LOGICAL ADDRESSING

IP address or global address is known as logical address. Different types of IP addresses are - IPv4 & IPv6.

IPv4 address (IP version 4 address)

→ It is 32 bit address or 4 byte address that uniquely and universally defines a device in a network or internetwork (Internet).

→ Size of address space -
An address space is total no. of IP addresses used by the protocol. If a protocol uses 'N' no. of bits for addressing then total no. of IP addresses generated N bits are 2^N.

⇒ Address space size = 2^N.

⇒ Address space contain 2^N no. of IP addresses.

IPv4 is 32 bits.

⇒ Address space size of IPv4 = 2^{32} = 4,294,967,296

→ Notation of IPv4
There are 2 different types of notation of IPv4. They are - (a) Binary Notation
(b) Dotted decimal Notation.

Binary Notation

In Binary Notation IPv4 address is represented by 32 bit & each octet is represented as a byte.

e.g -

1100 0010 0000 1111 1111 1010 01010101

Dotted Decimal Notation

In Dotted decimal notation IPv4 address is represented by decimal form with decimal point (dot) for separating byte.

e.g -

125. 255. 69. 03

→ Converting dotted decimal to Binary notation & viceversa –

(a) Dotted decimal to Binary –

Represent each decimal number by 8 bit. Or represent each decimal of section by 8 bit.

e.g – 128 · 11 · 3 · 31

1000 0000 00001011 00000011 00011111

(b) Binary Notation to dotted decimal –

Represent each octet or 8 bit as a decimal number & place a decimal point in between consecutive section.

e.g – 1000 0000 11111111 00010000 00001010

128 . 255 . 16 . 10

→ Types of Addressing –

There are 2 different types of addressing of IPv4. They are – (a) Classful addressing.
(b) Classless addressing.

Classful addressing

→ In classful addressing large part of available addresses were wasted.

Therefore classful addressing becomes obsolete & it is represented by the classless addressing.

→ In classful addressing the address space is divided into class. (CLASS A,
CLASS B,
CLASS C,
CLASS D,
CLASS E)

Classless addressing

→ To overcome the wastage of large addresses & address depletion & wastage there is use of classless addressing.

→ In classless addressing there is no concept of class but addresses are assigned in terms of Blocks or Block of address.

Classful addressing –

→ In classful addressing, address space is divided into 5 classes. They are,

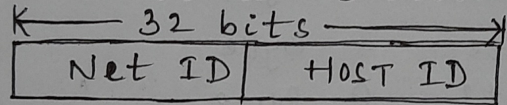
a) Class A
b) Class B
c) Class C
d) Class D
e) Class E

→ Class of address can be given either in binary or dotted decimal notation.

→ In Binary notation few bits of 1st byte specify class of an address.

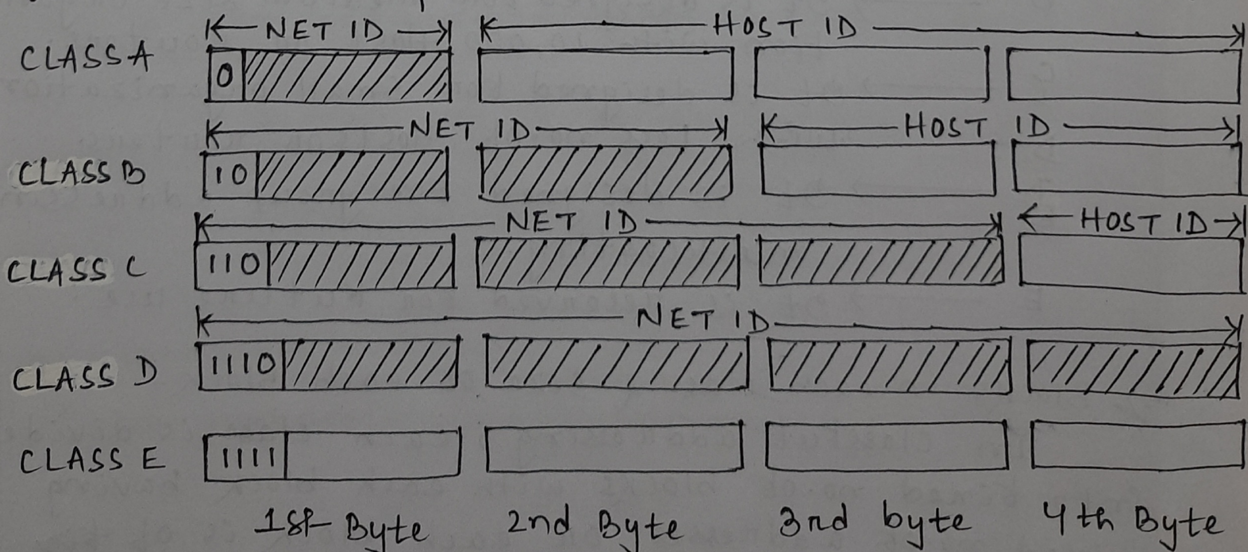
→ In Dotted decimal notation, 1st byte decimal value specify class of an address.

→ classful address is divided into two parts – Net ID & Host ID.



→ Length of Net ID & Host ID are of varying length depending on the class of address.

→ Net ID specify a network & Host ID specifies a host in the specified or identified network.



(Binary Notation of classes)

	1st Byte	2nd Byte	3rd Byte	4th Byte
CLASS A	← NET ID →	← HOST ID		→
	0 – 127			
CLASS B	← NET ID	→	← HOST ID	→
	128 – 191			
CLASS C	← NET ID		→	← HOST ID →
	192 – 223			
CLASS D	← NET ID			→
	224 – 239			
CLASS E	240 – 255			

(Dotted Decimal Notation of classes).

CLASSES	NET ID	HOST ID
A	1 Byte	3 Byte
B	2 Byte	2 Byte
C	3 Byte	1 Byte
D	4 Byte	0 Byte

CLASSES	APPLICATION
A	→ It is designed for large organization with Large no. of devices or host or routers.
B	→ It is designed for medium size organization with 10,000 Host or routers.
C	→ It is designed for Small organization with less no. of Hosts or routers.
D	→ It is designed for group addressing or multicasting.
E	→ It is reserved for future use.

→ Blocks in each class & size of each Block –

In classful addressing, each class is divided into fixed no. of blocks with each block having fixed no. of addresses or each block is of ~~fix~~ fixed size.

Block – Block contain no. of address in a ~~net~~ specified class of a network.

No. of Blocks in each class = No. of different networks in a specified class.

CLASS	No. of Blocks	Block size	Application
A	→ 128	→ 16,777,216	→ Unicast
B	→ 16,384	→ 65,536	→ Unicast
C	→ 2,097,152	→ 256	→ Unicast
D	→ 1	→ 268,435,456	→ Multicast
E	→ 1	→ 268,435,456	→ Reserved

How to calculate no. of Blocks & Block size?

CLASS	No. of Blocks (use Net ID field)	Block size (use HOST ID field)

A

No. of Blocks: [0|000 0000] ↓ [0|1111111]

Block size: [0000 0000] [00000000] [00000000] ↓ [11111111] [11111111] [11111111]

No. of Blocks = $2^7 = 128$

Block size = 2^{24} = 16,777,216

B

No. of Blocks: [10|000000] [0000 0000] ↓ [10|111111] [11111111]

Block size: [0000 0000] [0000 0000] ↓ [11111111] [11111111]

No. of Blocks = 2^{14} = 16,384

Block size = 2^{16} = 65,536

C

No. of Blocks: [110|00000] [0000 0000] [00000000] ↓ [110|11111] [11111111] [11111111]

Block size: [0000 0000] ↓ [11111111]

No. of Blocks = 2^{21} = 2,097,152

Block size = 2^8 = 256

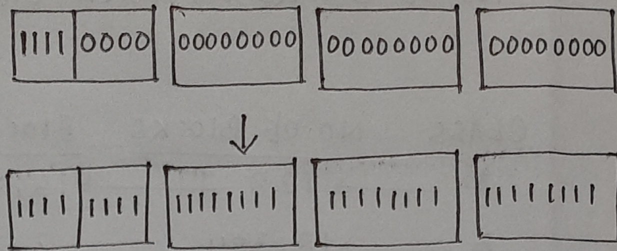
D

Each address in class D is used to specify or define one group of hosts.

[1110|0000] [00000000] [00000000] [00000000] ↓ [1110|1111] [11111111] [11111111] [11111111]

Block size = 2^{28} = 268,435,456

E Each address in class E is used to specify or define one group of hosts.



Block size = 2^{28}

= 268,435,456.

→ Mask (/n)

Mask is used to define Net ID & host ID. It is also otherwise known as default mask for ~~classful~~ Classful addressing.

A mask is of 32-bit long where contiguous 1's are followed by contiguous 0's.

Mask is represented by /n notation. This /n can also be applied to classless addressing also. Hence /n notation is known as classless interdomain routing (CIDR). The masking concept is not applied to class D & E.

CLASS	CIDR /n value	Mask address in Dotted decimal form	Mask address in Binary notation form
A →	/8 →	255.0.0.0 →	11111111 00000000 00000000 00000000
B →	/16 →	255.255.0.0 →	11111111 11111111 00000000 00000000
C →	/24 →	255.255.255.0 →	11111111 11111111 11111111 00000000

Masking concept provides two different types of concept. They are — Subnetting & Supernetting

Subnetting

→ If an organization is given a large block of addresses like block of class A & B, it could be divided into

Supernetting

→ If an organization require large block of addresses by using medium size block of address like block of C several groups & each group is assigned to smaller network & ~~thess~~ these small networks are called as subnet.

→ In subnetting several Class A & B blocks are divided into small blocks of class C address range. Therefore a large network is divided into several small network known as subnet.

then we use supernetting there.

→ In supernetting several networks are combined to create a supernetwork. Therefore in supernetting several class C blocks are combined to create a large block of address.

Drawback of classful addressing →

No. of Hosts or Routers in a network is less than address range of class A & B. And a class C block is too small for a midsize organization. Hence to solve the problem we go for classless addressing.

CLASSLESS ADDRESSING →

In classless addressing a block or range of address is given to an organization based on no. of hosts & routers in that organization.

This address range is given by an ISP. So to handle addressing scheme, Internet authorities given some restriction on classless address blocks. These ~~restri~~ ~~res~~ restrictions are,

1. Address in a block must be contiguous.
2. No. of address in a block must be power of 2.
3. First address of each block must be divisible evenly by no. of addresses.

e.g. – A block of 16 addresses

Block
205.16.37.32 (first address)
205.16.37.33
↓
205.16.37.47 (Last address)

No. of addresses in that block = 16 = 2^4

No. of addresses are contiguous.

First address 205.16.37.32 is divisible by 16.

(205.16.37.32 = 3,4440,387,360 in decimal form)

& 3,4440,387,360 is divisible by 16

⇒ The given block satisfy all the restriction of the classless addressing.

Mask –

→ In IPv4 classless addressing mask value is represented by notation x.y.z.t /n.

where x.y.z.t = one of the address of the block (any one IP address)

/n = Mask value.

→ In CIDR notation x.y.z.t /n, the leftmost 'n' bits are 1's & the right most (32-n) bits are 0's.

(a) First address of Block = It is found by setting right most (32-n) bits 0's.

(b) Last address of Block = It is found by setting right most (32-n) bits to 1's.

(c) No. of address in a Block = $2^{(32-n)}$

(d) Mask address of n/w = It is found by setting left most 'n' bits as 1's & right most (32-n) bit as 0's.

(e) IP address of network itself = 1st IP address of the Block.

e.g – A block of IP address is given to a small organi-zation & one of the IP address is 205.16.37.39/28 Now find out mask value, mask address, first & Last IP address of Block, total no. of IP address in Block & IP address of network.

Ans – One of the IP address of Block = 205.16.37.39/28

(a) Mask value = /n = /28.

(b) No. of IP address in Block = $2^{(32-n)} = 2^{(32-28)} = 2^4 = 16$

(c) Mask address = place 'n' no. of 1's from left most side & Place (32−n) no. of 0's from right most side.

255	255	255	240
11111111	11111111	11111111	11110000

= 255.255.255.240

← 28 no. of 1's from left most side →|← (32−28) no. of 0's from right most side. →

← 32 bit IP address →

(d) First & last IP address of Block

First IP address = set (32−n) bit 0's from right most side.

205.16.37.39

11001101 00010000 00100101 0010|0111

11001101 00010000 00100101 0010|0000 = 205.16.37.32

205 . 16 . 37 . 32

(e) Last IP address of Block = set (32−n) no. of 1's from right most side.

205.16.37.39

11001101 00010000 00100101 0010|0111

11001101 00010000 00100101 0010|1111 = 205.16.37.47

205 . 16 . 37 . 47

(f) IP address of n/w = first IP address of Block

So, IP address of n/w = 205.16.37.32

e.g - if an organization is assigned with a block of IP address & one of the IP address of the block is given as 250.8.15.30/15. Find out the mask value, mask address, no. of IP address, first & last IP address & IP address of n/w.

Ans -

(a) Mask value = /n = /15.

(b) No. of IP address in the Block $= 2^{(32-n)} = 2^{(32-15)}$

$= 2^{17}$ no. of

(c) Mask address =

$$\underbrace{\overbrace{11111111}^{255}\ \overbrace{1111111}^{254}}_{15\text{ bit }1\text{'s}}\underbrace{\overbrace{0}^{}\ \overbrace{00000000}^{0}\ \overbrace{00000000}^{0}}_{17\text{ bits }0\text{'s}} = 255.254.0.0$$

(d) First IP address

250.8.15.30

11111000 0000100|0 00001111 00011110

11111000 0000100|0 00000000 00000000 = 250.8.0.0

$\underline{11111000}_{250}$. $\underline{00001000}_{8}$. $\underline{00000000}_{0}$. $\underline{00000000}_{0}$

(e) Last IP address

250.8.15.30

11111000 0000100|0 00001111 00011110

11111000 0000100|1 11111111 11111111 = 250.9.255.255

$\underline{11111000}_{250}$ $\underline{00001001}_{9}$ $\underline{11111111}_{255}$ $\underline{11111111}_{255}$

(f) IP address of n/w = First IP address of Block

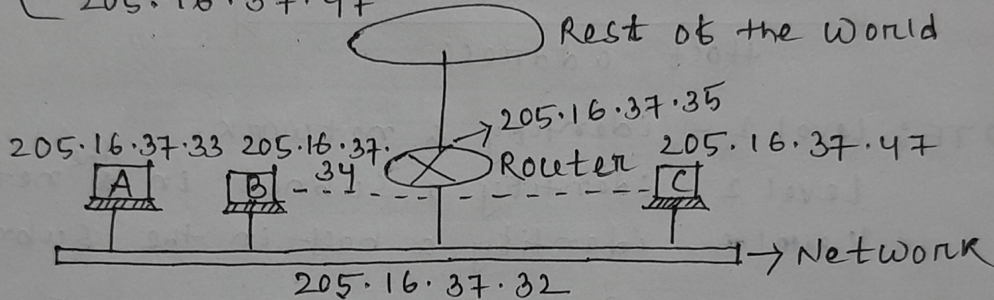
= 250.8.0.0

NETWORK ADDRESS

The first address in a block of IP address is not assigned to any device in the n/w rather it is the address of the network itself.

e.g- A block of IP address is given as-

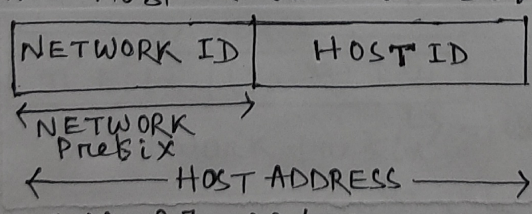
Block
- 205.16.37.32 → First IP address of Block assign to the n/w or used as n/w address
- 205.16.37.33
- 205.16.37.34
- ↓
- 205.16.37.47



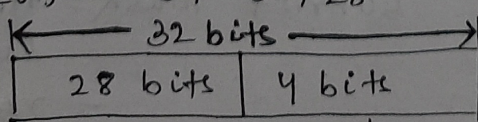
Different levels of hierarchy in network address-

1. Two-level hierarchy.
2. Three-level hierarchy.
3. Multi level hierarchy.

1. <u>Two level hierarchy</u> → In two level hierarchy there is no subnetting i.e: left most 'n' bits known as prefix define the network & the right most (32-n) bits define the host known as suffix.



e.g- 205.16.37.32/28



↳ Define network

↳ Define host in that network.

NOTE: Level 1 - identify a network.

Level 2 - identify a host in a network.

2. <u>Three level hierarchy</u> → In three level hierarchy there is subnetting that is a large block of IP address is divided into several small blocks of address or divide the large block of addresses into no. of subnets.

Network ID	Subnet ID	Host ID

Network Prefix

Subnet prefix

Host address

NOTE: Level 1 - identify a network.
Level 2 - identify a subnet in the network.
Level 3 - identify a host in the subnet.

e.g - An organization is given the block 17.12.14.0/26 which contain 64 addresses. The organization contain 3 offices & need to divide the address in 3 sublocks of 32, 16, 16 address.

Ans :- One of given IP address is 17.12.14.0/26. so /n = /26.

Subnet 1 = 32 addresses = 2^5

⇒ Host ID for Subnet 1 is = 5 bits

⇒ Three level hierarchy for subnet 1 is,

25 bits	2 bit	5 bits
network ID	subnet ID	Host ID

Hence for Subnet 1, network mask = Network ID = 25 bit,
Subnet mask = network ID + Subnet ID
= 25 + 2
= 27 bits.

Subnet 2 = 16 addresses = 2^4

⇒ Host ID for Subnet 2 is = 4 bits.

⇒ Three level hierarchy for subnet 2 is,

26 bits	2 bits	4 bits
Network ID	Subnet ID	Host ID

Hence for subnet 2,

Network mask = network ID = 26 bits.

Subnet mask = network ID + Subnet ID

= 26 + 2

= 28 bits.

Subnet 3 = 16 addresses = 2^4

⇒ Host ID for Subnet 3 = 4 bits.

⇒ Three level hierarchy for subnet 3 is,

26 bits	2 bits	4 bits
Network ID	Subnet ID	Host ID

Hence for subnet 3,

Network Mask value = Network ID = 26 bits.

Subnet Mask value = Network ID + Subnet ID

= 26 + 2

= 28 bits.

Now, we find out the first address & last address of each subnet.

Subnet 1

17.12.14.0/27

00010001 00001100 00001110 000|00000

00010001 00001100 00001110 000|00000 → First IP address is 17.12.14.0

17 . 12 . 14 . 0

00010001 00001100 00001110 000|11111 → Last IP address is 17.12.14.31

17 . 12 . 14 . 31

Subnet 2

Next subnet or subnet 2 begins with the next IP address i.e: 17.12.14.32 because of restriction of classless IP address - IP address in a block must be contiguous.

17.12.14.32 /28

00010001 00001100 00001110 0010|0000

00010001 00001100 00001110 0010|0000 → First address is, 17.12.14.32

00010001 00001100 00001110 0010|1111 → 17.12.14.47 is last IP address

Subnet 3

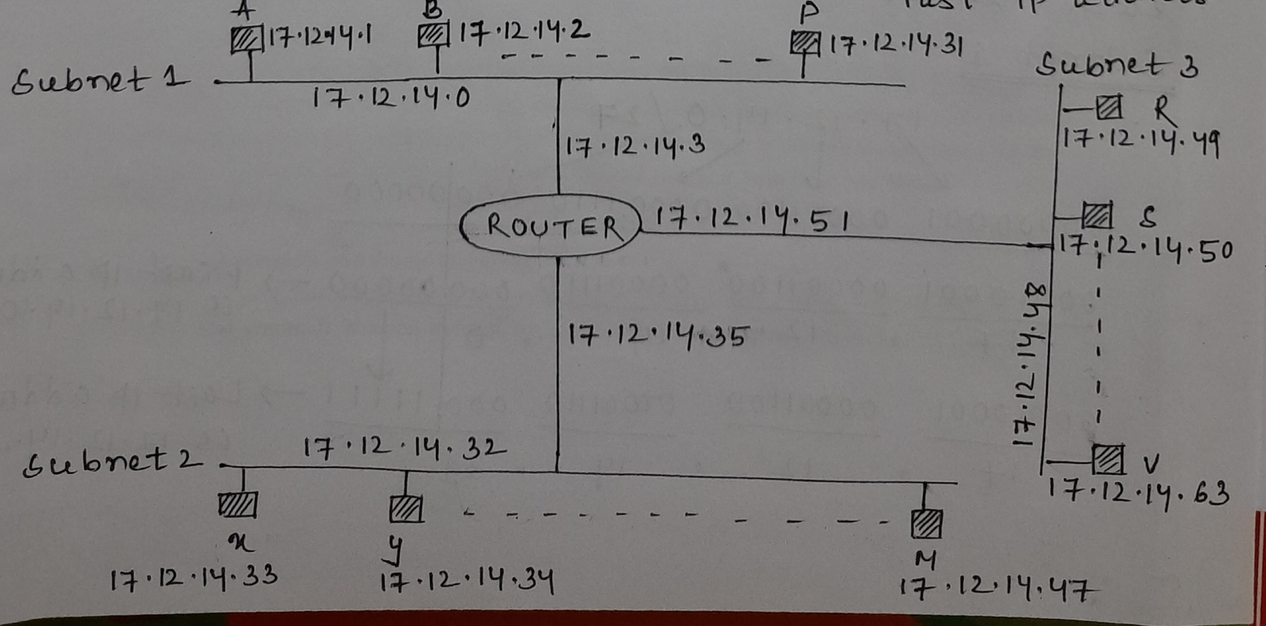
Next subnet or subnet 3 begins with the next IP address i.e: 17.12.14.48 because the addresses in a block must be contiguous in a block of classless address.

17.12.14.48 /28

00010001 00001100 00001110 0011|0000

00010001 00001100 00001110 0011|0000 → First IP address is, 17.12.14.48

00010001 00001100 00001110 0011|1111 → 17.12.14.63 is last IP address.



ADDRESS Aggregation → Assigning large block of IP address to an ISP & then each ISP divides its assigned block of IP address into smaller subblocks & grant each of the subblocks to customers or small organization. This is called address aggregation where many blocks of address are aggregated into one block & granted to an ISP.

e.g – An ISP is granted a block of address starting with 190.100.0.0/16. The ISP need to distribute these addresses 3 groups of customers. Find out the IP address range of each group.

(a) 1st group has 64 customers; each need 256 IP address.

(b) 2nd group has 128 customers; each need 128 IP address.

(c) 3rd group has 128 customers; each need 64 IP address.

Design the subblocks & how many addresses in each subblocks.

Ans:–

1st group has 64 customers & each customer has 128 IP address.

⇒ To identify each customer no. of bits required is = 6 bits ($2^6 = 64$)

⇒ To identify each host in a customer no. of bits required = 8 bits ($\because 2^8 = 256$)

Now, 32 bits pattern in 1st group is,

18 bits	6 bits	8 bits
Network	subnet	Host

← 32 bits →

Now, generate address range for subblocks or subnets for 1st group -

190.100.0.0 /18

	10111110 10001100 00	000000	00000000
Customer 1	10111110 10001100 00	000000	0000 0000 → 190.100.0.0
			↓
			1111 1111 → 190.100.0.255
Customer 2	10111110 10001100 00	000001	0000 0000 → 190.100.1.0
			↓
			1111 1111 → 190.100.1.255
Customer 3	10111110 10001100 00	000010	0000 0000 → 190.100.2.0
			↓
			1111 1111 → 190.100.2.255
↓	↓	↓	↓
Customer 64	10111110 10001100 00	111111	0000 0000 → 190.100.63.0
			↓
			1111 1111 → 190.100.63.255

2ND group has 128 Customers & each customers has 128 IP address.

⇒ To identify each customer no. of bits required is $= 7$ bits $(\because 128 = 2^7)$

⇒ To identify each host in a customer no. of bits required $= 7$ bits $(\because 2^7 = 128)$

Now, 32-bits pattern of 2nd group is,

18 bits	7 bits	7 bits
Network	Subnet	Host

← 32-bits →

2ND group starts with IP address 190.100.64.0.
Now generate address range of each subnets of the 2ND group-

190.100.64.0/18

10111110 10001100 01 000000 0 0000000

Customer 1 10111110 10001100 01 000000 0 0000000 → 190.100.64.0

↓

1111111 → 190.100.64.127

Customer 2 10111110 10001100 01 000000 1 0000000 → 190.100.64.128

↓

1111111 → 190.100.64.255

Customer 3 10111110 10001100 01 000001 0 0000000 → 190.100.65.0

↓

1111111 → 190.100.65.127

↓ ↓ ↓

Customer 128 10111110 10001100 01 111111 1 0000000 → 190.100.127.128

↓

1111111 → 190.100.127.255

3RD group has 128 customers & each customer has 64 no. of IP addresses.

⇒ To identify each customer no. of bits required is $= 7$ bits ($\because 2^7 = 128$)

⇒ To identify each host in a customer no. of bits required $= 6$ bits ($\because 2^6 = 64$)

Now, 32 bit pattern of 3RD group of address is,

19 bits	7 bits	6 bits
Network	Subnet	Host

← 32 bits →

3RD group starts with IP address 190.100.128.0. Now, generate IP address range of each subnets for 3RD group. Therefore, IP address range of different subnets of 3RD group is as follows –

190.100.128.0/19

	10111110 10001100 100	00000 00	000000	
Customer 1	10111110 10001100 100	00000 00	000000	→ 190.100.128.0
			↓ 111111	→ 190.100.128.63
Customer 2	10111110 10001100 100	00000 01	000000	→ 190.100.128.64
			↓ 111111	→ 190.100.128.127
Customer 3	10111110 10001100 100	00000 10	000000	→ 190.100.128.128
			↓ 111111	→ 190.100.128.191
Customer 4	10111110 10001100 100	00000 11	000000	→ 190.100.128.192
			↓ 111111	→ 190.100.128.255
↓	↓	↓	↓	
Customer 128	10111110 10001100 100	11111 11	000000	→ 190.100.159.192
			↓ 111111	→ 190.100.159.255

—o—

IPV6 ADDRESS (IP Version 6 ADDRESS)

→ It is 16 byte or 128 bit IP address.

→ It is represented by hexadecimal notation.

→ IPV6 16 byte address consists of 8 sections with each section consist of 2 byte that contain 4 hexadecimal digits and in between consecutive section there is a colon (:)

→ e.g- ABC0 : FFFB : 1235 : 0000 : CD00 : A0B1 : 1100 : 5582

→ IPV6 address can also be abbriviated as if there are many no. of 0's. Only the Leading 0's can be dropped but not the trailing 0's.

e.g - ABCD : 00FF : 0000 : 0000 : 0000 : B0FF : 0011 : AB13

↓ Abbreviated

ABCD : 00FF : 0 : 0 : 0 : B0FF : 0011 : AB13

↓ Abbreviated

ABCD : 00FF : : B0FF : 0011 : AB13

↓ Abbreviated

ABCD : FF : : B0FF : 11 : AB13

e.g - Expand the address of IPv6 given as,

0 : 15 : : 12 : 1 : 1213

0000 : 0015 : 0000 : 0000 : 0000 : 0012 : 0001 : 1213

→ Address space size of IPv6 is 2^{128}. Address space means total no. of IP addresses available in IPv6 by using 128 bits address is 2^{128}.

<u>Types of IPv6 address</u> →

a. Unicast address
b. Multicast address
c. Anycast address
d. Reserved address
e. Local address.

(a) <u>Unicast address</u> - It defines a single computer or Host in a network. It is of two types - geographical based & provider based. Basically we are using provider based.

Provider based unicast address format,

3	5	Provider identifier	Subscriber identifier	Subnet identifier	Node identifier

↳ Registry identifier

→ Type identifier

Type - It defines IPv6 address as a provider based address. It is 3 bit long.

Registry - It defines the agency that has registered the address. It is 5 bit Long.

Provider identifier - It defines the ISP or provider of internet services. It is of variable length or if it is fixed length then it is 16 bits.

Subscriber identifier - It defines the organization that subscribes Internet. It is of variable length or 24 bit (recomended).

Subnet identifier - It defines a specific subnet under the subscriber. It is also variable length or 32 bits (recomended)

Node identifier - It defines the node or host or device in the specified subnet. It is of 48 bit Length.

(b) Multicast address → It defines a group of hosts i.e: a packet having multicast address must be delivered to each member of the group.

Multicast address format - -

11111111	FLAG	SCOPE	GROUP ID
8 bits	4 bits	4 bits	112 bits

8 bits → This 8 bit shows that it is a multicast IPv6 address

FLAG → Flag field defines the group address. A group can be either Permanent or temporary.

If Flag = 0000, it is a permanent group.

If Flag = 0001, it is a temporary group.

[A permanent group can be accessed all the times but a temporary group can not be accessed all the times.]

SCOPE → Scope can be global, local, reserved etc.

GROUP ID → It defines a multicast group.

(c) Anycast address → It is like multicast address but the difference is, a packet destined for an anycast address is delivered to only one of the member of the anycast group which is nearest one. (One with shortest route).

Hence anycast address are given to all the Routers of an ISP.

(d) Reserve address → This address starts with 8 0's. (00000000). There are different types of reserved address. They are,

- Unspecified address
- Loopback address
- Compatible address
- Mapped address.

Unspecified address - It is used when a host doesnot know its own IPV6 address & send an inquiry to find its own address. The ~~exq~~ inquiry message is send by using unspecified address.

Unspecified address format--

00000000	00-----------0
8 bits	120 bits

Loopback Address - It is used by a host to test itself without going into network. It is used before data transmission to check itself.

Loopback address format--

00000000	00-------01
8 bits	120 bits

Compatible address - It is used during transition from IPV4 to IPV6 & IPV6 to IPV4. It is used when a computer using IPV6 wants to send a message to another computer using IPV6 but the message need to pass through a network that still operates in IPV4.

Compatible address format -

00000000	000----------00	IPV4
8 bits	88 bits	32 bits

Mapped Address – It is also used when a computer or host need transition. i.e: if a host now migrated to IPv6 but wants to use IPv4 address to send a packet to a computer still using IPv4.

Mapped Address format--

00000000	00------0	111----1	IPv4
8 bits	72 bits	16 bits	32 bits

(e) Local Address → Local address provides address of private network. There are two types of local address. They are → Link Local address.
→ Site Local address.

Link Local address – It is used for an isolated subnet. Address format of Link Local,

1111111010	00------0	NODE ADDRESS
10 bits	70 bits	48 bits

Site Local address – It is used for an isolated site with several subnets.

1111111011	00----0	SUBNET ADDRESS	NODE ADDRESS
10 bits	38 bits	32 bits	48 bits