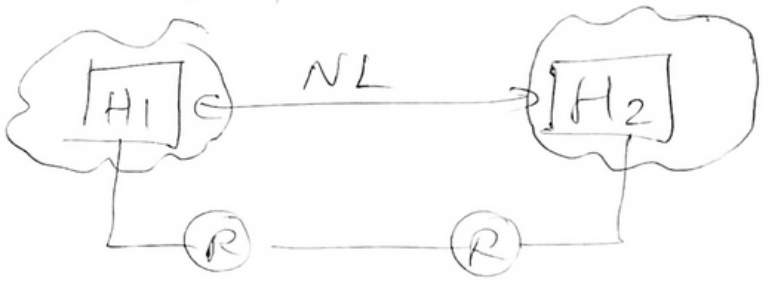
Network Layer

→ Host-to-Host



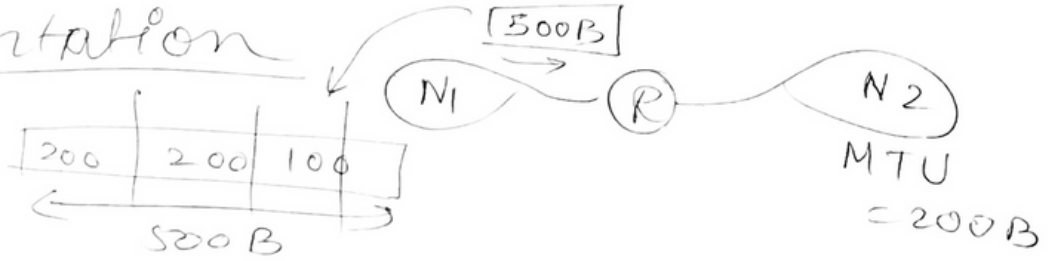
(Source to destination) delivery

- (Logical Address)

  IP Address
  - Network
  - Host

- Routing (Path, where next to send packet). Best Route.
  - → Intra domain
    - → RIP (Distance vector)
    - → OSPF (Link state)

- fragmentation



° IP address V/S Mac Address

- → Internet Protocol
- → 4 Byte IPV4
  6 Byte IPV6
- → ISP provides it (Internet Service Provider)
- → Logical address
- → Operates on NL
- → Identify the connection of device on n/w
- → S/W oriented
- → Can be changed

- → Media Access control
- → 6 Byte hexadecimal address.
- → NIC manufacturer (N/W Interface) provides it / card.
- → Physical address
- → Operates on DLL
- → Identify the device
- → H/W oriented.
- → can't be changed.

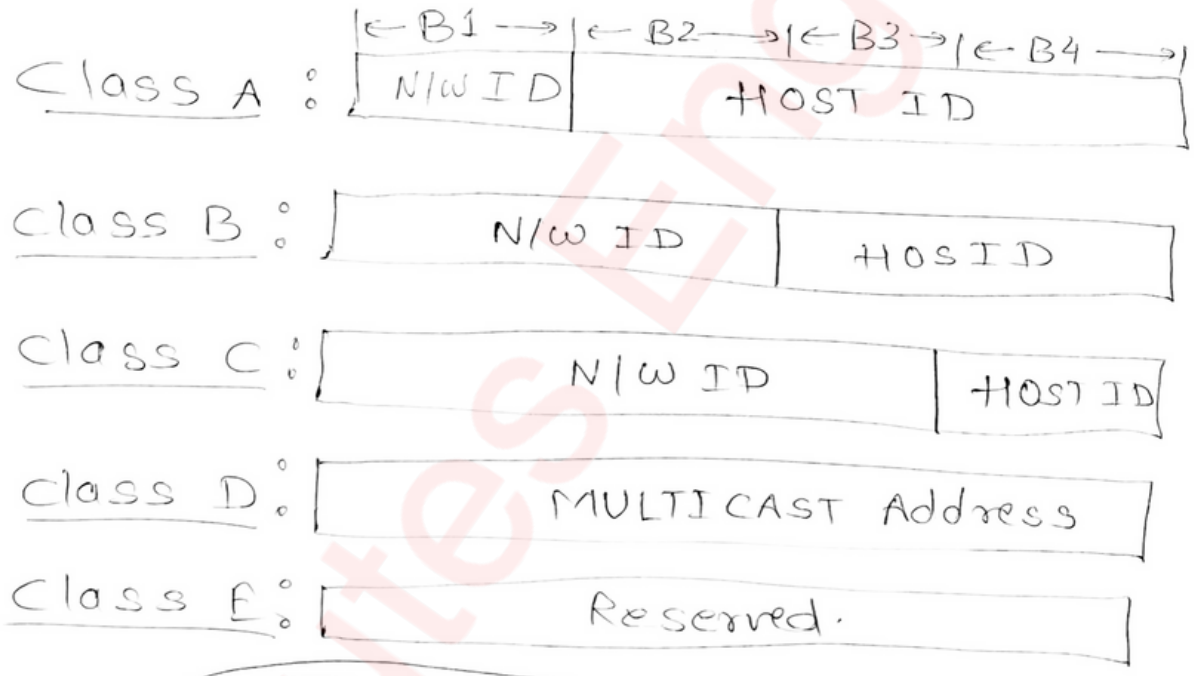
° Notation.

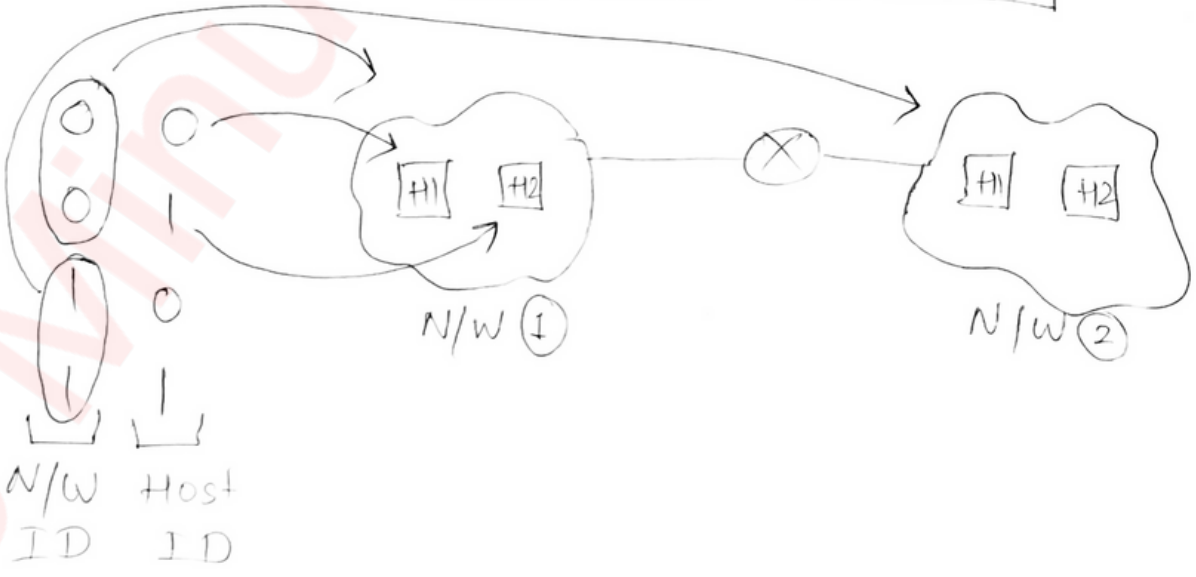
- → Binary Notation.
  [00000000 00000000 00000000 00000000]
- → Dotted-Decimal Notation.
  [172 . 16 . 254 . 2]

* Classfull Addressing

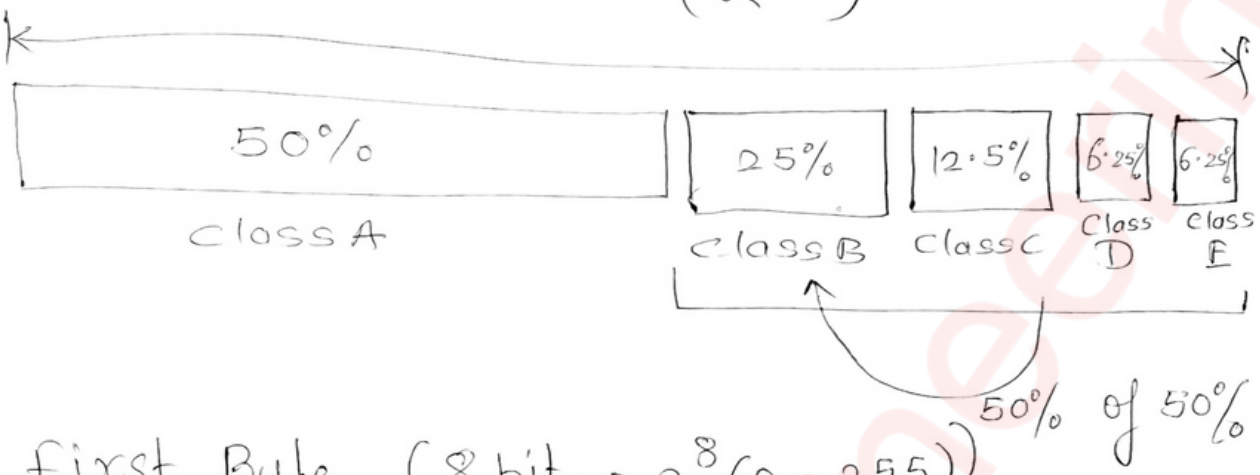
↳ 32 bit / 4 Byte / IPV4 address

- Class A
- Class B
- Class C
- Class D
- Class E





Address Space: 4, 294, 967, 296 Addresses (2^{32})



first Byte (8 bit → 2^8 (0 - 255))

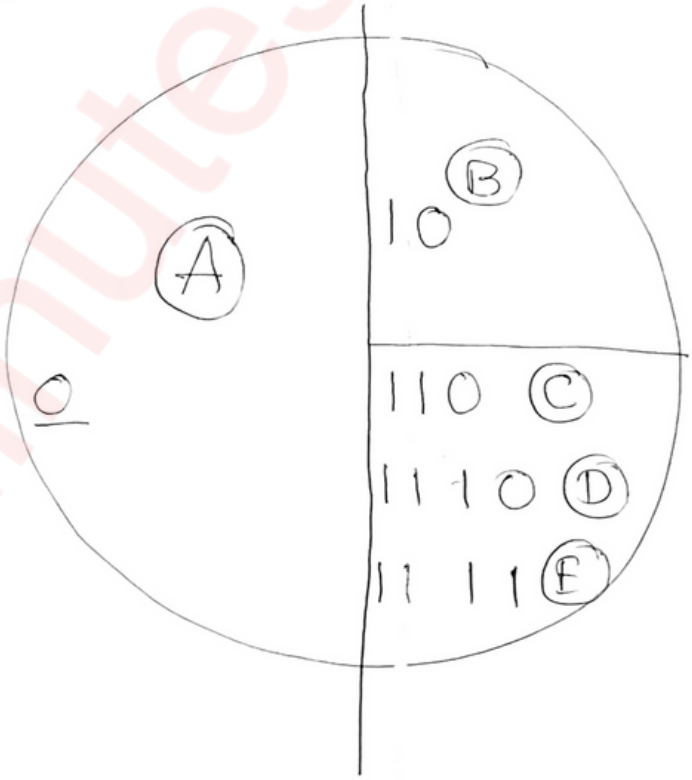
Class A → 0 to 127 [50% of 256]

class B → 128 to 191 [50% of 128]

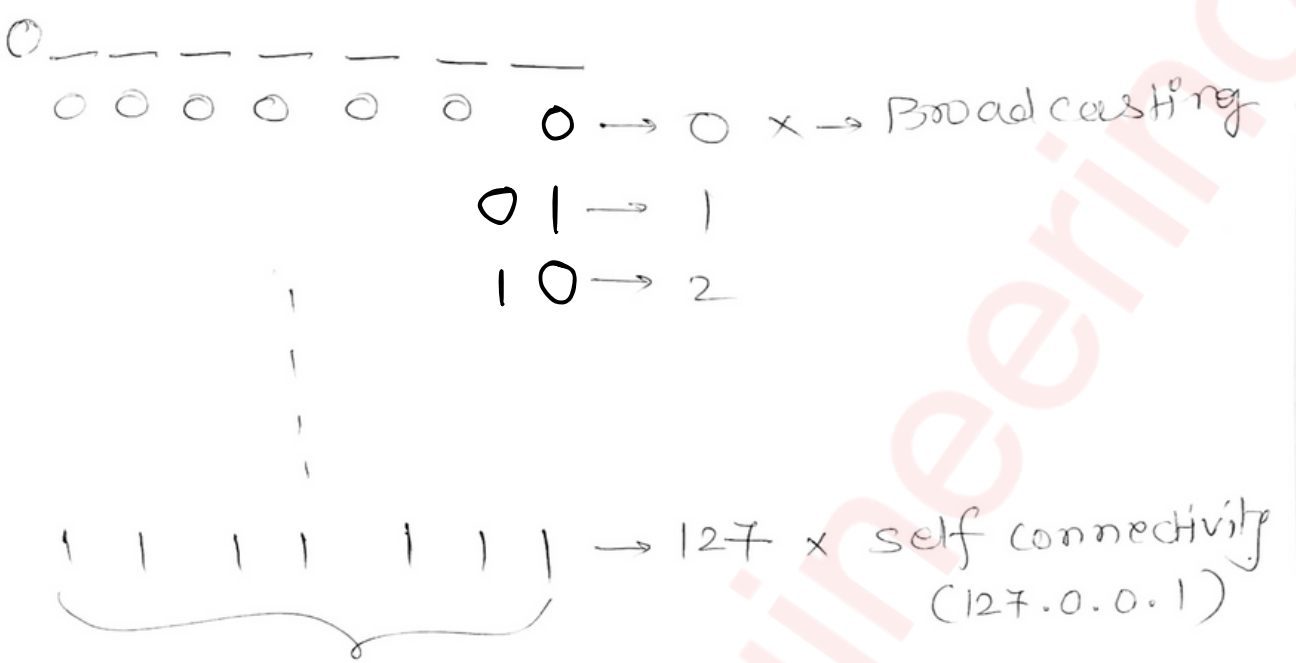
class C → 192 to 223 [50% of 64]

class D → 224 to 239 [50% of 32]

Class E → 240 to 255 [50% of 32]



Class A



$2^7 = 128$ n/w of class (A).

$2^{24} = 16M$ IP addr in class (A)

$[0, 127] \Longrightarrow [1, 126]$

$2^7 - 2$

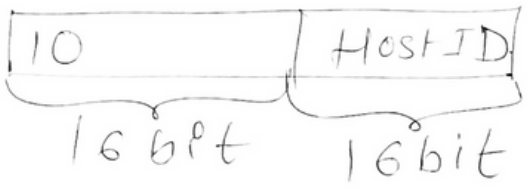
0 ——— 127
1 ——— 126

- $2^{24} - 2$ [1, 67, 77, 214] Host IDs. in class (A)

0 0 0 - - - 0 (all zeros) n/w ID

1 1 1 1 - - - 1 (all ones) Broadcasting address.

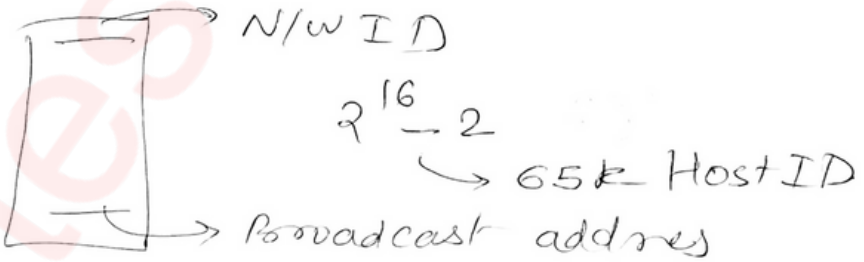
- Class B



2^{14} = 16 k n/w of Class (B)

2^{16} = IP addr in class (B)

Range of class B [128 → 191]



- Class C

2^{21} n/w of class (C) [20,97,152]

2^{8} = 256 IP addr.

1 1 0 _ _ _ _ _

0 0 0 0 0 → 192

1 1 1 1 1 → 223

32

Range [192, 223]

- Class D

NO N/W ID & Host ID

same for class (E).

1 1 1 0 _ _ _ _

0 0 0 0 → 224

1 1 1 1 → 239

16

Range [224, 239]

- Class E

Range [240, 255]

Reserved 1 1 1 1 0 0 0 0 → 240

1 1 1 1 → 255

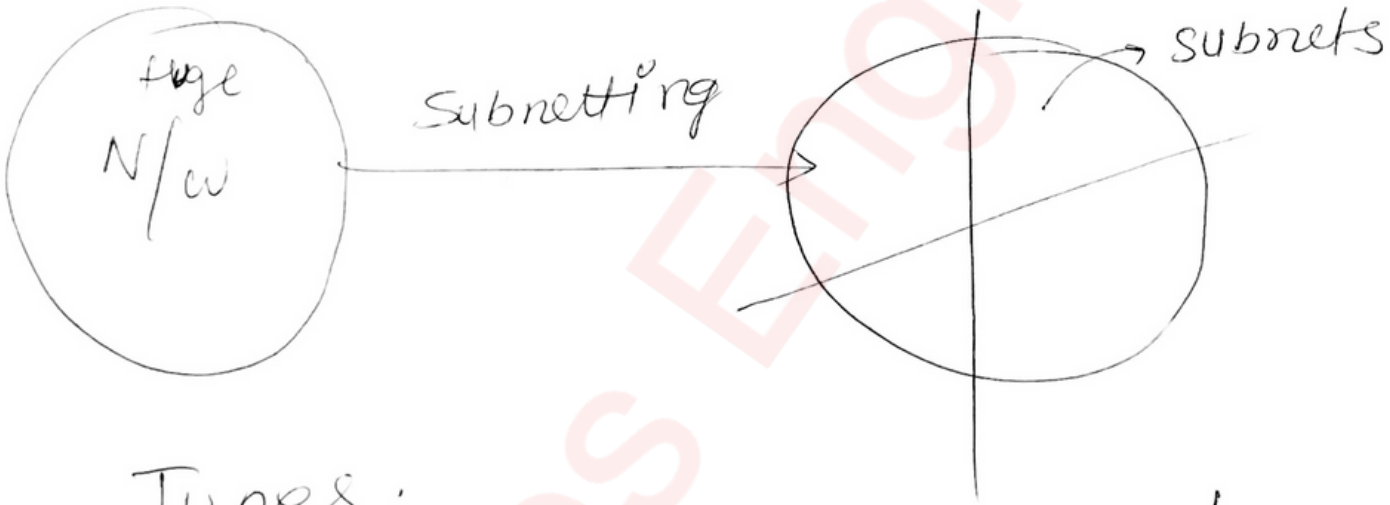
16.

- Subnetting

  → Dividing a huge n/w into smaller ones

  ((lass A & B) huge n/w.

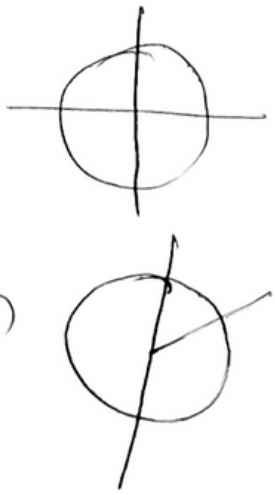
  Smaller n/ws (subnets)



Types:

→ fixed length

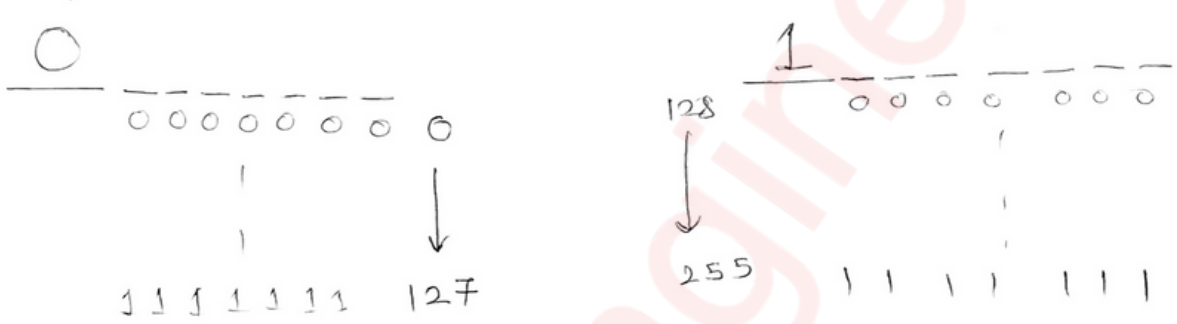
→ Variable length



- fixed length subnetting
  - ↳ equal no. of addresses

Eg: 201.10.20. _ _ _ _ _ _ _ _

NID



(201.10.20.0 → subnet ID to 201.10.20.127)

→ Broadcast addr

(201.10.20.128 to 201.10.20.255)

⇒ 128 − 2

⇒ 126 HOST ID.

⇒ 128 − 2

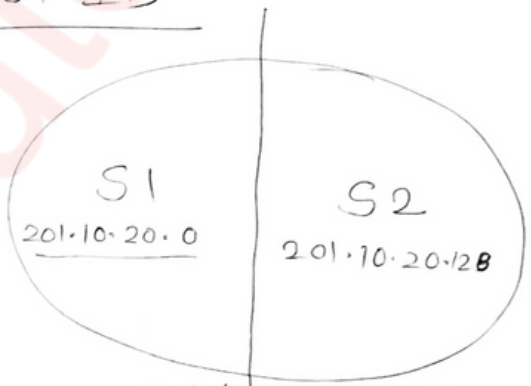
⇒ 126 HOST ID

Subnet Mask

255.255.255.128

10000000

"ANDing" with Mask



201.10.20.0

NID

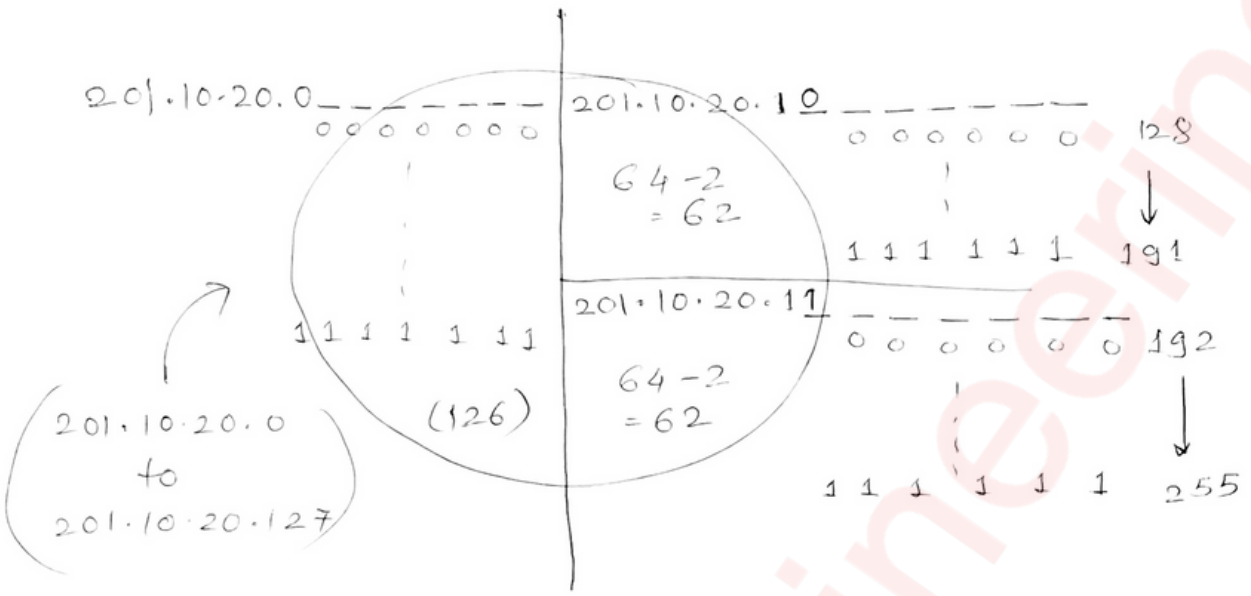
Mask Class (C)

255.255.255.0

201.10.20.255

N/W Broadcast addr

• Variable length subnetting



201.10.20.0 (NID)

Subnet Mask ⇒ 255.255.255.128 (A or B)

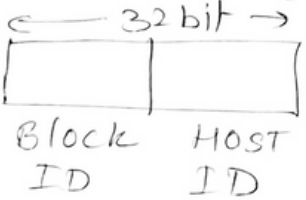
255.255.255.192 (In B)

B1 or B2

* Classless Addressing (CIDR)

→ NO classes, Blocks (✓)

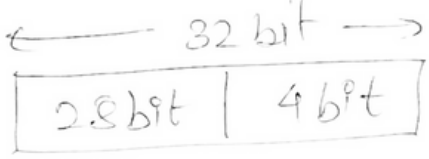
→ As per demand → supply/provide



Notation

→ a.b.c.d/m → no. of bits Represent block/NID ID

→ 201.10.20.5/28 → 28 1's (NID)



$\therefore 2^4 = 16$ Host IDs

11111111 . 11111111 . 11111111 . 11110000

255 . 255 . 255 . 240

Mask

for NID

IP address

201 . 10 . 20 . 5 /28

201 . 10 . 20 . 0000 0101

0000

201 . 10 . 20 . 0/28 (NID)

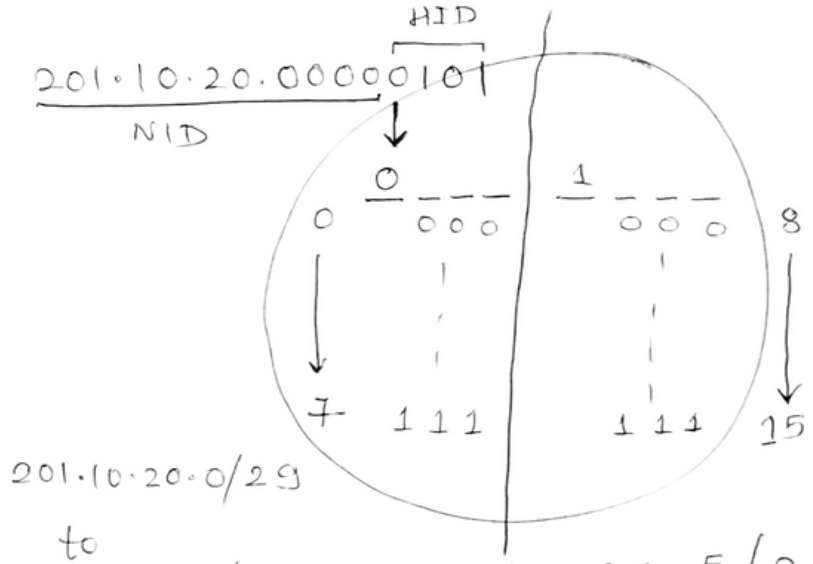
OR

201 . 10 . 20 . 5

AND 255 . 255 . 255 . 240

201 . 10 . 20 . 0

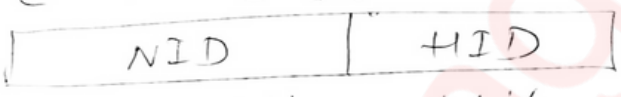
∘ Subnetting in CIDR



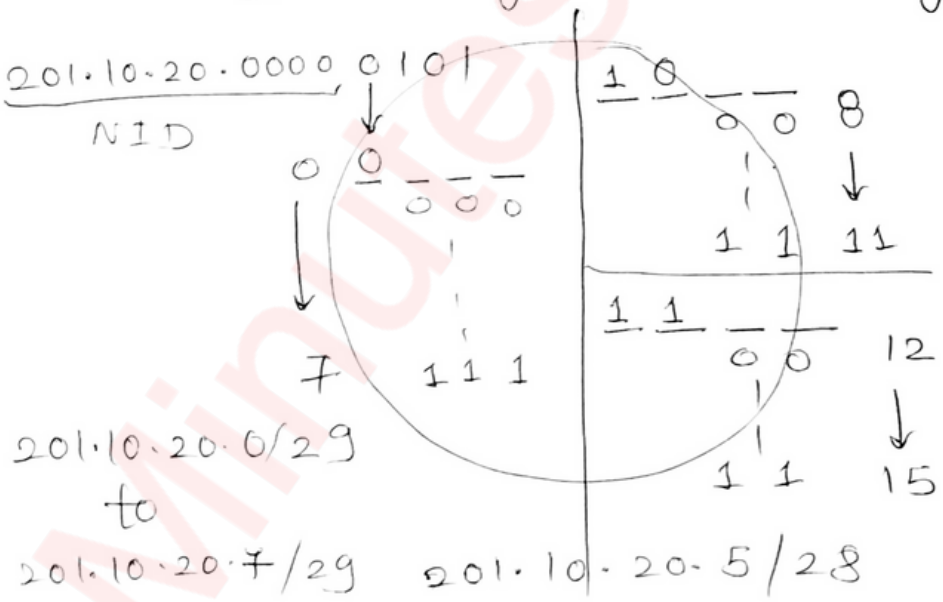
201.10.20.8/29
to
201.10.20.15/29

201.10.20.0/29
to
201.10.20.7/29

201.10.20.5/28



→ Variable length subnetting in CIDR



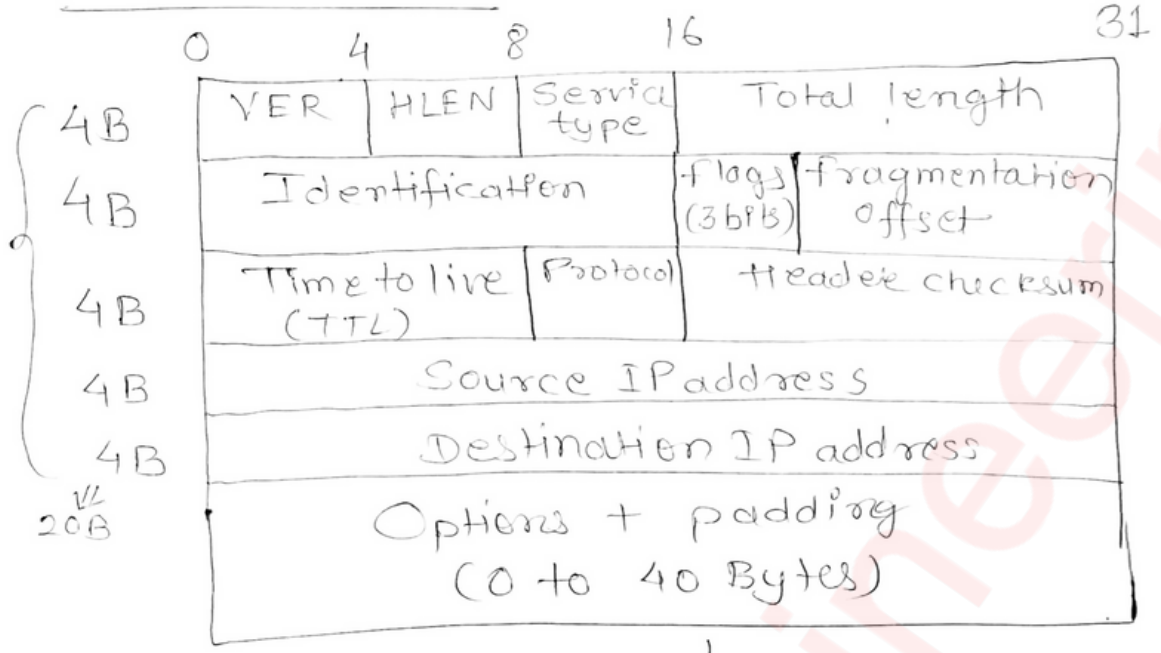
201.10.20.8/30
to
201.10.20.11/30

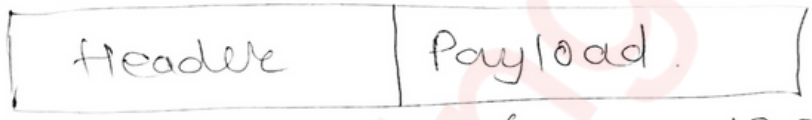
201.10.20.12/30
to
201.10.20.15/30

201.10.20.0/29
to
201.10.20.7/29

201.10.20.5/28

IPV4 Header





(20 - 60 Bytes) (0 - 65515 Bytes)

Total length = 20 + 65515

(Datagram = 65535 = 2^{16}

* VER (4bit) ⇒ 0100 → IPV4 0101 → IPV6

* HLEN (4bit) 0000 0 (0 - 4) x

60/15 = 4 ← scaling factor

0 0 0 0 ↓ 5 → 5 × 4 ⇒ 20

1 1 1 1 15 → 15 × 4 ⇒ 60

* TOS (8 bit)

P	P	P	D	T	R	C	0

Precedence Priority — TOS bits

LP → 0 0 0 0

HP → 1 1 1 1

0 0 0 0 → Default

0 0 0 1 → Minimize cost

0 0 1 0 → Max Reliability

0 1 0 0 → Max Throughput

1 0 0 0 → Min delay.

* Total length

Total length (16 bits)

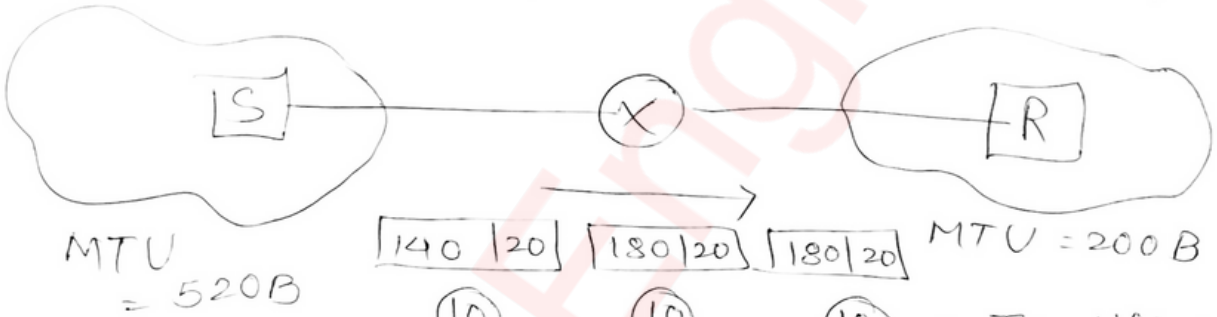
→ 65535

↙ ↘

HL + DL

DL = TL − (HL) × 4 ← scaling factor

* Identification, fragment offset & flags



(10) (10) (10) ← Identification

360 180 0 ← FO (13 bit)

⇓ ⇓ ⇓

$\frac{360}{8}$ $\frac{180}{8}$ $\frac{0}{8}=0$

→ 22.5

148 | 20 176 | 20 176 | 20

⇓ ⇓ ⇓

$\frac{352}{8}=44$ $\frac{176}{8}=22$ $\frac{0}{8}=0$

0 1 1 ← MF

Donot fragment ← DF

65535

65515 | 20

↓

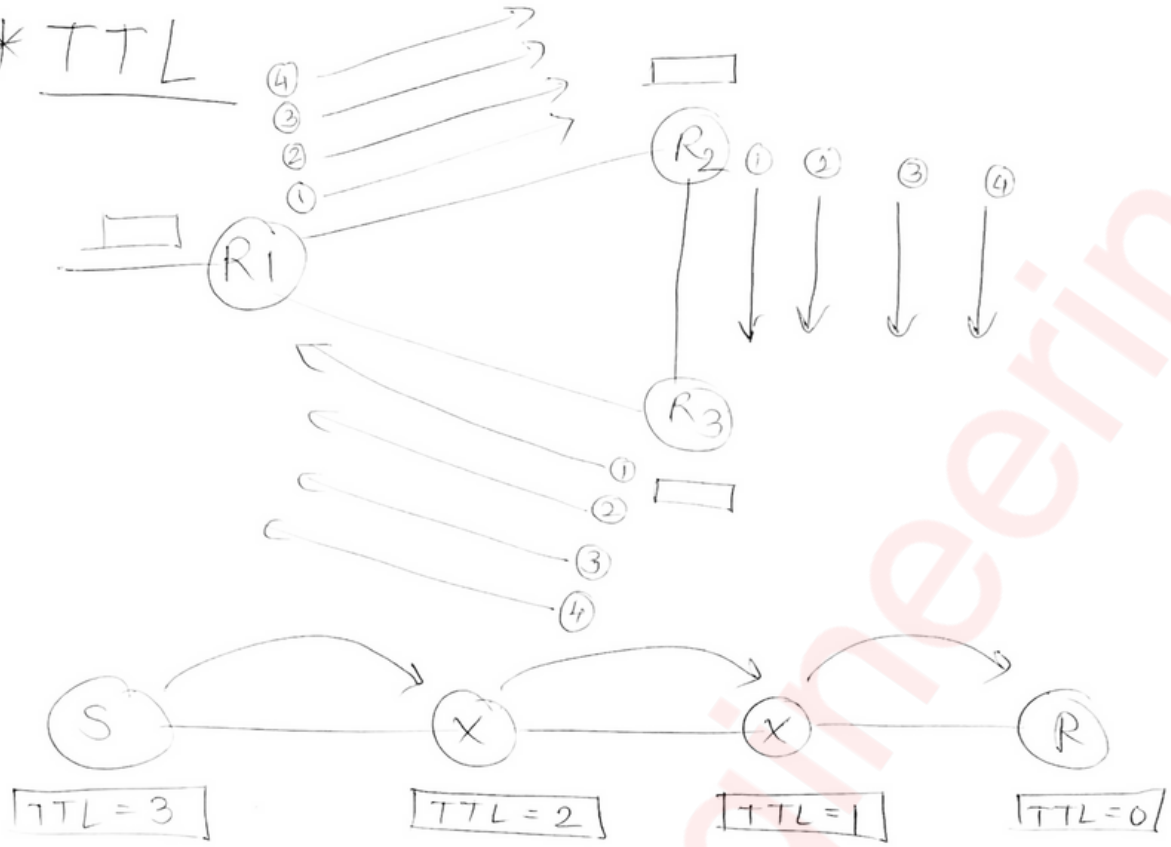
1 | 20

↓

FO = 65514 ≈ 2^{16}

$\Rightarrow \frac{2^{16}}{2^{13}} = 2^3 = 8$ ↑ Scaling factor

* TTL



At Routers the TTL > 0

at destination = 0

* Protocol (8 bits)

→ ICMP : 1

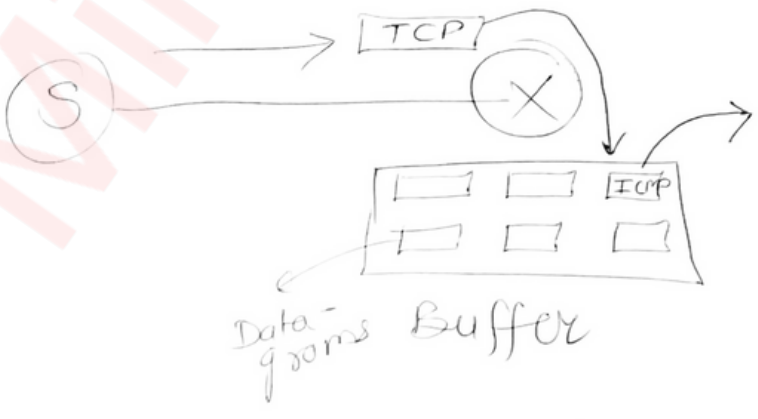
→ IGMP : 2

→ UDP : 17

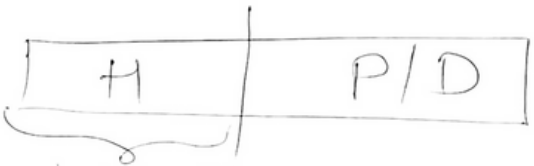
→ TCP : 6

ICMP < IGMP < UDP

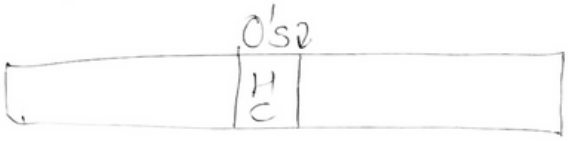
Imp. → TCP



* Header checksum (16 bit)



Divide it in 16 bit parts (2B)



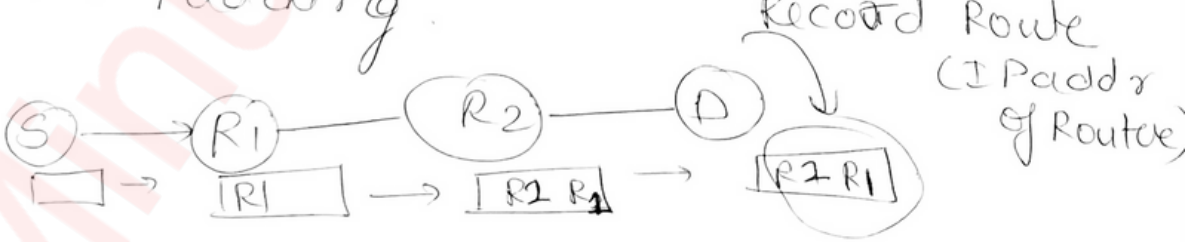
- TTL
- option
- TL
- HL

} can change

So, Recompute 'HC' at each point / Router / node.

* Option (0-40 B)

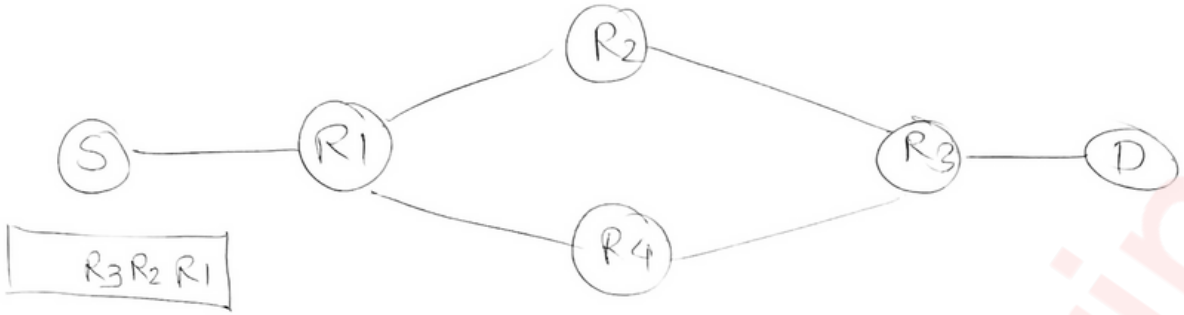
- Record Route
- Source Routing
- Padding



↳ IPaddr = 32 bit = 4B so

In total or max (10) Router

but we use addr max (9)



R3 R2 R1

↑

strict source Routing

R3 R1

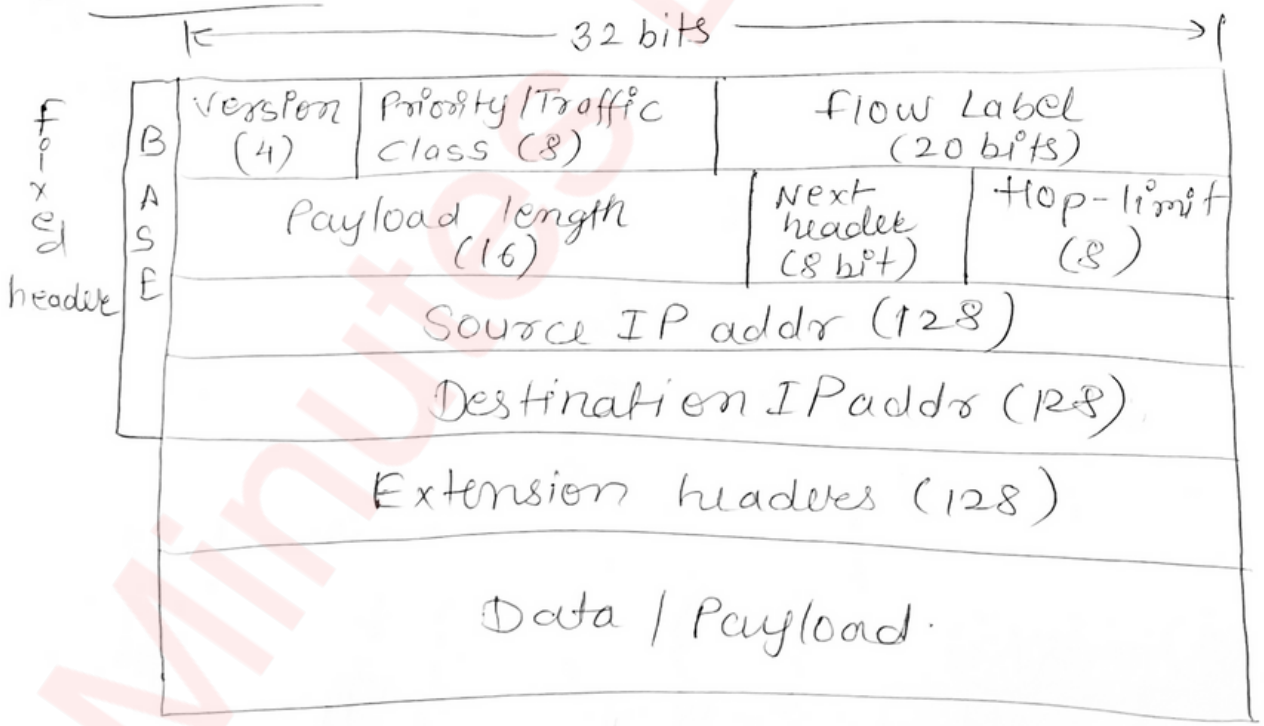
↑

loose source Routing.

- HLEN (4 bit)

→ $\frac{30}{4} = 7.5$ → +2 (padding.) = $\frac{32}{4} = 8$

IPV6



* Priority :- similar to servid field in IPV4.

0 → No specific traffic
1 → Background data
2 → Unattended data traffic
3 → Reserved
4 → Attended bulk data traffic
5 → Reserved
6 → Interactive traffic
7 → control traffic

* Flow lably
  → Real time processing (RTS)

* Hop limit : (TTL)

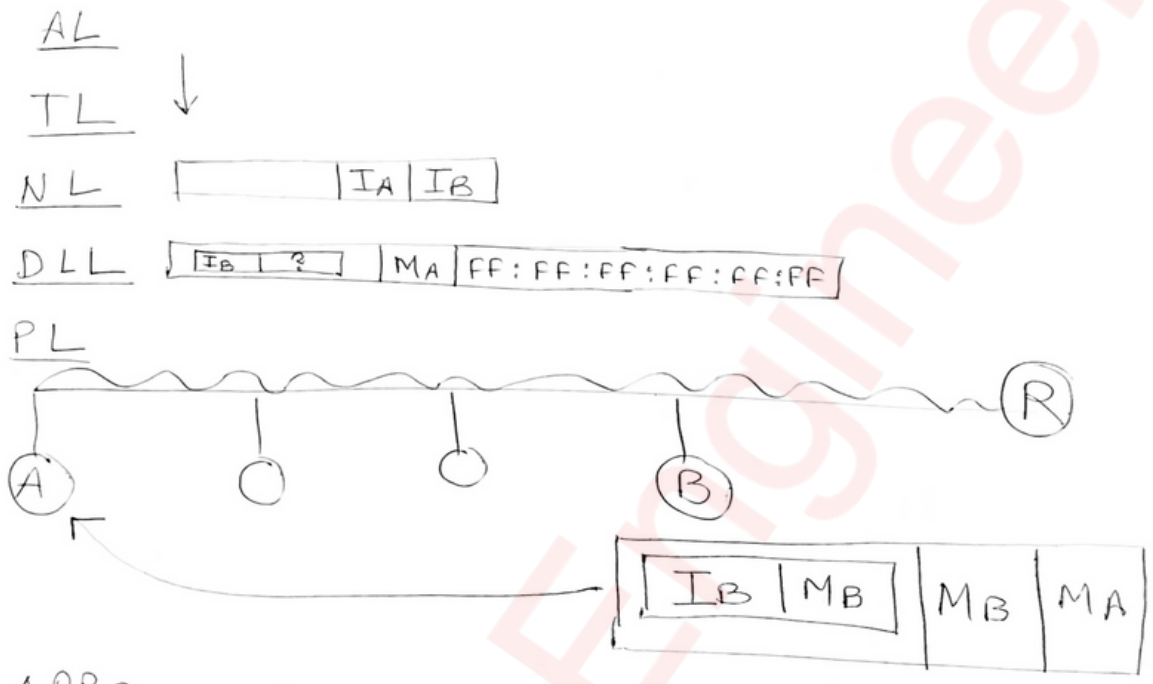
* Next header : Mention of Extension heade

- Routing headee (43)
- Hop by Hop option (0)
- fragment Headee (44)
- Authentication Headee (51)
- Destination option (60)
- Encapsulating security payload (50)

No next headee (59)

- Address Resolution Protocol (ARP)

$\Rightarrow$ (IP $\xrightarrow[\text{locate}]{\text{find}}$ MAC)

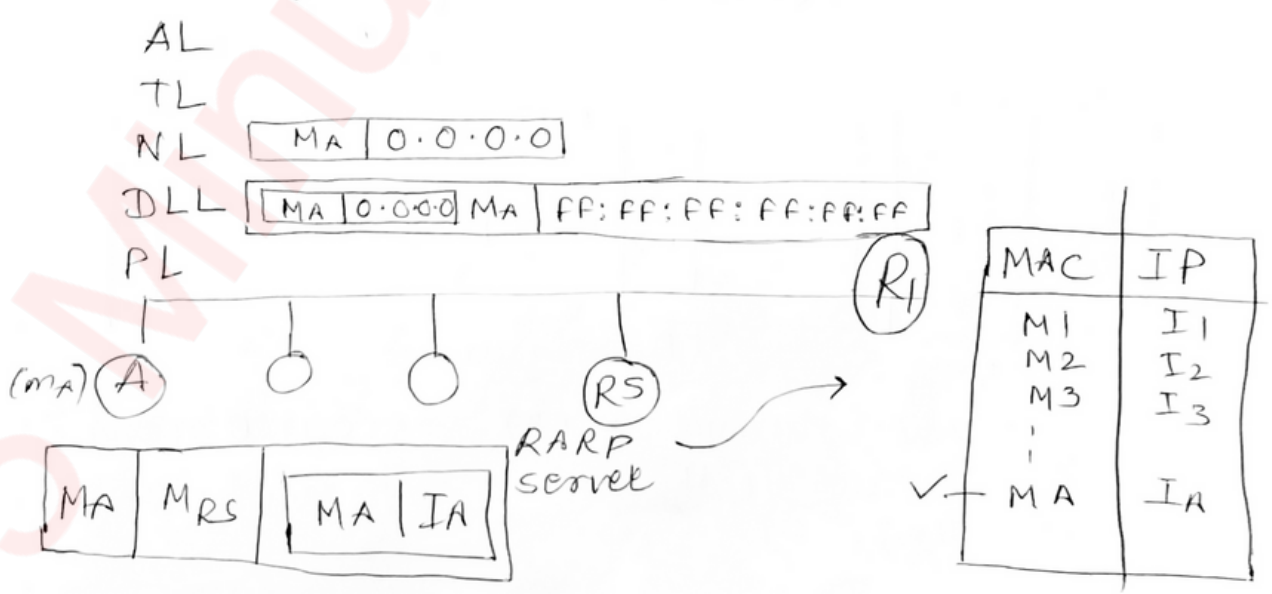


ARP Request → Broadcast

ARP Response → Unicast

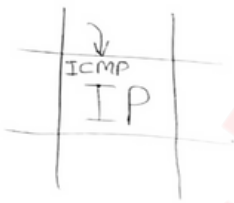
- Reverse Address Resolution Protocol (RARP)

$\Rightarrow$ (MAC $\xrightarrow[\text{locate}]{\text{find}}$ IP)



◦ Internet Control Message Protocol (ICMP)

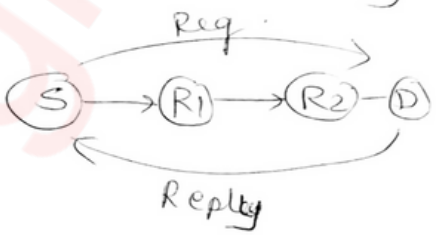
- In n/w layer

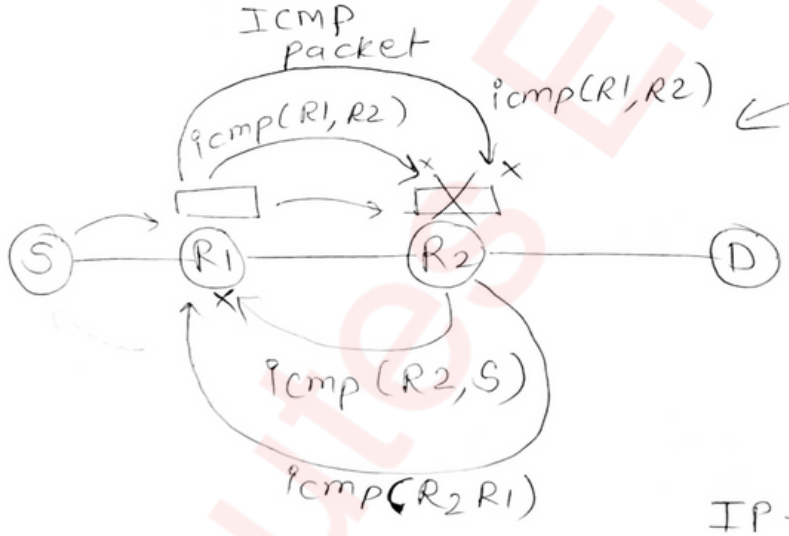


- Types
  - Error handling
  - Request & Reply
- ICMP < IGMP < UDP < TCP

◦ Error handling (feedback)

◦ Request & Reply

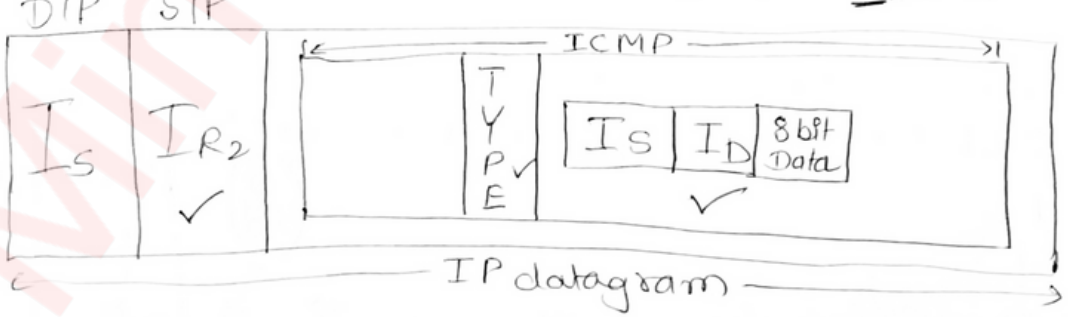




Not not generate icmp packet if a icmp packet discards

IP → ICMP

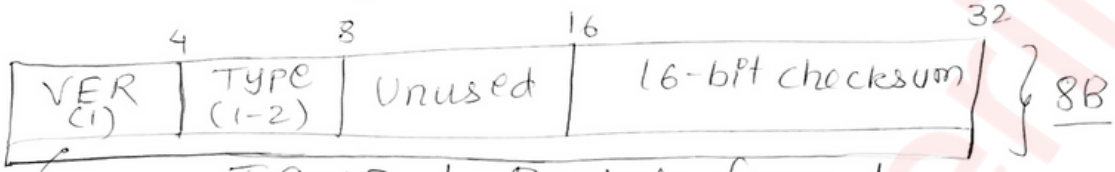
ICMP → (x) ICMP



→ Destination unreachable (3)
→ Time excuded (11)
→ Redirection (5)
→ source quence (4)
→ Parameter problem (12)

° IGMP (Internet Group mgmt Protocol)

↳ one-to-one & one to many communication



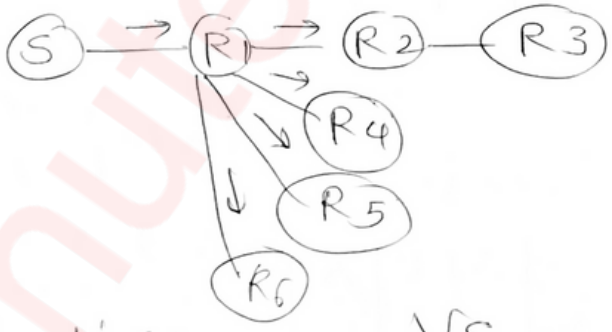
IGMPv1 Packet format

32 bit Group addr

* Routing: The process of designing a routing table.

* Switching: Sending a packet to some path.

* flooding: sending packet to all possible paths.. (NO routing table)



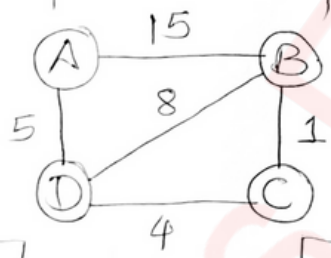
Routing		Flooding
1) ✓RT	VS	1) NO RT
2) less Reliable		2) More Reliable
3) Duplicate packets(x)		3) DP(✓)
4) Traffic less		4) high traffic

- Routing Algorithm
  - Static (Manually)
  - Dynamic
    - DVR (Distance vector)
    - LSR (Link state)

① DVR

A	0	A
B	15	B
C	∞	-
D	5	D

A	15	A
B	0	B
C	1	C
D	8	D



A	5	A
B	8	B
C	4	C
D	0	D

A	∞	-
B	1	B
C	0	C
D	4	D

At (A)

(B)

15
0
1
8

(D)

5
8
4
0

(A)

A	0	A
B		
C		
D		

(A-B) → (A,B) or (A,D)+(D-B)

(A-C) → (A,B)+(B-C) or (A,D)+(D-C)

(A-D) → (A,D) or (A,B)+(B-D)

∘ short cut

A B = 15 A D = 5

(B)

A	15
B	0
C	1
D	8

(15+0) (15)

(D)

5
8
4
0

(8+5) (13)

A	0	A
B	13	D
C	9	D
D	5	D

∘ 15+1 → 16 ∘ 4+5 → 9

∘ 8+15 → 23 ∘ 0+5 → 5

At (C)

(B)

A	15
B	0
C	1
D	8

(D)

5
8
4
0

A	9	D
B	1	B
C	0	C
D	4	D

C B = 1 C D = 4

⇒ 'n' routers → (n-1) times / Rounds.

(R1) ∘ A → B (15)

(R2) ∘ A → D → B (13)

(R3) ∘ A → D → C → B (10)

} (4-1) 3 times Rounds

(A)

A	0	A
B	10	D
C	9	D
D	5	D

(B)

A	10	C
B	0	B
C	1	C
D	5	C

(C)

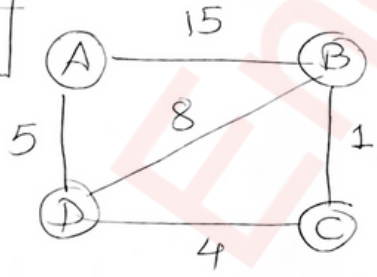
A	9	D
B	1	B
C	0	C
D	4	D

(D)

A	5	A
B	5	C
C	4	C
D	0	D

* LSR (Link state Routing)

A	
B	15
D	5



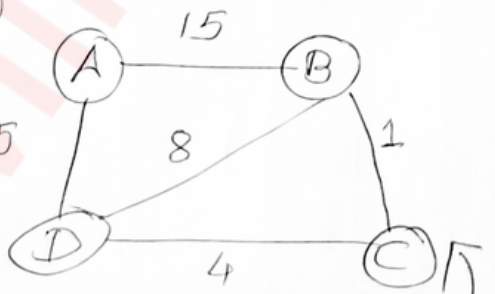
B	
A	15
D	8
C	1

D	
A	5
B	8
C	4

C	
D	4
B	1

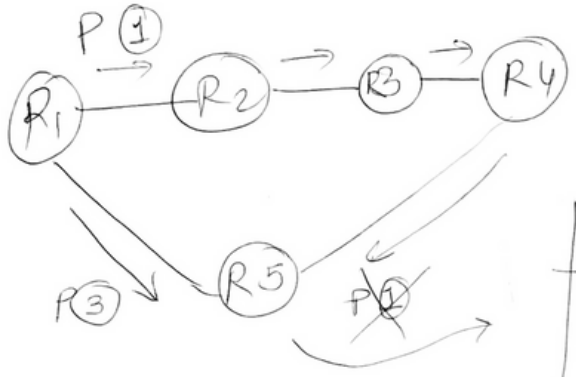
⇒ * Flooding of packets (Global knowledge)
At each router

At (A)



(Dijkistra algo)

A	0	A
B	10	D
C	9	D
D	5	D



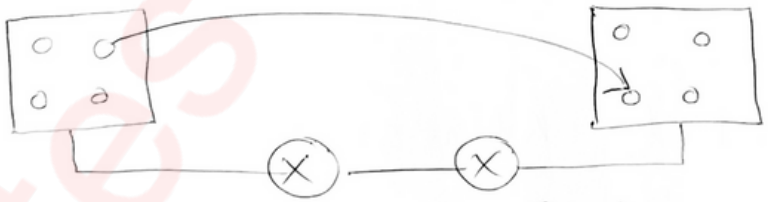
R	Latest Packet
R1	3
R2	5
R3	10
R4	9

sequence no
↑ → latest info
↓ → old info

P 4) corrupt

Timer solution.
"hold it for a period of time"

* Transport Layer (4th layer ↑)
  - → End - to - End Delivery (port - to - port)



(process - to - process)

⇒ TCP & UDP (connectionless & unreliable) at TL
- TCP → more Reliable, Inorder
- UDP → ✗

⇒ Error control (checksum)
⇒ flow control
⇒ congestion control.