Flow control COMPUTER NETWORK 18/06/2021

Q. A system has a 'n' layer protocol hierarchy, application generate msg of length m Byte. Let each of layers 'h' byte header is added with the msg. What fraction of N/W BW is filled header? — Un-useful Data.

Speed BW : x mbps

n = no of layer.

m = msg size

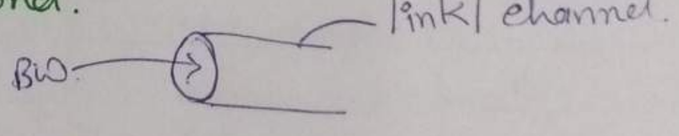
h = header size / layer

$$\text{efficiency} = \frac{\text{Useful}}{\text{Total}} \longrightarrow \frac{\text{Useful}}{\text{Useful} + \text{Un useful}}$$

$$\text{efficiency} = \frac{\text{Un Useful}}{\text{Total}} = \frac{n \cdot h}{m + n \cdot h}$$

$$= \frac{1}{1 + \frac{m}{n \cdot h}} \quad \underline{\underline{\text{Ans}}}$$

Bandwidth : It Represent rate at which no of bits placed on the link / channel in one second.



$$BW = \frac{\text{no of bits}}{\text{Time}} = \text{Bps or bps}$$

bit per second

↳ Max. Capacity of channel

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g.f nam, EnRoll No

→ Schedule conference

m = 01100100110 using hamming code

942 ~~32~~, 160, 174, 161, ~~[illegible]~~
186, ~~154~~, 136, 169, 129,

179, 192, 177, 182, ~~[illegible]~~ 170, 152
145, 168, 133, 167, 194,
195, 146, 193, 181, 190, 188.

A Any [illegible] 11001010l

How many redundant bits are used?
What is the length of data that to be transmitted to the receiver?
find out the value of redundent bit using odd parity bit

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* $m = 01100100110$

$m = 11$

$r = \cancel{3}\,4$

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

$2^{\cancel{r}} \geq 11 + \cancel{r} + 1$

$2^r \geq 12 + r$

$2^4 \geq 12 + 4$

$\boxed{16 \geq 16}$ True.

Data length $= m + r$

$= 11 + 4$

$= \boxed{15}$

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	1	1	0	0	1	0	1	0	1	1	0	0	1	0
							P8				P4		P2	P1

Even Parity.

P1: 1 3 5 7 9 11 13 15

0 0 1 0 0 0 1 0

P2: 2 3 6 7 10 11 14 15

1 0 1 0 1 0 1 0

P4: 4, 5 6 7 12 13 14 15

0 1 ɸ 0 0 1 1 0

P8: 8 9 10 11 12 13 14 15

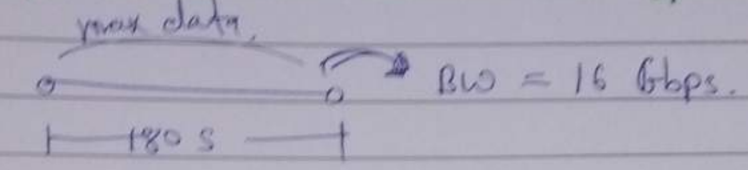
1 0 1 0 0 1 1 0

Final Data: 011001010110010

Condition for correct TCP operation is —

$\boxed{WRAT >= LT}$

Q If LT is 180 sec & BW is 16 Gbps then how many seq no are required for the correct TCP operations.



Max Data transmitted in 180 sec

1 sec → 16 gbps

180 sec → 16 × 180 g bits

$DS = 16 \times 180$ Bits $= 2 \times 180$ G Byte

$= 360$ gbit.

$\#$ SNo possible $= \dfrac{360\ gb}{1\ B/sec.} = 360$ g seq N.

$= 2^9 \times 2^{30}$

$= 2^{39}$ Seq No

$\boxed{39 \text{ bits}}$

Q How many extra bit required for correct TCP opn.

In TCP = SNo = 32 bits

Extra bits = 39 − 32

= 7 bits.

Q - Find WAT. of a link with. 40 mbps BW ~~ating~~ using 24 bits. seq No.

1 seq No — 1 Byte

2^{24} seq No = 1×2^{24} Byte = 8 mB

40 mbps ⟶ 1 sec

1 sec ⟶ $\frac{1}{40 \text{ mbps}}$

8 mbyte ⟶ $\frac{8 \text{ mb}}{40 \text{ mbps}}$

$$\frac{8 \times \cancel{10^6} \times \cancel{8}}{\cancel{40}_5 \times \cancel{10^6} \cancel{8}} =$$

1.6

LifeTime : A amount of time a Byte can be alive for their life.

The amount of time a Byte can be alive on internet.

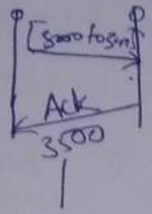
This is the max time for a Byte can be present in the internet Envioranment before being received by receiver.

⟹ In general Life time = 3 min

= 180 sec for a Byte.

Seq No are Possible = 2^{32} $[0 \text{ to } 2^{32}-1]$

$$\begin{array}{r} 3499 \\ 3000 \\ \hline 499 + 1 \end{array}$$
$\Rightarrow 500$ B.



3000 — Seq No $\Rightarrow$ 1st Byte
3001 — 2nd
3499 — last
} 500 Byte

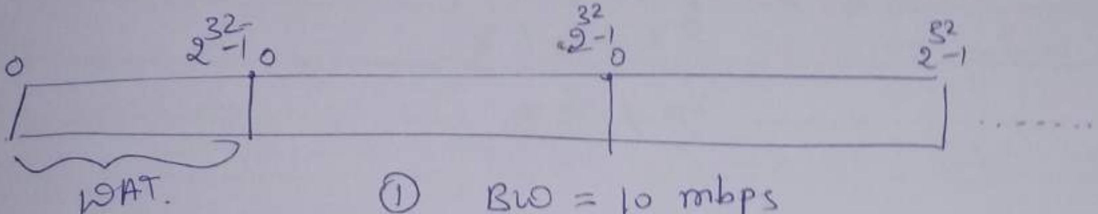
Seq No of Next segment (expected)

$2^{32} = 1 \times 2^{32}$ Byte $= 4$ GB.

At once, only 4 GB can be represented by 32 bit seq No

WAT → Wrap around time.

It is the time taken to use all the seq No. at one time.



① BW = 10 mbps

32 bit seq No

WAT = ?

1 S. No → 1 Byte

2^{32} S.No → 1 Byte × 2^{32} = 4 GB.

10 Mb → 1 sec

1 mb → $\frac{1}{10 \times 10^6}$ sec

4 GB → $\frac{4 \times 10^{30} \times 8}{10 \times 10^6}$ =

$T_t = \frac{L}{B}$

$= \frac{4 \text{ GB}}{10 \text{ mbps}}$

$= \frac{4 \times 2^{30} \times 8 \text{ bits}}{10 \times 10^6 \text{ bit/sec}}$

$= 3435.97$ sec

$= 57.26$ min.

$\boxed{\text{BW} \uparrow = \text{WAT} \downarrow}$

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[49151 - 65535] - Dynamic port
Application.

NOTE :- All the properties of circuit switching is applicable to TCP.
→ It is connection Oriented protocol.

There are 3 phases in circuit switching.
① $Conn^n$ establishment
② Data transfer.
③ $Conn^n$ finish.

(9). Sequence Number (32 bits)
⇒ Byte Oriented protocol.
⇒ In TCP the data is called Segment (group of Byte)
⇒ 32 bits is given to seq No - bcoz here the data is transmit on internet, so the data is large in size Therefore more Seq No is required.

[seq No is assigned to segments i.e. group of Byte]

NOTE In the DLL, seq No are given for every frame.
In the TCP, Seq No are given for every Byte in the Segment.

→ Seq No attached to the segment No. It is the random no b/w 0 to $2^{32}-1$ bcoz of Security reason.

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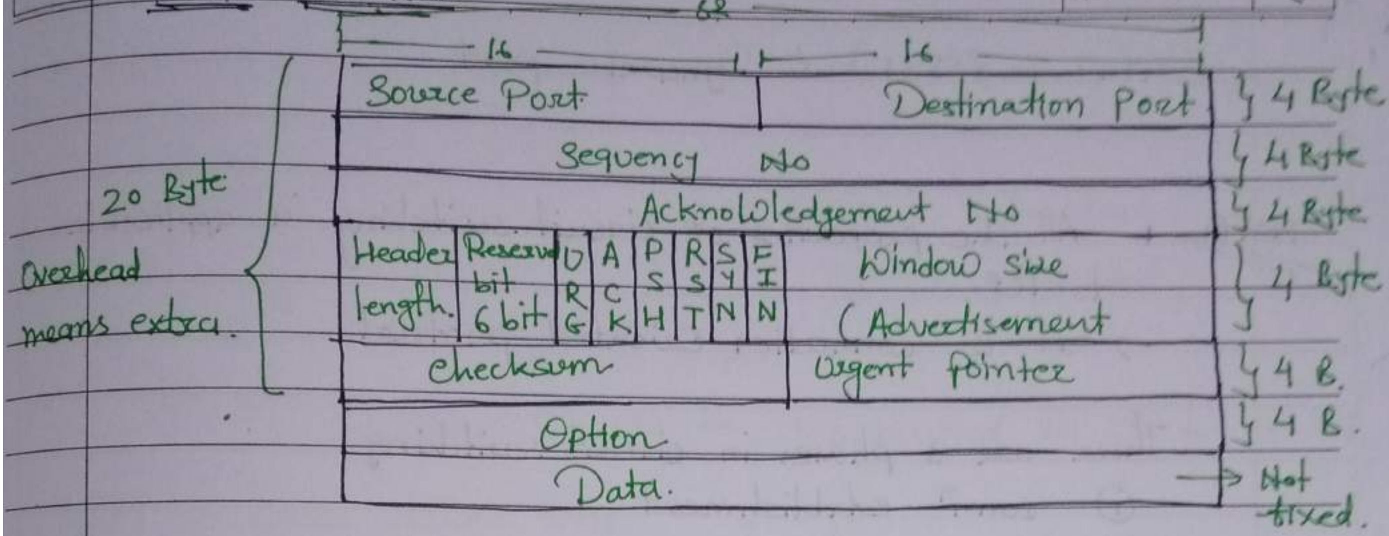
Header format



Port No : It is 16 bits.

⇒ To identify the process/service, port address is provided.

→ #port No, are possible $= 2^{16} = 65536$ [0 to 65535]

[0 - 1023] : predefined port, fixed port, universal po

80 : HTTP

20 : ftp

25 : SMTP.

⇒ In real time there are some pre~~x~~define application, we can not change

[1024 - 49151] : Registed ports

Networking company are using these many ~~protocol~~ ports to test the protocol which they are developing.

⇒ IANA, will give some port address from 1024 to 49151.

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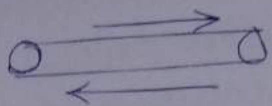
→ TCP ensure in order delievery. | Sequence Number 32 bit.

→ TCP full duplex 

→ TCP Work in collaboration with IP.
to have a good & well connⁿ for Every connection
We need. 4 address. (1) SPN } TCP → TL
(2) DPN
(3) SIP } IP ⇒ NL.
(4) DIP

→ TCP can use both selective & Commulative ACK.
(F+ACK)

- TCP Use a combination of selective Repeat & GBN protocol.
- Sendersize = receiver size.

⇒ TCP is a Byte oriented protocol.

⇒ TCP provide error checking & Recovery mechanism.
(Byte level) checksum.

TCP Segment Header:-

⇒ TCP segment header consist of two parts
(1) Header (2) Data.

→ The TCP header consist of ~~8~~ 11 field of which only 10 are required. & the 11 field optional & name is "Option"

* Transport Layer protocols: 4/7/21

⇒ There are mainly 2 transmission layer protocols that are used on the Internet

① TCP : transmission Control protocol

② UDP : User Datagram protocol.

TCP/IP — Port No; IPA — Identification of host.

TCP

A • - - - - - - - - - - - - - - • B

SPA — Source Port Address

SIP

DPA — Destination Port address

DIP

Major protocol. ① Bit oriented — HDLC

② Byte — TCP

③ Msg — UDP.

⇒ TCP is a reliable protocol.
because it guaranty the delievery of data pkt to its correct destination.
After receiving data pkt, receiver send an ACK. to the Sender

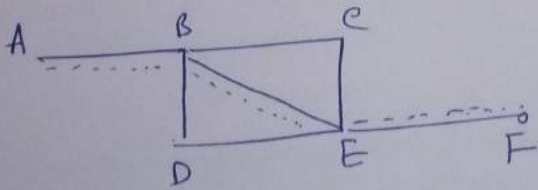
⇒ TCP is a Connection Oriented protocol.

① Connection establishment

② Data transmit

③ Connection termination.

Path decided



⇒ TCP handle both congestion & control flow.

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Q Consider 100 Base T cable ethernet with η at 50%. Assume frame size = 1 KB & propagation speed = 2×10^8 m/sec. Calculate the distance b/w node?

$$\eta = \frac{T_t}{T_t + 6.44 T_p}$$

$BW = 100$ mbps

$\eta = 50\%$

$L = 1$ KB

$V = 2\times10^8$ m/s

$$\frac{1}{2}\ \cancel{50\%} = \frac{1.024\times8\ \mu s}{1.024\times8\ \mu s + 6.44\ \frac{d}{2\times10^8\ m/sec}}$$

$$\boxed{d = 2.48\ km}$$

$T_t = L/B$

$= \frac{1\ KB}{10\ mbps}$

$= \frac{1024\times8\ bit}{10\times10^6\ b/s}$

$\boxed{T_t = 1.024\times 8\ \mu s}$

Q Consider a 10 mbps channel. LAN has station attached to a 2.5 km long cable. Given that transmission speed = 2.3×10^8 m/sec. & L = 128 byte & out of which 30 byte are overhead. find the effective transmission rate & max data rate at which n/w can send data.

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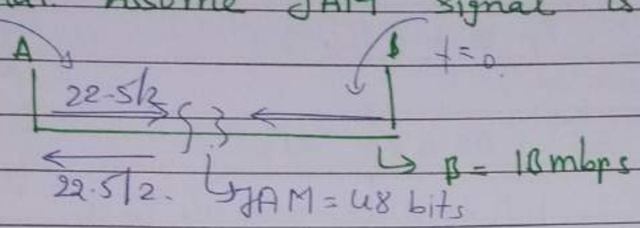
Q Suppose Node A & B are on the same 10 mbps of Ethernet segment & propogation delay b/w 2 node is 225 bits time. Suppose A & B send frame at t=0 the frame is collide than at what time A/B finish transmitting a JAM signal. Assume JAM signal is 48 bit long.



1 bit delay $= \frac{1}{BW}$

$= \frac{1}{10 \times 10^6}$ b/s

10×10^6 bits ——— 1 sec

1 bit $\longrightarrow \frac{1}{10 \times 10^6}$ Sec = 0.1 μs = 0.1 μs

T_p = 225 bit delay

= 225 ~~bits~~ * 0.1 μs / ~~bit~~ = 22.5 μs

$T_t = \frac{L}{B} = \frac{48.5 \text{ bits}}{10 \text{ mbps}} = 4.8$ μs

A finish transmission after delay

$= \frac{T_p}{2} + \frac{T_p}{2}$ + JAM delay

$= \frac{22.5}{2}$ (S→M) + $\frac{22.5}{2}$ μs (M to S) + 4.8 μs (JAM)

= 22.5 μs + 4.8 μs

= $\boxed{27.3 \text{ μs}}$

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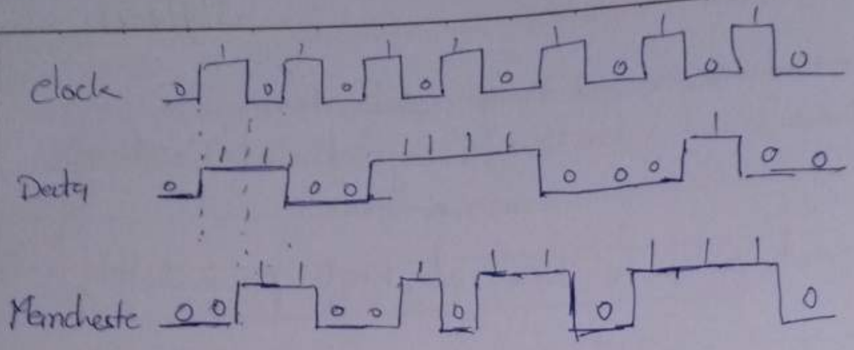

~~Q Group of N station share a 6~~

Q Consider. 802.3 LAN with N = 500 station channels to 500 M segment. Data rate is 10 Mbps & the slot time is 51.2 us. If pkt size is 512 byte What is the η of channel of $ no of collision. Slot are 1.716.

$N = 500$

$d = 500 M$

$BW = 10$ Mbps.

$T_{slot} = 51.2$ us

$e = 1.716$.

$L = 512$ Byte

$$\eta = \frac{T_t}{T_c + T_t + T_p}$$

$$= \frac{T_b}{T_t + T_c}$$

$$= \frac{512 \times 8}{1.716 * 51.2 + 512 \times 8}$$

$$\boxed{\eta = 82.3\%}$$

$T_t = L/B$

$= \frac{512 \text{ Byte}}{10 \text{ mbps}}$

$= \frac{512 \times 8 \text{ Bits}}{10 \times 10^6 \text{ b/s}}$

$= 512 \times 8 \times 10^{-7}$ sec

$= 51.2 * 8$ us

$T_p = \frac{d}{v}$

$\because T_p = 6$

$T_c = e * RTT$.

$= e * T_{slot}$

$= 1.716 * 51.2$ us

Limitations 3/7/2021

1) It can'nt be used for real time application
↳ delievery of data within some time

ethernet is not reliable bcz of high probabillity of collisions
↳ Delay.

2) It cannot be used for interactive application
It is not applicable for 1B/2B data
Min size is fix 46 B.

3) It can not be used for client-server application.
↳ Priority.

* client server applications require that server must be given higher priority than clients.

* Ethernet has no facility to set priorities

Manchester Encoding : (Phase Encoding)

Original Data	clock	oper	Manchester Encoding
0	0	XoR	0
	1		1
0	0	XoR	1
	1		0
1			
1			

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⇒ The length of payload is [46 B, 1500 B]

min — 46 B, max — 1500 B

(7) CRC [4 Byte]

⇒ It is a 4 Byte field

⇒ It is use for E.C

NOTE min Frame Size = [DA + SA + length + Datasize + CRC]

$= 6 + 6 + 2 + 46 + 4$ ↳ at DLL

$= 64$ Byte

Max Frame size = DA + SA + length + DS + CRC

$= 6 + 6 + 2 + 1500 + 4$

$= 1518$ Byte [w/o Preamble & SFD]

With Preamble & SFD

Min Fs = 64 B + 8 Byte = 72 B

Max Fs = 1518 + 8 = 1526 B.

Advantage :

⇒ It is very simple to understand & implement

⇒ It's maintainance is easy.

⇒ It is a cheap

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47 : 20 : 1B : 2E : 08 : EE

01000111 : 00100000 : 00011011 : 00101110 : 00000000 : 11101110

⇒ 1110 0010 : 0000 0100 11011000 01110100 00010000 0111 0111

E2 : 04 : D8 : 74 : 10 : 77 Ans

(5) length: It is a 2 Byte field which specifies the length (no of bytes) of the data field.

2 Byte = 16 bits

The max value that can be accomodated in this field.

$2^{16} = 65535$ [0 to 65535]

But it doesn't mean max data that can be send in one frame is 65535 Byte.

⇒ The max amount of data that can be send in a ethernet frame is 1500 Byte.

⇒ Advantage : This is to avoid the monopoly of any Station.

(6) Datafield :

Disadvantage : It is a variable field contains the actual Data.

⇒ Also called a payload field (Actual data).

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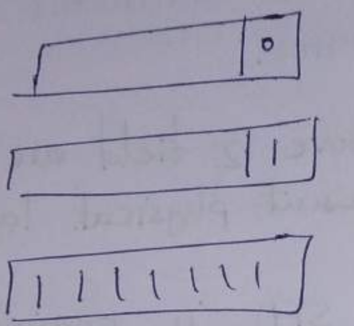
① Unicast : [If last Bit of 1^{st} Byte is zero]

② Multicast : [If last Bit of 1^{st} Byte is one]

③ Broadcast : If we have all 1 in MAC Address



: Even

: odd

: All 1's.

Q. Define the type of following MAC address

① 4A : 30 : 10 : 21 : 10 : 1A → Unicast

② 4B : 20 : 1B : 2E : 08 : EE —— Multicast.

③ FF : FF : FF : FF : FF : FF —— Broadcast

Q. Show how the address 47 : 20 : 1B : 2E : 08 : EE is sent out on line.

Mac address will be transferred byte by byte in which each Byte least significant bit is placed first.

⇒ MAC Address is sent Left to Right byte by byte. for each byte is sent.

② Start frame Delimeter :

⇒ It is a 1 B. field. Pattern

⇒ It is always to 10101011 }

⇒ The last 2 bit "11" indicate the end of start frame delimeter & marks the beginning of the frame.

Note * The above 2 field are added by the P.L & represent physical layer header.

⇒ Sometimes, SFD, is considered to be a part of preamble (8 byte)

③ Destination Address :-

⇒ It is a 6 Byte field the contains the MAC address of the destination for which the data is transmitted.

1B : AB : CA : BD : 12 : 00

|———MAC———|

④ Source Address :

⇒ It is a 6 Byte field that contains the MAC address of the src which is sending the data.

type of MAC Address

① Unicast ② Multicast ③ Broadcast

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* Specification of Ethernet 802.3 :-

① Data Rate = 100 mbps, 10 mbps, 1000 mbps = 1gbps
fast, slow, ↳ Very fast

② signal : manchester signal.

③ physical address : 48 bit mac address.
↑ ethernet address.

7 Byte	1 Byte	6 Byte	6B	2B		4B
Preamble	SFD	D.A	SA	length	Data	CRC

46 Byte 1500 Byte

① Preamble :

⇒ It is a 7 Byte ~~feild~~ field that contain's a Pattern of alternating 0's & 1's

10101010 10 ....,

⇒ It alerts the station that a frame is going to start.

⇒ It also enable the sender & receiver to establish the bit synchronisation

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$P_{max} \Rightarrow \frac{d P_{succ}}{dp} = 0$

At $\Rightarrow p = 1/n$ we get the max value of P_{succ}.

Thus $P_{succ} = {}^{n}C_{1} * 1/n * (1 - 1/n)^{n-1}$

$\underline{Max}$

$= \frac{n!}{1! * (n-1)!} * \frac{1}{n} * \left(1 - \frac{1}{n}\right)^{n-1}$

$= \cancel{n} * \frac{1}{\cancel{n}} * \left(1 - \frac{1}{n}\right)^{n-1}$

$$\boxed{P_{succ} = \left(1 - \frac{1}{n}\right)^{n-1}}$$

Imp - In CSMA/CD / ethernet.

1. $T_t >= 2T_p$
2. $\eta = \frac{1}{1 + 6.44a}$ $\quad a = T_p / T_t$
3. $P_{succ} = {}^{n}C_{1} * p * (1-p)^{n-1}$
4. $P_{succ_{max}} = \left(1 - \frac{1}{n}\right)^{n-1}$

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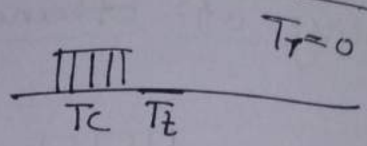
If data is not transmitted,



$$\eta = \frac{T_t}{T_c + T_t}$$

$$\boxed{\eta = \frac{T_t}{2e\,T_p + T_t}} \quad //.$$

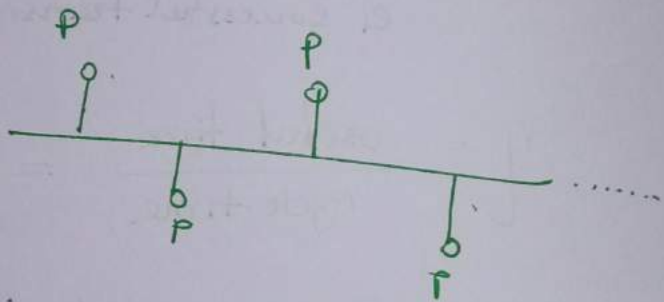
$\because\ 1 + 2e = 6.44$

$2e = 5.44.$

$$\boxed{\eta = \frac{T_t}{T_t + 5.44\,T_p}} \quad //.$$ Approax.

* Probabilistic Analysis:

n = no of stations...... connected to a CSMA/CD network.



successfully transmission condition -

① One station transmit the data.

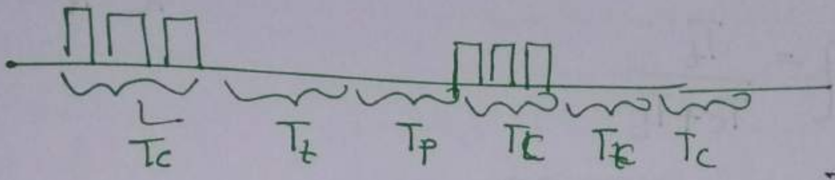
② after (n-1) station do not transmit the data

$$\text{Probability } P_{succ} = n_{C_1} * \underset{\downarrow}{P} * (1-P)^{n-1}$$

P → Prob of succ. Transm of one Station

$(1-P)^{n-1}$ → Prob of other (n-1) station don't send data

efficiency of ethernet



T_c = Collision time.

T_t = transmission delay

T_p = Propogation delay.

Cycle time = Total time = $T_c + T_t + T_p$

T_c = Time worked during collision.

$= e * 2T_p$ — time is wasted during each collision.

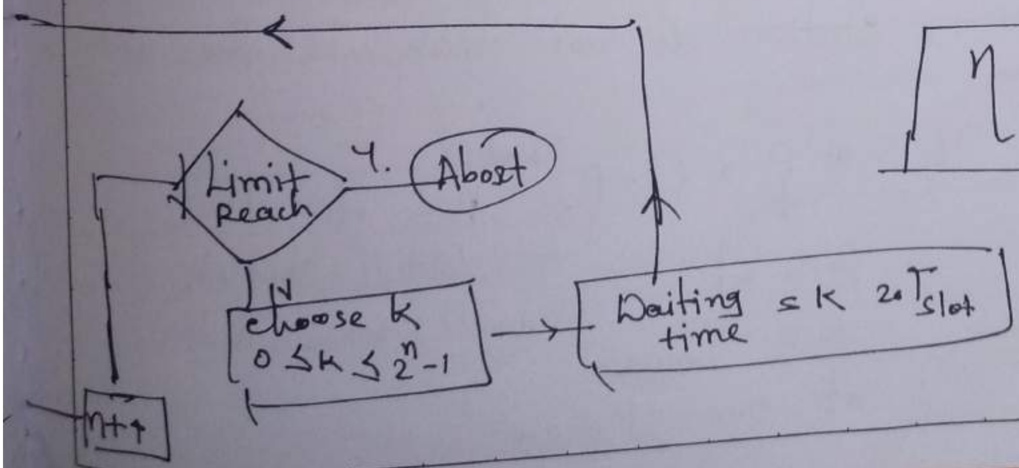
e — Avg no of collision before a successful transmission.

$$\eta = \frac{\text{useful time}}{\text{cycle time}} = \frac{T_t}{T_c + T_t + T_p} = \frac{T_t}{2eT_p + T_t + T_p}$$

$\boxed{1+2e = 6.44.}$ ← fix.

$$\boxed{\eta = \frac{T_t}{T_t + (1+2e)T_p}}$$

$$\boxed{\eta = \frac{T_t}{T_t + 6.44\, T_p}}$$



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B prob $\frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}$

exponentially decreaded.

Note: sending prob of B is ↓ (decreasing) exponentially hance called exponential backoff algorithm.

Disadvantage:

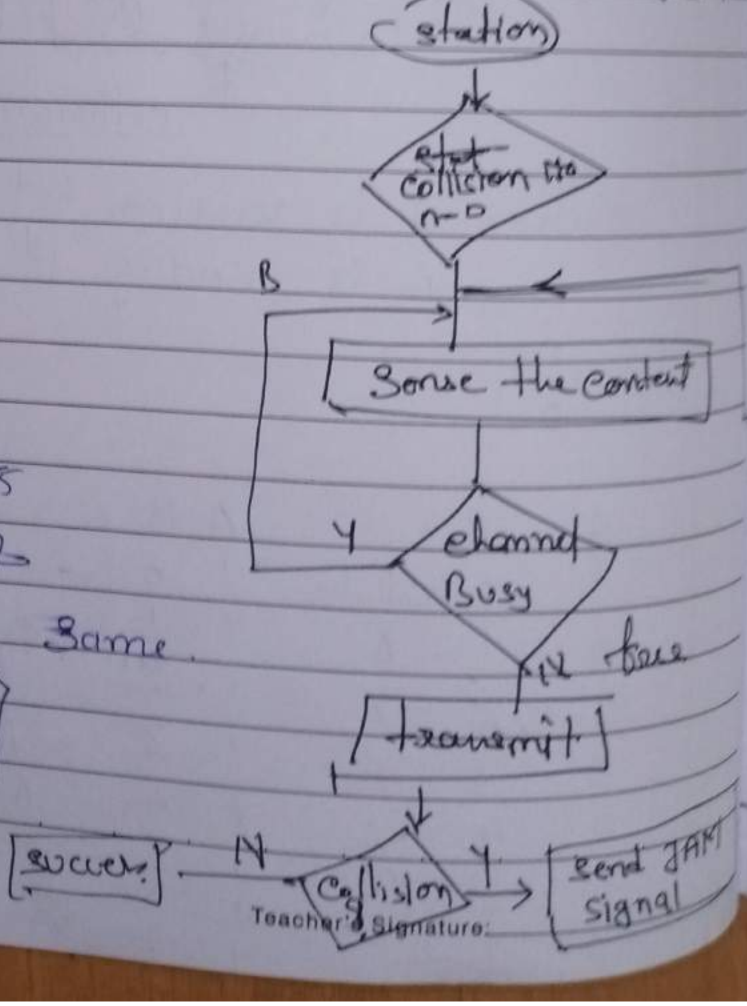
Capture effect: suffers from capture effect. (A win continuously)

— x —

* n = collision k = slot. $0 \leq k \leq 2^n - 1$

n		k
0	→	0
1	→	1
2	→	3
3	→	7
4	→	15
5	→	31
6	→	63
7	→	63
8	→	127
9	→	~~511~~ 255
10	→	511
11	→	1023
12		1023
⋮		⋮

Same.



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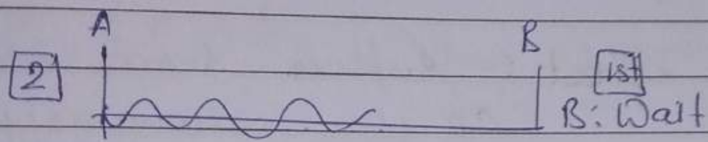
$T_{slot} = k \cdot 2T_T$

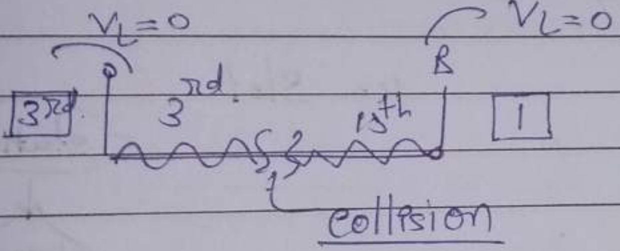
Sending prob of A = $5/8$ = 62.5 %

sending prob of B = $\frac{1}{8}$ = 12.5 %

Station A win. 2^{nd} Backoff.



Case 3



station A is sending 3^{rd} frame first time.
B is sending 1^{st} frame 3^{rd} time.

$n = 1$
0, 1

$n = 5$
$k = 0, 1, 2, 3, 4, 5, 6, 7$

A	B		A	B	
0	0	collide	1	0	B
0	1	A	1	1	collide.
0	2	A	1	2	A
0	3	A	1	3	A
0	4	A	1	4	A
0	5	A	1	5	A
0	6	A	1	6	A
0	7	A	1	7	A

Sending prob A = $\frac{13}{16}$ = 81.25%

B = $\frac{1}{16}$ = 6.25%

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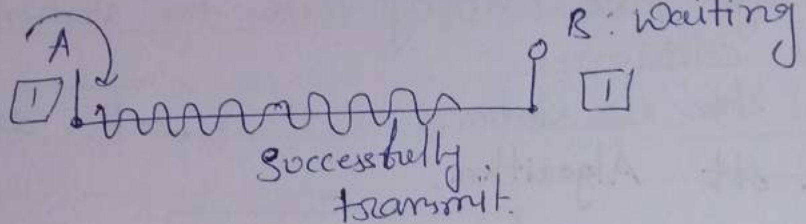
$\boxed{T_{slot} = K * RTT}$

Sending probability of $A = \frac{1}{4} = 25\%$

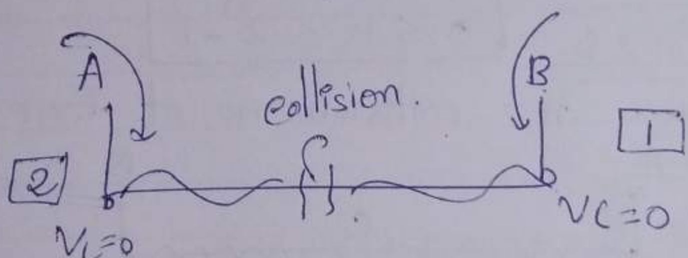
" " of $B = \frac{1}{4} = 25\%$

Total sending prob $= \frac{2}{4} = \boxed{50\%}$

Assume if station A win 1^{st} Back off



Case 2 :



station A is sending 2^{nd} frame 1^{st} time

station B sending 1^{st} from 2^{nd} time

$n = 1$

$0 \leq K \leq 2^1 - 1$

$0 \leq K \leq 1$

$K = 0, 1.$

A	B
0	0 — collision
0	1 — A
0	2 — A
0	3 — A
1	0 — B
1	1 — collision
1	2 — A send
1	3. — A send.

$n = 2$

$0 \leq K \leq 2^2 - 1$

$0 \leq K \leq 3$

$K = 0, 1, 2, 3$

delay or received by exponential Back off algo
goto A:
}
else { done with frame & no collision
}
else
wait until on going transmission is over & goto A.

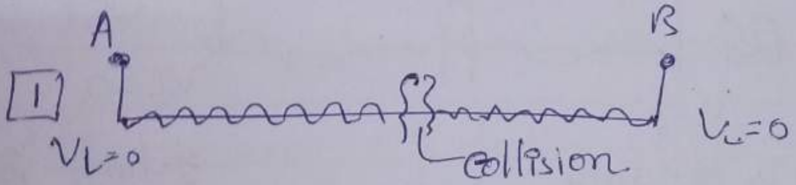
* Exponential BackOFF Algorithm

⇒ This algo give waiting time for station involved in the collision.

⇒ Works for 2 station, so it is called as Binary Back off Algorithm.

$$\boxed{0 \leq K \leq 2^n - 1}$$

where n = collision no of Frame



→ A sending its first frame   B sending First Frame.

Both are collide first time.

$\boxed{n = 1}$

$0 \leq K \leq 2^n - 1$

$0 \leq K \leq 2^1 - 1$

$0 \leq K \leq 1$

↳ {0, 1}

A	B
0	0 → collision
0	1 → A sends
1	0 → B sends
1	1 → collision

$0 \leq K \leq 2^n - 1$

$0 \leq K \leq 2^1 - 1$

$0 \leq K \leq 1$

↳ {0, 1}

EXPT. NO. NAME: Page No.: Date:

Q 2 km long broadband LAN has 10^7 bps are CSMA/CD what is min fram size if $v = 2*10^8$ m/s.

$d = 2$ km

$BW = 10^7$ bps

$v = 2*10^8$ m/s

$T_f >= 2 \cdot T_p$

$\frac{L}{BW} >= 2 \frac{d}{v}$

$L >= 2 * \frac{d}{v} * BW.$

$>= \cancel{2} * \frac{2 \times 10^3 m}{\cancel{2} * 10^8 m/s} * 10^7 bps$

$L >= \frac{2 \times 10^2}{} $ byte

$L >= \frac{\cancel{2} \times \cancel{100}^{25}}{\cancel{8}\,4}$ bit

$\boxed{L_{min} = 25 \text{ Bit}}$

Algorithm:

A: Sense the channel.
If channel is free
then transmit & monitor the channel.
If detect another transmission then
{
kill transmission & generate JAM signal
rep-date collision of frame (k)

Teacher's Signature:

EXPT. NO. | NAME: | Page No.: | Date:

Q. Consider building a CSMA/CD Network running at 1 Gbps over a channel. If distance b/w. Sender & receiver is 1km what is the minimum frame size if velocity $v = 2 * 10^8$ m/sec.

$B = 1$ Gbps

$d = 1$ km

$v = 2 * 10^8$ m/s.

$= 2 * 10^5$ km/s

$T_t >= 2 \cdot T_p$

$\frac{L}{B} >= 2 \cdot T_p$

$L >= 2 \cdot T_p \; B_w$

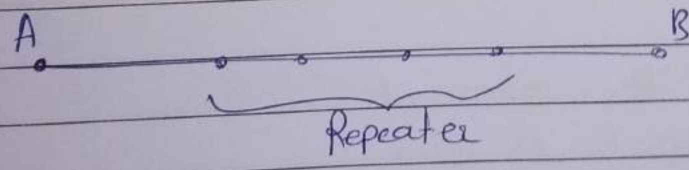
$>= 2 \cdot \frac{d}{v} \cdot B_w$

$>= 2 * \frac{1\,Km}{2 * 10^5\,Km/sec} * 1\,GBPS$

$>= 10^{-5} * 10^{9}$ ~~Bit~~ Byte.

$> \frac{10000}{8}$ Bit

$\boxed{L >= 1250 \text{ Bit}}$



$T_t >= (T_p + n * T_r) * 2$

Where n = no of Repeater

T_r = Repeater delay.

$\boxed{T_t >= 2(T_p + n * T_r)}$

Teacher's Signature:

Min Packet size in ethernet = $\boxed{T_t \geq 2 \cdot T_p}$

* **Detecting the collision:**

⇒ It is the responsibillity of the sender to detect the collision.

⇒ For detecting the collision, CSMA/CD implements the following condition.

For each station $\boxed{T_t >= 2 \cdot T_p}$

⇒ According to this condition

- Each station must transmit the data pkt of size whose transmission delay is at least twice of its propogation delay.

⇒ • If the size of pkt is smaller then collision, detection would not be possible.

$T_t >= 2 \cdot T_p$

$\frac{L}{B} >= 2 \cdot T_p$

$\boxed{L >= 2 \cdot T_p * BW}$

Where L = Packet size

$\boxed{L >= 2 \cdot \frac{d}{V} \cdot BW}$

$T_t >= 2 \cdot T_p$

$T_t >= RTT$

$\frac{L}{BW} \geq RTT$

$\boxed{L \geq RTT * BW}$

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⇒ If the channel a free, it transmit with probability p.

Advantage : Reduce # collision & improve efficiency of network.

CSR
CSMA / CD : ethernet : IEEE 802.3.

↳ Carrier Sense multiple access / collision Detection.

⇒ CSMA/CD protocal are same as CSMA with addition the collision detection feature.

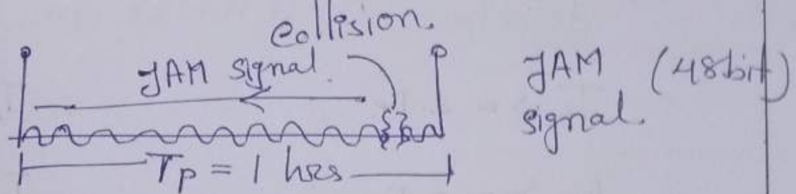
⇒ It is similar to CSMA.

⇒ It is used for Bus topology.

⇒ There is no flow control & pack level error control.

⇒ there is no ack.

⇒ Working / Procedure :



⇒ At t = 10:00 Am. Station A start transmission.

⇒ At t = 10:59 AB station B start transmission

⇒ At t = 11:00 AM. Collision occur. & generate JAM. signert

⇒ At t = 12:00 AM. station A will see the collision (through JAM signal) & stop the transmission.

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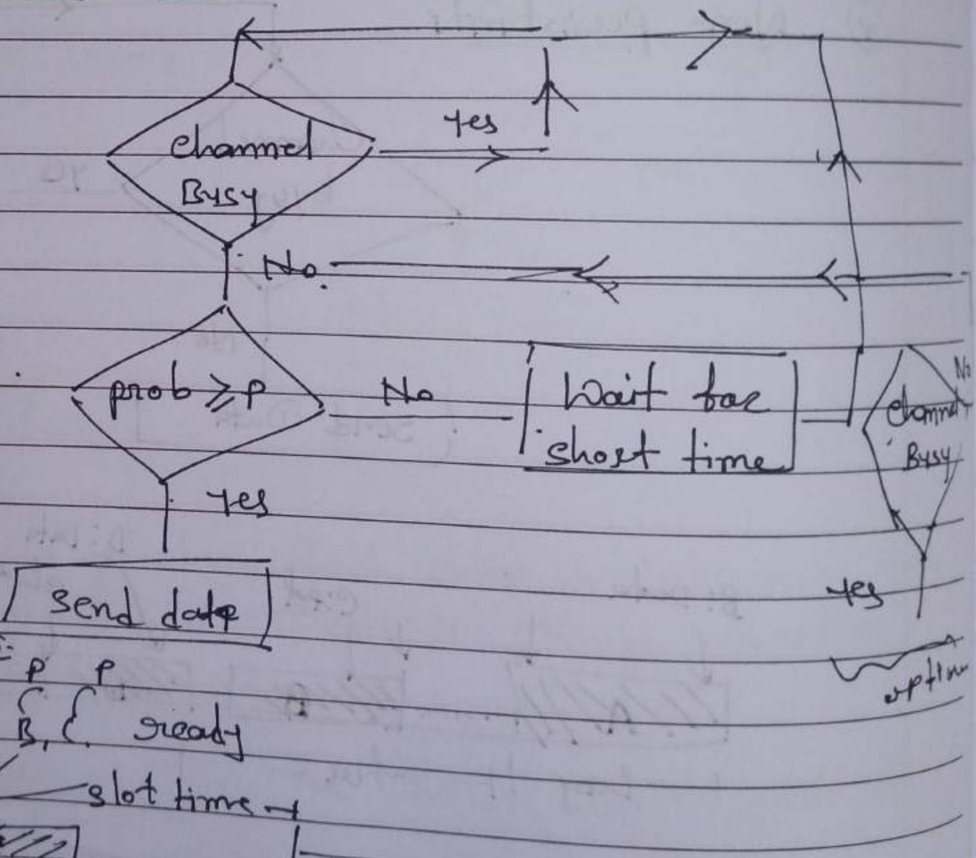
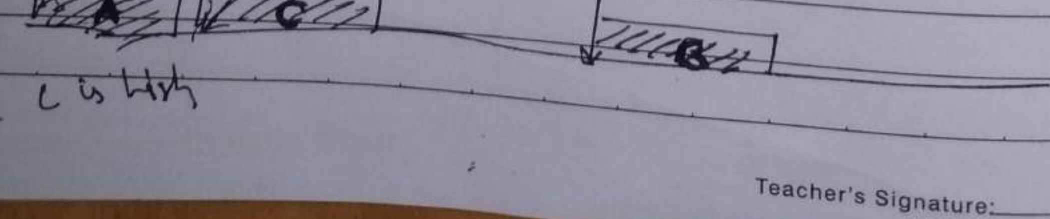
⟹ In non persistant, CSMA a node doesn't sense the channel continueously. It wait for a random amount of ~~time~~ interval of time before sending the data again.

<u>Advantage:</u> # collision less.

<u>Disadvantage:</u> channel utilization random because it gets free before has to wait random amount of time.

③ <u>P- persistant: CSMA:</u>

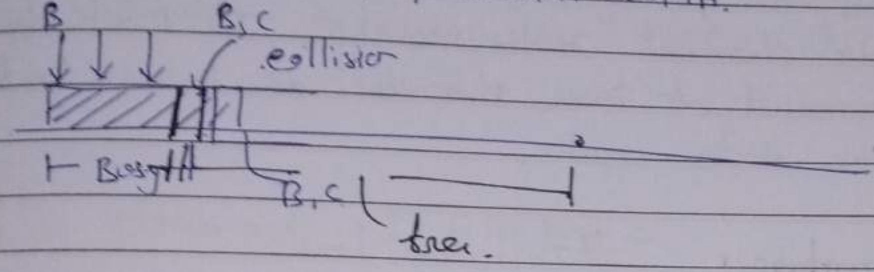




proc C is high

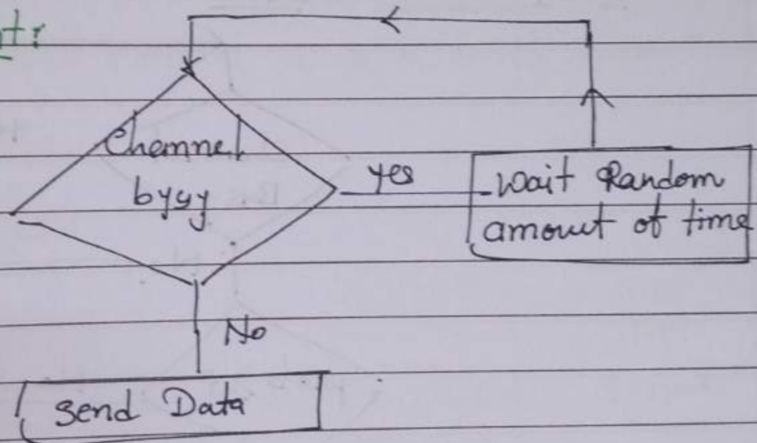
Teacher's Signature:

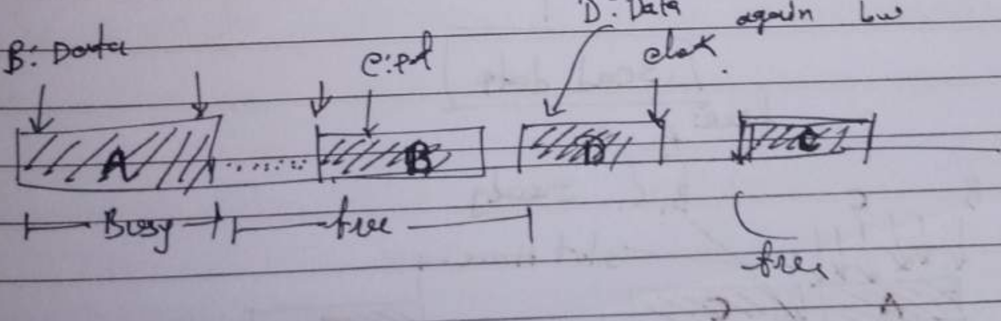
Here, it is called 1- persistant CSMA.



⇒ This method has the highest chance of collision because 2 or more may find the channel free at the same time. When the collision occur, the node wait a random amount of time & start all over again.

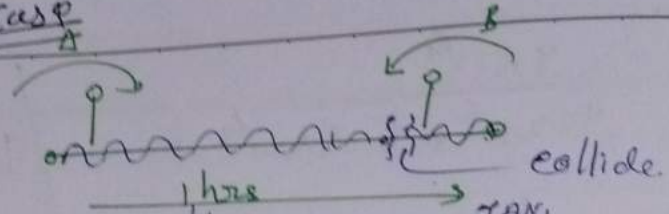
② Non- persistant:





WORST CASE

CASE 2



At 10:00 Am, A is sending the data.

at ~~11:00~~ 10:57 am B is sending the data.

at 11:00 Am data will be collide. at station B &

JAM signal will be generate.

At 12:00 Am : A will see the collision.

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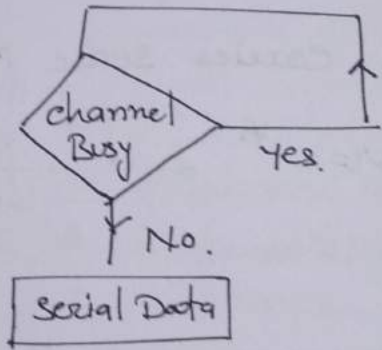
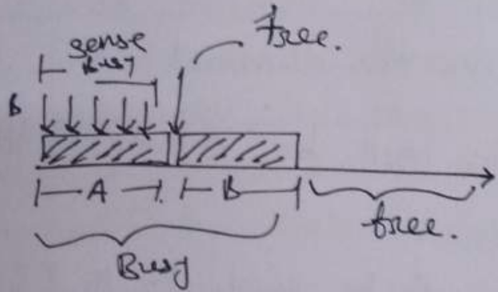
* CSMA : Carrier Sense Multiple access.

3 type

① Persistant CSMA.





⇒ In this method, station that want to transmit data sense the channel continuously to change wheather channel is free or not.

⇒ If the channel is busy, the station wait until it become free

⇒ When the station detect an idle channel, It immediately transmit the from with probability 1(one)

$$\cancel{\eta = \frac{8 \times 10^{-6}}{80 \times 10^{-6} s + 8 \times 10^{-6}} = 8}$$

$$\eta = \frac{800 \times 10^{-6} s}{80 \times 10^{-6} s + 800 + 10^{-6} s}$$

$$= \frac{800 \times 10^{-6} s}{880 \times 10^{-6} s}$$

$$\boxed{\eta = \frac{10}{11}}$$

Throughput $= \eta * BW$

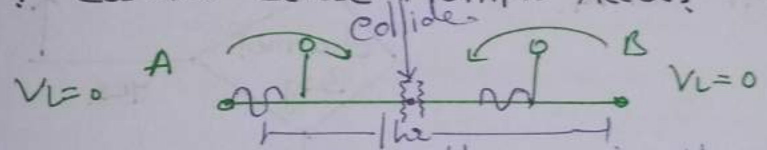
$= \frac{10}{11} * 10$ mbps

$= \frac{100}{11}$

$\boxed{= 9.09 \text{ mbps}}$

CSMA : Carrier Sense Multiple Access

CASE 1



→ At 10 am, A & B Both Sense the channel.

→ At 10:30 am ;- At mid ; data will be collide & JAM signal will be generate.

→ At 11:00 am. JAM signal will be reach to A & B station. Then station A & B will see the collision.

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$$\boxed{\eta = \frac{T_t}{T_{poll} + T_t}}$$

Advantage :

→ Unlike in TDM, no slot is wasted.
→ It lead to max η & BW utilization.

Disadvantage

⇒ Time is wasted during polling.
⇒ ~~Start~~ Starvation.

Q. A broadcast channel has 10 node & total capacity of 10 mbps. If use polling for medium access. once node finish transmission. There is a polling delay is 80 us. to poll next node. Whenever a node is polled it is allowed to transmit a max of 1000 B. Max throughput of broadcast is ______.

$N = 10$
$BW = 10 \text{ mbps}$
$T_{poll} = 80 \text{ us}$
$L = 1000 \text{ Byte}$

$$\eta = \frac{T_t}{T_{poll} + T_t + T_t}$$

$$T_t = \frac{L}{BW} = \frac{1000 \text{ Byte}}{10 \text{ mbps}}$$

$$= \frac{1000 \times 8 \text{ bit}}{10 \times 10^6 \text{ bps}}$$

800 us
$= 8 \times 10$

Teacher's Signature:

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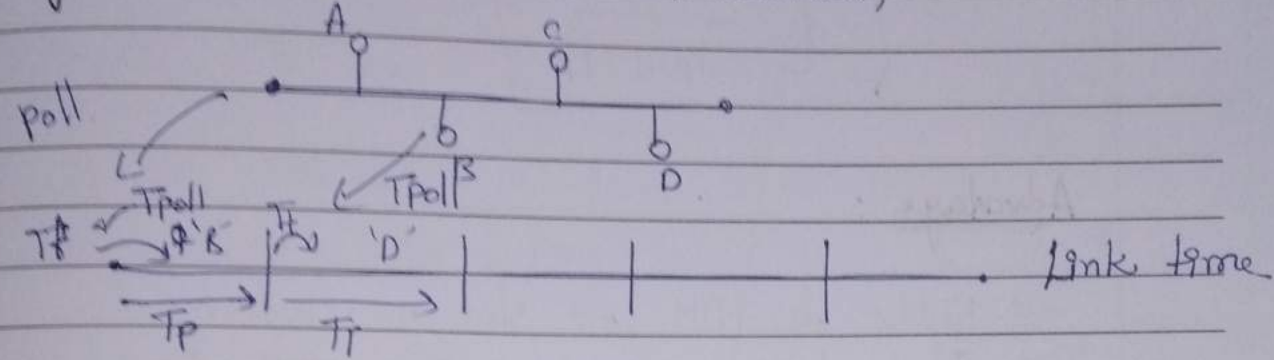
Polling : In this, access control method,



T_{poll} = time taken for polling

T_p = propogation time $= d/v$

T_t = transmission time $= L/BW$

→ A polling is conducted in which all the station willing to send data.

→ Polling algorithm chooses one of the station is to send the data.

⇒ the chosen station sends the data to the destination.

⇒ After the chosen station has send the data, cycle repeats

Time slot = total time / cycle time. $= \boxed{T_{poll} + T_t + T_p}$

$$\eta = \frac{\text{Useful}}{\text{Total}} = \frac{T_t}{T_{poll} + T_t + T_p}.$$

if T_p is not given in equation $\Rightarrow \boxed{T_p = 0}$

Q. If transmission delay & propogation delay is 1 ms each & 4 mbps BW then ___

① fined the η ② find eff BW ③ find n if each station Required 2 kbps.

$$\eta = \frac{T_t}{T_t + T_p}$$

$$= \frac{1\ ms}{1\ ms + 1\ ms}$$

$$= \frac{1\ ms}{2\ ms}$$

$$\eta = 0.5\ \%$$

~~Throughput ⇒ N * BW~~

~~50 mbps = N * 4 mbps~~

~~$N = \frac{50}{4} \cong 12$~~

~~$\boxed{N=12}$~~

throghput $= \eta * BW$

$= 50 \times 10$ mbps

$= 500$ mbps.

Max availlable effective BW = N * BW/stat.

500 mbps = N * 4 mbps

$$N = \frac{500\ mbps}{4\ mbps}$$

$\boxed{N=125}$ ✗

$\boxed{N=1000}$

in the LAN. So the throughput of each station can 2/3 mbps.

$$\text{Time slot} = 100 \text{ bit} + \text{end to end transmission.}$$

$$= \frac{100 \text{ bits}}{BW} + d/v.$$

$$= \frac{100 \text{ bits}}{\cancel{BW}\ 100 \times 10^6 \text{ bps}} + \frac{1 \text{ km}}{2 \times 10^8 \text{ m/s}}$$

$$= 10 \mu s + 0.5 \times 10^{-5}$$

$$= 10 \mu s + 5 \mu s$$

$$= 15 \mu s.$$

$$\eta = \frac{T_t}{T_t + T_p} = \frac{10}{15} \Rightarrow \boxed{\eta = \frac{10}{15}}$$

Max available effective BW = N * BW/station

$$= N * \frac{2}{3} \text{ Mbps}$$

$$\frac{100}{15} \text{ mbps} = N * \frac{2}{3} \text{ mbps}$$

throughput $= \eta * BW$

$$= \frac{10}{15} * 10 \text{Mbps}$$

$$= \frac{100}{15} \text{ mbps}$$

$$N = \frac{100 \times 3}{15 * 2}$$

$$\boxed{N = 10}$$

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→ In case, station doesn't have any data to send, its time slot goes waste.

→ Size of each time slots = $T_t + T_p$ $\qquad T_t = L/BW$

$T_p = d/v$.

$\eta = \frac{\text{useful time}}{\text{Total}}$

$= \frac{T_t}{T_t + T_p} \rightarrow \eta = \frac{1}{1 + T_p/T_t}$

$\boxed{\eta = \frac{1}{1+a}}$ $\qquad$ ∴ $\boxed{a = \frac{T_p}{T_t}}$

Throughput = η * BW.

→ Maximum available effective BW = Total # station * BW / station.

* Disadvantage :
⇒ If any station doesn't have the data to send during its time slot, then its time slot goes waste.

Q. In a TDM medium access control Bus each station is assigned 1 time slot per cycle for transmission. Assume that the length of each time slot is the time to transmit 100 bits + End to end propogation delay.

propogation speed = 2×10^8 m/s. length of LAN = 1KM & BW = 10 Mbps. Max no of station that can be allowed

Teacher's Signature:

78.15

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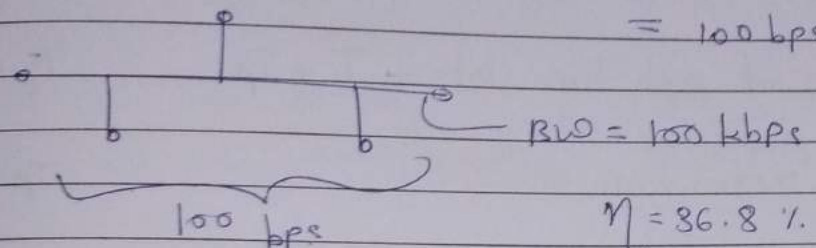
$$= \frac{500 \text{ bits}}{5000 ms} = \frac{1}{10} \times 10^3 \text{ bps}$$

$$= 100 \text{ bps}$$



$\eta = 36.8\ \%$

$$\text{throughput} = \eta * BW$$

$$= 36.8\% \times 100 \text{ kbps}$$

$$= 36.8 \times 100 \times 10^3 \text{ bps}$$

$$= \cancel{3680 \times 10^3}$$

$$= \frac{36.8}{100} \times 100 \times 10^3 \text{ bps}$$

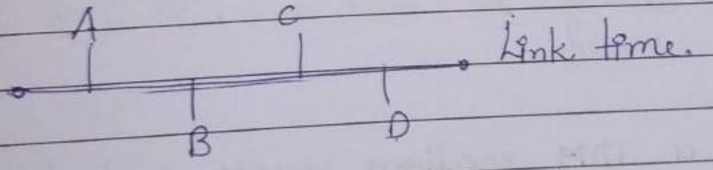
$$= 36.8 \text{ kbps}$$

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

$$\boxed{N = 368}$$

26/06/2021

* TDM (Time Division Multiplexing)



→ In TDM, time is divided into slot & each slot is given to one station in a round robin manner.

→ Time of the link is devided into fix size interval & allocate ~~for~~ station in advance.

Teacher's Signature:

Q If BW = 100 Mbps in slotted Aloha & every station need 1 Kbps what is max no of station that can be placed in LAN.

throughput $= \eta \times BW$

$= \cancel{36.8\%}$

$= 36.8\% \times 100$

$= 36.8$ mbps

$N = \dfrac{\text{throughput}}{BW}$

$= \dfrac{36.8 \text{ mbps}}{1 \text{ Kbps}}$

$= \dfrac{36.8 \times 10^{6} \text{ bps}}{10^{3} \text{ bps}}$

$\boxed{N = 36800}$

NOTE: ① $\eta = G \cdot e^{-G}$

② 1 Request perform in one time slot.

③ $\eta_{max} = 36.8\%$

④ The max η of slotted aloha is high due to less no. of collisions.

Q A group of N stations share 100 kbps slotted aloha. Each station output a 500 bits frame on an avg. of 500 ms. even if previous one has not been send. What is the required value of N?

$N = \dfrac{\text{throughput}}{BW.}$

~~throughput $= \eta * BW$~~

throughput = # bit transmit / unit time.

$= \dfrac{500 \text{ bits}}{10 \text{ ms}}$

NOTE : → Pure ALOHA $\eta = G * e^{-2G}$

→ 1 Request perform in 2 time slot.

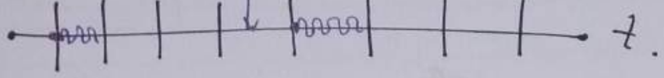
⇒ $\eta_{max} = 18.4\%$.

⇒ Max efficiency of P.A is very less due to large of no of collisions.

② Slotted ALOHA:

→ In this, time is divided into slots, where each slot is T_t & all station are forced to transmit only at the beginning of the time slot ______.

Not allow in the middle.



⇒ Any station can transmit its data in any time slot.

⇒ The only condition is that station must starts transmission from the beginning of the time slot.

⇒ If the beginning of the slot is missed, then station has to wait until the beginning of the next slot.

⇒ A collision may occure if 2 or more station try to transmit data at the beginning of the same time slot.

$\boxed{\text{Vulnerable time} = T_t}$

1 request / time slot.

$\boxed{\eta_{max} = 36.8\%}$

$\boxed{\eta = G \cdot e^{-G}}$

$$\eta_{max} = G \cdot e^{-G} = 1 \cdot e^{-G} = \frac{1}{e} = 36.8$$

$$\eta_{max} = 0.184 \Rightarrow \boxed{\eta_{max} = 18.4\%}$$ // V. Imp

Q. If B.W of a shared medium is 100 mbps then what is actual BW available in pure aloha.

max = 100mbps

$BW = 100$ mbps

$pA = \eta = 18.4\%$

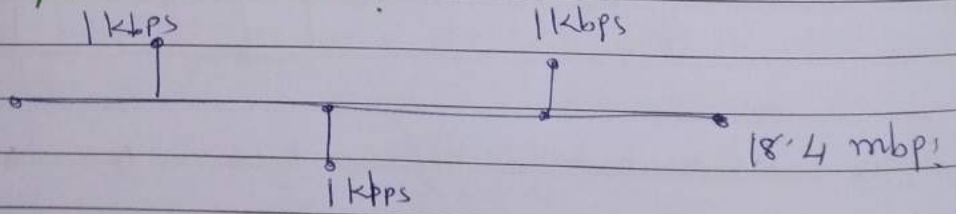
throughput $= \eta * B_W$

$= \cancel{100 \times 18.4\%}$

$= 18.4\% \times 100$ mbps

$= \boxed{18.4 \text{ mbps}}$

③ In above question, in that lan if every station ~~Same~~ want 1kbps. then how many station can take place in LAN ?



$$N = \frac{18.4 \text{ mbps}}{1\text{kbps}} = \frac{18.4 \cancel{\text{mbps}} \times 10^{\cancel{6}\,3}}{\cancel{10^3}}$$

$$N = \frac{\text{throughput of channel}}{\text{Bw / static}}$$

$= 18.4 \times 10^3$

$= 18400$

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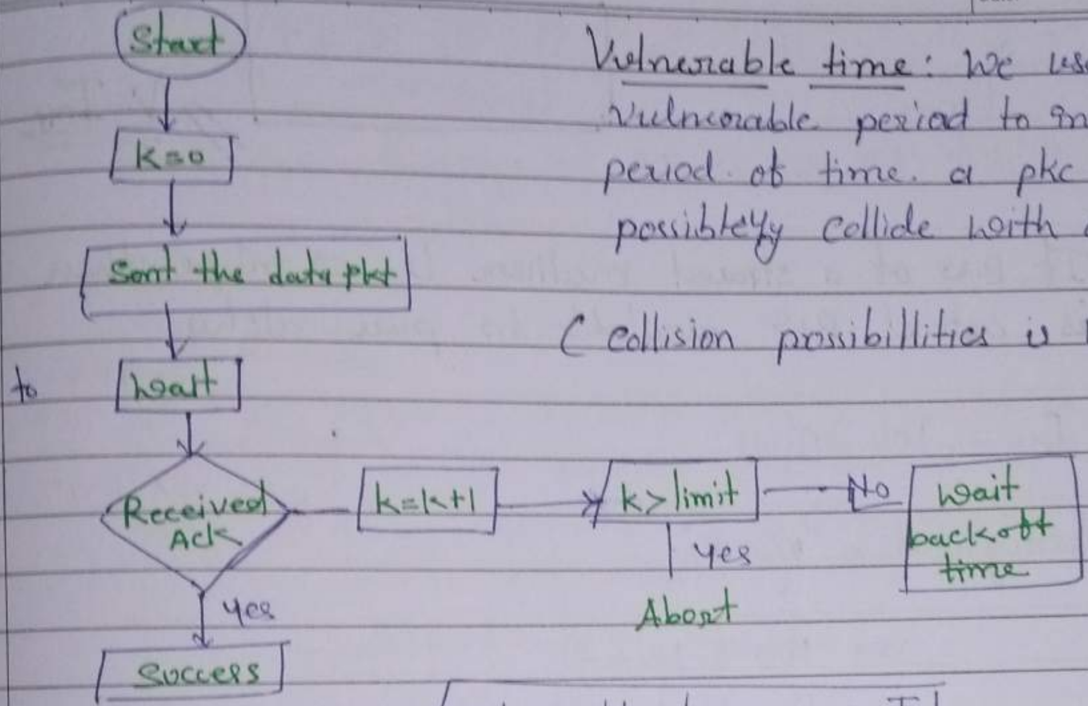


Vulnerable time: We use term vulnerable period to indicate the period of time a pkt can possibley collide with other pkt.

(Collision possibillities is 100%)

$\boxed{\text{Vulnerable time} = 2\,T_t}$

→ Vulnerable time means in this period if there is some other pkt than collision is happened.

→ One request pk per 2 time slot ($2T_t$).

Efficiency of ALOHA ⇒ $\boxed{\eta = G * e^{-2G}}$

G → No of stations want to transmit the data in time slot T_t

GMAX differentiate with respect to G

$$\frac{d\eta}{dG} = \frac{d}{dG}\left[G \cdot e^{-2G}\right]$$

$$0 = e^{-2G} + G\,e^{-2G}(-2)$$

$$G\,\cancel{e^{-2G}}\,2 = \cancel{e^{-2G}} \qquad \boxed{G = \tfrac{1}{2}} \rightarrow \frac{\#\text{request}}{\text{time slot}}$$

One request in 2 time slot

Teacher's Signature:

① **PURE ALOHA:**

⇒ It allows the stations to transmit data at any point of time.

⇒ After transmitting the data, pkt station wait for some time.

Following 2 cases are possible:

Case 1: transmitting station receive an ACK from the receiver station.

⇒ In this case, transmitting station assume that the transmission is successful.

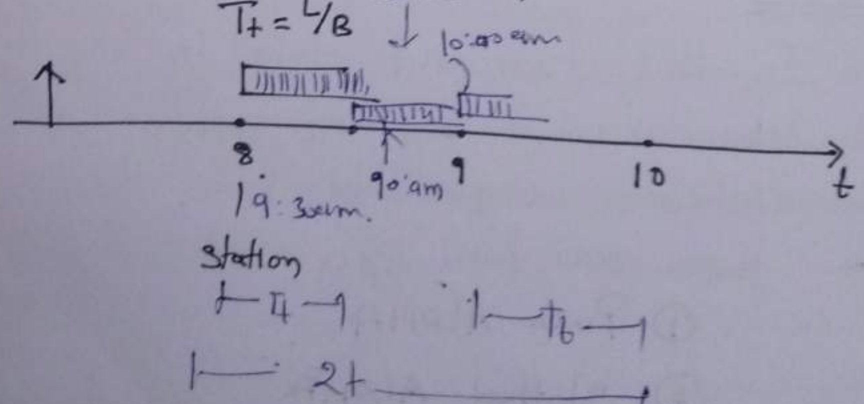
Case 2: Transmitting doesn't receive any ACK within specified time from the receiver station.

⇒ then thransmitting station assume that transmission is unsuccessful.

⇒ It use a backoff concept & wait for some random amount of time.

⇒ After backoff time, it transmit the data pkt again.

⇒ It keep trying until the backoff is reached after which it ends the transmission. (kill)



Only one station transmit data.

Access Control Method

25/06/2021

* Random Access technique:-

⇒ In the random access, there is no control on station.

→ Each station will have the right to use the common medium ~~It~~ without any control over it.

→ with increase in no. of station there is ~~an~~ increase probability of collision or access conflict.

⇒ the collision is occured when more than one user try to access the common channel./link/medium simultaneously.

→ As a result of such collision some frame can be either modified or destroyed.

⇒ RAM is also called contention base access.
In this, no station is assigned to control another.

⇒ RAM are useful for transmitting short msg.

⇒ The RAM are.
- ALOHA — In ALOHA, transmit data in any time. - No carrier sensing.
- CSMA/CD
- CSMA/CA.

* ALOHA

⇒ In this, transmit data in any time

⇒. there is no carrier sensing

⇒ Collision is possible.

⇒ there are two types
① Pure ALOHA
② Slotted ALOHA.

→ Different MAC are designed for different application by IEEE 802

- IEEE 802.1 → Define Architecture, mgmt & internetworking.

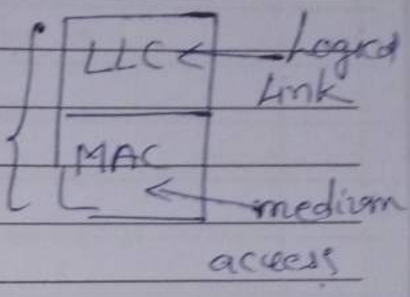
IEEE 802.2 → LLC standard
IEEE 802.3 → CSMA/CD : Ethernet
IEEE 802.4 → token Bus
.5 → token Ring
.6 → MAN N/w.
.7 → Bandpass technical Advisory group.
.8 → Fibre optics " " "
.9 → integrated data & voice N/w
10 → security Related infor, rules etc
.11 → Wireless LAN working group
.12 → Demand priority working group

.13 → Not in used bcoz it is unlucky no.
.14 → Cable medium
.15 → Wireless personal area
.16 → Broadband Wireless access
•

→ At a time only one user can send data that has to be decided with the help of medium access control (MAC) technique.

→ LLC : for
Error control, Flow control
framming

DLL



→ MAC : for Access control.

→ MAC technique determine the next user to talk i.e transmit data in to channel.

→ Computer N/w have protocol for AC i.e called multiple access protocols control the nodes data transmission onto the shared broadcast channel.

Broadcast multiple Access Protocol

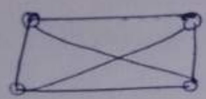
- static channelize tech
  - TDMA (Time)
  - FDMA (Frequency)
  - CDMA (code)
- Dynamic channelize tech
  - Reservation
    - R-ALOHA
  - Random Access Control
    - ALOHA
    - CSMA
    - CSMA/CD
    - CSMA/CA
  - Round Robin
    - polling
    - Token processing.

* Types of communication channel / links:

⇒ In CN, Comm^n link enable the station to communicate with each other.

⇒ there are 2 types

Point to point

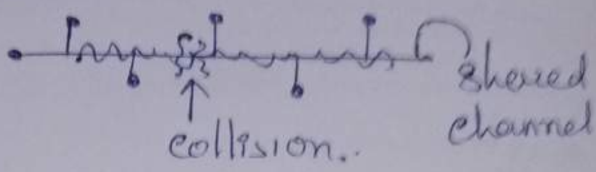


→ It is dedicated link that exist b/w the ~~sta~~ two station.

→ Entire capacity of the link is used for transmission b/w 2 connected station only.

→ There is no chance of collision.

Broadcast link



→ It is common link to which multiple stations are connected.

⇒ The capacity of the link is shared among the connected station for transmission.

⇒ There is a need of access control, because of collisions.

⇒ In a shared link, many station will share a common medium & try to transmit their data at the same time therefore, some access control method are required to control the access to the ~~share~~ shared medium.

⇒ In order to avoid collision we have to setup a procedure (Rule).

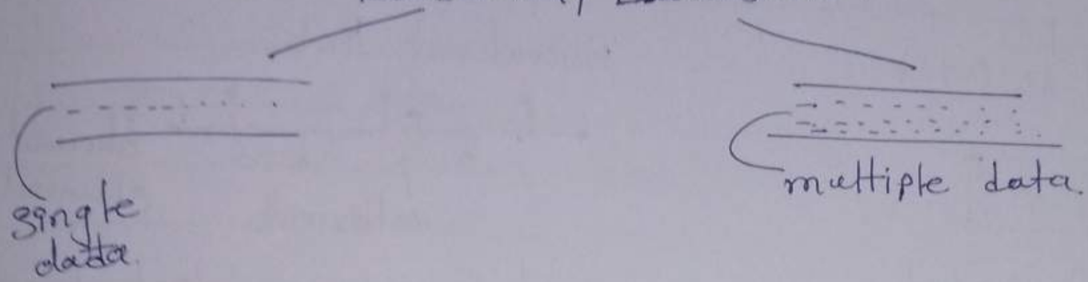
100 Base F : Fibre cable

10 Broad 30 —— distance

Bandwidth (mbps)

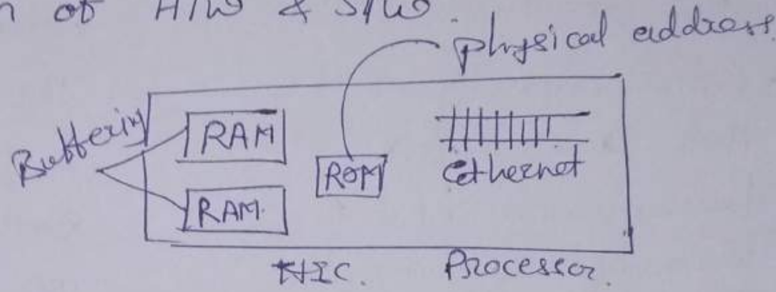
Technology

Baseband / Broadband.



NIC : Network Interface card

→ It is combination of H/w & S/w.



→ It contain 2 layer
(a) Physical layer → PA
(b) Data link layer →

→ RoM contains pA of PC.
→ It is 48 bit.

$\overline{8} : \overline{8} : \overline{8} : \overline{8} : \overline{8} : \overline{8}$

eg. 1K : 2B : BC : AB : FF : 05

→ We can use RAM to minimise the speed gap b/w pc & N/w.

→ For different topology, different NIC cards are used.

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Comparison

characteristic	Ds	PP.	Z.S.
cost	High	moderate	low.
Security	high	moderate	low.
# system conn^n.	Any no of system.	50-60	<10.
Market share.	80%.	10-15%.	<5%
Requirement	NOS, NIC, IP	NIC.	X.
Application.	Any	few	Very low.
used.	Big Organization	Small	Home user.

* LAN Component:

1. NOS:
2. NIC:
3. Cable:

specification of cable

Cable: 10 Base 2
10 Base 5
100 Base T

Twisted pair: cat5

Teacher's Signature:

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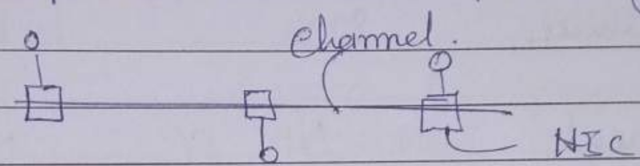
→ Any no of system can connect.

② Peer to Peer (Point to point) LAN:

→ In this, there is no dedicated server.
→ It is a Work group
→ It is based on name.
→ All system having same priority/status
→ Ordinary user use it.
→ without NOS, communication is possible. b/w system with the help of workstation/ Work group.



→ Only NIC is used to connect the system to one station
→ there is no client server concept
→ It is usually small organization.
→ 50 - 60 system will be connect.

③ Zero - slot LAN:

→ No nic is used to connect the system.
→ System are connected through serial port, parallel port & USB port

eg connect phone to computer by USB.
It doesn't need for NIC for Home server.

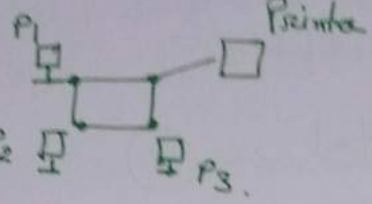
Teacher's Signature:

LAN: Local Area Network

24/06/2021

⇒ LAN is a high speed data N/w that cover a relatively small geographic area. It typically connect work stations, server, printer, pc, & other devices

Purpose



* ① H/w sharing
② S/w sharing
} Resource sharing

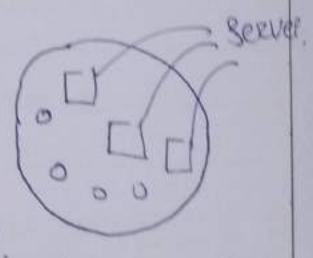
* Information sharing.

* **Classification of LAN**

there are three type of LAN:

① Dedicated server LAN.
② point to point LAN. (peer to peer)
③ Zero slot LAN

① **Dedicated Server LAN:**



→ for each & every Application. Here is seperate server.

⇒ To setup such type of N/w we need. [NOS], IP address & NIC [N/w interface card]

⇒ Any application we can run.

→ Cost is high.

⇒ Security high as for Everything username & password is maintained.

⇒ Market share is high as different type of application are used.

Q: In GB-4 If every 6^{th} pkt that is being transmitted is lost & if total no of pkt to be sent is 10, then how many transmission will be required.

1 2 3 4 5 6 7 8 9 6 7 8 9 10 8 9 10

| 6 | 7 | 8 | 9 |

| 8 | 9 | 10 |

total = 17

Q. #pkt = 10

ws = 5

4^{th} = lost

GB-N

1 2 3 4 5 6 7 8 4 5 6 7 8

| 4 | 5 | 6 | 7 | 8 |

| 8 | 9 | 10 |

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Q. Station A needs to send a msg consisting of pkt 9 pkts to station B using a sliding window protocol (window size is 3) & go back-n error control method. All pkt are ready & immediately available for transmission. If every 5* pkt that A transmit gets lost (but no Acks from B ever get lost), then what is the no of pkt that A will transmit for sending the message B?

(A) 12 (B) 14 ~~(C)~~ 16 (D) 18

\# Pkt = 9 WS = 3.

every 5^{th} pkt is lost

2^{nd} Method

N=9 WS = 3

1, 2, 3, 4, ~~5~~ 6 7 5 6 ~~7~~ 8 9

| 5 | 6 | 7 |

| 7 | 8 | 9 |

7 8 ~~9~~ 9

| 9 | |

16 total

Teacher's Signature:

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Q A 20 kbps satellite link a propogation delay of 400 ms. The transmitter use GB-N protocol scheme with N. seq No. Assuming that each frame is 100 Byte long. What is the max-data rate possible?

GB-N

$T_p = 400$ ms $BW = 20$ kbps $N = 10$

$P_s = 100$ Byte

throughput $= \frac{\# pkt}{time}$

$= \frac{N}{T_f + 2T_p}$

$= \frac{10 \times P_s}{(40 + 2(400))\ ms}$

$= \cancel{\frac{10}{840}\ ms}$

$= \frac{10 \times 100 \times 8 \text{ bits}}{840 \times 10^{-3} \text{ sec}}$

$= \frac{800 \text{ bps}}{84 \times 10^{-3}}$

$\boxed{\approx 9.523 \text{ Kbps}}$

$\therefore T_f = \frac{L}{BW}$

$= \frac{100 \text{ Byte}}{20 \text{ Kbps}}$

$= \frac{100 \text{ Byte} \times 8 \text{ bit}}{20 \times 10^3 \text{ b/s}}$

$= 40 \times 10^{-3}$ sec

$= 40$ ms

II^nd Method

Throughput $= \eta * BW$

$= \frac{1}{21} * 20$ kbps

$= 9.5$ kbps

≈ 10 kbps.

$\because \eta = \frac{1}{1+2a}$ $\because a = \frac{T_p}{T_f} = \frac{400 ms}{40 ms} = 10$

$= \frac{1}{1+2*10} = \frac{1}{21}$.

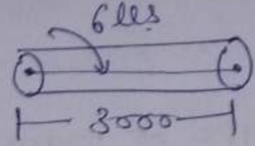
Teacher's Signature:

Q. A 3000 km long distance operate at 1.536 mbps is used to transmit 64 Byte frame to use sliding window protocol. If propogation speed is 6 us / km. How many bits required to Represent the seq No ?

$P_s = 64$ Byte

$BW = 1.536$ mbps.

$d = 3000$ km.



$T_p = 3000 \, \cancel{km} \times \frac{6\,\mu s}{\cancel{km}}$

$= 18000\,\mu s$

$= 18$ ms

$RTT = 2 * T_P$

$= 2 * 18$

$= 36$ ms

$W_s = BW * RTT$

$= 1.536 \times 10^6 \frac{bps}{s} \times 36 \times 10^{-3}\, s$

$W_s = 1.536 * 36 * 10^3$ bits

$\#PKt = \frac{W_s}{P_s}$

$= \frac{1.536 * 36 * 10^3 \cancel{bits}}{64 \times 8 \cancel{bits}}$

$W_p = 108$

$K = \log_2 W_p$

$K = \log_2 108$

$\boxed{K = 7 \text{ bits}}$

→ SRP is superior to other protocol but bcoz of complexity it is less used.

⇒ Protocol of all like HDLC (High level Data link control) (Low level protocol) use GB·N bcoz
- BW is high
- CPU is very busy doing routing job.
- Error rate is low.

* Three type of transmission.

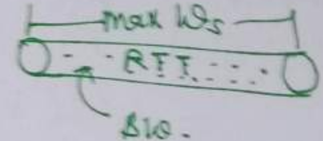
Bit Oriented ⇒ HDLC (High level data link control)

Byte Oriented ⇒ TCP → SR·P.

Msg oriented ⇒ UDP

* K? K = min no of bits required to represent SNo.

① $RTT = 2 * T_p$ ∵ $T_p = d/v$.



② $W_s = BW * RTT$.

③ $W_p = \frac{W_s}{P_s}$ where W_s = Max window size $[b/s * s]$ = bits

④ $\boxed{K = \lceil \log_2 W_p \rceil}$

W_p = #pkt in window

P_s = Pkt size.

$\eta = \frac{\text{throughput}}{BW}$

throughput = $\eta * BW$
↓
pkt transmit/RTT

$\frac{\#pkt}{RTT} = \eta * BW$

$\#pkt = \eta * BW * RTT$.

if $\eta = 100\%$ → $\#pkt = 1 * BW * RTT$

$\boxed{\#pkt = BW * RTT}$

CPU utilization	low	moderate	high due to searching & sorting algorithm.	GBN is better
level of difficulty in Implementation in	low	moderate	complex	GBN is better.
Ack.	use Independent Ack	commulative Ack but may use independent	only Independent	GBN Better
Types of transmission.	Half duplex	full duplex	full duplex	Both Better.
efficiency η	$\frac{1}{1+2a}$	$\frac{N}{1+2a}$	$\frac{N}{1+2a}$	Both Better

Note

→ GBN is more often used than other protocol.
→ SRP is less used bcoz of its complexity.
→ S&W is also less used bcoz of its low η.

⇒ S&W and SRP are similar in terms of retransmission

→ GBN & SRP are similar in terms of η its sender window size are same.

Teacher's Signature:

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→ In GBN, Receiver does not receive out of order pkt.
→ In GB-N, doesn't accept the corrupted frame & Silently discarded

→ In SR, Sender side use searching algorithm & receiver use sorting.
→ In SR, only lost pkt will be transmitted, not need to ~~do~~ retransmit to all.

Comparision

characteristic	S&W	GB-N	SR.R.	Remarks
WS	WS=WR=1	WS=N WR=1	WS=N WR=N	Better Require in SR very large If the system doesn't have lots of memory than go for GBN
Min. Seq No Required	2	N+1	2N	SR requires large no of bit in seq no field
Retransmission Required if Pkt is lost.	only lost pkt is resend.	Entire window is retransmitted	only lost pks	SR is far better than GB-N.
B/W Requirement	Low	high bcz to retransmit the entire window again.	moderate.	SR better than GBN in terms of BW

Teacher's Signature:

Window size:

① $W_s + W_R <= ASN$

② if N is define as ASN

$$W_s = W_R = N/2.$$

if $N=8$ $\quad W_s = W_R = \frac{8}{2} = 4.$

③ If N is define as Max seq No.

$$\boxed{W_s = W_R = \frac{N+1}{2}.}$$

ASN $=8$ $\Rightarrow$ S.No $= 0,1,2,3,4,5,6,\underline{7} \rightarrow$ Max No.

$$\boxed{W_s = W_R = \frac{7+1}{2} = 4}$$

④ If N is define as no. of bit required to represent ASN then. $\boxed{W_s = W_R = 2^{N-1}}$

e.g. $ASN = 8 = 2^3 = 2^N.$

$N = 3$ bits

$$W_s = W_R = 2^{3-1} = 2^2 = 4$$

Note:

$\Rightarrow$ In S & W Protocol $\boxed{W_s = W_R = 1}$: half duplex.

$\Rightarrow$ In GB-N $\quad W_s > 1., \; W_R = 1$

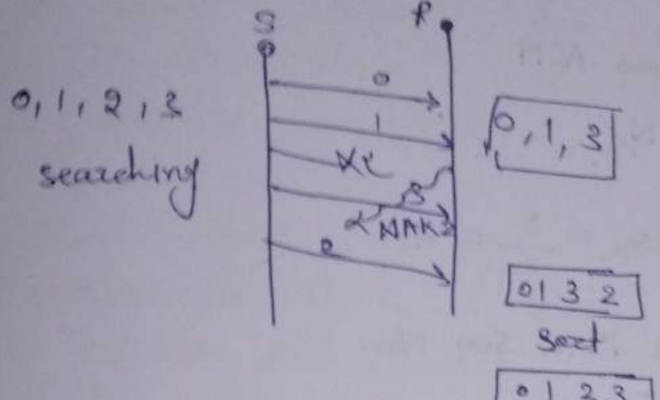
$\Rightarrow$ GBN use commulative Ack.

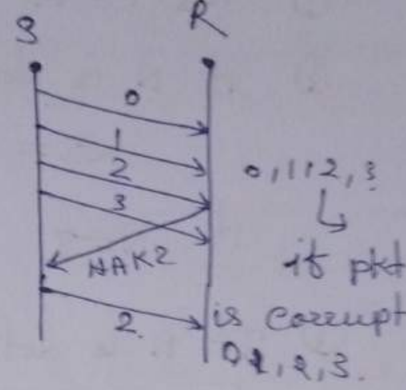
$\Rightarrow$ GBN may use Independent Ack.

Selective Repeat Protocol

23/06/2021.

⇒ Here sender send a window & receiver will wait for more than 1 pkt.





→ SR receiver can receive ~~at~~ out of order pkt. (Not in Sequence)

→ SR uses independent Ack. So high traffic & NACK.

→ In SR Protocol, sorting algorithm is required & searching algorithm to find missing pkt at sender side.

if we have N seq No then.

$$\boxed{W_S = W_R = N/2}$$

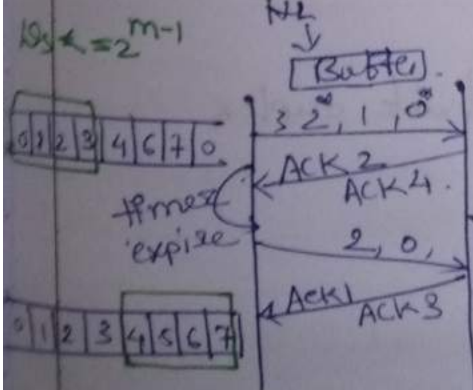
M = 3 bits ⇒ S No

~~#~~S No possible $= 2^m = 2^3 = 8 \Rightarrow 0, 1, 2, \ldots 7$

$W_S = W_R = N/2 = 8/2 = 4$

$W_S = W_R = 2^{m-1}$

$= 2^{3-1} = 2^2 = 4.$



frame 1 will be accepted as it falls in the window but it will not be transmitted to NL. the frame will be transmitted only when all 4 frame are received.

[1 3 0 2] → Sort [0 1 2 3] → NL

Q. If 4 bits seq no. is used in GB-N Calculate the sender window size & receiver window size.

$W_s = 2^4 - 1 = 16 - 1$
$= 15$ 0 to 14.

Ans $\boxed{15, 1}$

Q If max sender window size is 7 in GB-N find no. of seq bits 3

$W_s < 2^m$ $\quad W_s = 2^m - 1$
$7 < 2^m$ $\quad = \cancel{2^3 - 1}$
$\quad = \cancel{8 - 1}$
$7 = 2^m - 1$
$8 = 2^m \Rightarrow \boxed{m = 3}$

Note

Q If max sender window size is in GB-N = Q then no of seq bits = $\lceil \log_2 (1+Q) \rceil$

Q. If max seq no = K in GB-N then max W_s size = $\boxed{K}$

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*. Window size in GB-N.

① There are two windows.

W_S : Sender window

W_R : Receiver

$$\boxed{W_S + W_R <= ASN}$$ where ASN : Available sequence No.

② In GB-N $W_R = 1$

$W_S + W_R = ASN$ exp. $ASN = 8$

~~$W_S = ASN + $~~ $W_S + 1 = ASN$ $\boxed{W_S = 7}$

$$\boxed{W_S = ASN - 1}$$

③ If N is defined as ASN then, $W_R = 1$, $W_S = N-1$

④ If N is defined as Max seq no then:

$\boxed{W_R = 1}$ $\boxed{W_S = N}$

⑤ If N is defined as no. of bits available for seq no.

$\boxed{W_R = 1}$ $\boxed{W_S = 2^N - 1}$. $ASN = 8$

$2^3 = 8$

$W_S = 2^3 - 1$ $\therefore N = 3$ bits

$= 8 - 1$

$\boxed{W_S = 7}$ $\boxed{0 \text{ to } 6}$

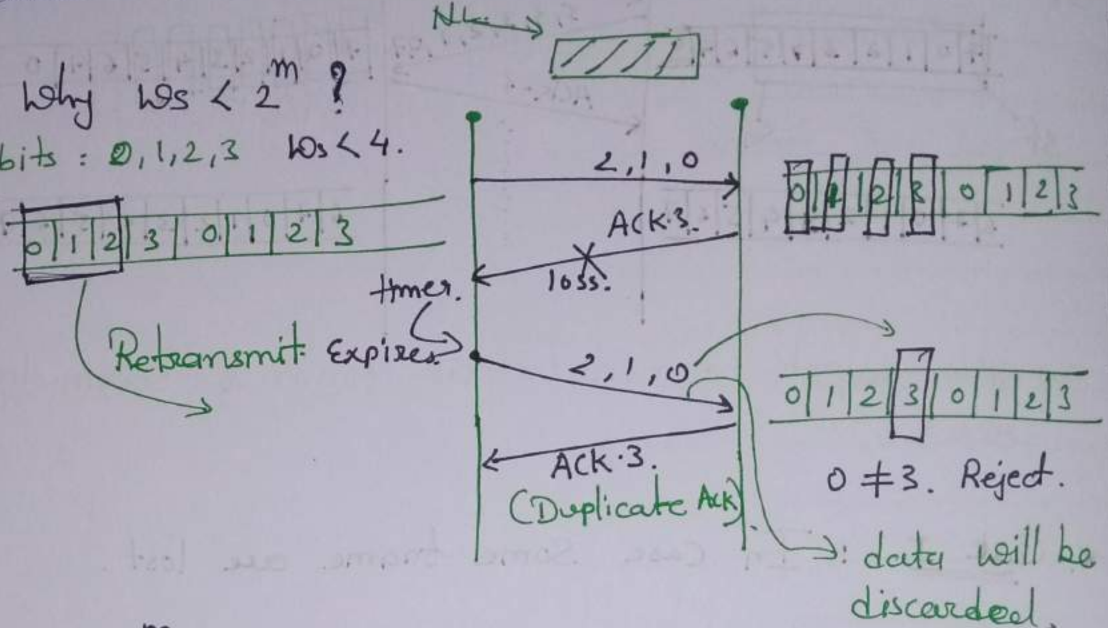
Teacher's Signature:

→ Here, burden of sender increased.

→ Because of more no of retransmission in noisy channel the overall BW utilization will be decreased.

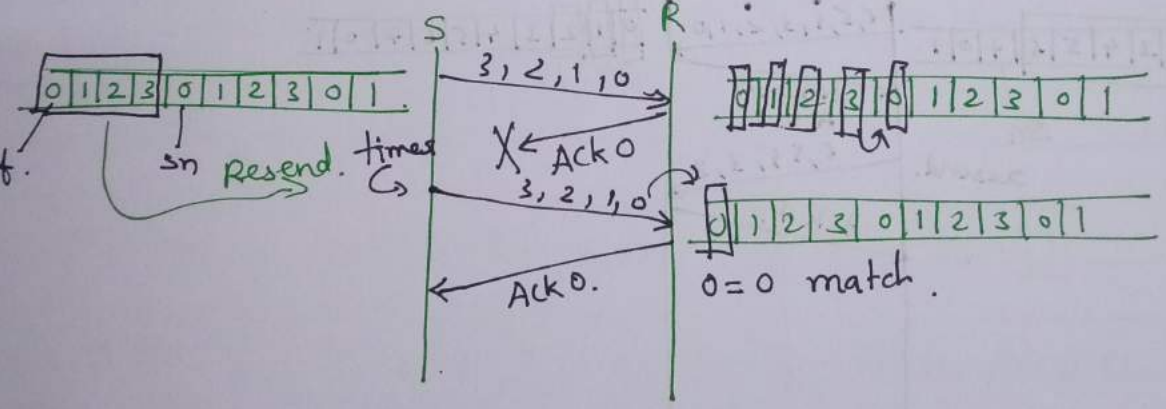
* Reason. Why WS < 2^m ?

m=2 bits : 0,1,2,3 WS < 4.

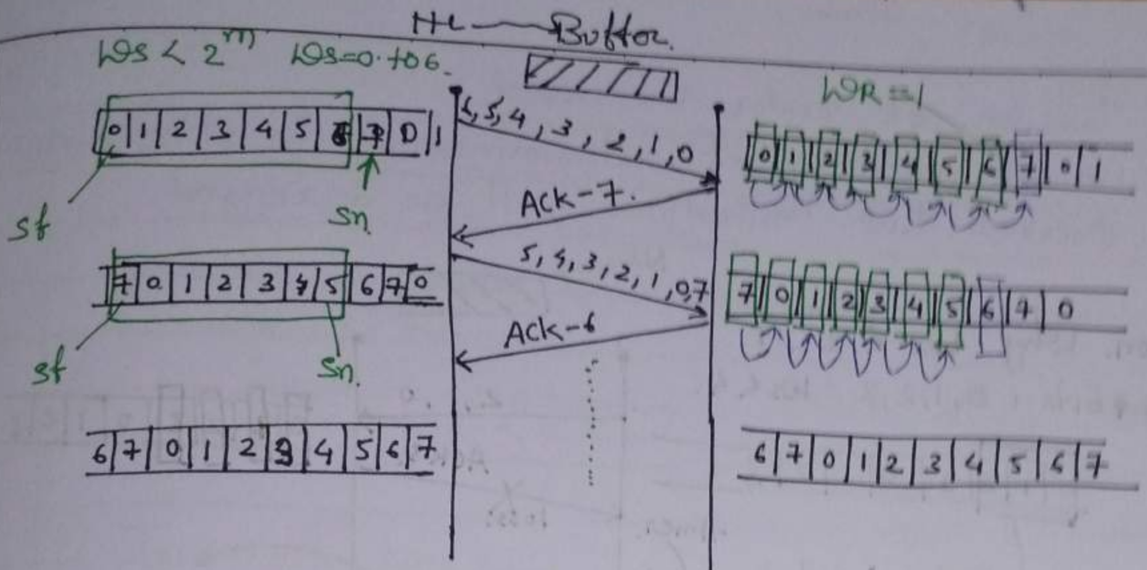


if WS <= 2^m : WS <= 4.

0 to 3.



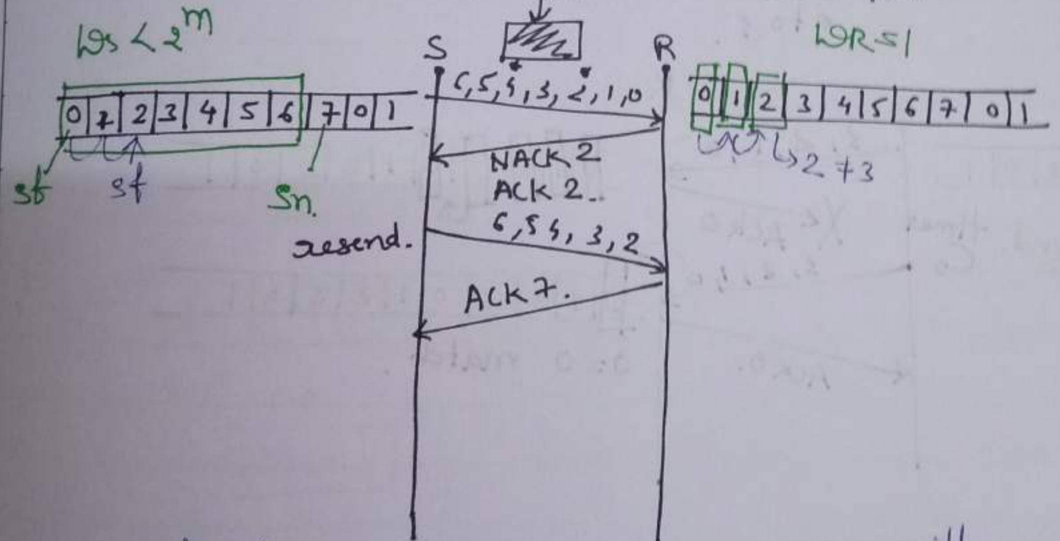
⇒ Duplicate data Received at receiver side. so Protocol is not working properly.



⇒ GBN supports commulative fram & commulative ack.

*. Case I : In case some frame are lost.

Let 2nd & 4th frame are lost.



⇒ If frame 2 is lost & 3 will come to the Receiver side but will not be excepted b'coz in GBN Receiver does not ~~or~~ out of Order Pkt

⇒ So Receiver will send. NACK 2 & ACK 2.

⇒ So Sf will be at 2, so after time quantum expires 2,3,4,5,6. frame retransmitted.

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⇒ In Buffer there will be more no of frame as we have to increase the B/W utilization.

condition

$\boxed{SWS < 2^m}$ m = no of seq. bits

$\boxed{RWS = 1}$

eg Seq bits = 3 bits

$WS < 2^3$

$WS < 8$

$\boxed{WR = 1}$

0	1	2	3	4	5	6

distinct seq no
0 to 7

⇒ Take the frame, attach the seq No & send to the Receiver.

S_f ⇒ Pointer. ⇒ From where the window is starting.

S_n ⇒ Where does the next window starts.

⇒ Max 7 frame we can transmit $\boxed{(0-6)}$

⇒ If 0-6 transmitted successfully, then Receiver send Ack = 7.

$S_n = 7$
$S_f = 7$
← When both will match, means all the data are received successfully

Teacher's Signature:

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* Sliding window protocol is called as pipelining.
  1. Go Back - N protocol.
  2. Selective Repeat protocol.

1. Go Back - N protocol:

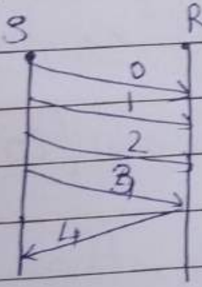
⇒ In GBN, sender send a window of size > 1 & Receiver waits for only one packet
$W_R = 1$

⇒ Receiver will never accept out of order packets

S: P_4 P_3 P_2 P_1 ⟶ R: P_1 P_2 P_3 firsts P_4

⇒ Receiver will receive packet in a order.

⇒ It used commulative Ack. Due to this traffic is less.



⇒ Ack are piggy back is possible

⇒ Even the 1st pkt TO cause entire window to be retransmitted

time out

Sequence bits

seq no.

1 bits ⟶ 0, 1

2 bits ⟶ 00, 01, 10, 11 — 0,1,2,3

3 bit ⟶ $2^3 = 8$ — 0, 7.

Teacher's Signature:

$$\eta = \frac{\text{useful time}}{\text{total}} = \frac{100}{400} = 0.25\% = 25\%$$

$$\text{throughput} = \eta * BW$$

$$= 25 * 80\,kbps$$

$$= 0.25 * 80 \times 10^3 \text{ bps.}$$

$$= \frac{0.25 * 80 \times 10^3}{8} \text{ byte per sec}$$

$$= 2.5 \times 10^3 \text{ byte/sec}$$

$$\boxed{\text{throughput } 2500 \text{ Byte/sec}}$$

2nd

$$\text{throughput} = \frac{P}{\text{total time}}$$

$$= \frac{1000 \text{ Byte}}{400 \text{ ms}} = \frac{1000}{400 \times 10^{-3} \text{ sec}}$$

$$= \frac{10 \times 10^3}{4} \text{ Byte/sec}$$

$$= \frac{10000}{4} \text{ B/s.}$$

$$= 2500$$

Disadvantage

⇒ It is extreamly inefficient bcoz transmit only 1 pkt/RTT.

⇒ Suitable for LAN, Not for WAN.

Q. Suppose that data are stored on ~~2044~~ 2.44 MB. flopp disk that weight 20 gm each. suppose that an airline carries 10^4 kg of this flopp at a speed 2000 km/hour over a distance of 8000 km. What is the data transmission Rate in bps of this system. _____.

Q. The values of Parameters for the stop & Wait ARQ are as given below.

Bit Rate = 1 Mbps $\quad T_p = 0.75$ ms

Ps. = 1980 Byte

Time to process a frame = 0.25 ms

As = 20 B.

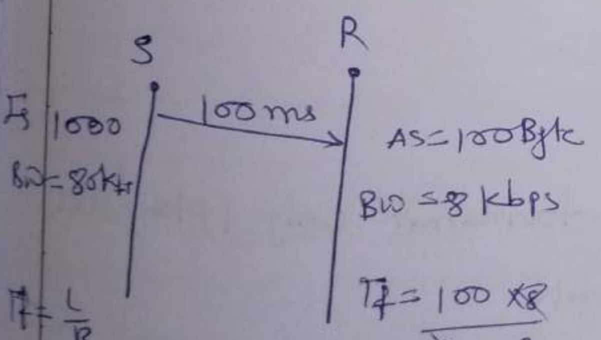
Assume there are no transmission Error. then the η(%) is 88.33 %

Q. A sender use stop & wait ARQ protocol have a reliable transmission of frame. Fs = 1000 Byte & BW = 80 kbps (Sender side)

(Receive side) Ack size = 100 Byte & BW = 8 kbps

$T_p = 100$ ms

Find sender throughput = ________ B/sec



$$\text{throughput} = \frac{L}{T_f + 2T_p}$$

$$=$$

$T_f = \frac{L}{B}$

$= \frac{1000 \times 8}{80 \times 10^3 \text{ bps}}$

$= 100 \times 10^{-3}$ bps

$= 100$ ms

$T_f = \frac{100 \times 8}{8 \times 10^3}$

$= 100$ ms.

total time = 100 + 100 + 100 + 100

= 400 ms

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(2) $\eta = \frac{T_f}{T_f + 2T_p} = \frac{8.192\ \mu s}{8.192\ \mu s + 2 \times 15\ ms}$

$= \frac{8.192 \times 10^{-6}\ s}{8.192 \times 10^{-6} + 2 \times 15 \times 10^{-3}\ sec} \times 100$

$= 0.027\ \% \times 100$

$\boxed{\eta = 27\ \%}$

Q. Consider 2 hosts X & Y connected by a single dized link of rate 10^6 bits/sec. The distance b/w the 2 hosts is 10000 km & $v = 2 \times 10^8$ m/sec.
host X sends a file of 50000 Byte as one large msg to host Y connectivity. Let the transmission & propogation delay be P ms & q ms respectively.

$d = 10000$ km $BW = 10^6$ bit/sec
$v = 2 \times 10^8$ m/sec $L = 50000$ Byte.

$T_p = \frac{d}{v} = \frac{10000\ km}{2 \times 10^8}$ $T_f = \frac{L}{BW} = \frac{50000 \times 8}{10^6\ bit/sec}$

$= \frac{10000\ km}{2 \times 10^{-3} \times 10^8\ km/sec}$ $= 5 \times 8 \times 10^4 \times 10^{-6}\ sec$

     $= 40 \times 10^{-2}$ sec

$= \frac{10000}{2 \times 10^5} = 5000 \times 10^{-5}\ sec$ $= \boxed{400\ msec}$

$= 50 \times 10^{-3}$ sec

$= \boxed{50\ msec}$

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Q. I want to send 10 pkt. If Every 4th pkt is lost using stop & wait protocol. How many total no of transmission are required

1, 2, 3, 4; 4 5 6 7 7, 8, 9, 10, 10   Total = $\boxed{13}$

Q. If we have to send 200 pkt on a link having a error probability of 0.8 then how many transmission are required

VIMP

<u>Note</u>: If on a channel prob. of error is P & we have to transmit n pkt., then total no of transmission is equal to $n\left(\frac{1}{1-P}\right)$

$$200\left(\frac{1}{1-0.8}\right) = \frac{200}{0.2} = \frac{200}{2} \times 10$$

$$= 1000$$

Q. If the packet size is 1KB & propogation time is 15 ms the channel capacity is 10^9 b/sec then find the transmission time & utilization at sender in stop & wait protocol.

(1) Transmission time

$$T_t = \frac{L}{BW} = \frac{1\text{KB}}{10^9 \text{ b/sc}} = 1024 \times 8 \times 10^{-9} \text{ bpsc}$$

$$= 8.192 \text{ us.}$$

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Conclusion.

$d\uparrow \rightarrow T_P\uparrow \rightarrow \eta\downarrow$

Q. A channel has a bit rate of 4kbps & one way propogation delay of 20 ms. The channel uses Stop & wait protocol. The transmission times of the Ack frame is negligible. To get a channel η of at least 50%, the min frame size should be ______.

$BW = 4kbps$ $\quad L = ?$ $\quad \eta \geq 50\%$

$T_P = 20\ ms$

$\eta = 50\%$

$$\eta = \frac{T_f}{T_f + 2T_P} \geq 50\%$$

$$\frac{T_f}{T_f + 2T_P} \geq \frac{1}{2}$$

$$2T_f \geq T_f + 2T_P$$

$$T_f \geq 2T_P$$

$$L \geq 2 \cdot T_P * BW$$

$$\geq 2 \times 20\ ms \times 4kbps$$

$$2 \times 20 \times 10^{-3} \cancel{s} \times 4 \times 10^{3}\ b/\cancel{s}$$

$$\geq 160\ bits$$

$$L_{min} \geq \frac{160}{8}$$

$$\boxed{L_{min} \geq 20\ Byte}$$

Q. Size of Packet is 1000Byte. velocity of data is 70% of light of speed. find out the throughput of link (a) 5 Km long (b) 1000km long.

Ans (a) $d = 5$ km.

$L = 1000$ Byte

$V = 70\%$ of light of speed

$= 70\% \times 3 \times 10^8$ m/sec.

$= 2.1 \times 10^5$ km/sec.

$T_P = d/V$

$= \frac{5 \cancel{Km}}{2.1 \times 10^5 \cancel{Km}/sec}$

$= \cancel{0.238}\ 2.38 \times 10^{-5}$ sec

$= \frac{2.38}{10} \times 10 \times 10^{-5}$ sec

$= 23.8$ μs.

Throughput $= \frac{L}{T_f + 2T_P}$

BW is not given.

$T_f <<<< T_P$

$\boxed{T_f = 0}$

Throughput $= \frac{L}{2T_P}$

$= \frac{1000 \times 8 \text{ bit}}{2 \times 23.8 \times 10^{-6} \text{ sec}}$

Throughput $= 168.06 \times 10^6$ bps

$= \boxed{168.06 \text{ mbps}}$

(b) $d = 1000$ km.

$T_P = \frac{d}{V} = \frac{1000 \text{ km}}{2.1 \times 10^5 \text{ km/sec}}$

$=$

Throughput $= \frac{L}{2T_P}$

$= \frac{1000 \times 8 \text{ bit}}{\quad}$

$\boxed{\text{Throughput} = 0.84 \text{ mbps}}$

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Q.1 If the Bandwidth of the line is 1.5 mbps, RTT is 45 ms & packet size is 1 KB, then find the link utilization is stop & wait.

BW = 1.5 mbps , RTT = 45 ms L = 1 KB.

Efficiency = ?

$$\eta = \frac{\text{throughput}}{BW}$$

$$\text{throughput} = \frac{L}{T_f + 2T_P}$$

$$= \frac{1 KB}{5.46 ms + 45 ms}$$

$$= \frac{1024 \times 8 \text{ bits/s}}{50.46 \times 10^{-3} \text{ sec}}$$

$$\eta = \frac{1024 \times 8 \text{ bits/sec}}{50.46 \times 10^{-3} \text{ sec} \times 1.5 \times 10^6 \text{ bit/s}}$$

$$= \frac{1024 \times 8}{50.46 \times 1.5 \times 10^3}$$

$$\boxed{\eta = 10.8 \%}$$

$$\cancel{\eta = \frac{T_f}{T_f + 2\frac{T_P}{T_f}}}$$

$$\cancel{= \frac{L/B}{1 + 45}}$$

$$\because T_f = \frac{L}{BW}$$

$$= \frac{1 KB}{1.5 \text{ mbps}}$$

$$= \frac{1024 \times 8 \text{ bits}}{1.5 \times 10^6 \text{ bps/sec}}$$

$$= 5.46 \text{ ms.}$$

$$\eta = \frac{T_f}{T_f + 2T_P}$$

$$= \frac{L/B}{L/B + RTT}$$

$$\eta = \frac{5.46 \times 10^{-3} \text{ sec}}{5.46 \times 10^{-3} \text{ sec} + 45 \times 10^{-3} \text{ sec}}$$

$$\boxed{\eta = 10.8 \%}$$

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$$\text{Throughput} = \frac{P_s}{\text{total time}} = \text{\#bits transfer / unit time}$$

$$\boxed{\text{Throughput} = \frac{L}{T_f + 2T_P}}$$

Sometimes
if $T_f <<<< T_P$

$$\eta = \frac{\text{Actual throughput}}{\text{max BW}}$$

$$\boxed{\text{throughput} = \frac{L}{2T_P}}$$

$$= \frac{\text{Actual BW}}{\text{max BW}}$$

$$\boxed{RTT = 2 * T_P}$$

$$\eta = \frac{\text{throughput}}{BW}$$

$$\therefore \boxed{\text{throughput} = \eta * BW}$$

Advantage:

1. it is very simple to implement.
2. The incoming packet from receiver is always an Ack.

Note:

1. Efficiency may also be reffered by the following name:
   - Link utilization.
   - Sender utilization / Utilization of sender.
2. Throughput may also refferred by following name.
   - Bandwidth utilization.
   - max actual throughput.
   - Effective Bandwidth.
   - Max data Rate possible.

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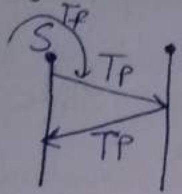
Efficiency : of SWP :

Total time $= T_f + T_p + T_p$

$= T_f + 2T_p$



Sender Busy time $= T_f$.

$$\eta = \frac{\text{Useful time}}{\text{Total time}} = \frac{T_f}{T_f + 2T_p}$$

$$\eta = \frac{T_f}{T_f + 2T_p}$$

$$\eta = \frac{1}{1 + 2\,T_p/T_f}$$

$$\boxed{\eta = \frac{1}{1+2a}}$$

Where $a = \frac{T_p}{T_f}$

$T_p = \frac{d}{V}$

$T_f = L/BW$.

$$\eta = \frac{1}{1 + 2\frac{T_p}{T_f}}$$

$$\boxed{\eta = \frac{1}{1 + 2\cdot\frac{d}{V} \times \frac{BW}{L}}}$$

Where
L = packet length
d = distance
V = Velocity
BW = Bandwidth.

① $\eta \propto \frac{1}{d}$

② $\eta \propto \frac{1}{BW}$

③ $\eta \propto V$

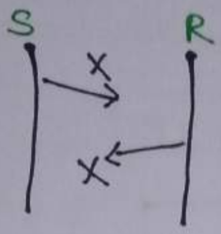
④ $\eta \propto L$

⟹ Stop & Wait protocol only suitable for $\boxed{\text{LAN}}$
Not suitable for $\boxed{\text{WAN}}$

But receiver reject the duplicate data because S.SNo ≠ R.SNo. & again resend the duplicate Ack.

⇒ When Sender receive the Ack then sender slide window will be slide & ~~Buff~~ Buffer will clear.

Problem:

① 

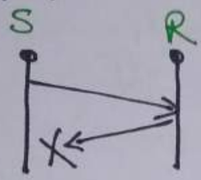
Solution

① Timeout / Timer

②

S is waiting for ack. & R is waiting for data.

② ACK lost

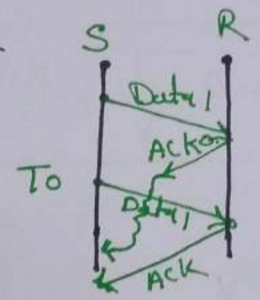


Sol^n

S is waiting for ACK. Next Data.

TO + SNO. of data.

③ Delay Ack



Sol^n TO + S.No of data + S.No of Ack.

⇒ In S & W ARQ, it supports only individual frame & individuals Ack.

⇒ In all sliding window protocol, the maximum senders sliding window size indicate the <u>no of frame to be transmitted</u>. in <u>One Round trip time</u>.

⇒ In all sliding window protocol, max sender window + max Receiver window will always equals to distinct sequence no. count.

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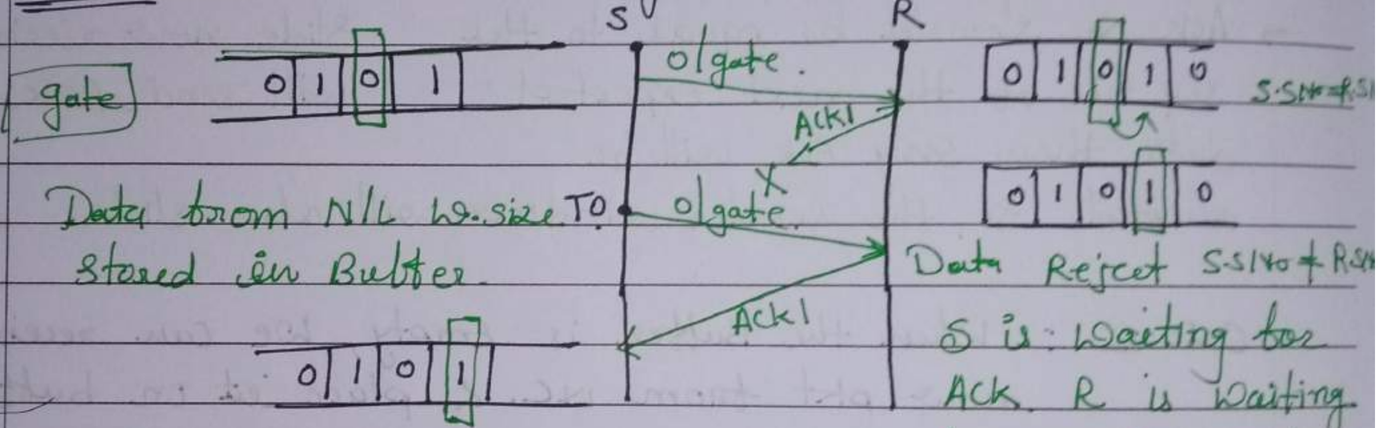
⇒ If data is lost, so Receiver slider window will not slide & sender will not get Ack. So timer will expire, but data is in buffer, we can resend it with the same seq no.

⇒ As the time expires, automatically protocol is resending the data.

CASE 3 : When acknolewdgement is lost.



S is waiting for Ack. R is waiting for next expected data.

⇒ When we want to transmit the data, timer will be started.

⇒ Let us assume the reaches the receiver safely, Receiver slider window will be slide & send the ack for the incoming pkt

⇒ Let ack is lost so ack will not reach Sender & timer will expire.

Resend the data with S. No.

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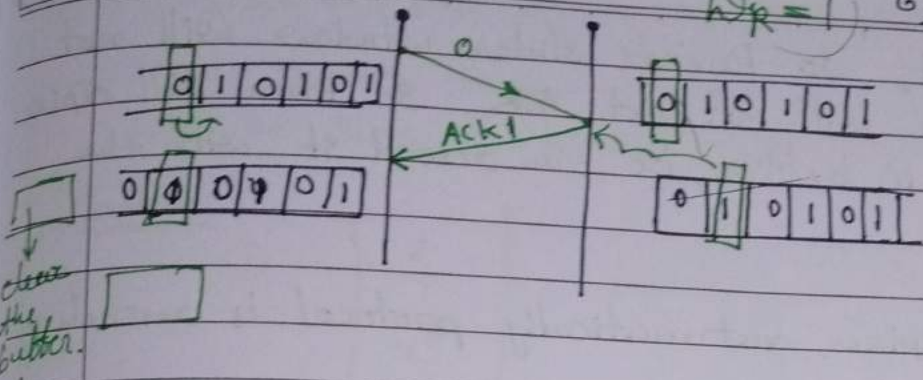
WS = 1 | WR = 1 | Saturday 6:30 am | 19/06/2021



Once the data reaches the receiver, Sending seq no. is matched with receiver window no.

If they match the data will be accepted & the window will slide now receiver will send Ack.

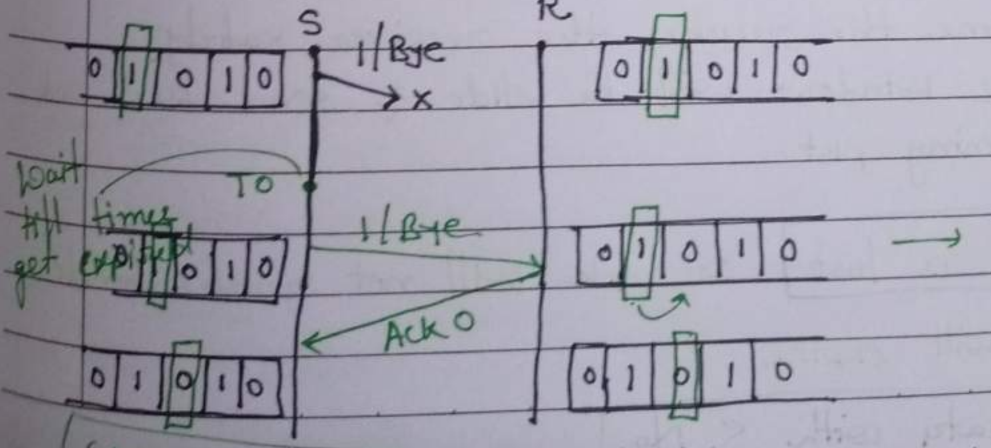
When data successfully received at receiver.

→ Ack No should be equal to the seq no. of the next expected data then only Ack will be accepted. So, the sender window will also slide.

Case: II : When the Buffer is Empty, We can receive new pkt from NC. & place it on buffer.

Timer is started & data is placed on buffer.

Let assume data has been lost.



$\boxed{(\text{Ack.No} + 1) \% 2}$

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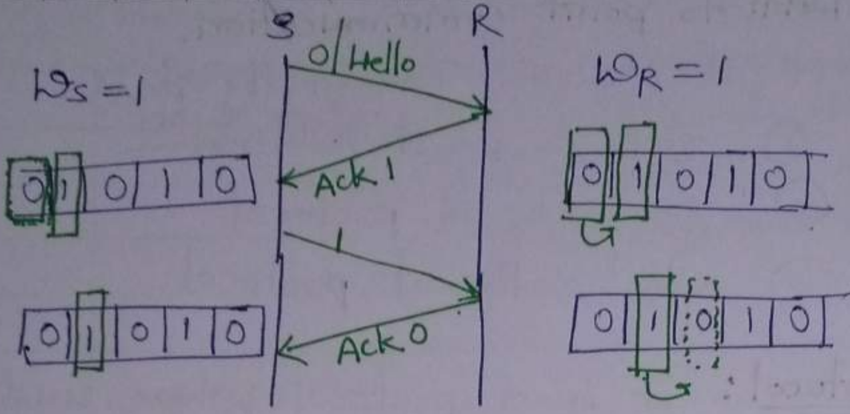
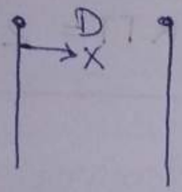


$W_s + W_R = 2$

1 bit Required to represent 2 window

⇒ To the DLL, N/w layer will give the data. The data of N/w layer is packet.

⇒ A Buffer is maintain at DLL.



Receiving is waiting for Data.
Sender is waiting for Ack.

Solution Timer : Timeout : Retransmission Time.

$$\boxed{T.Out = 2 \cdot RTT}$$ static at DLL.

There is timer as well as sliding window.

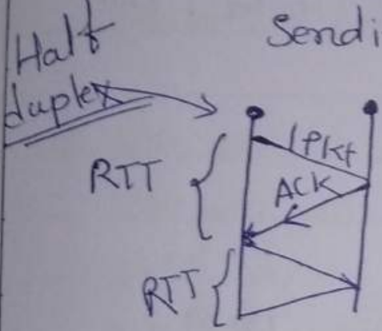
Case I: [When data & Ack reaches safely].

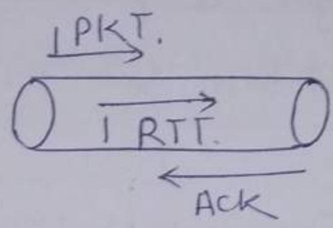
→ It is used for point to point communication.

⇒ SWP is a theoretical concept, Practically it is implemented as

1. stop & wait protocol
2. go-back-N protocol
3. selective Repeat protocol.

* ① <u>Stop & Wait Protocol</u>: It is a protocol where sender sends a packet & wait for Ack before sending next packet. [1 PKT / RTT]





$$RTT = 2 * T_P$$

$$\boxed{RTT = 2 * \frac{d}{V}}$$

⇒ It is use link b/w sender & Receiver as half duplex.

<u>Workings</u>:

1. Sender sends a data pkt to the Receiver
2. Sender wait for Ack for the sent pck from the receiver.
3. Receiver Receives & Process the data pkt.
4. Receiver sends a Ack to the sender
5. After Receiving the Ack, Sender sends the next data packet to the receiver

18/06/2021

ARQ – Automatic Repeat Request

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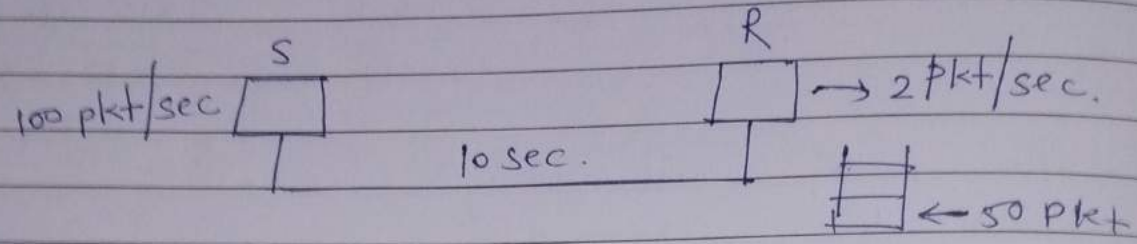
Flow control :– A set of procedure which are used for restricting the amount of data that a sender can send to the receiver.



Sender
1 sec → 10 pkt
10 sec → 10×10 pkt = 100 pkt.

Receiver.
1 sec → 2 pkt
10 sec → 10×2 pkt = 20 pkt

100
− 50
− 20
(30) — lost
↳ Retransmission
Burden at sender.

Flow control
- For noiseless channel → stop & wait
- Noisy channel. → sliding window.
  - S&R ARQ
  - go N ARQ
  - selective ARQ

Solution

Sliding window protocol: (SWP)

→ It is used for both in Data link layer & transport layer

transport layer ↑ Packet level

Data link layer ↑ Bit level

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Q1. Data size = 2k bits BW = 10 mbps. Find transmission time Tt / Tt ?

$$T_t = \frac{\text{Data size}}{BW} = \frac{2 \text{ kbits}}{10 \text{ mbps}} = \frac{2 \times 10^3 \text{ bits}}{10 \times 10^6 \times 8 \text{ bit/sec}}$$

1 kilo = 10^3 milli = 10^{-3}
1 mega = 10^6 micro = 10^{-6}
1 giga = 10^9 nano = 10^{-9}

$$= \frac{0.2 \times 10^{3-6}}{8}$$

$$= \frac{0.2 \times 1000 \times 10^{-3}}{8 \times 1000}$$

$$= \frac{200}{8} \times 10^{-6}$$

$$= 25 \mu s.$$

1 Kilo = 10^3 → For placing / transmitting the data.

1 kilo = 2^{10} for storage purpose

Data size	BW
1 kb = 2^{10} bits	1 kbps = 10^3 bps
1 mb = $2^{10} \times 2^{10}$ bits	1 mbps = 10^6 bps
1 gb = $2^{10} \times 2^{10} \times 2^{10}$ bits	1 gbps = 10^9 bps

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* **Error Correction** : It is error correcting policy

Data + policy

Data + parity bits = Code word.

$\underbrace{\boxed{\text{Data}}}_{m}\underbrace{\boxed{\text{Parity bits}}}_{r}$: sender.

case 3: if η at most 50%.

$$\eta <= 50\%$$

$$\frac{T_f}{T_f + 2T_p} <= \frac{1}{2}$$

$$2T_f <= T_f + 2 \cdot T_p$$

$$\boxed{T_f <= 2 \cdot T_p}$$

$$\frac{L}{BW} <= 2T_p$$

$$L <= 2T_p \cdot BW$$

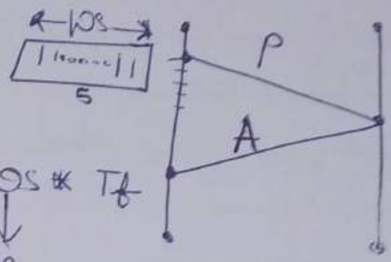
$$\boxed{L <= RTT * BW}$$

case4: for more than one packet transmission/RTT.

$$\eta = \frac{\text{useful}}{\text{total}}$$

$$\boxed{\eta = \frac{n * T_f}{T_f + 2T_p}}$$

∵ useful time $= WS * T_f$, $WS \downarrow n$.



$$\eta = \frac{n}{1 + 2\frac{T_p}{T_f}}$$

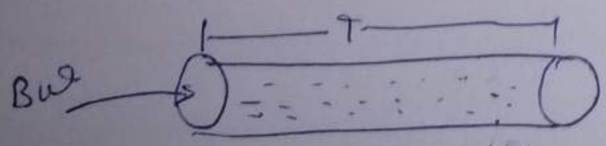
∵ total time $= T_f + T_p + T_p$
$= T_f + 2T_p$.

$$\boxed{\eta = \frac{n}{1 + 2a}}$$

* BW * delay Product:

$$\boxed{WS_{max} = BW * Delay}$$

↳ It is equivalent to max amount of data at any given time.



$BW * T \Rightarrow b/s * s = \text{bits}.$

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Case 1: if η of channel $= 50\%$

$$50\% = \frac{1}{1+2a}$$

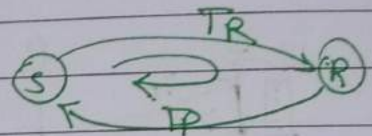
$$\frac{1}{2} = \frac{1}{1+2a} \Rightarrow 1+2a = 2$$

$$2a = 1 \Rightarrow a = \tfrac{1}{2}$$

$$2 \cdot \frac{T_p}{T_f} \Rightarrow 2 \cdot \frac{1}{2} = \boxed{1}$$

$$\boxed{T_f = 2 \cdot T_p} \rightarrow T_f = \text{Round trip time}$$

$$\boxed{RTT = 2T_p}$$



$(S-R) + (R-S)$

case: if η at least 50%

$$\eta \geq 50\%$$

$$\frac{T_f}{T_f + 2T_p} \geq \frac{1}{2}$$

$$2T_f \geq T_f + 2T_p$$

$$\boxed{T_f \geq 2T_p}$$

$$\boxed{\frac{L}{BW} \geq 2T_p}$$

$$\boxed{L \geq 2T_p \cdot BW}$$

$$\boxed{L \geq RTT * BW}$$

$$\boxed{RTT = 2 \cdot T_p}$$

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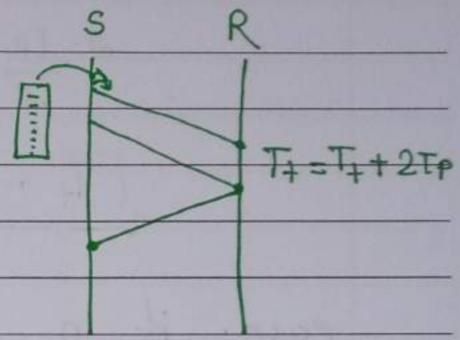
$$TT = T_f(pkt) + T_p(pkt) + T_f(Ack) + \cancel{A}\, T_p(Ack)$$

B

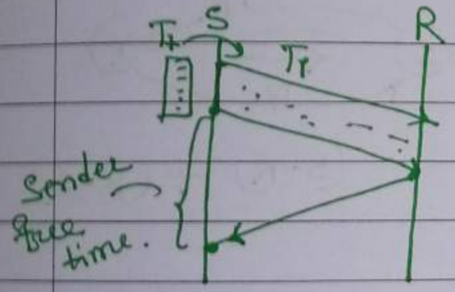
If ack size $= 0$

$$TT = T_f + T_p + 0 + T_p$$

$$= T_f + 2T_p$$



Sender Busy time $= T_f$



$$T_t = T_t + 2T_P$$

η of sender/channel $= \dfrac{\text{Useful time}}{\text{total time}}$

$$\eta = \frac{T_t}{T_t + 2T_p} = \frac{1}{1 + 2\dfrac{T_p}{T_t}} \qquad \because a = \frac{T_p}{T_t}$$

$$\boxed{\eta = \frac{1}{1+2a}}$$

$$T_p = d/v$$

$$T_t = L/BW$$

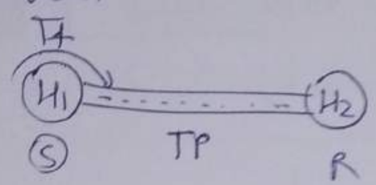
Teacher's Signature:

* **Propogation Delay**: the time taken by one bit to travel from end to other end. is Propogation delay. (TP)

$$TP = \frac{d}{V} = \frac{\cancel{km}}{\cancel{km}/sec} = sec.$$

$$\boxed{\begin{array}{l} V\uparrow = Tp\downarrow \\ V\downarrow = TP\uparrow. \end{array}}$$

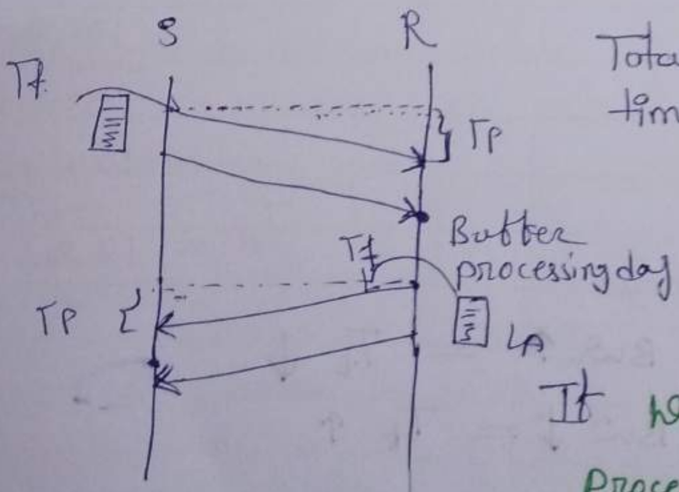
⇒ the time taken to send a packet from one host to another host



$\boxed{Time = Tp + T_f}$

⇒ Time taken to send a packet & get an ack from other end.

[consider ack size = Data size]



Total time = Tf (Pkt) + TP (Pkt)
+ Waiting time
+ processing delay
+ T_f (ACk) + Tp (ACk)

If waiting time & processing time is not given then take $\boxed{0}$

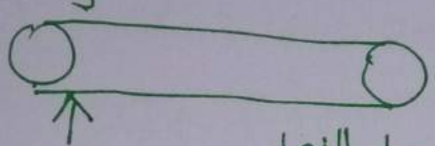
* **Transmission delay:** the amount of time taken by a router to transfer the packet to the outgoing link. is known as transmission delay.

T_t : transmission delay $= \dfrac{\text{Packet size}}{\text{Bandwidth}} = \dfrac{L}{BW}$.

$= \dfrac{\cancel{\text{Bits}}}{\cancel{\text{bits}}/\text{sec}}$

$= \text{sec}$

L = y bits



BW : x bps. will be given.

x bits $\longrightarrow$ 1 sec

1 bits $\longrightarrow$ $\frac{1}{x}$ sec

y bits $\longrightarrow$ y/x sec.

Suppose $L = 1000$ bits
$BW = 100$ mbps

$T_t = \dfrac{1000 \text{ bits}}{100 \text{ mbps}}$

$= \dfrac{10\cancel{00} \ \cancel{\text{bits}}}{\cancel{100} \times 10^6 \ \cancel{\text{b}}\text{ps}}$

$= 10 \times \underline{10^{-6}} \text{ sec}$ — μs

$\boxed{T_t = 10 \ \mu s}$

NOTE:
① $BW \uparrow = T_t \downarrow$
② $BW \downarrow = T_t \uparrow$

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* **Queue delay**: the amount of time the packet is waiting in the queue before being taken up for processing.

⇒ Queue delay at 1st packet is always 0.

⇒ Queue delay depend on processing (speed of router) & depend on buffersize
① Router processing speed
② size of the buffer (queue)

⇒ For discarded packet, queue delay is ∞ (if buffer is full)

* **processing Delay**: the time taken by a host to process a packet from queue is called processing time.

⇒ The amount of time taken by a router to process a packet is called processing time or processing delay.

eg loading at destination IP address
extracting N/ID
Searching Routing
deciding outgoing path.
} Processing delay.

Teacher's Signature:

Velocity: It represent the rate, distance covered in one sec

$$\boxed{V = \frac{d}{t}} \quad m/sec$$

$X =$ $\boxed{BW = \frac{L}{t}}$

L = packet size in bits.

t = Total time.

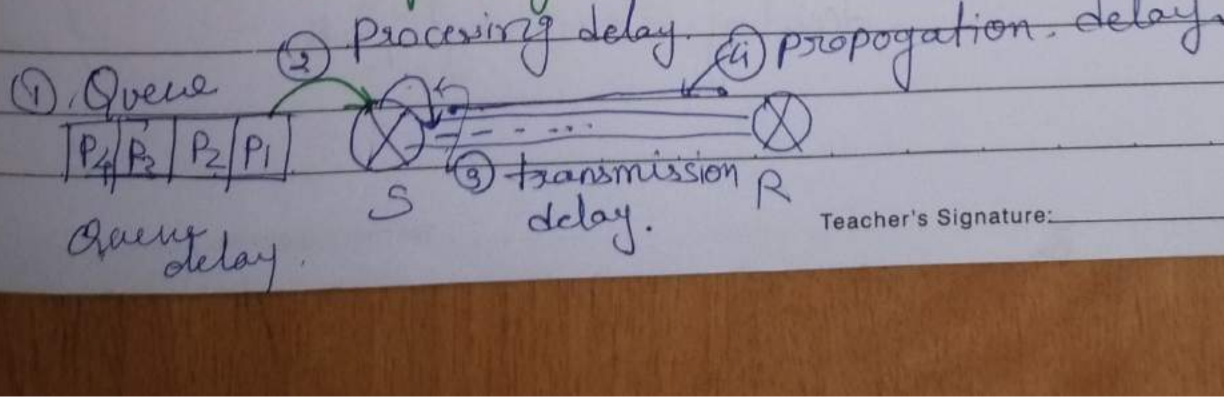
Throughput: is the actual amount of data that can be transfered through a n/w during a specified time period.

$$\boxed{\eta = \frac{\text{throughput}}{BW}}$$ eff. of channel /link/ sender

$$\boxed{\text{Throughput} * \eta * BW.}$$

Delay: there are four type of delay.

1. Queue delay
2. Processing delay
3. transmission delay
4. propogation delay.



Teacher's Signature: