Network Subnetting Lab Manual

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1. Introduction to Subnetting {#introduction}

Subnetting is the process of dividing a larger network into smaller sub-networks (subnets) by borrowing bits from the host portion of an IP address. After subnetting, an IP address consists of three parts:

- **NETWORK** - Identifies the major network
- **SUBNET** - Identifies the sub-network within the major network
- **HOST** - Identifies the specific device on the subnet

Key Terminology

- **Address**: Unique numerical ID assigned to a host or interface in a network
- **Subnet**: A portion of a network sharing a particular subnet address
- **Subnet Mask**: A 32-bit combination describing which portion refers to the subnet and which refers to the host
- **Interface**: A network connection point

IP Address Allocation

Before implementing subnetting, obtain legitimate IP addresses from the Internet Network Information Center (InterNIC). For private networks not connecting to the Internet, use reserved addresses from RFC 1918.

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2. Understanding IP Addresses {#ip-addresses}

IP Address Structure

An IP address uniquely identifies a device on an IP network. It consists of:

- **32 binary bits** divided into four octets (1 octet = 8 bits)
- Each octet ranges from **0 to 255** in decimal
- Expressed in **dotted decimal notation** (e.g., 172.16.81.100)

Binary to Decimal Conversion

Each bit position in an octet represents a power of 2:

```
Position:  7    6   5   4   3   2   1   0
Value:    128  64  32  16   8   4   2   1
```

Example 1: All bits set to 1

```
Binary:   1    1   1   1   1   1   1   1
Decimal: 128 +64 +32 +16 +8 +4 +2 +1 = 255
```

Example 2: Partial bits set

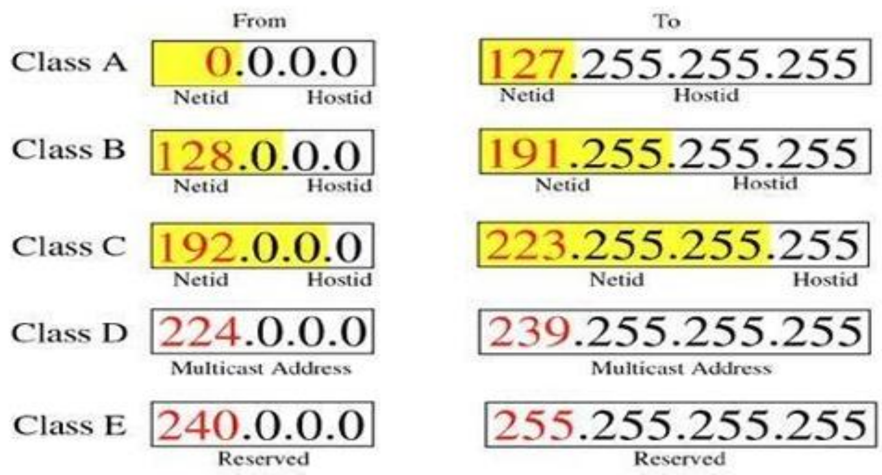
```
Binary:   0    1   0   0   0   0   0   1
Decimal:  0 +64 +0 +0 +0 +0 +0 +1 = 65
```

Example 3: Complete IP address

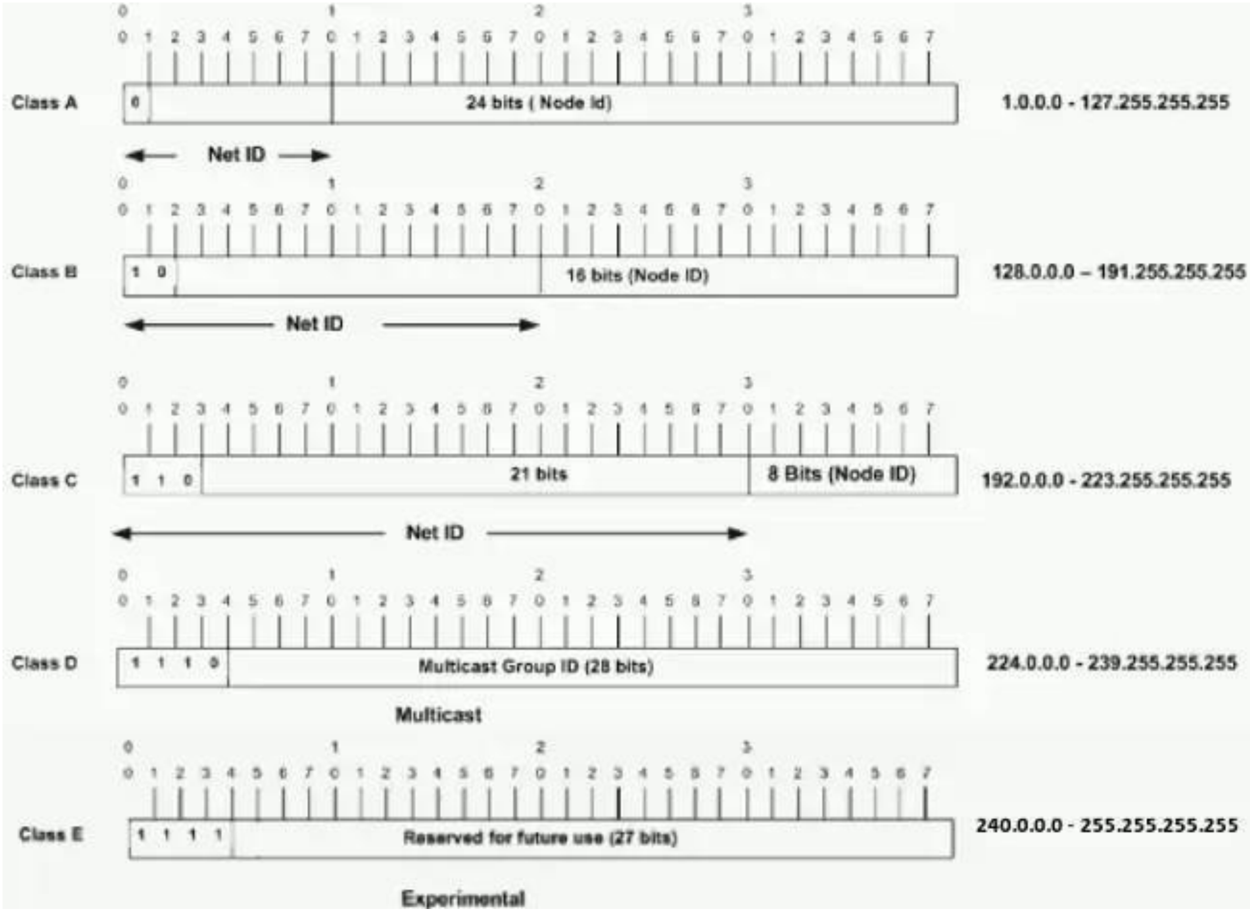
```
Decimal: 10.1.23.19
Binary:  00001010.00000001.00010111.00010011
```

IP Address Classes

IP addresses are divided into classes based on the three high-order bits (leftmost bits in the first octet):



Class	**First Octet Range**	**Network Bits**	**Host Bits**	**Default Mask**	**Typical Use**
A	1 - 127	8	24	255.0.0.0	Large networks (16+ million hosts)
B	128 - 191	16	16	255.255.0.0	Medium networks (256-65,534 hosts)
C	192 - 223	24	8	255.255.255.0	Small networks (<254 hosts)
D	224 - 239	-	-	-	Multicast (reserved)
E	240 - 255	-	-	-	Experimental (reserved)



Class A Details

- **Network portion**: First octet only
- **Host portion**: Last three octets (24 bits)
- **Range**: 1.0.0.0 to 127.255.255.255
- **Maximum hosts per network**: 16,777,214

Class B Details

- **Network portion**: First two octets
- **Host portion**: Last two octets (16 bits)
- **Range**: 128.0.0.0 to 191.255.255.255
- **Maximum hosts per network**: 65,534

Class C Details

- **Network portion**: First three octets
- **Host portion**: Last octet (8 bits)
- **Range**: 192.0.0.0 to 223.255.255.255
- **Maximum hosts per network**: 254

3. Network Masks {#network-masks}

A network mask identifies which portion of an IP address represents the network and which represents the host.

Default (Natural) Masks

- **Class A**: 255.0.0.0
- **Class B**: 255.255.0.0
- **Class C**: 255.255.255.0

Identifying Network and Host Portions

Example: Class A address without subnetting

```
IP Address:    8.20.15.1
Subnet Mask: 255.0.0.0

Binary representation:
Address: 00001000.00010100.00001111.00000001
Mask:    11111111.00000000.00000000.00000000
         ^^^^^^^^ ^^^^^^^^^^^^^^^^^^^^^^^^
         Network  Host

Network ID: 8
Host ID:    20.15.1
```

Rule:

- Bits with corresponding mask bit = 1 → Network ID
- Bits with corresponding mask bit = 0 → Host ID

4. Subnetting Process {#subnetting-process}

Why Subnet?

Without subnetting, you can only use one network from your Class A, B, or C allocation. Subnetting allows you to:

- Create multiple logical networks within a single major network
- Assign unique network IDs to each data link
- Efficiently utilize IP address space
- Organize network traffic

Creating Subnets

Subnetting extends the natural mask by borrowing bits from the host portion to create a subnet ID.

Example: Subnetting a Class C Network

Starting with network **204.17.5.0** (Class C with natural mask 255.255.255.0):

```
Original:
Address: 204.17.5.0       = 11001100.00010001.00000101.00000000
Mask:    255.255.255.0    = 11111111.11111111.11111111.00000000

After Subnetting (borrowing 3 bits):
Address: 204.17.5.0       = 11001100.00010001.00000101.00000000
Mask:    255.255.255.224  = 11111111.11111111.11111111.11100000
                                                        ^^^
                                                    Subnet bits
```

Subnet Calculation

With **3 borrowed bits**:

- **Number of subnets**: $2^3 = 8$ subnets
- **Hosts per subnet**: $2^5 - 2 = 30$ usable hosts
  - (5 remaining host bits, minus 2 for network and broadcast addresses)

Resulting Subnets

Subnet	Network Address	Subnet Mask	Usable Host Range	Broadcast
1	204.17.5.0	255.255.255.224	204.17.5.1 - 204.17.5.30	204.17.5.31
2	204.17.5.32	255.255.255.224	204.17.5.33 - 204.17.5.62	204.17.5.63
3	204.17.5.64	255.255.255.224	204.17.5.65 - 204.17.5.94	204.17.5.95
4	204.17.5.96	255.255.255.224	204.17.5.97 - 204.17.5.126	204.17.5.127
5	204.17.5.128	255.255.255.224	204.17.5.129 - 204.17.5.158	204.17.5.159
6	204.17.5.160	255.255.255.224	204.17.5.161 - 204.17.5.190	204.17.5.191
7	204.17.5.192	255.255.255.224	204.17.5.193 - 204.17.5.222	204.17.5.223
8	204.17.5.224	255.255.255.224	204.17.5.225 - 204.17.5.254	204.17.5.255

Important: Host IDs of all zeros or all ones are reserved (network address and broadcast address respectively).

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5. Lab Exercise: Three Router Configuration {#lab-exercise}

Objective

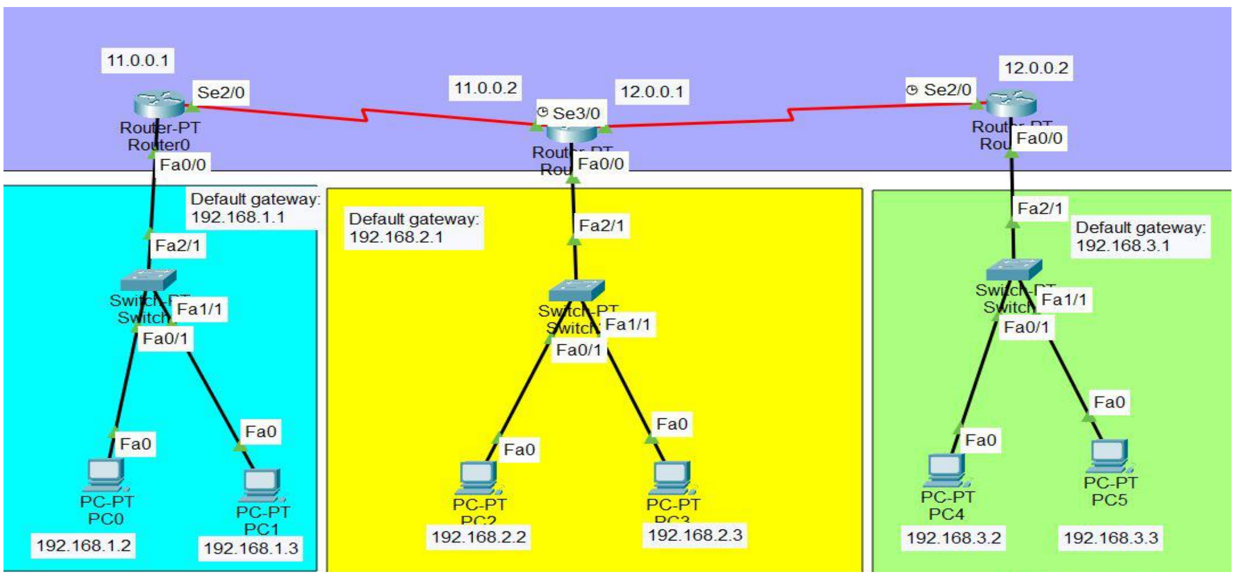
Configure and verify connectivity between three routers connecting multiple subnets.

Required Equipment

S.No	Device	Model	Quantity
1	PC	pc	6
2	Switch	PT-Switch	3
3	Router	PT-Router	3

Network Topology

Create the topology using automatic connecting cables to link devices.



Step 1: PC IP Configuration

Configure each PC with the following settings:

Device	IPv4 Address	Subnet Mask	Default Gateway
PC0	192.168.1.2	255.255.255.0	192.168.1.1
PC1	192.168.1.3	255.255.255.0	192.168.1.1
PC2	192.168.2.2	255.255.255.0	192.168.2.1
PC3	192.168.2.3	255.255.255.0	192.168.2.1

PC4	192.168.3.2	255.255.255.0	192.168.3.1
PC5	192.168.3.3	255.255.255.0	192.168.3.1

Configuration Steps:

1. Click on a PC
2. Go to Desktop → IP Configuration
3. Enter IPv4 address, subnet mask, and default gateway
4. Repeat for all PCs

Step 2: Router IP Configuration

Configure router interfaces with the following IP addresses:

Router0

Interface	IPv4 Address	Subnet Mask
FastEthernet0/0	192.168.1.1	255.255.255.0
Serial2/0	11.0.0.1	255.0.0.0

Router1

Interface	IPv4 Address	Subnet Mask
Serial2/0	11.0.0.2	255.0.0.0
Serial3/0	12.0.0.1	255.0.0.0

Router2

Interface	IPv4 Address	Subnet Mask
FastEthernet0/0	192.168.3.1	255.255.255.0
Serial2/0	12.0.0.2	255.0.0.0

Step 3: Configure Static Routes

Static routes enable routers to forward traffic to networks they're not directly connected to.

Command Syntax:

```
Router(config)# ip route <network_id> <subnet_mask> <next_hop>
```

Static Routes for Router0

Access Router0 CLI and enter the following commands:

```
Router> enable
Router# configure terminal
Router(config)# ip route 192.168.2.0 255.255.255.0 11.0.0.2
Router(config)# ip route 11.0.0.0 255.0.0.0 11.0.0.2
Router(config)# ip route 192.168.3.0 255.255.255.0 11.0.0.2
Router(config)# ip route 12.0.0.0 255.0.0.0 11.0.0.2
```

Static Routes for Router1

```
Router(config)# ip route 192.168.1.0 255.255.255.0 11.0.0.1
Router(config)# ip route 11.0.0.0 255.0.0.0 11.0.0.1
Router(config)# ip route 192.168.3.0 255.255.255.0 12.0.0.2
Router(config)# ip route 12.0.0.0 255.0.0.0 12.0.0.2
```

Static Routes for Router2

```
Router(config)# ip route 192.168.1.0 255.255.255.0 12.0.0.1
Router(config)# ip route 11.0.0.0 255.0.0.0 12.0.0.1
Router(config)# ip route 12.0.0.0 255.0.0.0 12.0.0.1
Router(config)# ip route 192.168.2.0 255.255.255.0 12.0.0.1
```

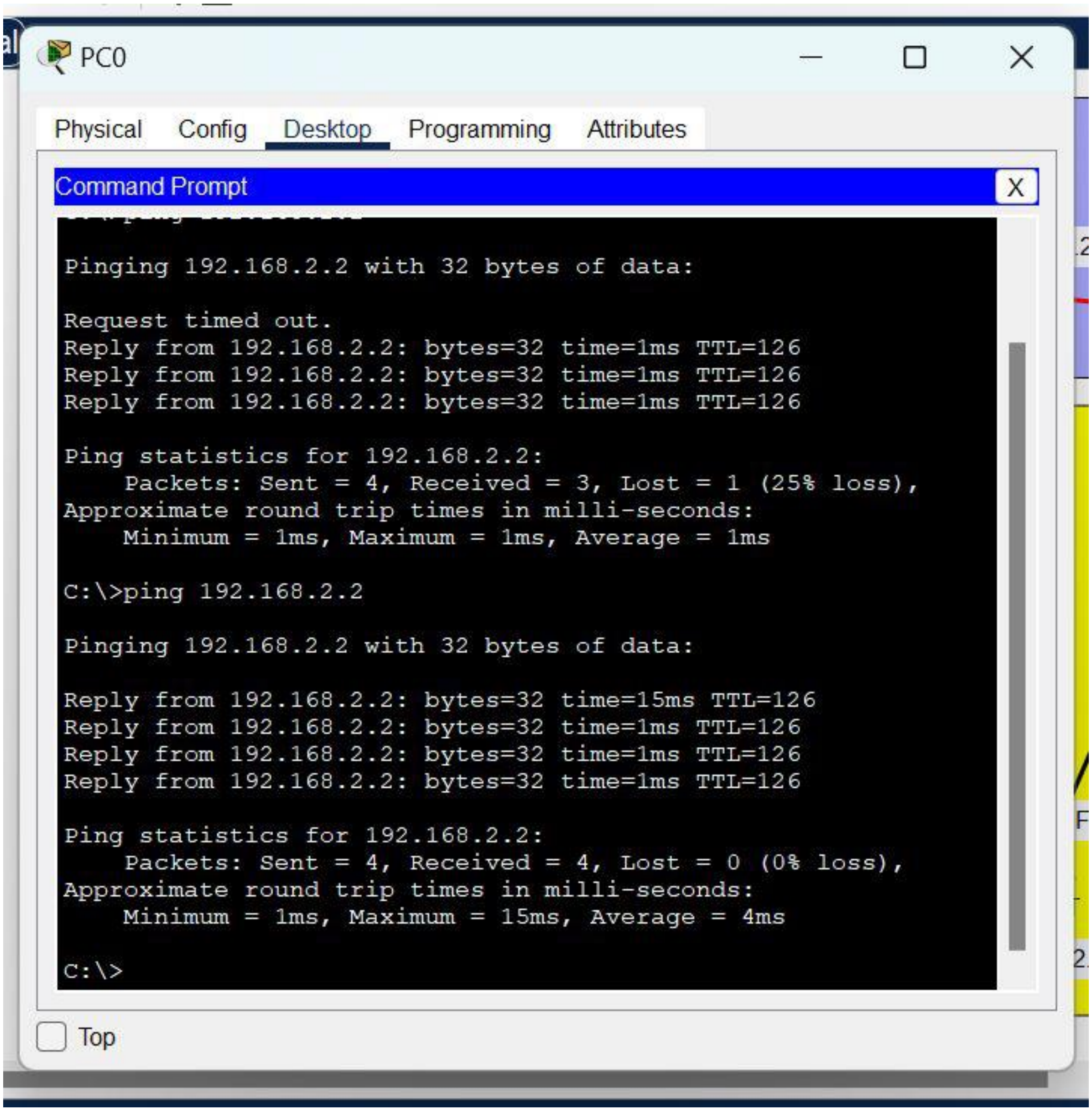
Step 4: Verify Network Connectivity

Test connectivity using the ping command.

Steps:

1. Click on PC0
2. Go to Desktop → Command Prompt
3. Type: `ping 192.168.2.2` (or any other PC's IP address)
4. Verify you receive replies

Example Output:



Successful replies indicate proper network configuration and routing.

Troubleshooting Tips

If pings fail, check:

- PC IP configurations (address, mask, gateway)
- Router interface IP addresses
- Static routes on all routers
- Cable connections between devices
- Interface status (up/down)

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6. Final Task: Company Network Design {#final-task}

Scenario

Design and implement a network topology for a company with three departments. Each department requires its own subnet for traffic separation and organization. The network must support inter-department communication when necessary.

Requirements

Departments:

1. Sales Department
2. HR Department
3. IT Department

Network Components:

- **2 Routers**: Provide routing between departmental subnets
- **3 Switches**: One per department for local connectivity
- **6 PCs**: Two per department
    - 2 PCs for Sales
    - 2 PCs for HR
    - 2 PCs for IT

Design Specifications

1. **Subnet Allocation**: Assign a unique subnet to each department
2. **Router Connections**: Both routers should interconnect the three departmental switches
3. **Routing Configuration**: Configure appropriate static routes to enable communication between all departments
4. **IP Addressing**: Develop a logical IP addressing scheme following subnetting principles

Implementation Steps

1. Create the network topology in Packet Tracer or similar simulator
2. Assign appropriate IP addresses to all devices
3. Configure router interfaces and static routes
4. Test connectivity between all departments using ping commands
5. Document your IP addressing scheme and routing configuration

Deliverables

- Complete network topology diagram
- IP addressing table for all devices
- Router configuration commands
- Verification tests showing successful inter-department communication

Success Criteria

- All PCs within a department can communicate with each other
- PCs from different departments can communicate through routers
- Network traffic is logically separated by department
- All devices have appropriate IP addressing with no conflicts