IP Addressing Overview

- **Range:** 0.0.0.0 to 255.255.255.255
- **Types of IP Addresses:**
  - **Public IP:** Used for communication over the internet.
  - **Private IP:** Used within local networks (e.g., 192.168.x.x, 10.x.x.x, 172.16.x.x - 172.31.x.x).
  - **Broadcast IP:** Used to send data to all devices in a network.
  - **Multicast IP:** Used for group communication.
  - **Reserved IPs:** Used for scientific and research purposes.

Difference Between Subnet and Subnet Masking

Feature	Subnet	Subnet Mask
Definition	A subnet is a logical division of an IP network that allows better management of IP addresses.	A subnet mask is a numerical value used to define the boundary between the network and host portions of an IP address.
Purpose	Helps in segmenting a large network into smaller, manageable networks.	Determines which part of an IP address belongs to the network and which part to the host.
Representation	Represented as a network address (e.g., **192.168.1.0/24**).	Represented in dotted decimal or CIDR notation (e.g., **255.255.255.0** or **/24**).
Example	`192.168.1.0/24` (Subnet for a Class C network)	`255.255.255.0` (Subnet mask for `/24`)
Function	Groups devices into smaller networks for better traffic management.	Helps routers and hosts identify network and host portions of an IP address.

Example to Understand the Difference

- **IP Address:** 192.168.1.25
- **Subnet Mask:** 255.255.255.0
  - **Network Portion:** 192.168.1.0
  - **Host Portion:** .25
- **Subnet:** 192.168.1.0/24 (This defines the network and all possible host addresses in it.)

Classful Addressing in IPv4:

Classful addressing is a method of IP address allocation that divides the available IPv4 address space into five fixed classes: A, B, C, D, and E. This method was widely used before 1993 but has since been replaced by classless addressing (CIDR) due to inefficiencies in address allocation.

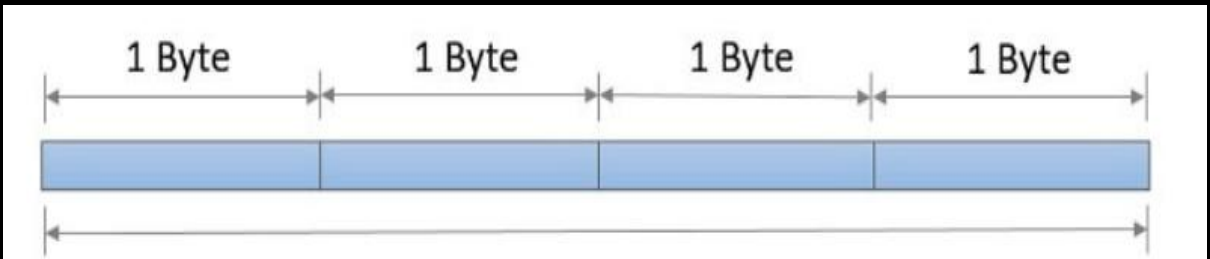
The classful addressing concepts divide the address space into a fixed number of blocks and each block has a fixed number of hosts. In IPv4 addresses of class A, B & C the first part of the address is considered as net-id (Network id) and the second part of the address is called host-id. The size of these parts varies with the classes.

- **Net-id:** The net-id denotes the address of the network.
- **Host-id:** The hoist-id denotes the address of the host attached to the corresponding network.

In Class A, the **net-id** is defined by the **first byte** of the address. And the **rest 3 bytes** defines the **host-id**.

In Class B, the **first two bytes** of the address defines the **network address** and the **rest two bytes** defines the **host-id**.

In Class C the **first three bytes** defines the **network address** and the **last byte** defines the **host-id**.

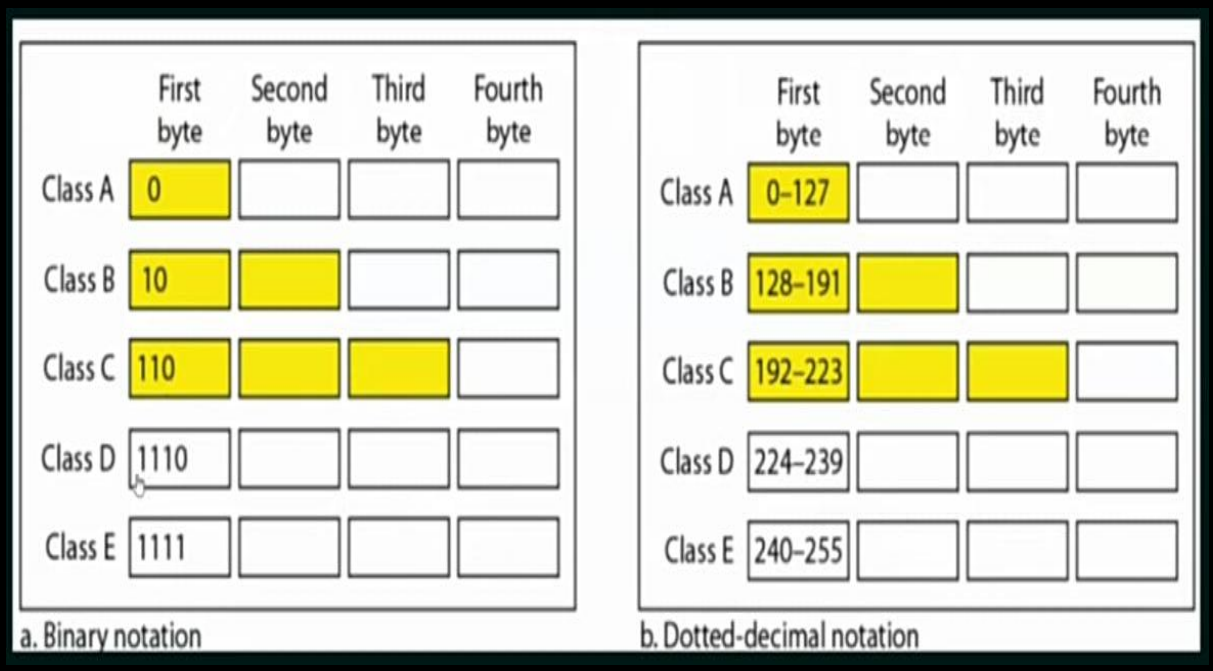


Key Features:

- IPv4 uses a 32-bit address format.
- The address space is divided into classes with fixed block sizes.
- Each class has a predefined number of networks and hosts.
- The first few bits of an IP address determine its class.

Network and Broadcast Address Calculation

- Given IP: **192.168.14.0**
  - **Network Address: 192.168.14.0** (First IP in the range)
  - **Broadcast Address: 192.168.15.255** (Last IP in the range)



Address Class	1st Octet range in decimal	1st Octet bits (Blue Dots do not change)	Network (N) and Host (H) Portion	Default mask (Decimal)	Number of possible networks and hosts per network
A	0–127	00000000 - 01111111	N.H.H.H	255.0.0.0	128 Nets (2^7) 16,777,214 hosts (2^{24}–2)
B	128–191	10000000 - 10111111	N.N.H.H	255.255.0.0	16,384 Nets (2^{14}) 65,534 hosts (2^{16}–2)
C	192–223	11000000 - 11011111	N.N.N.H	255.255.255.0	2,09,150 Nets (2^{21}) 254 hosts (2^8–2)
D	224–239	11100000 - 11101111	NA (Multicast)	-	-
E	240–255	11110000 - 11111111	NA (Experimental)	-	-

Subnet mask (Slash notation)

Class	Subnet Mask (in Decimal)	Subnet Mask (in Binary)	Slash Notation
A	255.0.0.0	11111111.00000000.00000000.00000000	/8
B	255.255.0.0	11111111.11111111.00000000.00000000	/16
C	255.255.255.0	11111111.11111111.11111111.00000000	/24

Activity Time!

Find the class of the following dotted decimal IPv4 addresses.

IP Address	Class
192.168.1.10	
10.10.200.6	
172.15.165.1	
230.10.65.30	

Find the class of the following IPv4 address:

a. 11110111 11110011 10000111 11011101

b. 10101111 11000000 11110000 00011101

c. 11011111 10110000 00011111 01011101

d. 11101111 11110111 11000111 00011101

Which of the following is an invalid subnet mask?

a. 255.255.0.0

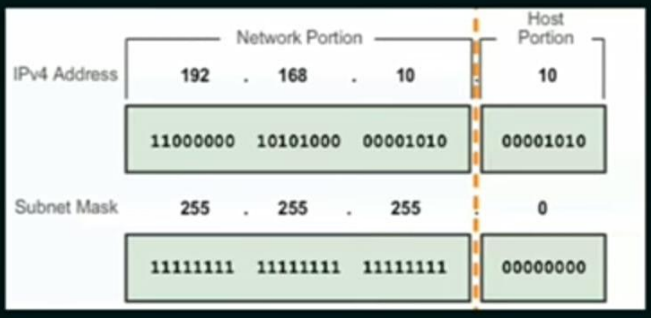
b. 255.0.0.0

c. 255.0.255.255

d. 255.255.255.0

Subnet Mask

- ★ To define the network and host portions of an address, a devices use a separate 32-bit pattern called a subnet mask.
- ★ The subnet mask does not actually contain the network or host portion of an IPv4 address, it just says where to look for these portions in a given IPv4 address



Subnet Mask

10.10.10.1
10.10.20.16
255.0.0.0 ; Same N/W

10.10.10.1
10.10.20.16
255.255.255.0 ; Different N/W

172.16.200.1
172.16.165.2
255.255.0.0 ; Same N/W

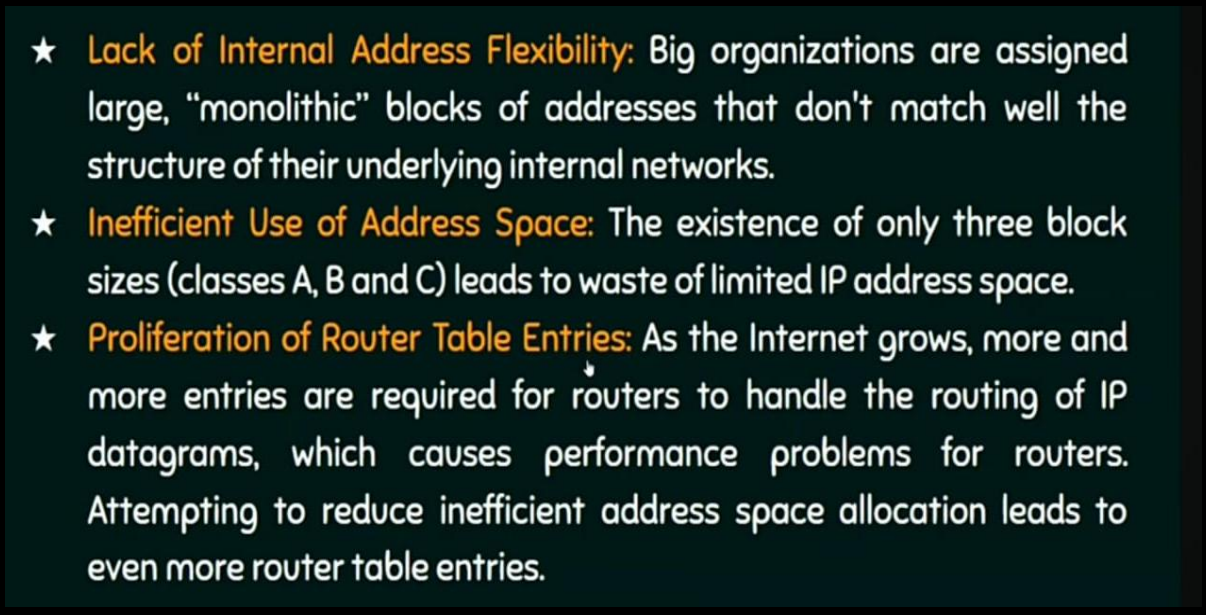
172.16.200.1
172.16.165.2
255.255.255.0 ; Different N/W

10.10.36.1
10.10.12.1
255.255.0.0 ; Same N/W

10.10.36.1
10.10.12.1
255.255.255.0

Disadvantages of Classful Addressing:

Classful addressing suffers from inefficient allocation of IP addresses, leading to significant wastage. The key issues include:



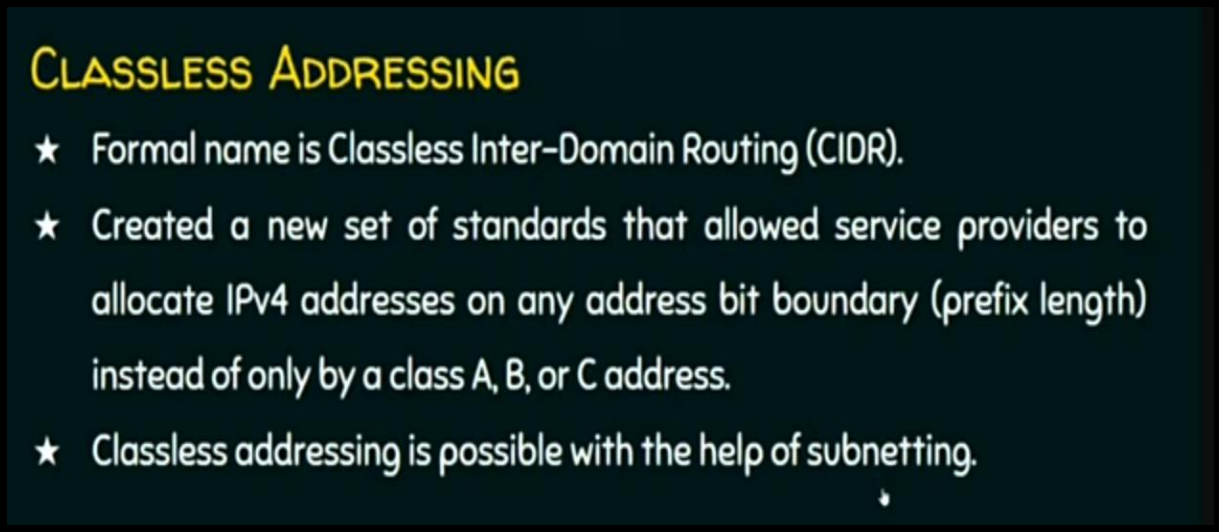
- Wastage in Class A: Each block contains an excessively large number of addresses, far more than any single organization typically needs.
- Wastage in Class B: Organizations receiving Class B blocks may not require the full range of addresses, leading to unused IPs.
- Insufficient Addresses in Class C: A single Class C block may be too small to meet an organization's requirements.
- Inefficiency in Class D: These addresses are used for multicast, meaning each address defines a group of hosts, which may not always be fully utilized.
- Reserved Class E: These addresses are reserved for future use, further reducing the available address pool.

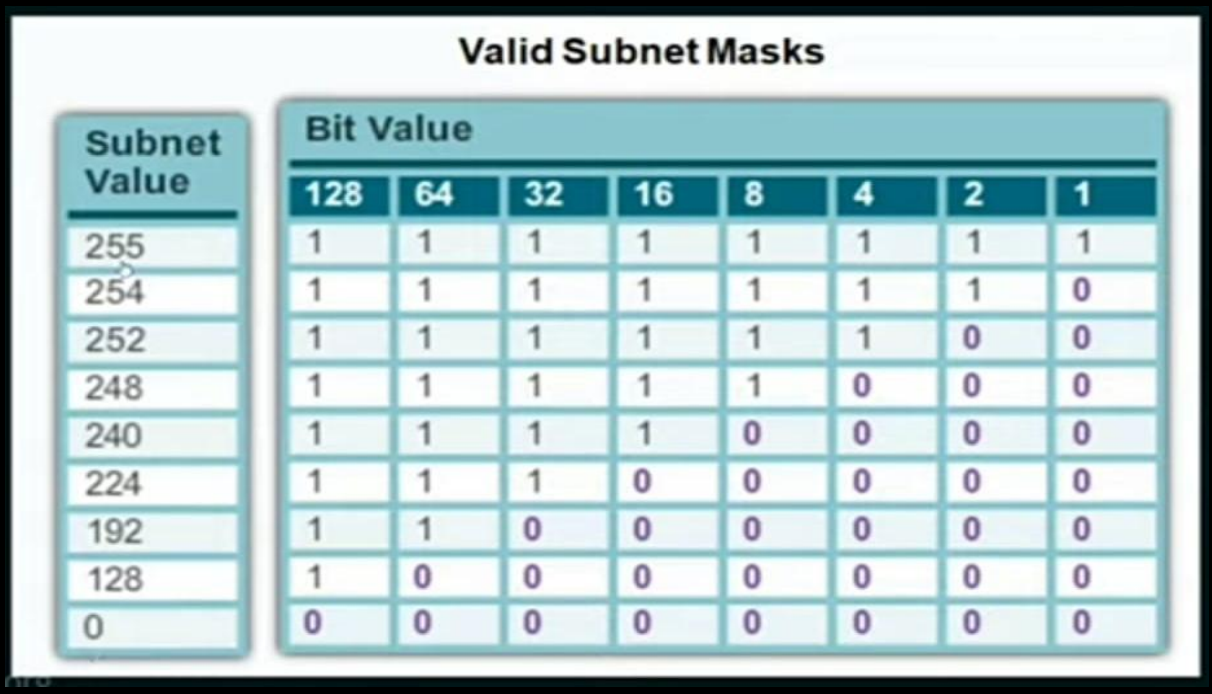
Key Issue

Classful addressing assigns fixed-size blocks, ignoring actual user requirements. This rigid allocation leads to significant address wastage.

CIDR (Classless Inter-Domain Routing)

- CIDR (Classless Addressing): Allows flexible allocation of IP addresses.
- Eliminates rigid classful addressing (Class A, B, C).





Subnet Value	Bit Value							
	128	64	32	16	8	4	2	1
255	1	1	1	1	1	1	1	1
254	1	1	1	1	1	1	1	0
252	1	1	1	1	1	1	0	0
248	1	1	1	1	1	0	0	0
240	1	1	1	1	0	0	0	0
224	1	1	1	0	0	0	0	0
192	1	1	0	0	0	0	0	0
128	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Valid Subnet masks

/n	Mask	/n	Mask	/n	Mask	/n	Mask
/1	128.0.0.0	/9	255.128.0.0	/17	255.255.128.0	/25	255.255.255.128
/2	192.0.0.0	/10	255.192.0.0	/18	255.255.192.0	/26	255.255.255.192
/3	224.0.0.0	/11	255.224.0.0	/19	255.255.224.0	/27	255.255.255.224
/4	240.0.0.0	/12	255.240.0.0	/20	255.255.240.0	/28	255.255.255.240
/5	248.0.0.0	/13	255.248.0.0	/21	255.255.248.0	/29	255.255.255.248
/6	252.0.0.0	/14	255.252.0.0	/22	255.255.252.0	/30	255.255.255.252
/7	254.0.0.0	/15	255.254.0.0	/23	255.255.254.0	/31	255.255.255.254
/8	255.0.0.0	/16	255.255.0.0	/24	255.255.255.0	/32	255.255.255.255

/2 : 11000000.00000000.00000000.00000000

Valid and Invalid Subnet Masks

Subnet Mask (Decimal)	Subnet Mask (Binary)	Valid/ Invalid
255.255.255.240		
255.230.255.0		
255.255.0.0		
240.0.0.0		
223.0.0.0		
255.0.255.0		

Valid and Invalid Subnet Masks

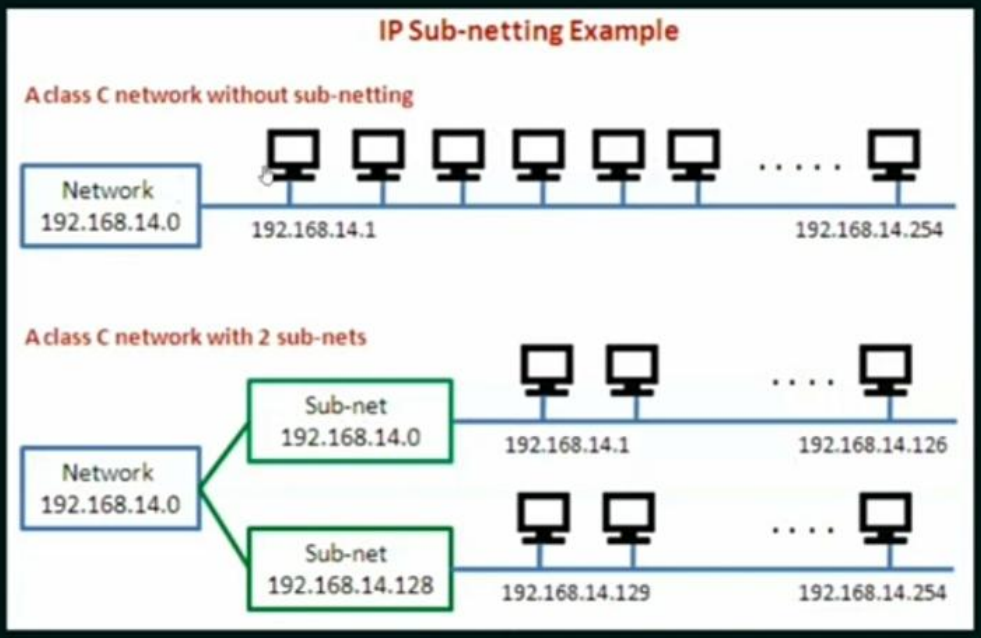
Subnet Mask (Decimal)	Subnet Mask (Binary)	Valid/ Invalid
255.255.255.240	11111111.11111111.11111111.11110000	Valid
255.230.255.0	11111111.11100110.11111111.00000000	Invalid
255.255.0.0	11111111.11111111.00000000.00000000	Valid
240.0.0.0	11110000.00000000.00000000.00000000	Valid
223.0.0.0	11011111.00000000.00000000.00000000	Invalid
255.0.255.0	11111111.00000000.11111111.00000000	Invalid

Identify the Invalid subnet mask from the following.

a. 255.240.0.0
b. 248.0.0.0
c. 255.255.128.0
d. 255.255.255.252
e. 255.255.242.0

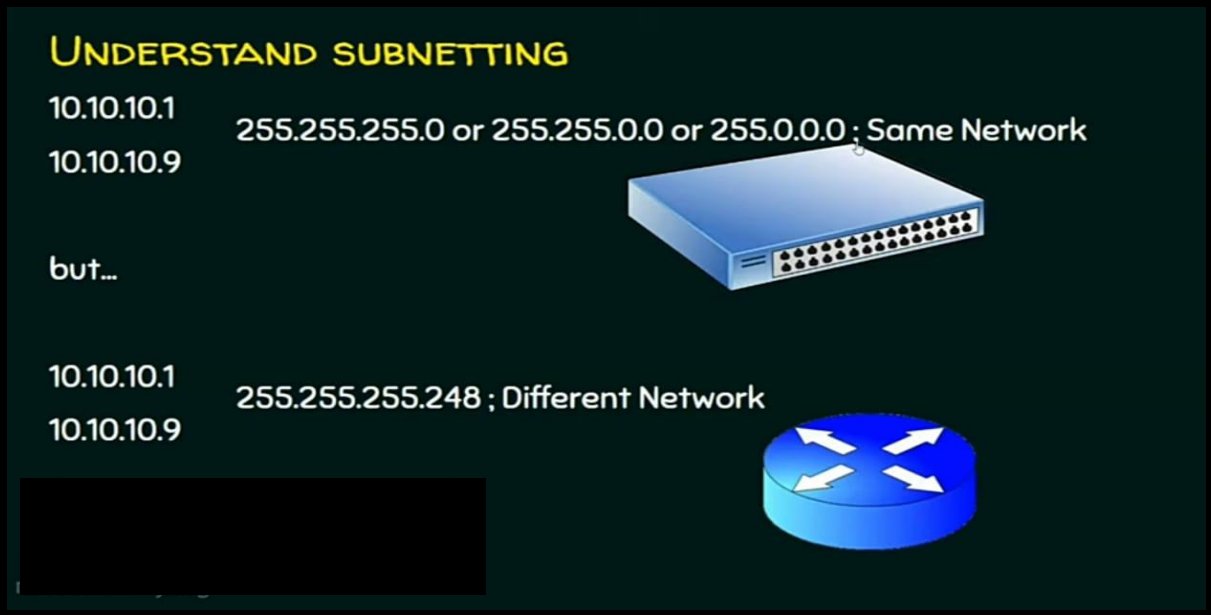
SUBNETTING

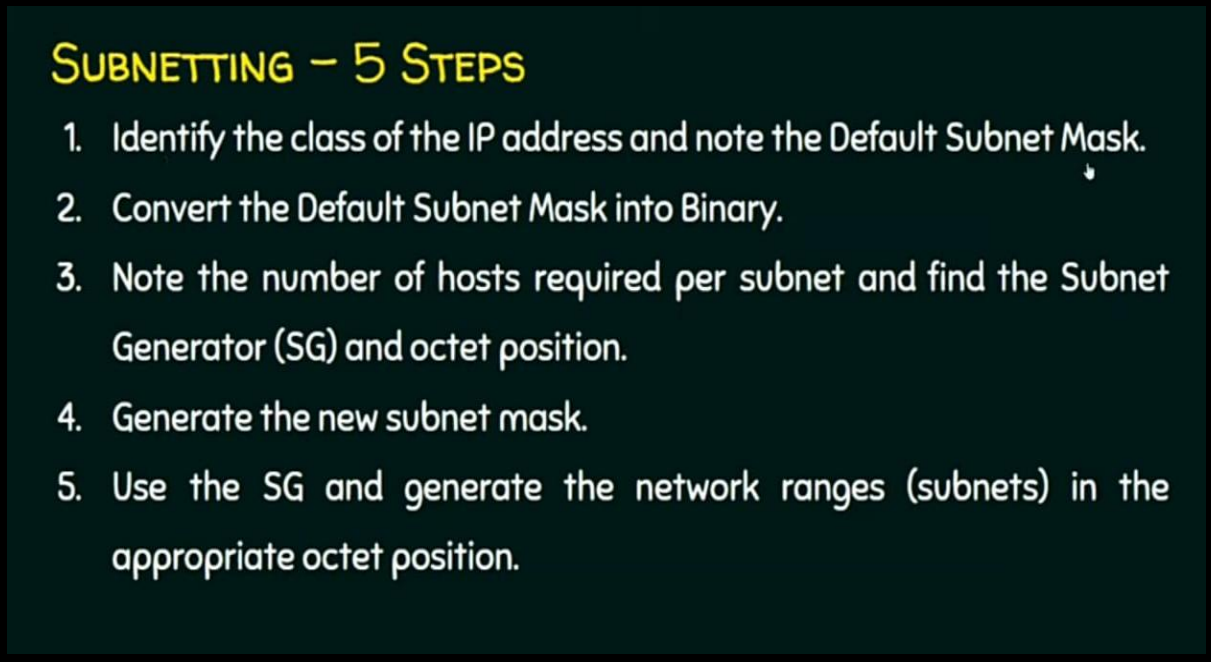
- ★ A subnetwork or subnet is a logical subdivision of an IP network.
- ★ The practice of dividing a network into two or more networks is called subnetting.
- ★ Computers that belong to a subnet are addressed with an identical most-significant bit-group in their IP addresses.



Subnetting:

- Divides a large network into smaller sub-networks (subnets).
- Improves efficiency and security.
- Helps optimize IP address usage.





QUESTION

Subnet the IP address 216.21.5.0 into 30 hosts in each subnet.

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 30 (11110) – 5 bits SG: 32 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0
4. New subnet mask: 255.255.255.224 or /27
5. Network Ranges (Subnets)
   216.21.5.0 – 216.21.5.31
   216.21.5.32 – 216.21.5.63
   216.21.5.64 – 216.21.5.95
   216.21.5.96 – 216.21.5.127
   216.21.5.128 – 216.21.5.159
   and so on....

QUESTION

Subnet the IP address 196.10.20.0 into 52 hosts in each subnet.

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 52 (110100) – 6 bits SG: 64 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0
4. New subnet mask: 255.255.255.192 or /26
5. Network Ranges (Subnets)
   196.10.20.0 – 196.10.20.63
   196.10.20.64 – 196.10.20.127
   196.10.20.128 – 196.10.20.191
   196.10.20.192 – 196.10.20.255

QUESTION

Subnet the IP address 150.15.0.0 into 500 hosts in each subnet.

SOLUTION

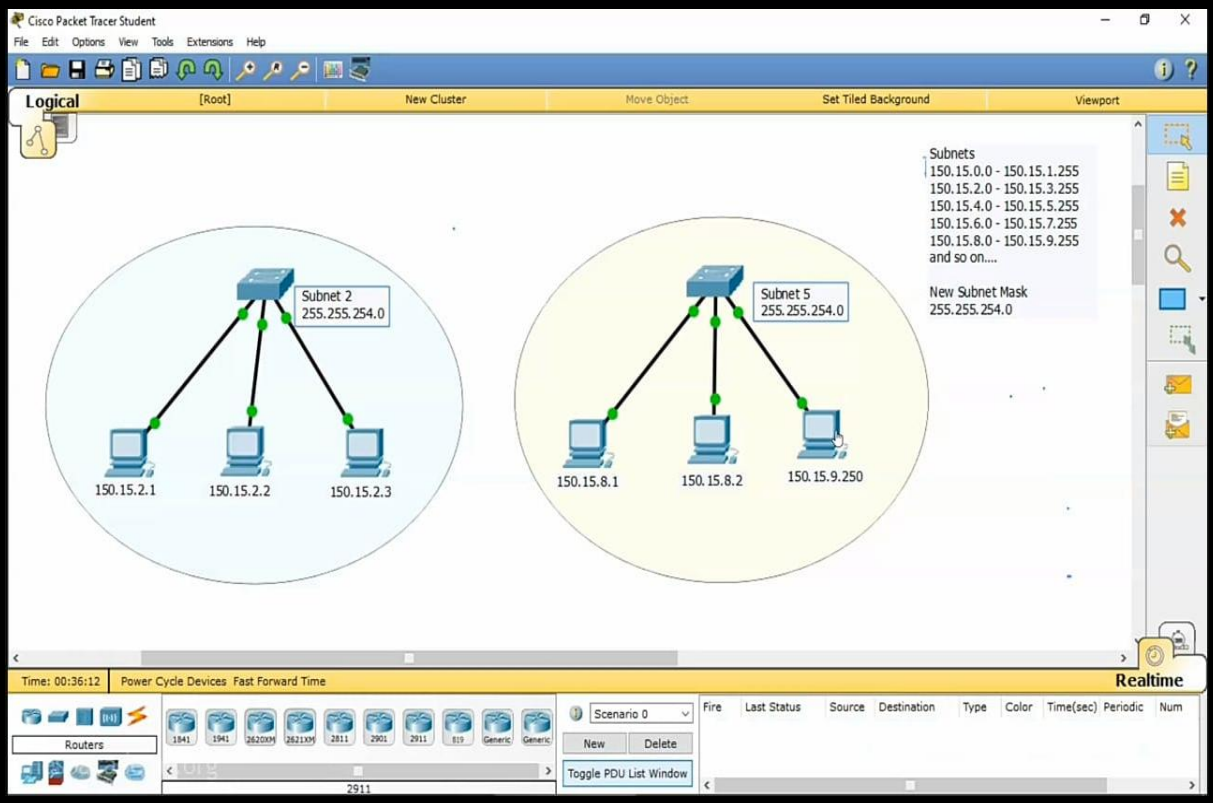
1. Class B – Default Subnet Mask: 255.255.0.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 500(111110100)–9 bits SG: 2 Octet Position: 3

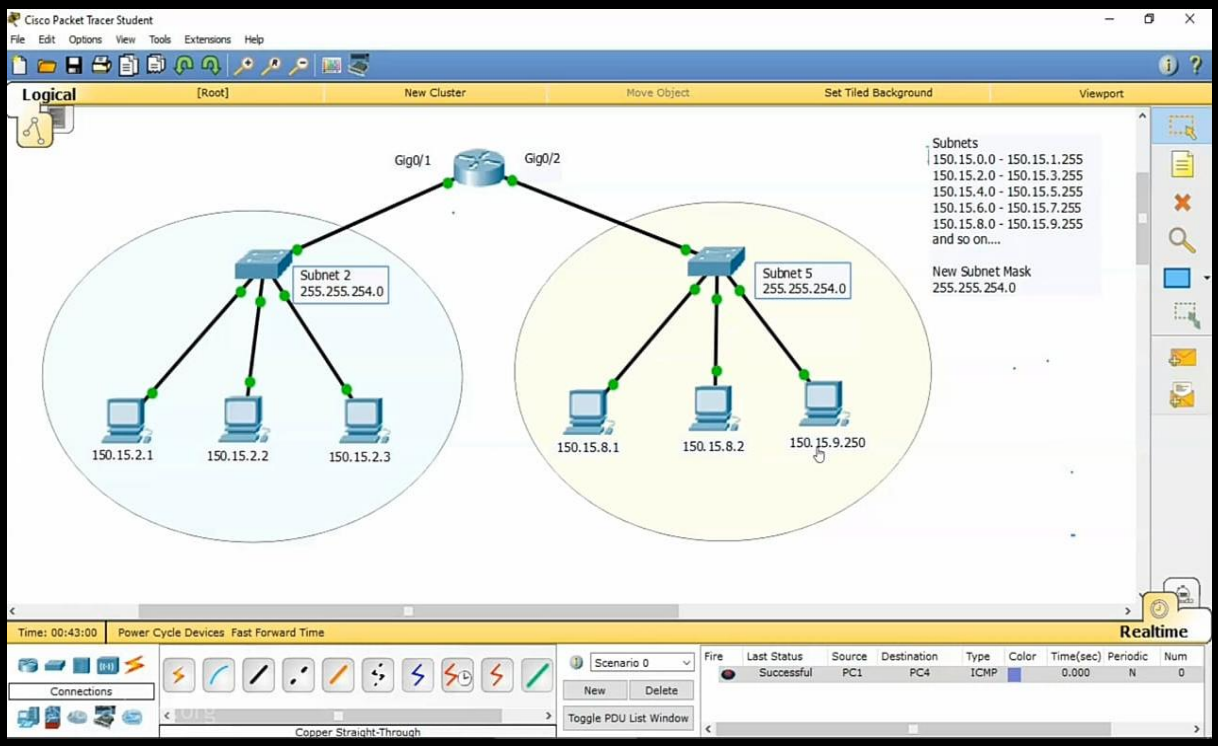
   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0 . 0 0 0 0 0 0 0 0
4. New subnet mask: 255.255.254.0 or /23
5. Network Ranges (Subnets)

   150.15.0.0 – 150.15.1.255
   150.15.2.0 – 150.15.3.255
   150.15.4.0 – 150.15.5.255
   150.15.6.0 – 150.15.7.255
   150.15.8.0 – 150.15.9.255
   and so on....

2^9 = 512 Hosts per Network (Subnet)
2^7 = 128 Subnets (Networks)

Inter-Subnet / Inter-LAN Communication using CPT:





Subnetting

- Used to divide large Class A and Class B networks into smaller subnetworks.
- Helps organizations efficiently utilize address space by allocating only the necessary number of IPs.
- Allows different subnets within the same organization to communicate more effectively.

Supernetting

- Designed to solve the issue of small Class C blocks being insufficient for many organizations.
- Combines multiple contiguous Class C blocks into a larger network, fulfilling the organization's needs.
- Reduces the number of routing table entries by aggregating smaller networks into a single entity.
- Example: Two /25 networks (192.168.1.0/25 and 192.168.1.128/25) can be aggregated into 192.168.1.0/24.

CIDR (Classless Inter-Domain Routing)

Definition

CIDR is a method for allocating IP addresses and routing Internet Protocol packets without relying on the traditional class-based IP addressing scheme (Class A, B, C). It improves address utilization and efficiency.

Key Features:

- Removes fixed class-based subnetting.
- Uses a flexible subnet mask to allocate addresses efficiently.
- Introduced CIDR notation (e.g., 192.168.1.0/24).

CIDR Notation

CIDR notation represents an IP address along with a suffix that indicates the number of bits used for the network portion. Example:

- An IP address followed by a / and a number (prefix length).
- **192.168.1.0/24** means the first 24 bits represent the network, and the remaining 8 bits represent hosts.
- **172.16.0.0/16** means the first 16 bits are for the network, and the remaining 16 bits are for hosts.
- **The subnet mask is derived from the prefix:**
  - **/8 → 255.0.0.0**
  - **/16 → 255.255.0.0**
  - **/24 → 255.255.255.0**

Benefits of CIDR

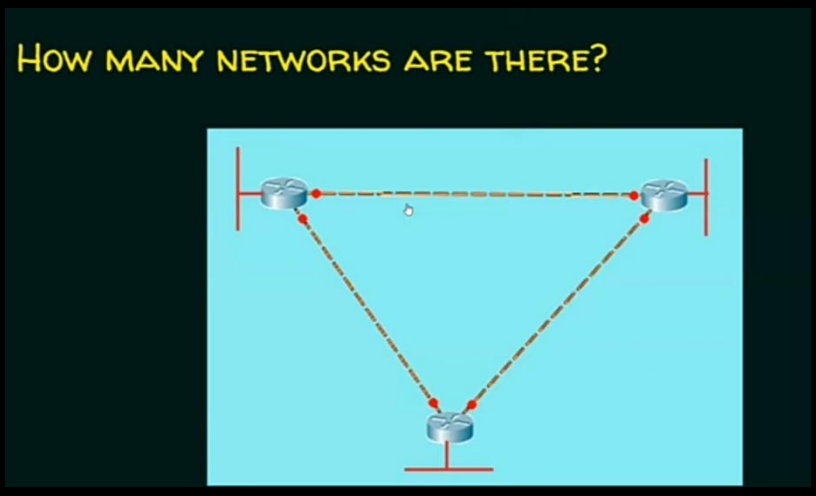
- **More Efficient IP Address Allocation**: Prevents wastage of IP addresses.
- **Reduces Size of Routing Tables**: Aggregates multiple networks into a single route.
- **Allows Supernetting**: Combines multiple smaller networks into a larger one.
- **Eliminates Class Boundaries**: Provides flexibility beyond Class A, B, and C networks.

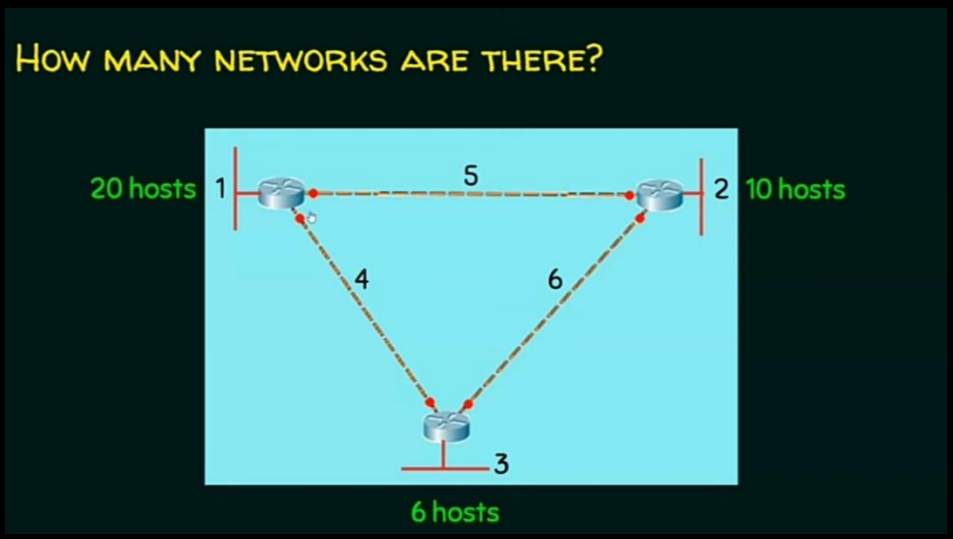
Example of CIDR Aggregation

Instead of having multiple networks like:

- 192.168.0.0/24
- 192.168.1.0/24
- 192.168.2.0/24

CIDR allows them to be represented as **192.168.0.0/22**, which covers the range 192.168.0.0 – 192.168.3.255.



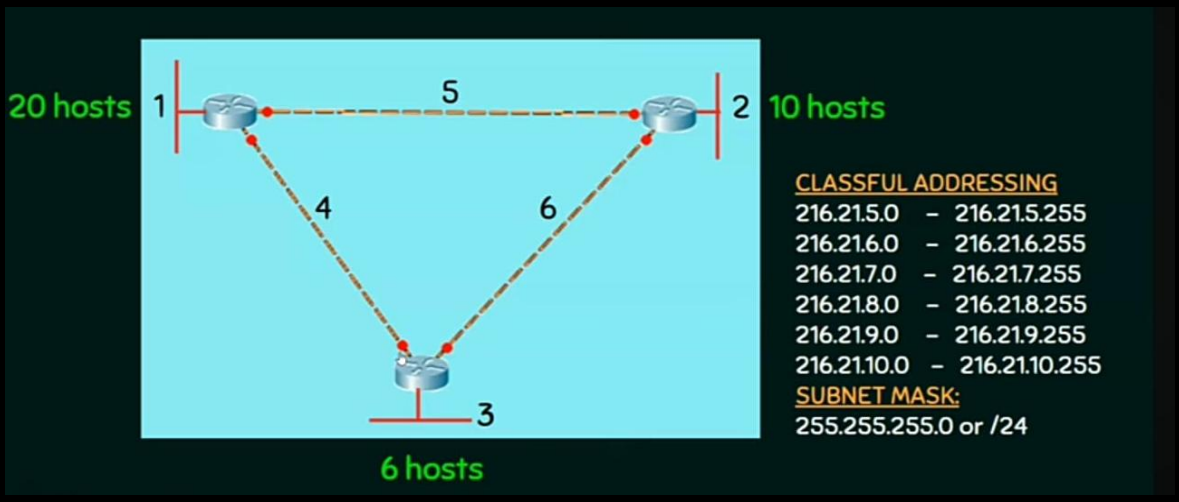


FLSM (Fixed Length Subnet Masking)

A fixed-length subnet mask (FLSM) is a method for dividing a network into subnets of equal size. FLSM is also known as classful subnetting.

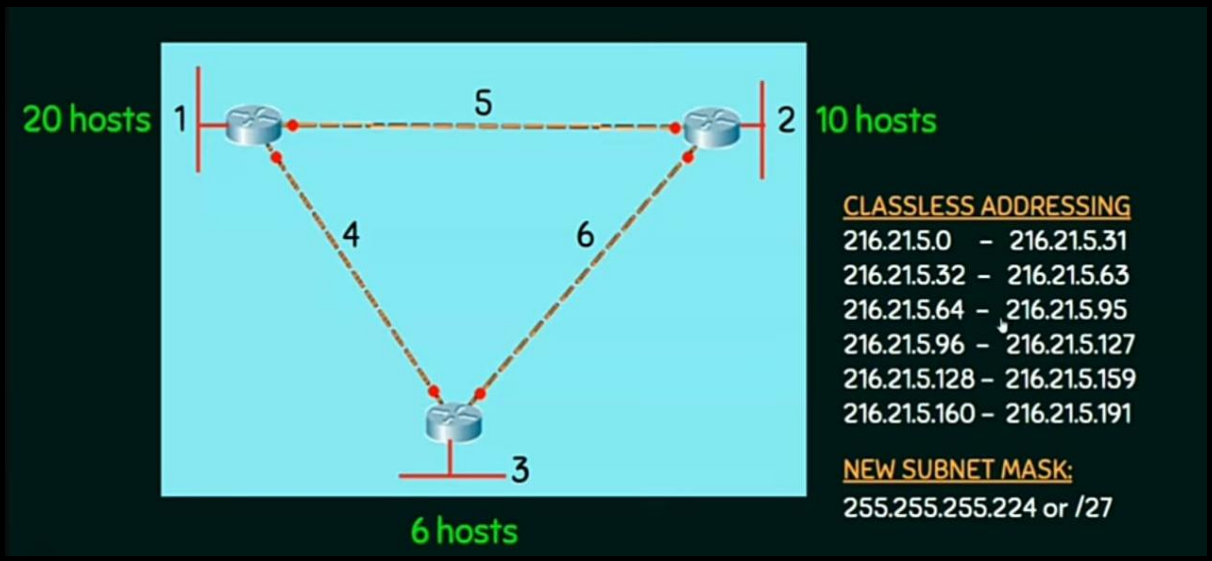
How it works:

- A block of IP addresses is divided into subnets of equal length.
- The same subnet mask is used for all subnets.
- FLSM can be used to create subnets for local area networks (LANs), security boundaries, or other purposes.



VLSM (Variable Length Subnet Masking)

VLSM is a subnetting technique that allows different subnet masks to be used within the same network, optimizing address space usage.



Key Features:

- Efficient IP address allocation by assigning subnets based on need.
- Uses multiple subnet masks within the same network.
- Works well with CIDR to avoid wastage.

Need for VLSM

- Traditional subnetting wastes addresses when all subnets have the same fixed size.
- Different subnet sizes can be used depending on the number of required hosts in each subnet.

Example of VLSM

Consider a network **192.168.1.0/24**, which needs:

- A subnet for 100 hosts
- A subnet for 50 hosts
- A subnet for 10 hosts

Using VLSM:

- **192.168.1.0/25** → 126 usable addresses (for 100 hosts)
- **192.168.1.128/26** → 62 usable addresses (for 50 hosts)
- **192.168.1.192/28** → 14 usable addresses (for 10 hosts)

Advantages of VLSM

- **Efficient IP Utilization**: No wastage of addresses.
- **Optimized Subnet Design**: Networks can have subnet sizes based on actual needs.
- **Better Route Aggregation**: Reduces number of entries in routing tables.

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4. CIDR vs. VLSM

Feature	CIDR	VLSM
Purpose	Aggregates networks for routing	Subdivides a network into varying subnet sizes
Usage	Used in ISP and large-scale routing	Used within an organization for efficient subnetting
Efficiency	Reduces global routing table size	Saves IP addresses within an organization
Example	192.168.0.0/22 (combining networks)	192.168.1.0/25, /26, /28 (subdividing a network)

Practical Application of CIDR and VLSM

CIDR in the Internet

- ISPs use CIDR to allocate IP address blocks efficiently.
- Reduces the size of routing tables in global routers.

VLSM in Enterprise Networks

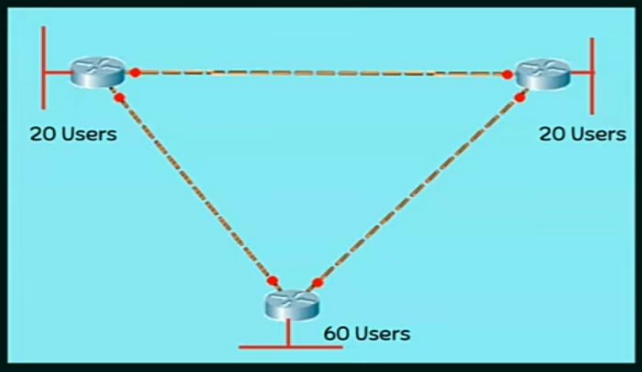
- Used to create different-sized subnets within an organization.
- Prevents waste of IP addresses when assigning them to departments with varying sizes.

Summary

- **CIDR** is used for efficient IP allocation and routing by eliminating fixed classes.
- **VLSM** allows for better subnetting by assigning different mask lengths based on need.
- Both concepts help in conserving IP address space and improving network efficiency.

Practice Questions

Subnet 192.168.10.0/24 to address the network by using the most efficient addressing possible.



SUBNETTING – 5 STEPS

1. Identify the class of the IP address and note the Default Subnet Mask.
2. Convert the Default Subnet Mask into Binary.
3. Note the number of hosts required per subnet and find the Subnet Generator (SG) and octet position.
4. Generate the new subnet mask.
5. Use the SG and generate the network ranges (subnets) in the appropriate octet position.

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 60 (111100) – 6 bits SG: 64 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0
4. New subnet mask: 255.255.255.192 or /26 (Only for the biggest network)
5. Network Ranges (Subnets)
   192.168.10.0 – 192.168.10.63 /26 (Handover this to 60 Users Network)
   192.168.10.64

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 20 (10100) – 5 bits SG: 32 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0
4. New subnet mask: 255.255.255.224 or /27
5. Network Ranges (Subnets)
   192.168.10.0 – 192.168.10.63 /26 (Handover this to 60 Users Network)
   192.168.10.64 – 192.168.10.95 /27 (Handover this to 20 Users Network)

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 20 (10100) – 5 bits SG: 32 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0
4. New subnet mask: 255.255.255.224 or /27
5. Network Ranges (Subnets)
   192.168.10.0 – 192.168.10.63 /26 (Handover this to 60 Users Network)
   192.168.10.64 – 192.168.10.95 /27 (Handover this to 20 Users Network)
   192.168.10.96 – 192.168.10.127 /27 (Handover this to another 20 Users Network)

SOLUTION

1. Class C – Default Subnet Mask: 255.255.255.0
2. 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0
3. No. of hosts/subnet: 2 (10) – 2 bits SG: 4 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 0 0
4. New subnet mask: 255.255.255.252 or /30
5. Network Ranges (Subnets)
   192.168.10.0 – 192.168.10.63 /26 (Handover this to 60 Users Network)
   192.168.10.64 – 192.168.10.95 /27 (Handover this to 20 Users Network)
   192.168.10.96 – 192.168.10.127 /27 (Handover this to another 20 Users Network)
   192.168.10.128–192.168.10.131 / 30 (Handover this to Crossover Link)

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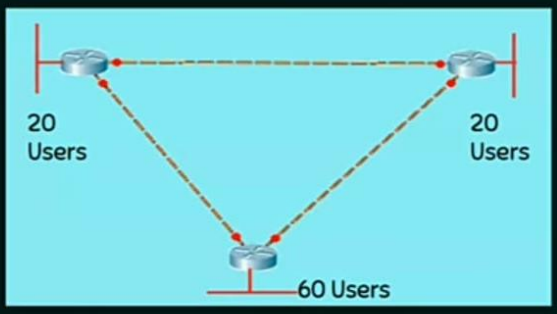

1. What is the purpose of CIDR, and how does it improve IP address allocation?
2. How does CIDR help in reducing the size of global routing tables?
3. What is the main advantage of using VLSM over fixed-length subnetting?
4. Given the network 10.0.0.0/8, how would you use VLSM to allocate subnets for departments needing 500, 200, and 50 hosts?