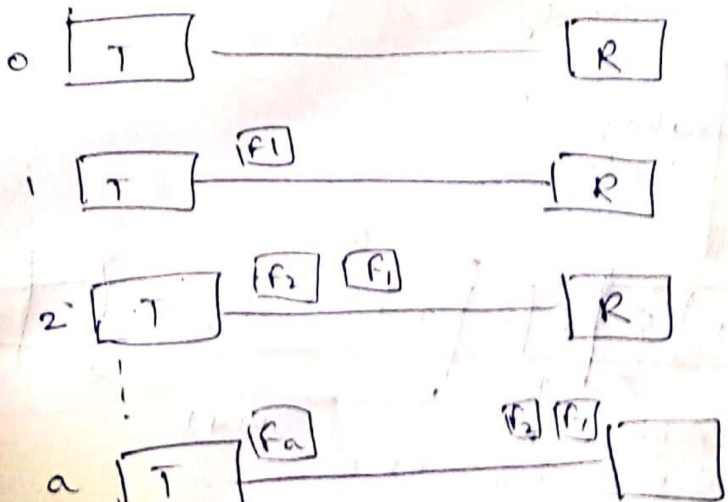
3.) ~~Acknowledgement~~ " " ack = 0

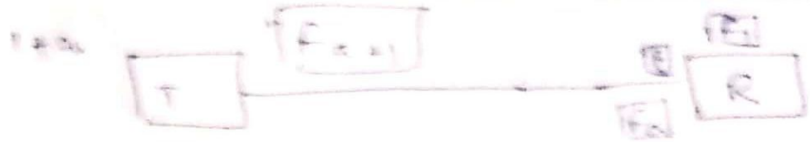
4.) Propagation time = a

\#

$W \geq 2a+1$

$W < 2a+1$

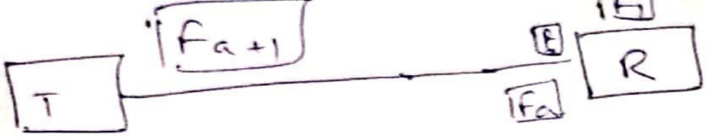




$$CU = \frac{1+2a}{1+2a} = 1 \; ; \; w \geq 2a+1$$

$$CU = \frac{w}{1+2a} \; ; \; w < 2a+1$$

1+a



1+2a

:) $$CU = \frac{1+2a}{1+2a} = 1 \; ; \quad w \geq 2a+1.$$

$$CU = \frac{W}{1+2a} \; ; \quad w < 2a+1$$

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