

2. Design and Implementation of a University Campus Network

Objective

The aim of this project is to develop a robust and efficient network infrastructure customized to meet the specific demands of a University Campus Network. The university's students and staff are organized across four faculties: Health and Sciences, Business, Engineering/Computing, and Art/Design. Each staff member is equipped with a personal computer, and students have access to PCs in various labs. Each department or faculty will be assigned its own distinct IP network. Switches should be configured with the necessary VLANs and security settings. RIPv2 will handle routing within the internal network, while static routing will be used for the external server. Devices in Building A should obtain dynamic IP addresses from a DHCP server located on a router. Design a network topology incorporating the main components needed to support the following:

Main Campus

- **Building A:** Administrative staff in the departments of management, HR and finance. The admin staff PCs are distributed in the building offices and it is expected that they will share some networking. The Faculty of Business is also situated in this building.
- **Building B:** Faculty of Engineering and Computing and Faculty of Art and Design.
- **Building C:** Students labs and IT department. The IT department hosts the University Web server and other servers - There is also an email server hosted externally on the cloud.

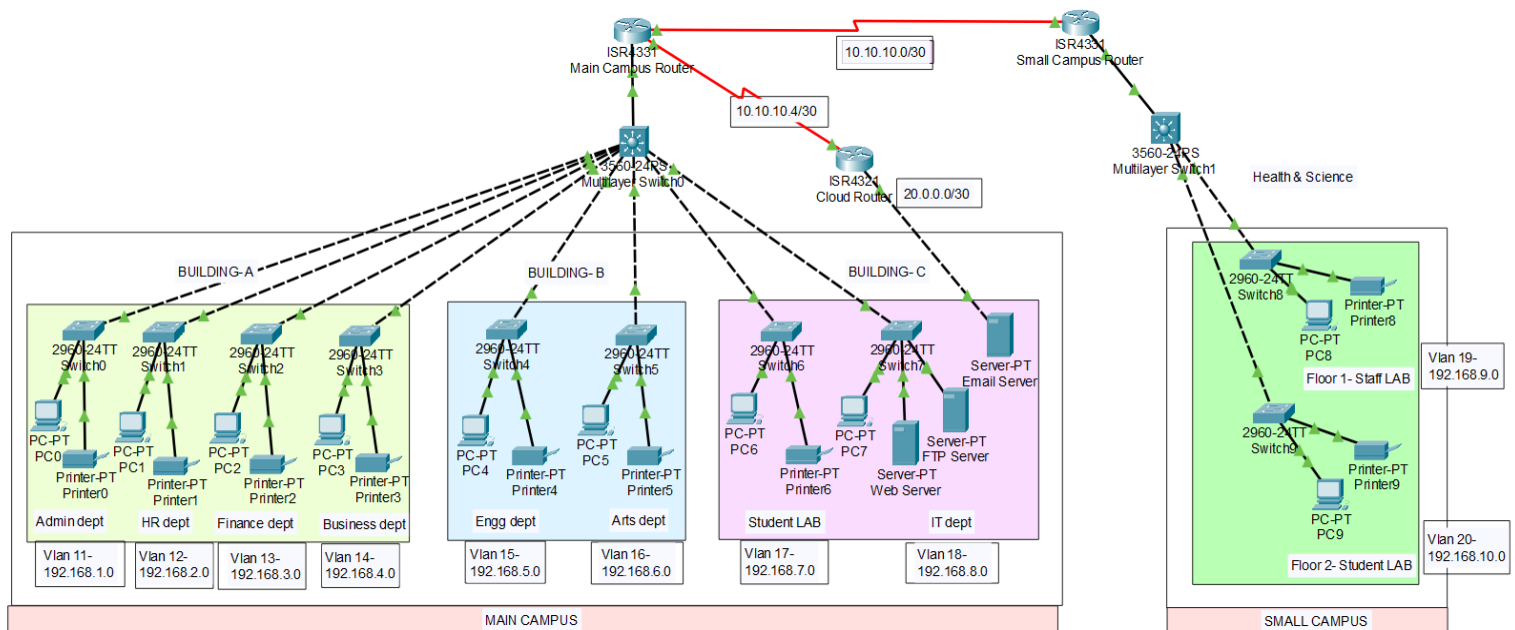
Small Campus

Faculty of Health and Sciences (staff and students labs are situated on separate floors).

Network Technology implemented

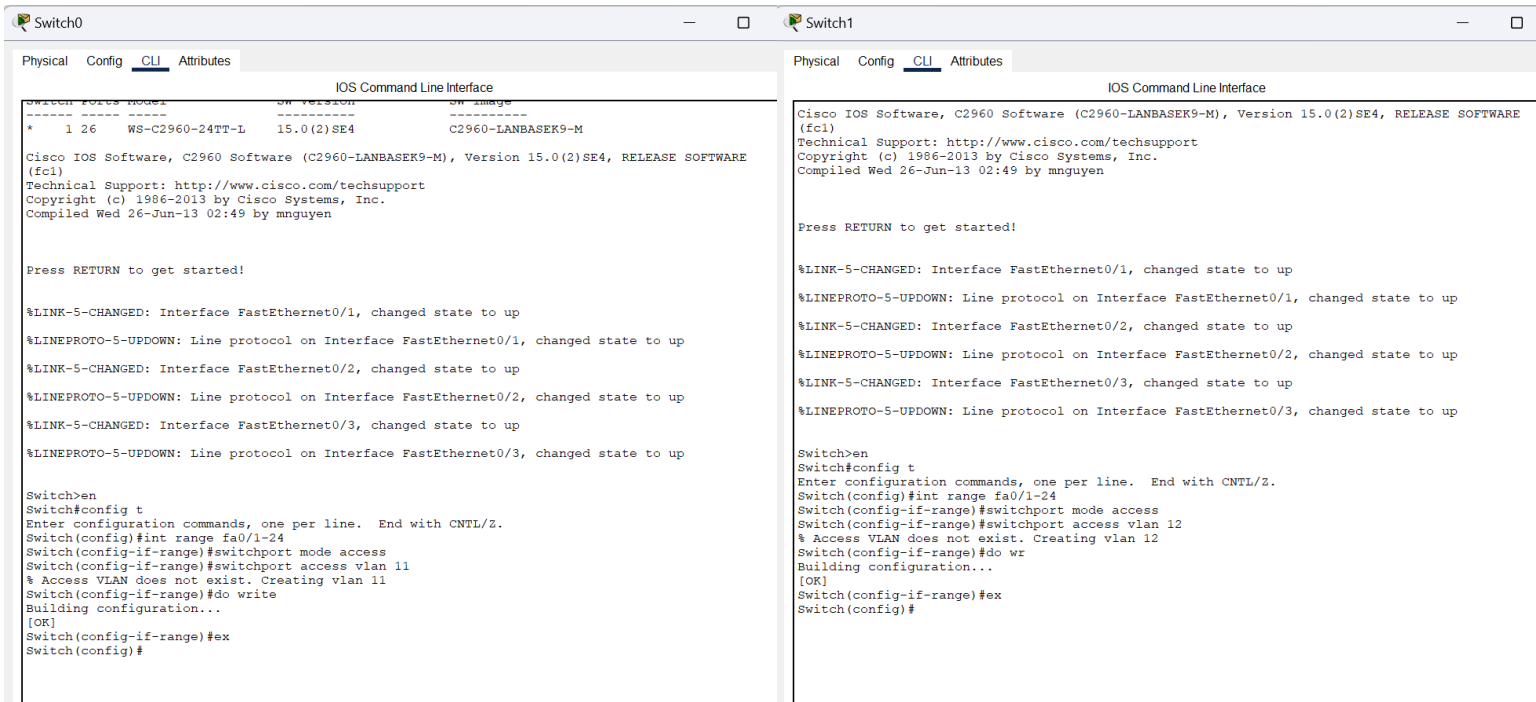
- Creating a Simple Network using a Router, Access Layer Switch and Distribution Layer Switch
- Connecting Networking devices with Correct cabling
- Creating VLANs and assigning ports VLAN numbers
- Subnetting and IP Addressing
- Configuring Inter-VLAN Routing (Router on a stick)
- Configuring DHCP Server (Router as the DHCP Server)
- Configuring SSH for secure Remote access
- Configuring RIPv2 as the routing protocol
- Host Device Configurations
- Test and Verifying Network Communication

Network Topology Diagram



Configuration details

Stick VLAN implementation on Access Layer L2 Switches



The snapshots of two switches of Building A for Admin and HR departments are attached above. For all the left departments of buildings B & C and Small Campus floor Switch2-9 interfaces will be configured the same way as shown in the snapshot according to their VLAN numbers allotted to them.

Stick VLAN implementation on Distribution Layer L3 Switches

```
Multilayer Switch0
Physical Config CLI Attributes
IOS Command Line Interface

Switch(config)#int fa0/1
Switch(config-if)#switvh
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/1 (1), with Switch
FastEthernet0/3 (11).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/7 (1), with Switch
FastEthernet0/3 (17).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/4 (1), with Switch
FastEthernet0/3 (14).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/8 (1), with Switch
FastEthernet0/3 (18).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/3 (1), with Switch
FastEthernet0/3 (13).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/5 (1), with Switch
FastEthernet0/3 (15).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/2 (1), with Switch
FastEthernet0/3 (12).

      ^
% Invalid input detected at '^' marker.

Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 11
% Access VLAN does not exist. Creating vlan 11
Switch(config-if)#wx
      ^
% Invalid input detected at '^' marker.

Switch(config-if)#
Switch(config-if)#ex
Switch(config)#int fa0/2
Switch(config-if)#switchport mode access
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).
```

```
Multilayer Switch0
Physical Config CLI Attributes
IOS Command Line Interface

Switch(config-if)#switchport access vlan 12
% Access VLAN does not exist. Creating vlan 12
Switch(config-if)#ex
Switch(config)#int fa0/3
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 13
% Access VLAN does not exist. Creating vlan 13
Switch(config-if)#ex
Switch(config)#int fa0/
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/7 (1), with Switch
FastEthernet0/3 (17).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/4 (1), with Switch
FastEthernet0/3 (14).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/8 (1), with Switch
FastEthernet0/3 (18).

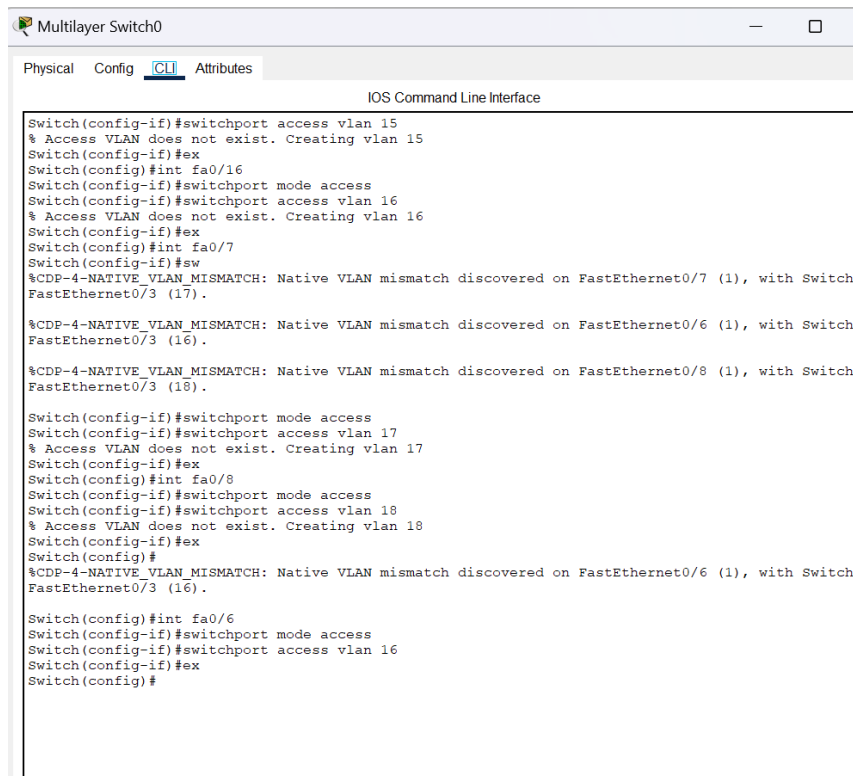
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/5 (1), with Switch
FastEthernet0/3 (15).

      ^
% Invalid input detected at '^' marker.

Switch(config)#int fa0/4
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 14
% Access VLAN does not exist. Creating vlan 14
Switch(config-if)#ex
Switch(config)#int fa0/5
Switch(config-if)#switchport mode access
Switch(config-if)#
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/7 (1), with Switch
FastEthernet0/3 (17).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/8 (1), with Switch
```

A screenshot of a network configuration window titled "Multilayer Switch0". The window has tabs for "Physical", "Config", "CLI", and "Attributes", with "CLI" selected. Below the tabs is a header "IOS Command Line Interface". The main area contains a series of configuration commands and system messages. The commands configure interfaces fa0/15, fa0/16, fa0/7, fa0/8, and fa0/6, setting them to access mode and assigning them to VLANs 15, 16, 17, 18, and 16 respectively. System messages indicate that VLANs 15, 16, and 17 were created because they did not exist. Additionally, there are three CDP-4-NATIVE_VLAN_MISMATCH messages for interfaces fa0/7, fa0/6, and fa0/8, all reporting a mismatch with Switch FastEthernet0/3.

```
Switch(config-if)#switchport access vlan 15
% Access VLAN does not exist. Creating vlan 15
Switch(config-if)#ex
Switch(config)#int fa0/16
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 16
% Access VLAN does not exist. Creating vlan 16
Switch(config-if)#ex
Switch(config)#int fa0/7
Switch(config-if)#sw
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/7 (1), with Switch
FastEthernet0/3 (17).

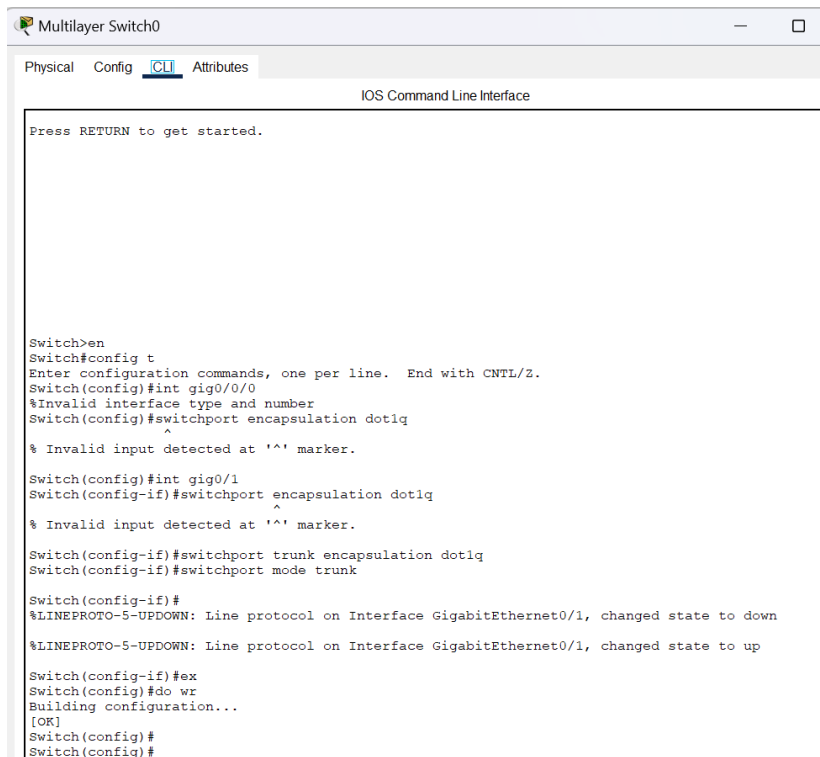
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).

%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/8 (1), with Switch
FastEthernet0/3 (18).

Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 17
% Access VLAN does not exist. Creating vlan 17
Switch(config-if)#ex
Switch(config)#int fa0/8
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 18
% Access VLAN does not exist. Creating vlan 18
Switch(config-if)#ex
Switch(config)#
%CDP-4-NATIVE_VLAN_MISMATCH: Native VLAN mismatch discovered on FastEthernet0/6 (1), with Switch
FastEthernet0/3 (16).

Switch(config)#int fa0/6
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 16
Switch(config-if)#ex
Switch(config)#
```

Configure Trunk link on L3 Switch

A screenshot of a network configuration window titled "Multilayer Switch0". The window has tabs for "Physical", "Config", "CLI", and "Attributes", with "CLI" selected. Below the tabs is a header "IOS Command Line Interface". The main area shows the configuration of a trunk link on interface gig0/1. The commands include enabling the switch, entering configuration mode, setting the interface to gig0/1, and configuring it as a trunk with dot1q encapsulation. System messages indicate that the line protocol on gig0/1 changed from down to up. The configuration ends with the 'do wr' command to save the configuration.

```
Press RETURN to get started.

Switch>en
Switch#config t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#int gig0/0/0
%Invalid interface type and number
Switch(config)#switchport encapsulation dot1q
^
% Invalid input detected at '^' marker.

Switch(config)#int gig0/1
Switch(config-if)#switchport encapsulation dot1q
^
% Invalid input detected at '^' marker.

Switch(config-if)#switchport trunk encapsulation dot1q
Switch(config-if)#switchport mode trunk

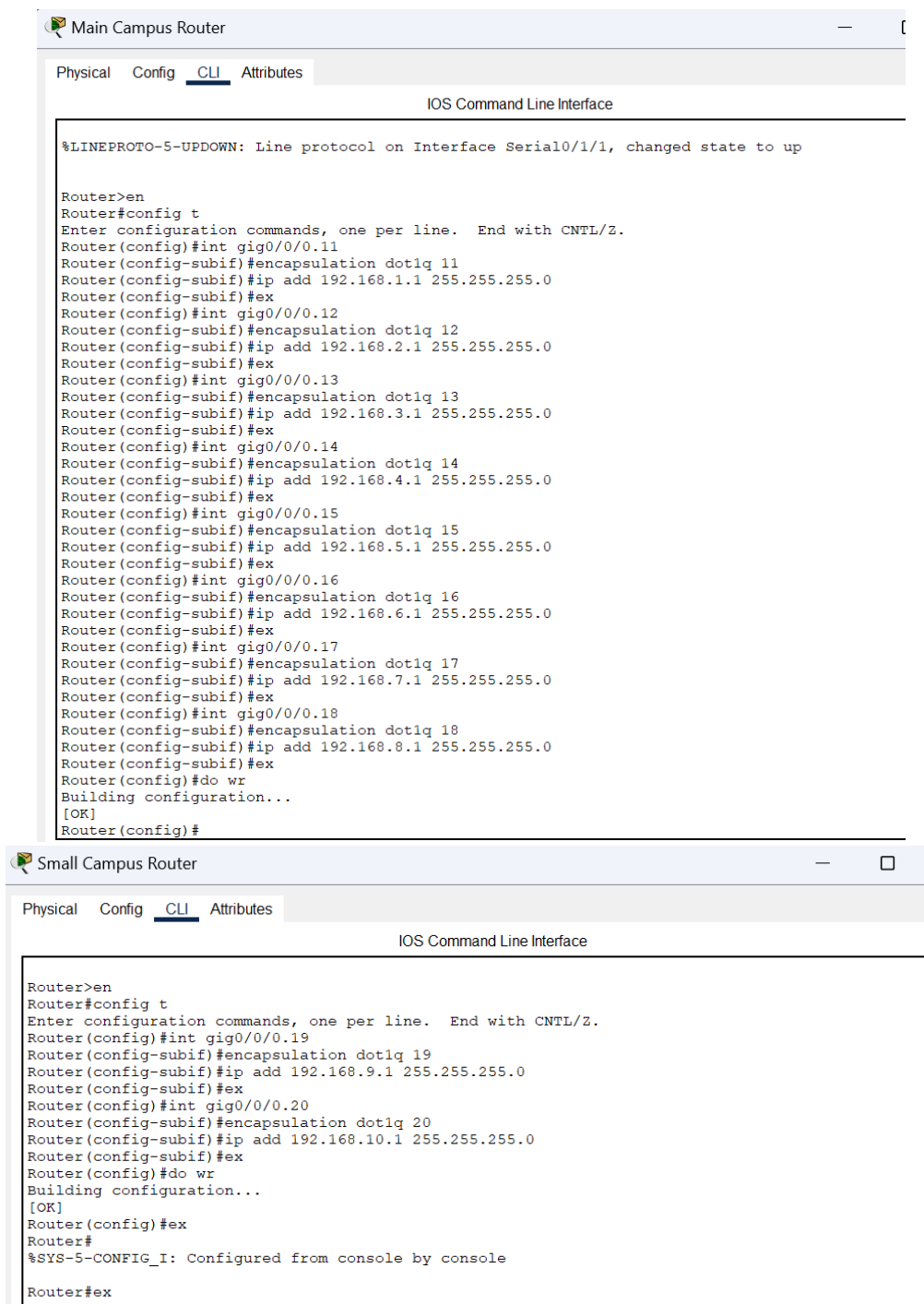
Switch(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up

Switch(config-if)#ex
Switch(config)#do wr
Building configuration...
[OK]
Switch(config)#
Switch(config)#
```

The snapshots of configuration of VLAN on Layer3 Switch for Main Campus is attached above. The left Small Campus floor Layer3 Switch interfaces will be configured the same way as shown in the snapshot according to the VLAN numbers and the Trunk Link is also configured in the Small Campus floor Layer3 Switch for the interface connecting to the Router.

Stick inter-VLAN implementation on Router by creating sub-interfaces for every VLAN

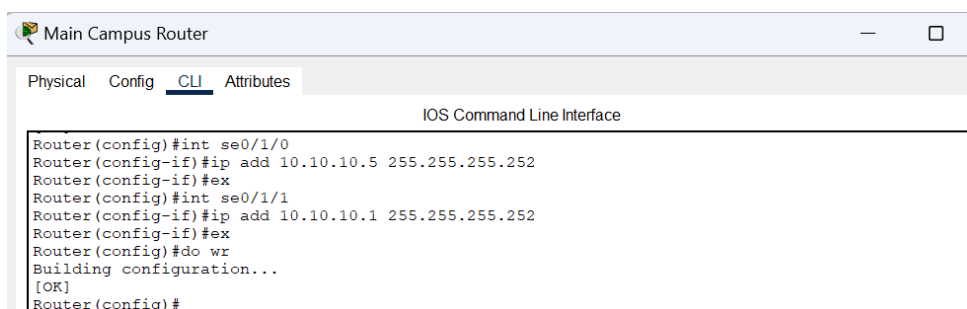


```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int gig0/0/0.11
Router(config-subif)#encapsulation dot1q 11
Router(config-subif)#ip add 192.168.1.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.12
Router(config-subif)#encapsulation dot1q 12
Router(config-subif)#ip add 192.168.2.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.13
Router(config-subif)#encapsulation dot1q 13
Router(config-subif)#ip add 192.168.3.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.14
Router(config-subif)#encapsulation dot1q 14
Router(config-subif)#ip add 192.168.4.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.15
Router(config-subif)#encapsulation dot1q 15
Router(config-subif)#ip add 192.168.5.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.16
Router(config-subif)#encapsulation dot1q 16
Router(config-subif)#ip add 192.168.6.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.17
Router(config-subif)#encapsulation dot1q 17
Router(config-subif)#ip add 192.168.7.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.18
Router(config-subif)#encapsulation dot1q 18
Router(config-subif)#ip add 192.168.8.1 255.255.255.0
Router(config-subif)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#

Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int gig0/0/0.19
Router(config-subif)#encapsulation dot1q 19
Router(config-subif)#ip add 192.168.9.1 255.255.255.0
Router(config-subif)#ex
Router(config)#int gig0/0/0.20
Router(config-subif)#encapsulation dot1q 20
Router(config-subif)#ip add 192.168.10.1 255.255.255.0
Router(config-subif)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#ex
```

Configuring IP addresses on Router serial port interfaces



```
Router(config)#int se0/1/0
Router(config-if)#ip add 10.10.10.5 255.255.255.252
Router(config-if)#ex
Router(config)#int se0/1/1
Router(config-if)#ip add 10.10.10.1 255.255.255.252
Router(config-if)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#
```

Small Campus Router

Physical Config CLI Attributes

IOS Command Line Interface

```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int se0/2/0
Router(config-if)#ip add 10.10.10.2 255.255.255.252
Router(config-if)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG_I: Configured from console by console
ex
```

Cloud Router

Physical Config CLI Attributes

IOS Command Line Interface

```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#se0/1/0
      ^
% Invalid input detected at '^' marker.

Router(config)#int se0/1/0
Router(config-if)#ip add 10.10.10.6 255.255.255.252
Router(config-if)#ex
Router(config)#int gig0/0/0
Router(config-if)#ip add 20.0.0.1 255.255.255.252
Router(config-if)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

Configuration of SSH on L3 Switches and both Routers

Multilayer Switch1

Physical Config CLI Attributes

IOS Command Line Interface

```
Copyright (c) 1986-2007 by Cisco Systems, Inc.
Compiled Thu 05-Jul-07 22:22 by pt_team

Press RETURN to get started!

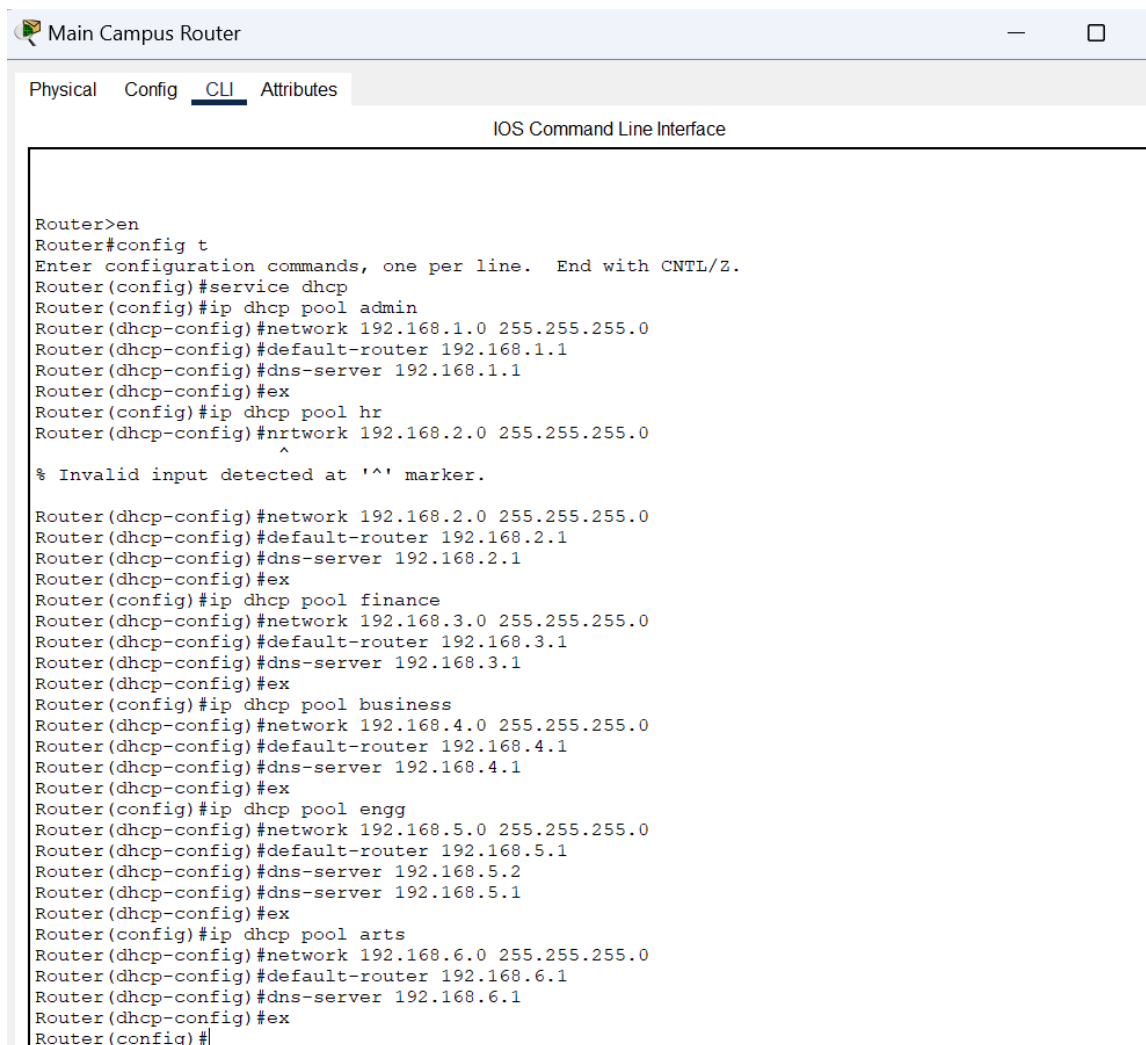
%LINK-5-CHANGED: Interface GigabitEthernet0/1, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet0/1, changed state to up
%LINK-5-CHANGED: Interface FastEthernet0/1, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
%LINK-5-CHANGED: Interface FastEthernet0/2, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/2, changed state to up

Switch>en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#hostname MultilayerSW2
MultilayerSW2(config)#ip domain name cisco.net
MultilayerSW2(config)#username admin password cisco
MultilayerSW2(config)#crypto key generate rsa
The name for the keys will be: MultilayerSW2.cisco.net
Choose the size of the key modulus in the range of 360 to 2048 for your
General Purpose Keys. Choosing a key modulus greater than 512 may take
a few minutes.

How many bits in the modulus [512]: 1023
% Generating 1023 bit RSA keys, keys will be non-exportable...[OK]

MultilayerSW2(config)#line vty 0 15
*Mar 1 0:9:40.227: %SSH-5-ENABLED: SSH 1.99 has been enabled
MultilayerSW2(config-line)#login local
MultilayerSW2(config-line)#transport input ssh
MultilayerSW2(config-line)#exit
MultilayerSW2(config)#do wr
Building configuration...
[OK]
MultilayerSW2(config)#
```

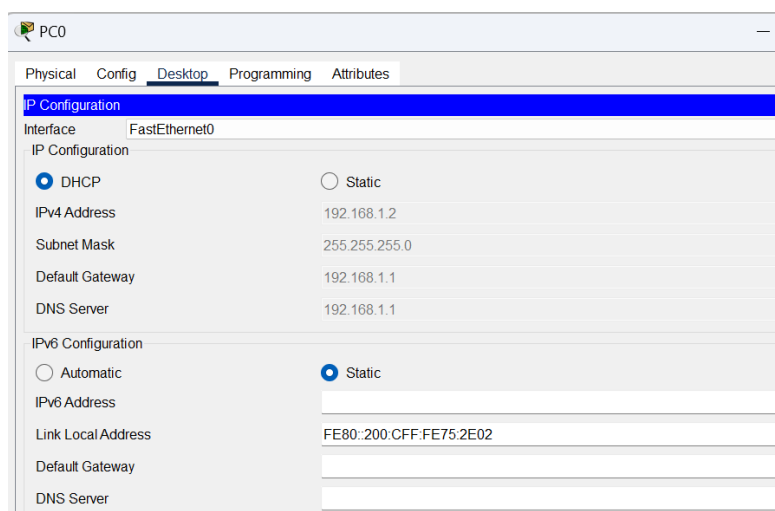
DHCP implementation on Routers for all the departments



```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#service dhcp
Router(config)#ip dhcp pool admin
Router(dhcp-config)#network 192.168.1.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.1.1
Router(dhcp-config)#dns-server 192.168.1.1
Router(dhcp-config)#ex
Router(config)#ip dhcp pool hr
Router(dhcp-config)#network 192.168.2.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.2.1
Router(dhcp-config)#dns-server 192.168.2.1
Router(dhcp-config)#ex
Router(config)#ip dhcp pool finance
Router(dhcp-config)#network 192.168.3.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.3.1
Router(dhcp-config)#dns-server 192.168.3.1
Router(dhcp-config)#ex
Router(config)#ip dhcp pool business
Router(dhcp-config)#network 192.168.4.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.4.1
Router(dhcp-config)#dns-server 192.168.4.1
Router(dhcp-config)#ex
Router(config)#ip dhcp pool engg
Router(dhcp-config)#network 192.168.5.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.5.1
Router(dhcp-config)#dns-server 192.168.5.2
Router(dhcp-config)#dns-server 192.168.5.1
Router(dhcp-config)#ex
Router(config)#ip dhcp pool arts
Router(dhcp-config)#network 192.168.6.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.6.1
Router(dhcp-config)#dns-server 192.168.6.1
Router(dhcp-config)#ex
Router(config)#
```

The DHCP implementation for the remaining departments on the Small Campus Router has been done on the same way as shown above.

Dynamic IP address configuration on all the hosts



IP Configuration	
Interface	FastEthernet0
IP Configuration	
<input checked="" type="radio"/> DHCP	<input type="radio"/> Static
IPv4 Address	192.168.1.2
Subnet Mask	255.255.255.0
Default Gateway	192.168.1.1
DNS Server	192.168.1.1
IPv6 Configuration	
<input type="radio"/> Automatic	<input checked="" type="radio"/> Static
IPv6 Address	
Link Local Address	FE80::200:CFF:FE75:2E02
Default Gateway	
DNS Server	

Configuring RIPv2 as the routing protocol

Small Campus Router

Physical Config CLI Attributes

IOS Command Line Interface

```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router rip
Router(config-router)#version 2
Router(config-router)#network 10.10.10.0
Router(config-router)#network 192.168.9.0
Router(config-router)#network 192.168.10.0
Router(config-router)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

Cloud Router

Physical Config CLI Attributes

IOS Command Line Interface

```
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router rip
Router(config-router)#version 2
Router(config-router)#network 10.10.10.4
Router(config-router)#network 20.0.0.0
Router(config-router)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG_I: Configured from console by console
```

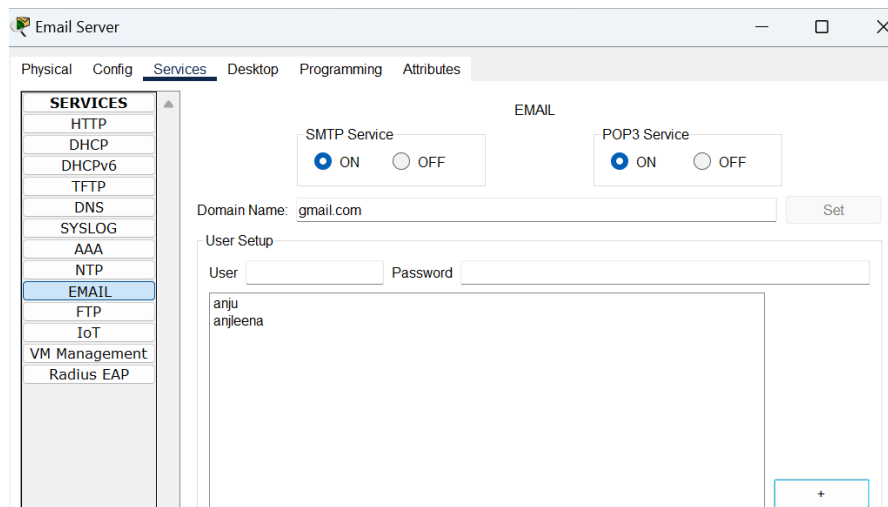
Main Campus Router

Physical Config CLI Attributes

IOS Command Line Interface

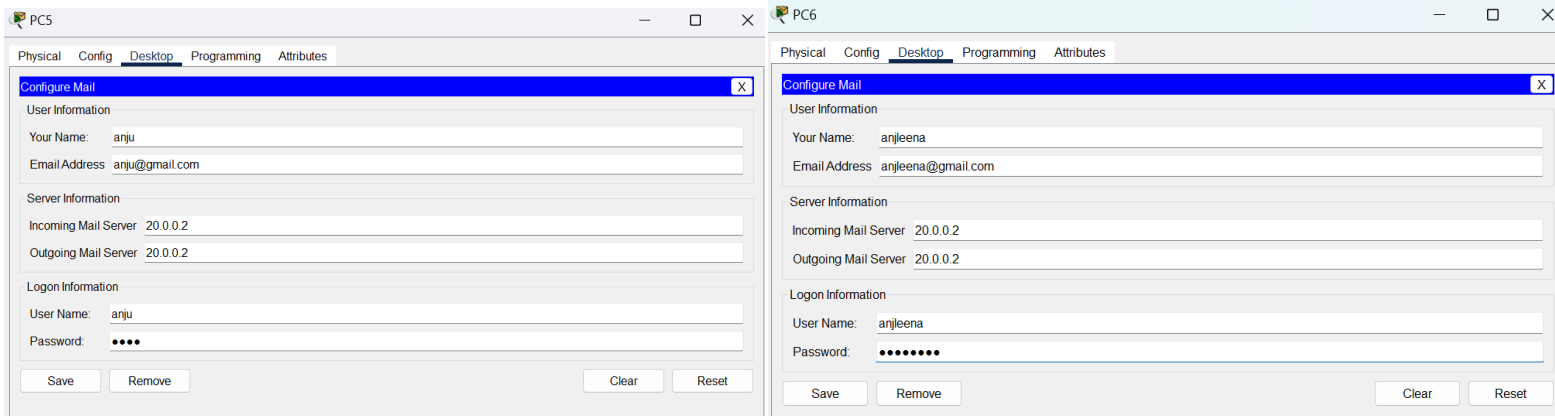
```
Router>
Router>en
Router#config t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router rip
Router(config-router)#version 2
Router(config-router)#network 10.10.10.0
Router(config-router)#network 10.10.10.4
Router(config-router)#network 192.168.1.0
Router(config-router)#network 192.168.2.0
Router(config-router)#network 192.168.3.0
Router(config-router)#network 192.168.2.0
Router(config-router)#network 192.168.4.0
Router(config-router)#network 192.168.5.0
Router(config-router)#network 192.168.6.0
Router(config-router)#network 192.168.7.0
Router(config-router)#network 192.168.8.0
Router(config-router)#ex
Router(config)#do wr
Building configuration...
[OK]
Router(config)#ex
Router#
%SYS-5-CONFIG I: Configured from console by console
```


Configuring Email server

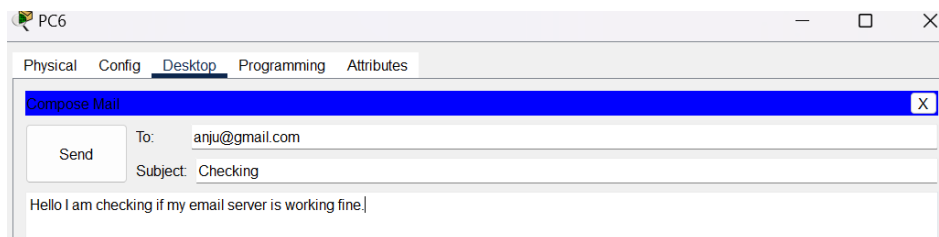


The 'Email Server' configuration window shows the 'Services' tab. In the left sidebar, 'EMAIL' is selected. The main area is titled 'EMAIL' and contains two service toggle buttons: 'SMTP Service' (set to ON) and 'POP3 Service' (set to ON). Below these, the 'Domain Name' is set to 'gmail.com'. A 'User Setup' section contains a list of users: 'anju' and 'anleena'. A '+' button is at the bottom right.

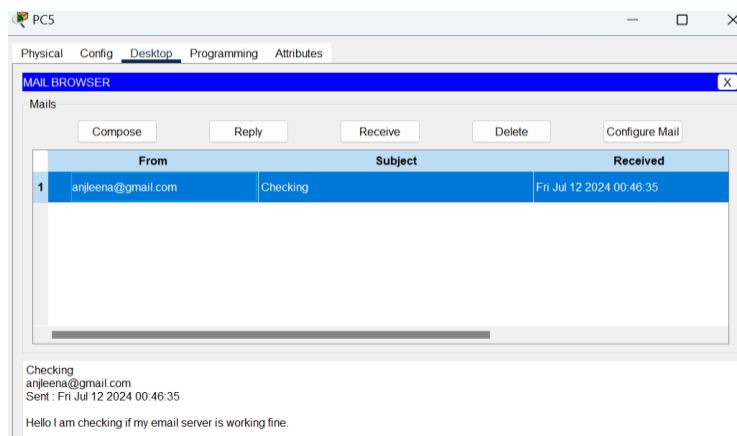
Checking by creating account and sending email



Two 'Configure Mail' windows are shown side-by-side. The left window (PC5) is for user 'anju' with email 'anju@gmail.com'. The right window (PC6) is for user 'anleena' with email 'anleena@gmail.com'. Both windows have identical fields for 'Your Name', 'Email Address', 'Incoming Mail Server' (20.0.0.2), 'Outgoing Mail Server' (20.0.0.2), 'User Name', and 'Password'. Buttons for 'Save', 'Remove', 'Clear', and 'Reset' are at the bottom.



The 'Compose Mail' window for PC6 shows the 'Desktop' tab. It has a 'Send' button and fields for 'To:' (anju@gmail.com) and 'Subject:' (Checking). The email body contains the text: 'Hello I am checking if my email server is working fine.'



The 'MAIL BROWSER' window for PC5 shows a table of received emails. The table has columns for 'From', 'Subject', and 'Received'. One email is listed: from 'anleena@gmail.com' with subject 'Checking', received on 'Fri Jul 12 2024 00:46:35'. Below the table, the email content is displayed: 'Checking', 'anleena@gmail.com', 'Sent: Fri Jul 12 2024 00:46:35', and 'Hello I am checking if my email server is working fine.'

	From	Subject	Received
1	anleena@gmail.com	Checking	Fri Jul 12 2024 00:46:35

Checking
anleena@gmail.com
Sent: Fri Jul 12 2024 00:46:35
Hello I am checking if my email server is working fine.

Result and analysis

Key achievements

1. Network Topology:

- The network topology was designed to include a main campus with three buildings (A, B, and C) and a small campus for the Faculty of Health and Sciences.
- Each building and department were assigned distinct IP networks, with VLANs configured to segment the network logically.

2. VLAN Configuration:

- VLANs were created and assigned to the appropriate ports on both Access Layer L2 switches and Distribution Layer L3 switches.
- Inter-VLAN routing was implemented using a router-on-a-stick configuration, ensuring efficient communication between different VLANs.

3. DHCP and IP Addressing:

- DHCP servers were configured on routers to dynamically assign IP addresses to devices in Building A and other departments.
- Static IP addressing was used for critical devices such as servers.

4. Routing Protocols:

- RIPv2 was configured as the routing protocol for internal network routing, ensuring efficient data packet forwarding.
- Static routing was used for external server communication.

5. Security Measures:

- Switchport security was implemented on switches to prevent unauthorized access.
- SSH was configured for secure remote access to network devices.

6. Network Testing and Verification:

- Comprehensive testing was conducted to verify network communication, including ping tests, traceroutes, and connectivity checks.
- The network demonstrated stable and reliable performance, with all devices able to communicate as expected.

Analysis and Performance

1. Scalability:

- The network design allows for future scalability, with the ability to add more VLANs and devices as needed without significant reconfiguration.

2. Performance:

- The use of VLANs and inter-VLAN routing improved network performance by reducing broadcast domains and enhancing data traffic management.

3. Security:

- Implementing switchport security and SSH for remote access significantly enhanced the network's security posture, protecting against unauthorized access and potential threats.