Multilayer Switch (MLS) Workbook

A Hands-On Guide to VLAN Configuration, Inter-VLAN Routing, and Troubleshooting

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Date: January 31, 2025

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Chapter 1

Tutorial: Inter-VLAN Routing with ROAS and Multilayer Switches

1.1 Introduction

Virtual Local Area Networks (VLANs) are used in network environments to segment traffic and improve performance and security. However, devices in separate VLANs cannot communicate with each other by default. Inter-VLAN routing allows devices from different VLANs to communicate, and this can be achieved through two main methods: **Router-on-a-Stick (ROAS)** and **Multilayer Switch (MLS) Inter-VLAN Routing**.

1.2 Router-on-a-Stick (ROAS)

1.2.1 Overview

Router-on-a-Stick (ROAS) is a method of inter-VLAN routing that uses a single router with a trunk link to a switch. The router performs all routing functions between VLANs.

1.2.2 How It Works

1. A trunk link is established between the router and the switch.
2. Subinterfaces are created on the router for each VLAN.
3. Each subinterface is assigned an IP address that acts as the default gateway for its respective VLAN.
4. The switch forwards VLAN-tagged traffic to the router, which then routes it to the appropriate VLAN.

1.2.3 Configuration Steps

On the Switch

```
configure terminal
interface GigabitEthernet0/1
switchport mode trunk
switchport trunk allowed vlan 10,20
exit
```

On the Router

```
configure terminal
interface GigabitEthernet0/1
no shutdown
interface GigabitEthernet0/1.10
encapsulation dot1Q 10
ip address 192.168.10.1 255.255.255.0
exit
interface GigabitEthernet0/1.20
encapsulation dot1Q 20
ip address 192.168.20.1 255.255.255.0
exit
```

1.2.4 Advantages and Disadvantages

Advantages:

- Cost-effective for small networks.
- Simple to implement.

Disadvantages:

- Limited scalability due to reliance on a single router interface.
- Potential bottleneck due to the router processing all inter-VLAN traffic.

1.3 Inter-VLAN Routing with a Multilayer Switch (MLS)

1.3.1 Overview

A multilayer switch (MLS) can perform routing functions at Layer 3, eliminating the need for an external router.

1.3.2 How It Works

1. The MLS is configured with Switched Virtual Interfaces (SVIs) for each VLAN.
2. Each SVI is assigned an IP address that acts as the default gateway for its VLAN.
3. The MLS handles inter-VLAN routing internally, reducing latency.

1.3.3 Configuration Steps

Enable Routing on the Switch

```
configure terminal
ip routing
```

Create and Configure SVIs

```
interface vlan 10
ip address 192.168.10.1 255.255.255.0
no shutdown
exit
interface vlan 20
ip address 192.168.20.1 255.255.255.0
no shutdown
exit
```

1.3.4 Advantages and Disadvantages

Advantages:

- Higher performance as traffic remains within the switch.
- Scalability for larger networks.
- Reduced latency due to elimination of external routing hops.

Disadvantages:

- Higher cost compared to ROAS.
- Requires a switch with Layer 3 capabilities.

1.4 Choosing Between ROAS and MLS

Feature	Router-on-a-Stick (ROAS)	Multilayer Switch (MLS)
Cost	Lower	Higher
Performance	Slower (bottlenecks)	Faster
Scalability	Limited	Scalable
Complexity	Simple	Moderate
Hardware Needed	Router & L2 Switch	L3 Switch

Table 1.1: Comparison of ROAS and MLS

For small networks with limited VLANs, ROAS is a cost-effective solution. For larger enterprise networks requiring higher performance, MLS is the preferred method.

1.5 Conclusion

Inter-VLAN routing is essential for modern networks to ensure seamless communication between VLANs. While ROAS is a simple and cost-effective solution, MLS offers improved performance and scalability. Choosing the right method depends on network size, traffic load, and budget considerations. Implementing the correct inter-VLAN routing solution ensures an efficient, high-performing, and well-segmented network infrastructure.

Part I

Exercises and Hands-On Practice

Chapter 2

Network Topology for Router-on-a-Stick (ROAS)

2.1 Network Topology

The topology below represents a **Router-on-a-Stick (ROAS) network**, where a **single router** is responsible for **inter-VLAN routing** using **subinterfaces**.

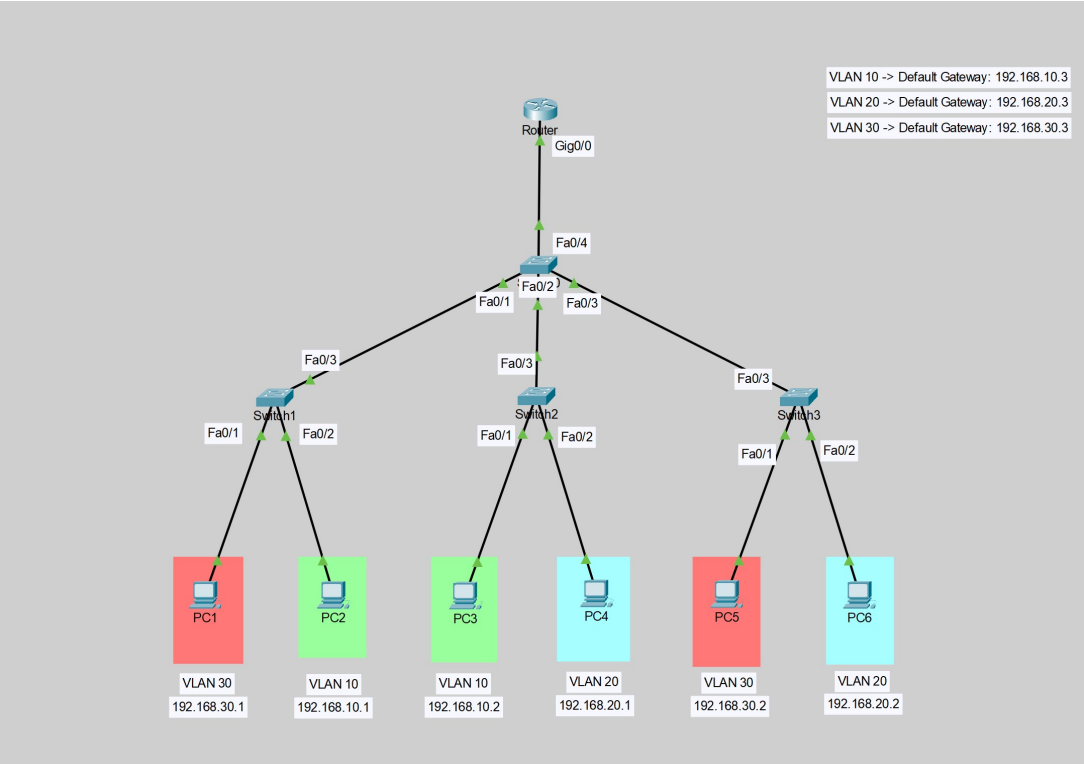

Figure 2.1: *Network topology created using the Packet Tracer Simulator.*

2.2 Scenario

- **A router** is connected to three **Layer 2 switches** using a **trunk link**.

- Each PC is assigned to a specific **VLAN (10, 20, or 30)**.
- The **router performs inter-VLAN routing** using **subinterfaces**.
- Each VLAN has a corresponding **default gateway** assigned on the router.

Chapter 3

Router-on-a-Stick (ROAS)

1. Configure the `GigabitEthernet0/0` interface as a trunk.
2. Assign subinterface `0/0.10` for VLAN 10 with IP `192.168.10.1/24`.
3. Assign subinterface `0/0.20` for VLAN 20 with IP `192.168.20.1/24`.
4. Assign subinterface `0/0.30` for VLAN 30 with IP `192.168.30.1/24`.
5. Configure `FastEthernet0/1` as a trunk on Switch1.
6. Configure `FastEthernet0/1` as a trunk on Switch2.
7. Configure `FastEthernet0/1` as a trunk on Switch3.
8. Assign `FastEthernet0/2` on Switch1 to VLAN 10.
9. Assign `FastEthernet0/2` on Switch2 to VLAN 20.
10. Assign `FastEthernet0/2` on Switch3 to VLAN 30.
11. Verify trunking status on switches.
12. Show the current VLAN configuration.
13. Display the routing table to check inter-VLAN routing.
14. Show all subinterfaces configured on the router.
15. Check encapsulation settings for all subinterfaces.
16. Verify if PC1 can ping PC2.
17. Verify if PC3 can ping PC1.
18. Save the running configuration.
19. Debug IP routing issues.
20. Remove subinterface `0/0.30`.
21. Disable the trunk link on Switch1.
22. Reset the router configuration.

Chapter 4

Network Topology for Multilayer Switch (MLS)

4.1 Network Topology

The topology below shows a **Multilayer Switch (MLS) network** where multiple VLANs are implemented. The goal of this workbook is to configure the **Layer 3 switch** for inter-VLAN routing and ensure successful communication between VLANs.

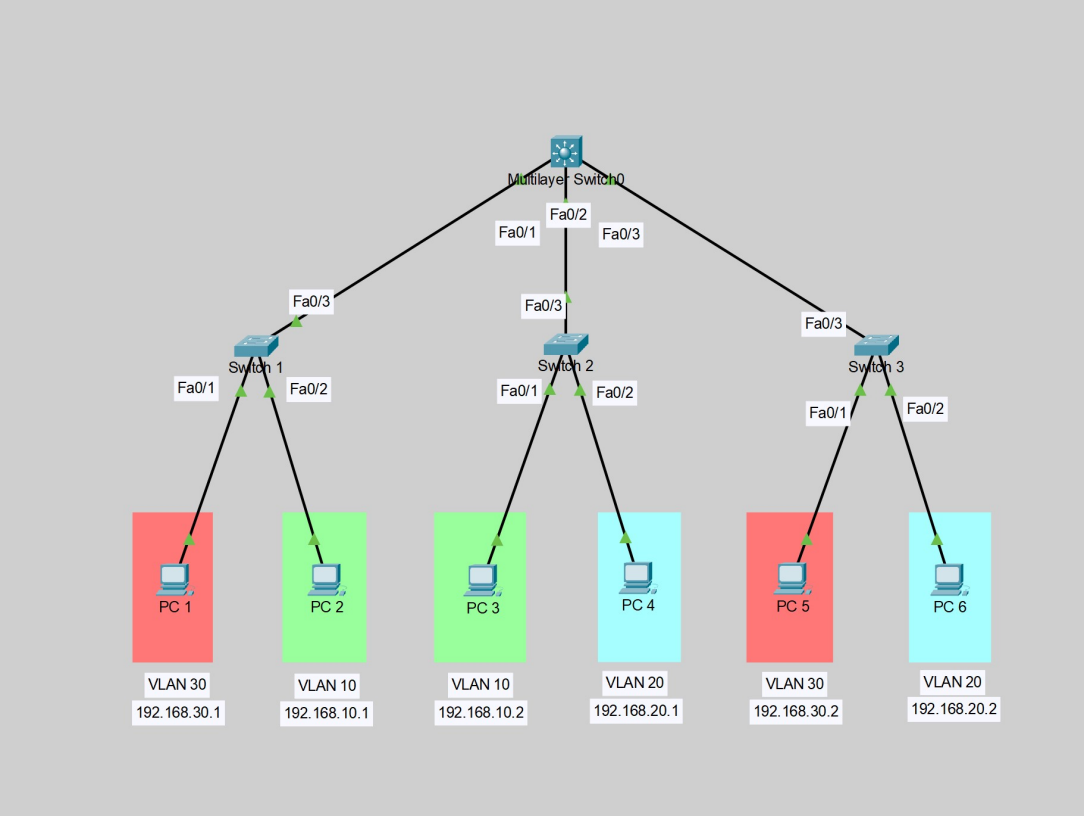

Figure 4.1: *Network topology created using the Packet Tracer Simulator.*

4.2 Scenario

- This network consists of **three access switches**, **one multilayer switch**, and **six PCs**.

- Each PC is assigned to a specific **VLAN (10, 20, or 30)**.
- The **multilayer switch** will perform **inter-VLAN routing** using **SVI (Switched Virtual Interfaces)**.

Chapter 5

Multilayer Switch (MLS)

1. Create VLAN 10, 20, and 30 on a multilayer switch
2. Set interface range `FastEthernet0/1 - 0/2` as trunk ports on multilayer switch.
3. Verify VLAN configurations on the multilayer switch.
4. Show the trunking status of all interfaces on multilayer switch.
5. Set the `Fa0/3` link on switches 1, 2, and 3 to trunk mode.
6. Set the `Fa0/1` link on Switch 1 to connect PC1 in VLAN 30 and the `Fa0/2` link to connect PC2 in VLAN 10.
7. Set the `Fa0/1` link on Switch 2 to connect PC3 in VLAN 10 and the `Fa0/2` link to connect PC4 in VLAN 20.
8. Set the `Fa0/1` link on Switch 3 to connect PC5 in VLAN 30 and the `Fa0/2` link to connect PC6 in VLAN 20.
9. Configure the gateway addresses on the multilayer switch (SVI interfaces for VLANs).
10. Perform an inter-VLAN connectivity test using the ping command.

Part II

Answer Key and Explanations

Chapter 6

Router-on-a-Stick (ROAS) - Answers

1. Configure the `GigabitEthernet0/0` interface as a trunk

```
Router(config)# interface GigabitEthernet0/0
Router(config-if)# no shutdown
Router(config-if)# exit
```

2. Assign subinterface `0/0.10` for VLAN 10 with IP `192.168.10.1/24`

```
Router(config)# interface GigabitEthernet0/0.10
Router(config-subif)# encapsulation dot1Q 10
Router(config-subif)# ip address 192.168.10.1 255.255.255.0
Router(config-subif)# exit
```

3. Assign subinterface `0/0.20` for VLAN 20 with IP `192.168.20.1/24`

```
Router(config)# interface GigabitEthernet0/0.20
Router(config-subif)# encapsulation dot1Q 20
Router(config-subif)# ip address 192.168.20.1 255.255.255.0
Router(config-subif)# exit
```

4. Assign subinterface `0/0.30` for VLAN 30 with IP `192.168.30.1/24`

```
Router(config)# interface GigabitEthernet0/0.30
Router(config-subif)# encapsulation dot1Q 30
Router(config-subif)# ip address 192.168.30.1 255.255.255.0
Router(config-subif)# exit
```

5. Configure `FastEthernet0/1` as a trunk on Switch1.

```
Switch1(config)# interface FastEthernet0/1
Switch1(config-if)# switchport mode trunk
Switch1(config-if)# exit
```

6. Configure `FastEthernet0/1` as a trunk on Switch2.

```
Switch2(config)# interface FastEthernet0/1
Switch2(config-if)# switchport mode trunk
Switch2(config-if)# exit
```

7. Configure `FastEthernet0/1` as a trunk on Switch3.

```
Switch3(config)# interface FastEthernet0/1
Switch3(config-if)# switchport mode trunk
Switch3(config-if)# exit
```

8. Assign `FastEthernet0/2` on Switch1 to VLAN 10

```
Switch1(config)# interface FastEthernet0/2
Switch1(config-if)# switchport mode access
Switch1(config-if)# switchport access vlan 10
Switch1(config-if)# exit
```

9. Assign `FastEthernet0/2` on Switch2 to VLAN 20

```
Switch2(config)# interface FastEthernet0/2
Switch2(config-if)# switchport mode access
Switch2(config-if)# switchport access vlan 20
Switch2(config-if)# exit
```

10. Assign `FastEthernet0/2` on Switch3 to VLAN 30

```

Switch3(config)# interface FastEthernet0/2
Switch3(config-if)# switchport mode access
Switch3(config-if)# switchport access vlan 30
Switch3(config-if)# exit
```

11. Verify `trunking status` on switches.

```
Switch# show interfaces trunk
```

12. Show current VLAN configuration

```
Switch# show vlan brief
```

13. Display the routing table

```
Router# show ip route
```

14. Show all subinterfaces

```
Router# show ip interface brief
```

15. Check encapsulation settings

```
Router# show interfaces GigabitEthernet0/0.10
Router# show interfaces GigabitEthernet0/0.20
Router# show interfaces GigabitEthernet0/0.30
```

16. Verify if PC1 can ping PC2.

17. Verify if PC3 can ping PC1.

```
PC1> ping 192.168.20.1
PC3> ping 192.168.10.1
```

18. Save the running configuration

```
Router# write memory
Switch# write memory
```

19. Debug IP routing issues

```
Router# debug ip routing
```

20. Remove subinterface 0/0.30

```
Router(config)# no interface GigabitEthernet0/0.30
```

21. Disable trunk link on Switch1

```
Switch1(config)# interface FastEthernet0/1
Switch1(config-if)# switchport mode access
Switch1(config-if)# exit
```

22. Reset the router configuration

```
Router# write erase
Router# reload
```

Chapter 7

Multilayer Switch (MLS) - Answers

1. Create VLAN 10, 20, and 30 on a multilayer switch.

```
configure terminal
vlan 10
vlan 20
vlan 30
exit
```

2. Set interface range `FastEthernet0/1 - 0/2` as trunk ports on multilayer switch.

```
configure terminal
interface range FastEthernet0/1 - 2
switchport mode trunk
exit
```

3. Verify VLAN configurations on the multilayer switch.

```
show vlan brief
```

4. Show the trunking status of all interfaces on multilayer switch.

```
show interfaces trunk
```

5. Set the `Fa0/3` link on switches 1, 2, and 3 to trunk mode. For Switch 1:

```
configure terminal
interface FastEthernet0/3
switchport mode trunk
exit
```

   For Switch 2:

```
configure terminal
interface FastEthernet0/3
switchport mode trunk
exit
```

   For Switch 3:

```
configure terminal
interface FastEthernet0/3
switchport mode trunk
exit
```

6. Set the `Fa0/1` link on Switch 1 to connect PC1 in VLAN 30 and the `Fa0/2` link to connect PC2 in VLAN 10.

```
configure terminal
interface FastEthernet0/1
switchport mode access
switchport access vlan 30
exit

interface FastEthernet0/2
switchport mode access
switchport access vlan 10
exit
```

7. Set the `Fa0/1` link on Switch 2 to connect PC3 in VLAN 10 and the `Fa0/2` link to connect PC4 in VLAN 20.

```
configure terminal
interface FastEthernet0/1
switchport mode access
switchport access vlan 10
exit

interface FastEthernet0/2
switchport mode access
switchport access vlan 20
exit
```

8. Set the `Fa0/1` link on Switch 3 to connect PC5 in VLAN 30 and the `Fa0/2` link to connect PC6 in VLAN 20.

```
configure terminal
interface FastEthernet0/1
switchport mode access
switchport access vlan 30
exit

interface FastEthernet0/2
switchport mode access
switchport access vlan 20
exit
```

9. Configure the gateway addresses on the multilayer switch (SVI interfaces for VLANs).

```
configure terminal
interface Vlan10
ip address 192.168.10.3 255.255.255.0
no shutdown
exit

interface Vlan20
ip address 192.168.20.3 255.255.255.0
no shutdown
exit

interface Vlan30
```

```
ip address 192.168.30.3 255.255.255.0
no shutdown
exit
```

10. Perform an inter-VLAN connectivity test using the ping command.

Step 1: Verify VLAN Interface Status

First, check if the VLAN interfaces (SVIs) are active:

```
show ip interface brief
```

Ensure that the VLAN interfaces (`Vlan10, Vlan20, Vlan30`) have assigned IP addresses and are **up**.

Step 2: Ping Between VLANs

Run the following ping tests from the Multilayer Switch:

Ping from VLAN 10 (`192.168.10.3`) to VLAN 20 (`192.168.20.3`)

```
ping 192.168.20.3
```

Ping from VLAN 10 (`192.168.10.3`) to VLAN 30 (`192.168.30.3`)

```
ping 192.168.30.3
```

Ping from VLAN 20 (`192.168.20.3`) to VLAN 30 (`192.168.30.3`)

```
ping 192.168.30.3
```

Step 3: Ping from a PC

From **PC1 (VLAN 30, IP: 192.168.30.10)**, test connectivity to **PC2 (VLAN 10, IP: 192.168.10.10)**:

```
ping 192.168.10.10
```

From **PC4 (VLAN 20, IP: 192.168.20.10)**, test connectivity to **PC5 (VLAN 30, IP: 192.168.30.10)**:

```
ping 192.168.30.10
```

Expected Output

If inter-VLAN routing is **correctly configured**, the `ping` should be successful. If there is an issue, check:

- **SVI configurations** (`show run`)
- **Routing status** (`show ip route`)
- **Trunk links between switches** (`show interfaces trunk`)

✓This confirms that inter-VLAN communication is working properly!