Computer Networks Laboratory

Design and Implementation of a VLAN-Based Network Using Switch, Router, and IPv4 Subnetting

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1. Aim of the Experiment

To design, configure, and simulate a small enterprise network using a Layer-2 switch and a router, incorporating VLANs, IPv4 subnetting, and inter-VLAN routing using Cisco Packet Tracer, such that the same design can later be implemented on real networking hardware.

2. Learning Objectives

After completing this experiment, students will be able to:

- Understand the need for network segmentation using VLANs
- Perform IPv4 subnetting based on host requirements
- Assign IP addresses, subnet masks, and default gateways correctly
- Configure VLANs and trunk ports on a Layer-2 switch
- Configure inter-VLAN routing using Router-on-a-Stick
- Verify network connectivity in simulation
- Map simulation design to real hardware implementation

3. Problem Statement

An organization consists of three departments:

- Admin Department
- Faculty Department
- Student Department

Each department must be placed in a separate VLAN for security and traffic isolation. Inter-department communication should be enabled through a router.

The organization is allocated the following IPv4 address block:

192.168.10.0/24

4. Network Requirements

Department	VLAN ID	Required Hosts
Admin	10	20
Faculty	20	30
Students	30	50

Table 1: Department-wise VLAN and Host Requirements

5. Network Topology Diagram

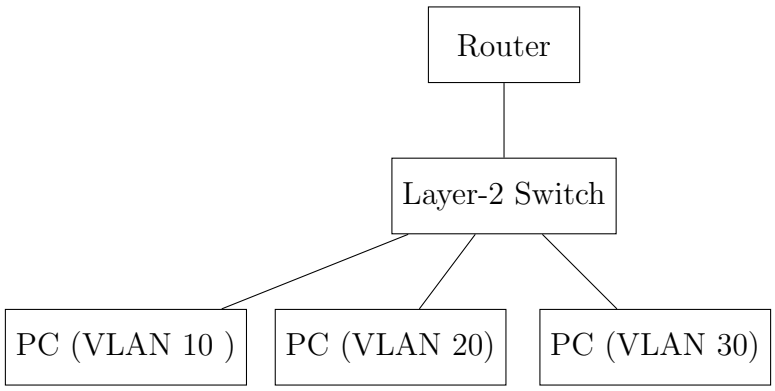

Figure 1: Logical Network Topology (Router-on-a-Stick)

6. IPv4 Subnetting Design

6.1 Why Subnetting is Required

Subnetting is performed to:

- Efficiently utilize IP address space
- Isolate departments at Layer-3
- Assign one subnet per VLAN

Each VLAN represents a separate broadcast domain and therefore requires a unique IP subnet.

6.2 Subnet Calculation

Given network:

192.168.10.0/24

Subnet allocation is done based on host requirement (largest first).

VLAN	Network Address	Subnet Mask	Usable Hosts
30	192.168.10.96	/26	62
20	192.168.10.32	/26	62
10	192.168.10.0	/27	30

Table 2: Subnet Allocation

7. Default Gateway Assignment Logic

- The default gateway for each VLAN is the router's sub-interface IP.
- First usable IP of each subnet is chosen as gateway.

VLAN	Gateway IP	Subnet Mask
10	192.168.10.1	255.255.255.224
20	192.168.10.33	255.255.255.192
30	192.168.10.97	255.255.255.192

Table 3: Default Gateway Assignment

8. VLAN Configuration on Switch

8.1 Why VLANs are Configured

VLANs:

- Logically separate departments
- Reduce broadcast traffic
- Improve security

8.2 VLAN Creation Steps

```
Switch> enable
Switch# configure terminal
Switch(config)# vlan 10
Switch(config-vlan)# name ADMIN
Switch(config)# vlan 20
Switch(config-vlan)# name FACULTY
Switch(config)# vlan 30
Switch(config-vlan)# name STUDENTS
```

8.3 Access Port Assignment

```
Switch(config)# interface range fa0/1 - 2
Switch(config-if-range)# switchport mode access
Switch(config-if-range)# switchport access vlan 10
```

(Similarly configure ports for VLAN 20 and VLAN 30)

9. Trunk Port Configuration

Why Trunking is Required

A trunk port allows multiple VLAN traffic to pass between the switch and router using VLAN tagging (IEEE 802.1Q).

```
Switch(config)# interface fa0/24
Switch(config-if)# switchport mode trunk
```

10. Router-on-a-Stick Configuration

Why Router-on-a-Stick

A single router interface is divided into multiple logical sub-interfaces, each serving one VLAN.

Configuration Steps

```
Router> enable
Router# configure terminal
Router(config)# interface g0/0.10
Router(config-subif)# encapsulation dot1Q 10
Router(config-subif)# ip address 192.168.10.1 255.255.255.224
```

(Repeat for VLAN 20 and VLAN 30)

11. End Device IP Configuration

Each PC is assigned:

- An IP from its VLAN subnet
- Correct subnet mask
- Default gateway of its VLAN

12. Verification and Testing

Students must verify:

- VLAN membership using `show vlan brief`
- Trunk status using `show interfaces trunk`
- Inter-VLAN connectivity using `ping`

13. Phase-II: Mapping to Real Hardware

The same logical design will be implemented using real Cisco switches and routers without any change in IP plan or VLAN design.

14. Conclusion

This experiment demonstrates how VLANs, subnetting, and routing work together to build a scalable and secure enterprise network. The design approach ensures a seamless transition from simulation to real-world deployment.