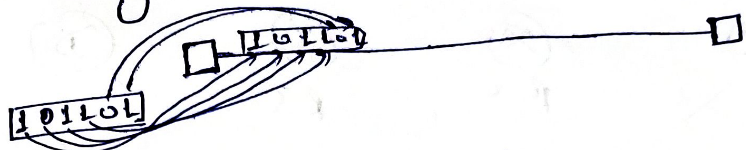
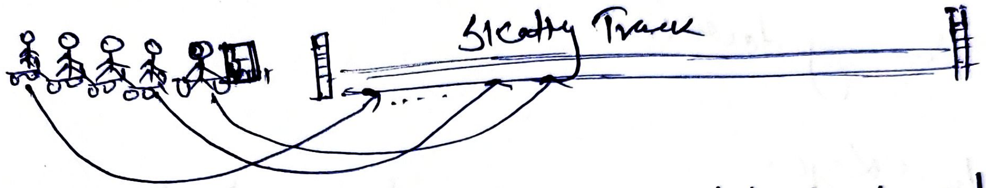
① Transmission delay. — Time reqd to put a packet (bits) on the link.

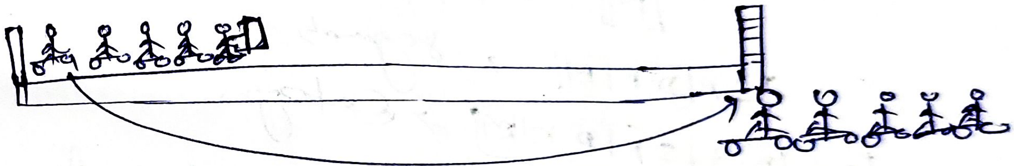


1st bit of pkt $= t_1$, last bit of pkt $= t_2$, Xmsn delay $= t_2 - t_1$

$$Delay_{tr} = \text{pkt length} / \text{transmission rate.}$$



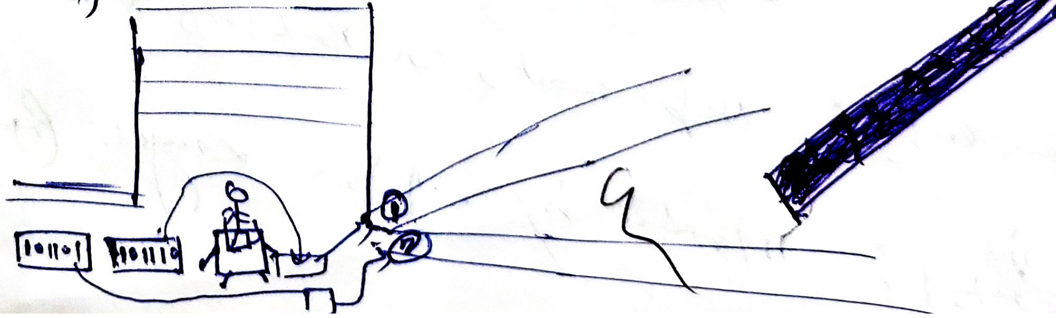
② Propagation Delay :- Time takes for a bit to travel from point A to point B in transmission media.



$$Delay_{pg} = (\text{distance}) / (\text{propagation speed})$$

③ Processing Delay :
① Take pkt from i/p port
② Remove header & perform an error detection procedure.
③ deliver pkt to o/p port.

④ Queuing Delay :- Time a pkt waits in the i/p queue & o/p queue of a router.

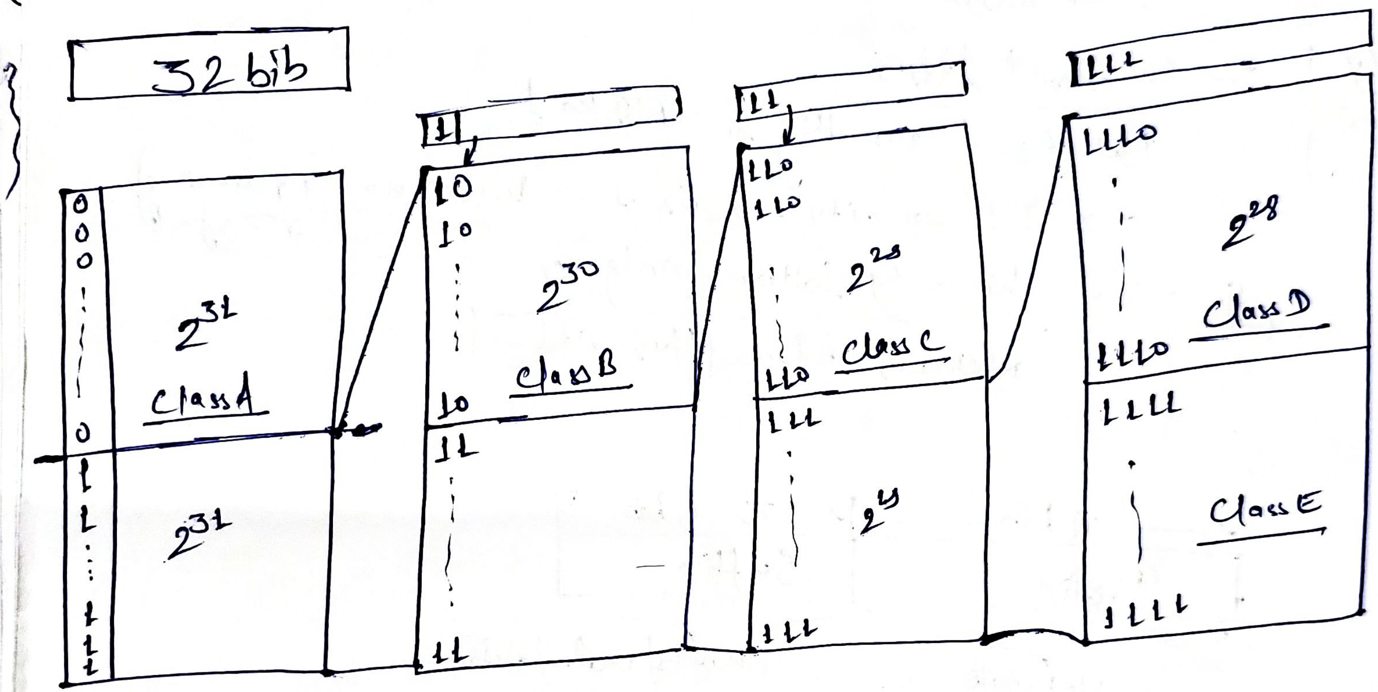


128.11.3.31 → Dotted decimal

10000000. 00001011. 00000011. 00011111 → Binary

80 0B 03 1F → Hexadecimal

## Classful Addressing.




* Class A IP Address

| ← 8 bits → | ← 24 bits → |
| --- | --- |

0 0 0 0 0 0 0 0 — 0. X1. X2. X3 (0.0.0.0 → Null Address)
0 0 0 0 0 0 0 1

⋮

255.255.255 → Reserved for special purpose)

1 1 1 1 1 1 1 1 — 127. X1. X2. X3 (127.0.0.0 ⋮ 127.255.255.255)
(Loop back IP addresses / diagnostic purposes)

* This host

→ Range ⇒ 1. X1. X2. X3 ⋮ 126. X1. X2. X3 → $2^7 = 128$ n/ws of Class-A

$2^{24} \simeq 16$ million IP add. (Hosts) / n/w

→ Used by big organization (NASA, ISRO)

→ Class - B IP Address

| 16 bits | 16 bits |
|---|---|
| 10 | |

10 ------ . x1 . x2 . x3
000000 . x1 . x2 . x3
⋮
111111 . x1 . x2 . x3

$2^{14}$ n/w's of class B type

$2^{16}$ i/p addresses/network
(65536)

⇒ Range : (128 - 191)

→ Used by ~~small~~ medium organization.
(Bank, university)

→ Class - C IP address

| ← 24 bits → | ← 8 bits → |
|---|---|
| 110 | |

110 ------ . x1 . x2 . x3
0 0 0 0 0
⋮
1 1 1 1 1

$2^{21}$ n/w's of class C type

$2^{8}$ i/p addresses/network
(256)

⇒ Range :- (192 - 223) → used by very small organization

→ class - D IP address → Range :- (224 - 239)
→ Multicasting purpose.

→ class - E IP address → Range :- (240 - 255)
→ Used for military or privacy (secret) purposes.

* classes A-C ⇒ Unicast address.
class D ⇒ Multicast address
class E ⇒ Reserved for future use.

Pro's → Easy to know the class of address.

Cons → No flexibility for no. of hosts in a n/w

(*) ⇒ Private addresses:- 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16,
169.254.0.0/16

## Subnetting

* Dividing a n/w into sub-networks.

→ Consider Class 'C' i/p address (aside from students)

218.13.42.0

0 | 0 0 0 0 0 0 0
0 0 0 0 0 0 1
⋮
1 1 1 1 1 1 1

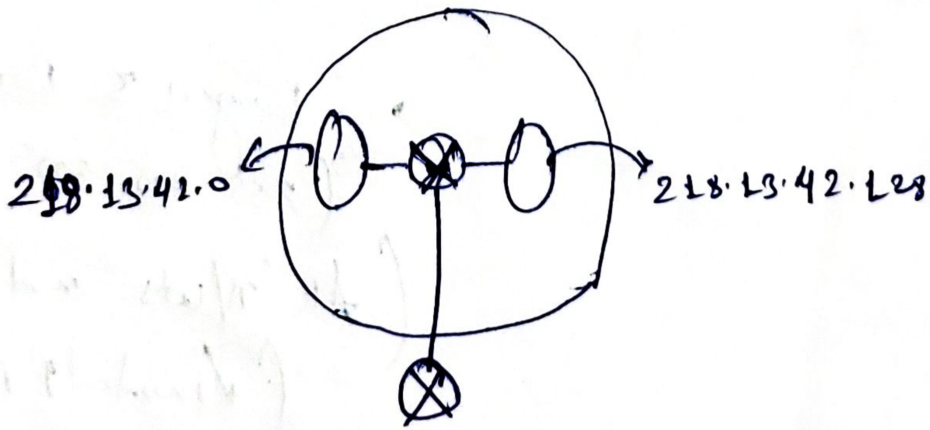
1 | 0 0 0 0 0 0 0
0 0 0 0 0 0 1
⋮
1 1 1 1 1 1 1

218.13.42.0 ⇓ subnet id of 1st n/w

218.13.42.127 ⇓ Directed Broadcast addr. of 1st n/w

218.13.42.128 ⇒ subnet id of 2nd n/w

218.13.42.255 ⇒ Directed broadcast addr. of 2nd subnet



→ **Disadvantages of Subnet**

① 2 i/p addresses are reserved for every subnet.

② More the subnet's, more no. of i/p addresses will be reserved.

* Dividing the same n/w into 4 subnets
218.13.42.0

0 0 0 0 0 0 0 0 (0-63)
⋮
0 0 1 1 1 1 1 1

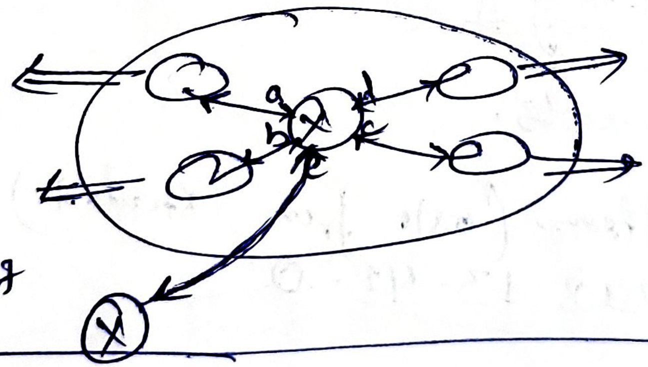
1 0 0 0 0 0 0 0 (128-191)
⋮
1 0 1 1 1 1 1 1

0 1 0 0 0 0 0 0 (64-127)
⋮
0 1 1 1 1 1 1 1

1 1 0 0 0 0 0 0 (192-255)
1 1 1 1 1 1 1 1

218.13.42.0
⋮
218.13.42.63

218.13.42.64
⋮
218.13.42.127



218.13.42.128
⋮
218.13.42.191

218.13.42.192
⋮
218.13.42.255

* Subnet Mask: A 32 bit binary no., which is used to determine the subnet where a particular hosts belongs to.

Subnet Mask: 32 bits

1's ⇒ Network id bit and Subnet id bits

0's ⇒ Host id bit

⇒ Let's suppose the data needs to be send to user 218.13.42.132

S-1) Convert user id i/p address into binary form

S-2) Determine type of i/p address & no. of subnets, like 218.13.42.132 ⊳ class 'C' type address & total 4 subnets are there, so,

24 bits + 2 bits = 26 1's will be there

Subnet Mask :⇒ 11111111.11111111.11111111.11000000

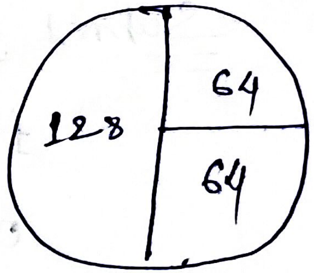
AND 11011010.00001101.00101010.10000100

11011010.00001101.00101010.10000000

218 . 13 . 42 . 128 .

→ Class C Address :- 200.1.2.0 needs to be divided into 3 parts

No. of hosts := $2^8$ = 256 →




200.1.2. 0 | 0000000 → 200.1.2.0 (subnet id)

0000001

⋮

1111111 → 200.1.2.127 (Directed Broadcast address)

Subnet Mask →
1's → N/w id bits and Subnet id bits
0's = Host id bits.
255.255.255.128

| | |
|---|---|
| 200.1.2.10 : 000000 | 200.1.2.11 : 000000 |
| 000001 | 000001 |
| ⋮ | ⋮ |
| 111111 | 111111 |
| 200.1.2.128 – 200.1.2.191 | 200.1.2.192 – 200.1.2.255 |
| SM:- 255.255.255.192 | SM:- 255.255.255.192 |

* Given subnet mask one can define the no. of subnets present in n/w.

Eg:- 255.255.255.192

Subnet Mask:

1's = N/w id bits + subnet id bits.

CA → 8 + SID = 26, SID = 18, No. of subnets $= 2^{18}$

CB → 16 + SID = 26, SID = 10, No. of subnets $= 2^{10}$

CC → 24 + SID = 26, SID = 2, No. of subnet $= 2^{2}$

⇒ Default Subnet Mask → Class A :- 255.0.0.0

Class B :- 255.255.0.0

Class C :- 255.255.255.0

(1)

FLSM :- Fixed Length Subnet Mask

(1) equal size subnets

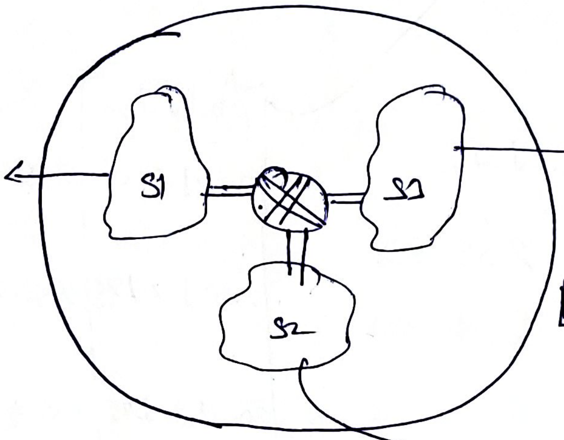
(2) equal size host IDs.

200.1.2.0

\-

200.1.2.127

SM :- 255.255.255.128




200.1.2.128

\-

200.1.2.191

SM :- 255.255.255.192

200.1.2.192

\-

200.1.2.255

SM :- 255.255.255.192

(2)

| | IP | Network Id | Directed Broadcast | Limited Broadcast Address |
|---|---|---|---|---|
| Class A :- | | X.0.0.0 | X.255.255.255 | 255.255.255.255 |
| Class B :- | | X.Y.0.0 | X.Y.255.255 | 255.255.255.255 |
| Class C :- | | X.Y.Z.0 | X.Y.Z.255 | 255.255.255.255 |

Limited Broadcast

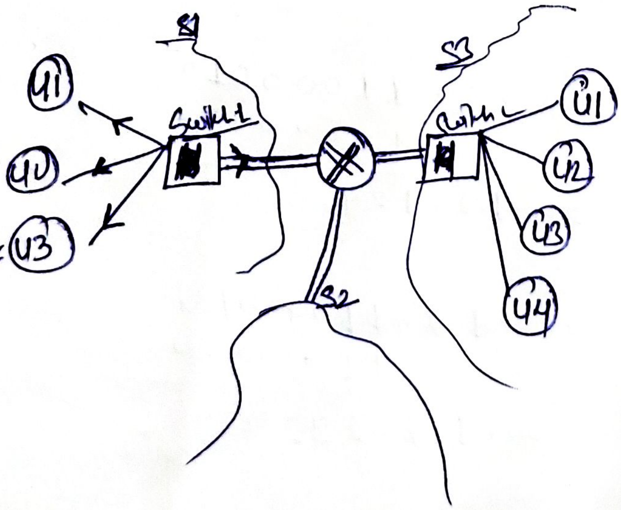
DA

NL :- 255.255.255.255

DLL :- FF:FF:FF:FF:FF:FF

SA

200.1.2.2




Directed Broadcast

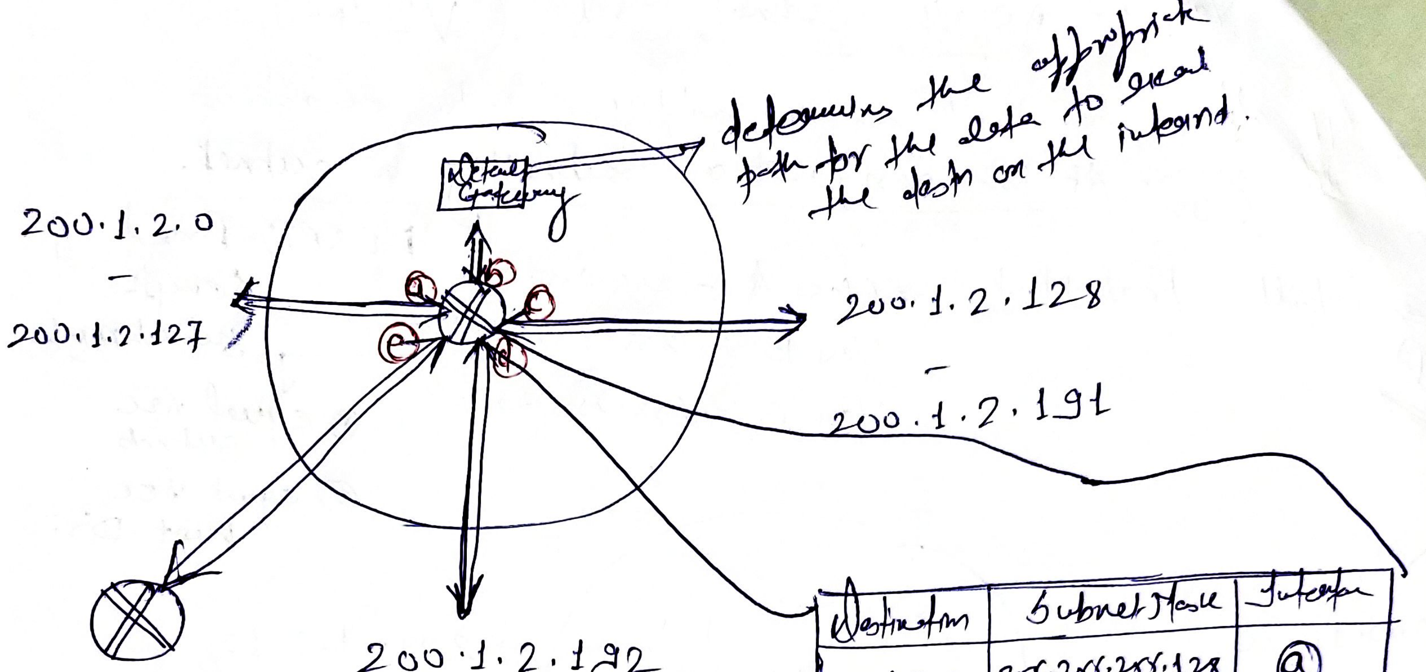
DA

NL :- 200.1.2.191

DLL :- FF:FF:FF:FF:FF:FF

SA

200.1.2.2




| Destination | Subnet Mask | Interface |
|---|---|---|
| 200.1.2.0 | 255.255.255.128 | a |
| 200.1.2.128 | 255.255.255.192 | c |
| 200.1.2.192 | 255.255.255.192 | d |
| 0.0.0.0 (Default) | 0.0.0.0 | b |

Default Address when a pkt doesn't belong to any of the subnet.

- If there is only one match, router forwards the data pkt on the corresponding interface.
- If there are more than one match, router forwards the data pkt. on the interface corresponding to the longest subnet mask.
- If there is no match, router forwards the data packet on the interface corresponding to the default entry.

**Ex:-** 200.1.2.194

$$\begin{array}{l} 200.1.2.11000010 \\ \quad\quad\;\, .10000000 \\ \hline 200.1.2.128 \end{array} \quad \times$$

$$\begin{array}{l} 200.1.2.11000010 \\ \quad\quad\;\, .11000000 \\ \hline 200.1.2.192 \end{array} \quad \checkmark$$