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.

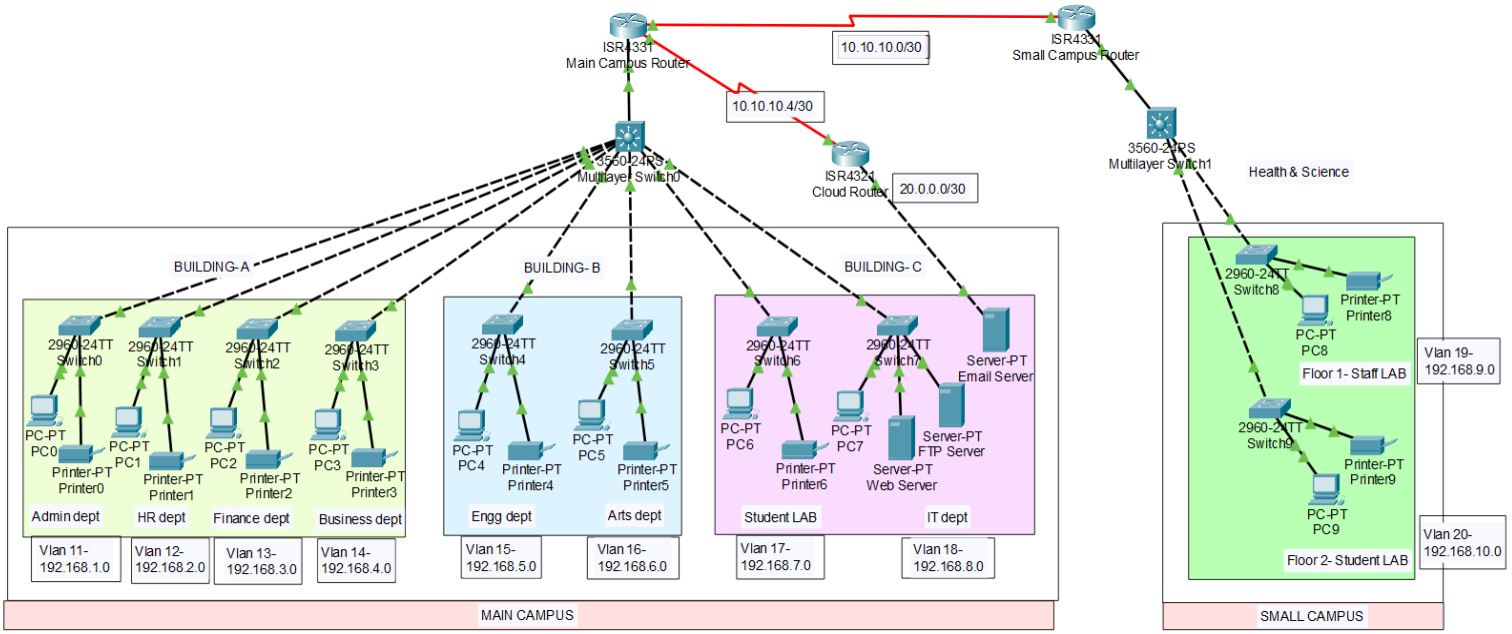
Small Campus

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

Switch0

Physical Config CLI Attributes

IOS Command Line Interface

```
------ ----- -----          ----------          ----------
*    1 26    WS-C2960-24TT-L    15.0(2)SE4          C2960-LANBASEK9-M

Cisco IOS Software, C2960 Software (C2960-LANBASEK9-M), Version 15.0(2)SE4, RELEASE SOFTWARE
(fc1)
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Compiled Wed 26-Jun-13 02:49 by mnguyen


Press RETURN to get started!


%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

%LINK-5-CHANGED: Interface FastEthernet0/3, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/3, changed state to up


Switch>en
Switch#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#int range fa0/1-24
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 11
% Access VLAN does not exist. Creating vlan 11
Switch(config-if-range)#do write
Building configuration...
[OK]
Switch(config-if-range)#ex
Switch(config)#
```

Switch1

Physical Config CLI Attributes

IOS Command Line Interface

```
Cisco IOS Software, C2960 Software (C2960-LANBASEK9-M), Version 15.0(2)SE4, RELEASE SOFTWARE
(fc1)
Technical Support: http://www.cisco.com/techsupport
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Press RETURN to get started!


%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

%LINK-5-CHANGED: Interface FastEthernet0/3, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/3, changed state to up


Switch>en
Switch#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Switch(config)#int range fa0/1-24
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 12
% Access VLAN does not exist. Creating vlan 12
Switch(config-if-range)#do wr
Building configuration...
[OK]
Switch(config-if-range)#ex
Switch(config)#
```
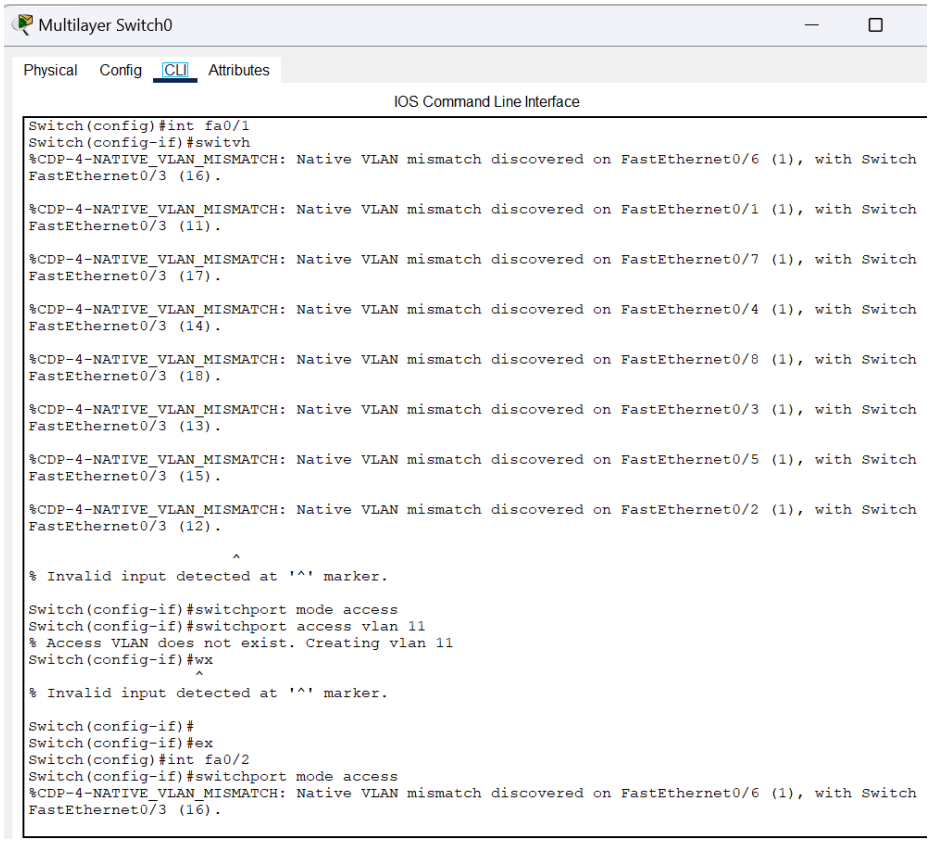
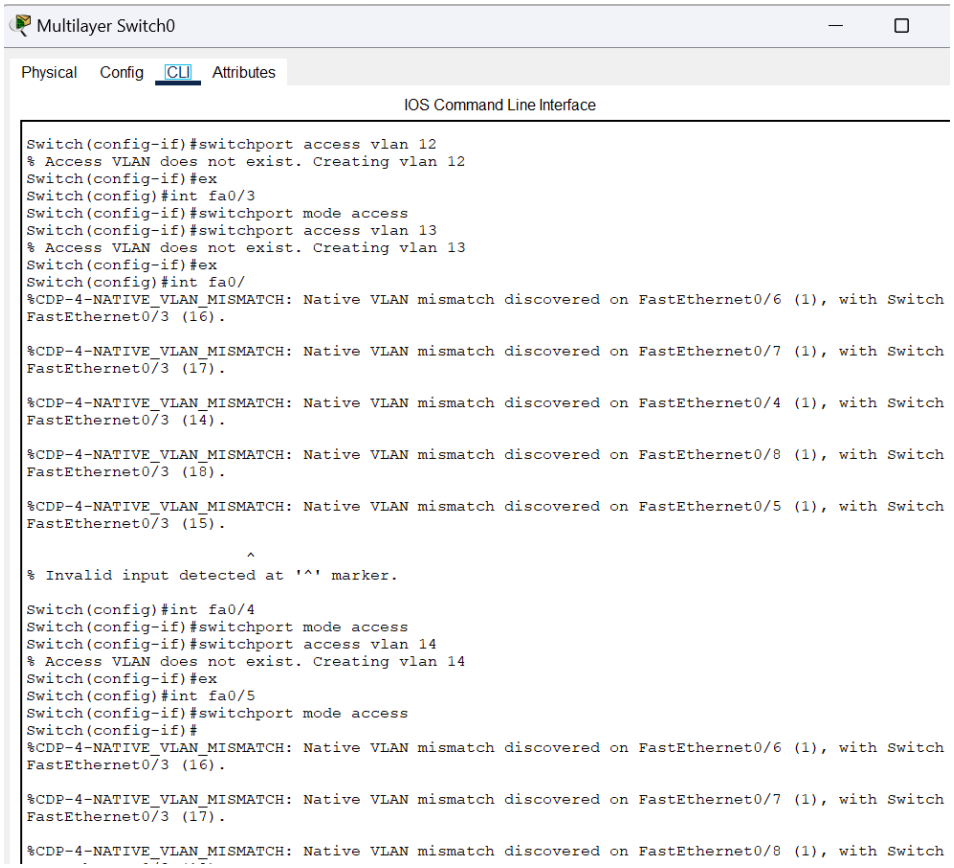
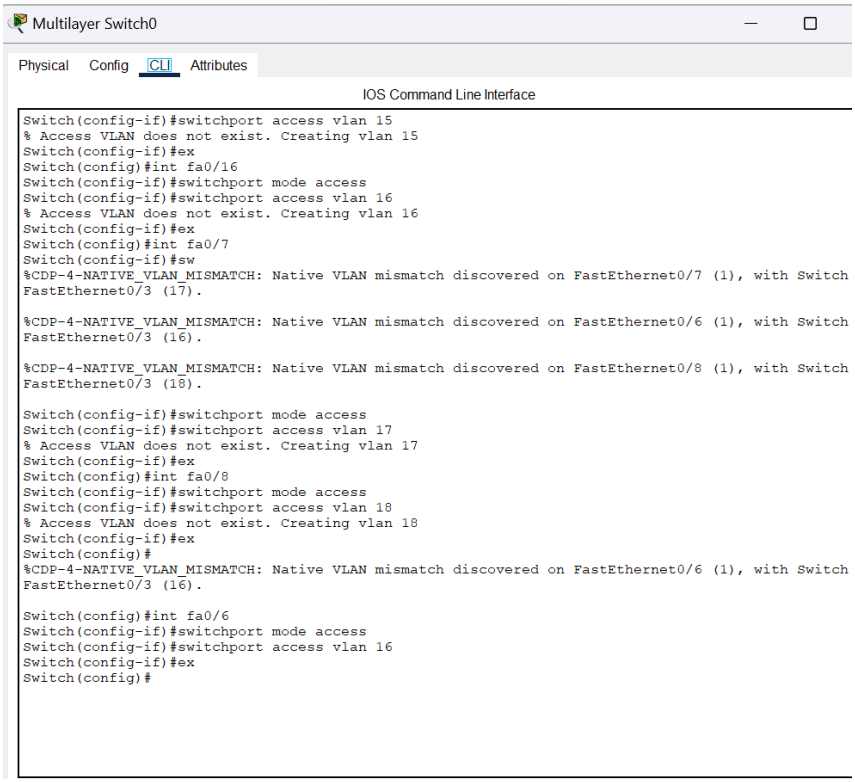

The snapshots of two switches of Building A for Admin and HR departments are attached above. For all the left departments of buildings B & C and Small Campus floor Switch2-9 interfaces will be configured the same way as shown in the snapshot according to their VLAN numbers allotted to them.

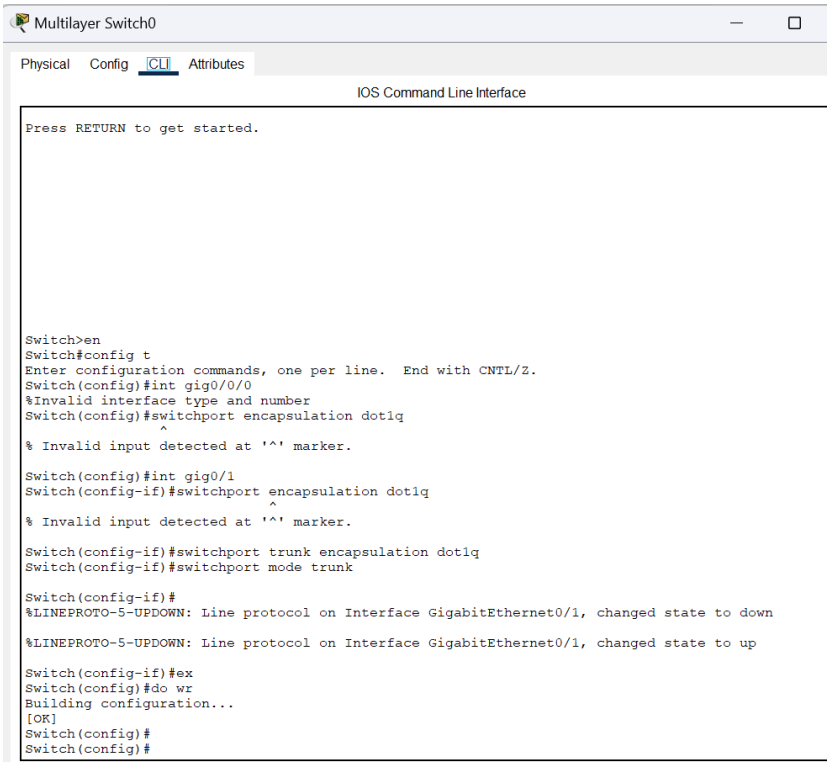
Stick VLAN implementation on Distribution Layer L3 Switches





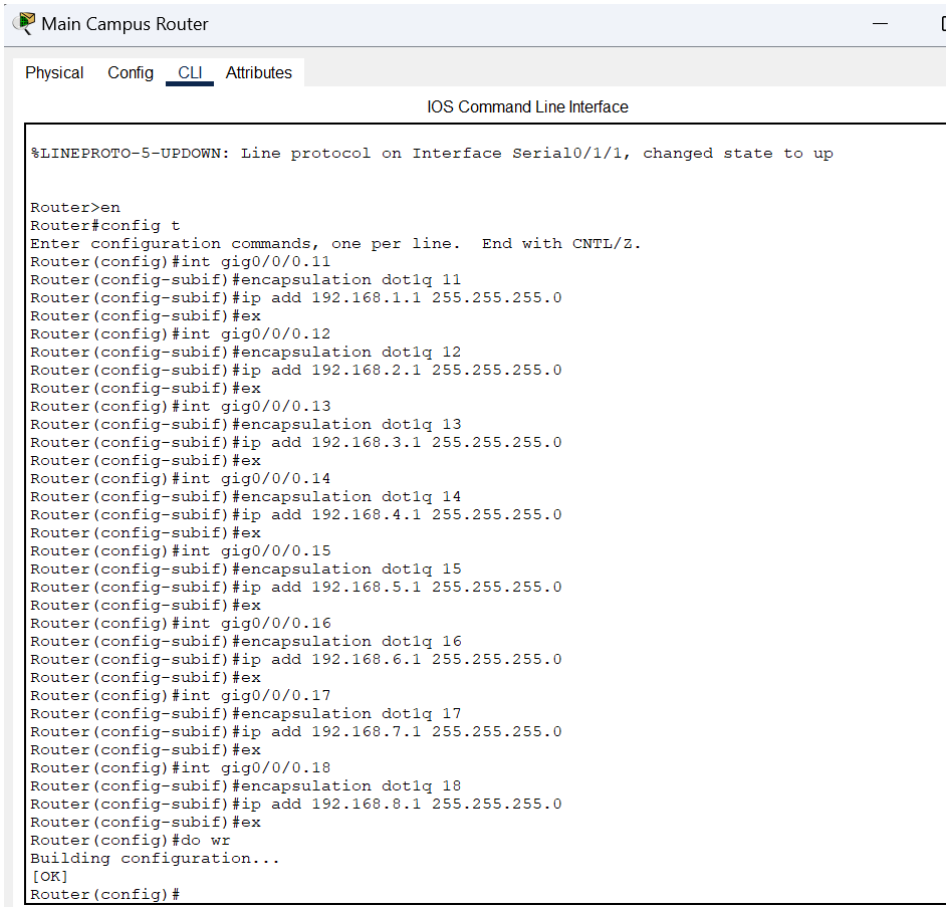


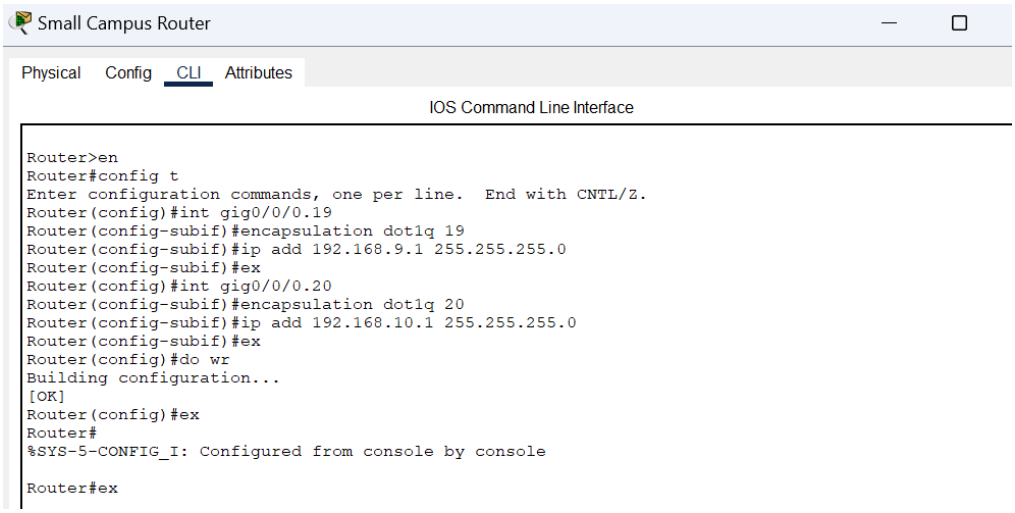
Configure Trunk link on L3 Switch



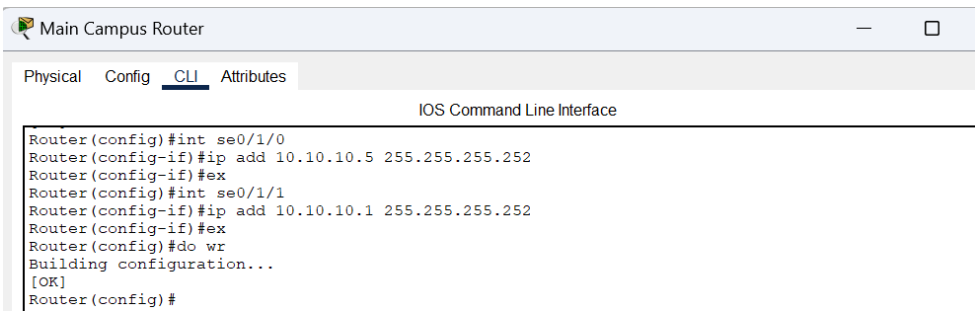
The snapshots of configuration of VLAN on Layer3 Switch for Main Campus is attached above. The left Small Campus floor Layer3 Switch interfaces will be configured the same way as shown in the snapshot according to the VLAN numbers and the Trunk Link is also configured in the Small Campus floor Layer3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

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





Configuring IP addresses on Router serial port interfaces



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

```
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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)#
```
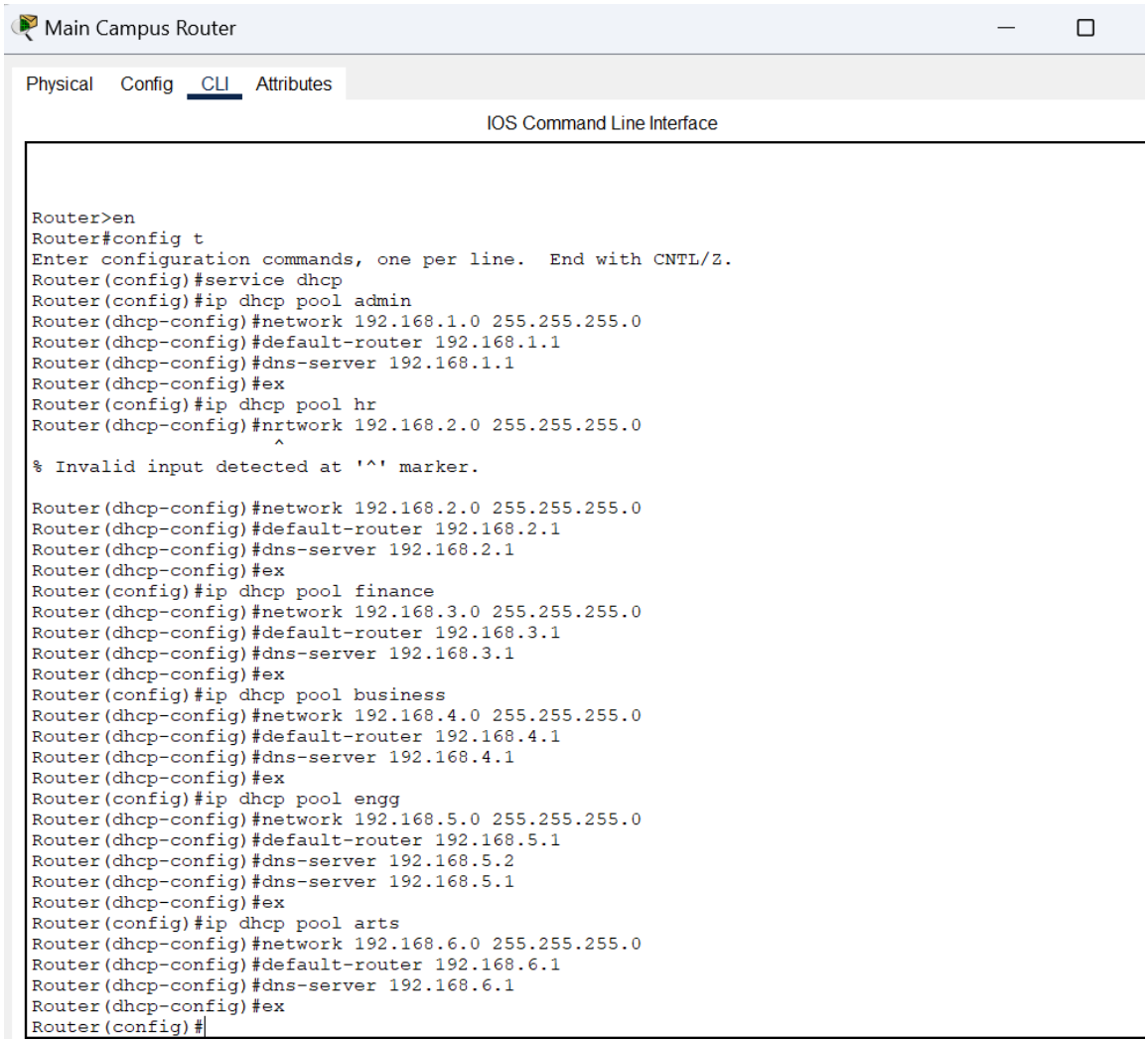
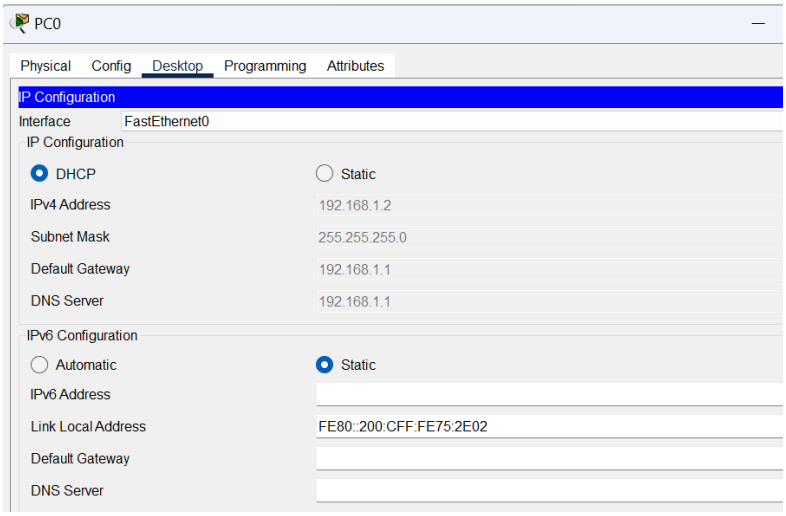

DHCP implementation on Routers for all the departments

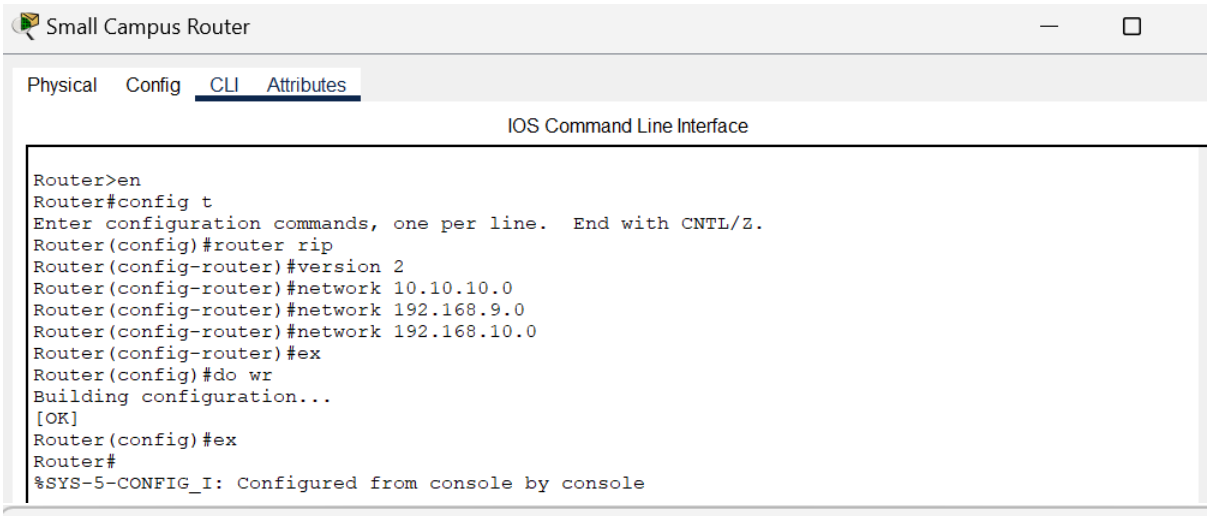


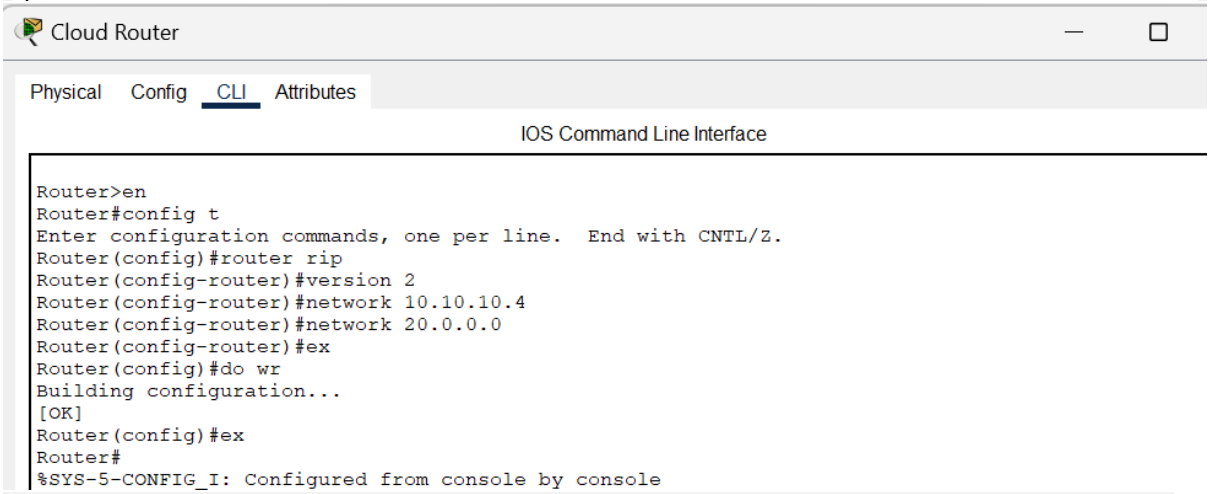
The DHCP implementation for the remaining departments on the Small Campus Router has been done on the same way as shown above.

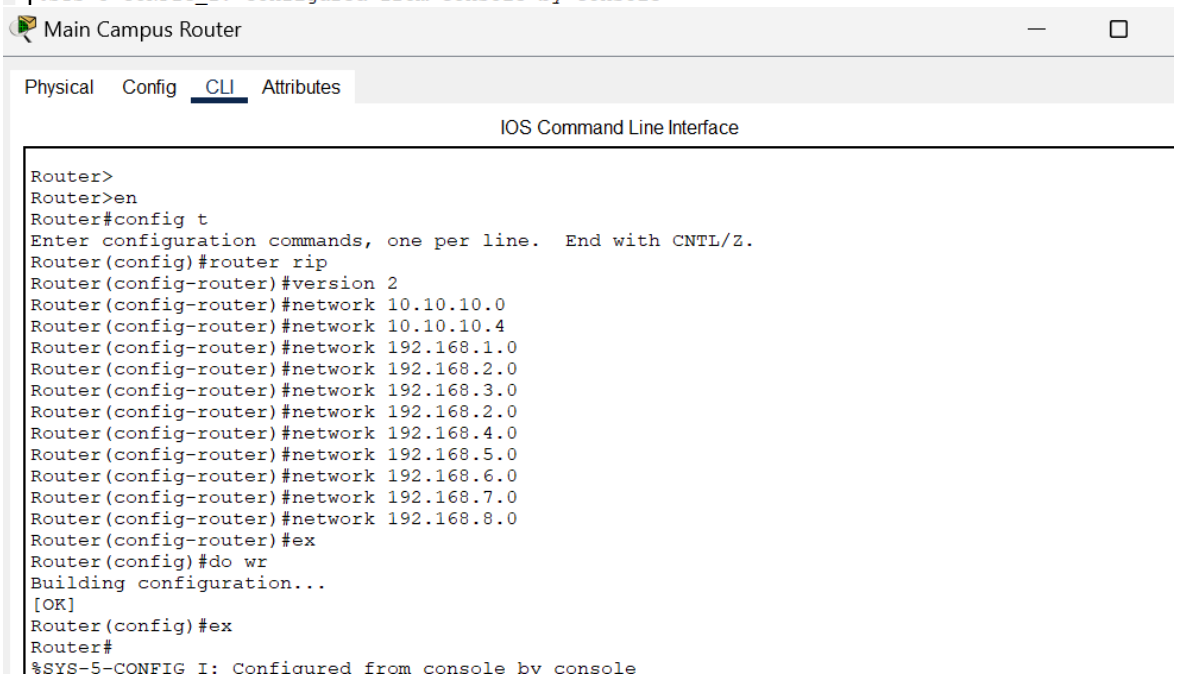
Dynamic IP address configuration on all the hosts



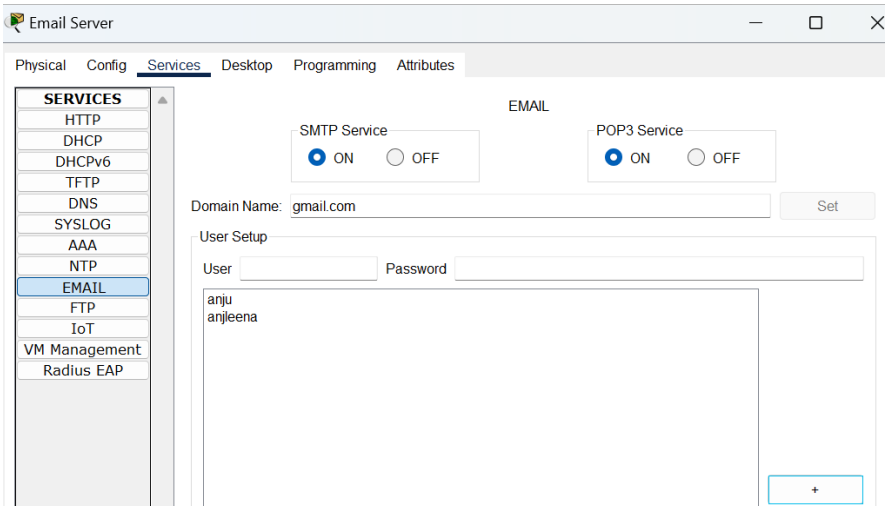
Configuring RIPv2 as the routing protocol



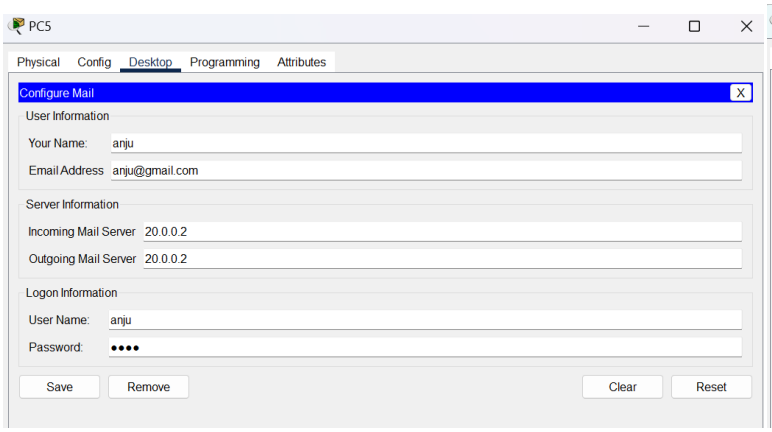


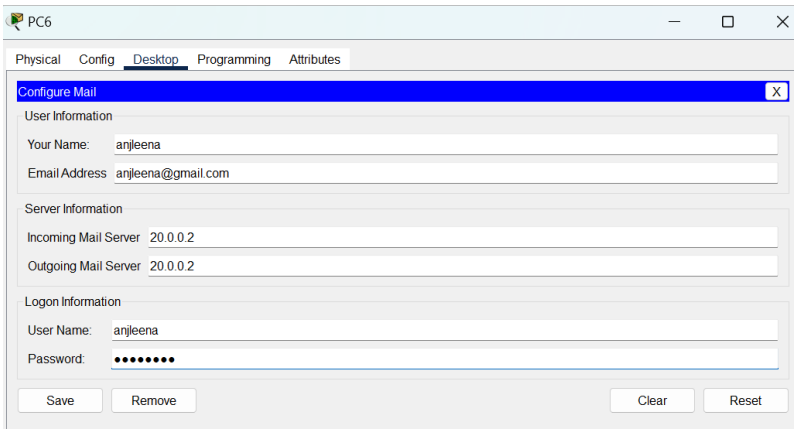


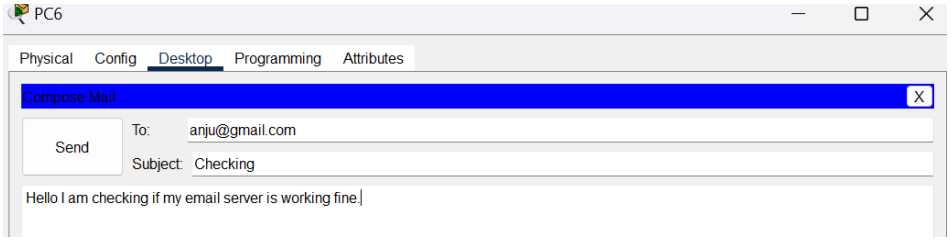
Configuring Email server

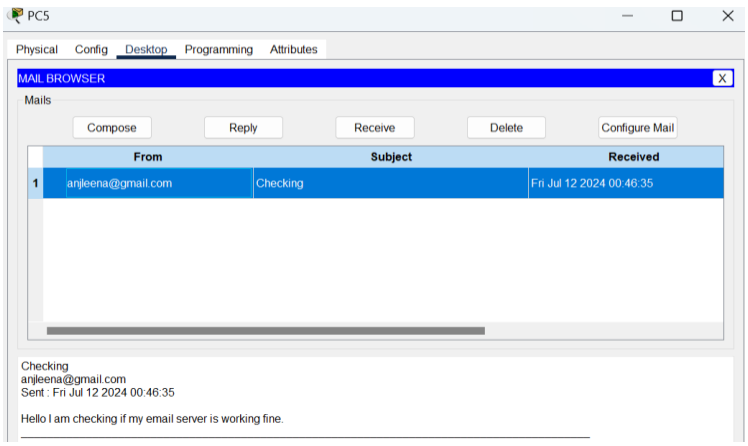


Checking by creating account and sending email









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.