IPV4 ADDRESSES

- The Internet Protocol addresses are 32 bits in length; this gives us a maximum of 2^{32} addresses. These addresses are referred to as IPv4 (IP version 4) addresses or simply IP addresses if there is no confusion.
- This means that, theoretically, if there were no restrictions, more than 4 billion (4,29,49,67,296) devices could be connected to the Internet. The actual number is much less because of the restrictions imposed on the addresses.
- The need for more addresses, in addition to other concerns about the IP layer, motivated a new design of the IP layer called the new generation of IP or IPv6 (lP version 6). In this version, the Internet uses 128-bit addresses that give much greater flexibility in address allocation ($3.4 * 10^{38}$). These addresses are referred to as IPv6 (IP version 6) addresses.

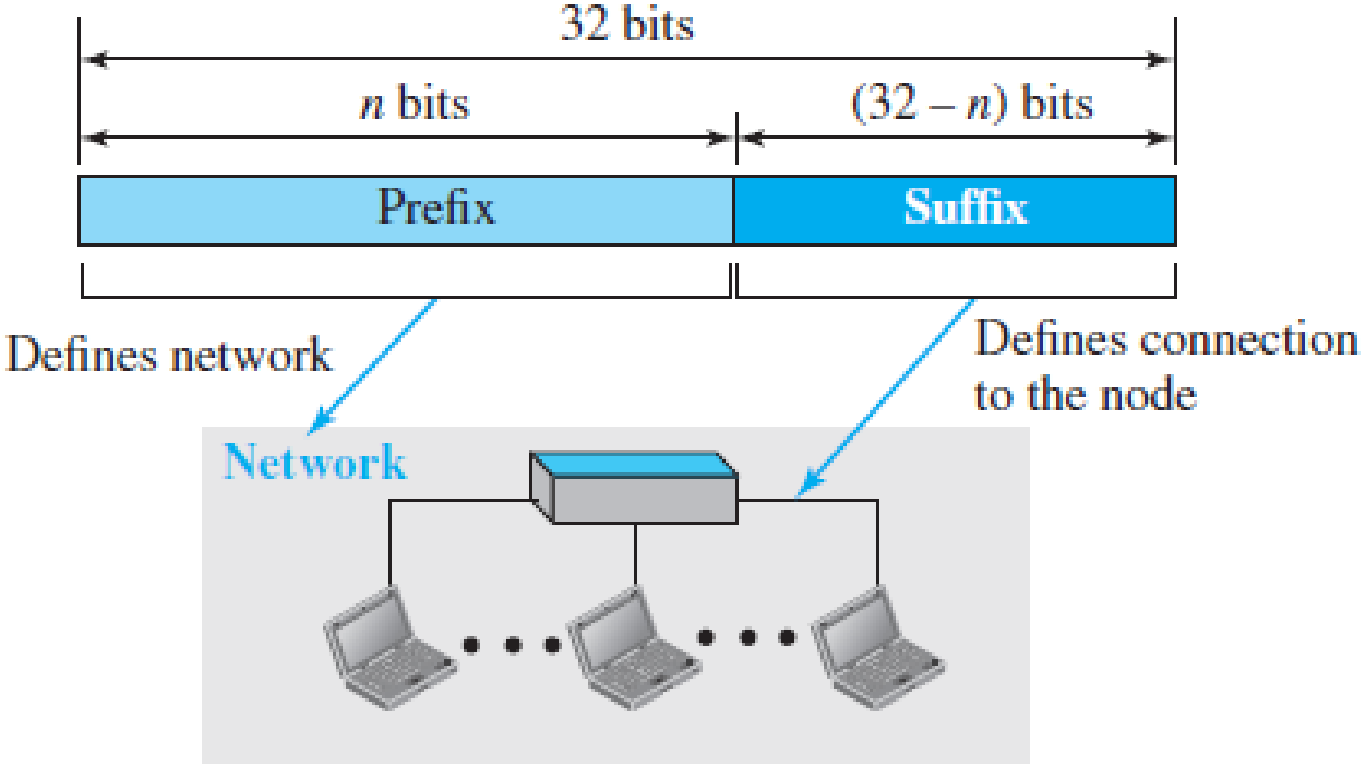
- An IP address is uniquely and universally defining the connection of a host or a router to the Internet.
- They are unique in the sense that each address defines one, and only one, connection to the Internet. Two devices on the Internet can never have the same address at the same time.
- The IPv4 addresses are universal in the sense that the addressing system must be accepted by any host that wants to be connected to the Internet.
- The IP address is the address of the connection, not the host or the router, because if the device is moved to another network, the IP address may be changed.

Notations

- There are two prevalent notations to show an IPv4 address: binary notation and dotted decimal notation.
- **Binary Notation** - In binary notation, the IPv4 address is displayed as 32 bits. Each octet is often referred to as a byte. So, it is common to hear an IPv4 address referred to as a 32-bit address or a 4-byte address. An example of an IPv4 address in binary notation: 01110101 10010101 00011101 00000010
- **Dotted-Decimal Notation** - To make the IPv4 address more compact and easier to read, Internet addresses are usually written in decimal form with a decimal point (dot) separating the bytes. The following is the dotted decimal notation of the above address: 117.149.29.2

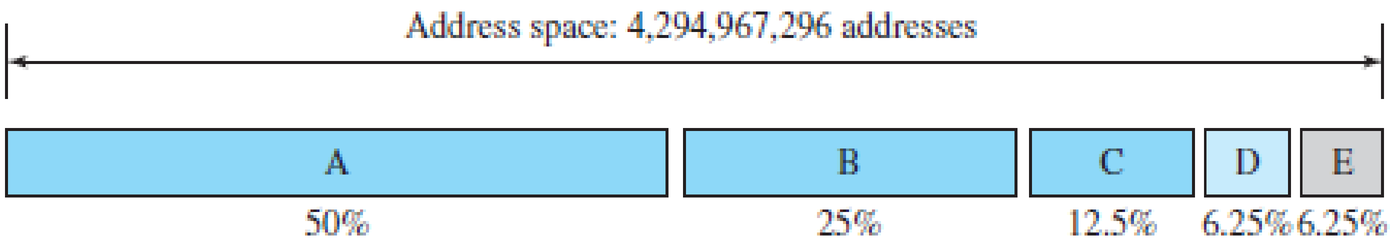
Classful Addressing

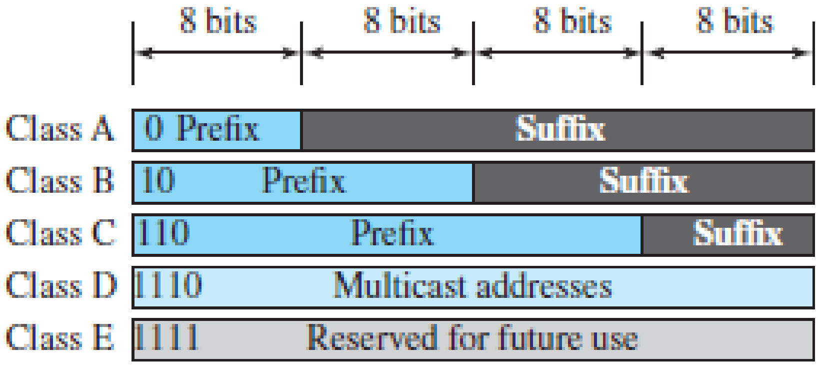
- IPv4 addressing, at its inception, used the concept of classes. This architecture is called classful addressing.
- A 32-bit IPv4 address is hierarchical and divided only into two parts:
- The first part of the address, called the *prefix*, defines the network (NetworkID).
- The second part of the address, called the *suffix*, defines the node (connection of a device to the Internet (HostID)).
- The prefix length is n bits and the suffix length is (32 − n) bits.



- A prefix can be fixed length or variable length.
- IPv4 was first designed as a fixed-length prefix and is referred to as classful addressing,
- In classful addressing, the address space is divided into five classes: A, B, C, D, and E. Each class occupies some part of the address space.
- Now-a-days it has become obsolete because of many problems, now the new scheme referred to as classless addressing, uses a variable-length network prefix.

- To accommodate both small and large networks, three fixed-length prefixes were designed (n = 8, n = 16, and 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.

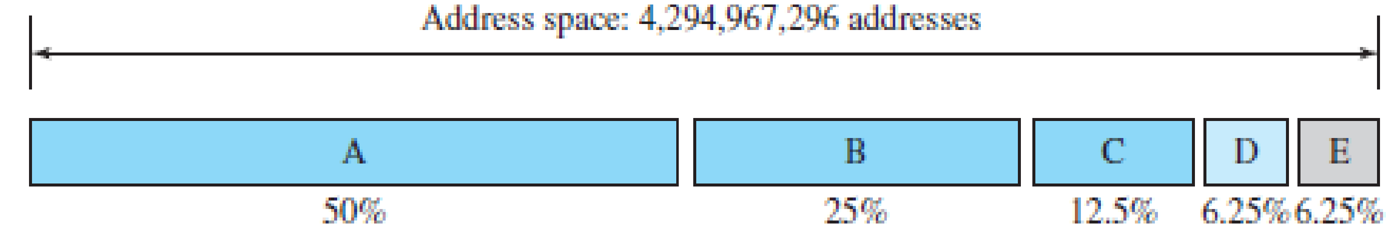


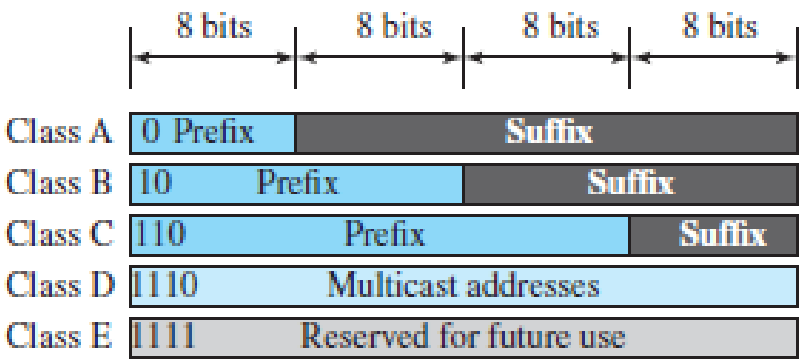


Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Class A

- In Class A NetID = 8 bits and HostID = 24.
- How to identify class A address
    - First bit is reserved to 0 in binary notation
    - Range of 1st octet is [0, 127] in dotted decimal notation
- Total number of connections in class A is 2^{31} (2,14,74,83,648)
- There are 2^7 -2 = 126 networks in Class A network.
    - In Class A, total network available are 2 less, because:
    - IP Address 0.0.0.0 is reserved for broadcasting requirements
    - IP Address 127.0.0.1 is reserved for loopback address used for software testing.
    - The range of 1st octet is [0, 127] but since two addresses are reserved it is: [1, 126].
- There are 2^{24} – 2 (1,67,77,214) HostID in Class A.
    - In all the classes, total number of hosts that can be configured are 2 less because:
    - This is to account for the two reserved IP addresses in which all the bits for host ID are either zero or one.
    - When all Host ID bits are 0, it represents the Network ID for the network.
    - When all Host ID bits are 1, it represents the Broadcast Address.
- Class A is used by organizations requiring very large size networks like Indian Railways.

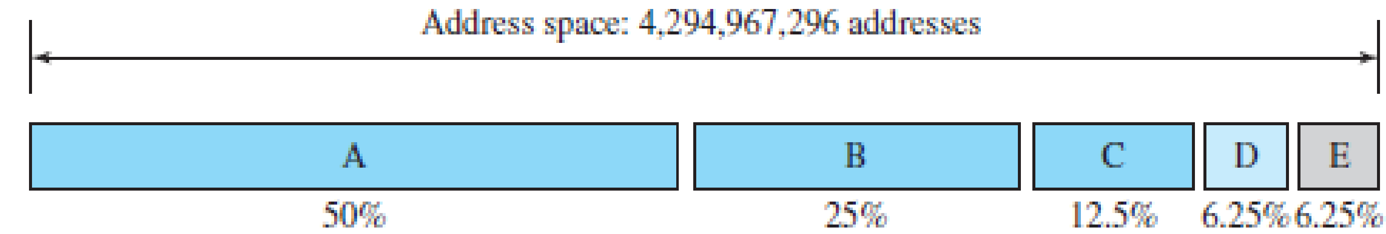


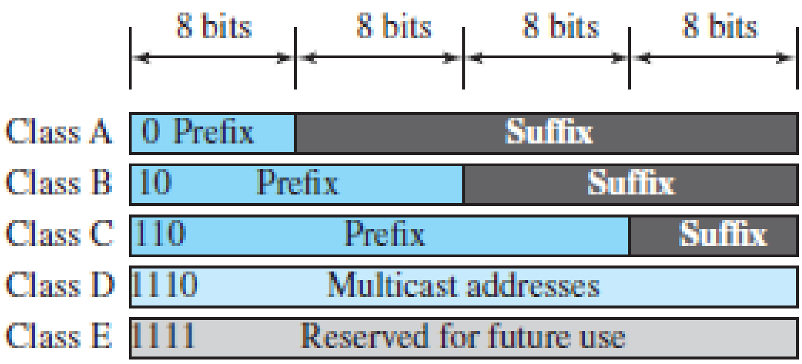


Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Class B

- In Class B NetID = 16 bits and HostID = 16.
- How to identify class B address
  - First two bits are reserved to 10 in binary notation
  - Range of 1^{st} octet is [128, 191] in dotted decimal notation
- Total number of connections in class B is 2^{30} (1,07,37,41,824)
- Total number of networks available in class B is 2^{14} (16,384)
- Total number of hosts that can be configured in every network in class B is $2^{16} - 2$ (65,534)
- Class B is used by organizations requiring medium size networks

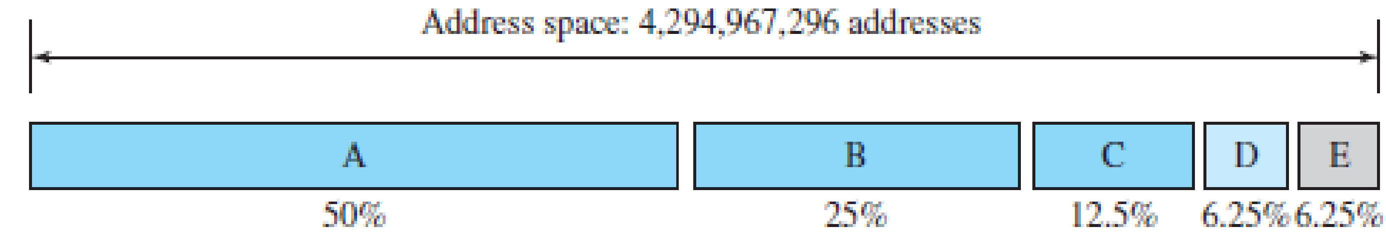


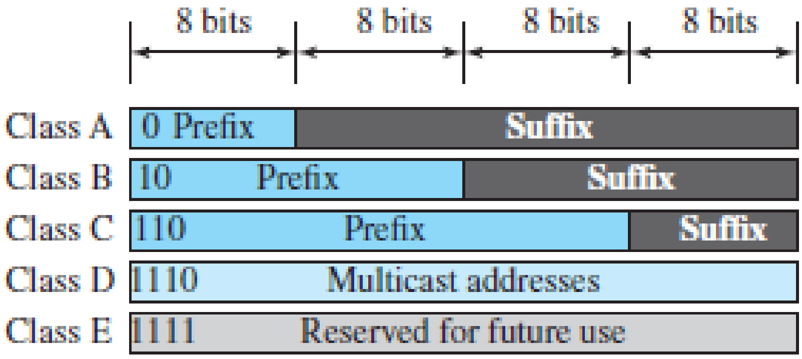


Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Class C

- In Class C NetID = 24 bits and HostID = 8.
- How to identify class C address
  - First three bits are reserved to 110 in binary notation
  - Range of 1st octet is [192, 223] in dotted decimal notation
- Total number of connections in class C is 2^{29} (53,68,70,912)
- Total number of networks available in class C is 2^{21} (20,97,152)
- Total number of hosts that can be configured in every network in class C is $2^8 – 2$ (254)
- Class C is used by organizations requiring small to medium size networks.





Class	Prefixes	First byte
A	$n = 8$ bits	0 to 127
B	$n = 16$ bits	128 to 191
C	$n = 24$ bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

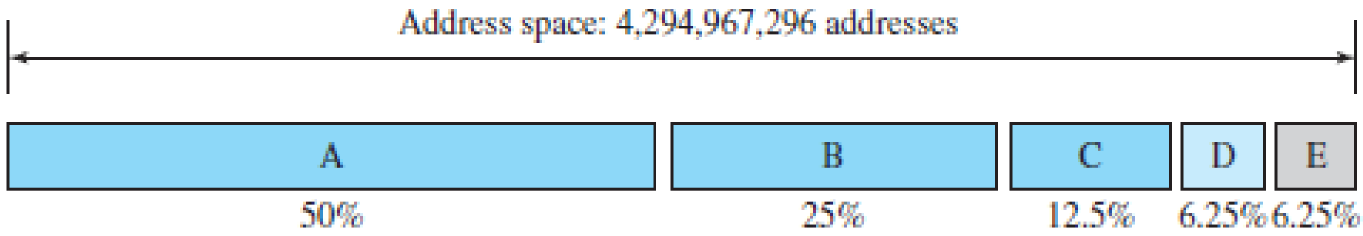
Q In the IPv4 addressing format, the number of networks allowed under Class C addresses is **(Gate-2012) (1 Marks)**

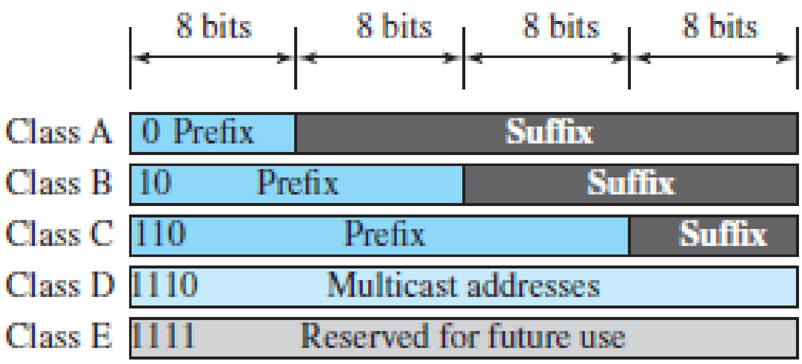
(A) 2^{14} **(B)** 2^{7} **(C)** 2^{21} **(D)** 2^{24}

Answer: (C)

Class D

- Class D is not divided into Network ID and Host ID.
- How to identify class D address
  - First four bits are reserved to 1110 in binary notation
  - Range of 1st octet is [224, 239] in dotted decimal notation
- Total number of IP Addresses available in class D = 2^{28} (26,84,35,456)
- Class D is reserved for multicasting, in multicasting, there is no need to extract host address from the IP Address, this is because data is not destined for a particular host.

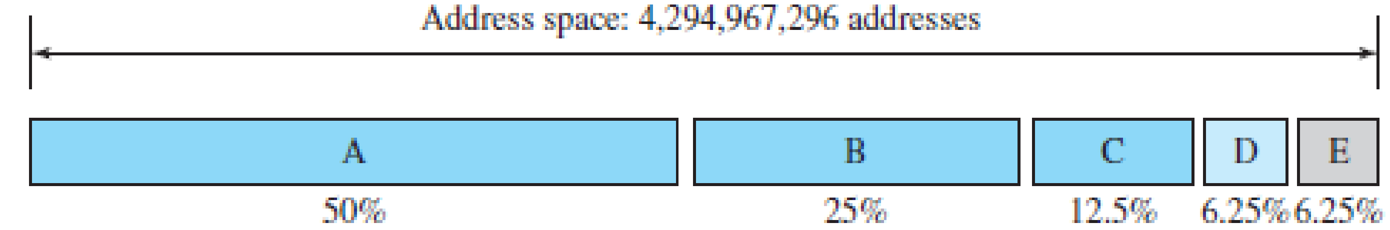


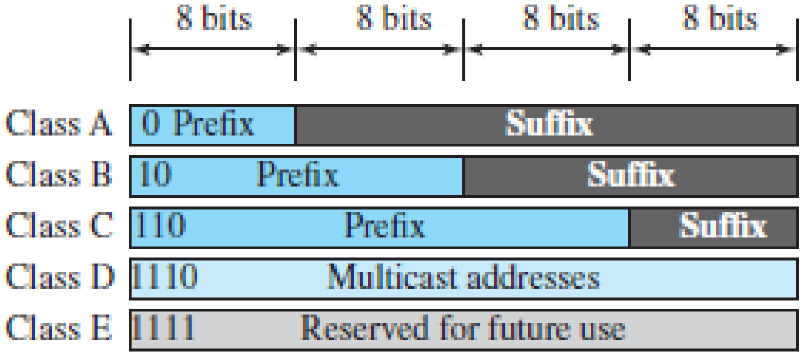


Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Class E

- Class E is not divided into Network ID and Host ID.
  - How to identify class E address
    - First four bits are reserved to 1111 in binary notation
    - Range of 1st octet is [240, 255] in dotted decimal notation
- If the 32-bit binary address starts with bits 1111, then IP Address belongs to class E.
- Range of 1st octet = [240, 255]
- Total number of IP Addresses available in class E = 2^{28} (26,84,35,456)
- Class E is reserved for future or experimental purposes.





Class	Prefixes	First byte
A	$n = 8$ bits	0 to 127
B	$n = 16$ bits	128 to 191
C	$n = 24$ bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Points to note

- All the hosts in a single network always have the same network ID but different Host ID.
- Two hosts in two different networks can have the same host ID.
- Only those devices which have the network layer will have IP Address, switches, hubs and repeaters does not have any IP Address.

Q If the IP address of the system 63.12.11.13 to which class it belongs to?

Q if the IP address of a system is 36.11.119.14 calculate the net id, directed broadcast add, first and last add?

Q if the IP address of a system is 141.119.89.63 calculate the net id, directed broadcast add, first and last add?

Q if the IP address of a system is 23.19.18.17 calculate the net id, directed broadcast add, first and last add?

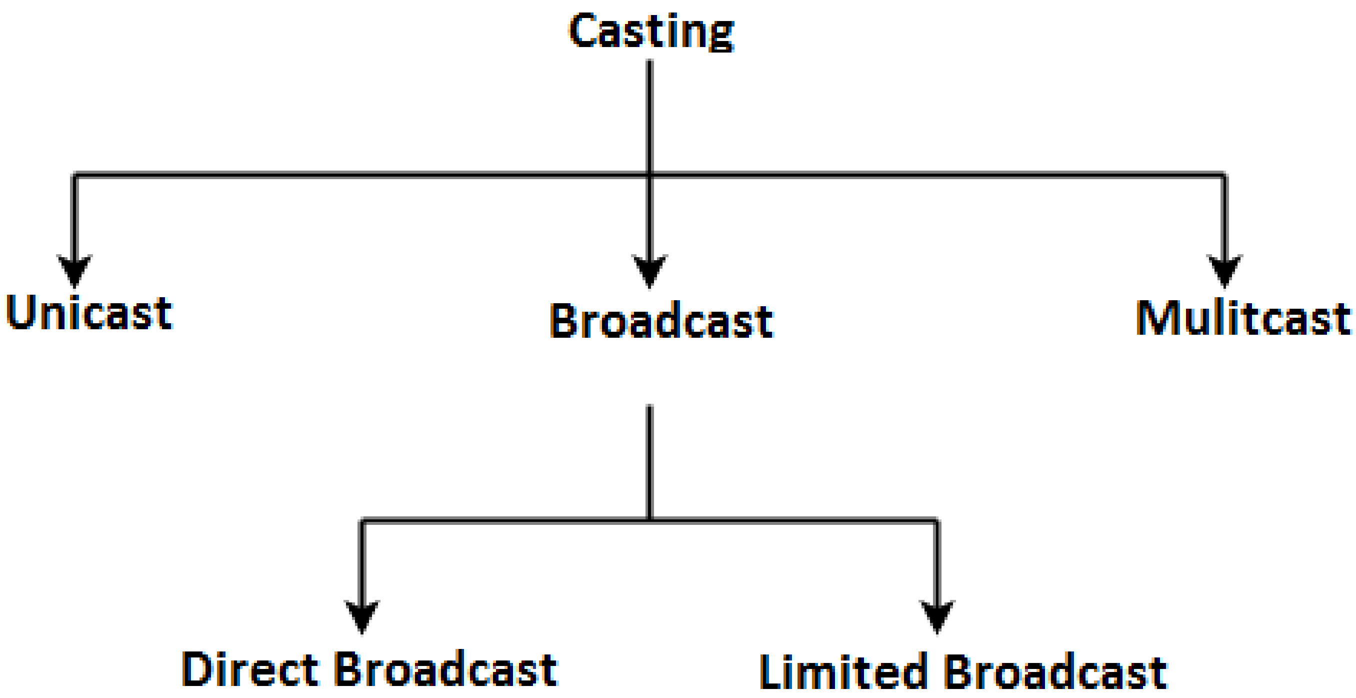
Q if the IP address of a system is 131.86.17.18 calculate the net id, directed broadcast add, first and last add?

Q if the IP address of a system is 97.15.21.16 calculate the net id, directed broadcast add, first and last add?

Casting in Networks

Types of Casting

- Casting in a network is basically of three type: Unicast, Multicast and Broadcast.

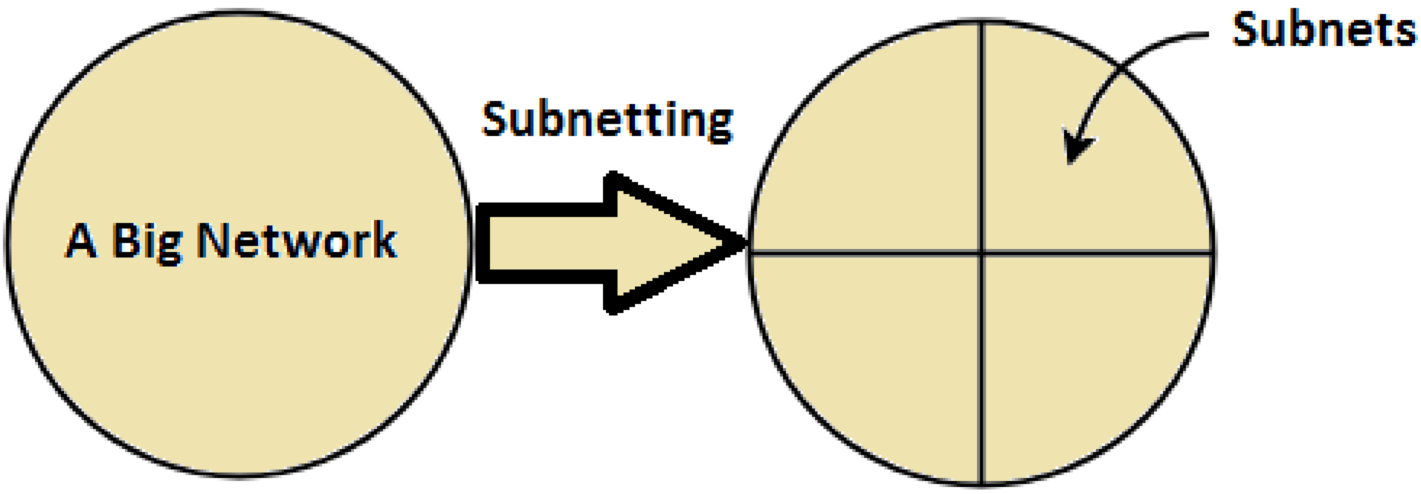


- **Unicast**: Transmitting data from one source host to one destination host is called as **unicast**. It is a one to one transmission.

- **Broadcast:** Transmitting data from one source host to all other hosts residing in a network either same or other network is called as **broadcast**. It is a one to all transmission.
    - **Limited Broadcast**: Transmitting data from one source host to all other hosts residing in the same network is called as limited broadcast. Limited Broadcast Address for any network is
        - All 32 bits set to 1 = 11111111.11111111.11111111.11111111 = 255.255.255.255
    - **Direct Broadcast**: Transmitting data from one source host to all other hosts residing in some other network is called as direct broadcast.
        - Direct Broadcast Address for any network is the IP Address where, Network ID is the IP Address of the network where all the destination hosts are present and Host ID bits are all set to 1.
- **Multicast**: Transmitting data from one source host to a particular group of hosts having interest in receiving the data is called as multicast. It is a one to many transmissions.

Subnetting

- Maintenance of a very big network like class A and class B is very difficult for network administrator.
- Having all the computer from different departments in a company on the same networks is less secure from company prospective.
- So, if an organization was granted a large block in class A or B, it could divide the addresses into several contiguous groups and assign each group to smaller networks (called subnets) or, in rare cases, share part of the addresses with neighbours.
- **Conclusion:** An organization (or an ISP) that is granted a range of addresses may divide the range into several subranges and assign each subrange to a subnetwork (or subnet). A subnetwork can be divided into several sub-subnetworks. A sub-subnetwork can be divided into several sub-sub-subnetworks, and so on.



Advantages

- It improves the security.
- The maintenance and administration of subnets is easy.

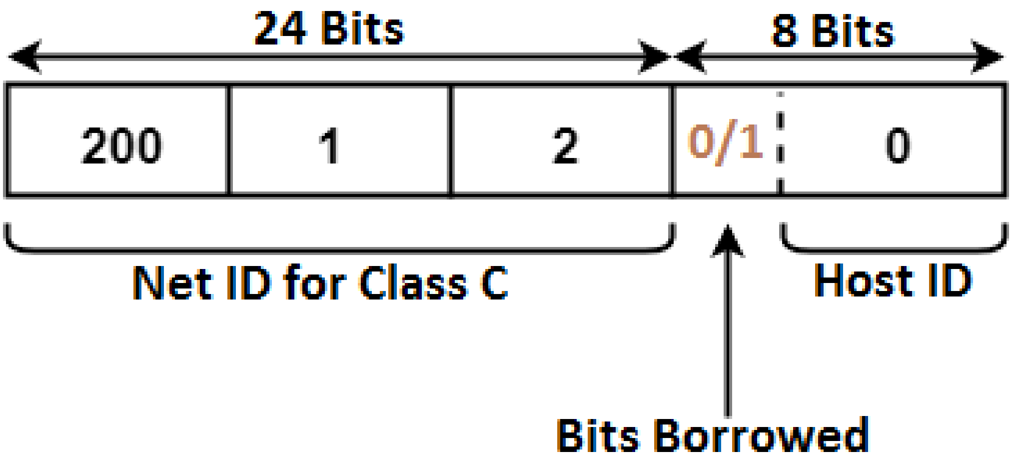
Disadvantages

- Identification of a station is difficult
- Not possible to directed broadcast from outside network.
- 2 IP addresses are waisted in every subnet

Example 1. Consider the network having IP Address 200.1.2.0. Divide this network into two subnets.

Now, since the given class of IP address belong to class C. To design two subnets and to represent their subnet IDs, we require 1 bit.

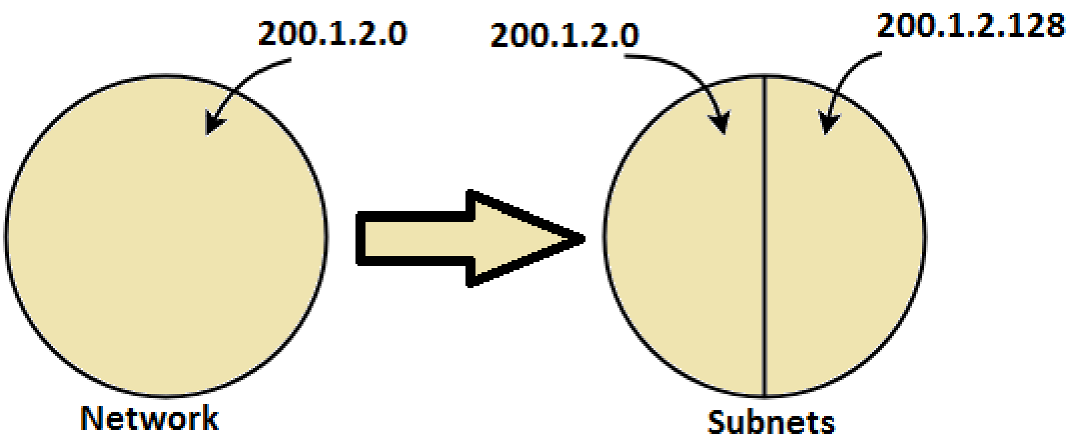
- We borrow one bit from the Host ID part.
- Now, Host ID part remains with only 7 bits.



- If borrowed bit is 0, it represents the first subnet. If borrowed bit is 1, it represents the second subnet.

Network Address of the two subnets will be represented as:

- 200.1.2.**0**0000000 = 200.1.2.0 (When borrowed bit is 0)
- 200.1.2.**1**0000000 = 200.1.2.128 (When borrowed bit is 1)



1st Subnet

- IP Address of the subnet / Subnet id = 200.1.2.0
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.01111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

2nd Subnet

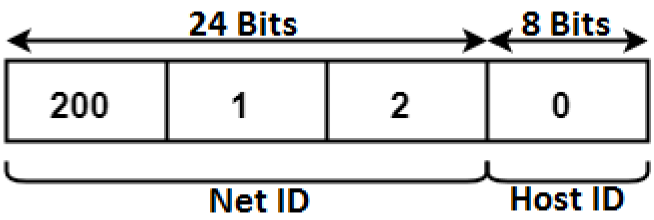
- IP Address of the subnet / Subnet id = 200.1.2.128
- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.128, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.11111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Subnet ID

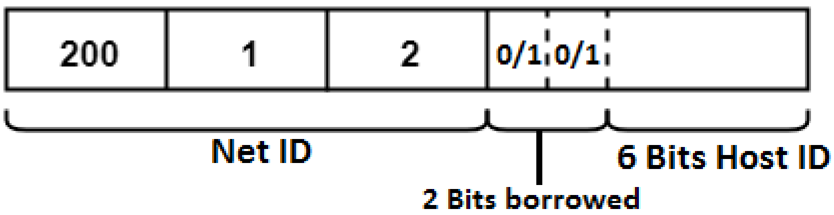
- Each subnet has its unique network address known as its Subnet ID.
- The subnet ID is created by borrowing some bits from the Host ID part of the IP Address.
- The number of bits borrowed depends on the number of subnets created.
- Subnetting increases the number of I's in the mask

Example 2: Consider we have a big single network having IP Address 200.1.2.0. We want to do subnetting and divide this network into 4 subnets.

The IP address is clearly in Class C Network.



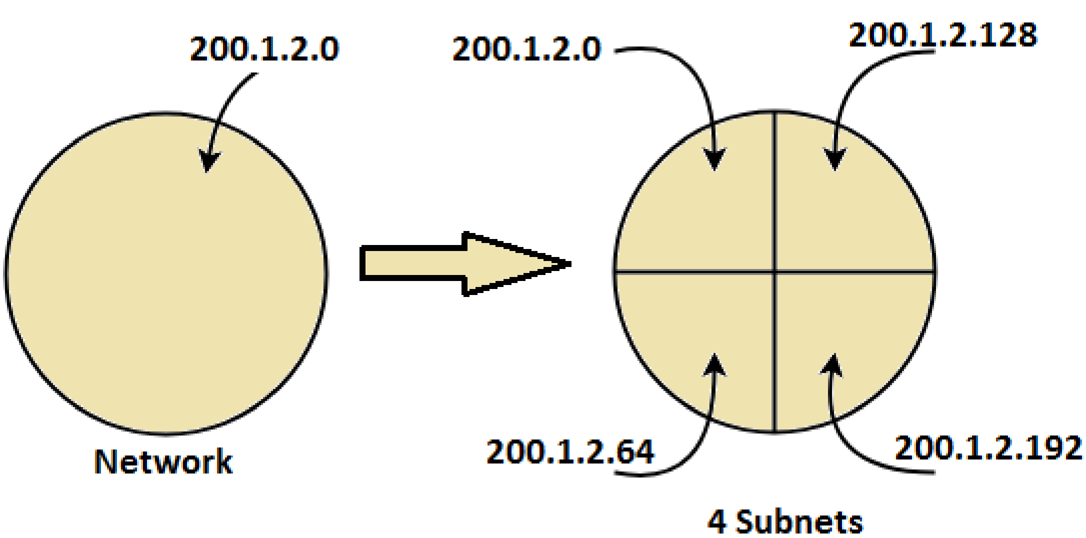
Now, to divide a network into 4 subnets we will need to borrow 2 bits from the host. The host will now remain with 6 bits.



- If borrowed bits is 00, it will represent the 1st subnet.
- If borrowed bits is 01, it will represent the 2nd subnet.
- If borrowed bits is 10, it will represent the 3rd subnet.
- If borrowed bits is 11, it will represent the 4th subnet.

IP Address of the four subnets respectively are:

- 200.1.2.**00**000000 = 200.1.2.0
- 200.1.2.**01**000000 = 200.1.2.64
- 200.1.2.**10**000000 = 200.1.2.128
- 200.1.2.**11**000000 = 200.1.2.192



1st Subnet

- IP Address of the subnet / Subnet id = 200.1.2.0
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.0, 200.1.2.63]
- Direct Broadcast Address = 200.1.2.**00**111111 = 200.1.2.63
- Limited Broadcast Address = 255.255.255.255

2nd Subnet

- IP Address of the subnet / Subnet id = 200.1.2.64
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.64, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**01**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255

3rd Subnet

- IP Address of the subnet / Subnet id = 200.1.2.128
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.128, 200.1.2.191]
- Direct Broadcast Address = 200.1.2.**10**111111 = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255

4th Subnet

- IP Address of the subnet / Subnet id = 200.1.2.192
- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.192, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

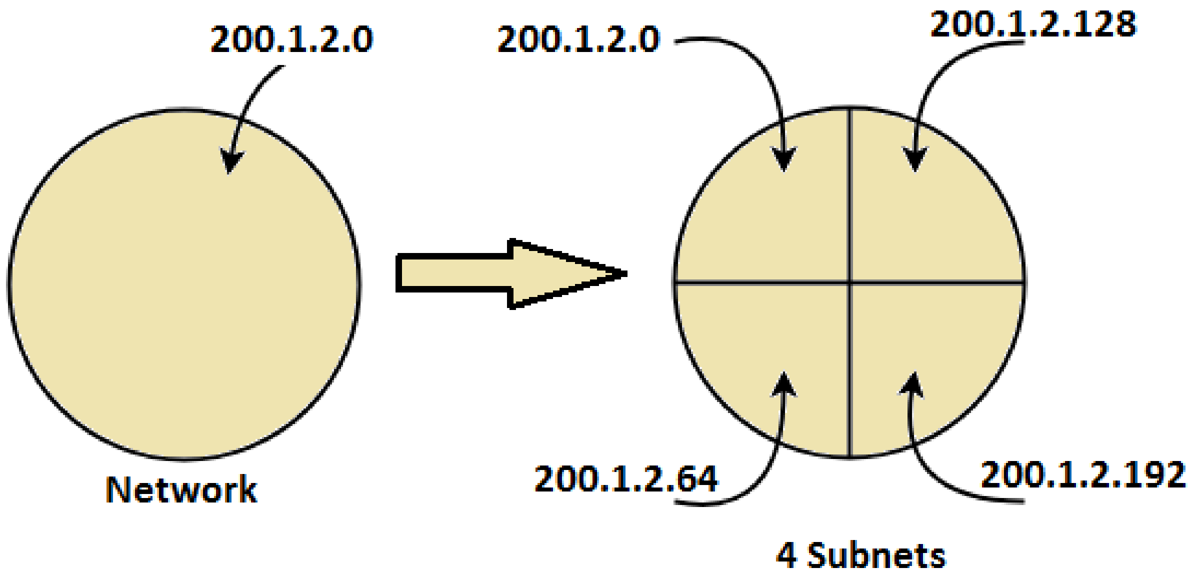
Subnet Masks

- In case of subnetting the problem is how to identify to which subnet the incoming packet from outside the network must be delivered. To solve this problem, we use the idea of subnet mask.
- Subnet mask is a 32-bit number which is a sequence of 1's followed by a sequence of 0's where:
  - 1's represents the Network ID part along with the subnet ID.
  - 0's represents the host ID part.

- Default mask for different classes of IP Address are:
  - Default subnet mask of Class A = 255.0.0.0
  - Default subnet mask for Class B = 255.255.0.0
  - Default subnet mask for Class C = 255.255.255.0

- Networks of same size always have the same subnet mask.

For, example: The subnet masks of the following 4 subnets will be:



As it is fixed length subnets thus for each subnet the subnet mask will be:

- 11111111.11111111.11111111.11000000 (i.e. we set the first 26 bits to 1's (Network ID + SubNetID) and remaining bits to 0.)
- Subnet mask = 255.255.255.192

Q if the IP address of a system is 141.121.119.168, with subnet mask 255.255.252.0, calculate the net id, directed broadcast add, first and last add?

Q if the IP address of a system is 203.112.111.117, with subnet mask 255.255.255.224, calculate the net id, directed broadcast add, first and last add?

Q if the IP address of a system is 61.119.189.176, with subnet mask 255.255.192.0, calculate the net id, directed broadcast add, first and last add?

Q how to identify to which subnet the incoming packet from outside the network must be delivered.

- Take Subnet mask in binary notation
- Take ip address of the incoming packet in binary notation
- Do bit wise and operation
- we will get Subnet id

Net id	Subnet Mask	Interface
200.1.2.0	255.255.255.192	w
200.1.2.64	255.255.255.192	x
200.1.2.128	255.255.255.192	y
200.1.2.192	255.255.255.192	z
0.0.0.0	0.0.0.0	default

GATE | GATE-CS-2015 (Set 2) | Question 65

Consider the following routing table at an IP router

Network No.	Net Mask	Next Hop
128.96.170.0	255.255.254.0	Interface 0
128.96.168.0	255.255.254.0	Interface 1
128.96.166.0	255.255.254.0	R2
128.96.164.0	255.255.254.0	R3
0.0.0.0	Default	R4

For each IP address in Group-I identify the correct choice of the next hop from Group-II using the entries from the routing table above.

```
   List-I              List-II
A. 128.96.171.92     1. Interface 0
B. 128.96.167.151    2. Interface 1
C. 128.96.163.121    3. R2
D. 128.96.165.121    4. R3
                     5. R4

Codes:
     A B C D
(a)  1 3 5 4
(b)  1 4 2 5
(c)  2 3 4 5
(d)  2 3 5 4
```

Ans: a

Types of Subnetting

Subnets can be of two types:

1. Fixed Length Subnetting
2. Variable Length Subnetting

Fixed Length Subnetting

- Fixed length subnetting (classful subnetting) divides the network into subnets such that:
    - All the subnets are of same size.
    - All the subnets have equal number of hosts.
    - All the subnets have same subnet mask.

Variable Length Subnetting

- Variable length subnetting (classless subnetting) divides the network into subnets such that:
    - All the subnets are not of same size.
    - All the subnets do not have equal number of hosts.
    - All the subnets do not have same subnet mask.

Point to Note:

- For, dividing a subnet into three subnets we will first divide the subnet into two parts and will then further divide it into one of them into two parts.

Q Consider we have a big single network having IP Address 200.1.2.0. We want to do subnetting and divide this network into 3 subnets, such that first contains 128 hosts, and other two contains 64 hosts each?

1st Subnet

- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 64
- Range of IP Addresses = [200.1.2.0, 200.1.2.127]
- IP Address of the subnet / Subnet id = 200.1.2.0
- Direct Broadcast Address = 200.1.2.**01**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.128

2nd Subnet

- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.128, 200.1.2.191]
- IP Address of the subnet / Subnet id = 200.1.2.128
- Direct Broadcast Address = 200.1.2.**10**111111 = 200.1.2.191
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.192

3rd Subnet

- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.192, 200.1.2.255]
- IP Address of the subnet / Subnet id = 200.1.2.192
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.192

Q Consider we have a big single network having IP Address 200.1.2.0. We want to do subnetting and divide this network into 3 subnets, such that first and second contains 64 hosts, and third contains 128 hosts each?

1st Subnet

- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.0, 200.1.2.63]
- IP Address of the subnet / Subnet id = 200.1.2.0
- Direct Broadcast Address = 200.1.2.**00**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.192

2st Subnet

- Total number of IP Addresses = 2^6 = 64
- Total number of hosts that can be configured = 64 – 2 = 62
- Range of IP Addresses = [200.1.2.0, 200.1.2.63]
- IP Address of the subnet / Subnet id = 200.1.2.0
- Direct Broadcast Address = 200.1.2.**00**111111 = 200.1.2.127
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.192

3rd Subnet

- Total number of IP Addresses = 2^7 = 128
- Total number of hosts that can be configured = 128 – 2 = 126
- Range of IP Addresses = [200.1.2.128, 200.1.2.255]
- IP Address of the subnet / Subnet id = 200.1.2.128
- Direct Broadcast Address = 200.1.2.**11**111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255
- Subnet Mask: 255.255.255.128

Note:

- Practically we always take most significant bits of the host id to create sub-net.
- Theoretically we can take any bits from the host id for e.g. 255.255.255.1

Examples: If the subnet mask 255.255.255.128 belongs to class C, find the total number of subnets and Number of hosts in each subnet.

Since it is given that the subnet mask is of class C. That is, the first three octets represent the network ID and the remaining 1 octet represents Host ID.

255.255.255.128 = 11111111. 11111111. 11111111. 10000000

Now, it is clearly visible that 1 bit is borrowed from the host ID so, total number of subnets are:

$2^1 = 2$

And the number of hosts in each subnet will be: $2^7 - 2 = 126$

Q Suppose computers A and B have IP addresses 10.105.1.113 and 10.105.1.91 respectively and they both use the same netmask N. Which of the values of N given below should not be used if A and B should belong to the same network? **(Gate-2010) (2 Marks)**

(A) 255.255.255.0 **(B)** 255.255.255.128
(C) 255.255.255.192 **(D)** 255.255.255.224

Answer: (D)

Q If a class B network on the Internet has a subnet mask of 255.255.248.0, what is the maximum number of hosts per subnet? **(Gate-2008) (2 Marks)**

(A) 1022 **(B)** 1023 **(C)** 2046 **(D)** 2047

Answer (C)

Q Host X has IP address 192.168.1.97 and is connected through two routers R1 and R2 to another host Y with IP address 192.168.1.80. Router R1 has IP addresses 192.168.1.135 and 192.168.1.110. R2 has IP addresses 192.168.1.67 and 192.168.1.155. The netmask used in the network is 255.255.255.224. Which IP address should X configure its gateway as? **(Gate-2008) (2 Marks)**

(A) 192.168.1.67 **(B)** 192.168.1.110
(C) 192.168.1.135 **(D)** 192.168.1.155

Answer: (B)

Q which ip address should x configure its gateway as? **(Gate-2008) (2 Marks)**

a) 192.168.1.67 **b)** 192.168.1.110

c) 192.168.1.135 **d)** 192.168.1.155

Q The address of a class B host is to be split into subnets with a 6-bit subnet number. What is the maximum number of subnets and the maximum number of hosts in each subnet? **(Gate-2007) (2 Marks)**

(A) 62 subnets and 262142 hosts. **(B)** 64 subnets and 262142 hosts.

(C) 62 subnets and 1022 hosts. **(D)** 64 subnets and 1024 hosts.

Answer: (C)

Q A sub netted Class B network has the following broadcast address: 144.16.95.255. Its subnet mask **(Gate-2006) (2 Marks)**

(A) is necessarily 255.255.224.0

(B) is necessarily 255.255.240.0

(C) is necessarily 255.255.248.0

(D) could be any one of 255.255.224.0, 255.255.240.0, 255.255.248.0

Answer: (D)

Q An organization has a class B network and wishes to form subnets for 64 departments. The subnet mask would be: **(Gate-2005) (1 Marks)**

(a) 255.255.0.0 **(b)** 255.255.64.0

(c) 255.255.128.0 **(d)** 255.255.252.0

Answer (d)

Q A company has a class C network address of 204.204.204.0. It wishes to have three subnets, one with 100 hosts and two with 50 hosts each. Which one of the following options represents a feasible set of subnet address/subnet mask pairs? **(Gate-2005) (2 Marks)**

(A) 204.204.204.128/255.255.255.192 204.204.204.0/255.255.255.128 204.204.204.64/255.255.255.128	**(B)** 204.204.204.0/255.255.255.192 204.204.204.192/255.255.255.128 204.204.204.64/255.255.255.128
(C) 204.204.204.128/255.255.255.128 204.204.204.192/255.255.255.192 204.204.204.224/255.255.255.192	**(D)** 204.204.204.128/255.255.255.128 204.204.204.64/255.255.255.192 204.204.204.0/255.255.255.192

Answer: (D)

Q A subnet has been assigned a subnet mask of 255.255.255.192. What is the maximum number of hosts that can belong to this subnet? **(Gate-2004) (1 Marks)**

(A) 14 **(B)** 30 **(C)** 62 **(D)** 126

Answer: (C)

Q The subnet mask for a particular network is 255.255.31.0. Which of the following pairs of IP addresses could belong to this network? **(Gate-2003) (2 Marks)**

(A) 172.57.88.62 and 172.56.87.233 **(B)** 10.35.28.2 and 10.35.29.4

(C) 191.203.31.87 and 191.234.31.88 **(D)** 128.8.129.43 and 128.8.161.55

Answer: (D)

Address Depletion

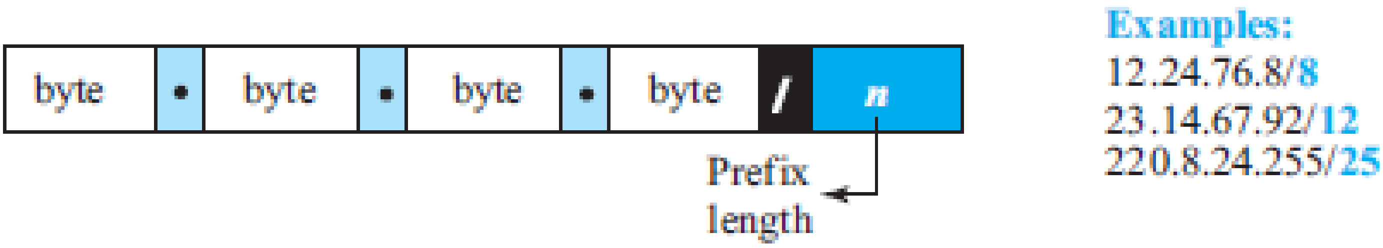
- The addresses were not distributed properly as class A and B are usually very large for any organization and class C is usually very small
- flexibility is not there is classful addressing, we cannot have the exact allocation as we want for e.g. if some company wants 50 IP address then must go for 256, resulting into address depletion.
- Wastage of addresses, for example: Class E addresses were almost never used, wasting the whole class.
- **Conclusion:** The Internet was faced with the problem of the addresses being rapidly used up, resulting in no more addresses available for organizations and individuals that needed to be connected to the Internet.

Classless Addressing (Blocks/Network)

- Classless Addressing is an improved IP Addressing system.
- The class privilege is removed from the distribution to compensate for the address depletion, so no class.
- Here we can ask exact set of IP address which are required and a Variable-length blocks are assigned which satisfy the request.

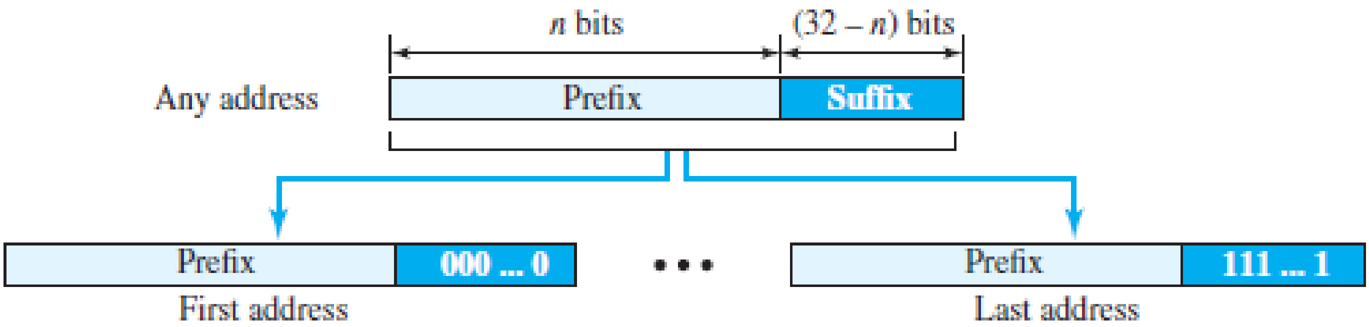
CIDR Notation

- The question is as there are no classes, how to identify block id and host id, as address in classless addressing does not define the block or network to which the address belongs.
- To solve this problem now we have a new CIDR notation, this notation is informally referred to as *slash notation* and formally as ***classless interdomain routing*** or ***CIDR.***
- To find the prefix(net_id), *n* is added to the address, separated by a slash.
- n represent number of bits in net_id



Extracting Information from an Address

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



Example: Address: 167.199.170.82/**27** (10100111 11000111 10101010 01010010)

First address can be found by setting 32-n rightmost bits as 0 as shown below:

First address: 167.199.170.64/**27** **(**10100111 11000111 10101010 010***00000****)*

Last address can be found by setting 32-n rightmost bits as 1.

Last Address: 167.199.170.95/**27** 10100111 11000111 10101010 010**11111**

Q one of the address of the block is 17.63.110.24/27, find the no of address, bid, broadcast address?

Q one of the address of the block is 110.23.120.14/20+, find the no of address, bid, broadcast address?

Address Mask

- The address mask is a 32-bit number in which the *n* leftmost bits are set to 1s and the rest of the bits (32 − *n*) are set to 0s.
- It is another way to find the first and last addresses in the block.
- Using the three bit-wise operations NOT, AND, and OR a computer can find:
  1. The number of addresses in the block N = **NOT** (mask) + 1.
  2. The first address in the block = (Any address in the block) **AND** (mask).
  3. The last address in the block = (Any address in the block) **OR** [(**NOT** (mask)].

Example: A classless address is given as 167.199.170.82/**27**.

The mask by setting 27 leftmost bits to 1 and 5 rightmost bits to 0 in dotted-decimal notation is: 255.255.255.224 (11111111 11111111 11111111 11100000)

- Number of addresses in the block: N = **NOT** (mask) + 1 =
  - 00000000 00000000 00000000 00011111 + 1 = 0.0.0.31 + 1 = 32 addresses

- First address: First = (address) **AND** (mask) =
  - 10100111 11000111 10101010 01010010
  - 11111111 11111111 11111111 11100000
  - 167.199.170.64

- Last address: Last = (address) **OR** (**NOT** mask) =
  - 10100111 11000111 10101010 01010010
  - 00000000 00000000 00000000 00011111
  - 167.199.170.255

Q In the network 200.10.11.144/27, the fourth octet (in decimal) of the last IP address of the network which can be assigned to a host is ________ **(Gate-2015) (2 Marks)**

Q An Internet Service Provider (ISP) has the following chunk of CIDR-based IP addresses available with it: 245.248.128.0/20. The ISP wants to give half of this chunk of addresses to Organization A, and a quarter to Organization B, while retaining the remaining with itself. Which of the following is a valid allocation of addresses to A and B? **(Gate-2012) (2 Marks)**
(A) 245.248.136.0/21 and 245.248.128.0/22
(B) 245.248.128.0/21 and 245.248.128.0/22
(C) 245.248.132.0/22 and 245.248.132.0/21
(D) 245.248.136.0/24 and 245.248.132.0/21
Answer: (A)

Rules for Creating CIDR Block (Network)

- All the IP Addresses in the CIDR block must be contiguous.
- The size of the block (total number of IP Addresses contained in the block) must be presentable as power of 2, size of any CIDR block will always be in the form 2^1, 2^2, 2^3, 2^4, 2^5 and so on. (calculation can be easy)
- First IP Address of the block must be divisible by the size of the block. (so that we get the host id from all 0 to all 1)

Q Consider a block of IP Addresses ranging from 100.1.2.32 to 100.1.2.47.

1. Is it a CIDR block?
2. If yes, give the CIDR representation?

- We need to conform 3 rules here:
  - Are the addresses contiguous? 32 to 47 is contiguous.
  - Are the total addresses in power of 2? Total addresses = 47 -32 + 1 = 16 = 2^4
  - Is the first address divisible by size of the block?

- First IP address = 100.1.2.32 = 100.1.2.00100000, it is divisible by 2^4 as last four LSB's are 0. So, the given block is a CIDR.
- **CIDR Notation**
    - Since the block has 2^4 total addresses, thus 4 bits are required in HostID therefore the number of bits present in the network ID part is: 32-4 = 28.
    - So, the CIDR notation is: 100.1.2.32 / 28

Q Consider a block of IP Addresses ranging from 20.10.30.32 to 20.10.30.63

1. Is it a CIDR block?
2. If yes, give the CIDR representation?

Q Consider a block of IP Addresses ranging from 150.10.20.64 to 150.10.20.127

1. Is it a CIDR block?
2. If yes, give the CIDR representation?

Point to note:

- Any binary pattern is divisible by 2^n, if and only if its least significant n bits are 0.
- Example: 01100100.00000001.00000010.01000000 (i.e. 100.1.2.64).
  It is divisible by 2^5 since its least significant 5 bits are zero.
  It is divisible by 2^6 since its least significant 6 bits are zero.
  It is not divisible by 2^7 since its least significant 7 bits are not zero.

Subnetting in CIDR

Q Consider the network having IP Address 20.30.40.10/25 Divide this network into two subnets.

20.30.40.0/26

20.30.40.64/26

Q Consider the network having IP Address 20.30.40.10/25 Divide this network into Four subnets.

20.30.40.0/27

20.30.40.32/27

20.30.40.64/27

20.30.40.96/27

Q Consider the network having IP Address 20.30.40.10/25 Divide this network into Three subnets.

20.30.40.0/26

20.30.40.64/27

20.30.40.96/27

Q Consider the network having IP Address 20.30.40.10/25 Divide this network into Three subnets.

20.30.40.0/26

20.30.40.32/27

20.30.40.64/27

Q Consider the network having IP Address 40.30.10.20/20 Divide this network into Three subnets.

40.30.0.0/21 - 40.30.7.255/21

40.30.8.0/22 - 40.30.11.255/22

40.30.12.0/22 - 40.30.15.255/22

Example: An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 sub blocks of addresses to use in its three subnets: one sub-block of 10 addresses, one sub block of 60 addresses, and one sub block of 120 addresses. Design the sub blocks.

Clearly, There are $2^{32-24} = 256$ addresses in this block.

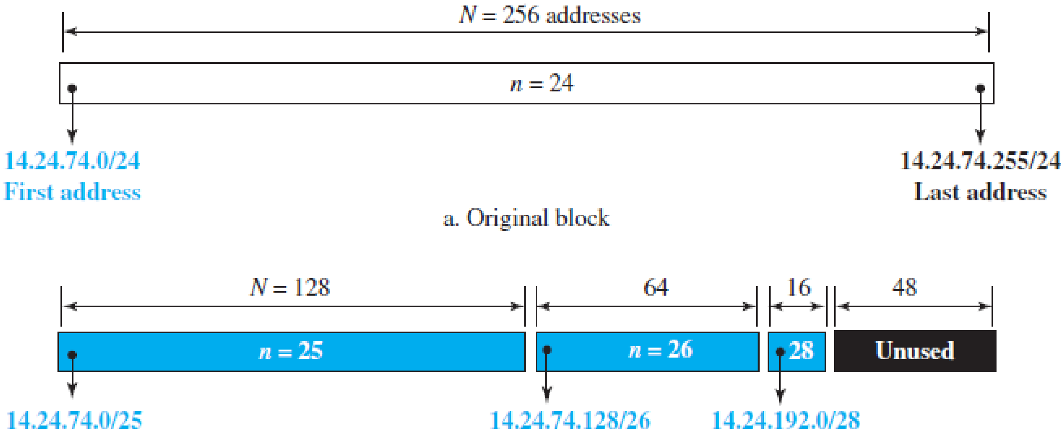
- The first address is 14.24.74.0/24.
- The last address is 14.24.74.255/24.

We assign addresses to subblocks, starting with the largest and ending with the smallest one.

- The largest subblock requires 120 addresses, it is not a power of 2. So, we allocate 128 addresses.
  - The subnet mask for this subnet can be found as $n_1 = 32 - \log_2 128 = 25$.
  - The first address in this block is 14.24.74.0/25.
  - The last address is 14.24.74.127/25.

- The second largest sub block, it requires 60 addresses, since it is not a power of 2 either. We allocate 64 addresses.
  - The subnet mask for this subnet can be found as $\mathbf{n_2 = 32 - log_2 64} = 26$.
  - The first address in this block is 14.24.74.128/26.
  - The last address is 14.24.74.191/26.

- The number of addresses in the smallest sub block, which requires 10 addresses, is not a power of 2 either. We allocate 16 addresses.
  - The subnet mask for this subnet can be found as $\mathbf{n_3 = 32 - log_2 16} = 28$.
  - The first address in this block is 14.24.74.192/28.
  - The last address is 14.24.74.207/28.



- If we add all addresses in the previous sub-blocks (128 + 64 + 16), the result is 208 addresses, which means 48 addresses are left in reserve.

Designing subnets for CIDR Notations

- Assume:
  - The total number of addresses granted to the organization is **N**
  - The prefix length is ***n***
  - The assigned number of addresses to each sub-network is $\mathbf{N_{sub}}$
  - The prefix length for each sub-network is $\boldsymbol{n_{sub}}$.

  Then,
- The number of addresses in each sub-network should be a power of 2.

- The prefix length for each sub-network should be found using the following formula: $\mathbf{n_{sub} = 32 - log_2 N_{sub}}$

- The starting address in each sub-network should be divisible by the number of addresses in that sub-network. This can be achieved if we first assign addresses to larger sub-networks.

Disadvantages of Subnetting

- Subnetting leads to loss of IP Addresses, in each subnet we lose two IP addresses one for network address and one for DBA.
- Communication process gets complicated.

Super netting in Classful addressing

- Subnetting increase size of routing table, super netting is a perception so a counter idea is also possible which is super netting
- The size of a class C block with a maximum number of 256 addresses did not satisfy the needs of most organizations. Even a midsize organization needed more addresses.
- One solution was super netting. In super netting, an organization can combine several blocks to create a larger range of addresses. In other words, several networks are combined to create a super network or a supernet.
- An organization can apply for a set of class C blocks instead of just one. For example, an organization that needs 1000 addresses can be granted four contiguous class C blocks. The organization can then use these addresses to create one super network.
- Super netting decreases the number of Is in the mask.

Super netting / Aggregation with CIDR

- Rules for Super netting in CIDR
  - All network should be contiguous
  - Size of all the network should be same
  - first net id should be divisible by size of the block

Let us take an example:

Perform CIDR aggregation on the following IP Addresses-

128.56.24.0/24

128.56.25.0/24

128.56.26.0/24

128.56.27.0/24

- Are the blocks contiguous? Clearly the blocks are contiguous in nature.

- Are the total number of IP addresses in power of 2?
  Clearly we are having 24 bits as network ID in each 4 blocks, host ID is: 32 – 24 = 8 bits.
  Total addresses for 4 blocks: $2^8 + 2^8 + 2^8 + 2^8 = 2^{10}$
  So, the total addresses are also power of 2.

- Is first address divisible by total addresses?

  The first address: 128.56.24.0/24 = 128.56.00011000.00000000 is divisible by 2^{10} since its 10 least significant bits are zero.

Now, all the rules for CIDR block are **satisfied.**

To aggregate them, we have total 2^{10} addresses that means we need to have 10 bits for host ID and 22 bits for network ID

The CIDR representation of aggregation would be: ***128.56.24.0/22***

Q Consider the following networks and merger them to have a supernet

200.1.0.0/24

200.1.1.0/24

200.1.2.0/24

200.1.2.0/24

200.1.0.0/22

Q Consider the following networks and merger them to have a supernet

100.1.2.0/25

100.1.2.128/26

100.1.2.192/26

100.1.2.0/24

- ISP provides four things
    - IP address
    - DGW (router which is connecting us to internet)
    - SM (using subnet mask we understand weather the destination is in our network or some other network)
    - DNS

Q Two computers C_1 and C_2 are configured as follows. C_1 has IP address 203.197.2.53 and netmask 255.255.128.0. C_2 has IP address 203.197.75.201 and netmask 255.255.192.0. which one of the following statements is true? **(Gate-2006) (2 Marks)**

(A) C_1 and C_2 both assume they are on the same network

(B) C_2 assumes C_1 is on same network, but C_1 assumes C_2 is on a different network

(C) C_1 assumes C_2 is on same network, but C_2 assumes C_1 is on a different network

(D) C_1 and C_2 both assume they are on different networks.

Answer (C)