Experiment No: 2
Experiment Name: Study and Configuration of IP Addressing and Subnetting in a LAN.

Objectives:
By the end of this experiment, students will be able to:

- Understand IPv4 addressing and classification.
- Distinguish between public and private IP addresses.
- Perform fixed-length subnetting and calculate subnet ranges.
- Use CIDR notation for efficient IP representation.
- Assign IP addresses to PCs and routers in Cisco Packet Tracer.
- Test connectivity using basic network commands.

Theoretical Background:

1. IPv4 Address Structure

- **IPv4** is a 32-bit address, divided into 4 octets.
- Written in **dotted decimal** format, e.g., 192.168.1.1

2. IP Address Classes

Class	Range	Default Subnet Mask	Use Case
A	1.0.0.0 – 126.255.255.255	255.0.0.0 (/8)	Large organizations
B	128.0.0.0 – 191.255.255.255	255.255.0.0 (/16)	Medium networks
C	192.0.0.0 – 223.255.255.255	255.255.255.0 (/24)	Small networks

3. Private vs Public IP Addresses

Address Type	Class A	Class B	Class C
Private	10.0.0.0 – 10.255.255.255	172.16.0.0- 172.31.255.255	192.168.0.0 – 192.168.255.255
Public	All other addresses not reserved as private or special use		

4. Subnet Masks and CIDR Notation

- **Subnet Mask** defines the **network vs host** portion.
- **CIDR** (Classless Inter-Domain Routing) notation, e.g., /24 means **255.255.255.0**.

CIDR	Subnet Mask	Hosts per Subnet
/24	255.255.255.0	254
/25	255.255.255.128	126
/26	255.255.255.192	62

Example-01: Suppose you are given an IP address of **192.168.10.33/27**. Find out the Network ID, Broadcast ID, first and last valid IP, subnet mask and possible valid host per network.

Solution:

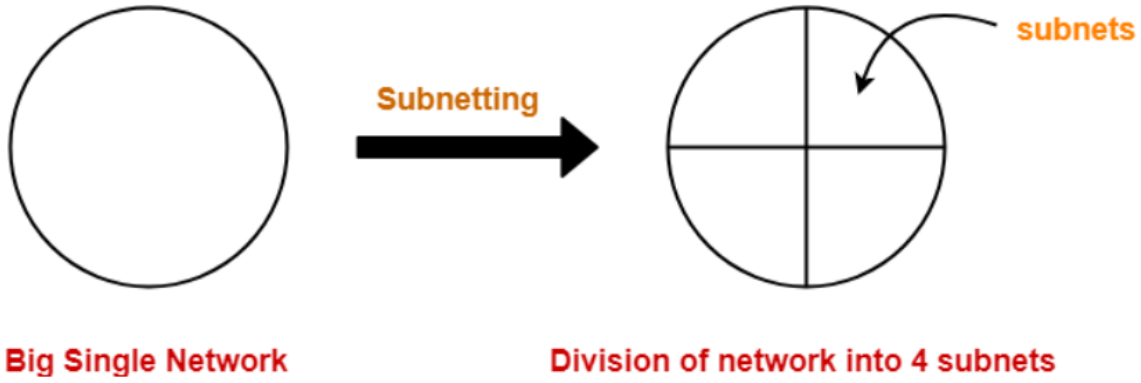
Given IP: 192.168.10.33/27 → In Binary form: 11000000. 10101000. 00001010.001/00001

- NA: 11000000. 10101000. 00001010.001/00000 → 192.168.10. 32
- BA: 11000000. 10101000. 00001010.001/11111 → 192.168.10. 63
- 1st HA: 192.168.10.33
- LAST HA: 192.168.10.62
- SM: 11111111. 11111111. 11111111. 111/00000 → 255. 255. 255. 224
- Possible Valid host: 2^5-2=32-2=30

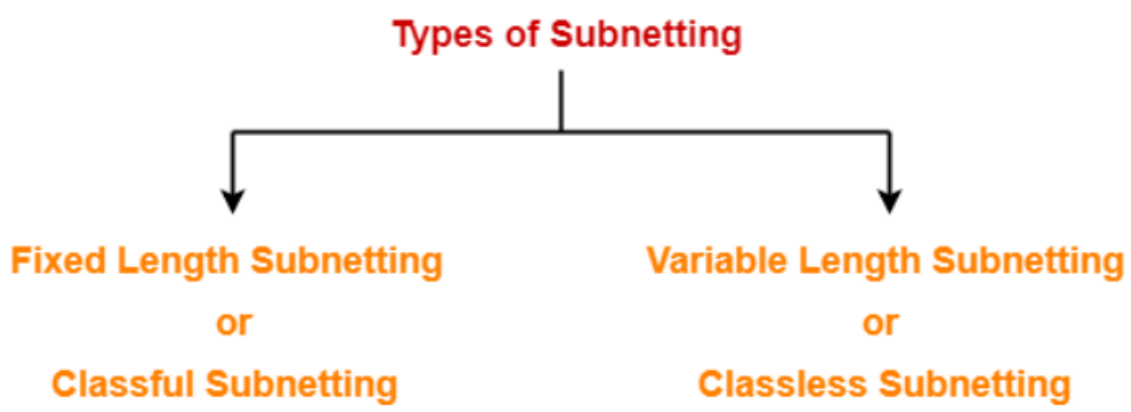
Example-02 (Self-Study): Suppose you are given an IP address of **172.16.16.10/22**. Find out the subnet mask, Network ID, Broadcast ID, first and last valid IP and possible host per network.

Subentting: In networking, the process of dividing a single network into multiple sub networks is called as subnetting. The sub networks so created are called as subnets.

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



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.

Example of Fixed Length IP Addressing

Let's take a **Class C** network:
Network Address: 192.168.10.0/24
This provides **256 IPs** (254 usable hosts, as 2 are reserved for network and broadcast).

Now let's say you want to create **4 equal subnets**. Using FLSM:

- We need to divide 256 IPs into 4 equal subnets.
- 256 ÷ 4 = 64 IPs per subnet.
- Subnet mask needed: **/26** (since 26 = 64)

Subnet Details:

Subnet	Network Address	Subnet Mask	First Host	Last Host	Broadcast Address
1	192.168.10.0	255.255.255.192 (/26)	192.168.10.1	192.168.10.62	192.168.10.63
2	192.168.10.64	255.255.255.192	192.168.10.65	192.168.10.126	192.168.10.127
3	192.168.10.128	255.255.255.192	192.168.10.129	192.168.10.190	192.168.10.191
4	192.168.10.192	255.255.255.192	192.168.10.193	192.168.10.254	192.168.10.255

Key Points:

- **Each subnet** has **64 IPs (62 usable)**.
- Even if a department needs only 10 hosts, it still gets 62 — hence **wastage**.
- Easier to manage than VLSM but **less efficient** in IP utilization.

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.

Scenario:

You are given a **Class C network:** `192.168.1.0/24` **(256 IPs)**
You need to create subnets for the following departments:

Department	Hosts Needed
Admin	100
Sales	50
Accounts	20
Management	10

Step-by-Step VLSM Allocation:

Start with the largest subnet first (Admin needs 100 hosts)

1. Admin — Needs 100 hosts

- Nearest power of 2 ≥ 100 → 128 IPs → `/25` subnet
- Subnet: `192.168.1.0/25` → Hosts: 192.168.1.1 – 192.168.1.126
- Broadcast: `192.168.1.127`

2. Sales — Needs 50 hosts

- Nearest power of 2 ≥ 50 → 64 IPs → `/26` subnet
- Next available block: `192.168.1.128/26`
- Hosts: 192.168.1.129 – 192.168.1.190
- Broadcast: `192.168.1.191`

3. Accounts — Needs 20 hosts

- Nearest power of 2 ≥ 20 → 32 IPs → `/27` subnet
- Next block: `192.168.1.192/27`
- Hosts: 192.168.1.193 – 192.168.1.222
- Broadcast: `192.168.1.223`

4. Management — Needs 10 hosts

- Nearest power of 2 ≥ 10 → 16 IPs → `/28` subnet
- Next block: `192.168.1.224/28`
- Hosts: 192.168.1.225 – 192.168.1.238
- Broadcast: `192.168.1.239`

Summary Table:

Department	Subnet Address	Subnet Mask	Host Range	Broadcast
Admin	192.168.1.0/25	255.255.255.128	192.168.1.1 – 126	192.168.1.127
Sales	192.168.1.128/26	255.255.255.192	192.168.1.129 – 190	192.168.1.191
Accounts	192.168.1.192/27	255.255.255.224	192.168.1.193 – 222	192.168.1.223
Management	192.168.1.224/28	255.255.255.240	192.168.1.225 – 238	192.168.1.239

Advantages of VLSM:

- Efficient IP utilization
- Custom-fit subnets based on host requirements
- Minimizes IP wastage

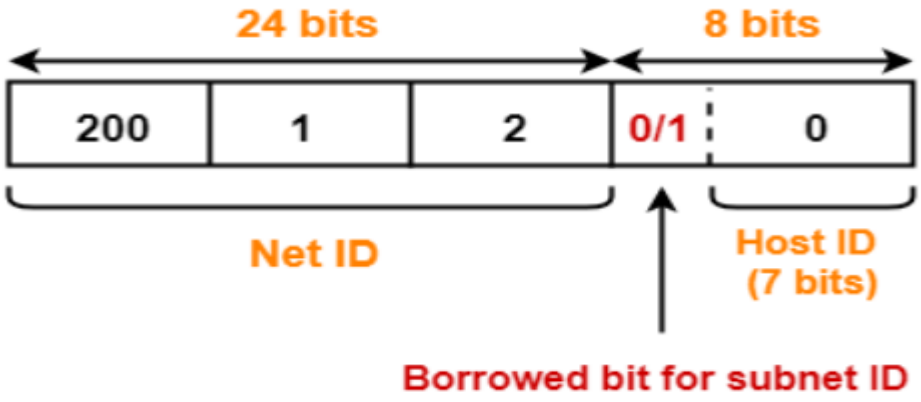
Example-01: Consider, we have a big single network having IP Address 200.1.2.0. We want to do subnetting and divide this network into 2 subnets.

Solution:

Clearly, the given network belongs to class C

For creating two subnets and to represent their subnet IDs, we require 1 bit. So,

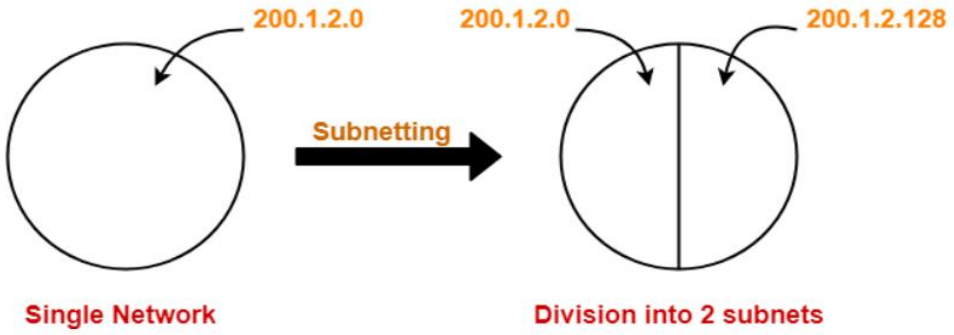
- We borrow one bit from the Host ID part.
- After borrowing one bit, Host ID part remains with only 7 bits



- 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.**0**0000000 = 200.1.2.0
- 200.1.2.**1**0000000 = 200.1.2.128



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.**0**0000000, 200.1.2.**0**1111111] = [200.1.2.0, 200.1.2.127]
- Direct Broadcast Address = 200.1.2.**0**1111111 = 200.1.2.12
- Limited Broadcast Address = 255.255.255.255

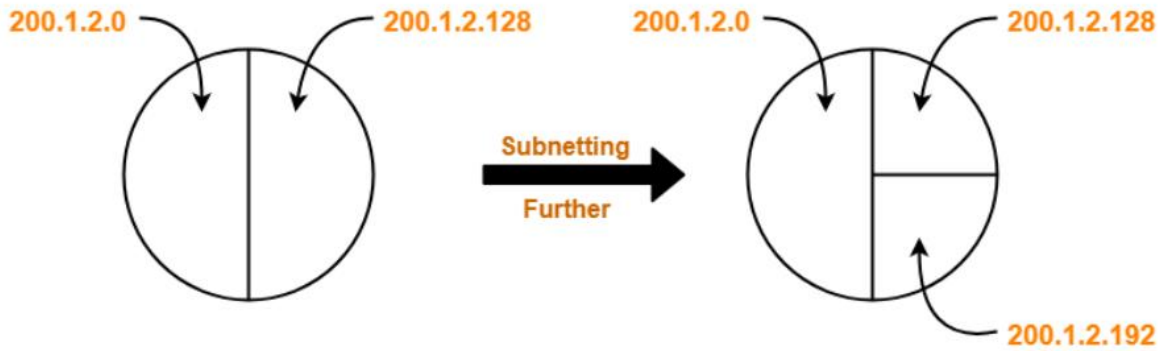
For 2nd Subnet

- 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.**1**0000000, 200.1.2.**1**1111111] = [200.1.2.128, 200.1.2.255]
- Direct Broadcast Address = 200.1.2.**1**1111111 = 200.1.2.255
- Limited Broadcast Address = 255.255.255.255

Example-02 (Self-Study): 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.

Example-03 (Self-Study): 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.

Hints for Example-03:



Lab Setup in Cisco Packet Tracer

Devices Required:

- 2 PCs
- 1 Switch
- (Optional) 1 Router

Step-by-Step Procedure:

1. Connect Devices

- Connect PCs to Switch using straight-through cables.
- Optionally, connect a router to the switch.

2. Assign IP Addresses to PCs

Device	IP Address	Subnet Mask	Default Gateway
PC0	192.168.1.10	255.255.255.0	192.168.1.1
PC1	192.168.1.11	255.255.255.0	192.168.1.1

- On each PC:
  - Go to **Desktop > IP Configuration**
  - Enter IP address, subnet mask, and default gateway

3. Assign IP to Router Interface (Optional)

```
Router> enable
Router# configure terminal
Router(config)# interface fa0/0
Router(config-if)# ip address 192.168.1.1 255.255.255.0
Router(config-if)# no shutdown
```

4. Test Connectivity

- Use ping to test communication between devices:
- ping 192.168.1.11

5. View IP Settings on PC

- Open **Command Prompt** on PC:
- ipconfig

Verification & Troubleshooting

Issue	Solution
Ping fails	Check cable connection and IPs
IP conflict	Ensure unique IPs for each device

Issue	Solution
Subnet mismatch	Use consistent subnet masks
Router not responding	Ensure interface is up and configured

Extra:

In **IPv4 addressing**, Class A addresses **do not use** the starting addresses with **0** and **127** because these ranges are **reserved** for special purposes. Here's the explanation:

Class A IP Address Range

- Class A: `0.0.0.0` to `127.255.255.255`
- Default subnet mask: `255.0.0.0`
- Network bits: 8 bits (first octet)

But, not all addresses from `0` to `127` are usable. Let's break it down:

Why is 0.x.x.x not used?

- `0.0.0.0` is **reserved** to mean **"this network"** or **"unspecified address"**.
- It is used in routing or when a device doesn't yet have an IP address (e.g., DHCP clients).
- **Any IP starting with 0** is considered **invalid** for assignment to hosts.

Example:

- In routing tables, `0.0.0.0/0` is the **default route** (i.e., "any destination").

Why is 127.x.x.x not used?

- `127.0.0.0/8` is reserved for **loopback addresses**.
- Most commonly used is `127.0.0.1` which refers to **"localhost"**.
- It is used for testing TCP/IP stacks within a local machine.
- Packets sent to this address **never leave the host**.

Example:

- `ping 127.0.0.1` is used to test whether the TCP/IP stack is working properly on your computer.

Conclusion

After completing this experiment, students are now able to:

- Understand IPv4 structure, classes, and subnetting
- Use CIDR for efficient IP address planning
- Assign IP addresses to devices in a LAN
- Verify basic network connectivity using tools like ping