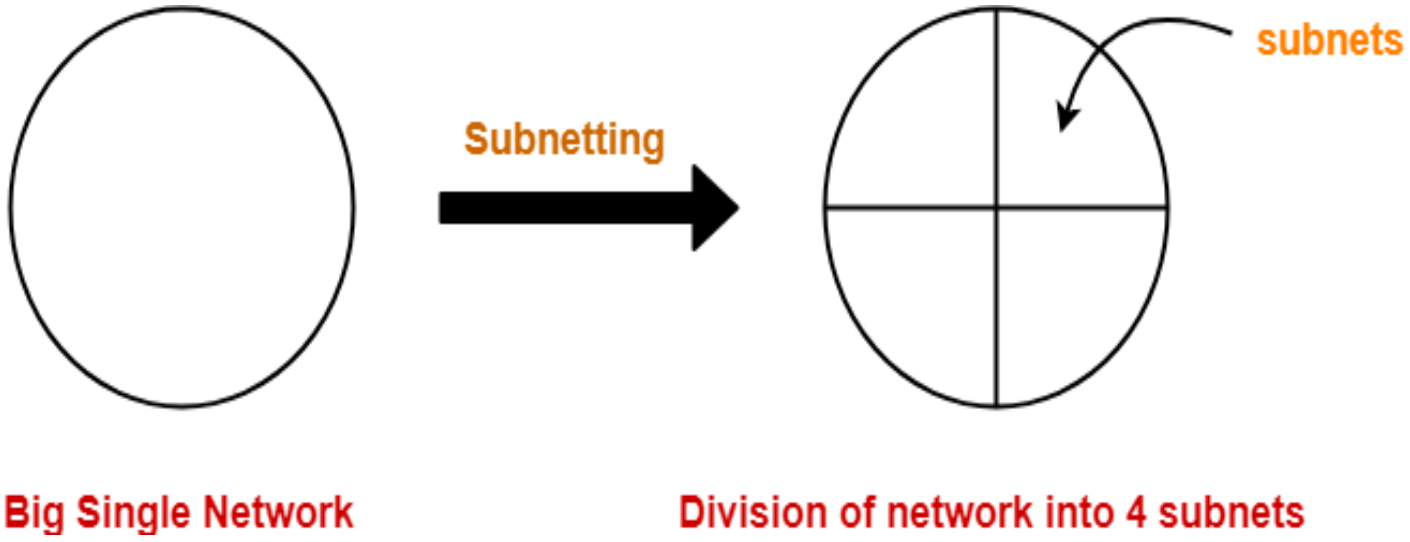
Subnetting

Overview

- The process of dividing a single network into multiple sub networks is called as subnetting.
- The sub networks so created are called as subnets.

Example

- Following diagram shows the subnetting of a big single network into 4 smaller subnets-



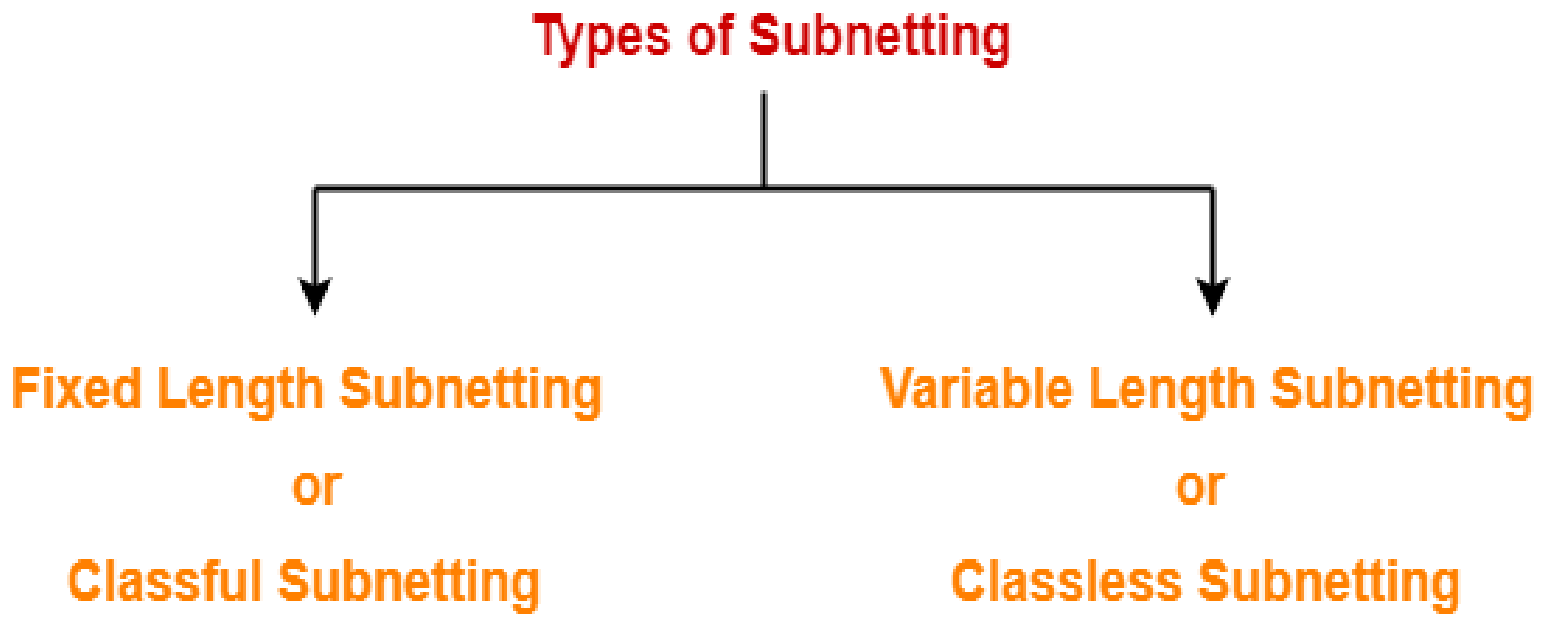
Advantages

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

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.

Types of Subnetting



. Fixed Length Subnetting

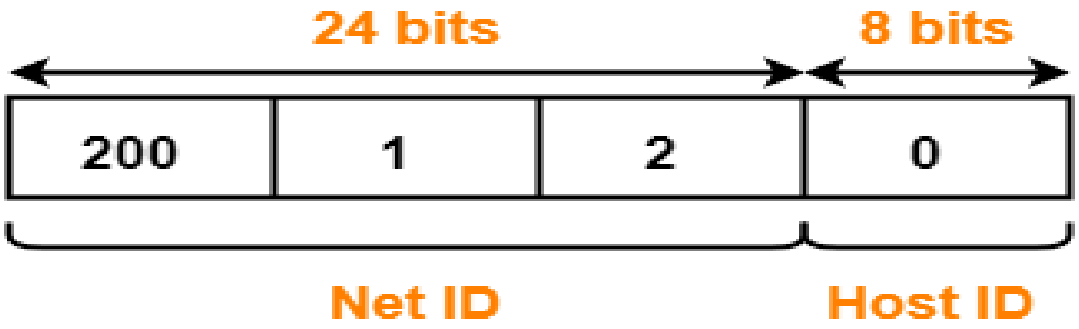
- Fixed length subnetting also called as classful subnetting divides the network into subnets where-
  - All the subnets are of same size.
  - All the subnets have equal number of hosts.
  - All the subnets have same subnet mask.

Variable Length Subnetting

- Variable length subnetting also called as classless subnetting divides the network into subnets where-
  - 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.

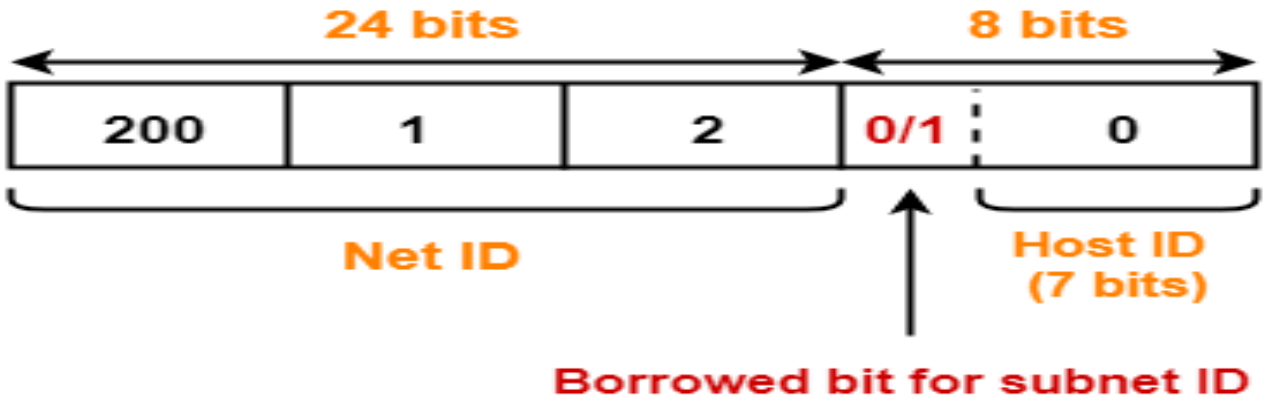
Example-01

- Consider-
  - We have a big single network having IP Address 200.1.2.0.
  - We want to do subnetting and divide this network into 2 subnets.
  - Clearly, the given network belongs to class C.



Example-01

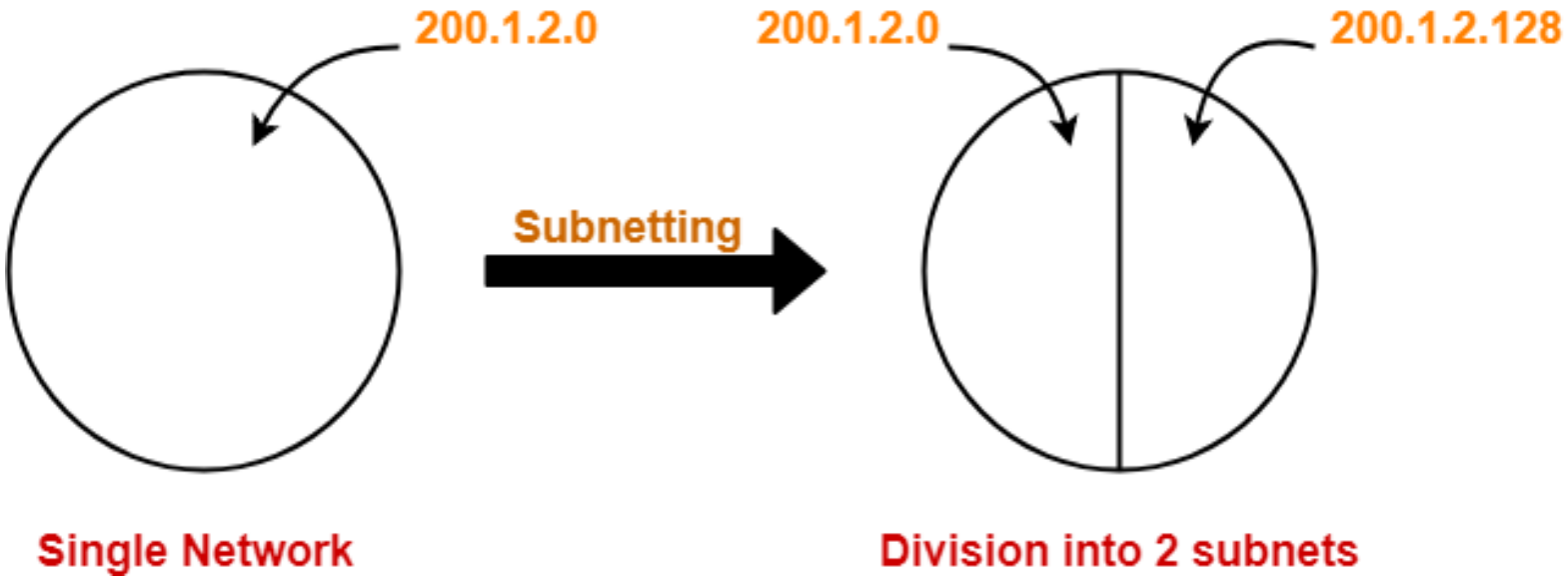
- For creating two subnets and to represent their subnet IDs, we require 1 bit.
- So,
  - We borrow one bit from the Host ID part.
  - After borrowing one bit, Host ID part remains with only 7 bits.



Example-01

- If borrowed bit = 0, then it represents the first subnet.
- If borrowed bit = 1, then it represents the second subnet.
- IP Address of the two subnets are-
  - 200.1.2.00000000 = 200.1.2.0
  - 200.1.2.10000000 = 200.1.2.128

Example-01


200.1.2.0
Subnetting
200.1.2.0
200.1.2.128
Single Network
Division into 2 subnets

Example-01

- **For 1st Subnet-**
  - IP Address of the subnet = 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 = [200.1.2.00000000, 200.1.2.01111111] = [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

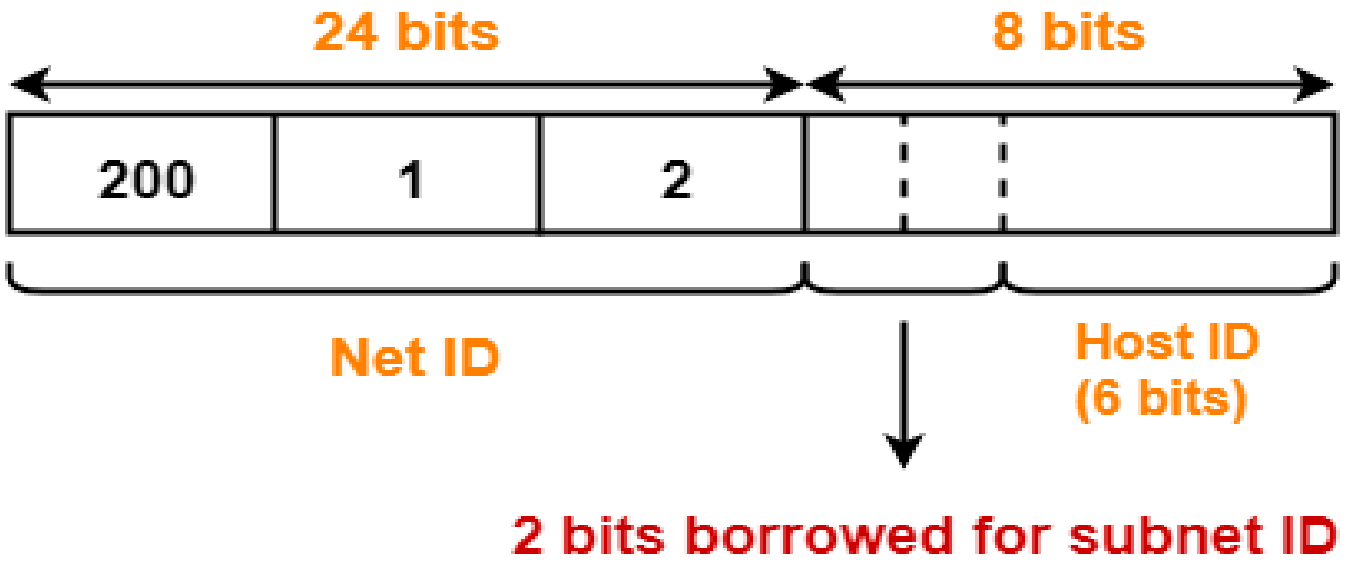
Example-01

- **For 2nd Subnet-**
  - IP Address of the subnet = 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 = [200.1.2.10000000, 200.1.2.11111111] = [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

Example-02

- 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.
- Clearly, the given network belongs to class C.
- For creating four subnets and to represent their subnet IDs, we require 2 bits.
- So,
  - We borrow two bits from the Host ID part.
  - After borrowing two bits, Host ID part remains with only 6 bits.

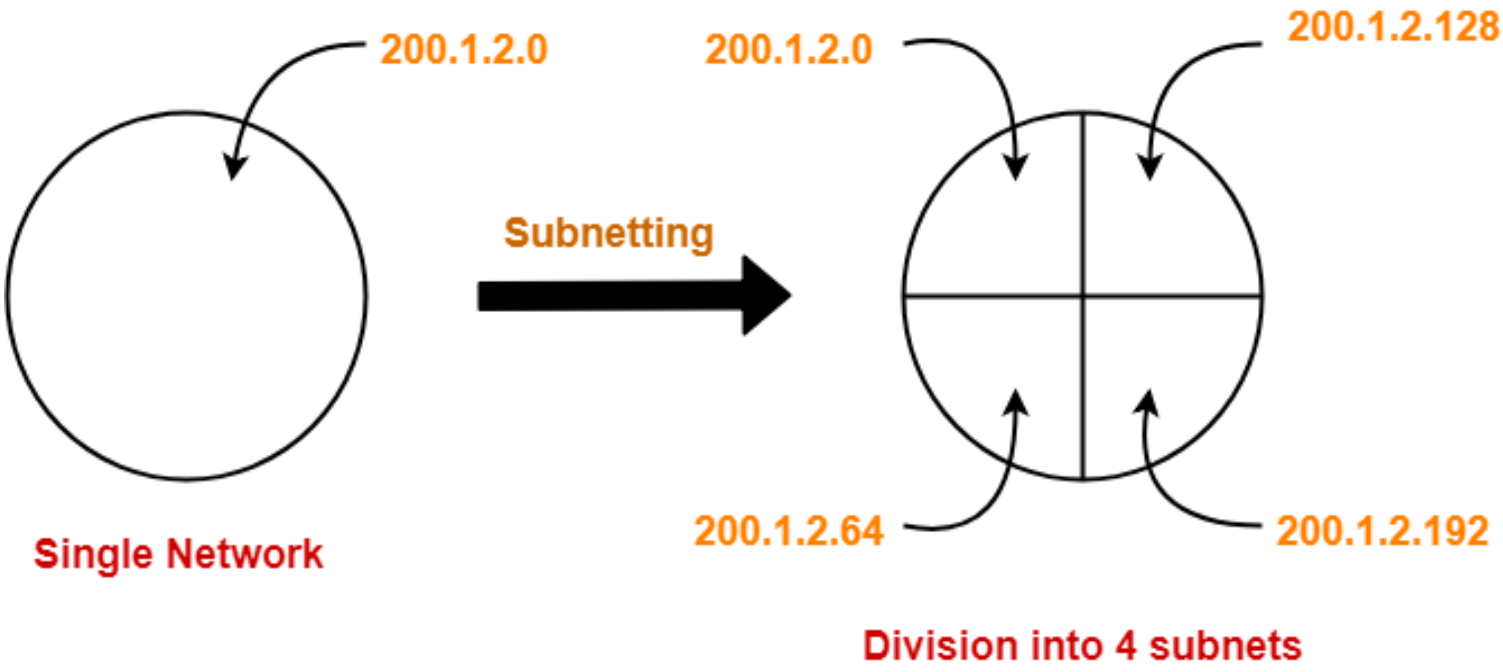
Example-02


24 bits
8 bits
200
1
2
Net ID
Host ID
(6 bits)
2 bits borrowed for subnet ID

Example-02

- If borrowed bits = 00, then it represents the 1st subnet.
- If borrowed bits = 01, then it represents the 2nd subnet.
- If borrowed bits = 10, then it represents the 3rd subnet.
- If borrowed bits = 11, then it represents the 4th subnet.
- IP Address of the four subnets are-
  - 200.1.2.00000000 = 200.1.2.0
  - 200.1.2.01000000 = 200.1.2.64
  - 200.1.2.10000000 = 200.1.2.128
  - 200.1.2.11000000 = 200.1.2.192

Example-02


200.1.2.0
Single Network
Subnetting
200.1.2.0
200.1.2.128
200.1.2.64
200.1.2.192
Division into 4 subnets

Example-02

- For 1st Subnet-
  - IP Address of the subnet = 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 = [200.1.2.00000000, 200.1.2.00111111] = [200.1.2.0, 200.1.2.63]
  - Direct Broadcast Address = 200.1.2.00111111 = 200.1.2.63
  - Limited Broadcast Address = 255.255.255.255

Example-02

- For 2nd Subnet-
  - IP Address of the subnet = 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 = [200.1.2.01000000, 200.1.2.01111111] = [200.1.2.64, 200.1.2.127]
  - Direct Broadcast Address = 200.1.2.01111111 = 200.1.2.127
  - Limited Broadcast Address = 255.255.255.255

Example-02

- For 3rd Subnet-
  - IP Address of the subnet = 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 = [200.1.2.10000000, 200.1.2.10111111] = [200.1.2.128, 200.1.2.191]
  - Direct Broadcast Address = 200.1.2.10111111 = 200.1.2.191
  - Limited Broadcast Address = 255.255.255.255

Example-02

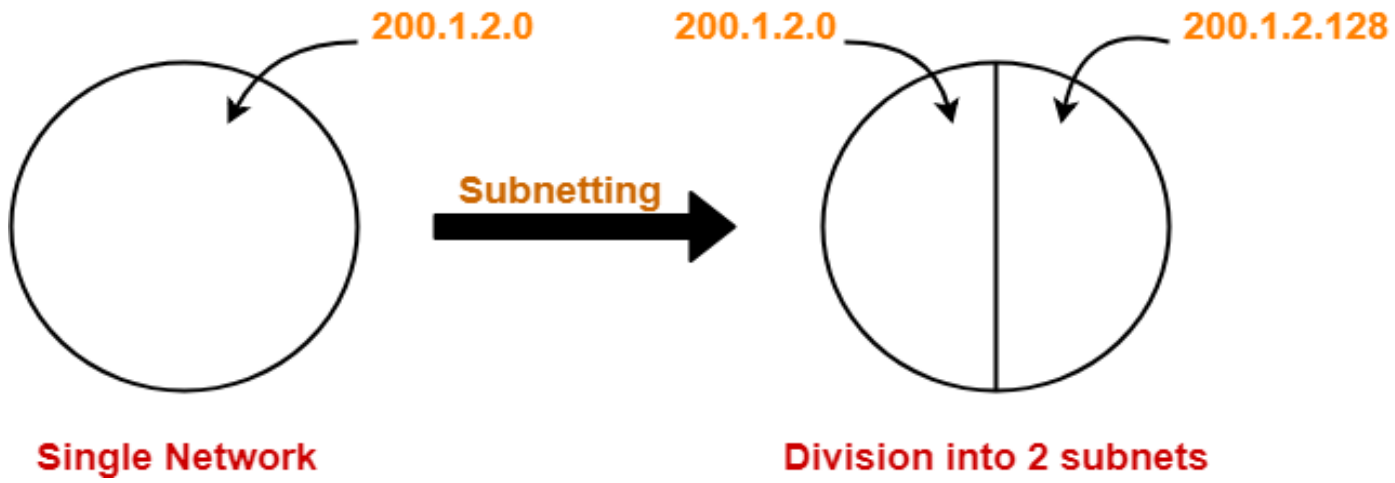
- For 4th Subnet-
  - IP Address of the subnet = 200.1.2.192
  - Total number of IP Addresses = 2^6 = 64
  - Total number of hosts that can be configured = 64 – 2 = 62
  - Range of IP Addresses = [200.1.2.11000000, 200.1.2.11111111] = [200.1.2.192, 200.1.2.255]
  - Direct Broadcast Address = 200.1.2.11111111 = 200.1.2.255
  - Limited Broadcast Address = 255.255.255.255

Example-03

- 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.
- Here, the subnetting will be performed in two steps-
  1. Dividing the given network into 2 subnets
  2. Dividing one of the subnets further into 2 subnets

Example-03

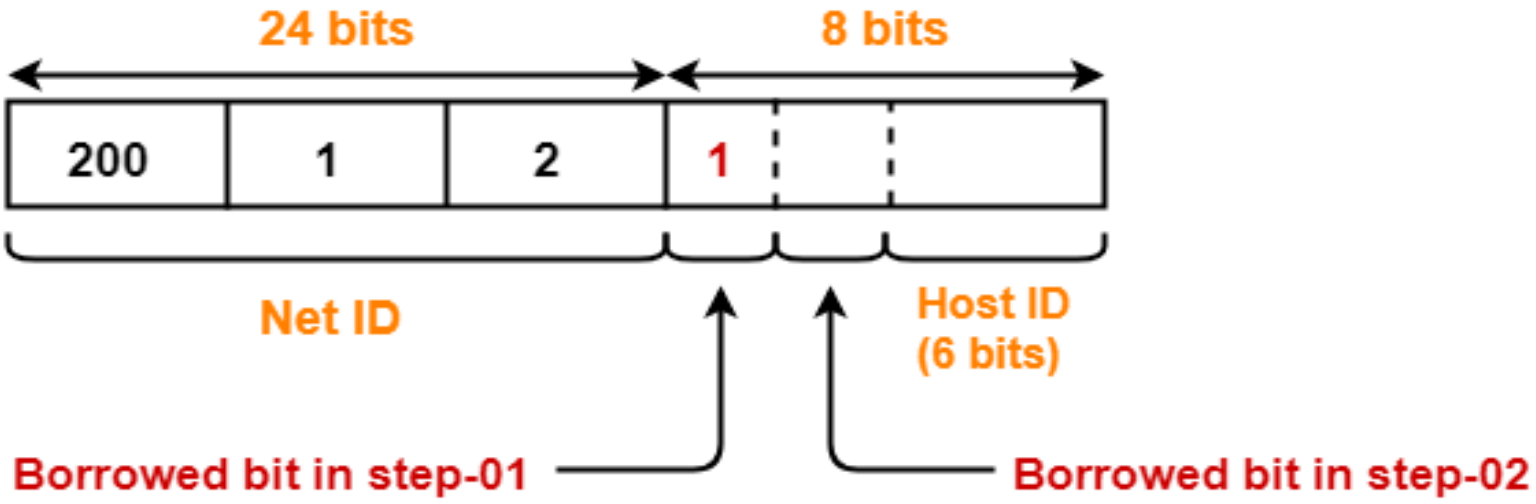
- Step-01: Dividing Given Network into 2 Subnets-
  - The subnetting will be performed exactly in the same way as performed in Example-01.
  - After subnetting, we have-



Example-03

- Step-02: Dividing One Subnet into 2 Subnets-
  - We perform the subnetting of one of the subnets further into 2 subnets.
  - Consider we want to do subnetting of the 2nd subnet having IP Address 200.1.2.128.
- For creating two subnets and to represent their subnet IDs, we require 1 bit.
- So,
  - We borrow one more bit from the Host ID part.
  - After borrowing one bit, Host ID part remains with only 6 bits.

Example-03

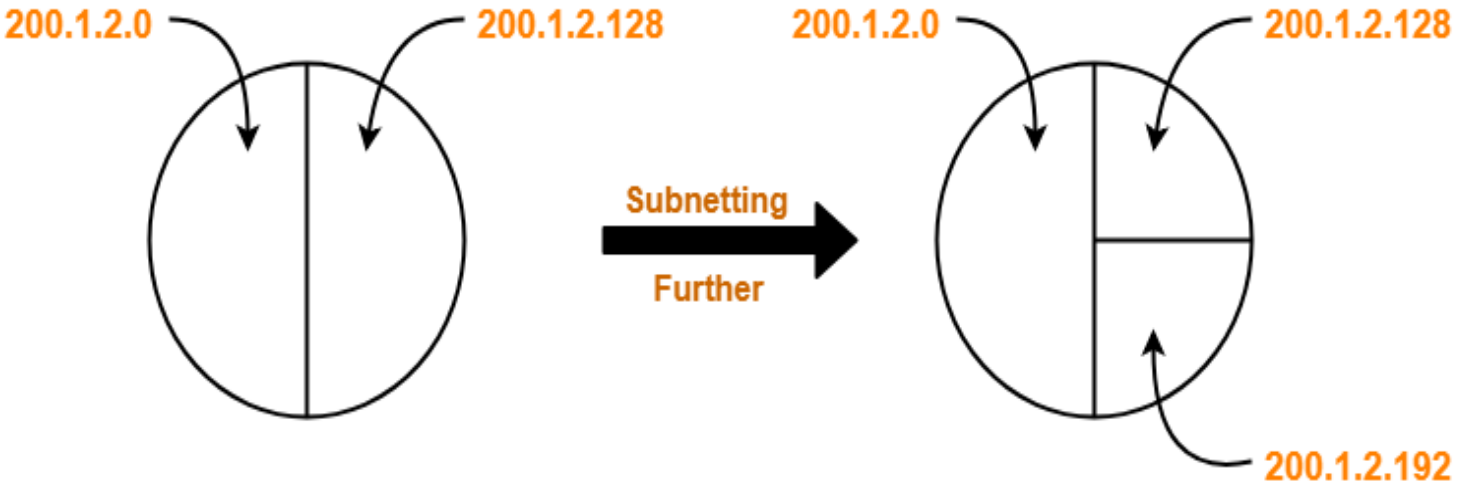

24 bits
8 bits
200
1
2
1
Net ID
Host ID
(6 bits)
Borrowed bit in step-01
Borrowed bit in step-02

Example-03

- If 2nd borrowed bit = 0, then it represents one subnet.
- If 2nd borrowed bit = 1, then it represents the other subnet.
- IP Address of the two subnets are-
  - 200.1.2.10000000 = 200.1.2.128
  - 200.1.2.11000000 = 200.1.2.192

Example-03

- Finally, the given single network is divided into 3 subnets having IP Address-
  - 200.1.2.0
  - 200.1.2.128
  - 200.1.2.192



Example-03

- For 1st Subnet-
  - IP Address of the subnet = 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 = [200.1.2.00000000, 200.1.2.01111111] = [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

Example-03

- For 2nd Subnet-
  - IP Address of the subnet = 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 = [200.1.2.10000000, 200.1.2.10111111] = [200.1.2.128, 200.1.2.191]
  - Direct Broadcast Address = 200.1.2.10111111 = 200.1.2.191
  - Limited Broadcast Address = 255.255.255.255

Example-03

- For 3rd Subnet-
  - IP Address of the subnet = 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 = [200.1.2.11000000, 200.1.2.11111111] = [200.1.2.192, 200.1.2.255]
  - Direct Broadcast Address = 200.1.2.11111111 = 200.1.2.255
  - Limited Broadcast Address = 255.255.255.255

Disadvantages of Subnetting

- Subnetting leads to loss of IP Addresses.
  - —During subnetting, we have to face a loss of IP Addresses.
    - This is because two IP Addresses are wasted for each subnet.
    - One IP address is wasted for its network address.
    - Other IP Address is wasted for its direct broadcasting address.

Disadvantages of Subnetting

2. Subnetting leads to complicated communication process.

—After subnetting, the communication process becomes complex involving the following 4 steps-

- Identifying the network
- Identifying the sub network
- Identifying the host
- Identifying the process

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 global network ID part and the subnet ID part.
  - 0's represents the host ID part.

How to Calculate Subnet Mask?

- For any given IP Address, the subnet mask is calculated-
  - By setting all the bits reserved for network ID part and subnet ID part to 1.
  - By setting all the bits reserved for host ID part to 0.

Example-01

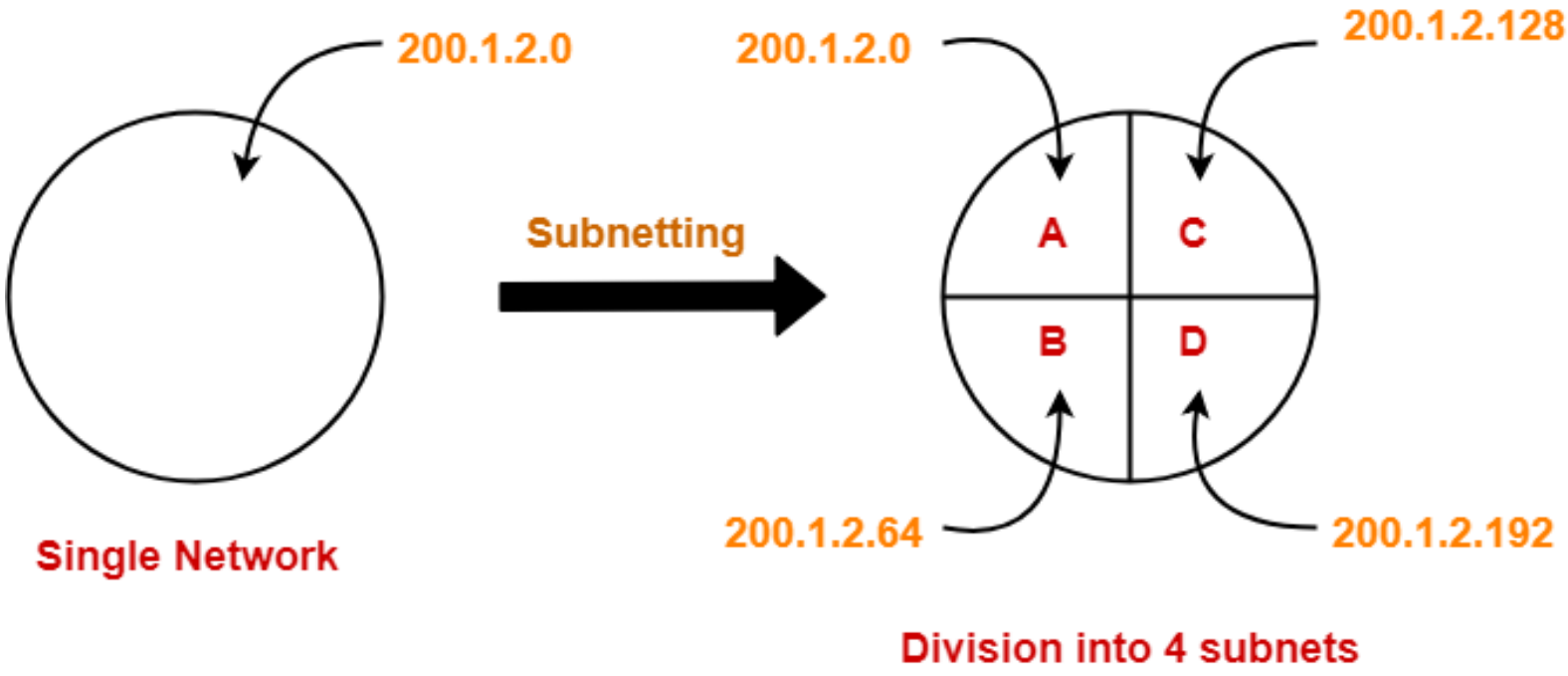
- Consider we have a network having IP Address 200.1.2.0.
  - Clearly, this IP Address belongs to class C.
- In class C-
  - 24 bits are reserved for the Network ID part.
  - 8 bits are reserved for the Host ID part.
- Subnet mask is obtained-
  - By setting the first 24 bits to 1.
  - By setting the remaining 8 bits to 0.
- So, Subnet mask

  = 11111111.11111111.11111111.00000000

  = 255.255.255.0

Example-02

- Consider a single network having IP Address 200.1.2.0 is divided into 4 subnets as shown-



Example-02

- Now, let us calculate the mask subnet for each subnet.
- For each subnet-
  - —24 bits identify the global network.
  - —2 bits identify the subnet.
- 6 bits identify the host.
  - —For each subnet, subnet mask is obtained-
  - —By setting the first 26 bits to 1.
  - —By setting the remaining 6 bits to 0.

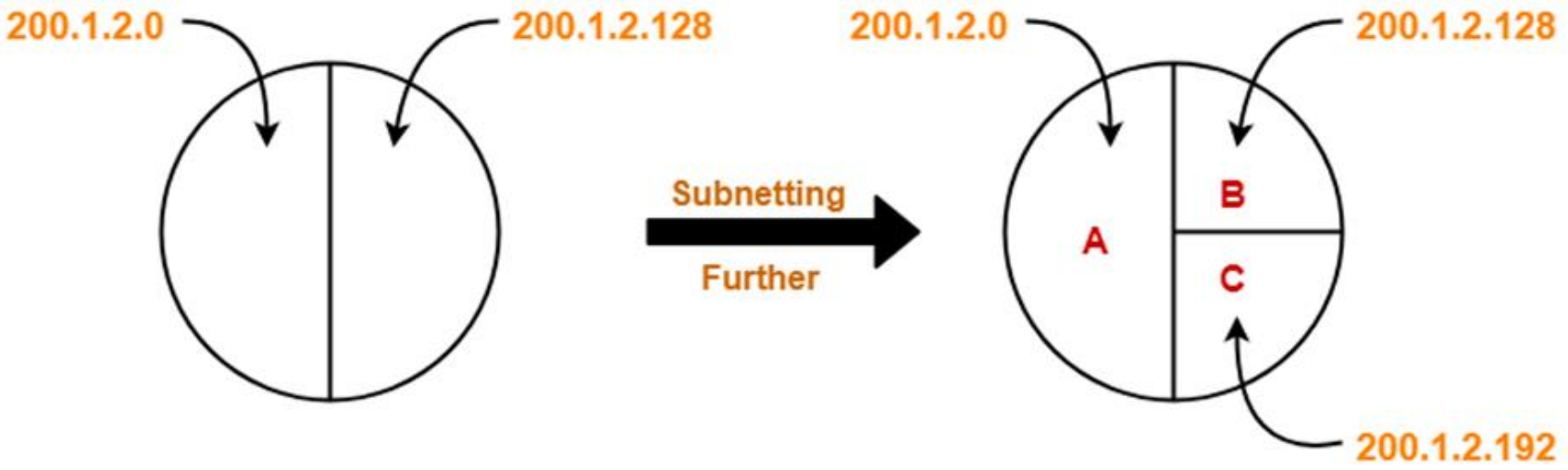
Example-02

- So, Subnet mask
  = 11111111.11111111.11111111.11000000
  = 255.255.255.192

- NOTE
  - In fixed length subnetting, All the subnets have same subnet mask since the size of each subnet is same.

Example-03

- Consider a single network having IP Address 200.1.2.0 is divided into 3 subnets as shown-



Example-03

- For Subnet A-
  - —24 bits identify the global network.
  - —1 bit identify the subnet.
  - —7 bits identify the host.
- For subnet A, subnet mask is obtained-
  - —By setting the first 25 bits to 1.
  - —By setting the remaining 7 bits to 0.
- So, Subnet mask

  = 11111111.11111111.11111111.10000000

  = 255.255.255.128

Example-03

- For Subnet B and Subnet C-
  - 24 bits identify the global network.
  - 2 bits identify the subnet.
  - 6 bits identify the host.
- For subnet B and subnet C, subnet mask is obtained-
  - By setting the first 26 bits to 1.
  - By setting the remaining 6 bits to 0.

Example-03

- So, Subnet mask
  = 11111111.11111111.11111111.11000000
  = 255.255.255.192

- NOTE
  - In variable length subnetting, All the subnets do not have same subnet mask since the size of each subnet is not same.

Use of Subnet Mask

- Subnet mask is used to determine to which subnet the given IP Address belongs to.

Important Notes

1. Default mask for different classes of IP Address are-
   a. Default subnet mask for Class A = 255.0.0.0
   b. Default subnet mask for Class B = 255.255.0.0
   c. Default subnet mask for Class C = 255.255.255.0
2. Network size is the total number of hosts present in it.
3. Networks of same size always have the same subnet mask.

Important Notes

4. Networks of different size always have the different subnet mask.
5. For a network having larger size, its subnet mask will be smaller (number of 1’s will be less).
6. For a network having smaller size, its subnet mask will be larger (number of 1’s will be more).

Example

An ISP is granted a block of addresses starting with 190.100.0.0/16 (65,536 addresses). The ISP needs to distribute these addresses to three groups of customers as follows:

a. The first group has 64 customers; each needs 256 addresses.

b. The second group has 128 customers; each needs 128 addresses.

c. The third group has 128 customers; each needs 64 addresses.

Design the subblocks and find out how many addresses are still available after these allocations.

Solution

Group 1

For this group, each customer needs 256 addresses. This means that 8 (log2 256) bits are needed to define each host. The prefix length is then 32 − 8 = 24. The addresses are

1st Customer:	*190.100.0.0/24*	*190.100.0.255/24*
2nd Customer:	*190.100.1.0/24*	*190.100.1.255/24*
. . .		
64th Customer:	*190.100.63.0/24*	*190.100.63.255/24*

Total = 64 × 256 = 16,384

Solution

Group 2

For this group, each customer needs 128 addresses. This means that 7 (log2 128) bits are needed to define each host. The prefix length is then 32 − 7 = 25. The addresses are

1st Customer:	*190.100.64.0/25*	*190.100.64.127/25*
2nd Customer:	*190.100.64.128/25*	*190.100.64.255/25*
. . .		
128th Customer:	*190.100.127.128/25*	*190.100.127.255/25*

Total = 128 × 128 = 16,384

Solution

Group 3

For this group, each customer needs 64 addresses. This means that 6 ($log_2 64$) bits are needed to each host. The prefix length is then 32 − 6 = 26. The addresses are

1st Customer:	*190.100.128.0/26*	*190.100.128.63/26*
2nd Customer:	*190.100.128.64/26*	*190.100.128.127/26*
. . .		
128th Customer:	*190.100.159.192/26*	*190.100.159.255/26*

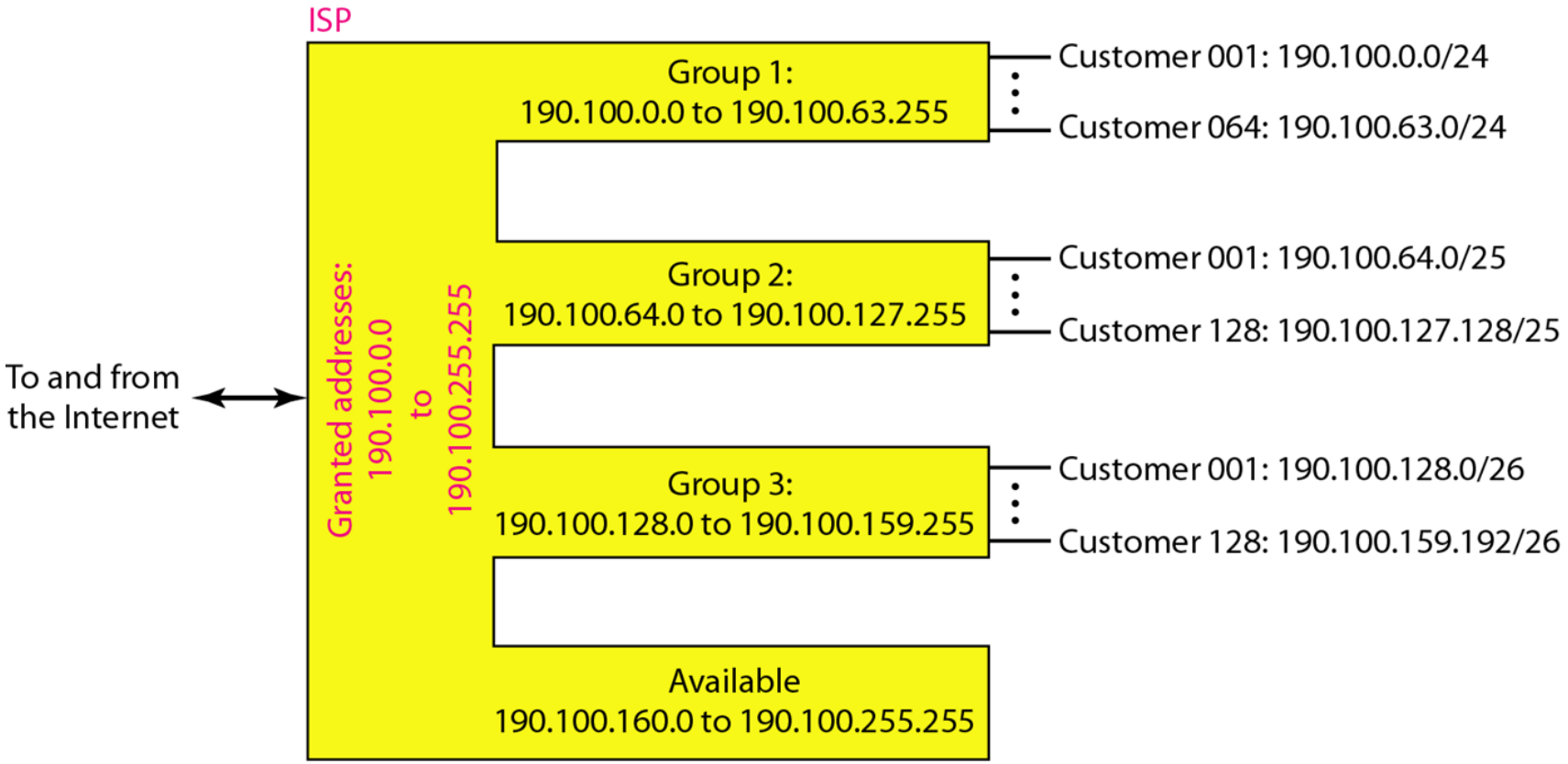
Total = 128 × 64 = 8192

Number of granted addresses to the ISP: 65,536

Number of allocated addresses by the ISP: 40,960

Number of available addresses: 24,576

Solution


ISP
Granted addresses:
190.100.0.0
to
190.100.255.255
Group 1:
190.100.0.0 to 190.100.63.255
Customer 001: 190.100.0.0/24
Customer 064: 190.100.63.0/24
Group 2:
190.100.64.0 to 190.100.127.255
Customer 001: 190.100.64.0/25
Customer 128: 190.100.127.128/25
Group 3:
190.100.128.0 to 190.100.159.255
Customer 001: 190.100.128.0/26
Customer 128: 190.100.159.192/26
Available
190.100.160.0 to 190.100.255.255
To and from
the Internet

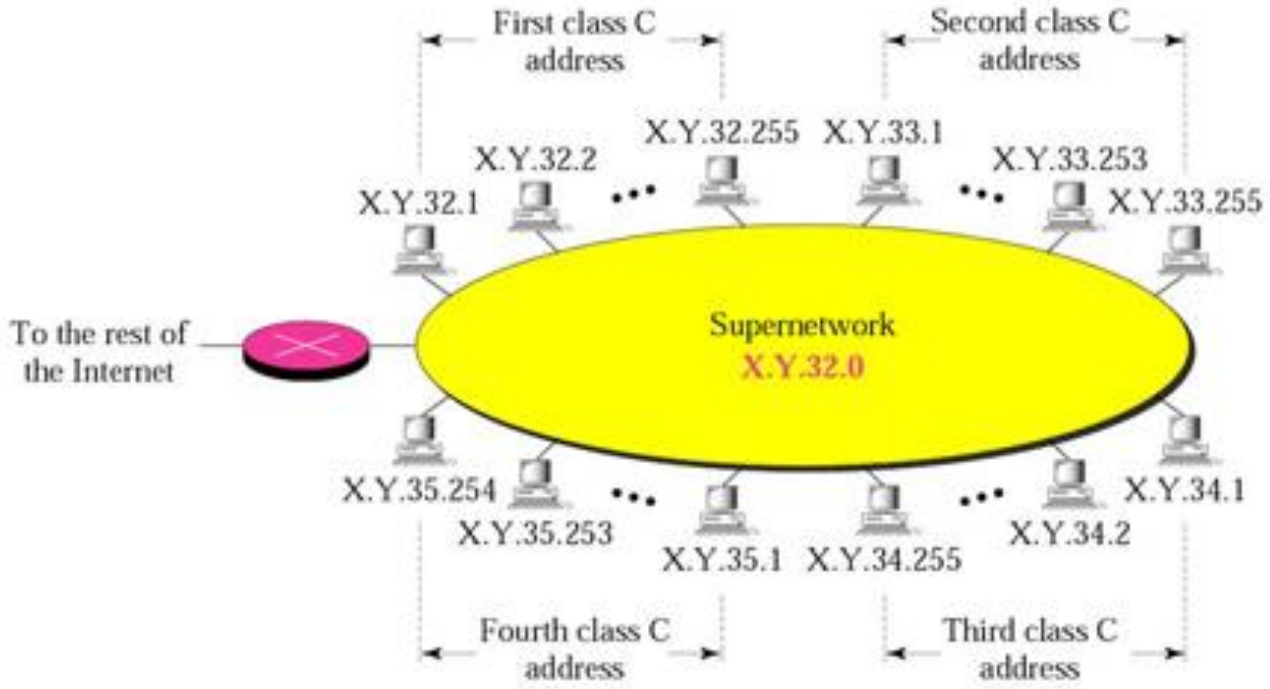
Addresses for private networks

Range			*Total*
10.0.0.0	to	10.255.255.255	2^{24}
172.16.0.0	to	172.31.255.255	2^{20}
192.168.0.0	to	192.168.255.255	2^{16}

Supernetting

- Supernetting is the opposite of Subnetting.
- In subnetting, a single big network is divided into multiple smaller subnetworks.
- In Supernetting, multiple networks are combined into a bigger network termed as a Supernetwork or Supernet.

Supernetting



Supernetting

- Supernetting is mainly used in Route Summarization, where routes to multiple networks with similar network prefixes are combined into a single routing entry, with the routing entry pointing to a Super network, encompassing all the networks.
- This in turn significantly reduces the size of routing tables and also the size of routing updates exchanged by routing protocols.

Supernetting Rules

1. All the Networks should be contiguous.
2. The block size of every networks should be equal and must be in form of 2^n.
3. First Network id should be exactly divisible by whole size of supernet.

Example

- Suppose 4 small networks :
- 200.1.0.0/24,
- 200.1.1.0/24,
- 200.1.2.0/24,
- 200.1.3.0/24
- Build a bigger network which have a single Network Id.

Explanation

- Before Supernetting routing table will be look like as:

NETWORK ID	SUBNET MASK	INTERFACE
200.1.0.0	255.255.255.0	A
200.1.1.0	255.255.255.0	B
200.1.2.0	255.255.255.0	C
200.1.3.0	255.255.255.0	D

Explanation

- First, lets check whether three condition are satisfied or not:

1. Contiguous: You can easily see that all network are contiguous all having size 256 hosts.

   Range of first Network from 200.1.0.0 to 200.1.0.255. If you add 1 in last IP address of first network that is 200.1.0.255 + 0.0.0.1, you will get the next network id that is 200.1.1.0. Similarly, check that all network are contiguous.

2. Equal size of all network: As all networks are of class C, so all of the have a size of 256 which in turn equal to 2^8.

Explanation

3. First IP address exactly divisible by total size: When a binary number is divided by 2^n then last n bits are the remainder. Hence in order to prove that first IP address is exactly divisible by while size of Supernet Network. You can check that if last n v=bits are 0 or not.

- In given example first IP is 200.1.0.0 and whole size of supernet is $4*2^8 = 2^{10}$. If last 10 bits of first IP address are zero then IP will be divisible.

11001000	00000001	00000000	00000000
200 .	1 .	0 .	0

- Last 10 bits of first IP address are zero (highlighted by green color). So 3rd condition is also satisfied.

Explanation

- Therefore, you can join all these 4 networks and can make a Supernet. New Supernet Id will be 200.1.0.0.

Advantages of Supernetting

1. Control and reduce network traffic
2. Helpful to solve the problem of lacking IP addresses
3. Minimizes the routing table

Disadvantages of Supernetting

- It cannot cover different area of network when combined
- All the networks should be in same class and all IP should be contiguous