Computer Networks

GATE CSE NOTES

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Standard : Division : Roll :

Subject : Computer Network.

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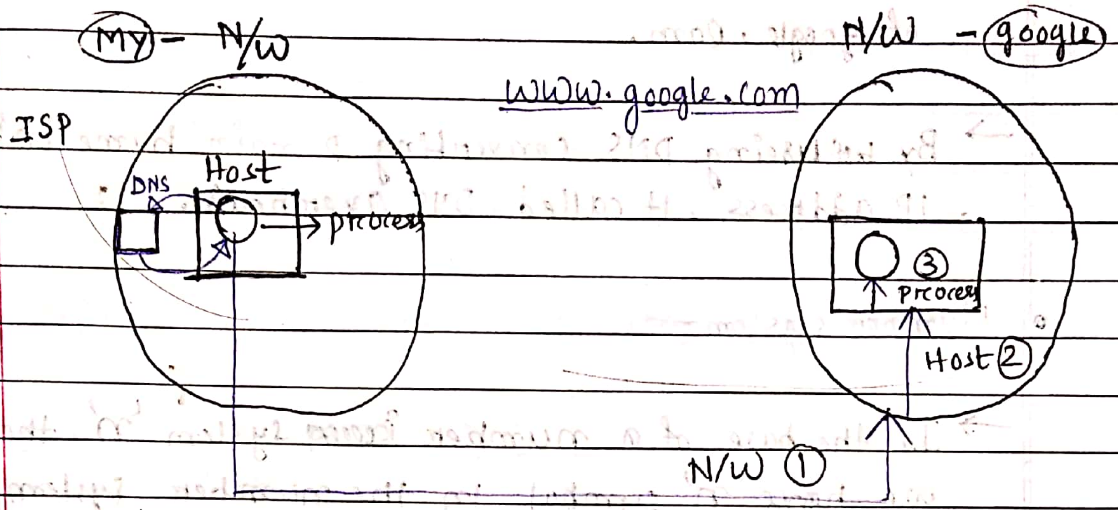
IP address Subnetting & Supernetting

INTRODUCTION TO COMPUTER NETWORK AND IP ADDRESS:



→ www.google.com (using this Domain name we can identify destination N/w, destination host and destination process)

→ www.google.com (this Domain name convert into some numbers, so that it can identify N/w, host, process)

www.google.com

⇓

IP address.

N/W ID	Host ID

(port num)

→ here, N/W ID to identify destination N/w. and Host ID to identify destination Host.

→ port number (80) used to reach in destination process. (most of the port number fixed)

→ ISP (Internet Service provider) provide DNS (Domine name server) Inside the ~~New~~ N/W it provide the IP address of google.com.

→ By ~~use~~ useing DNS converting Domain name into IP address, It called DNS overhead.

- Number system —

→ If the base of a number ~~xxxx~~ system 'n', then we have 'n' symbol in the number system.
0, 1, 2, --- (n-1)

Unary — 0
*Binary — 0, 1
⋮
Octa — 0, 1, 2, 3, 4 ···· 7.
⋮
Decimal — 0, 1, 2, 3, ··· 9.
⋮
Hexadecimal — 0, 1, 2, ······ 9, A, B, ··· F
(A = 10, B = 11, F = 15)

2^{10} — K
2^{20} — M
2^{30} — G
2^{40} — T

(2^1) 1 bit	(2^2) 2 bit	(2^3) 3 bit
0	0 0	0 0 0
1	0 1	0 0 1
	1 0	0 1 0
	1 1	0 1 1
		1 0 0
		1 0 1
		1 1 0
		1 1 1

1 — 2^1
2 — 2^2 — 4 part
3 — 2^3 — 8 part

n bit

K	n-K

2^n

# of choose, $K \rightarrow 2^K$ (devide)

2^K parts $\longrightarrow 2^n$ numbers.

1 part $\rightarrow \frac{2^n}{2^K} = 2^{n-K}$.

→ In computer network IP address is 32 bits.

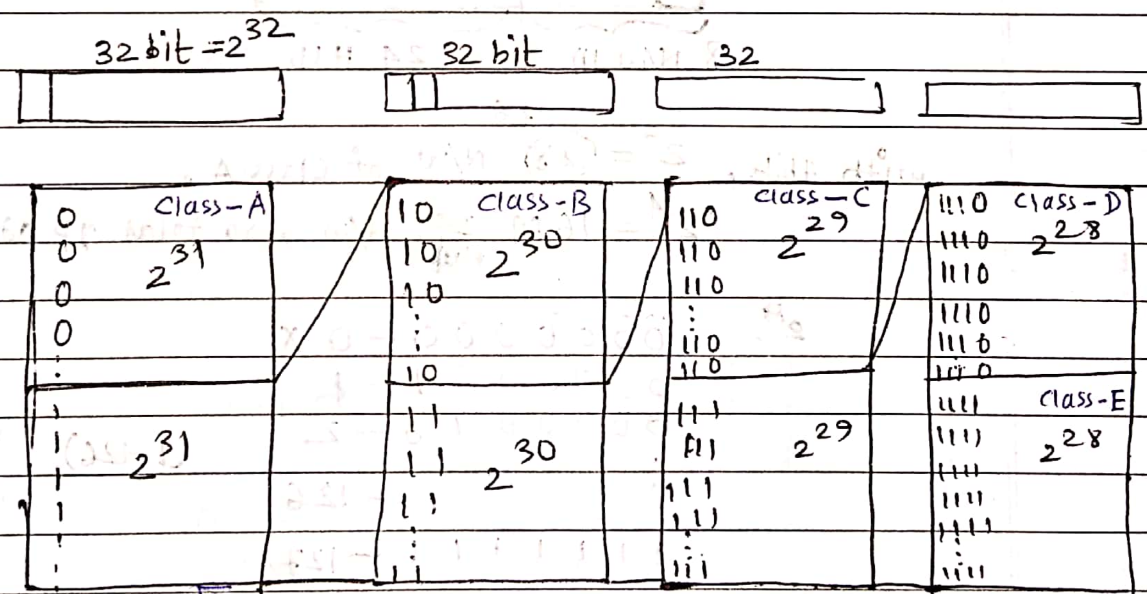
32 bits 2^{32}

IP add →

8	24
N ID	H ID
$2^8 = 256$	$2^{24} = 16M$.

here N/w are very less than Host.

- Class full IP address –



Total add space $= 2^{32}$

Choose bit $= 1$

size of each part $= \frac{2^{32}}{2^1} = 2^{31}$

0
10
110
1110
1111

IP Address Representation–

→ IP add represent in three way's

(A) BINARY REPRESENTATION: 0's & 1's of 32 bits.

(B) Convert the Entire 32 bit in it decimal numbers.

* (C) Dotted Decimal Representation: 32 ~~bit~~ byte are divided into 4 Bytes and every byte is converted into Decimal number.

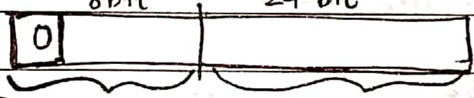
ex–

10 . 20 . 30 . 40

Class – A:

→ # IP in class-A is 2^{31}.

8 bit 24 bit



8 N/W ID 24 HID

with 7bits, $2^7 = 128$ (126) N/W of Class A.

$2^{24} = 16M$ IP / N/W, so total IP add present $= 2^{24} \times 2^7 = 2^{31}$.

0 0 0 0 0 0 0 0 – 0 X

0 0 0 0 0 0 0 1 – 1

0 0 0 0 0 0 1 0 – 2

⋮

– 126

1 1 1 1 1 1 1 – 127 X

(1–126) $[2^8 - 2^7 = 128]$

range = B/W $\boxed{1-126}$ ⇒ class A.

Class -B:

Total IP address $= 2^{30}$.

10 N/W ID	Host ID
16 bits N/W ID	16 bits HID

\# N/W $2^{14} \cong 16K$

\# 2^{16} IP/N/W

So, Total IP address present in class-B $= 2^{14} \times 2^{16} = 2^{30}$

Rang of class-B B/W $\boxed{128-191}$

10 000000 — 128
000001 — 129
000010 — 130
⋮
111111 — 191

$\boxed{2^8 - 2^6 = 192}$

Class-C

Total IP address $= 2^{29}$

110	
24 bits NID	8 bit HID

\# N/W $2^{21} \simeq 2M$.

2^8 IP/N/W

So, Total IP add present in class C $= 2^{21} \times 2^8 = 2^{29}$

Rang of class-C B/W $\boxed{192-223}$ $\boxed{2^8 - 2^5 = 224}$

110 - - - - -
00000 — 192
00001 — 193
00010
⋮
11111 — 223

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Class-D

total number of IP address present $= 2^{28}$.
and range $= \boxed{224 - 239}$

$(2^8 - 2^4)$

1110 - - - -

0000 - 224
0001 - 225
0010 - 226
⋮
1111 - 239

$\boxed{224 + 2^4 \Rightarrow 240}$

$224 + 16 = 240$

Class-E

range $= \boxed{240 - 255}$

$\boxed{240 + 2^4 \Rightarrow 256}$

- Type of casting — (Unicast, limited Broadcast, Directed Broadcast)

→ Sending one packet to another, is called casting.

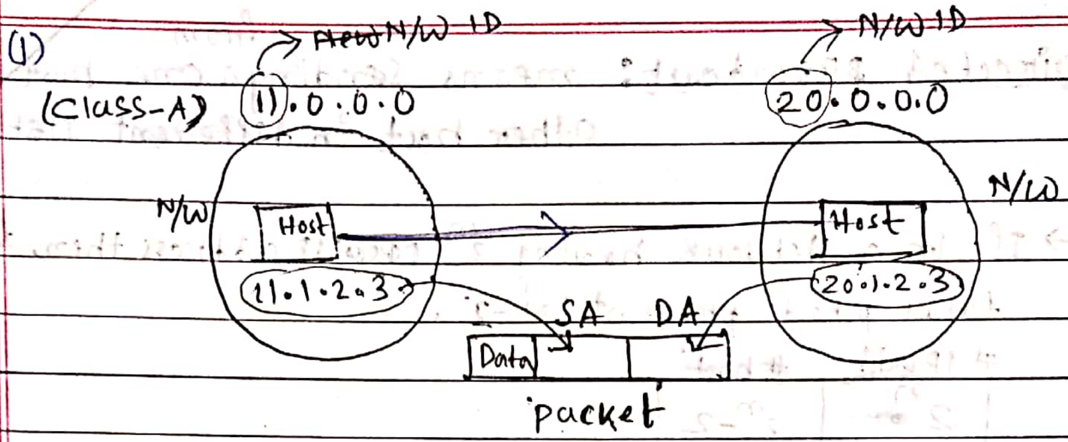
→ casting '2' types :-

(I) Unicast :- means sending a packet from one host to only ~~anone~~ one particular host.

(II) Broadcast :- means sending a packet from one host to many host.

range — CA — (1–126)
CB — (127–191)
CC — (192–223)
CD — (224–239)
CE — (240–255)

(i)

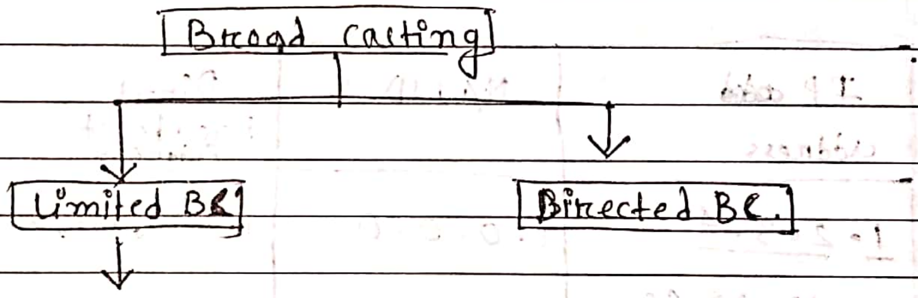


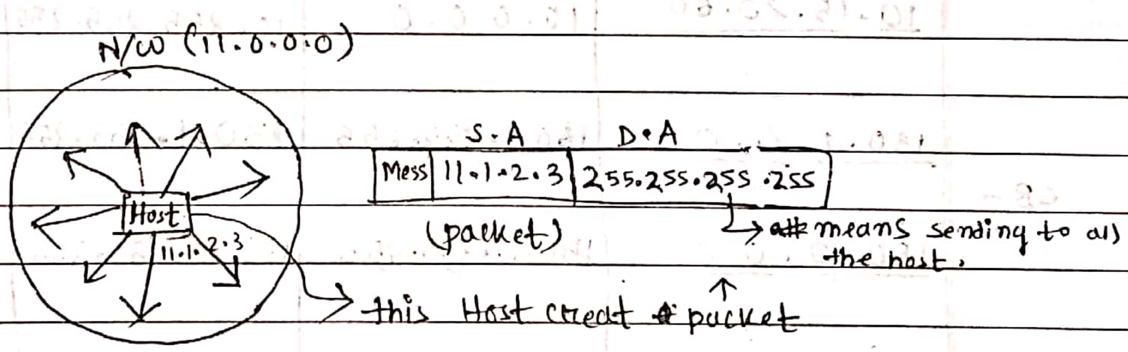
SA → Source address.

DA → Destination address.

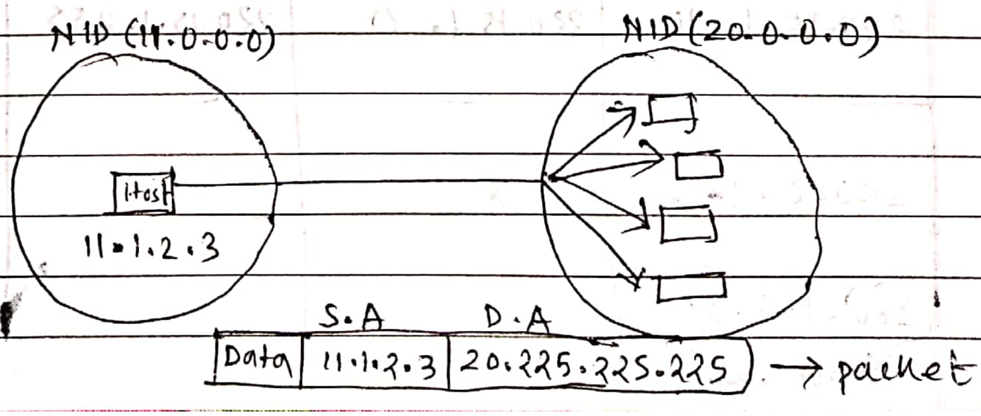
(1) Unicasting

(ii)





Limited BC: sending from one host to many host in same N/W is called limited Broad casting.



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• **Directed Broadcast:** means sending from one host to many Other host in other Network.

→ If in a Network having 2^n IP address then, total host present (2^n-2).

	# IP add	# host
	2^n	2^n-2
CA →	2^{24}	$2^{24}-2$
CB →	2^{16}	$2^{16}-2$
CC →	2^8	2^8-2

CA = (1-126), CB = (128-191), CC = (192-223)

	IP address	N/W ID	Direct Broadcast Address	Limited Broadcast Address
CA –	1.2.3.4	1.0.0.0	1.255.255.255	255.255.255.255
	10.15.20.60	10.0.0.0	10.255.255.255	255.255.255.255
CB –	130.1.0.0	130.1.0.0	130.1.255.255	"
	150.0.0.0	150.0.0.0	150.1.255.255	"
CC –	200.1.10.100 (NID . HID)	200.1.10.0	200.1.10.255	"
	220.15.1.10	220.15.1.0	220.15.1.255	"
CE	250.0.1.2	×	×	×
	300.1.2.3 × not valid			

- **Subnets, Subnet Mask, Routing:**
- **Subnetting:**

→ Dividing a big network in to many small network is called subnetting.

adv:

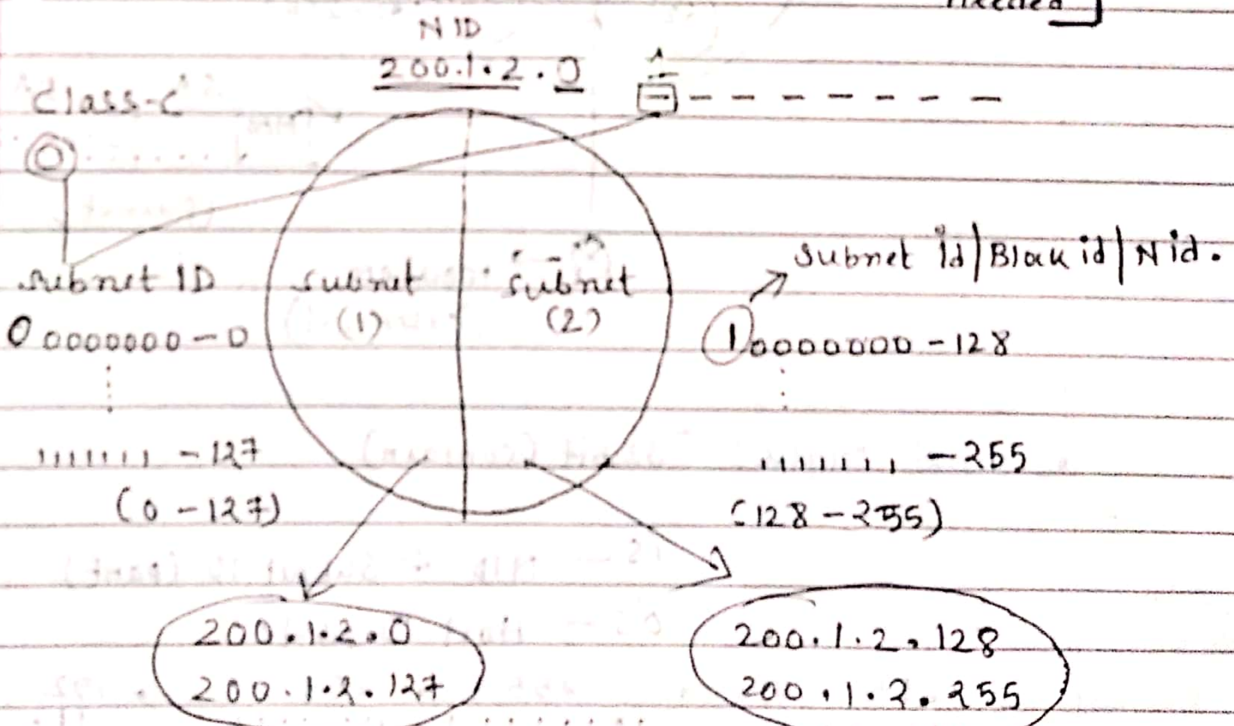
(i) Maintenence of smallest network is easy compare to big network.

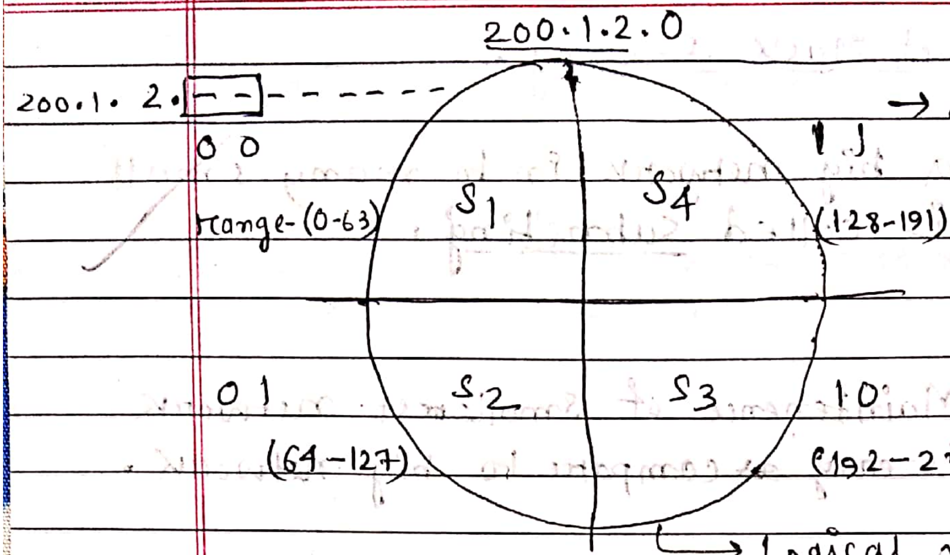
(ii) security can be Improved.

disadv:

(i) Now 4 steps required to Identification –

a. Identify network
b. " subnet.
c. " host.
d. " process. [normaly 3 steps needed]

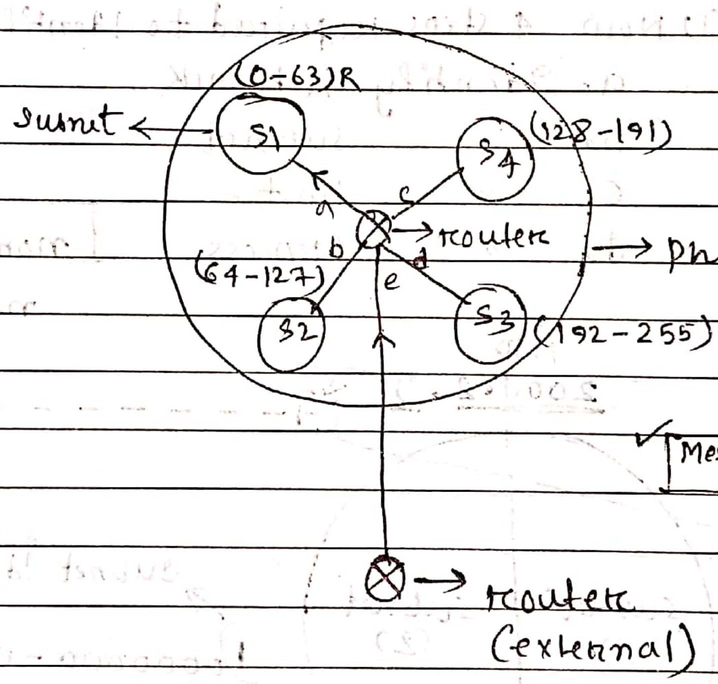




→ always in subnetting we are going to take bits from the host id part.

→ Logical view.

→ here wasted 2×4=8 IP addresses.(to 4 subnet)



→ physical view

SA	DA
Mess		200.1.2.20

(packet)

Subnet Mask: 32 bit (contain)

1's — NID & Subnet ID (part)

0's — Host ID (part)

255 . 255 . 255 . 192

11111111 . 11111111 . 11111111 . 11 000000

Network ID — SID — Host ID.

200.1.2.130

	255	255	255	192
Subnet Mask –	11111111	11111111	11111111	11000000
IP add –	11001000	00000001	00000010	10000010
∴	11001000	00000001	00000010	10000000
	200	1	2	128

200.1.2.128

→ given an IP add and subnet mask we can find out the network id of network to which the IP address denolgs.

EX – Subnet mask : 255.255.255.192
IP add : 200.1.2.10
200.1.2.0

It belongs to subnet (S_1)

→ router ~~we~~ will used the subnet mask in order to find out what is the Interface we should forward the packet to.

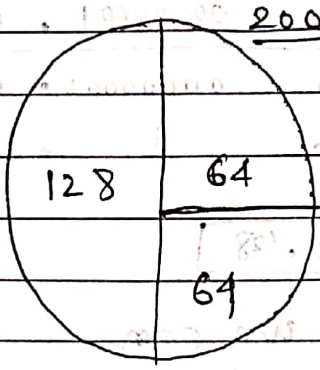
Routing table

N ID	Subnet M	Interface
200.1.2.0	255.255.255.192	a
200.1.2.64	"	b
200.1.2.128	"	c
200.1.2.192	"	d
0.0.0.0	0.0.0.0	e

If coming packet (IP add + subnet Mask) is match with ~~that~~ N ID then the packet send over (a, b, c, d).
if desn't match then ~~next~~ packet sent out (Default entry)

Variable length Subnet masking –

CC – 200.1.2.0



→ subnet size is different it is called (VLSM) variable length subnet masking.

200.1.2.0
NID HID

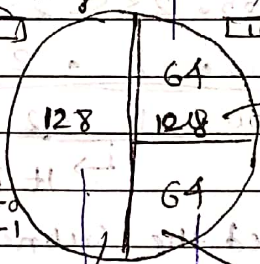
200.1.2.[ ]– – – – – – – → choose '1' bit

7 bit remaining

.0 SNID

$(2^7 = 128)$

200.1.2.0 – – – – – – –
0 0 0 0 0 0 0 – 0
0 0 0 0 0 0 1 – 1
:
1 1 1 1 1 1 1 – 127



SM 255.255.255.192

10

6 bit remaining $(2^6 = 64)$

200.1.2.10 – – – 0 – – –
0 0 0 0 0 0 – 0 (200.1.2.128)
1 1 1 1 1 1 – 191 (200.1.2.191)

11

6 $(2^6 = 64)$

200.1.2.11 – – – – – – SID
0 0 0 0 0 0 – (200.1.2.192)
:
1 1 1 1 1 1 – (200.1.2.255) DBA

SID ← 200.1.2.0
200.1.2.127 } 128 IP add

Subnet mask
255.255.255.128

SM
255.255.255.192

~~→ Subnet having same size ...~~

→ If subnet's have same size, then they have same subnet mask.

Routing table –

NID	SM	Interface
200.1.2.0	255.255.255.128	a
200.1.2.128	255.255.255.192	b
200.1.2.192	255.255.255.192	c
0.0.0.0	0.0.0.0	d

Subnet mask

$\boxed{255.255.255.\cancel{255}\ 192}$

11111111.11111111.11111111.11000000

here, 26 1's (NID + SID) | 6 0's (HID)

$\downarrow$

$2^6 = 64$ IP/SN

Class-A, $8 + SID = 26$

$SID = 18$

#Subnets $= 2^{18}$

C-B, $16 + SID = 26$

$SID = 10$

#Subnets $= 2^{10}$

C-C, $24 + \overset{SID}{\cancel{8}} = 26$

$SID = 2$

$\# SN = 2^2 = 4$

Question — given $\boxed{225.255.255.15}$ (SM) how many subnet possible. If it is class-C.

$\rightarrow$ 225.225.255.15

11111111.11111111.11111111.1111

$2 \,|\, 15$
$2 \,|\, 7 - 1$
$2 \,|\, 3 - 1$
$2 \,|\, 1 - 1$
$0 - 1$

Network ID + subnet = 28

$\Rightarrow$ $24 + SID = 28$

$SID = 4$

$= 2^4$ (subnets)

• Questions on Subnet masking:

00000000 – 0
10000000 – 128
11000000 – 192
11100000 – 224
11110000 – 240
11111000 – 248
11111100 – 252
11111110 – 254
11111111 – 255

for the given subnet mask how many subnet possible.

Subnet mask	No of Hosts	Subnet in class A	Subnet in class B	Subnet in class C	NID is 16 bit
255.0.0.0	$2^{24}-2$	2^0	—	—	✗
255.128.0.0	$2^{17}-2$	2^1	—	—	✗
255.192.0.0	$2^{22}-2$	2^2	—	—	2^0
255.240.0.0	$2^{20}-2$	2^4	—	—	2^2
255.255.0.0	$2^{16}-2$	2^8	2^0	—	2^6
255.255.254.0	2^9-2	2^{15}	2^7	—	2^{13}
255.255.255.0	2^8-2	2^{16}	2^8	2^0	2^{14}
255.255.255.224	2^5-2	2^{19}	2^{11}	2^3	2^{17}
255.255.255.240	2^4-2	2^{20}	2^{12}	2^4	2^{18}

(a) 1's + 0's
8 24

NID + SID = ~~8~~
8 8

SID = 0

Q. given subnet mask as 255.255.255.192 and IP address is 200.1.2.3 : find the Subnet ID and how many subnet there :

→

SM – 255.255.255.192

IP – 200.1.2.3

↳ (class-c network)

SID = 200.1.2.0

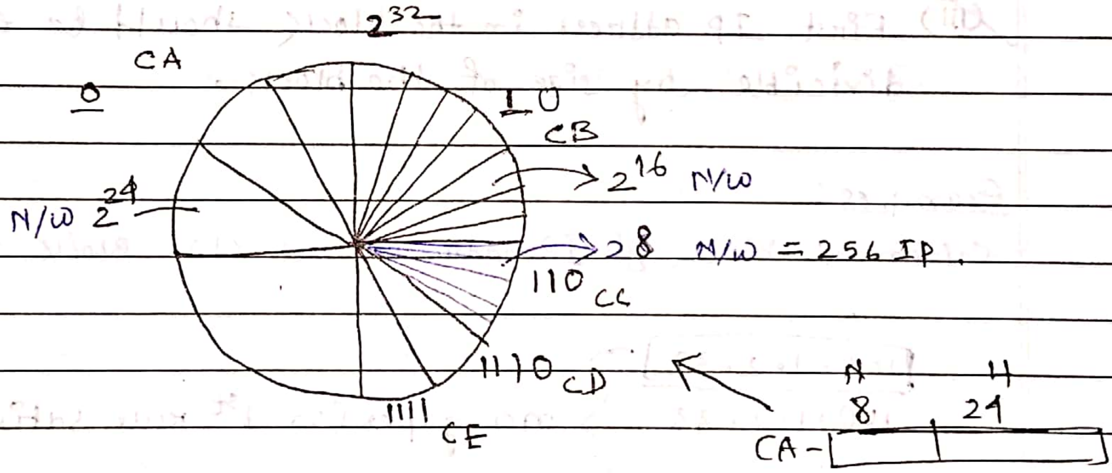
subnet mask → $\underbrace{11111111.11111111.11111111}_{NID}.\underbrace{11}_{SID}\underbrace{000000}_{HID}$

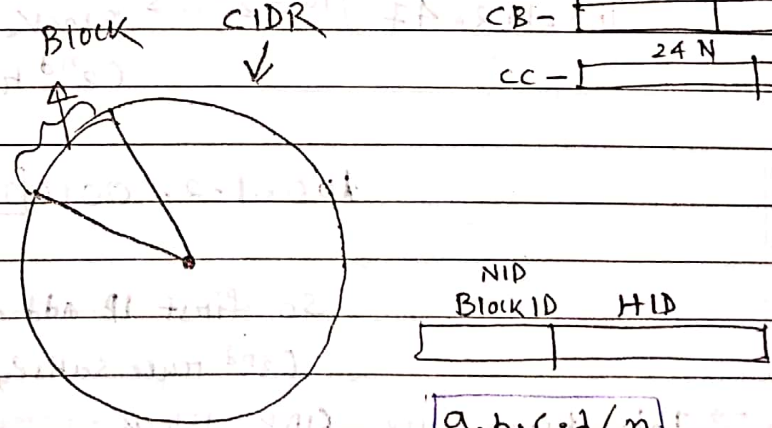
$\overset{24}{NID} + SID = 26$

SID = 26 − 24 ⇒ 2 bit

so, no of subnet = 2^2 ⇒ 4.

- CLASSES INTER DOMAIN ROUTING (CIDR) :





a.b.c.d/n

→ here n represent what are the bits in Block ID (NID).

CIDR representation

Ex- $\boxed{20.10.50.100/20}$ (n=20 bit in Network ID part)

total bit = 32
NID = 20
HID = 32-20
= 12

Contain = 2^{12} IP addresses
= $2^{12}-2$ host

• Rules for forming CIDR blocks –

(i) All IP Addresses should ~~combine~~ be contiguous.

(ii) The Block size should always be power of '2'. (2^n)
(easy to divide IP add into NID and HID)

(iii) First IP address in the block should be evenly divisible by size, of the block.

Examples:

Given a block of IP addresses are CIDR Block or not ?

$\boxed{100.1.2.32}$
100.1.2.33
...
100.1.2.47

no gaps (so 1st rule satisfyed)

16 = 2^4 → Block size is power of '2' (2nd rule satisfyed).

100.1.2. 0010$\boxed{0000}$ 2^4
remainder

So first IP add divisible by 2^4.
(3rd rule satisfyed)

→ This block are CIDR Block.

Example –

Whether this IP address form the CIDR block or not.

20.10.30.32
20.10.30.33
20.10.30.34
⋮
20.10.30.63

$32 = 2^5$ size of the block power of '2'.

20.10.30.001|00000|

→ this block are qualify for CIDR block.
→ No of IP add 2^5, HID = 5 ; BID = 32 − 5 = 27 $\boxed{20.10.30.32/27}$

Example –

findout whether ~~this~~ this block are CIDR or not.

150.10.20.64
150.10.20.65
150.10.20.66
⋮
150.10.20.127

$64 = 2^6$ (2^{nd} rule followed)

150.10.20.01|000000|

→ this block are also CIDR block.
→ in this block, 2^6 IP addresses and 6 host ID.

HID = 6
HID + BID = 32
BID = 28

CIDR representation, $\boxed{150.10.20.64/28}$

$\underbrace{150.10.20.0100}_{BID}|\underbrace{0000}_{HID}$

Example –

CIDR Block given find the range.

$\boxed{100.1.2.35/20}$ → $\underbrace{100.1.0000}_{BID}|\underbrace{0010}_{2\ bit}.\underbrace{00100011}_{35\ bit}$

BID size = 20 bits

000000000000 – 0
⋮
111111111111

range – 100.1.0.0
⋮
100.1.15.255

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• Subnetting in CIDR -

example -

20.30.40.10/25 → here NID = 25 and HID = 7 bit.

20.30.40.0|0001010

↳ NID ↳ 7 bit HID.

We will choose bits from HID part for subnetting.

If we choose 1 bits from Host ID then ~~we are going~~ ~~divide the~~ we will got 2 subnets.

20.30.40.0 0001010 (NID, HID)
$\boxed{0}$000000

20.30.40.0 0001010 (NID, HID)
$\boxed{1}$000000

20.30.40.0 0001010

$\boxed{0}$000000 — 0
000001 — 1
000010 — 2
⋮
$\boxed{0}$111111 — 63

range,

Block ID 20.30.40.0/26 to 20.30.40.63

↳ for one subnet.

20.30.40.0 0001010

$\boxed{1}$000000 — 64
000001 — 65
000010 — 66
⋮
$\boxed{1}$111111 — 127

range.

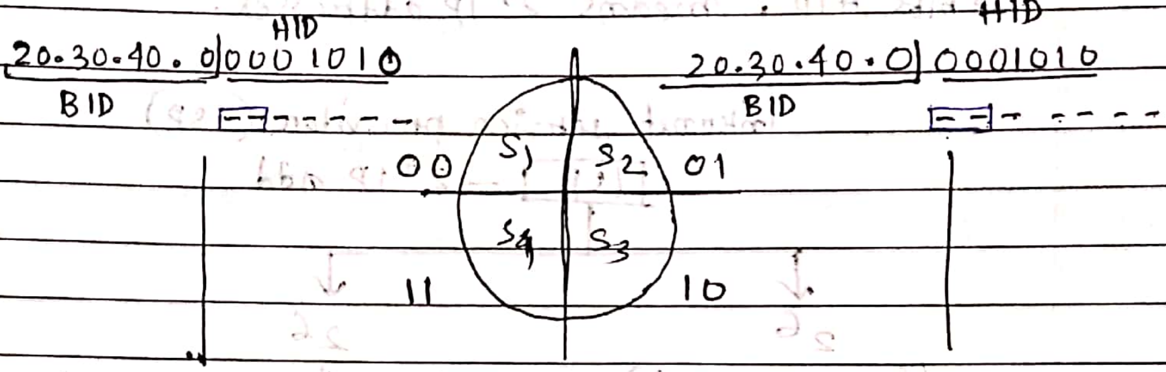
20.30.40.64/26 to 20.30.40.127

↳ for ~~an~~ second subnet.

Example –

$\boxed{20.30.40.10/25}$

dividing the entire network into 4 subnets:-



If you choose '2' bits from HID part, then ~~you get~~ ~~4 sub~~ the entire network will be divide into '4' parts.

	First IP add	Last IP add
Subnet (S1) ID →	20.30.40.0/27.	20.30.40.31/27
Subnet (S2) ID →	20.30.40.32/27.	20.30.40.63/27
Subnet (S3) ID →	20.30.40.64/27.	20.30.40.95/27
Subnet (S4) ID →	20.30.40.96/27.	20.30.40.127/27
	NID	Directed Broadcast add

/25 – NID (HID = 7) (2^7 IP address)

/26 + /26

$\underbrace{2^6 + 2^6}_{2^7}$

/25 (2^7)

/27 /27 /27 /27

$\underbrace{2^5 + 2^5 + 2^5 + 2^5}_{2^7}$.

→ variable length subnet masking.

- **VLSM in CIDR blocks:**

~~Example~~

$\boxed{20.30.40.10/25}$

here ~~form~~ this block 25 bit Network ID and (32-25) = 7 bits HID, means 2^7 IP addresses.

Internet service provider (ISP)

ISP — 2^7 IP add

2^6 (for company A)

2^6

2^5 (for company B)

2^5 (to Individual customers)

25 bits NID | HID

20.30.40.0 | 0 0 0 10 1 0

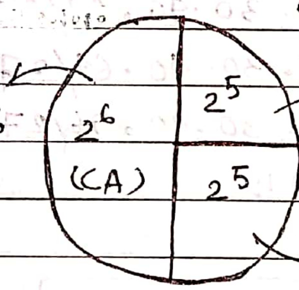
0 0 0 0 0 0 0

1 0 . . . . .

64

0 . . . . . .

20.30.40.0/26



64 32

1 0

→ 20.30.40.64/27

64 32

1 1 . . . . .

→ 20.30.40.96/27

Example —

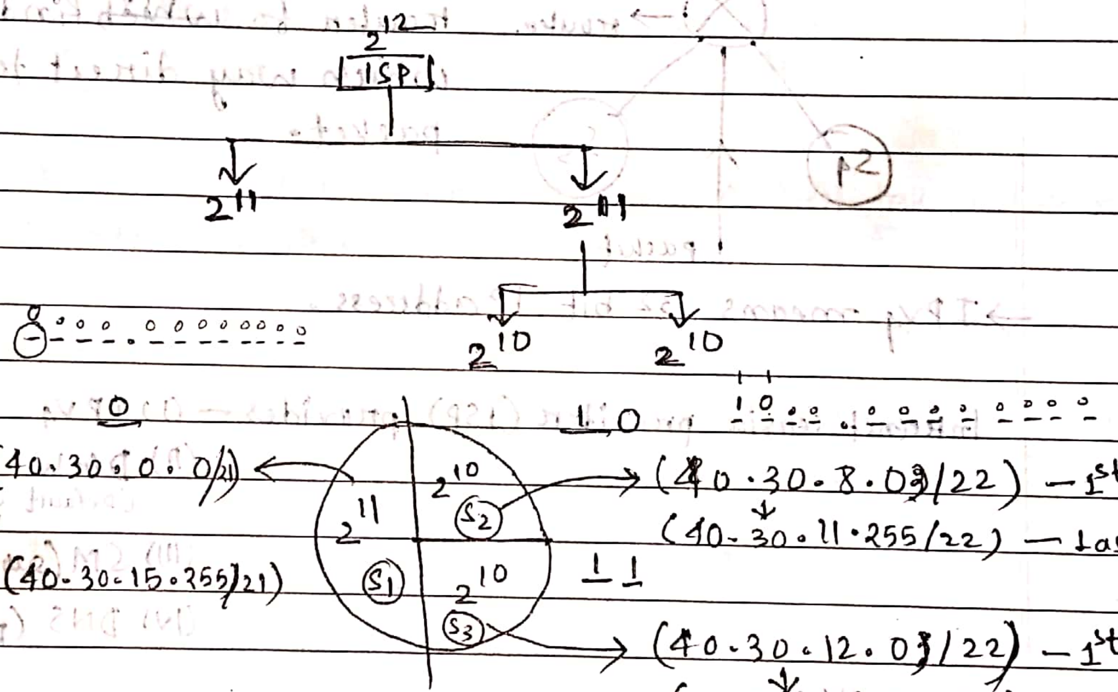
$\boxed{40.30.10.10/20}$

here 20 bits BID(NID) and (32-20) bits = 12 bits Host ID (HID) so, total number of IP address possible 2^{12}.

40.30.0000|1010.00001010
20 bit Block ID | Host ID

0000.00000000 — 1st IP add (40.30.0.0)

1111.11111111 — Last IP add (40.30.15.255)



first IP — (40.30.0.0/21)

Last IP — (40.30.15.255/21)

(40.30.8.0/22) — 1st

(40.30.11.255/22) — last

(40.30.12.0/22) — 1st

(40.30.15.255/22)

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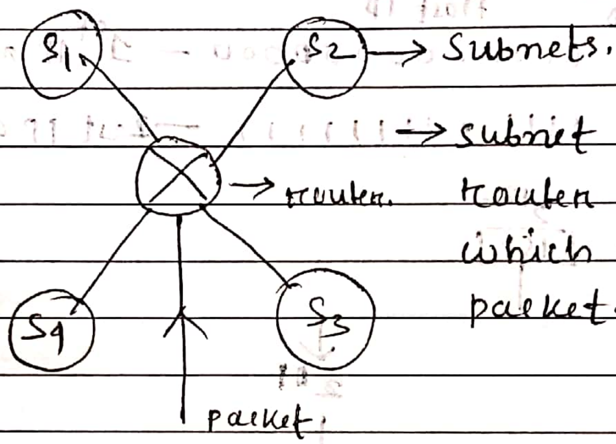
• Some problems on Subnet masking —

→ subnet mask (SM) also called network mask (NM).

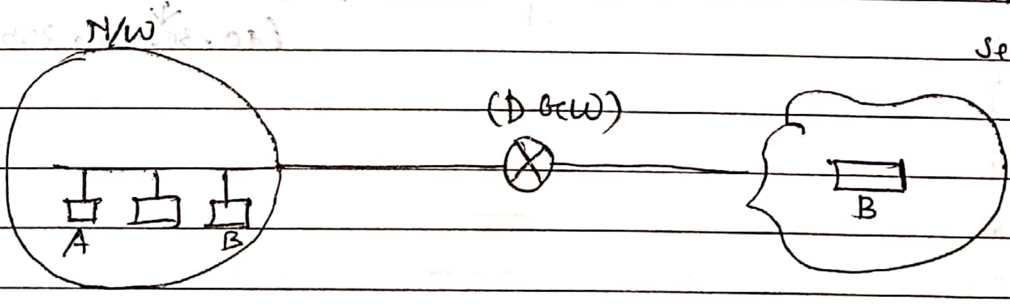
S.M
IP
SID → subnet ID of subnet ~~where~~ to which IP belongs to.



→ subnet masking used by the router to ~~which~~ find out which way direct to the packet.

→ IPv4 means 32 bit IP address.

Internet service provider (ISP) provides — (I) IPV4
(II) DGW (Default gateway IP add)
(III) SM (subnet mask)
(IV) DNS (Domine name Server).



→ To send a packet, first you should know that IP add Destination and also ~~IP~~ DA are inside or outside.

Example -

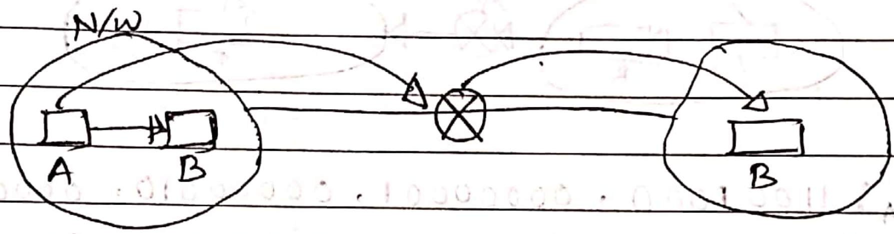
200.1.2.0

a host A : IP_A : 200.1.2.10

SM_A : 255.255.255.128

200.1.2.128

B : IP_B : 200.1.2.130



To send packet from host A, A first take its own IP add and SM.

IP_A : 11001000 . 00000001 . 00000010 . 00001010

SM_A : 11111111 . 11111111 . 11111111 . 10000000

11001000 . 00000001 . 00000010 . 00000000

(Network ID of A according to A) NID_{AA} : 200 . 1 . 2 . 0

IP_B : 11001000 . 00000001 . 00000010 . 10000010

SM_A : 11111111 . 11111111 . 11111111 . 10000000

(Network ID of B according to A) NID_{BA} : 11001000 . 00000001 . 00000010 . 10000000

200 . 1 . 2 . 128

In this case

Here, Network ID of A and B are different so, A first send the packet to router (Router know that where its Destination) and router send the packet to Destination address. (B)

Example–

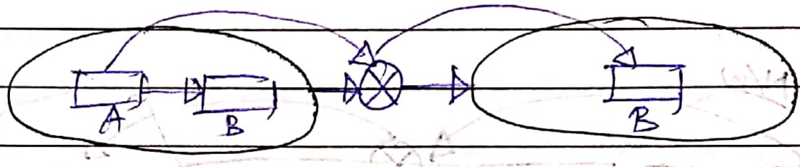
belongs to (200.1.2.0)

Ans: a host A : IP_A : 200.1.2.10

SM_A : 255.255.255.128

this IP belongs to (200.1.2.0)

another host B : IP_B : 200.1.2.126



IP_A : 11001000 . 00000001 . 00000010 . 00001010

SM_A : 11111111 . 11111111 . 11111111 . 10000000

NID_{AA} : 11001000 . 00000001 . 00000010 . 00000000

200 . 1 . 2 . 0

IP_A : 11001000 . 00000001 . 00000010 . ~~00001~~ 01111110

SM_A : 11111111 . 11111111 . 11111111 . 10000000

11001000 . 00000001 . 00000010 . 00000000

200 . 1 . 2 . 0

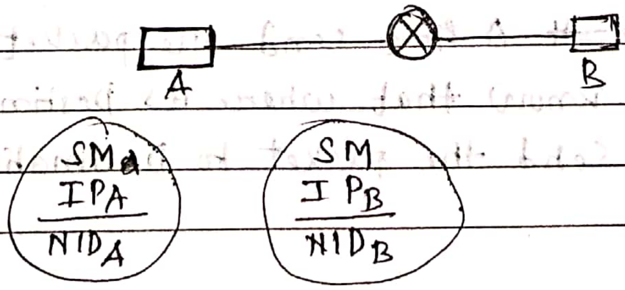
So, A and B both are in same network. So, A send the packet Directly to B.

Ex –

. SM (subnet mask) : 255.255.255.255

here, no of 1's (32), means (NID+SID)=32.

no of 0's (0), means HID = 0 .



Ex:-
given a Directed Broadcast Address (DBA) can you find out network ID and subnet mask.

→ DBA: 200.1.15.255 (If in host ID part put all 1's then it is DBA)

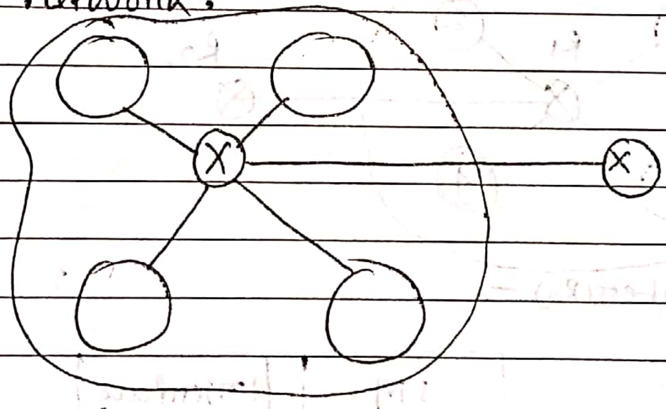
11001000 . 00000001 . 0000 1111 . 11111111
8 bit 8 bit host ID

- many NID = /20
  = /21
  = /22
  = /...

(because all 1's are in this part)

- Supernetting or aggregation:

→ Combining many small networks into one big network.



rules: (to aggregation)
1) all the network should be Contiguous. (means NID)
2) size of all Network same (2^n).
3) First network ID should divisible by (2^n).

Example— How aggregate all this 4 network.

① 200.1.0.0/24
② 200.1.1.0/24 → (possible)
③ 200.1.2.0/24
④ 200.1.3.0/24

→ (I) all the address are contiguous form.
(II) here, size of all network is same. (2^8, 2^8, 2^8, 2^8).
(III) first IP address should be divisible by size of the total supernet.
($4 \times 2^8 = 2^{10}$)

200.1.0.0
200.1.000000|00. 00000000

so, when you divisible the 1^{st} network then reminder will be '0'.

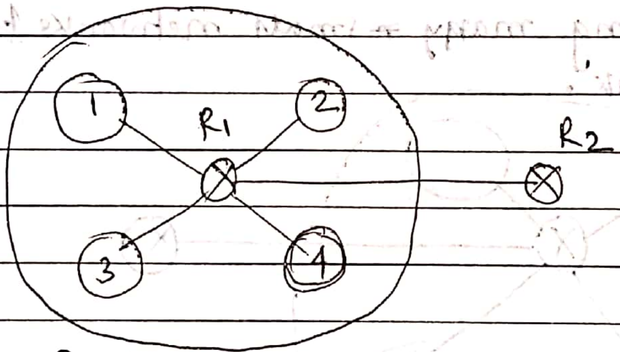


Table for Router(R2) —

N ID	SM	Interface
200.1.0.0	255.255.255.0	a
200.1.1.0	255.255.255.0	a
200.1.2.0	255.255.255.0	a
200.1.3.0	255.255.255.0	a

~~Subnet mask~~ :

~~Subnet~~
Supernet mask: 32 bit number.

→ In supernet mask 1's represent fixed part and no. of 0's represent variable part.

fixed	fixed	fixed		variable
200	1	000000	00	00000000
200	1	000000	01	00000000
200	1	000000	10	00000000
200	1	000000	11	00000000

~~zeros~~
255 . 255 . ~~0000~~ 111111 | 00 . 00000000

$\boxed{255 . 255 . 252 . 0}$ → supernet mask for this enter supernet.

Supernet ID : $\frac{IP}{\frac{SM}{NID}}$

200 . 1 . 0 . 0
255 . 255 . 252 . 0
~~255.255.255~~
$\boxed{200 . 1 . 0 . 0}$ — supernet ID.

routing table :-

NID	SM	Interface
200.1.0.0	255.255.252.0	a

→ by the one entry, it represent all '4' Networks.

Date ______
Page ______

Example - How aggregate all this network. It possible or not to given block.

$$\left.\begin{array}{l} 200.1.32.0/24 \\ 200.1.33.0/24 \\ \vdots \\ 200.1.47.0/24 \end{array}\right] \rightarrow \text{valid networks for supernetting.}$$

(i) contiguous.
(ii) Size of ~~N~~ all network (2^8) same. ~~2^8~~
(iii) 200.1.32.0 should divisible by ($2^8 \cdot 2^4 = 2^{12}$)

200.1.0010 $\boxed{0000.00000000}$

~~200.1.32.~~ $\boxed{00000000}$

Yes, it possible to ~~make~~ convert into supernet.

Total Network = 16   HID = 2^8

So, ~~e~~ ~~contine~~ size of the entire Network $= 2^4 \times 2^8$
$= 2^{12}$

→ If all '3' networks are satisfyed then, 1'st NID will be supernet ID. = 200.1.32.0/20

20 bit	12 bit
NID	HID

supernet mask: $\boxed{255.255.240.0}$

Example - * (many possible b/w 2, 4, 8, 16, 32 ...)

(1) 100.1.2.0/25

(2) 100.1.2.128/26

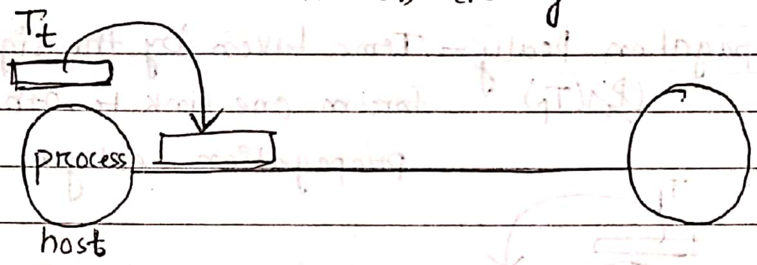
(3) 100.1.2.192/26

→ In this case first marge (2) and (3) then marge (1) with new supernet.

FLOW CONTROL METHOD

- DELAYS in Computer networks:

Transmission delay (T_t): The time taken to ~~transimesion~~ transmit the data packet from a host on to a outgoing link is called transmission delay.



Ex- BW = 1bps.
Data size = 1bit
So, what is the transmission delay of the data.

→ 1 sec — 1bit
10 bit — 10sec

If the size of Data packet = L bits and BW is 'B' bps. then time taken to transmit this data L is,

$$T_t = (L/B) \text{ Sec}.$$

Ex- L (length of the Data) is 1000 bits
BW = 1Kbps
What is the transmission delay of the data.

→ $L_t = L/B \Rightarrow \frac{1000 \text{ bits}}{1000} = 1 \text{ sec}.$

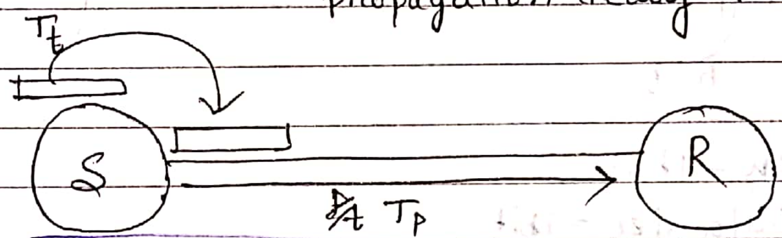
Ex- L = 1Kb, BW = 1Kbps ~~Dat~~
$T_t = ?$

→ $T_t = \frac{1024}{1000} = 1.024 \text{ sec}.$

Data → powers of 2 | BW → powers of 10.

K = 1024	K = 1000
M = 1024 × 1024	M = 10^6
G = 1024 × 1024 × 1024	G = 10^9

Propagation Dealy (T_p) – Time taken by the signal to reach from one link to other link is called propagation dealy.



$$\boxed{T_p = \frac{d}{v} = \frac{\text{distance}}{\text{velocity}}}$$

$v = 3 \times 10^8 \times 0.7$
$= 2.1 \times 10^8$ m/s

Ex –

$d = 2.1$ km
$v = 2.1 \times 10^8$ m/s

What is T_p = ?

→ $T_p = \frac{d}{v} \Rightarrow \frac{2.1 \text{ km}}{2.1 \times 10^8 \text{ m/s}}$

$\Rightarrow \frac{2.1 \times 10^3 \text{ m/s}}{2.1 \times 10^8 \text{ m/s}}$

[Micro sec = 10^{-6}

$\boxed{T_p \Rightarrow 10^{-5}}$ second.

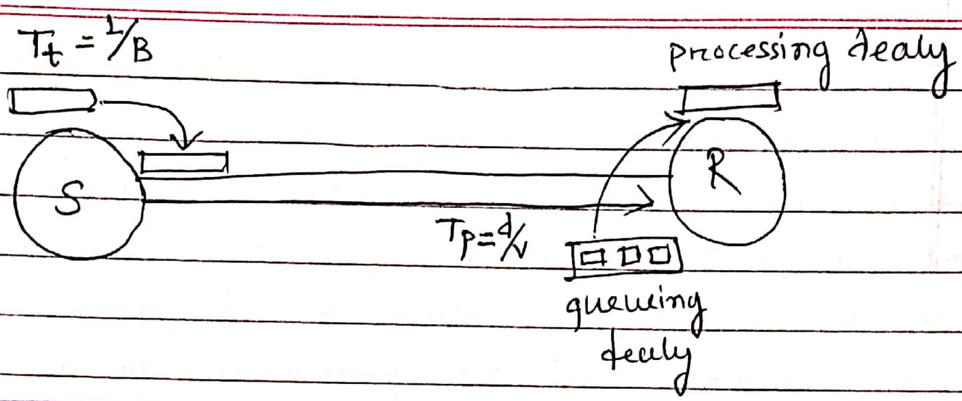
[msec = 10^{-3} (mili sec)

✓ Convert into msce = $\frac{10^{-5} \times 10^3}{10^{-3}}$

$= 10^{-2}$ miliseond

✓ Convert microsecond = $\frac{10^{-5} \times 10^6}{10^{-6}}$

$= 10\ \mu$sec.



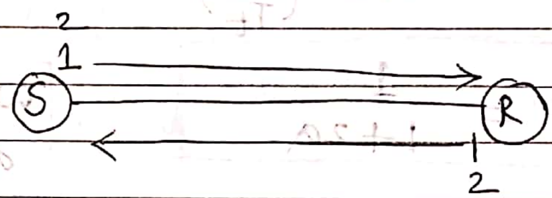
queueing dealy – The amount of time any packet ~~set~~ sit in the buffer and wait before being process is called queueing dealy.

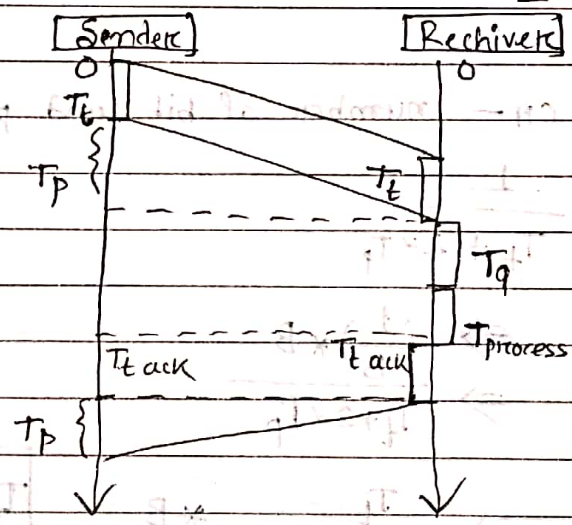
processing dealy – The packet will be taken by the rechiver and then it will be processed that is called processing dealy.

- Flow control methods :

Flow control is the management of data flow b/w computers or devices or ~~flow~~ b/w nodes in a network so that the data can be ~~to~~ handled at an efficient pace. Too much data arriving before a device can handle it causes data overflow, meaning the data is either lost or must be retransmitted.

Stop and wait —





T_t = Transmission dealy
T_p = propagation dealy.
T_q = queueing dealy.
$T_{process}$ = processing dealy.

~~The data reciever process~~

The total time taken to send '1 packet' $= T_{t\,data} + T_p + \cancel{T_q}^{0} + \cancel{T_{process}}^{0} + T_{t(ack)} + T_p$

$= \boxed{T_{t\,data} + 2 * T_p + \cancel{T_{t\,ack}}^{0}}$

$= \boxed{T_t + 2 * T_p}$

T_q and $T_{process}$ taken as '0'.
T_t(ack) taken as '0' as ack is very small as compared to data

$$\eta(\text{efficiency}) = \frac{\text{useful time}}{\text{total cycle time}}$$

$$= \frac{T_t}{T_t + 2*T_p}$$

$$= \frac{T_t/T_t}{\frac{T_t+2*T_p}{T_t}}$$ divide by T_t (Nu & De)

$$= \frac{1}{1+2*\left(\frac{T_p}{T_t}\right)}$$

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

where, $a = \frac{T_p}{T_t}$

Throughput in CN – number of bit send per second.

Throughpt = $\frac{1}{T_t + 2*T_p}$

or

effective BW

or

BW utiligation

$$\Rightarrow \frac{\left(\frac{1}{B}\right)*B}{T_t+2*T_p}$$

$$\Rightarrow \frac{T_t}{T_t+2*T_p}*B \qquad \boxed{T_t = \frac{1}{B}}$$

$$\Rightarrow \left(\frac{1}{1+2a}\right)*B$$

$$\boxed{\text{Throughput} \Rightarrow \eta * B}$$

Q. Given, $T_t = 1\,msec$ and $T_p = 1\,msec$.
What is efficiency $(\eta) = ?$

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

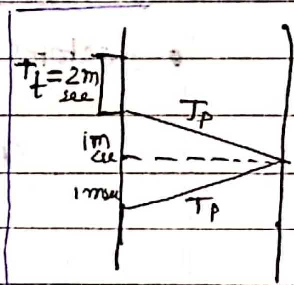
$$\Rightarrow \frac{1}{1+2*\frac{1}{1}}$$

$$\Rightarrow \frac{1}{3}$$

$$\boxed{a = \frac{T_p}{T_t}}$$

Q. Given, $T_t = 2\,msec$, $T_p = 1\,msec$.
$\eta = ?$

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



Total = 4 msec
50 % of ~~to~~ total time.

Q. Given, $B = 4\,Mbps$, $T_p = 1\,msec$, then
What will be the length of packet so that efficiency is atleast 50 %.

$\rightarrow$
$$L \geq 2 * T_p * B$$
$$L \geq 2 * 10^{-3} * 4 * 10^{6}$$
$$L \geq 8 * 10^{3}\ \text{bits}$$

So, the length of the packet should be at least 8000 bit, so that we get 50 % of efficiency.

$$\eta \geq 0.5$$

$$\frac{T_t}{T_t + 2*T_p} \geq \frac{1}{2}$$

$$\Rightarrow 2T_t \geq T_t + 2T_p$$

$$\Rightarrow T_t \geq 2T_p$$

$$\Rightarrow \frac{L}{B} \geq 2*T_p$$

$$\Rightarrow \boxed{L \geq 2*T_p*B}$$

Q. Given, $\eta = 1/2$ and $B = 4$ Mbps.
EB or Throughput = ?

[BW = bandwidth]

→

effective BW $= \eta * B$

$= 1/2 * 4$ Mbps

$= 2$ Mbps (∵ η is 50%)

- factors which affect stop-and-wait efficiency –

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

$$= \frac{1}{1+2 * \frac{T_p}{T_t}}$$

$$\boxed{\eta = \frac{1}{1+2 * \frac{d}{V} * \frac{B}{L}}}$$

So, Bandwidth(B) increases efficiency decrease.

B↑ η↓ – LAN WAN

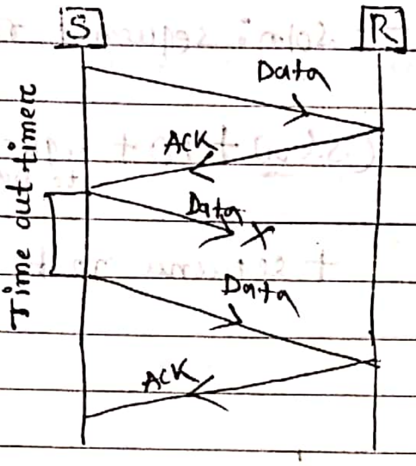
L↑ η↑

Where, velocity and Bandwidth are not going to change

L = length of the packet

• problem in stop and wait –

① Data packet loss – (problem)

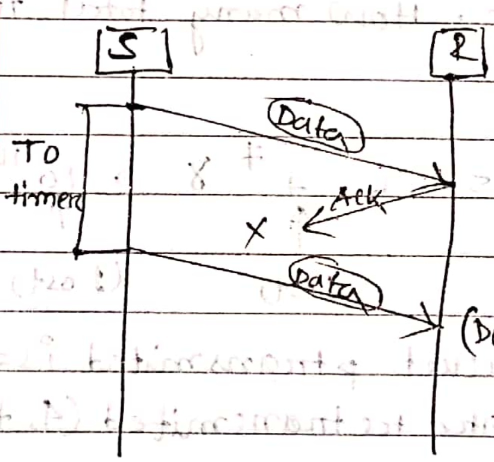


→ S & R wait forever
S (wait for ack)
R (wait for Data)

Deadlock
soln: Time out timer

(Stop & wait + TO)
= stop & wait ARQ.
(Automatic repeat request)

② Ack lost – (problem)

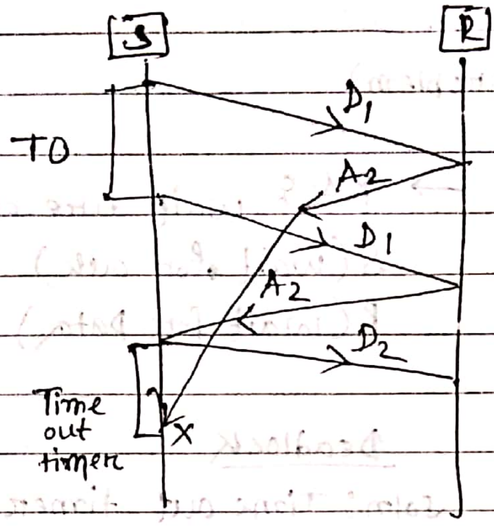


(Duplicate packet problem)

soln: sequence number for data.

(stop and wait + Timeout timer + sequence number to the data)

③ Delayed Ack – (problem)



(missing packet)

→ soln: sequence no. to Ack.

(S&W + TO + sequence no. of + to Data

+ sequence no to Ack)

→ Ack no. is always the no. of next expected data packet.

• How Increase the efficiency of stop and wait –

Ⓠ In stop & wait, sender is sending '10' packets in which every 4^{th} packet is lost. How many total transmissions are required.

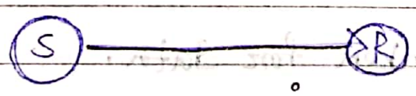
→

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

↑ (lost) ↑ (lost) ↑ (lost)

Total number of packet transmited is = 13.
and packets which are retransmited (4, 7, 10)

Ⓠ



error probability in this channel is 20 %. If send 400 packet on this link. how many packet transmited in total.

→ ~~X / 1466 4400×20/100~~

→ ~~1/ 1466~~ ~~+180~~ ~~+3/1480~~

$\Rightarrow 400 + 400 \times 20\% + 80 \times 20\% + 16 \times 20\% + \cdots\cdots$

** If send 'n' packet which have error probability of p,

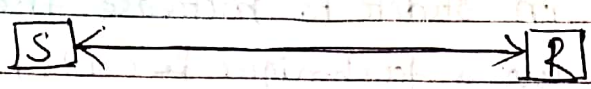
$$n + np + np^2 + np^3 + \cdots\cdots$$
$$= n(1 + p + p^2 + p^3 + \cdots)$$
$$= \boxed{n\left(\frac{1}{1-p}\right)} \rightarrow$$ this many packet send totally.

$\Rightarrow 400\left(\frac{1}{1-0.2}\right)$

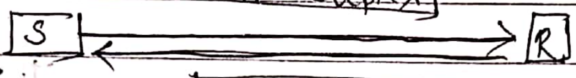
$\Rightarrow \frac{400}{0.8} \Rightarrow 500$ Packet

- Capacity of channel / wire / link –

- **Capacity of a channel/link/wire =**



Half-duplex



Full-duplex

example-

(i) a 'walkie-talkie' is half duplex device because only one party can talk at a time.

(ii) a telephone is full-duplex device because both parties can talk simultaneously.

- In case of half duplex, capacity of the channel = $\boxed{BW * T_p}$
- In case of full duplex, capacity of the channel = $\boxed{2 * BW * T_p}$

BW = Bandwidth
T_p = Propagation delay

→ If the channel capacity is very high is called, Thick pipe.
→ If the channel capacity not very high is called, Thin pipe.

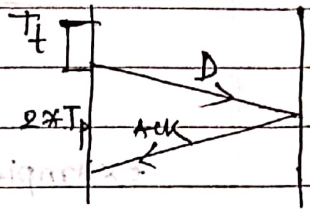
→ Efficiency of stope and wait is ~~less~~ in ~~case~~ Thick pipe.
Efficiency of stop and wait is ~~mode~~ more in Thin pipe.

$$\eta = \frac{1}{1+2a} \Rightarrow \frac{1}{1+2\frac{T_p}{T_t}} \Rightarrow \frac{1}{1+2*T_p*B}$$

→ When this part Increase then efficiency of stop and wait will be less.

- **pipelining**—

In order to increase the η, we use a technique is called pipeline.



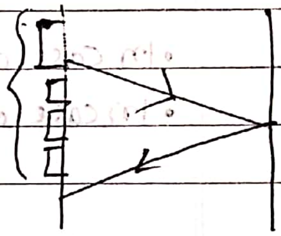
T_t sec — 1 packet

1 sec — $\frac{1}{T_t}$ packet.

$(T_t + 2T_p)$ — $\frac{T_t + 2T_p}{T_t}$ "

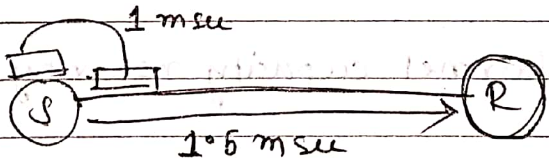
= $1+2a$ packet.

→ When sending more than one packet is called windo.



Q) If $T_p = 1.5$ millisecond and $T_t = 1$ millisec, then how many packets can be transmitted before waiting for acknowledgement of first packets.

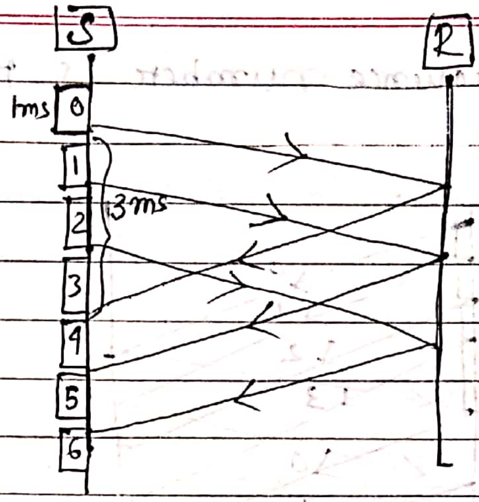
→



Round trip time(RTT) $= 2*T_p$

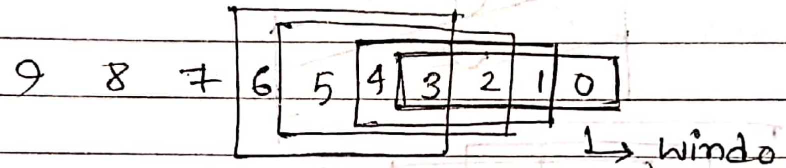
$$\eta = \frac{1}{1+2a} \Rightarrow \frac{1}{1+2*\frac{1.5}{1}} \Rightarrow \frac{1}{4}$$

to increase the efficiency of 'η'.



packet no. - 0, 1, 2, 3 ...

(windo is a buffer)



(sliding windo)

9 8 9 $\boxed{6\ 5\ 4\ 3}$ 2 1 0

→ what the packet which are present Right side of windo ~~its~~ are already transmitted and they are acknowledged.

→ packets which are presend inside the windo are just being transmitted but they are not acknow--ledged.

→ packets which are present left side of windo are add to be transmitted.

In this question,

no of packets are tranimitting are $= (1+2a)$

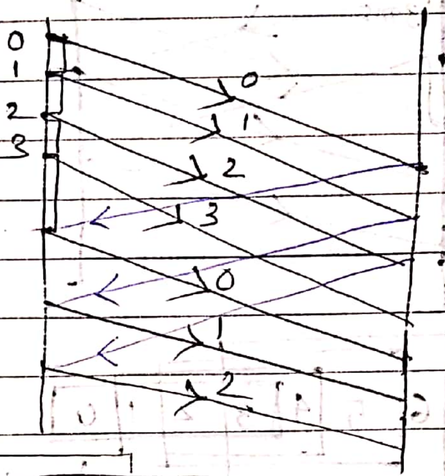
$= 1 + 2 * 1.5$

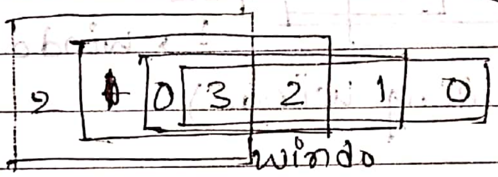
$= 4.$

In sliding ~~win~~ windo, (1+2a) are max utiligation In sender side

$\boxed{W_s = 1+2a}$

How many sequence number is required in this ~~cat~~ case :-





$\boxed{a = \frac{T_p}{T_t}}$

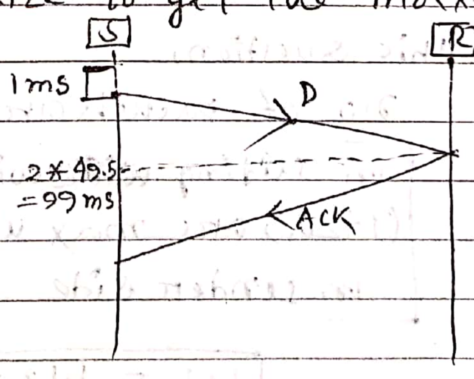
~~w.m~~ sliding windo protocol -

* (1) max sender windo size $(W_s) = 1+2a$
* (2) minimum number of sequence required $= 1+2a$
* (3) minimum no of dites required in sequence

$$\text{no of } \frac{\cancel{\text{bits}}}{\text{field}} = \lceil \log_2(1+2a) \rceil$$

(Q) If, $T_t = 1ms$ and $T_p = 49.5$ msec.
findout ~~the maximum~~ what should be sender windo size to get the maximum efficiency.

→



$W_s = 1+2a$
$= 1 + 2 * 49.5$
$= 100$

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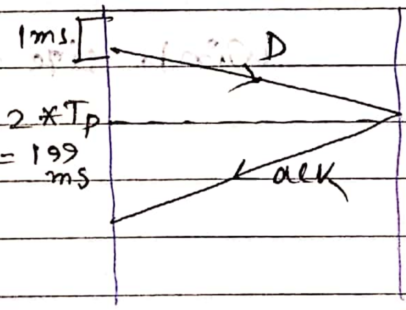
- minimum no. of sequence required = 1+2a
  = 100.

- What should be the minimum no of bits in sequence number field should be = $\lceil \log_2 100 \rceil$
  $= \lceil 6.8 \rceil = 7$

$2^7 = 128$, In 128 seq no, we get 100 sequence no. and remaining 28 sequence no not used.

(Q) If, $T_t = 1$ msec and $T_p = 99.5$ ms. What will be the sender windo size in order to increase efficiency. What are the minimum sequence no. required. and how many bits are required in seq no. field.

→ • $W_s = 1+2a$
$= 1 + 2 * 199$
$= 200$ packet



- no. of seq no need,
  = 200

- how many no. of bits need in seq no field,
  $= \lceil \log_2 (200) \rceil$
  $= \lceil 7.8 \rceil \Rightarrow 8$ bit ~~(required to send 200 seq)~~

(8 bit required in seq no filed to send 200 packet)

→ assume that, given, $\boxed{N=7}$, means 7 bit in seq no field.

$\boxed{N = \text{number of sequence no.}}$

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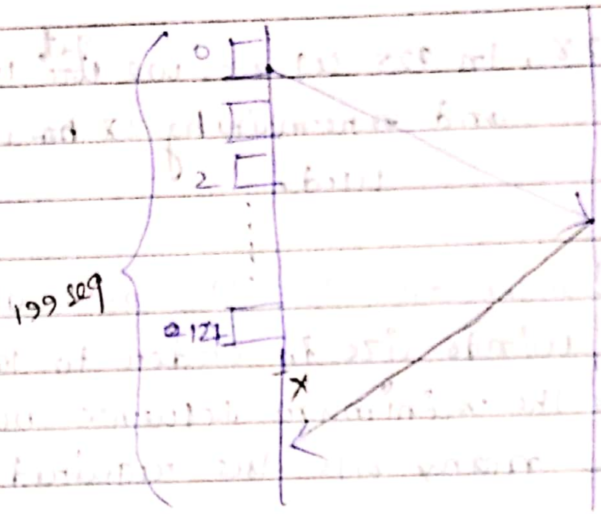
~~Ex~~ $2^7 = 128$ seq no.

$$\eta = \frac{128}{200} = 64\%\ (\text{efficiency})$$

need ~~to~~ 200 seq and have 128 seq no. ~~the~~ so that seq & efficiency will be 64%.



Windo size = $\min(2a+1, 2^n)$

$= \min(200, 128)$

→ Sliding windo protocol is a theoritical concept. practically it is implement in two way—

(I) GBN (Go Back N)　　(II) SR (Selective Repeat)

(1) Go Back N =

(i) Sender window size in Go Back N is N.
Sender window size greater than '1'. (N>1)

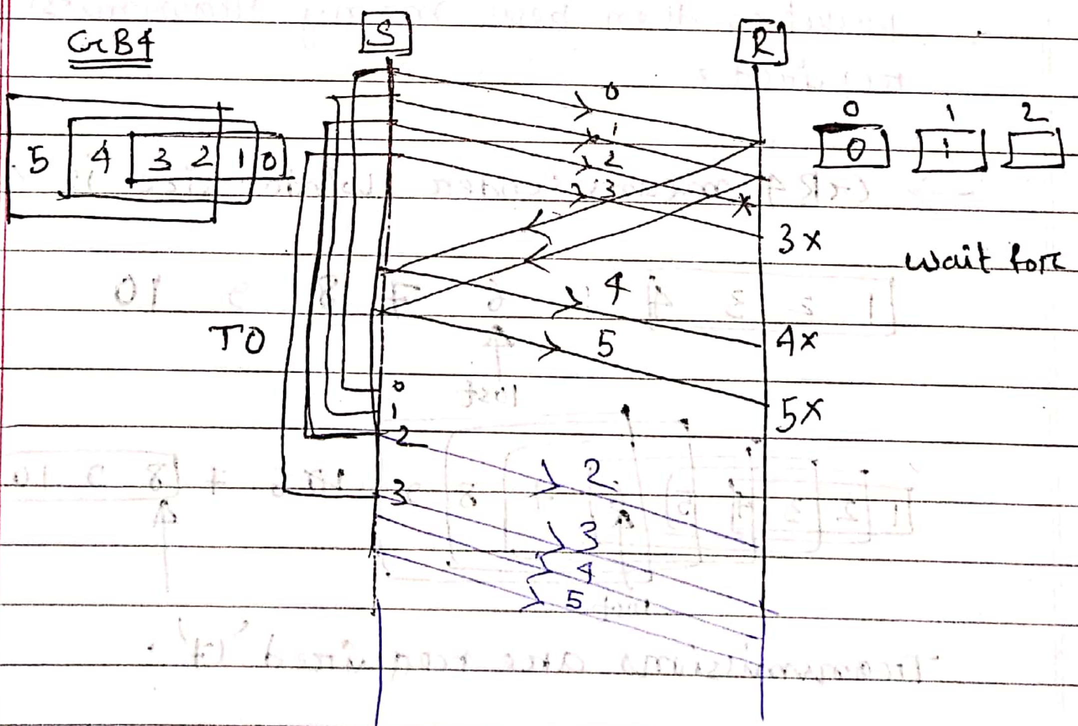
Ex: $T_t = 1$ msec, $T_p = 49.5$ ms, η (efficiency) = ?, GB 10.

→ $W_s = 1 + 2a = 100$
$N = 10$
$\eta = \frac{10}{100} = 10\%$

W = Sender windo size.
N = no. of pack send.
η = efficiency

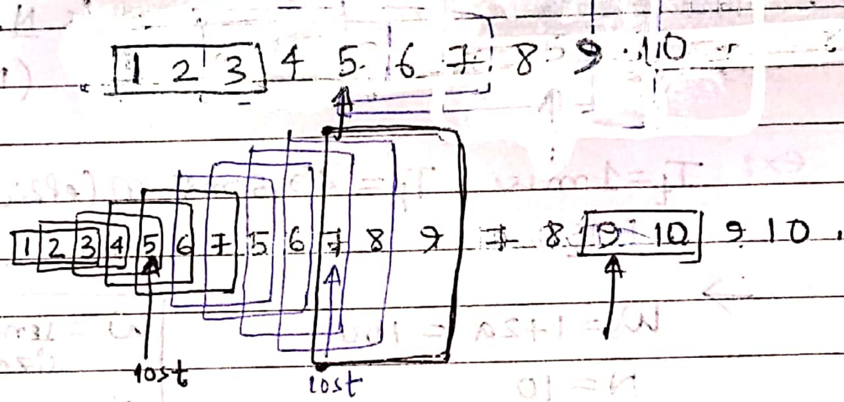
(ii) Receiver windo size = 1.

GB4



Ex – In GB3, If every 5^{th} packet that is being transmitted is lost and if we have to send 10 packets, then how many transmissions are required.

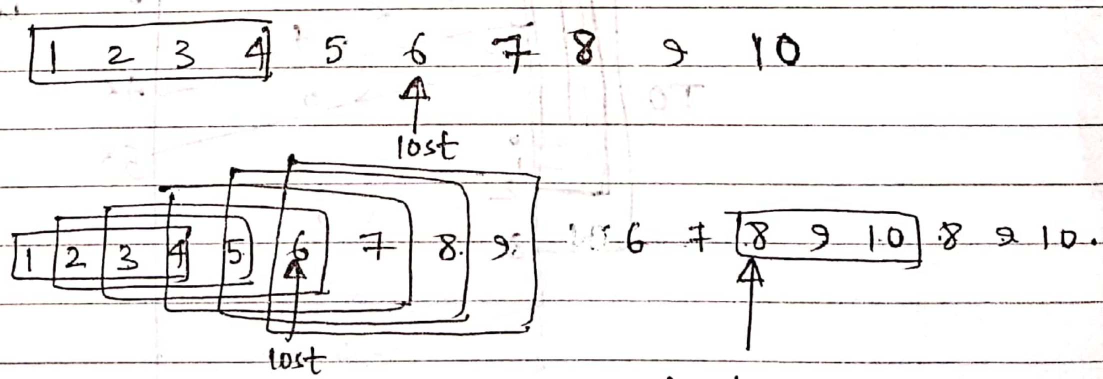
→ GB3 means sender windo size '3'.



Transmissions are required '18'.

Ex – In GB4, If every 6^{th} packet that is being transmitted is lost and if we have to send 10 packets, then how many transmissions are required.

→ GB4 means sender windo size is '4'.



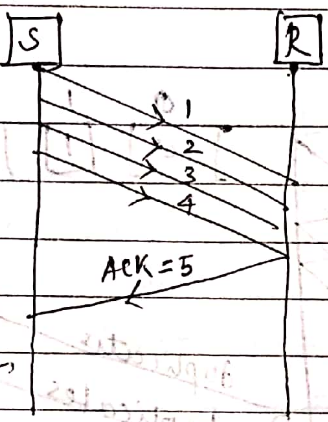
Transmissions are required '17'.

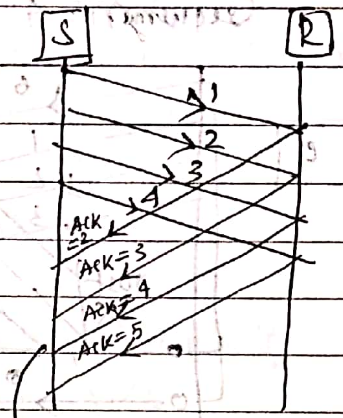
(iii) Acknowledgement — (ACK)

(depending on the what receiver saying, sender is going to follow)

Cummulative Ack

Independent Ack



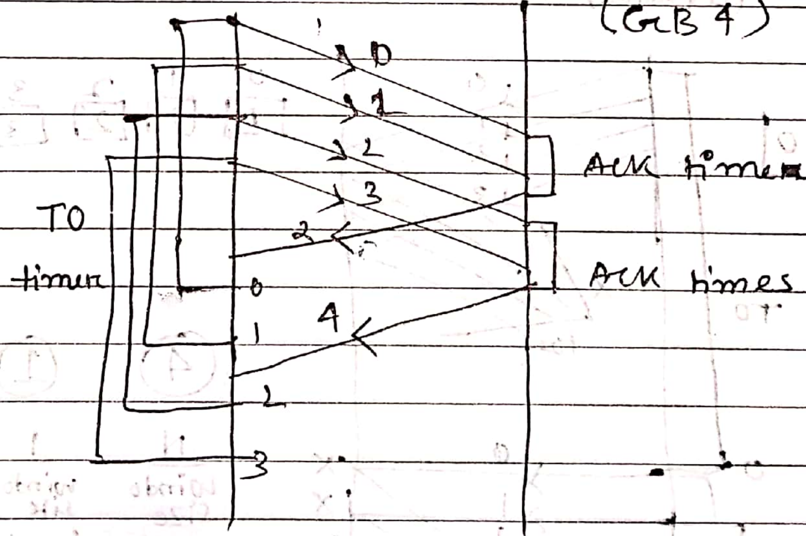


Adv: less traffic.
dis: less reliable.

Adv: Reliablity is high.
dis: Traffic is high.

→ GoBack N use Cummulative acknowledgement.

(GB 4)



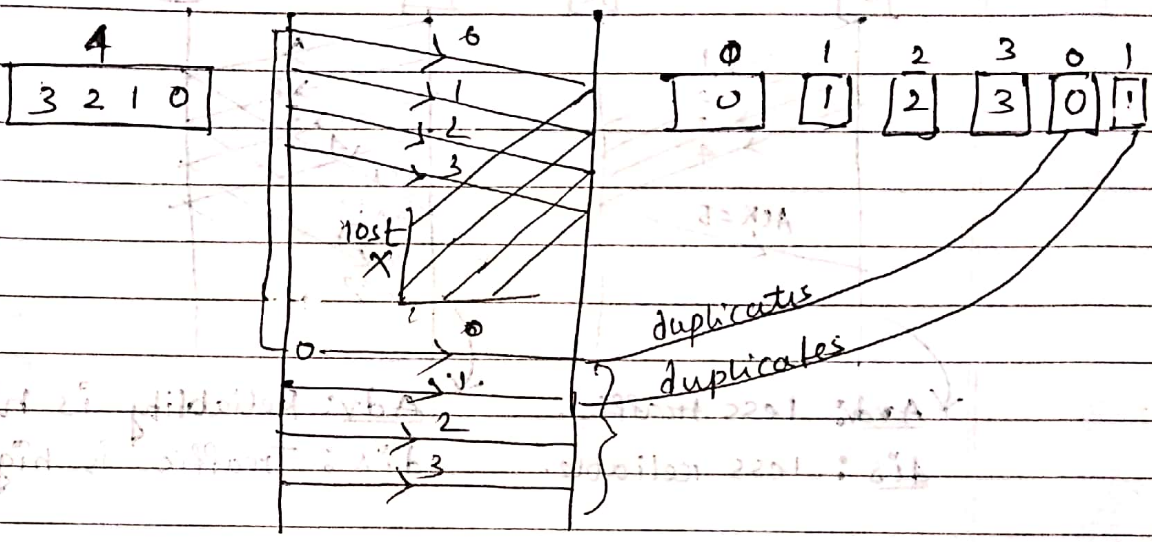
Time out Timer > Ack Time

GBN → window size.

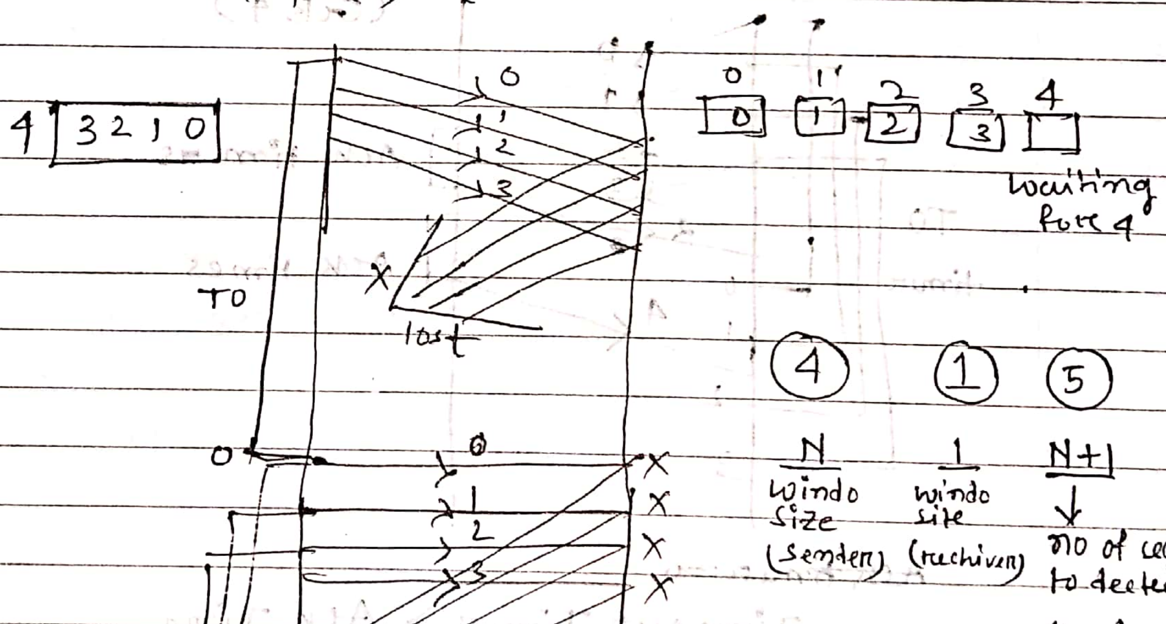
Relationship b/w window size sizes and sequence numbers.

→

GB4 (sequence) n = 4



GB4 (sequence) n = 5



4 1 5

N — windo size (sender)

1 — windo size (receiver)

N+1 ↓ no of seq. to detect the duplicates

$\boxed{W_S + W_R \leq ASN}$ (seq no)

(N + 1)

(1 + 1)

- Types of Question =

1) If $W_S = N$, $W_R = 1$ — $seq = N+1$
given
bits $= \lceil \log_2 (N+1) \rceil$

Where, $W_S \rightarrow$ sender windo size.
$W_R \rightarrow$ Rechiver " ".
seq $\rightarrow$ required seq no.
bits $\rightarrow$ bit required to find $(N+1)$ seq no.

2) If $seq = N$, $W_S = N-1$, $W_R = 1$
given
ex- $seq = 4$, $W_S = W_R = ?$
$W_S = 4-1 = 3/2$
$W_R = 1$

3) If $bit = K$, $seq = 2^K$, $W_S = 2^K - 1$, $W_R = 1$
given

$\rightarrow$ $\boxed{W_S + W_R \leq \underbrace{ASN}_{\text{seq no.}}}$

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(2) Selective Repeat (SR) :-

P-(i) $\boxed{W_S > 1}$ [sender windo size greater than '1']

(Q) $T_t = 1ms$, $T_p = 49.5 ms$
$W_S = 50$, so, in SR protocol η(efficiency) = ?.

→ Max ~~windo capacity~~ Packet can send $= 1+2a$ (always)

$= 1 + 2\left(\frac{T_p}{T_t}\right)$

$= 1 + 99$

$= 100$

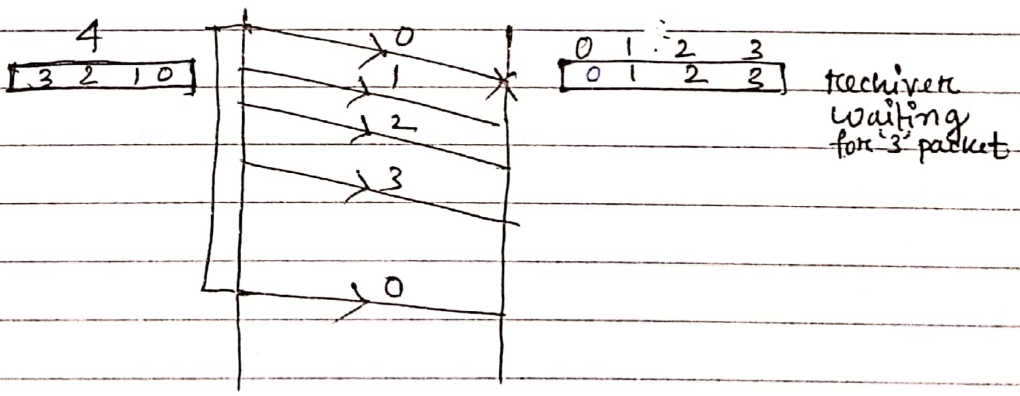
η (efficiency) $= \frac{50}{100} = 50\ \%$

Then, they can ~~ask~~ give. BW = 4 Mbps, Throughput = ?

→ $Th = \eta * BW$

$= \frac{1}{2} * 4 = 2$ Mbps.

P-(ii) $\boxed{W_R = W_S}$ [Reciver and sender windo size is same]



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Ex- $W_s = 3$, 10 packet being send ~~and~~ out of which every 5^{th} packet is lost, then how many ~~may~~ packet will ~~send~~ be send in total using SR protocol.

→

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

(5^{th} lost, 5^{th} lost)

→ total packet will send = 10 + 2
= 12.

→ Number of retransmission in SR protocol is less compar.
→ Number of retransmission in GBN protocol is high.

Ex- $W_s = 3$, packet = 10 &, 4^{th} packet is lost, then how ~~m~~ many packet will be send in total using SR protocol.

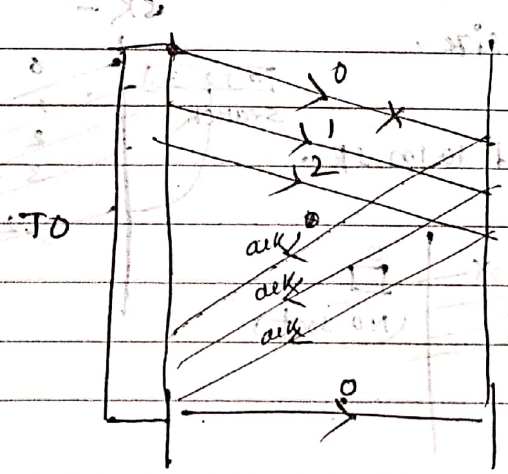
→

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

(lost, lost, lost)

→ total no of packet will send = 10 + 3
= 13.

P-(iii) Ack (IN SR acknowledgement are Independent)



→ both the case (GBN & SR) when packet lost they react same way.

→ In case of packet corrupted, GBN discard packet silently and SR produce Negative acknowledgement.

• Comparison b/w (Stop and wait, GBN, and SR) → all sliding windo protocols.

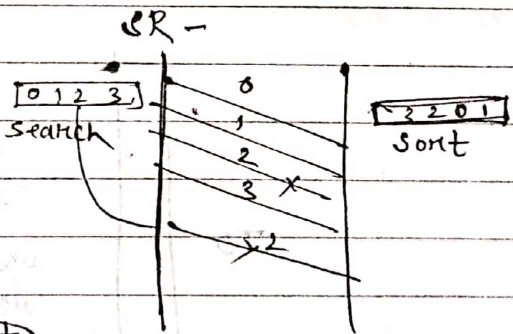
	Stop and wait	GBN	SR
efficiency	$\frac{1}{1+2a}$	$\frac{N}{1+2a}$	$\frac{N}{1+2a}$
Buffers	(1+1)	(N+1)	(N+N)
seq numbers	(1+1)	(N+1)	(N+N)
Retransmission (1 pack lost)	1	N	1
BW	low	high	moderate
CPU (~~implementation~~)	low	moderate	high
Implementation	low	moderate	complex.
ack	Independent ack	Cummulative ack	Independent ack

N → sender windo size.

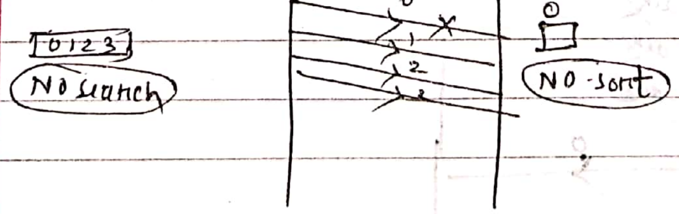
$a \to \frac{T_p}{T_t}$

→ sorting is required ~~to~~ in SR.

SR –



GBN –



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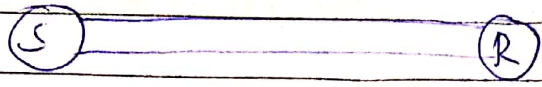
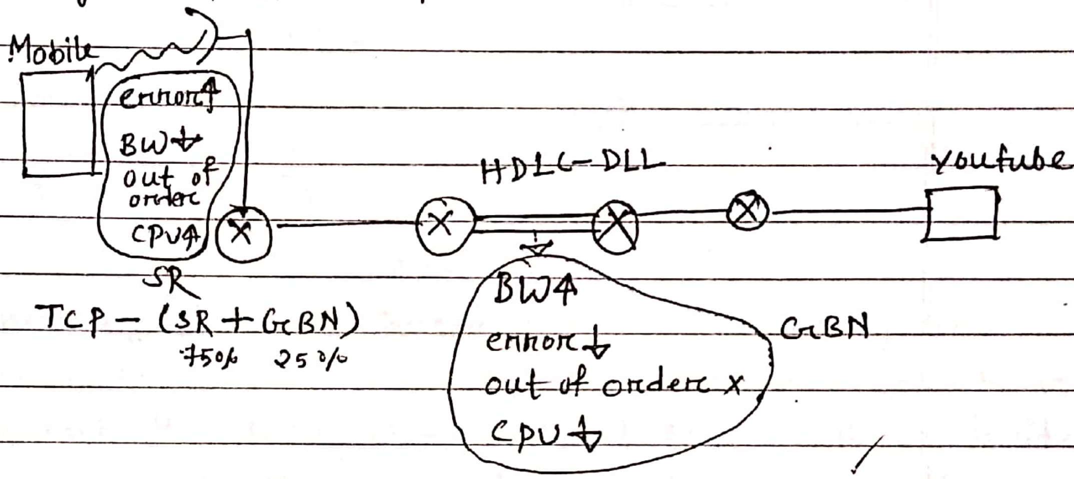
⑧

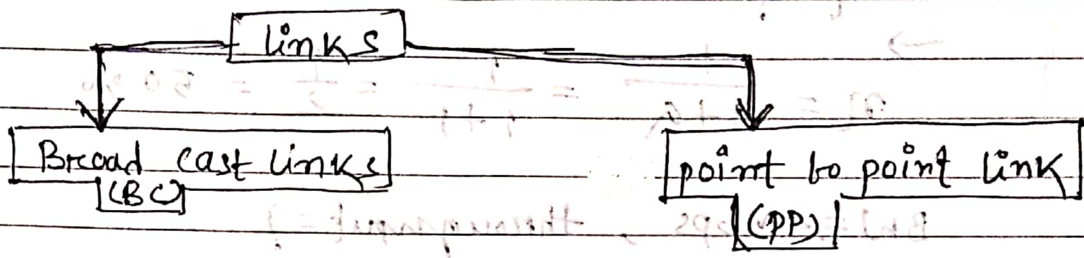


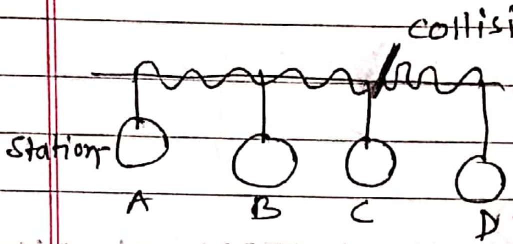
BW↑ CPU↓ Buffer↓ — use GBN.
BW↓ CPU↑ Buffer↑ — SR.

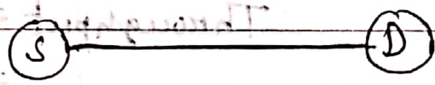
⑧ Utiligation of '2'- protocol.



- **Access control method** –



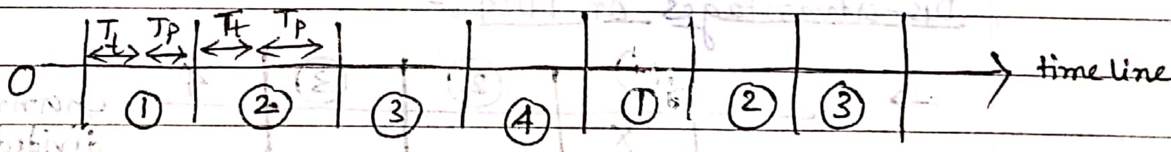




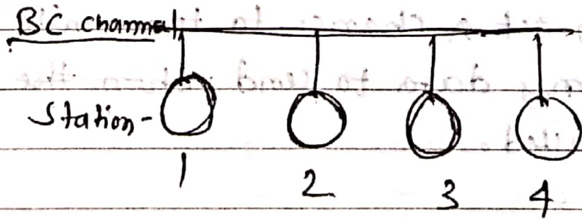
→ whenever I have a Broad cast channel, only one station should send the data. If more than one station ~~sto~~ send the data there should be no collision inside the channel. If you could some how make this happen is called access control method.

- **Various way to Implementation of access control methods** –

- TDM (time division multiplexing):
  ↳ Symplist access control method.



⟹ process continue in a Round Robin meaner.



total time ~~ca~~ taken $= T_t + PT_t$.

$$\left(a = \frac{T_p}{T_t}\right)$$

$$\eta\,(\text{efficiency}) = \frac{\text{useful time}}{\text{cycle time}} = \frac{T_t}{T_t + T_p} = \frac{1}{1+a}$$