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UNIT-II

IPv4 ADDRESSING ARCHITECTURE

IPv4 ADDRESSES:- 848

- *) The identifier used in the IP layer of TCP/IP protocol suite to identify the connection of each device to the internet is called the Internet address or IP address.
- *) An IPv4 is a 32-bit address that uniquely identifies the connection of a host or router to the internet.

ADDRESS SPACE:-

An address space is the total number of addresses used by the protocol.

For example, if a protocol uses b bits to define an address, then the address space is 2^b .

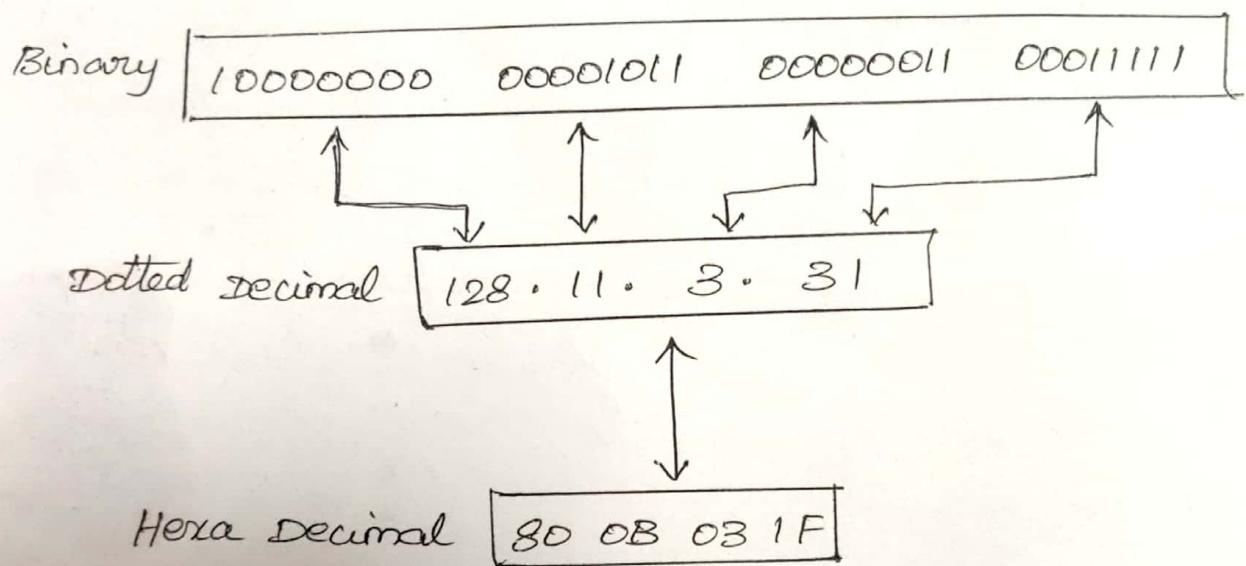
IPv4 uses 32 bit address, which means that,

$$\begin{aligned} \text{Address space of } & \{ \text{IPv4} \} = 2^{32} \\ & = 4,294,967,296 \\ & \approx 4 \text{ Billion.} \end{aligned}$$

NOTATION:-

There are three common notations to show an IPv4 address.

- i) Binary notation (base 2)
- ii) Dotted-decimal notation (base 256)
- iii) Hexa-decimal notation (base 16).



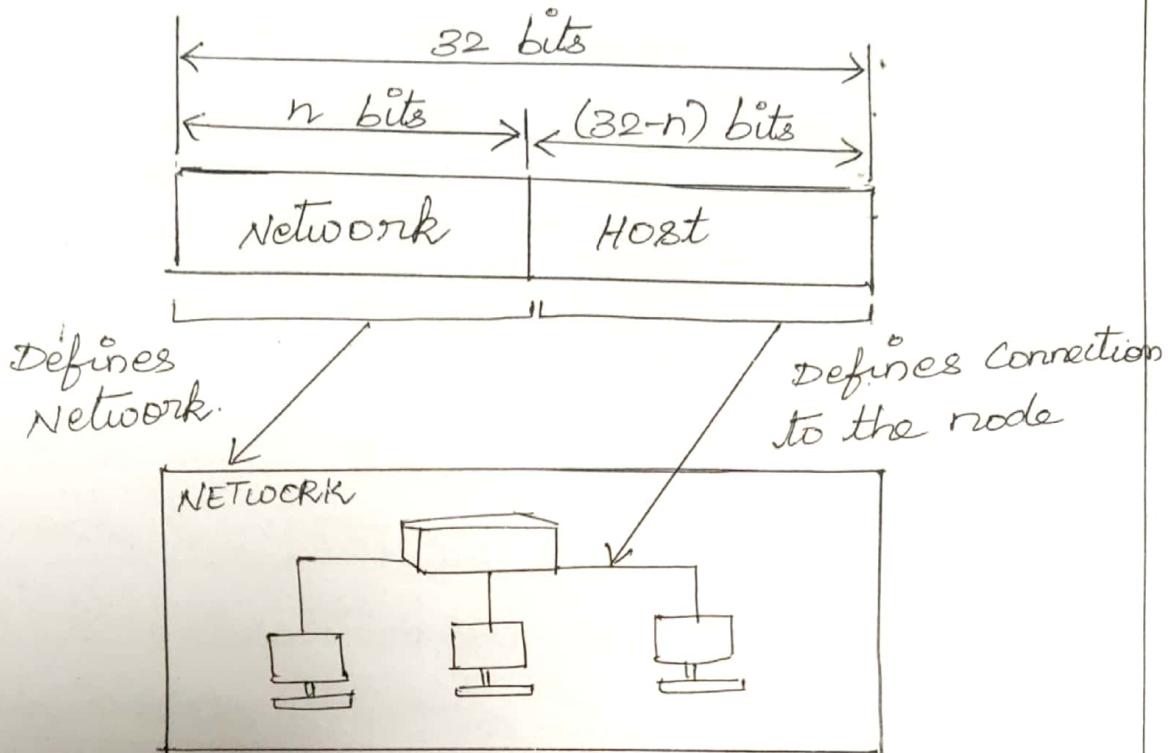
HIERARCHY IN ADDRESSING:-

The 32-bit IPv4 address is hierarchical which is divided into two parts.

- (1) prefix or network address
- (2) suffix or host address.

The network address = n bits

The host address = $32 - n$ bits

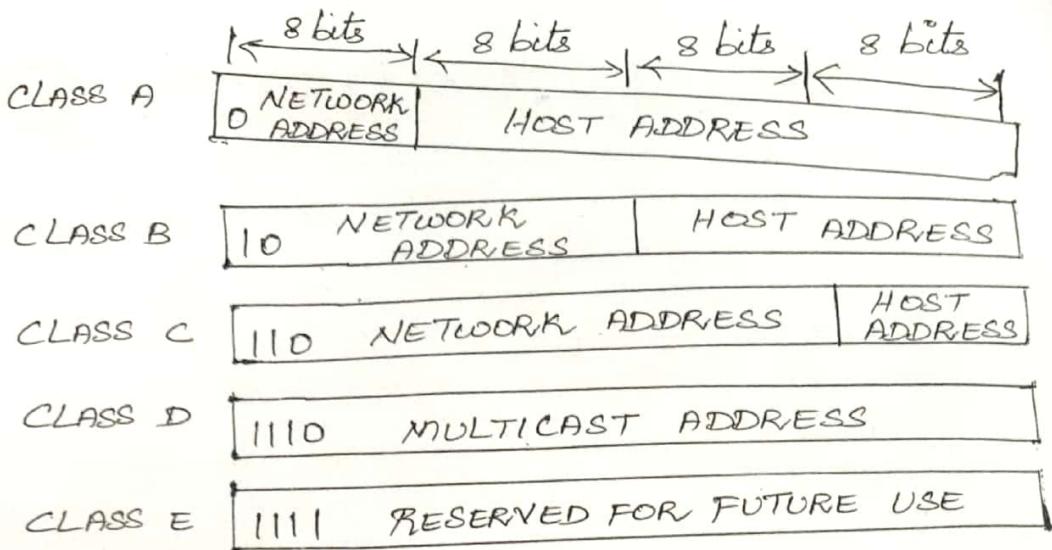


CLASSFUL ADDRESSING:-

- *) The IPv4 was initially designed with fixed-length network address.
- *) Three fixed-length network addresses were designed to accommodate small and large networks. ($n=8, n=16, n=24$).
- *) The whole address space was divided into five classes (Class A, B, C, D and E).
- *) This scheme is referred to as "classful addressing".



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*) In class A, The network length is 8 bits, but since the first bit is 0, we have only seven bits as the network identifier.
 $2^7 = 128$ networks can have CLASS A address.

*) In class B, The network length is 16 bits, but since first two bits are used to define the class, we have only 14 bits as the network identifier.

$2^{14} = 16,384$ networks can have CLASS B address

*) In class C, The network length is 24 bits, but since first three bits are used to define the class, we have only 21 bits as network identifier.

$2^{21} = 2,097,152$ networks can have CLASS C address.



CLASS	NETWORK ADDRESS	FIRST BYTE
A	$n = 8 \text{ bits}$	0 to 127
B	$n = 16 \text{ bits}$	128 to 191
C	$n = 24 \text{ bits}$	192 to 223
D	Not Applicable	224 to 239
E	NOT Applicable	240 to 255

ADDRESS DEPLETION:-

- *) The reason for classful addressing has become obsolete (No more in use) because of address depletion.
- *) Since the addresses were not distributed properly, the Internet was faced with the problem of the addresses being rapidly used up, resulting in no more addresses available for organization and individuals.

SUBNETTING & SUPERNETTING:-

- *) To overcome address depletion problem, two strategies were proposed.
 1. Subnetting
 2. Supernetting



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CLASSE

- *) In subnetting, a class A or class B block is divided into several subnets.
- *) Each subnet has a larger prefix length than the original network.
- *) For example, if class A is divided into four subnets, each subnet has prefix or network address as $n_{\text{sub}} = 10$.
- *) At the same time, if all of the addresses in a network are not used, subnetting allows the addresses to be divided among several organizations.
- *) Supernetting was designed to combine several class C blocks into a large block to organizations that need more than 256 addresses.
- * This idea did not work because it makes the routing of packets more difficult.

ADVANTAGE:-

- *) Given an address, the class of the address can be found easily, since ~~each~~ the network address of each class is fixed.
- *) No extra information is needed to find the network address and host address.



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CLASSLESS ADDRESSING:-

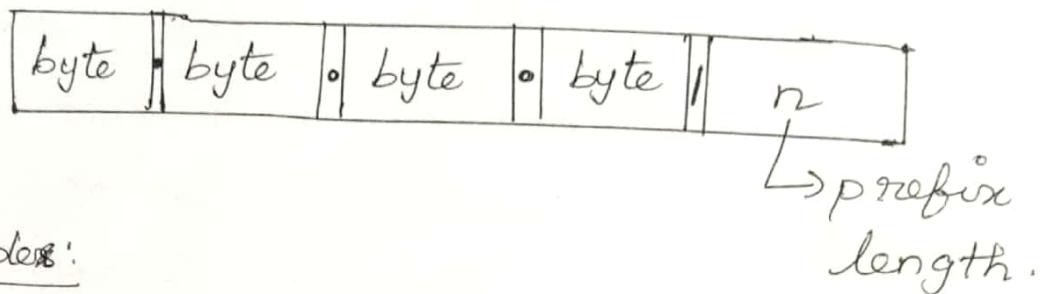
- *) In 1996, The internet authorities announced a new architecture called classless addressing.
- *) In classless addressing, variable-length blocks are used that belong to no classes. we can have a block of 1 address, 2 addresses, 4 addresses, 128 addresses and so on.
- *) The prefix in an address defines the block (network); The suffix defines the node (device).
- *) The prefix length in classless addressing is variable.

PREFIX LENGTH : SLASH NOTATION

- *) The prefix length is not inherent in the address, we need to separately give the length of the prefix.
- *) In classless addressing, the prefix length, n , is added to the address, separated by a slash.



* The notation is informally referred to as slash notation and formally known as "classless interdomain routing" or CIDR strategy.



Example:

12.24.76.8 /8

23.14.67.92 /12

220.8.24.255 /25

EXTRACTING INFORMATION FROM AN ADDRESS:-

Given a classless addressing with slash notation, the following information can be extracted.

- 1) The number of addresses in the block,
$$N = 2^{32-n}$$
- 2) To find the first address, we keep the n leftmost bits and set the $(32-n)$ rightmost bits all to 0's.
- 3) To find last address, we keep n leftmost bits and set $(32-n)$ rightmost bits all to 1's.



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Example:-

167. 199. 170. 82 / 27.

The no. of addresses in the network

$$\begin{aligned} &= 2^{82-n} \\ &= 2^{(82-27)} \\ &= 2^5 \\ &= 32 \text{ addresses.} \end{aligned}$$

To find first address,

167. 199. 170. 82 / 27

↳ convert to binary form

10100111 11000111 10101010 01010010

↳ first address got by changing $(32-n)$ rightmost bits to 0's.

$$(32-n) = 5 \text{ bits}$$

∴ 5 rightmost bits changed to 0's.

↳ 10100111 11000111 10101010 01010010
↓

10100111 11000111 10101010 01000000

↓
167. 199. 170. 64 / 27.



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To find last address,

167.199.170.82 /27

↳ convert to binary form

10100111 11000111 10101010 01010010

↳ last address got by changing ($32-n$) rightmost bits to 1's.

∴ 5 rightmost bits must be changed to 1's

10100111 11000111 10101010 01010010
↓

10100111 11000111 10101010 0101111
↓

167.199.170.95

ADDRESS MASK:-

- *) Address mask is used to find the first and last addresses of a address block.
- *) The address mask is a 32-bit number in which n leftmost bits are set to 1's and the rest of the bits ($32-n$) are set to 0's.
- *) A Computer can easily find the address mask because it is the complement of $(2^{(32-n)} - 1)$.



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1. The number of addresses in block N,

$$= \text{NOT}(\text{mask}) + 1$$

2. The first address in the block

$$= (\text{Any address in block}) \text{ AND } (\text{mask})$$

3. The last address in the block

$$= (\text{Any address in block}) \text{ OR } [\text{NOT}(\text{mask})]$$

Example:-

167. 199. 170. 82 /27. \rightarrow Address Block

256. 256. 256. 224 \rightarrow mask.

Convert address block and mask into
Binary form.

167. 199. 170. 82 /27 =

10100111 11000111 10101010 10110110

256. 256. 256. 224 =

1111111 1111111 1111111 1100000

To find Number of addresses in Block N,

$$N = \text{NOT}(\text{mask}) + 1$$

$$\begin{aligned}
 &= \text{NOT}(111111111111111111000000) + 1 \\
 &= (00000000000000000000000000011111) + 1 \\
 &= (0.0.0.31) + 1 \\
 &= 0.0.0.32 \\
 &= 32 \text{ addresses.}
 \end{aligned}$$

ii) To find first address,

$$\text{FIRST} = (\text{address}) \text{ AND } (\text{mask}).$$

123/160

$$\begin{aligned}
 &= (101001111100011110101010 \overset{01010010}{10110110}) \\
 &\quad \text{AND} \\
 &(11111111111111111111111111000000) \\
 &= \underline{\underline{0010}}
 \end{aligned}$$

$$= 10100111110001111010101010100000$$

$$= 167.199.2170.82$$

First address =

iii) To find Last address,

$$\text{LAST} = (\text{address}) \text{ OR } [\text{NOT}(\text{mask})]$$

$$\begin{aligned}
 &= 10100111110001111010101010110110 \\
 &\quad \text{OR} \\
 &\underline{\underline{00000000000000000000000000111111}} \\
 &= 10100111110001111010101011111111
 \end{aligned}$$



10100111 11000111 10101010 1111111

= 167. 199. 170. 255

SUBNETTING:-

- *) In subnetting an address block is divided into several subnets.
- *) more levels of hierarchy can be created using subnetting .
- *) An organisation (or an ISP) that is granted a range of addresses may divide the range into several subranges and assign each subrange to a subnetwork.
- *) A subnetwork can again be divided into several sub-subnetworks and so on.

DESIGNING SUBNETS:-

- *) The subnetworks in a network should be carefully designed to enable the routing of packets .
- *) we assume the total number of addresses granted to the organization as N .



Number of addresses to organization = N

The prefix length (network address) = n

The assigned number of addresses to each subnet = N_{sub}

The prefix length of each subnet = n_{sub}

*) The following steps need to be carefully followed to guarantee the proper operation of subnetworks.

→ The number of addresses in each subnetwork should be a power of 2.

→ The prefix length of each subnetwork

$$n_{\text{sub}} = 32 - \log_2 N_{\text{sub}}$$

→ The starting address in each subnetwork should be divisible by the number of addresses in that subnetworks.

Example:-

An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its 3 subnets: one subblock of 10 addresses



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one sub-block of 60 addresses and one sub-block of 120 addresses. Design the subnets.

Solution :-

(1) Given address block = 14.24.74.0 / 24.

The prefix length = 24.

The subnet requirements are,

subnet 1 = 10 addresses

subnet 2 = 60 addresses.

subnet 3 = 120 addresses.

(2) Arrange the subnet requirements in descending order.

Subnet	Requirement
3	120
2	60
1	10



(3) The total number of addresses available in the given block is found by the formula,

$$N = 2^{(32-n)}$$

Here, prefix length, $n = 24$

$$N = 2^{(32-24)}$$

$$N = 2^8$$

$N = 256$ addresses.

$$\boxed{N = 256}$$

(4) First address = $14 \cdot 24 \cdot 74 \cdot 0 / 24$

Last address = $14 \cdot 24 \cdot 74 \cdot 255 / 24$.

(5) The first block requires 120 addresses.
But the subnet address must be a power of 2.

So we allocate 128 addresses to first subnet.

The subnet mask for this subnet is found by, $n_{sub} = 32 - \log_2 N_{sub}$.

$$n_1 = 32 - \log_2 128$$
$$= 32 - 7$$

$$\boxed{n_1 = 25}$$



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First address ^{in this} block = 14.24.74.0 /25

Last address in this ^{block} = 14.24.74.127 /25

- (6) The second sub-block requires 60 addresses, which is also not a power of 2. so we allocate ~~not~~ 64 addresses.
The subnet mask can be found as

$$n_{\text{sub}} = 32 - \log_2 N_{\text{sub}} \quad \begin{array}{r} 128 \\ 64 \\ \hline 192 \end{array}$$

$$n_2 = 32 - \log_2 64 \quad \underline{192}$$

$$n_2 = 32 - 6$$

$$\boxed{n_2 = 26}$$

First address = 14.24.74.128 /26

Last address = 14.24.74.191 /26.

- (7) The third sub-block requires 10 addresses, which is also not a power of 2. so we allocate 16 addresses. The subnet mask can be found as

$$\begin{array}{r} 192 \\ 16 \\ \hline 208 \end{array}$$

$$n_{\text{sub}} = 32 - \log_2 N_{\text{sub}}$$

$$n_3 = 32 - \log_2 16$$

$$n_3 = 32 - 4$$

$$\boxed{n_3 = 28}$$

First address = 14.24.74.192 / 28

Last address = 14.24.74.207 / 28

(8) Total no. of addresses }
available in this block } = 256
of address

Total no. of addresses } = 208
allocated to subnets }

Remaining addresses = 256 - 208
= ~~48~~ 48 addresses.

IPV4 addressing

Identifier used in IP layer of the TCP/IP protocol suite to identify the connection of each device to the internet & called internet address or IP address.

- 1) IP address is a 32 bit address uniquely and universally defines the connection of a host or a router to the internet
- 2) one and only one connection to the internet
- 3) Address space — Total no of addresses used by the protocol.

If a protocol uses b bits to define an address, address space is 2^b —

IPV4 — 32 bit addresses — 2^{32} or 4,294,967,296

4 billion devices could be connected to the internet.

Notation

3 common notations (base 2)

2) dotted decimal notation (base 10)

3) hexadecimal (base 16).

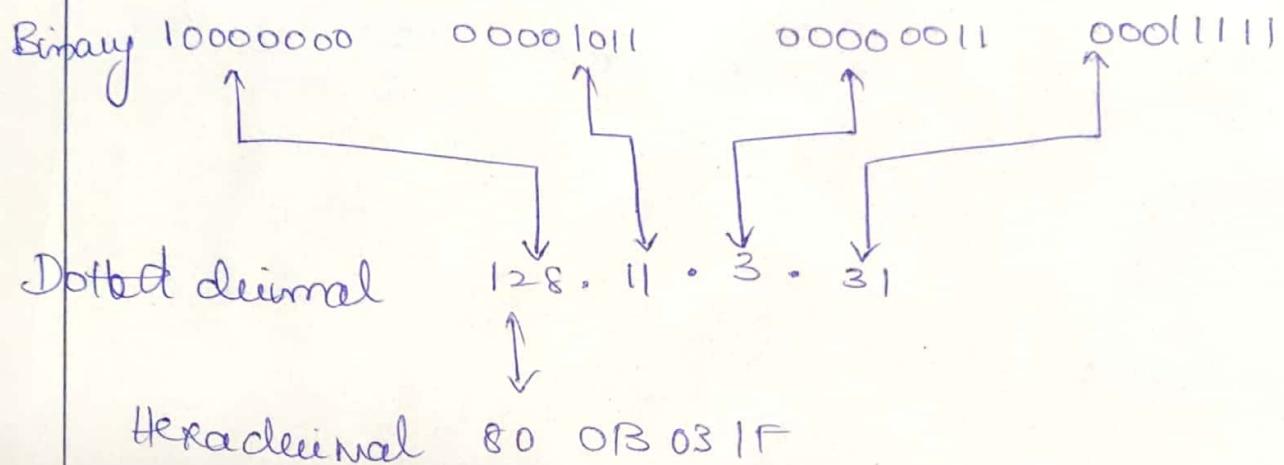
Binary — displayed as 32 bits.

Address more readable — one or more space is inserted between each octet (8 bits)

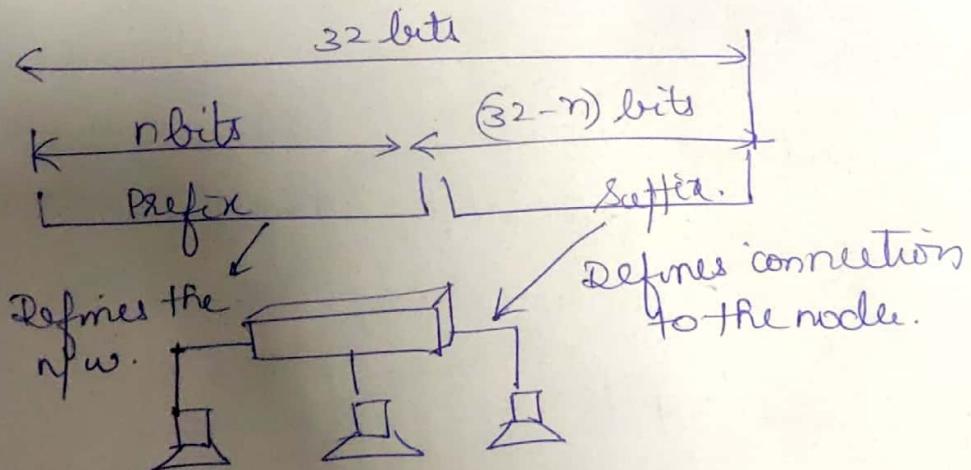
Each octet is called bits.

Dotted decimal notation

Written in dotted decimal form with a decimal point separating the bytes. 8 bits - 0 to 255.



Hierarchy in addressing



Prefix can be fixed or variable length.

N/W identifier designed as fixed length prefix.

Classful addressing

Address space

	A	B	C	D	E	
	50	25	12.5%	6.25	6.25%	
	8	8	8	8	8	
Class A	0 Prefix	Suffix				First byte A n=8 0 to 127
Class B	10 Prefix	Suffix				B n=16 128 to 191
C	110 Prefix	Suffix				C n=24 192 to 223
D	1110 Multicast address					D Not applicable 224 to 239
E	1111 Reserved for future					E Not applicable 240 to 255

① A classless address is given as 167.199.170.82/27.

Given a classless addressing with slash.

1) The no of addresses in the block.

$$N = 2^{32-n}$$

2) To find the first address, keep the n leftmost bits and set the $(32-n)$ rightmost bits all to 0's.

3) To find the last address, keep n leftmost bit set $(32-n)$ rightmost bits to 1's

1) No of addresses in the n/w

$$= 2^{32-n}$$

$$= 2^{32-27} = 2^5 = 32 \text{ addresses.}$$

2) To find first address.

167.199.170.82/27

Step 1 convert to binary form

10100111 11000111 10101010 01010010

Step 2 First address is got by changing $(32-n)$ rightmost bits.

10100111 11000111 10101010 01010010
 ↓
 01000000

167. 199. 170. 64 / 27

Step 3 Find last address

167. 199. 170. 82 / 27

Convert to binary form.

10100111 11000111 10101010 01010010.

Last address got by changing $(32-n)$ rightmost bit to 1's
 \therefore rightmost bit changed to 1's

10100111 11000111 10101010 01010010

↓
 10100111 11000111 10101010 01011111

167. 199. 170. 895

Ex 18.2 Address mask is used to find first and last addresses of address block.

1) Address mask is a 32 bit no in which n leftmost bits are set to 1s and rest of bits $32-n$ are set to 0s

2) Computer can find the address mask because it's complement of $(2^{32-n} - 1)$

1) The noof addresses in block N = $\text{NOT}(\text{mask}) + 1$

2) The first address in the block = $(\text{Any address in block}) \text{ AND } (\text{Mask})$

3) The last address in the block = $(\text{Any address in block}) \text{ OR } (\text{NOT}(\text{mask}))$

eg 167.199.170.82 /27 Address block.

256. 256. 256. 224

256
32
224

167. 199. 170. 82 /27

10100111. 11000111 10101010 10110110.

256. 256. 256. 224

11111111 11111111 11111111 11110000

To find the mask address in block N.

$N = \text{NOT}(\text{mask}) + 1$

$= \text{NOT}(11111111. 11111111. 11111111. 11100000) + 1$

$= (00000000. 00000000. 00000000. 00011111) + 1$

$= (0.0.0.31) + 1 = 32 \text{ addresses}$

14. 14. 14. 172 /28
14. 24. 74. 208 /28

In a classless addressing, address 230. 8-24-86
can belong to many blocks.

Dr T
SRI
P

3) An ISP has requested a block of 1000 addresses.
 Since 1000 is not a power of 2. 1024 addresses are granted.
 Prefix length $n = 32 - \log_2 1024 = 22$.
 An available block 18.14.12.0/22.

4) An organisation, with beginning address 14.24.74.0/24
 organisation needs to have 3 subblocks of addresses to
 exist in 3 subnets -

one block of 10 address
 one subblock of 60 address
 one subblock of 120 address.

a) largest subblock requires 120 addresses, power of 2.

$$2^7 = 128 \text{ addresses. } n_1 = 32 - \log_2 128 \\ = 32 - 7 \log_2 2 \\ = 25$$

First address 14.24.74.0/25

Last address 14.24.74.127/25

b) largest subblock requires 60 addresses . power of 2

$$2^6 = 64 \text{ address } n_2 = 32 - \log_2 64 \\ = 32 - 6 \log_2 2 \\ = 26$$

128
64
192

First address 14.24.74.128/26

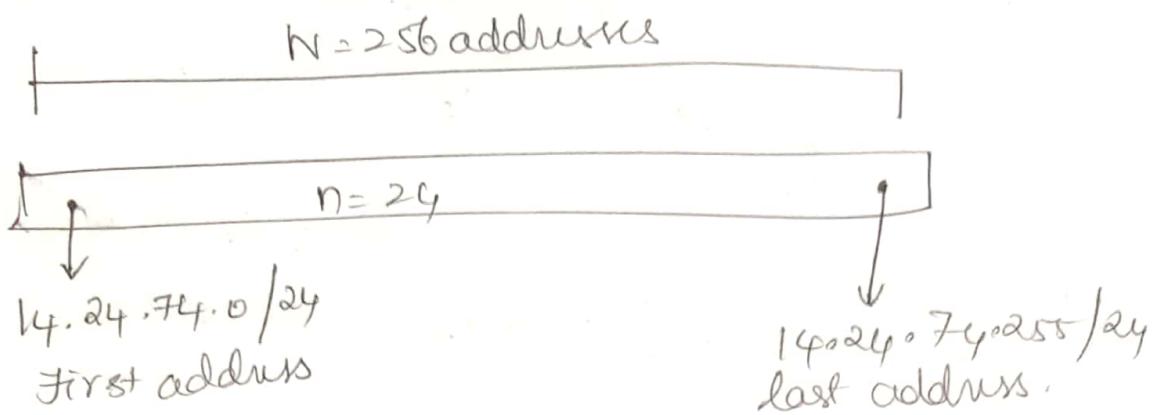
Last address 14.24.74.191/26

c) smallest block 10 address

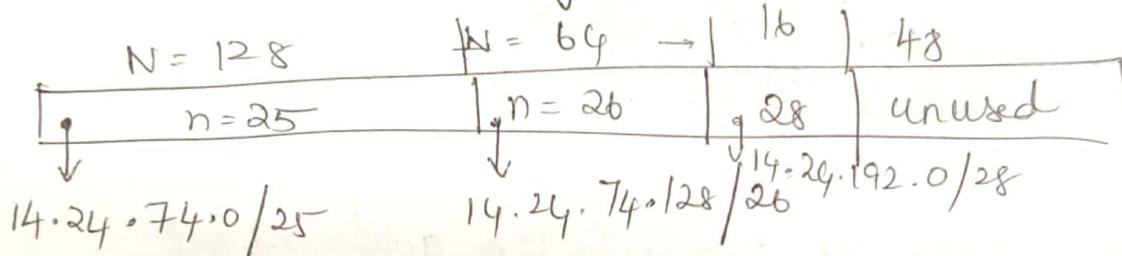
$$2^4 = 16 \text{ address } n_3 = 32 - \log_2 2^4 = 32 - 4 = 28$$

First address 14.24.74.192/28
 14.24.74.208/28

192
16
08



(a) Original block



Subblock.



①

Basics of subnetting

Class A Subnet Mask : 255.0.0.0 /8 1111111.0000000.0000000.0000000

B Subnet Mask : 255.255.0.0 /16.

C Subnet Mask : 255.255.255.0 /25.

/9 255.128.0.0. 1111111.1000000.0000000.0000000

/17 255.255.128.0 1111111.1111111.1000000.0000000

/25 255.255.255.128 1111111.1111111.1111111.1000000.

/10 255.192.0.0 1111111.1100000.0000000.0000000

/18 255.255.192.0 1111111.1111111.1100000.0000000

$2^4 = 16$ subnets Host bits are reduced to 2
/26 255.255.255.192 1111111.1111111.1111111.1100000

→ 4 subnets

16 host IP addresses

$2^4 = 16$ host IP

is reduced to

$2^4 = 16,384$ per subnets

4 separate subnets having 16,384.



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(2)



126. $255 \cdot 255 \cdot 255 \cdot 192$

$1111\ 1111 \cdot 1111\ 1111 \cdot 1111\ 1111 \cdot 1100\ 0000$

Class B

65536	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
2 ¹⁶	2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 ¹	2 ²	2 ³	2 ⁴	2 ⁵	2 ⁶	2 ⁷	2 ⁸	2 ⁹	2 ¹⁰	2 ¹¹	2 ¹²	2 ¹³	2 ¹⁴	2 ¹⁵	2 ¹⁶	2 ¹⁷
2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	8

← subnet network

→ host subnet

Class B

If u borrow 4 from octet 3.

16 subnet - each having 4096 hostip address

If u borrow 5 from octet 3.

32 subnets - each having 2048 hostip address

(3)

class C

If u borrow 4 bits from octet 3.

256	128	64	32	16	8	4	2
2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹
0	0	0	0	0	0	0	0
21	22	2 ³	2 ⁴	2 ⁵	2 ⁶	2 ⁷	2 ⁸
2	4	8	16	32	64	128	256

16 subnets - 16 host ip addresses.

If u borrow 5 bits from octet 5.

32 subnets from 8 host ip addresses.



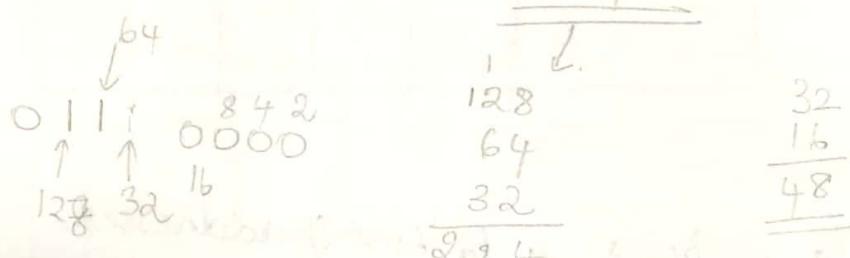
(4)

~~eg~~

① Given the IP address and subnet mask of 172.16.134.48

255.255.255.224. which of the following describe the address

- a) this is a useable host address?
- b) this is a broadcast address
- c) this is a new address
- d) this is not a valid address.

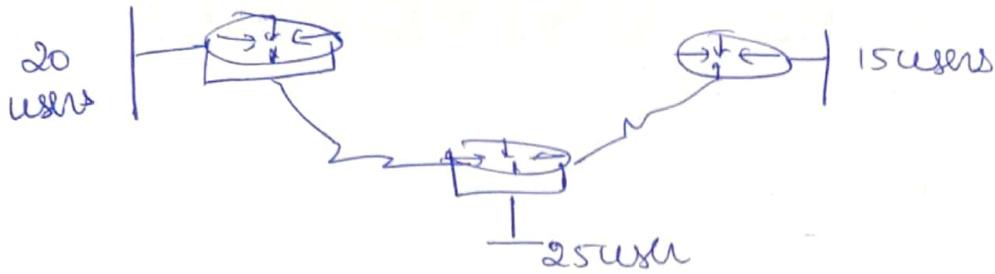


5 bits are taken There are 32 host in each subnet

48 is between .32 and .64 subnet. \Rightarrow this useable host address
Possible host which subnetwork does this address reside.

- 1) 172.16.134.0 172.16.134.56.
- 2) 172.0.0.0 .56 lies between .32 and .64
- ✓ 3) 172.16.134.32
- 4) 172.16.134.48
- 5) 172.16.134.47
- 6) 172.16.134.63

(5)



The company n/w shown in the drawing has to be subnetted. The company has leased one Class C IP address 200.1.2.0 which of the following n/w addresses and masks would be appropriate for one of the n/w's.

- 1) 200.1.2.96 . 255.255.255.192
- 2) 200.1.2.160 255.255.255.224
- 3) 200.1.2.80 255.255.255.224
- 4) 200.1.2.32 255.255.255.240 .

240 11100000 \Rightarrow 16 hosts
192 11000000 \Rightarrow 64 hosts

Required is 32 hosts . why . 15+25+20 .
60 .

1110 0000 \Rightarrow 224
128
64
32 b.c.
 $80 \div 32 \times$.



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(6)

②

192.168.2.64 /26.

126 subnet mask \Rightarrow 26's 1's rest 0's.

Subnet
mask

1111 1111 1111 1111 1111 1111 1100 0000

IP
address

1100 0000 1010 1000 0000 0010 0100 0000
" " " "
0000 00 ← n/w id

(i) no of hosts

(ii) Network address

1111 11 ← broadcast

(iii) Broadcast address.

Network address = 192.168.2.64]
] ← hosts

Broadcast address = 192.168.2.127

hosts = 192.168.2.65



192.168.2.126.

TUV SUD
⑦ Find number of subnets and no of valid hosts per subnet

$$\text{Subnets} = 2^{\text{# of subnet bits}}$$

$$\text{Valid hosts} = 2^{\text{# of host bits}} - 2 \quad [\text{Netid & Broadcast add}] \\ = \text{IP address to allocate}$$

e.g. ① 192.168.1.0 /28.
.....0000.

$$192.168.1.0 \Rightarrow 255.255.255.240.$$

.....1111111.1111111.1111111.11110000

① Class C.

$$② \text{Subnets} = 2^{32-28} = 2^4 = 16 \text{ addresses.}$$

$$③ \text{Hosts} = 2^4 = 16 - 2 = 14$$

$$\begin{aligned} 2^7 &= 128 \\ 2^6 &= 64 \\ 2^5 &= 32 \\ 2^4 &= 16 \\ 2^3 &= 8 \\ 2^2 &= 4 \\ 2^1 &= 2 \\ 2^0 &= 1 \end{aligned}$$

e.g. ② 150.150.0.0 /30.

① Class B. 255.255.0.0.

.....1111111.1111111.1111111.1111100
↓ Network.

$$② \text{Subnets} = \cancel{2^{32-30}} = \cancel{2^2} = 4 \text{ addresses.} \\ = 2^{14} = 16,384$$

$$③ \text{Hosts} = 2^2 = 4 - 2 = 2 \text{ valid hosts.}$$



(8)

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168.173.70.134 /29.

128 192 224 240 248 252 254 255

128 64 32 16 8 4 2 1

00000000. 00000000. 00000000. 00000000 = 32 bit.

8 16 24

11111000

10000110

10000000

168.173.70.134 /29.

1) Check for /29. = $32 - 29 = 3$.2) $2^3 = 8$

11111000

1) Subnet mask = 255.255.255.248.

168.173.70.0

2) Network id = 168.173.70.128

168.173.70.8

3) First ip = 168.173.70.129

16

24

32

40

48

56

64

72

80

88

96

104

112

120

128

136

4) Last ip = 168.173.70.134

5) Broadcast ip = 255.255.255.255

168.173.70.135000 0111
11111000

1000000000

11110000

10000110

→ 136

(9)

$$153.34.173.242 / 17$$

① Class B

② $17 = 2^{32-17} = 2^{15}$

$$\underbrace{1111111}_{\text{Network ID}} \cdot \underbrace{1111111}_{\text{Host ID}} \cdot 10000000.0000.$$

Mask is 255. 255. 128. 0.

③ No of
$$\begin{array}{r} 173 \quad 1010110 \\ - 10000000 \\ \hline 70 \end{array}$$

153.34.0.0
153.34.128.0
153.34.256.0

$$70 \Rightarrow 0b1000110.$$

$$\begin{array}{r} 10000000 \\ \hline \end{array}$$

N/w id $\Rightarrow 153.34.128.0$

④ First address = 153.34.128.1

⑤ Last address = 153.34.255.254

⑥ Broad cast = 153.34.255.255



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(10)

92. /68

172. 10. 60. 16 /29

/29

1111 1111 . 1111 1111 . 1111 1000 . 0000 0000

255 . 255 . 248 . 0 .

N/w id $60 \Rightarrow 0011\ 1100$

mask $\begin{array}{r} 1111\ 1000 \\ \hline 0011\ 1000 \end{array}$

N/w id 172. 10. 56. 0.

First id 172. 10. 56. 1

Last id 172. 10. 6011 1100 .

Not mask \Rightarrow $\begin{array}{r} 0000\ 0111 \\ \hline 0011\ 1111 \end{array}$

Broad cast 172. 10. 63. 255

Last 172. 10. 63. 254

(10)

$$192 \cdot 168 \cdot 60 \cdot 55 / 20$$

$$\text{Mask} \Rightarrow 2^{32} - 20$$

$/20$ 1111 1111 1111 1111 1111 0000 0000 0000

$$255 \cdot 255 \cdot 240 \cdot 0$$

Net Ad 192. 168. 1111 0000

$$\Rightarrow 60 \quad \begin{array}{r} 00111100 \\ \hline 00110000 \end{array}$$

$$\Rightarrow 48$$

$$192 \cdot 168 \cdot 48 \cdot 0$$

First add 192. 168. 48. 1

Last add 192. 168. 1111 0000.

$$\Rightarrow 60. \quad 00111100$$

Not mask $\begin{array}{r} 00001111 \\ \hline 00111100 \end{array}$

63 \Rightarrow $\begin{array}{r} 00111100 \\ \hline 00111100 \end{array}$

$$192 \cdot 168 \cdot 63 \cdot 254$$

$$192 \cdot 168 \cdot 63 \cdot 255$$

Broadcast \nearrow

$$\begin{array}{r} 1 \\ 18 \\ 16 \\ \hline 64 \end{array}$$



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172.10.85.60 /22.

(12)

Class B

22 \Rightarrow 1111 1111. 1111 1111 . 1111 1100. 00000000

1) Mask 255. 255. 252. 0 .

2) First address 172. 10. 85. 60 .

↓

85	01010101
mask	<u>11111100</u>
01010100	

Net id \Rightarrow 172. 10. 84. 0

3) First add 172. 10. 84. 1

Last add 01010101
00000011
01010111

Broadcast 172. 10. 87. 255

Last add 172. 10. 87. 254

(13)

172.10.60.16 / 29

Mask 1111 1111 . 1111 1111 . 1111 1111 - 1111 1000

255.255.255.248 .

Netid \Rightarrow 001010000 ;

Mask $\begin{array}{r} 11111000 \\ \hline 00010000 \end{array}$

172.10.60.16 .

172.10.60.17 .

Broadcast 0001 0000 .

Not mask $\begin{array}{r} 0000\ 011111 \\ \hline 00010111 \end{array}$

172.10.60.23

Last add 172.10.60.22 .

VLSM:-

- Variable length Subnet Mask.
- It extends classic subnetting.
- VLSM is a process of breaking down subnets into smaller subnets, according to need of individual networks.

Steps:-

- 1) Find the largest segment i.e.) The segment which needs the largest no. of hosts.
- 2) Do subnetting to fulfill the requirement of largest segment.
- 3) Assign the appropriate subnet mask for the largest segment.
- 4) for second largest segments, take one of these newly created subnets and apply a different more appropriate subnet mask to it.
- 5) Assign appropriate subnet mask for second largest segment.
- 6) Repeat this process until the last network.

Ex:-

Admins 192.168.1.0 /24

(no. of bits used for
nw address)

departments

Sales	100
Purchase	50
Accounts	25
Management	5

Step 1:-

make a list of subnets possible.

Subnet Mask
~~255.255.255.0~~

Hosts / Subnet

255.255.255.128	254
255.255.255.192	126
255.255.255.224	62
255.255.255.240	30
255.255.255.248	14
255.255.255.252	6
	2

Step 2:-

Sort the requirements of IPs

- in descending order.
- 1) Sales 100
 - 2) Purchase 50
 - 3) Accounts 25
 - 4) Management 5



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Example of VLSM.

192.168.1.0 /24.

4 departments :

Sales	100
Purchase	50
Accounts	25
Management	5

prefix length = 24.

(1) Total number of addresses available in the given block is found by the formula

$$N = 2^{(32-n)}$$

$$N = 2^{(32-24)}$$

$$N = 2^8$$

$N = 256$ addresses.

(2) First address = 192.168.1.0 /24

Last address = 192.168.1.255 /24.

(3) The first block requires 100 addresses. But the subnet address must be a power of 2. so we allocate 128 addresses to first subnet.

The subnet mask for this subnet is found by

$$\begin{aligned}n_{\text{sub}} &= 32 - \log_2 N_{\text{sub}} \\&= 32 - \log_2 \cancel{N_{\text{sub}}} 128 \\&= 32 - 7 \\n_1 &= 25\end{aligned}$$

First address in this block = ~~14.24~~
192.168.1.0 / 25

Last address in this block =

192.168.1.127 / 25

The subnet mask is 255.255.255.128

(4) The ~~first~~ second block requires 50 addresses. But the subnetmask address must be a power of 2. so we allocate 64 addresses to second subnet.

The subnet mask for this subnet is found by,

$$\begin{aligned}n_{\text{sub}} &= 32 - \log_2 N_{\text{sub}} \\&= 32 - \log_2 64 \\&= 32 - 6\end{aligned}$$

$$n_2 = 26$$



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The subnet mask for this subnet is

255.255.255.192 /26

First address in this block =

192.168.1.128 /26

Last address in this block =

192.168.1.191 /26.

(5) The third block requires 25 addresses. But the subnetwork address must be a power of 2. So we allocate 32 addresses to third subnet.

The prefix is found by,

$$\begin{aligned}n_{\text{sub}} &= 32 - \log_2 N_{\text{sub}} \\&= 32 - \log_2 32 \\&= 32 - 5 \\&= 27\end{aligned}$$

$$n_3 = 27$$

The subnet mask for this subnet is

255.255.255.224 /27

First address in this block =

192.168.1.192 /27

Last address in this block =

192.168.1.223 /27.

(6) The fourth block requires 5 addresses. But the subnetwork address must be a power of 2. so we allocate 8 addresses to this host.

The prefix is found by,

$$\begin{aligned}n_{\text{sub}} &= 82 - \log_2 N_{\text{sub}} \\&= 82 - \log_2 8 \\&= 82 - 3\end{aligned}$$

$$n_4 = 29$$

The subnet mask for this subnet is

255.255.255.232 /29

First address in this block =

192.168.1.224 /29

Last address in this Block =

192.168.1.232 /29.

Subnetting

- 1) More levels of hierarchy can be created using subnetting.
- 2) An organisation that is granted a range of addresses may divide the range into several subranges and assign each subrange to a subnet (or subnet).
- 3) A subnet is divided into several sub-networks. A sub-subnetwork can be divided into several sub-sub-subnetworks and so-on.

Supernetting was devised to combine several class C blocks onto a larger block to be attractive for organisations that needed more than 256 addresses available in class C block.

Special Addresses

5 special addresses used for special purposes.

The-host address

- * only address in the block 0.0.0.0/32.
- * whenever a host needs to send an IP datagram
- does not know its own address to use source address.

Limited-broadcast address

- * The only address in block 255.255.255.255/32
- * It is used whenever a router or a host needs to send a datagram to all devices in a network.
- * The routers in the n/w block the packet having this address as a destination. For the packet cannot travel outside the network.

loop back address

- * The block $127 \cdot 0 \cdot 0 \cdot 0 / 8$ is called loop back block
- * A packet with one of the addresses in this block destination address never leaves the host - it will remain in the host.
- * used to test a piece of software in the machine
- eg * client and a server program in one of the addresses is used as server address.

Private address

- 4 blocks are assigned -
 - $10 \cdot 0 \cdot 0 \cdot 0 / 8$
 - $172 \cdot 16 \cdot 0 \cdot 0 / 12$
 - $192 \cdot 168 \cdot 0 \cdot 0 / 16$.
 - $169 \cdot 254 \cdot 0 \cdot 0 / 16$.

Multicast addresses

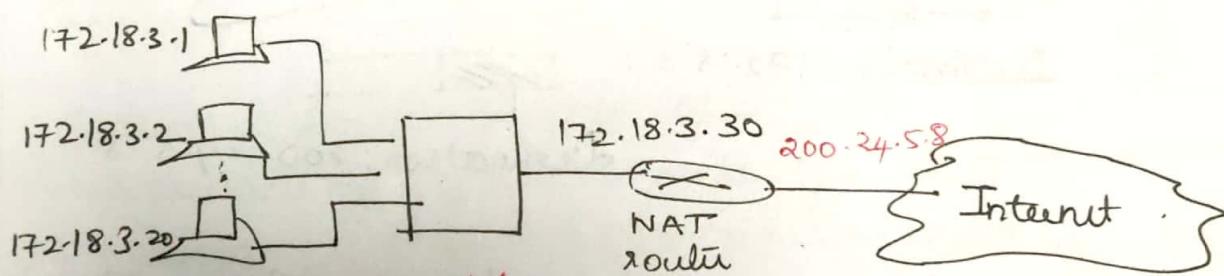
Block $224 \cdot 0 \cdot 0 \cdot 0 / 24$ is reserved for multicast addresses.

Network Address Translation [NAT]

- * If an ISP has granted a small range of addresses to a small business or a household
- * If business grows or household needs a large range,
- * ISP may not be able to grant the demand because the addresses before and after the range may have been allocated to other networks.
- * In most situations, only a portion of computers in a small network need access to the Internet simultaneously.
- * i.e. the number of allocated addresses does not have to match the number of computers in the n/w.

Network Address Translation [NAT]

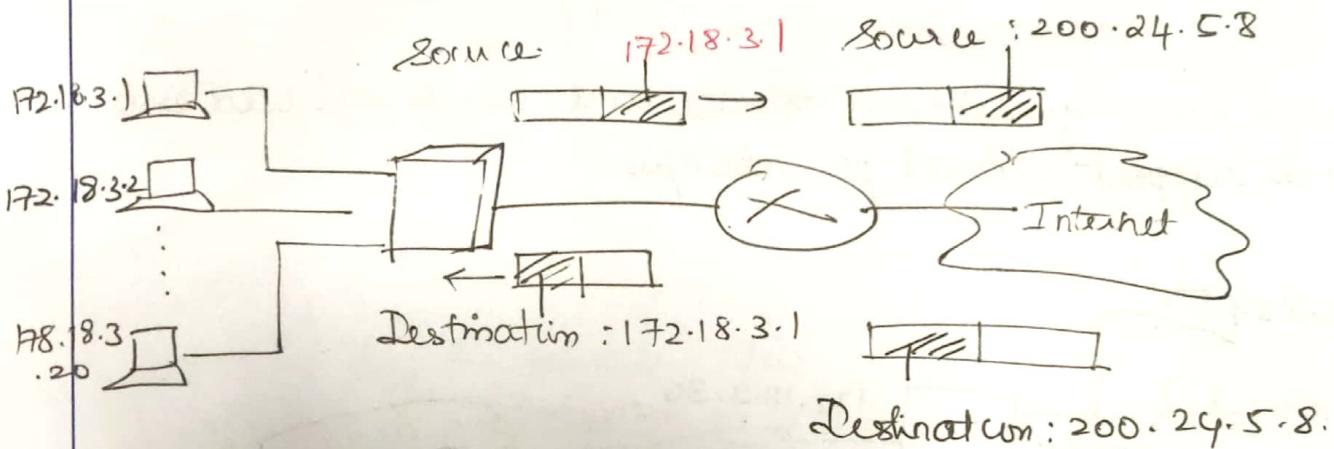
- * The mapping between private and universal addresses, and support virtual private n/w.



- * Private n/w uses private addresses
- * Router that connects the n/w to the global address uses one private address and one global address.
- * Private n/w is invisible to the rest of the Internet; the rest of the Internet sees only NAT router with address 200.24.5.8

Address Translation

- * All of the outgoing packets go through the NAT router, which replace the source address in the packet with global NAT address.
- * All incoming packets also pass through the NAT router, which replace the destination address in the packet (NAT router which replace the destination address in the packet (NAT router global address) with appropriate private address.



Translation table

Translating the source address for a outgoing packet is straight forward. For translating tens or hundreds of private IP address, NAT router has a translation table.

* Using one IP address

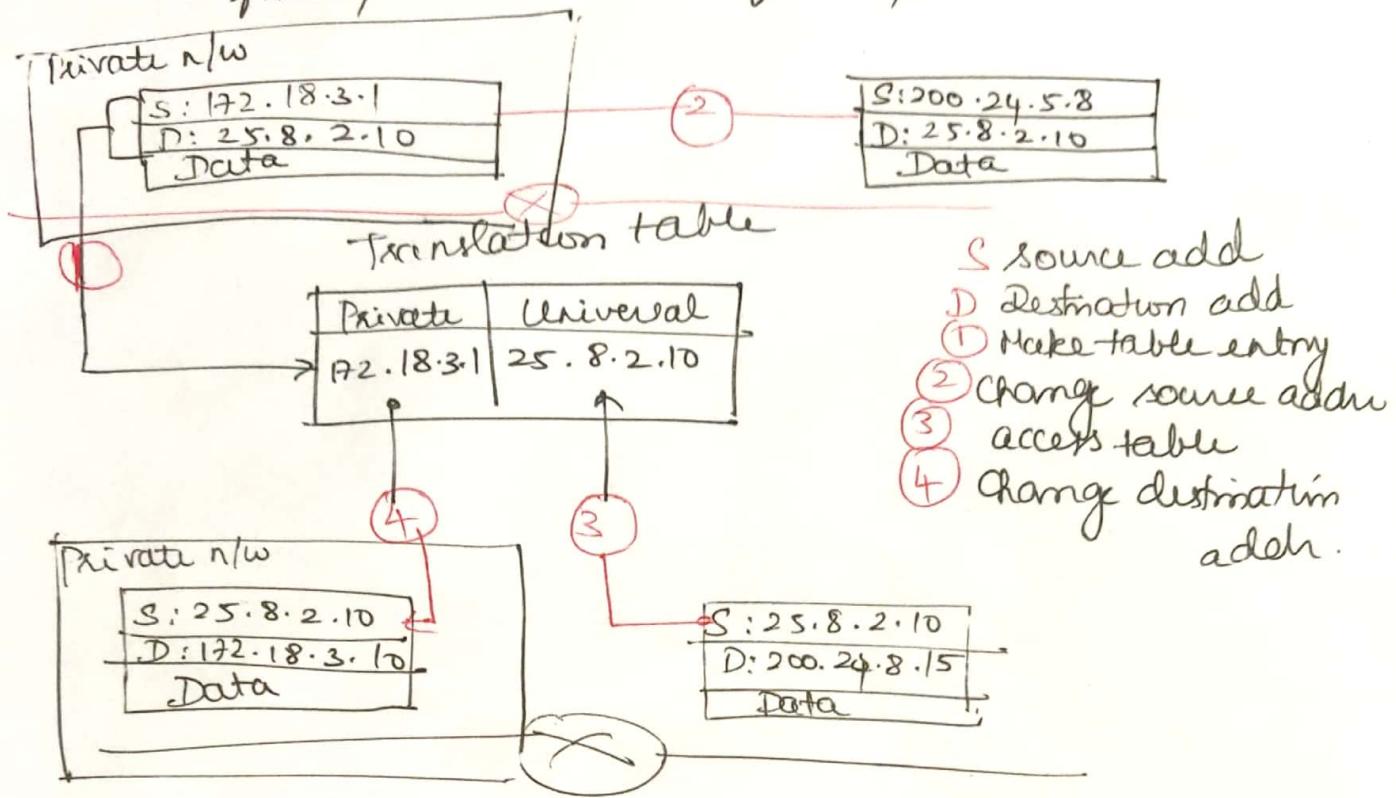
Translation has only 2 columns

- * private address

- * external address

When router translates the source address of outgoing packet, it makes note of destination address where the packet is going.

when the response comes back from the destination the router uses the source address of the packet (as external address) to find private address of the packet



- 1) Initiated by the private n/w
- 2) NAT mechanism requires private n/w start the commn.
- 3) ISP assigns a single address to a customer.

- 2) Using pool of IP addresses
- 3) Using Both IP addresses and Port Addresses

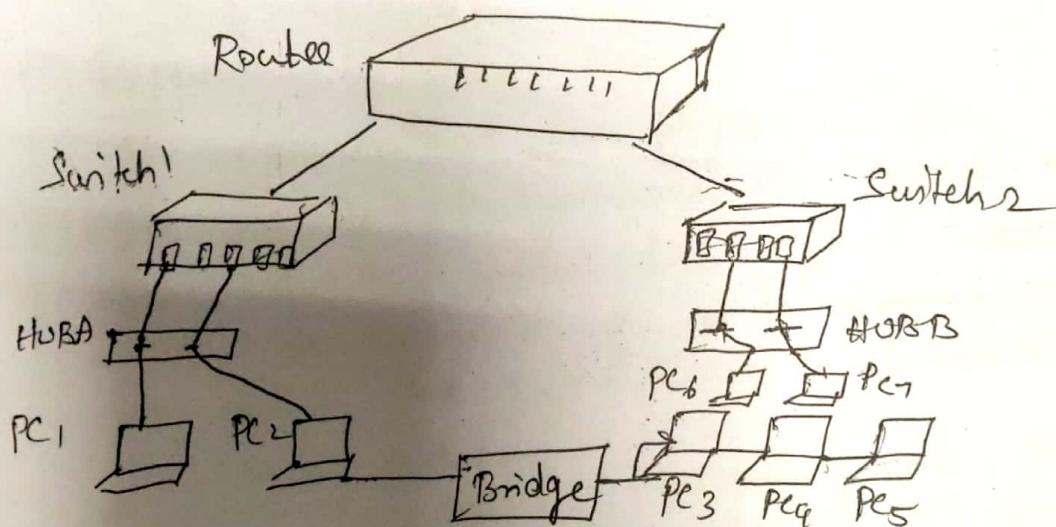
Private Address	Private Port	External Address	External Port	Transport Protocol
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
:	:	:	:	:



⑤
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Network Devices





Network Devices

- 1) Repeater
- 2) Hub
- 3) Bridge
- 4) Switch
- 5) Router

1) Repeater

- * It operates at the physical layer.
- * Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.
- * When the signal becomes weak, repeater copy or receive the signal bit by bit and regenerate it at the original strength.
- * It is a 2 port device.

2) Hub

- * It is basically a multipoint repeater.
- * It connects multiple wires coming from different branches .. i.e) for example, star topology, which connects different stations.
- * Hub connects multiple ports. i.e) when a packet arrives at one port, it is copied to other ports so that

②

- * Hub cannot filter data, so data packet sent to all connected devices.
- * And also hub do not have capability to select the best path for data packets which leads to inefficiencies and wastage of packets.

Types of hub:-

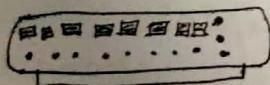
a) Active hub:-

- * These are hubs which have their own power supply and can boost and relay the signal along the network.
- * It serves both as a repeater as well as wiring center. They are used to extend maximum distance between nodes.

b) Passive hub:-

- * These are the hubs which collect wiring from nodes and power supply from active hub.
- * These hubs relay signals onto the network without cleaning and boosting them and can't be used to extend distance between nodes.

Hub diagram





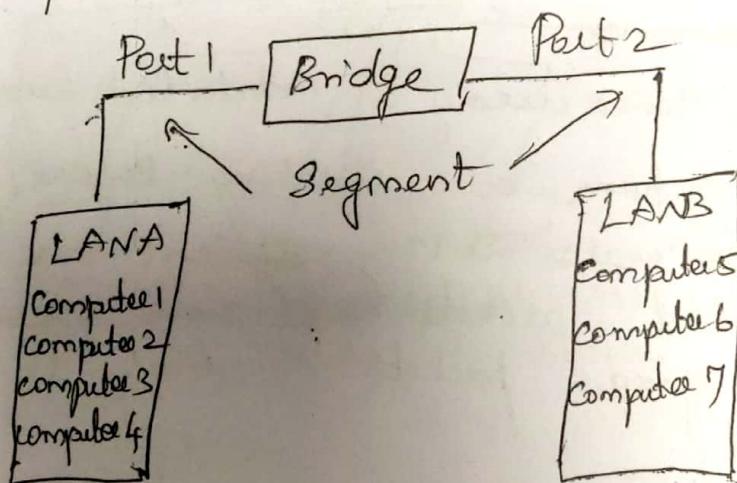
(3)

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3) Bridge

- * It operates at data link layer.
- * It is like a repeater with add on functionality of filtering content by reading the MAC address of source and destination.
- * It is also used for interconnecting two LANs working on the same protocol; ^{such as ethernet or tokenring.} It has a single input & single output port thus making it a 2 port device.



Two types of Bridges:-

a) Transparent Bridges:-

- * These are the bridge in which the stations are completely unaware of the bridge's existence i.e) whether or not a bridge is added or deleted from the network, reconfiguration of the stations is unnecessary.
- * These bridges makes use of two processes - i) bridge forwarding and bridge learning.

form it is used to create multiplexing; on age learning -
④ Defining of nodes connected to bridge

b) Source Routing bridges-

- * In these bridges, routing operation is performed by source station and the frame specifies which route to follow.
- * It can discover frame by sending a special frame called discovery frame, which spreads through the entire network using all possible paths to destination.

c) Switch

- * A switch is a multi port bridge with a buffer and a design that can boost its efficiency and performance.
- * It is a device working in data link layer.
- * It can perform error checking before forwarding data that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only.

(a) Filtering:-

- * Filtering capability can check the destination address of a frame and can decide from which outgoing port the frame should be sent.
- * e.g.:- we have a LAN with 4 stations that are connected to a link layer switch.
- * If a frame destined for station 11:23:13:45:61:42 arrives at port 1, the



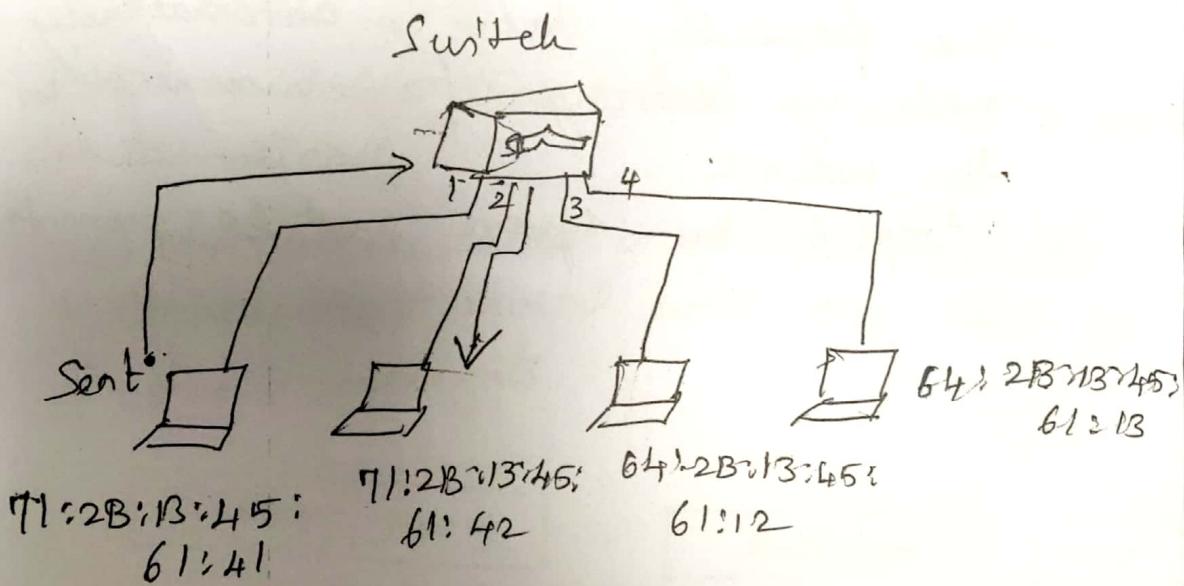
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(5)

The link layer switch consults its table to find the departing port.

According to the table, frame for $71:2B:13:45:61:42$ should be sent only through port 2:



Switching Table:-

Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	2
64:2B:13:45:61:12	3
64:2B:13:45:61:13	4

(b)

(b) Transparent switches

- * A transparent switch is a switch to which the stations are unaware of the switch's existence.
- * According to IEEE 802.1d Specification a system equipped with transparent switches must meet the following criteria.
 - (i) frames must be forwarded from one station to other.
 - (ii) The forwarding table is automatically made by learning frame movements in the network.
 - (iii) Loops in the system must be prevented.

Learning:-

(B)

- The earliest switches had switching tables that were static.
- The system administrator would manually enter each table entry during switch setup.
- If a station was added or deleted, the table had to be modified manually.
- The static table can be replaced by a dynamic table that maps addresses to ports automatically.
- A dynamic table is constructed by a transparent switch with the help of frames' movements.

Address	Port
---------	------

a. original

Address	port
71:2B:13:45:61: 41	1

b. After A sends a frame to D.

Address	Port
71:2B:13:45:61:41	1
64: 2B:13: 45:61:13	4

c. After D sends a frame to B.

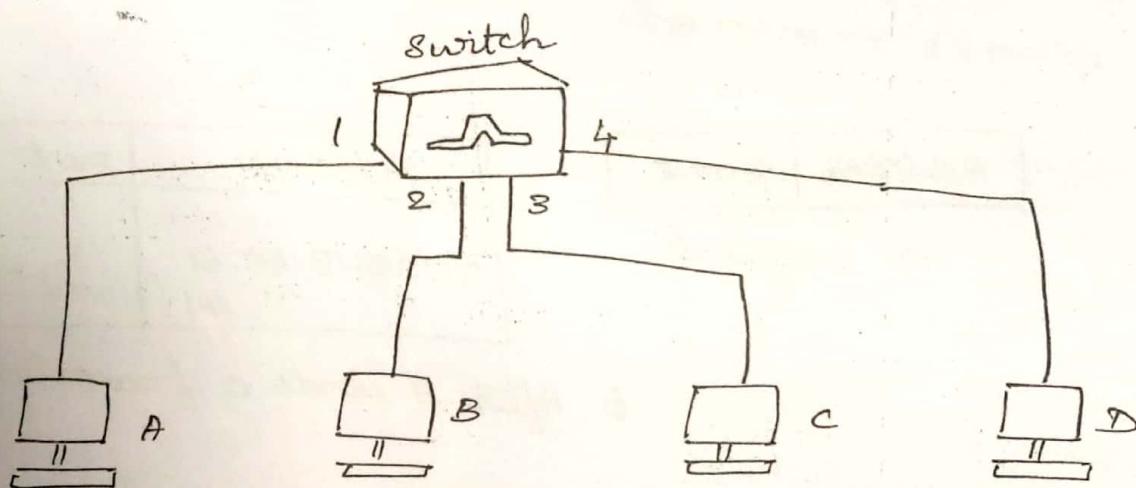
Q

Address	port
71:2B:1B:45:61:41	1
64:2B:1B:45:61:13	4
71:2B:1B:45:61:42	2

d. After B sends a frame to A.

Address	port
71:2B:1B:45:61:41	1
64:2B:1B:45:61:13	4
71:2B:1B:45:61:42	2
64:2B:1B:45:61:12	3

e. After C sends a frame to D.



71:2B:1B:45:
61:41

71:2B:1B:45:
61:42

64:2B:1B:45:
61:12 64:2B:1B:45:
61:13



(7)

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5) Routers:-

- * It is a device like a switch that routes data packets based on their IP addresses.
- * Router is a network layer device.
- * It connects LANs and WANs together and have a dynamically updating routing table-based on which they make decisions on routing the data packets.
- * Router divide broadcast domain of host connected through it.