Network Layer

Transport

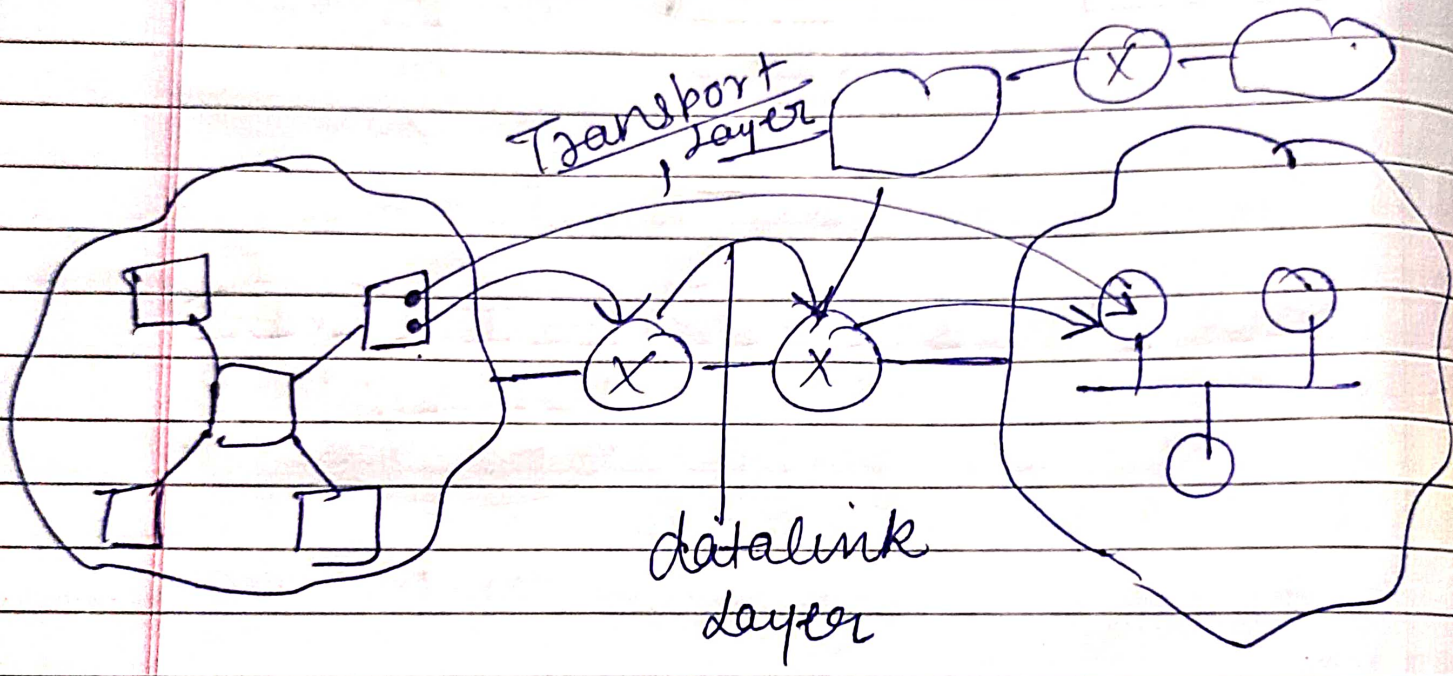
↓

[Network layer]

↓

Datalink.

① Host to Host (Source-Destination/ machine-machine)



2. Logical (IP) address

- Network: it tells that in which network the message is to send
- Host: a particular node at which host the message is to be sent.

3. Routing :-

RIP OSPF
methods

when message is at router then it will decide which route it has to take to send message
it will try to follow Shortest path

4. Fragmentation →

Every router has its capacity to store the packet so if message is greater than packet then we need fragmentation So that message can fit into router.

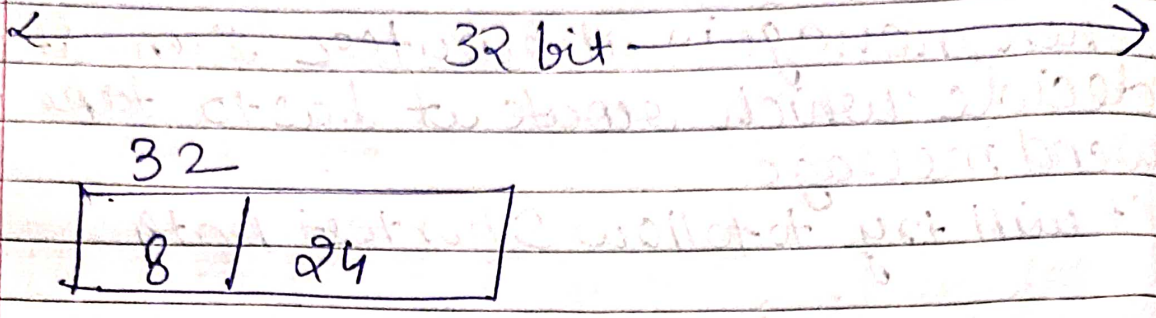
5. Conjestion control →

If the entire network filled up then it called Conjestion control.

Classfull addressing →

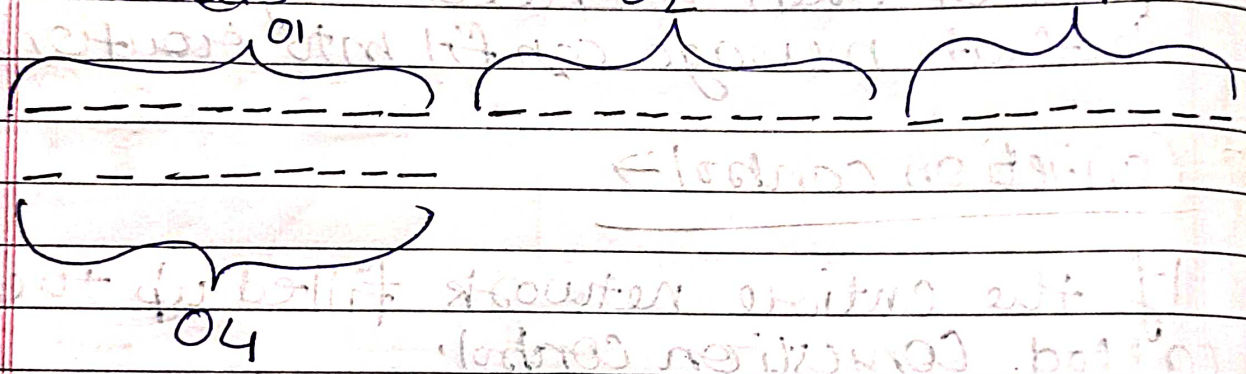
- IP addresses are divided into 5 different classes. A, B, C, D &

- before classfull addres

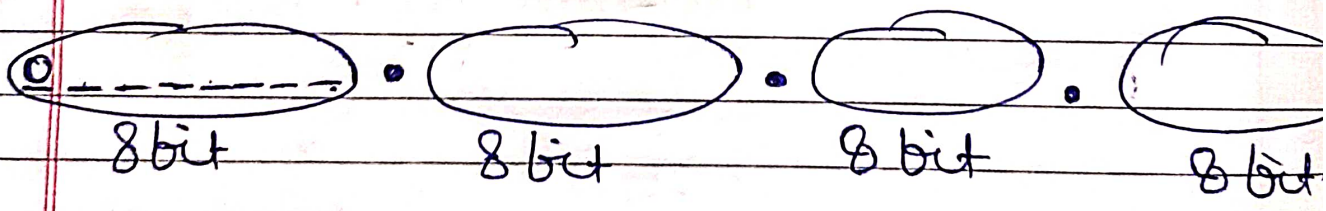


Class A IP Addressing

- 32 bit IP addresses are divided into 4 octats.



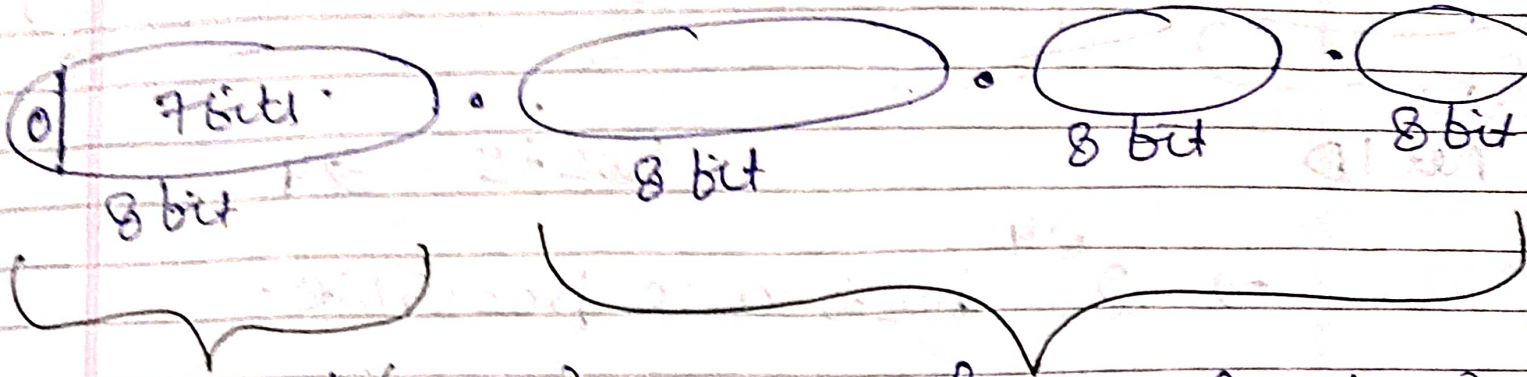
- IP numbers are represented by dotted decimal



- first bit of first octet is always 0 because there are 232 IP address just to identify class A first bit is set to 0.

Number of addresses in class A

$\Rightarrow 2^{31}$ nos



network (8 bits) id

host (24 bits) id

Number of networks in class A ⇒

- no. of bits in octet 1 = 8
- 1 bit is reserved for class A identification
- 7 bits left
- no. of network = $2^7 = 128$

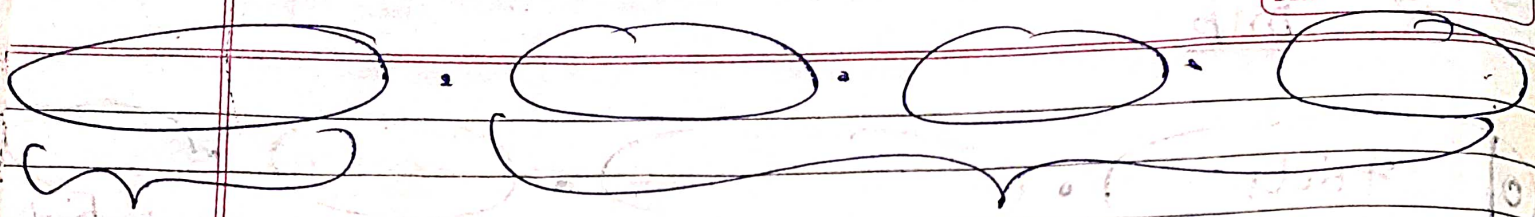
★ First network address 00000000 is not used by any organisation.

IANA → Internet assign number authority this address is with IANA.

★ Last network address 01111111 (127) is also not used by any organization

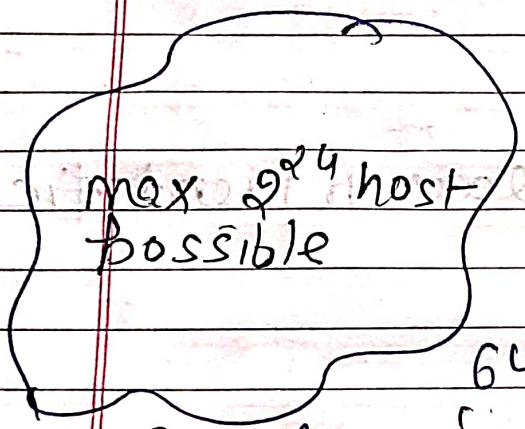
Number of useful address of network of class A ⇒ $2^7 - 2 = 128 - 2 = 126$

Number of host possible in every network



$\Rightarrow 2^{24}$ hosts are possible.

Range of class A $\Rightarrow$ 0 to 127



64.0.0.0 to 64.255.255.255

first IP address of host
This cannot be used by any host it is use to represent a network

Last IP address.
This cannot be used by any host because it is it is used as broadcast address.

Q To find Network ID of a IP address use is its default mask.

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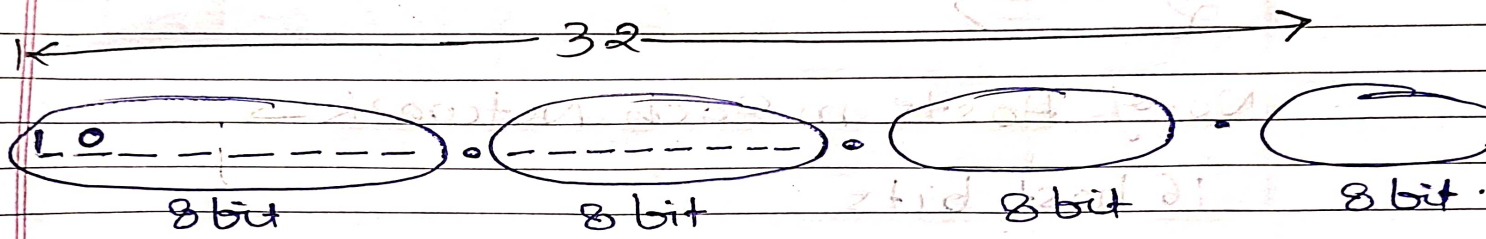
For class A ⇒ 255.0.0.0

64.0.0.8 } do AND
255.0.0.0 }

01000000.00000000.00000000.00001000
11111111.00000000.00000000.00000000
01000000. 0. 0. 0

64.0.0.0

Class B



→ first two positions are fixed as Prefix to identify the ~~network~~ class. (10)

Range → 128 – 191

~~Range~~ first Octet has 8 bits.
Out of which 2 bits are reserved
6 are left

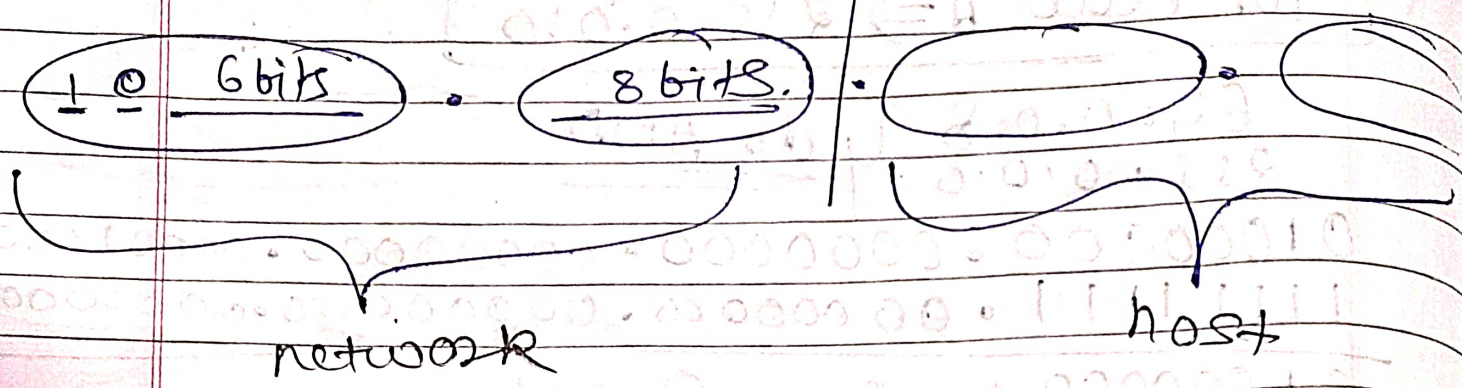
$2^6 \Rightarrow 64$

No. of addresses → Total bits = 32
2 fixed
30 left

2^{30} addresses.

No. of Networks :-

2 Octets are fixed for network



total network bits = 14

Total no. of networks in class B

2^{14} ⇒

No. of Hosts in Each Network →

16 host bits

2^{16}

Two IP addresses cannot be used →

→ first address is used to represent network

→ Last address is used as broad cast address

Useful hosts → $2^{16} - 2 = 65536 - 2$

65534

Q 130.2.3.4

class B (128-191)

Network → 130.2.0.0

default mask → 255.255.0.0

11111111.11111111.00000000.00000000

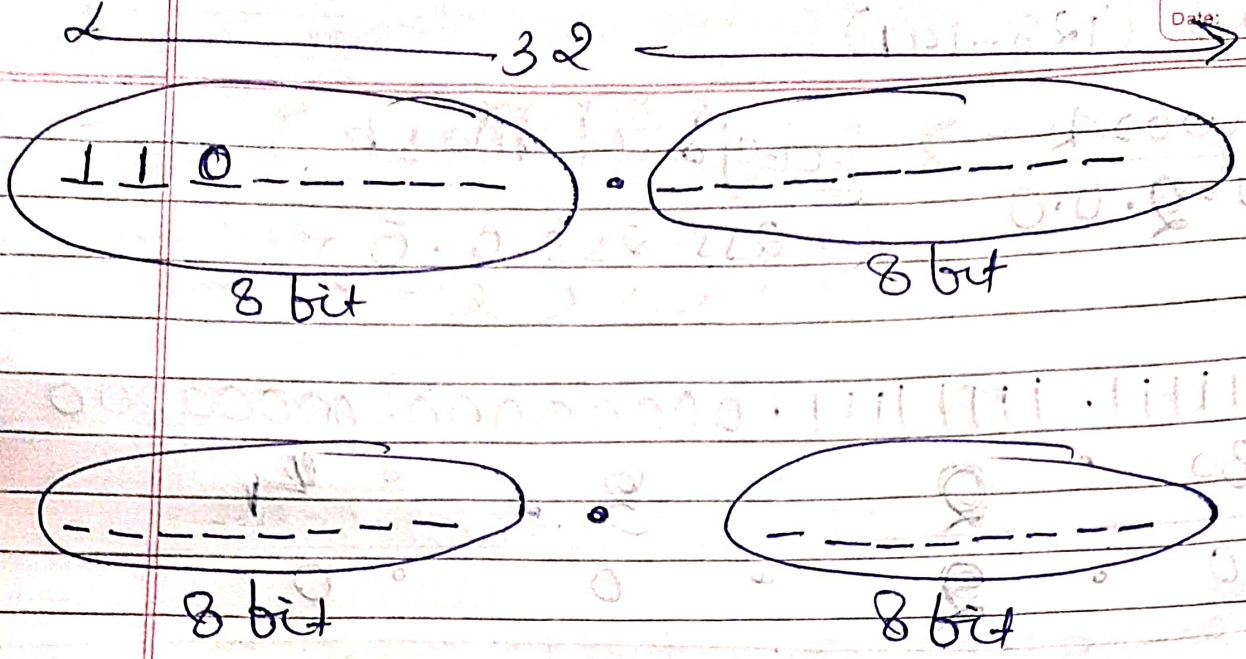
130 . 2 . 3 . 4

130 . 2 . 0 . 0

first → 130.2.0.0

last → 130.2.255.255

Class C



Range :-

First 3 bits of first octates are fixed 110 prefix

1 1 0 [0 0 0 0 0]

1 1 0

:

:

1 1 0 [1 1 1 1 1]

Range → 192 - 223

Number of IP Addresses -

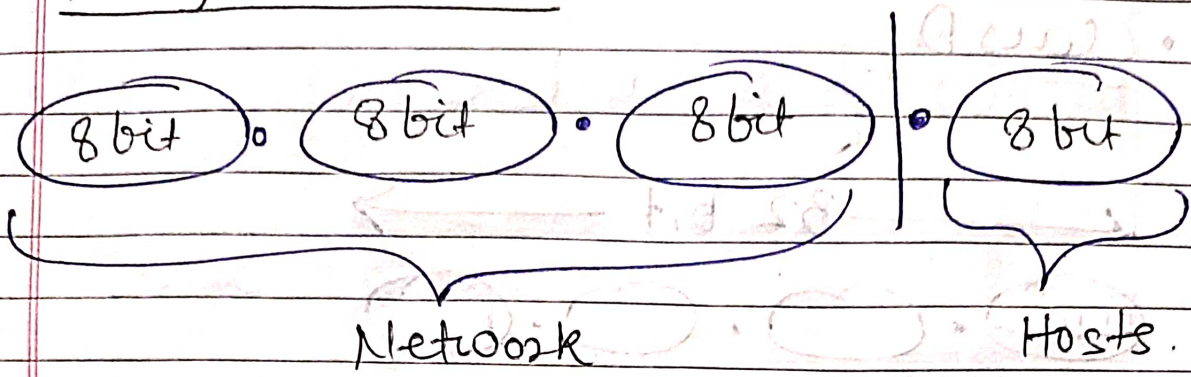
32 bits in total

3 fixed bits

left = 29 bits.

$\Rightarrow 2^{29}$

No. of Networks →



Total no of Network bits = 24

3 bits fixed 110 for prefix.

21 left.

$\Rightarrow 2^{21}$ Total number of Network.

Number of Hosts

No. of Host bits → 8

No of Hosts $\Rightarrow 2^8 = 256$

2 addresses are not available

no. of useful hosts = 256 − 2 = 254

Q 194.2.3.4

Subnet mask
255.255.255.0
194.2.3.4

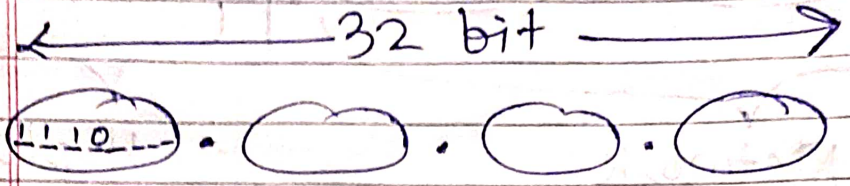
Class C

Network Id ⇒ 194.2.3.0

194.2.3.0 — first address
194.2.3.255 last address

Class D and E

- Class D



first 4 bits of first octet is fixed
1110 prefix

1 1 1 0 0 0 0 0 ⇒ 224

1 1 1 0 1 1 1 1 ⇒ 239

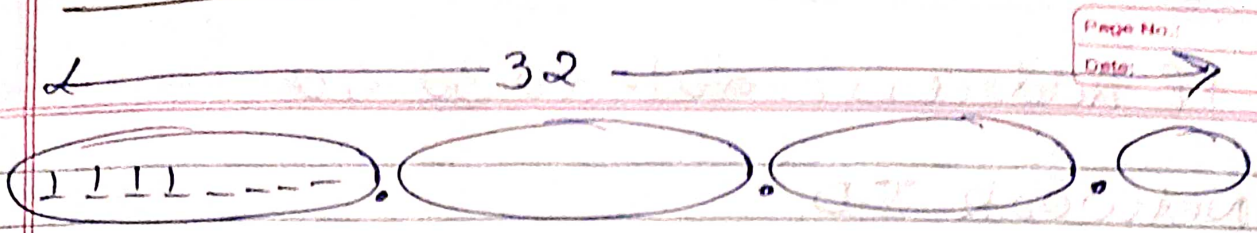
Range → 224 – 239

No of IP addresses →

bits = 28
total no of IP address = 2^{28}

No Network or No Host because it is reserved for multicasting Group Email / Broadcast

- Class E.



first 4 bits of first octet is fixed.
1111 prefix.

Range → 240 - 255

No of IP addresses ⇒ 2^{28}

No Network or Host because All the networks/addresses are reserved for military purposes

Ranges of All Classes

Class A	0 - 127
Class B	128 - 191
Class C	192 - 223
Class D	224 - 239
Class E	240 - 255

Numericals

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Q IP Address = 201.20.30.40

① Network ID

it belongs to class C

default mask = 255.255.255.0

201.20.30.40

Network Id ⇒ 201.20.30.0

② 4th Host ID ⇒ 201.20.30.4

③ Last Host ID ⇒ 201.20.30.254

④ Broad Cast Add ⇒ 201.20.30.255

Limited within organisation ⇒ 255.255.255.255

direct

Problem with classful addressing

→ Wastage of IP addresses.

→ Maintaing is time consuming.

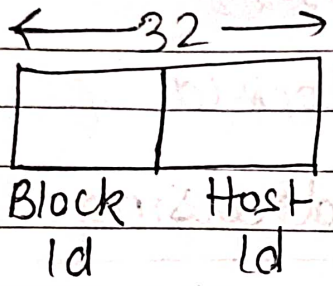
→ Flexibity is not here.

→ More prone to errors.

What is classless Addressing

→ Here is no classes

→ only blocks of required size. based on user's request →



→ Notation.

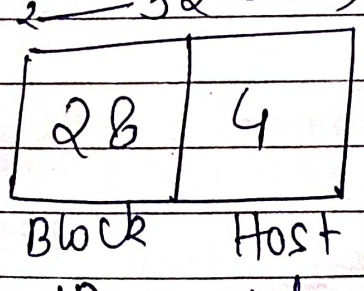
x.y.z.w/n

↓

n represents mask OR
no. of bits used to represent block/network

Ex →
200.10.20.40/28

28 numbers of 1 which represent networks



- No. of bits used to represent host = 4
- No. of hosts = $2^4 = 16$
- mask of this IP address ⇒

11111111 . 11111111 . 11111111 . 11110000
255 . 255 . 255 . 240

- Network Id / Block Id

200.10.20.40/28

00101000
11110000
00100000
$2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0$

200.10.20.32 Block Id

Rules of classless addressing.

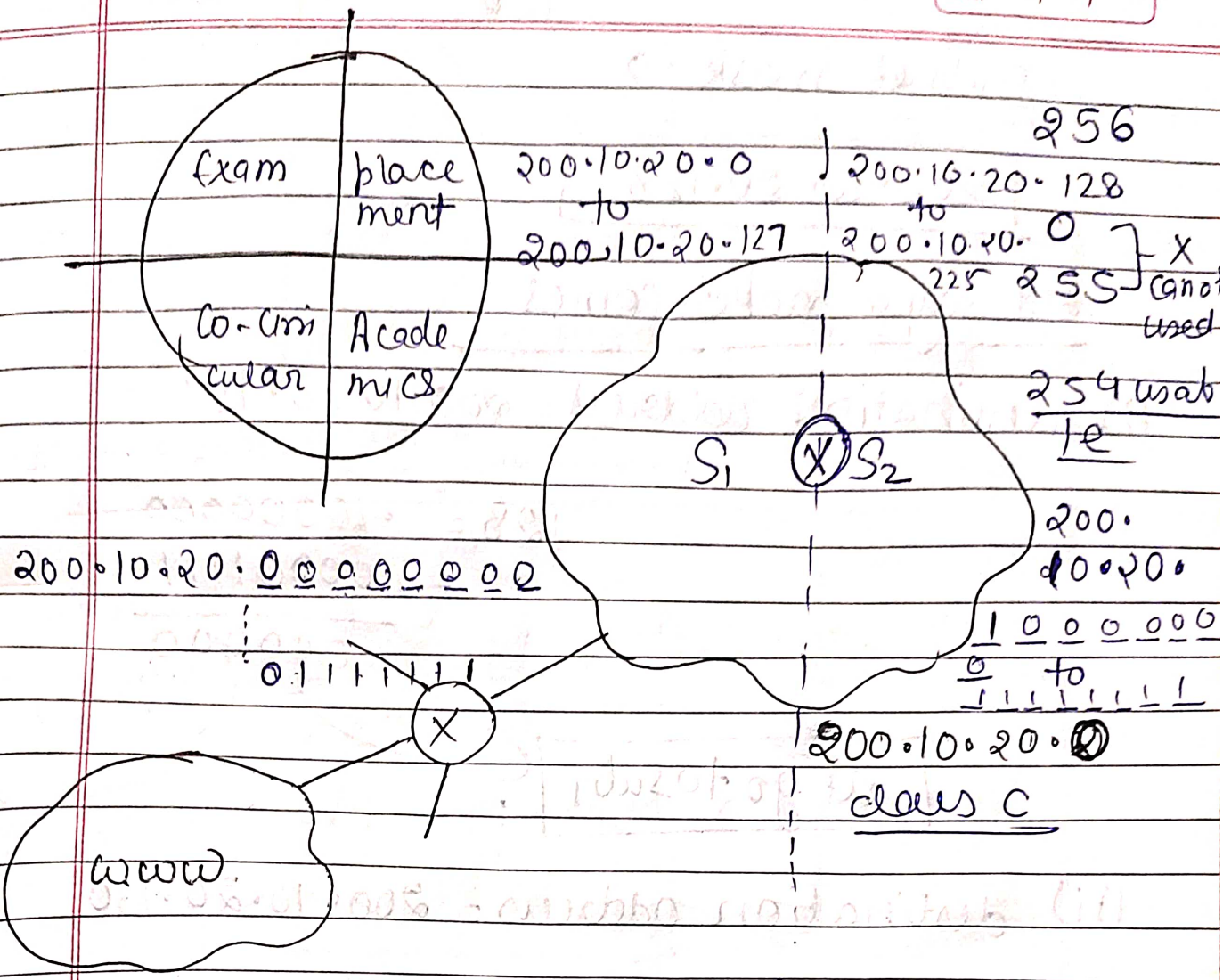
→ Address should be contiguous

→ No. of address in a block must be in power 2

→ First address of every block must be evenly divisible by size of a block.

Subnetting →

Dividing the big network into small networks.



divide the network in 2 parts

200.10.20._ _ _ _ _ _ _ _

No of hosts in ~~Net~~ subnet ⇒ 0 to 127

= 128

but out of 128 hosts 2 are not usable they are reserved for network id and broadcast id

So 126 hosts are available

To get default mask of subnet ~~fix~~

fix the MSB of first address as @ 1

200.10.20.1 0 0 0 0 0 0 0

128

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Subnet mask →

200.10.20.128

Let say a packet comes

(i) destination address = 200.10.20.15

128 = .10000000
15 = .00001111
000000

it go to Sub1

(ii) destination address = 200.10.20.130

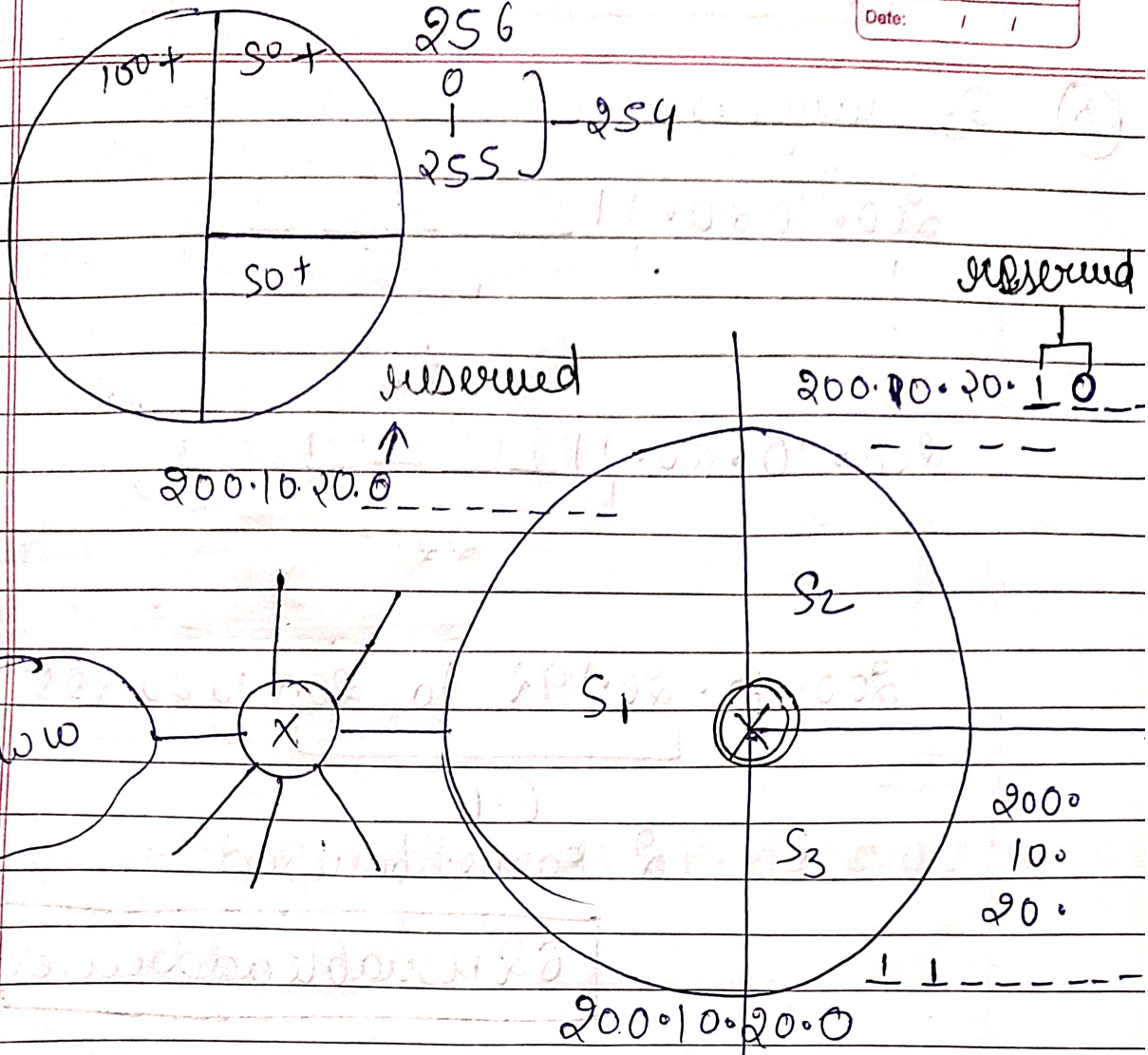
128 ⇒ .10000000
130 ⇒ .10000010
.10000000

⇒ 128.

200

it go to Sub2

Variable length Subnet masking (VLSM)



Reserve one bit to 0 and 1 of each subnet to divide then if we want to divide one more subnet into two then reserve second bit also.

① S1 range → 200.10.20.0 to 200.10.20.127

200.10.20.00000001
200.10.20.00000001
⋮
200.10.20.01111111

128
2 reserved
126.

② S2 range → 200.10.20.128 to 200.10.20.191

200.10.20.10000000
⋮
200.10.20.10111111

64 total

2 cannot be used

62 useful

(3) S3 range =>

200.10.20.11000000

192

to

200.10.20.11111111

225

200.10.20.192 to 200.10.20.255

64

2 cannot be used

62 usuable addresses.

(4) Calculating ~~sub~~ default subnet mask.

In Class C Default mask = 255.255.255.0

Default mask of S1 => 1 bit was fixed

total fixed = 25

24 previous +1

11111111.11111111.11111111.10000000

255.255.255.128

Default mask of S_2

2 bits are reserved.
24 was already fixed
total 26 fixed.

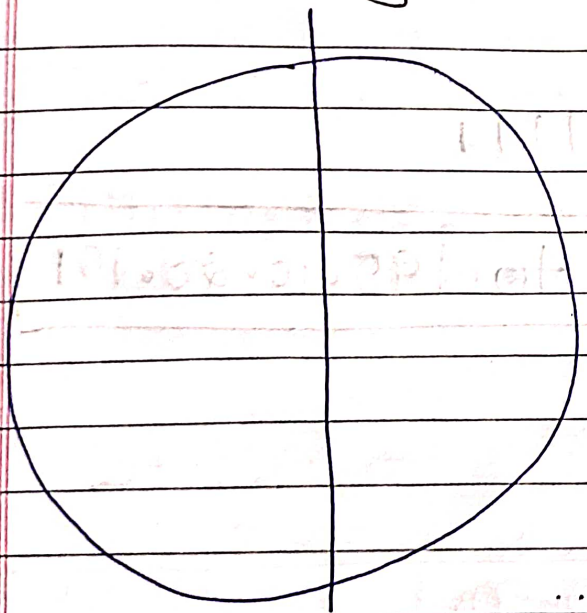
11111111.11111111.11111111.11000000

255.255.255.192

Default mask of S_3

Same as S_2

Subnetting in classless Interdomain Routing (Subnetting in CIDR)



host

195.10.20.10000000

bits left for host = 6
total host = 2^6 = 64
2 cannot used = 62 left.

195.10.20.128/26

32

26	6

NID host.

to divide it in subnet of S_1

fix one bit of host bits as 0

195.10.20.10 0 0 0 0 0 0

10 0 0 0 0 0 1

⋮

100 1 1 1 1 1

Range | 195.10.20.128 to 159 |

S_2

195.10.20.10100000

⋮

195.10.20.10111111

Range | 195.10.20.160 to 195.10.20.191 |

Numerical on CIDR

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A classless interdomain routing (CIDR) receive a packet with address. 131.23.151.76 The router's routing table has following entitities. →

Prefix	Output interface.
131.16.0.0/12	3
131.28.0.0/14	5
131.19.0.0/16	2
131.22.0.0/15	1

131.23.151.76

11111111.1111 0000.00000000
131 . 2

packet will forwarded to which interface

① 11111111.1111 0000.00000000.00000000
131.00010111.0.0
131.00010000.0.0

131.16.0.0/12 (3) ✓ Ans.

② 11111111.1111 1100.0.0
131.00010111.0.0
00010100
131.20.0.0 ✗

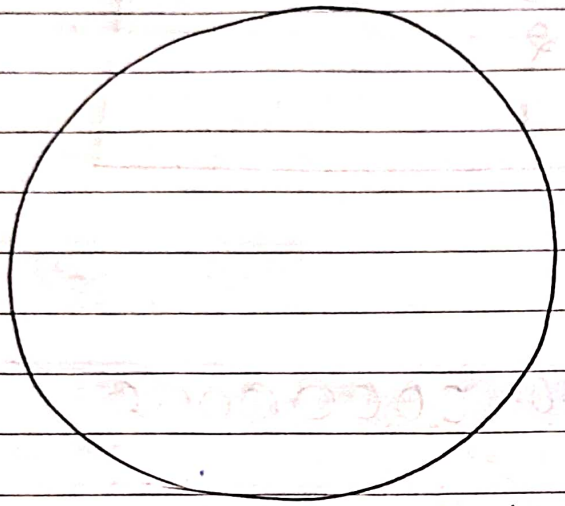
③ 11111111.11111111.0.0
131.00010111.0.0
131.23.0.0 ✗

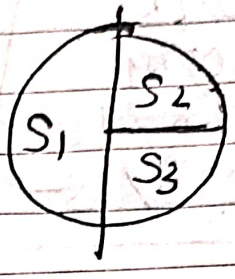
④ 11111111.11111110.0.0
131.00010111.0.0
131.22.0.0 ✓

2 or more matching then choose answer whose prefix has more number of 1's

Ans Interface1

Variable length Classless Interdomain Routing





245.248.128.0/20

→ here 20 are number of network bits.
→ total bits are 32
→ bits left for host = 32-20 = 12

total hosts = 2^{12}

Out of total hosts 2 addresses are reserved first for network Id and last for broadcast.

245.248.1000 0000 . 0000 0000

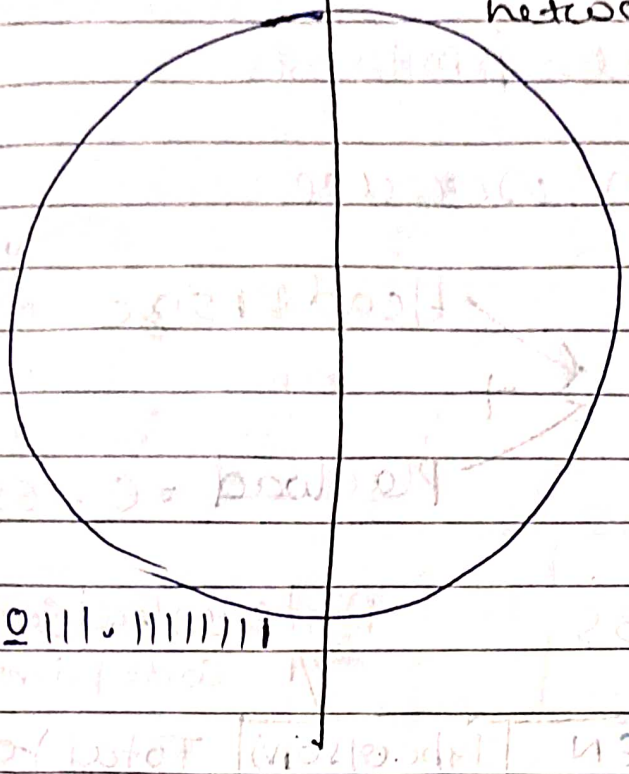
network bits

To divide network into subnet fixed one bit of a host part as either 0 or 1

245.248.10000000.00000000
network

245.248.10001111.11111111

245.248.10001000.00000000
network



Now network is divided in 2 part now we have to divide second subnet into two more bits so fix two ~~more~~ bits in second net

245.248.128.0/21
to
245.248.135.255
/21

S1
S2
S3

245.248.10001000.00000000
• 136.0

245.248.10001011.11111111
• 139.255

245.248.10001000.00000000
• 136.0

245.248.10001111.11111111
• 143.255

Bcz 20 bits were already reserved we fixed one more bit then total = 21

IPv4 Header format

→ Internetworking protocol

→ works on Network Layer

→ Connectionless protocols

→ Datagram service

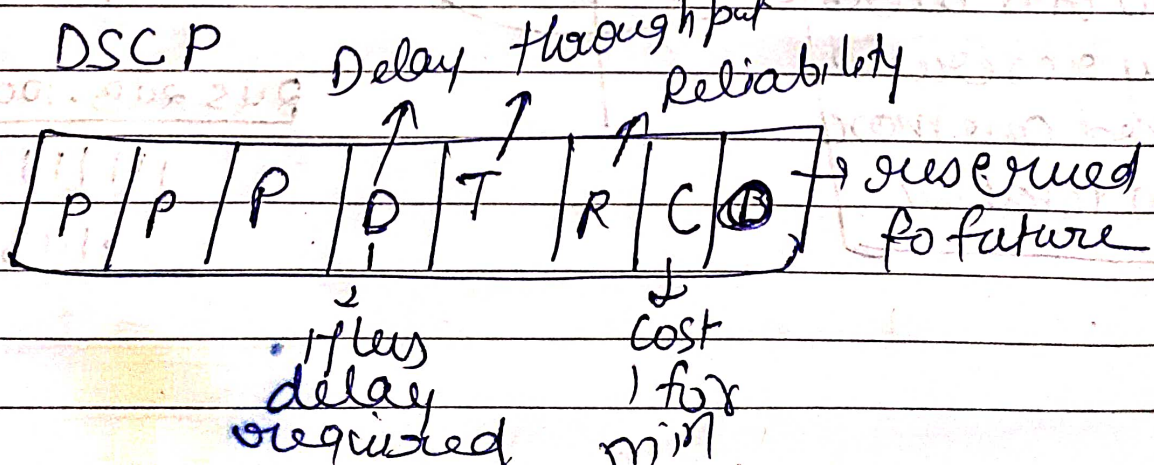
Datagram = Header size = 20-60 bytes (160 bits) + Payload = 0 - 65515 Bytes

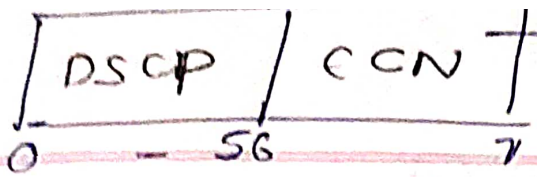
⇒ 65535

Differential service Code point ↑

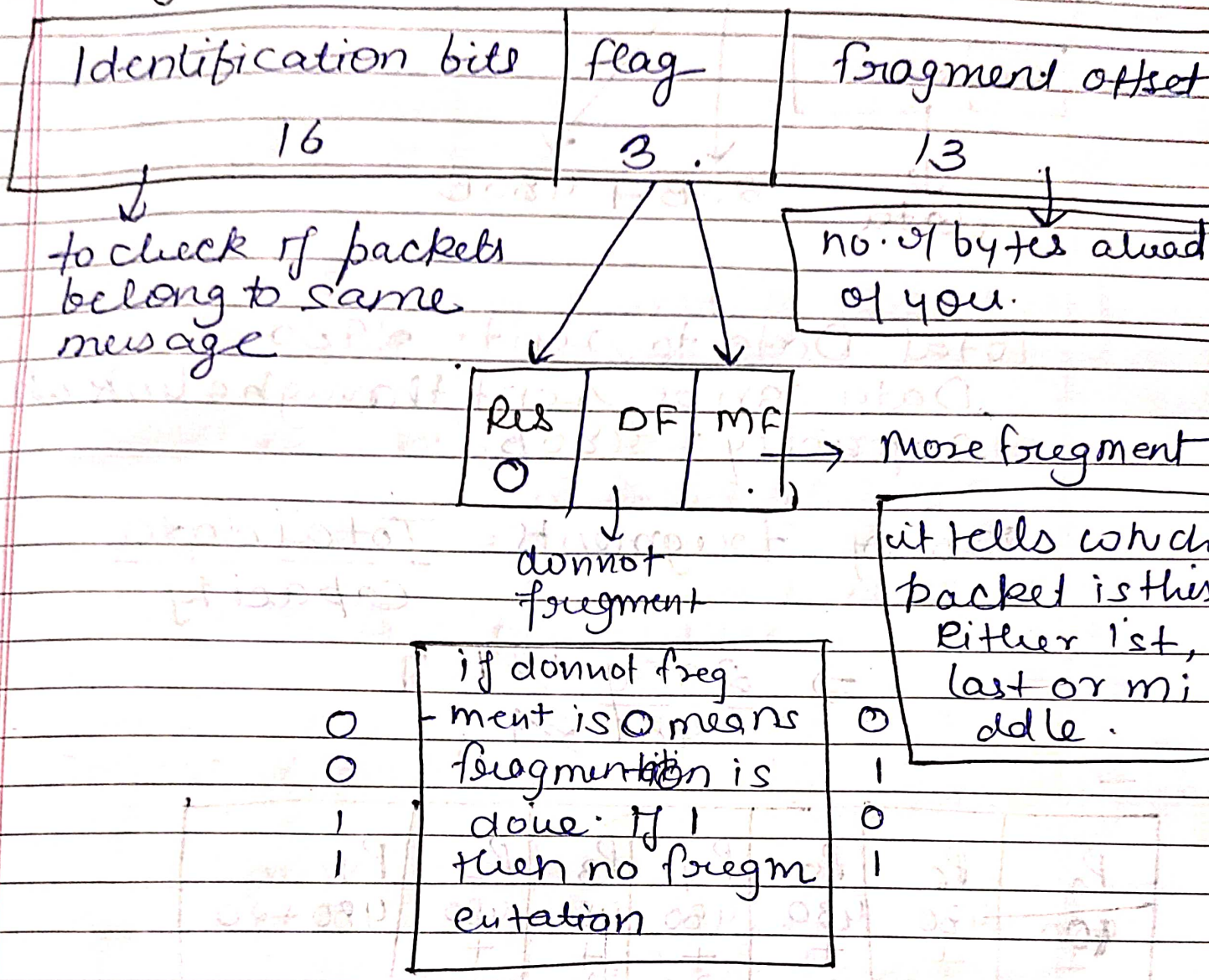
VER 4	HLEN 4	Type of service (DSCP) 8	Total length 16
Identification bits 16		flag 3	fragment offset 13
Time to LIVE TTL 8		Protocol 8	Header checksum 16
Source IP Address 32 bits			
Destination IP address 32 bits			
→ options & Padding			

DSCP

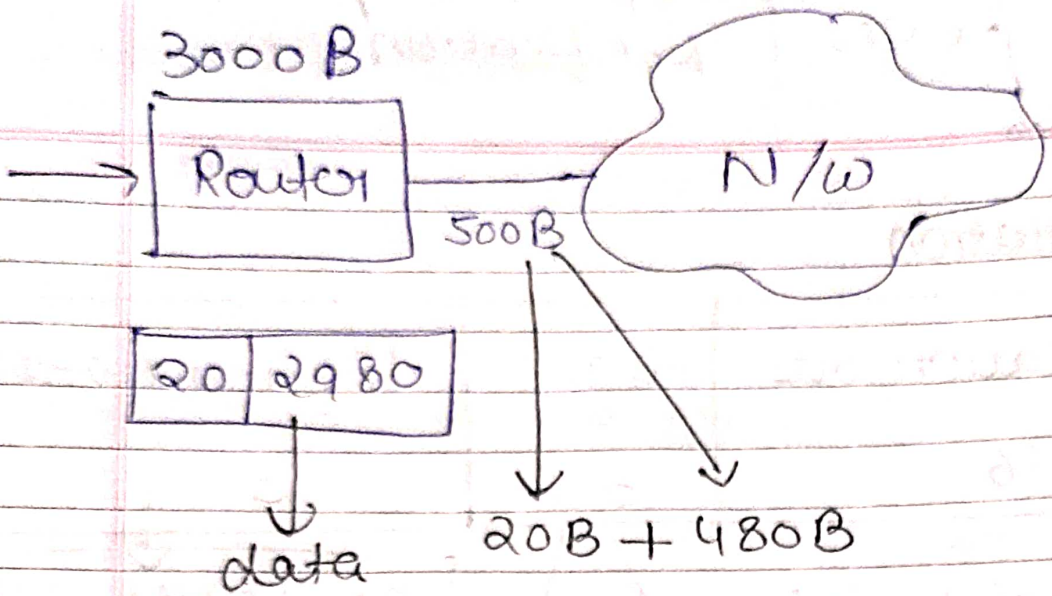




Fragmentation



① A datagram of 3000B (20B of IP header + 2980B IP payload) reached at Router and must be forward with MTU of 500B. How many fragments will be generated and also write MF, Offset, Total length value for all.



Total Data to sent = 2980

Data can be sent through a link whose capacity = 480B

No of fragments = $\frac{\text{Total data}}{\text{capacity}}$

$\Rightarrow \frac{2980}{480} \; 149 \; 7$

P_7	P_6	P_5	P_4	P_3	P_2	P_1
480 + 20	480 + 20	480 + 20	480 + 20	480 + 20	480 + 20	480 + 20
120	500	500	500	500	500	500

	MF (more fragment)	Offset
P_1	1	0
P_2	1	60
P_3	1	120
P_4	1	180
P_5	1	240
P_6	1	300
P_7	0 (because this packet is not followed by anyone.	360

Offset:- How many number of data bytes ahead of something.

P_2 is 60's ahead = 480 data
divide it by 8 = $\frac{480}{8} = 60$

$P_3 \rightarrow \frac{960}{8} = 120$

480
480
960

Options & padding

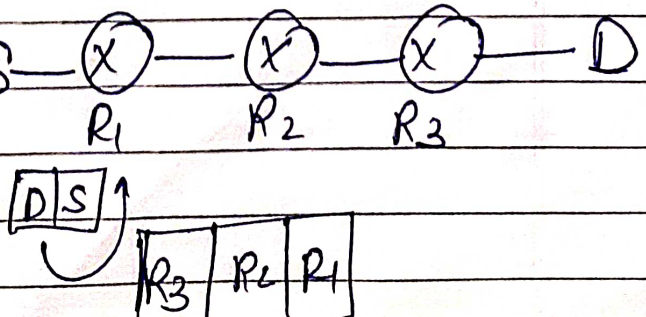
Header → 0-60B

Options → 0-40

→ If header is 20 bytes then there are no options.

→ if header is 60 bytes then there are 40 options.

→ Record route



When a packet reached a route then it will record a route.

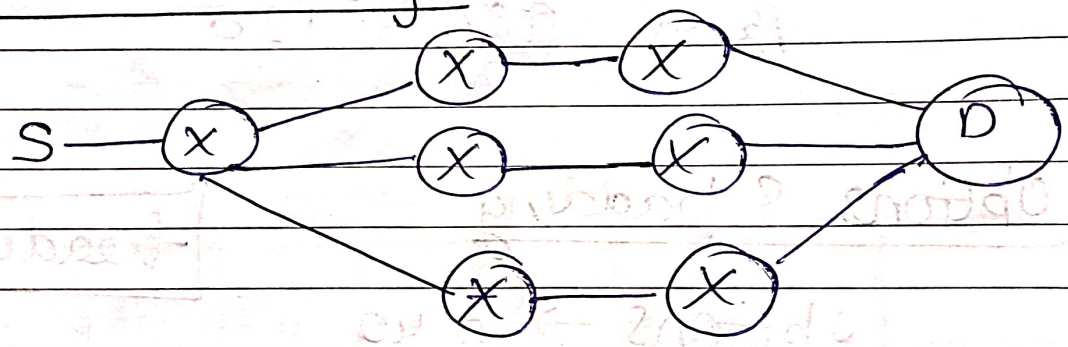
max option bytes are = 40 bytes
size of address is = 4 bytes
total routers can record =

$\frac{40}{4}$ = 10 routers maximum

↓
a can be used / can be used for activation

ISP → Internet ~~ves~~ service provider

→ Source Routing :-



If source decides through which router it must go. then it is called Source Route.

→ As a user we cannot use it only network admin can use it

Source Routing

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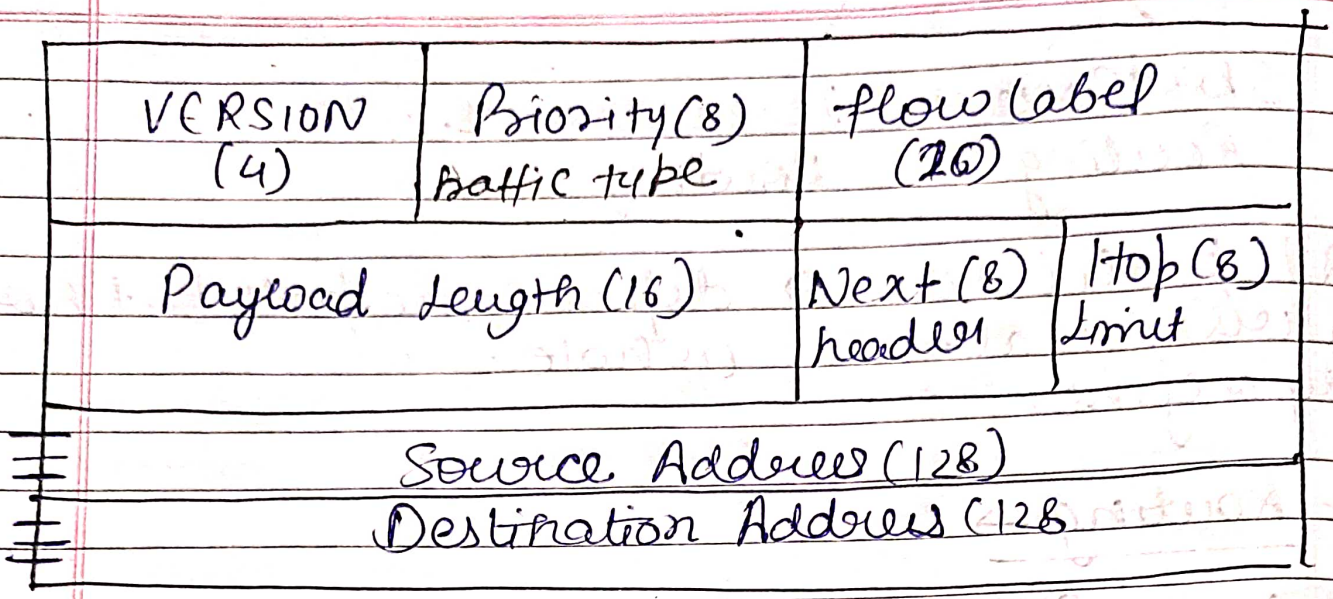
Strict Source Routing	Loose Source Routing
→ All path (no - where) are already define	→ define some path but not whole.

Routing →

Add 1 Byte extra If header is not multiple of 4.

IPV6 Header

- Internetworking protocols

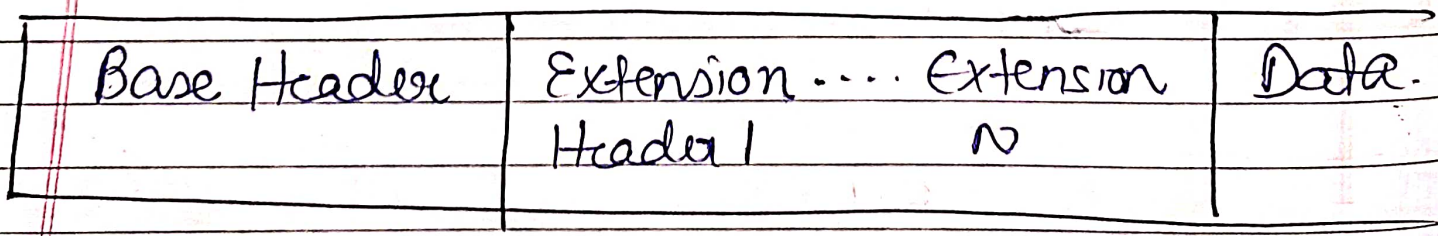


Base Header = 40 Bytes (320 bits) fixed.

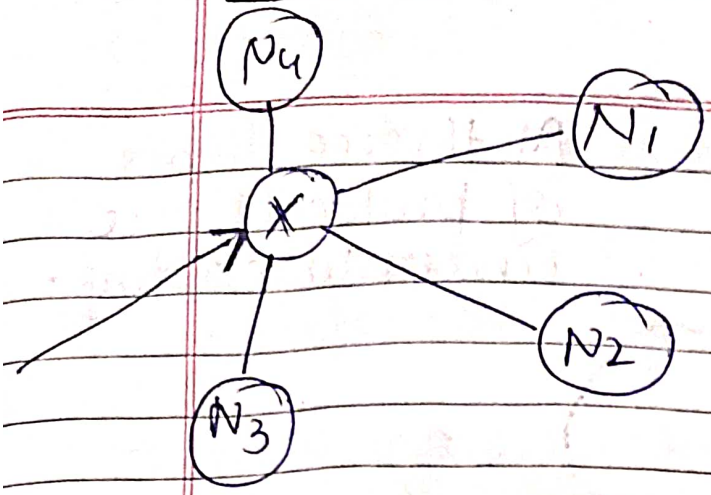
Extension Header

to send jumbo data

- Routing Header (43)
- Hop by Hop option (0)
- Fragment Header (44)
- Authentication Header (51)
- Destination options (60)
- Encapsulating Security Payload (50)



Routing Protocols



if a packet received by router is send to a optimal correct path.

How Router can find where to send.

By routing table.

↓

Collecn of Entries.

* How to create Static Routing Table

This is created by administrator

← Routing protocols →

Intra domain

Inter domain

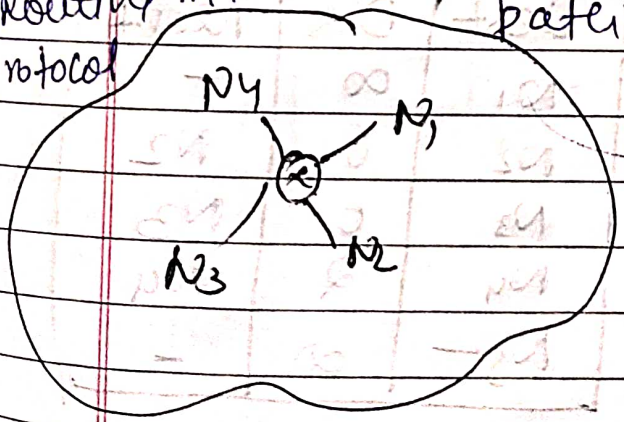
Distance vector (RIP)

Link state (OSPF) Open shortest path First

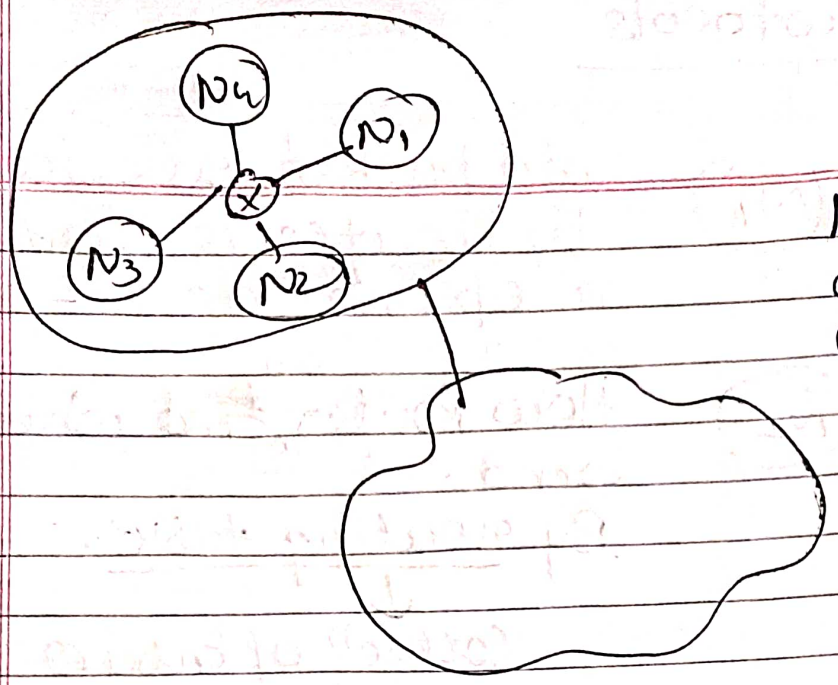
Path vector (BGP) Border gateway protocol.

Autonomous System.

Routing info protocol



Intra



All three types of protocols are under unicasting.

Distance vector routing algorithm

Des	Dis	Next
N1	∞	–
N2	3	N5
N3	∞	–
N4	4	N4
N5	0	N5

Des	Dis	Next
N1	0	N1
N2	1	N2
N3	∞	–
N4	∞	–
N5	∞	–

Dest	Dist	Next
N1	1	N1
N2	0	N2
N3	6	N3
N4	∞	–
N5	3	N5

Des	Dis	Next
N1	∞	–
N2	∞	–
N3	2	N3
N4	∞	–
N5	4	N5

Dest	Dis	Next
N1	∞	–
N2	6	N2
N3	0	N3
N4	2	N4
N5	∞	–

→ Each Router will maintain their each routing table.

→ Create Local Routing table

→ We use Hello message method by this router can know about their neighbour.

→ Now share distance vector of routing table only with neighbour.

Sol $N_1 \rightarrow N_2$

At N_1
→ (N_2)

At N_2
→ (N_1, N_3, N_5)

At N_3
→ (N_2, N_3, N_4, N_5)

At N_4
(N_3, N_5)

At N_5
→ (N_2, N_4)

Step 1

At N_1

(N_2)

1
0
6
∞
3

Dest	Dist.	Next
N_1	0	N_1
N_2	1	N_2
N_3	7	N_2 N_3
N_4	∞	N_2, N_3
N_5	4	N_5

$N_1 \to N_3$

$N_1 \to N_2$ and $N_2 \to N_3$

$\Rightarrow 7$

$N_4 \to 4$

$N_1 \to N_2$ and $N_2\ N_4$

$1 + \infty = \infty$

$N_1 \to N_5$

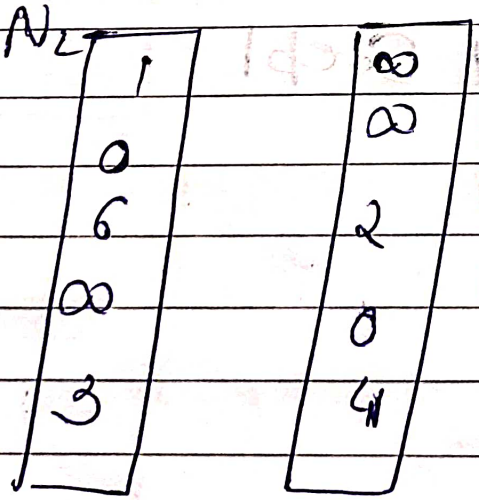
$N_1 \to N_2$, $N_2 \to N_5$

$1 + 3 = 4$

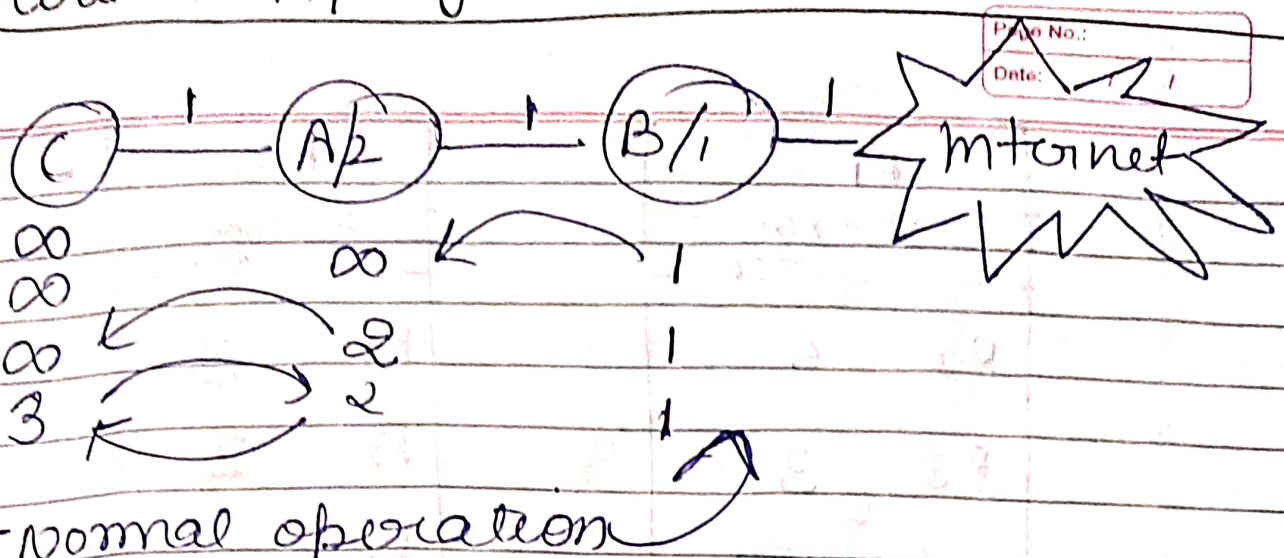
$N_5 \to N_1$

$N_5 \to N_2$ & $N_2 \to N_1$

$N_5 \to N_2$ & $N_4 \to N_1$



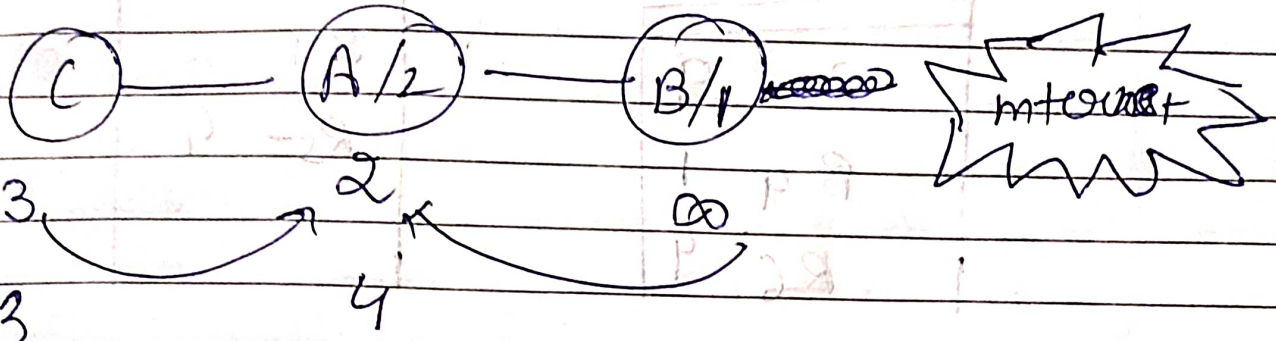
Count-to infinity problem in Distance vector



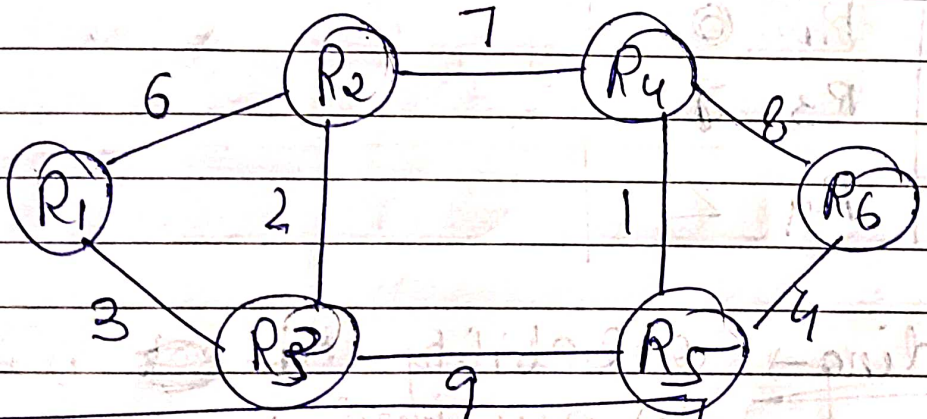
Case I Normal operation

Case II Abnormal case

- the link of B to Internet breaks.



Link State Ranking →



link state	up-down
	1 0

R1	
Seqno.	TTL
R2	6
R3	3

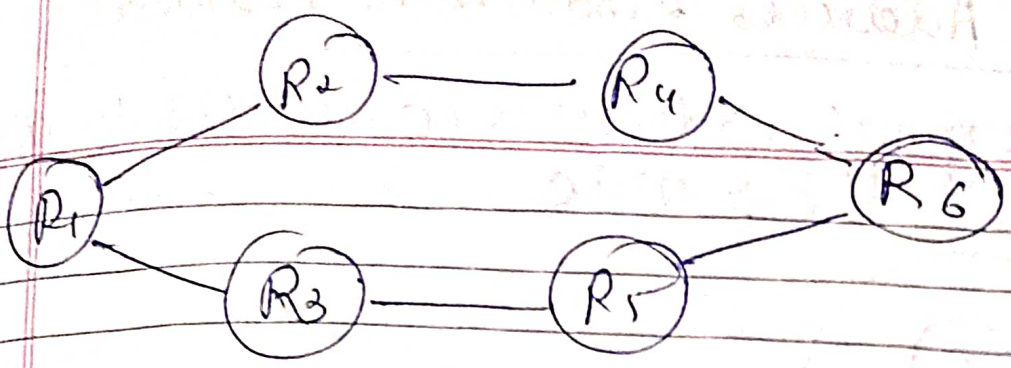
R3	
Seqno.	TTL
R1	3
R2	2
R5	9

R5	
R3	9
R4	1
R6	4

R6	
R4	8
R5	4

R2	
R1	6
R3	3
R4	2

flooding → reliebility AI using more in numbers.



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Dijkstra Algo

	R1	R2	R3	R4	R16
R1	0	3	∞	∞	∞
R1R3	6	3	∞	12	∞
R1R3R2	5	3	12	12	∞
R1R3R2R4				12	21

R1 R3 R2 R4 R5 — 16

R1 R3 R2 R4 R5 —

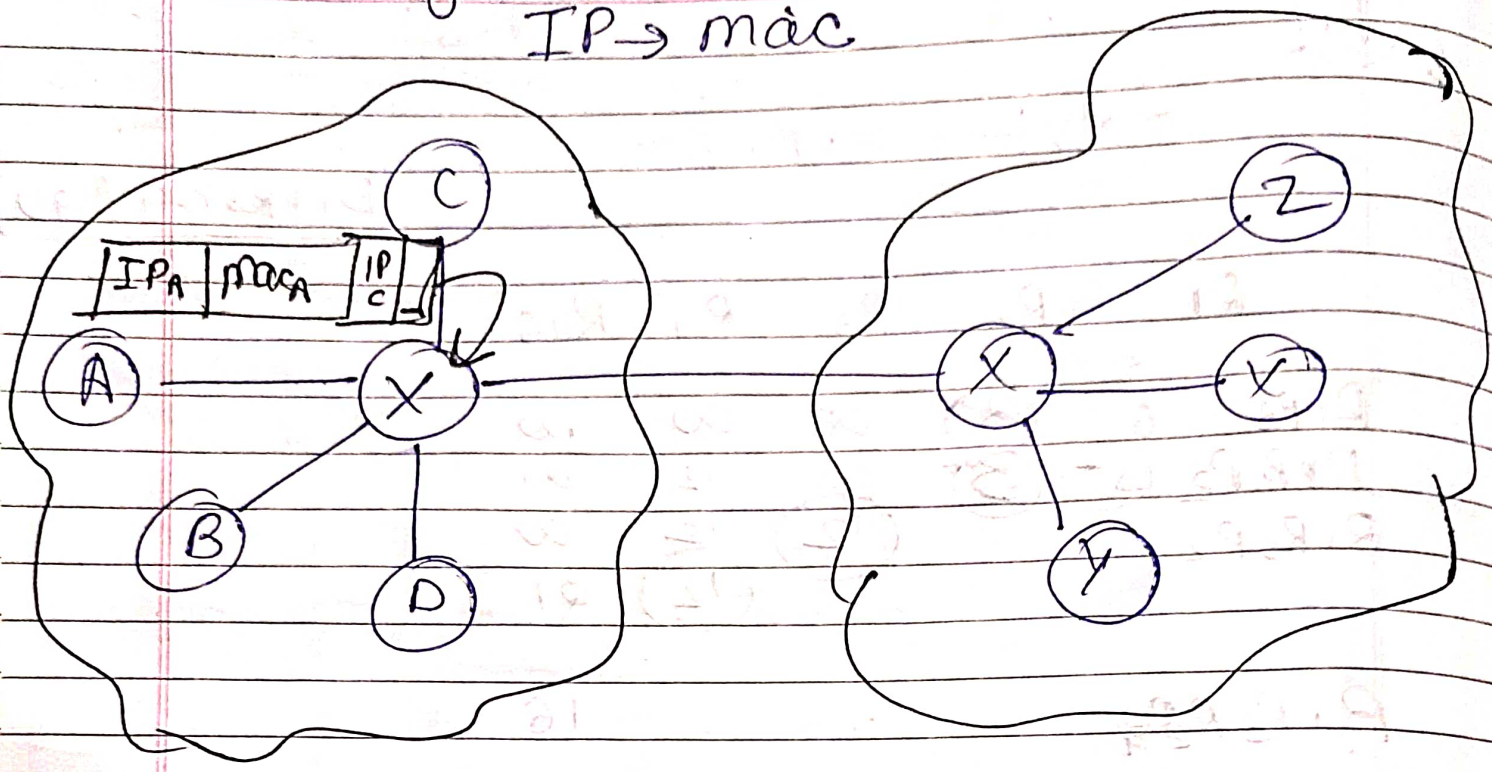
		Via
R1	0	R1
R2	5	R1
R3	3	R1
R4	12	R3 R2
R5	12	R3
R6	16	R3 R5

for Router 1

ARP (Address Resolution Protocol)

→ here logical address is converted to MAC

IP → mac



Network 1 Network 2

Hardware type 16	protocol Type 16
Hardware length (MAC)	protocol length operations Req 1, Rep 2

Sender Hardware Address
Sender protocol Address
Target Hardware address
Target Protocol Address

Network Address Translation (NAT)

→ It translates two IP address.

→ It translate private IP to public IP and vice versa.

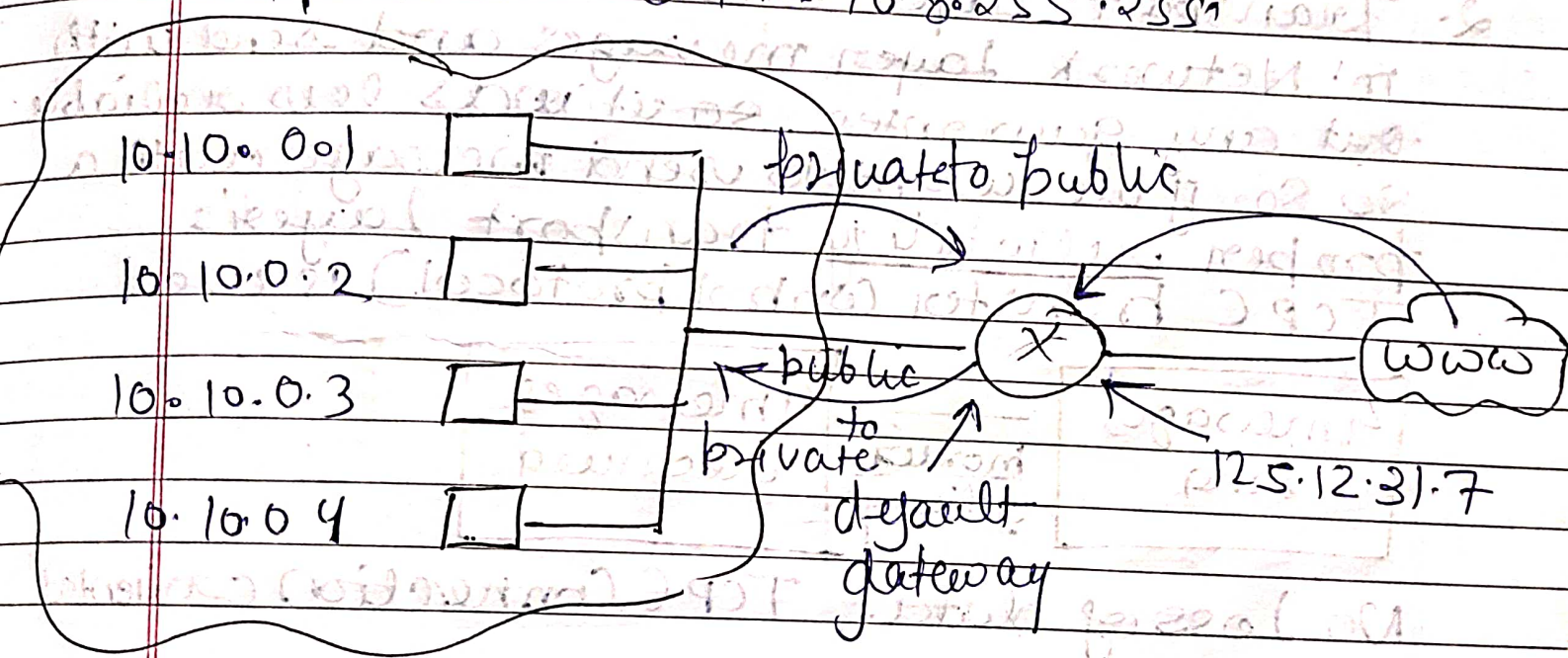
> Same hotel me room number unique hoge lekin different hotel may have same room number

→ Range of private IP's

→ 10.0.0.0 to 10.255.255.255 (2^{24})

→ 172.16.0.0 to 172.31.255.255

→ 192.168.0.0 to 192.168.255.255



Nat translation Table

Private IP	Public IP
10.10.0.2	25.25.25.2