National University of Computer and Emerging Sciences
Islamabad Campus

COMPUTER NETWORKS

Final Project
University Campus Project

Submitted by: Hasan Ali
Roll number: 22i-0919
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• Introduction

This project aims to design and implement a university campus network using Cisco technologies, which will consist of four distinct blocks. Each block will be assigned a unique routing protocol to manage its internal network traffic. The network will support seamless communication between all blocks, allowing them to send emails to one another and ensuring that each network has dynamic IP address assignment through DHCP. The IP addressing scheme and subnets for each block will be efficiently planned and calculated using Variable Length Subnet Masking (VLSM) to optimize address space utilization. The campus network will be designed to meet the communication and scalability needs of a modern educational institution, providing both connectivity and security for all users.

• Objective

The objectives of this project are as follows:

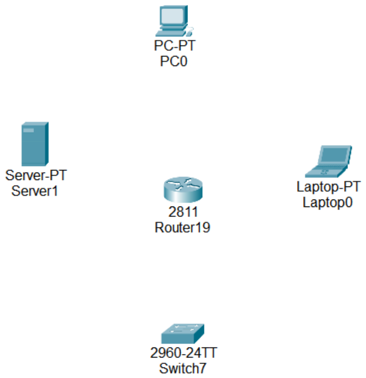
1. **Design a Scalable Network:** Create a well-structured network layout with four blocks, each configured with different routing protocols (e.g., RIP, OSPF, EIGRP, or BGP) to demonstrate protocol diversity and its impact on campus-wide communication.
2. **VLSM IP Addressing:** Calculate and assign IP addresses and subnets using VLSM to optimize address allocation for each block and its associated devices.
3. **Enable Communication:** Ensure all blocks and their respective networks can communicate effectively, including email exchanges between all blocks.
4. **DHCP Configuration:** Implement Dynamic Host Configuration Protocol (DHCP) to automate IP address assignment for all devices within each block.
5. **Routing and Protocol Configuration:** Configure each block's router with a unique routing protocol to ensure efficient routing between blocks and optimal network performance.
6. **Simulate and Test the Network:** Validate the design by testing email functionality, network connectivity, and DHCP operations across the entire campus network.

This project will demonstrate the application of routing protocols, IP addressing, and network configuration techniques in a real-world educational environment.

• Details and Steps

These are the devices I used in my project:

1. **PCs and Laptops:** I chose PCs and laptops to represent the end-user devices on campus. These devices help test network connectivity, email communication, and DHCP functionality between different blocks.
2. **2960-24TT Switch:** The Cisco 2960-24TT switch was selected for its 24 Ethernet ports, making it ideal for connecting multiple devices in each block. It handles local traffic management and ensures devices within the same block can communicate.
3. **2811 Router:** The Cisco 2811 router was chosen to route traffic between the blocks using different routing protocols. It also supports DHCP to assign IP addresses dynamically to devices across the network.
4. **Server:** I included a server to provide essential network services such as email (SMTP), DHCP, and potentially DNS. The server centralizes services, allowing seamless communication and IP address management within the campus network.



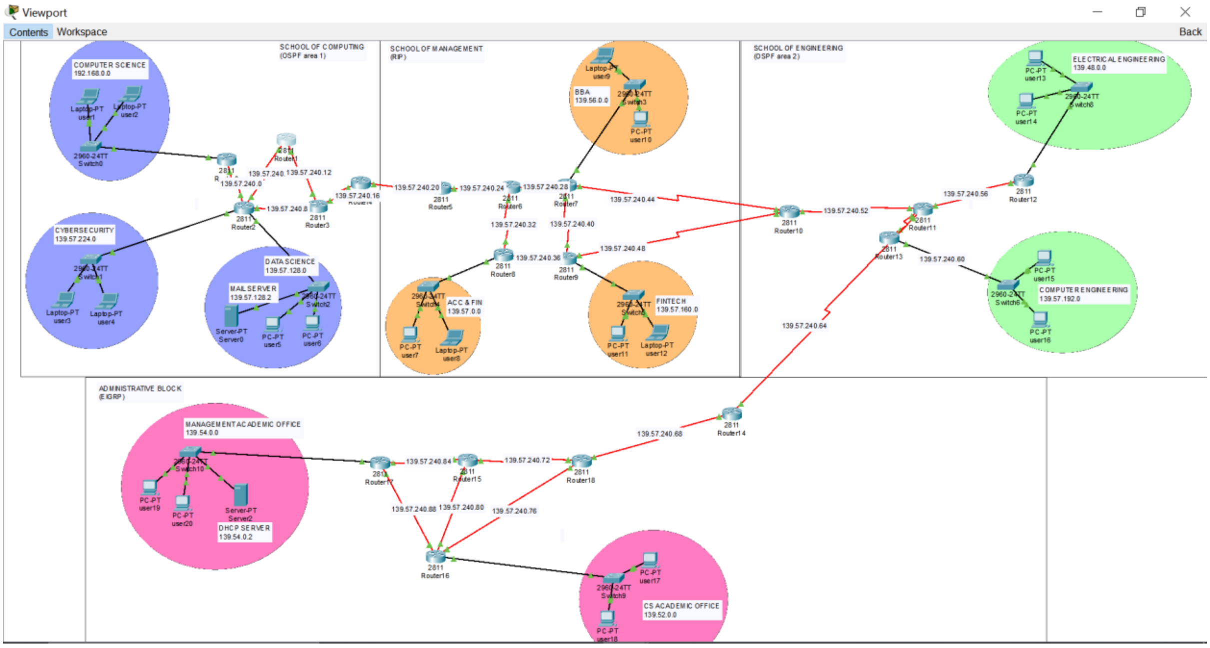
I created a topology consisting of four blocks, each representing a different building within the university. Each block is interconnected by multiple routers, with each block running a distinct routing protocol.

- **The first block, "School of Computing,"** uses the ***OSPF Area 1*** protocol and includes three networks: Computer Science, Cybersecurity, and Data Science.
- **The second block, "School of Management,"** operates with the ***RIP protocol*** and contains three networks: Accounting and Finance, Fintech, and BBA.
- **The third block, "School of Engineering,"** uses the ***OSPF Area 2*** protocol and supports two networks: Electrical Engineering and Computer Engineering.
- **The fourth block, "Administrative Block,"** employs the ***EIGRP*** protocol and consists of two networks: Management Academic Office and CS Academic Office.

This setup ensures that each block's network is efficiently managed with its own routing protocol while maintaining seamless communication across the campus.

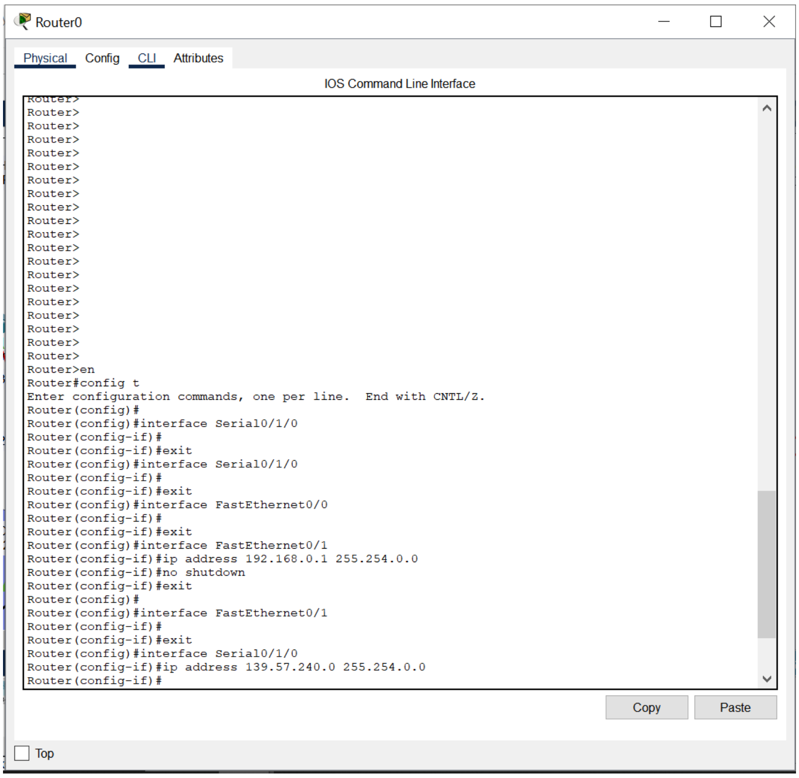
I added a **DHCP server** in the **"Management Academic Office"** network for dynamic IP allocation and an **Email server** in the **"Data Science"** network to enable email communication across the campus.

This is what my topology looks like:



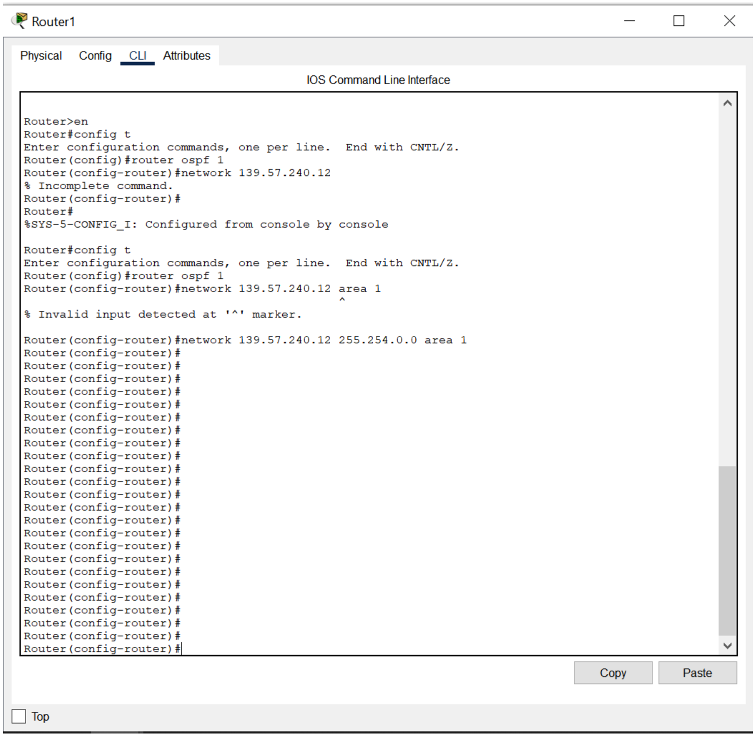
I randomly selected an IP address, **139.49.169.186**, and assigned different hosts to each network. Using a VLSM calculator, I calculated the subnet masks and then assigned IP addresses to all the devices across the networks.

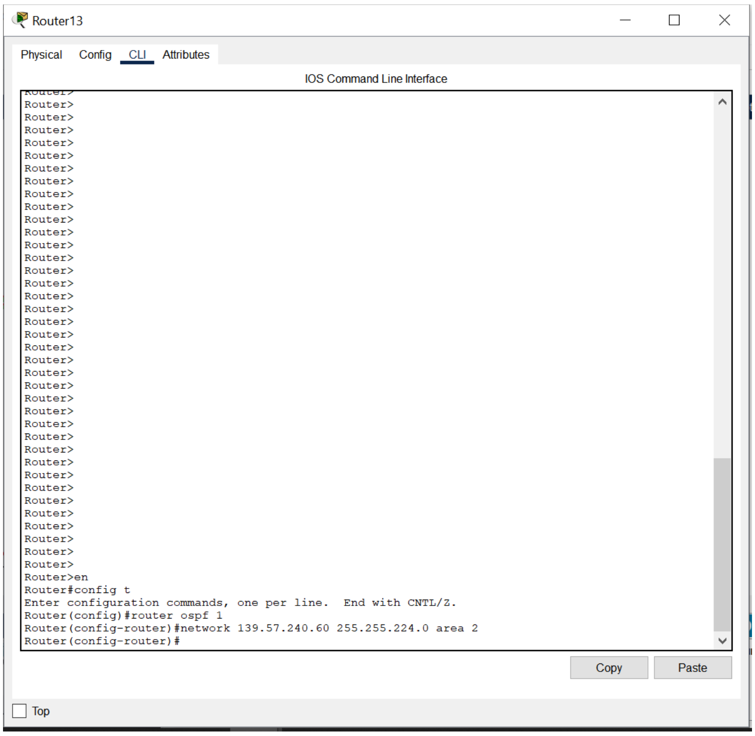
I provided basic configurations to each router and connected them by assigning IP addresses to their respective interfaces, ensuring proper communication between the routers across the networks. Following screenshot shows the configuration of one of the routers:

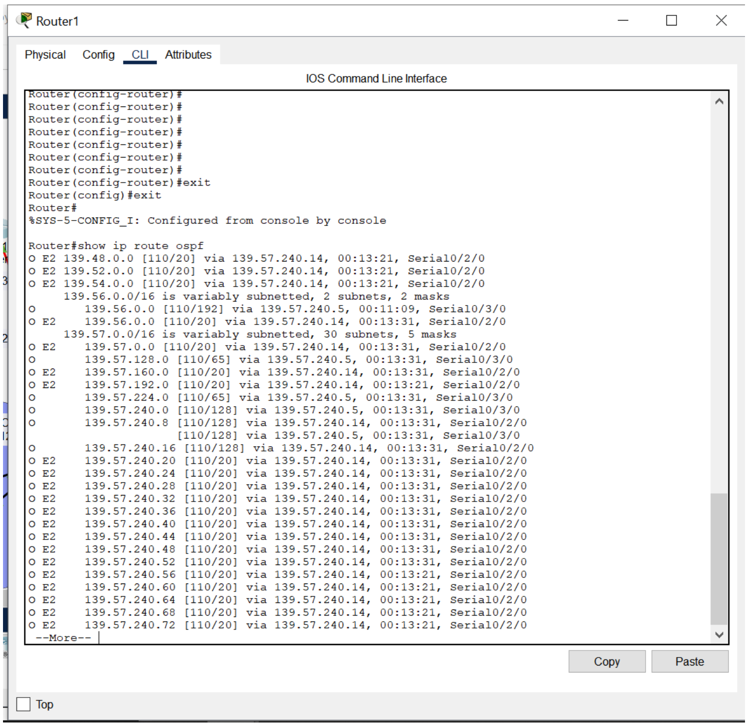


Next, I configured the routing protocols on each router according to the block they belong to. Below are the screenshots for one router from each block, along with proof of successful configuration and routing:

1. OSPF Area 1 and Area 2






Router1
Physical
Config
CLI
Attributes
IOS Command Line Interface
Router(config-router)#
Router(config-router)#
Router(config-router)#
Router(config-router)#
Router(config-router)#
Router(config-router)#
Router(config-router)#
Router(config-router)#exit
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console
Router#show ip route ospf
O E2 139.48.0.0 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.52.0.0 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.54.0.0 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
139.56.0.0/16 is variably subnetted, 2 subnets, 2 masks
O 139.56.0.0 [110/192] via 139.57.240.5, 00:11:09, Serial0/3/0
O E2 139.56.0.0 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
139.57.0.0/16 is variably subnetted, 30 subnets, 5 masks
O E2 139.57.0.0 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O 139.57.128.0 [110/65] via 139.57.240.5, 00:13:31, Serial0/3/0
O E2 139.57.160.0 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.192.0 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O 139.57.224.0 [110/65] via 139.57.240.5, 00:13:31, Serial0/3/0
O 139.57.240.0 [110/128] via 139.57.240.5, 00:13:31, Serial0/3/0
O 139.57.240.8 [110/128] via 139.57.240.14, 00:13:31, Serial0/2/0
[110/128] via 139.57.240.5, 00:13:31, Serial0/3/0
O 139.57.240.16 [110/128] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.20 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.24 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.28 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.32 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.36 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.40 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.44 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.48 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.52 [110/20] via 139.57.240.14, 00:13:31, Serial0/2/0
O E2 139.57.240.56 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.57.240.60 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.57.240.64 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.57.240.68 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
O E2 139.57.240.72 [110/20] via 139.57.240.14, 00:13:21, Serial0/2/0
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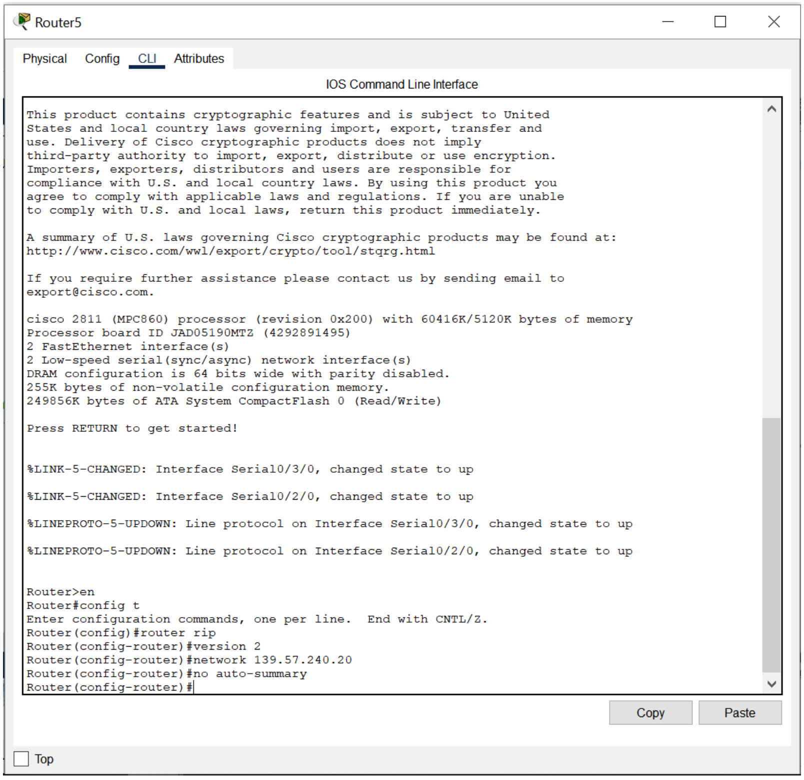
Top

2. RIP


Router5
Physical
Config
CLI
Attributes
IOS Command Line Interface
This product contains cryptographic features and is subject to United
States and local country laws governing import, export, transfer and
use. Delivery of Cisco cryptographic products does not imply
third-party authority to import, export, distribute or use encryption.
Importers, exporters, distributors and users are responsible for
compliance with U.S. and local country laws. By using this product you
agree to comply with applicable laws and regulations. If you are unable
to comply with U.S. and local laws, return this product immediately.
A summary of U.S. laws governing Cisco cryptographic products may be found at:
http://www.cisco.com/wwl/export/crypto/tool/stqrg.html
If you require further assistance please contact us by sending email to
export@cisco.com.
cisco 2811 (MPC860) processor (revision 0x200) with 60416K/5120K bytes of memory
Processor board ID JAD05190MTZ (4292891495)
2 FastEthernet interface(s)
2 Low-speed serial(sync/async) network interface(s)
DRAM configuration is 64 bits wide with parity disabled.
255K bytes of non-volatile configuration memory.
249856K bytes of ATA System CompactFlash 0 (Read/Write)
Press RETURN to get started!
%LINK-5-CHANGED: Interface Serial0/3/0, changed state to up
%LINK-5-CHANGED: Interface Serial0/2/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/3/0, changed state to up
%LINEPROTO-5-UPDOWN: Line protocol on Interface Serial0/2/0, changed state to up
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 139.57.240.20
Router(config-router)#no auto-summary
Router(config-router)#
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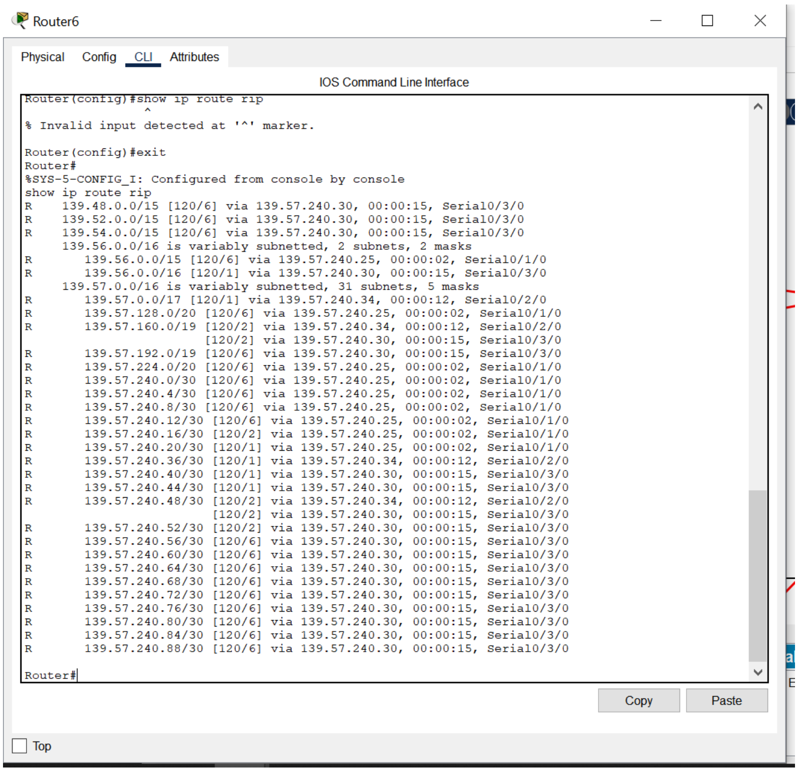
Top



```
Router6
Physical  Config  CLI  Attributes
IOS Command Line Interface
Router(config)#show ip route rip
                    ^
% Invalid input detected at '^' marker.

Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console
show ip route rip
R    139.48.0.0/15 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R    139.52.0.0/15 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R    139.54.0.0/15 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
     139.56.0.0/16 is variably subnetted, 2 subnets, 2 masks
R       139.56.0.0/15 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.56.0.0/16 [120/1] via 139.57.240.30, 00:00:15, Serial0/3/0
     139.57.0.0/16 is variably subnetted, 31 subnets, 5 masks
R       139.57.0.0/17 [120/1] via 139.57.240.34, 00:00:12, Serial0/2/0
R       139.57.128.0/20 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.160.0/19 [120/2] via 139.57.240.34, 00:00:12, Serial0/2/0
                        [120/2] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.192.0/19 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.224.0/20 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.0/30 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.4/30 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.8/30 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.12/30 [120/6] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.16/30 [120/2] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.20/30 [120/1] via 139.57.240.25, 00:00:02, Serial0/1/0
R       139.57.240.36/30 [120/1] via 139.57.240.34, 00:00:12, Serial0/2/0
R       139.57.240.40/30 [120/1] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.44/30 [120/1] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.48/30 [120/2] via 139.57.240.34, 00:00:12, Serial0/2/0
                         [120/2] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.52/30 [120/2] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.56/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.60/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.64/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.68/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.72/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.76/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.80/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.84/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0
R       139.57.240.88/30 [120/6] via 139.57.240.30, 00:00:15, Serial0/3/0

Router#
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Top
```
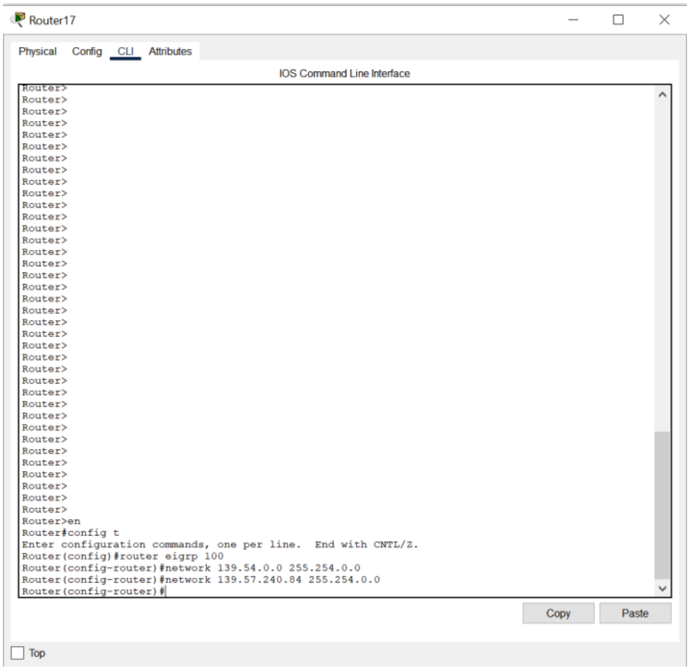

3. EIGRP



```
Router17
Physical  Config  CLI  Attributes
IOS Command Line Interface
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
Router>
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Router>
Router>
Router>
Router>
Router>en
Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#router eigrp 100
Router(config-router)#network 139.54.0.0 255.254.0.0
Router(config-router)#network 139.57.240.84 255.254.0.0
Router(config-router)#
Copy  Paste
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```
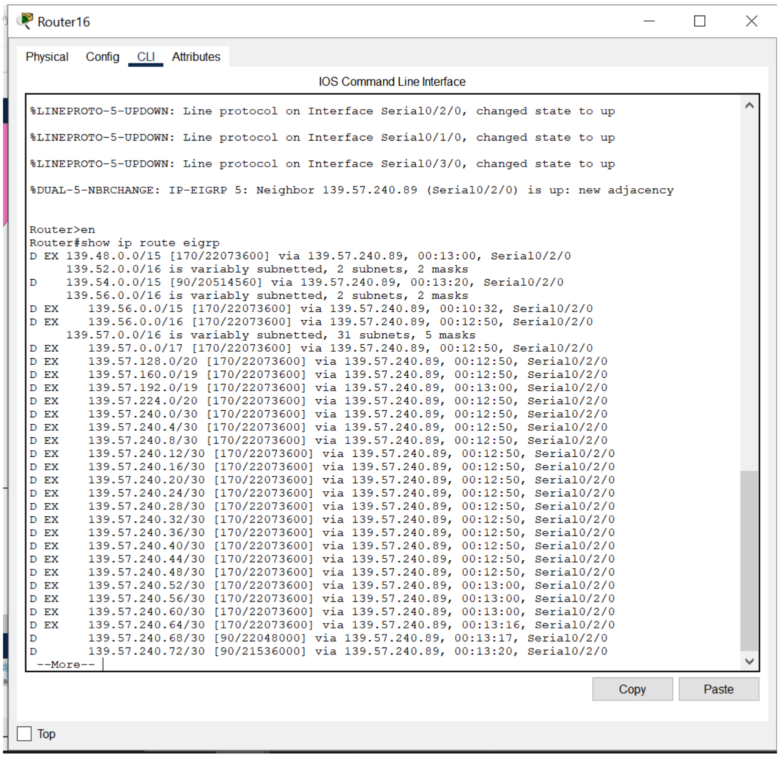
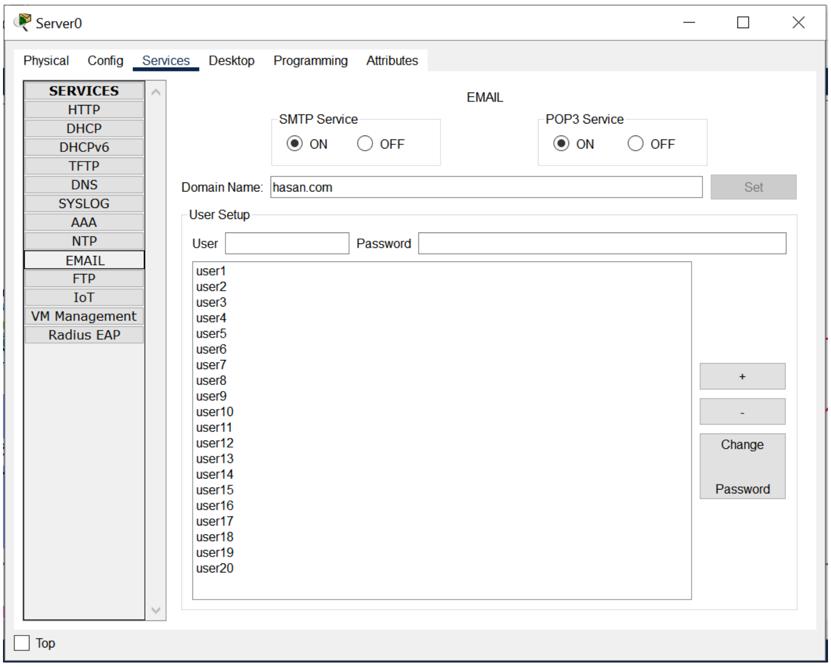
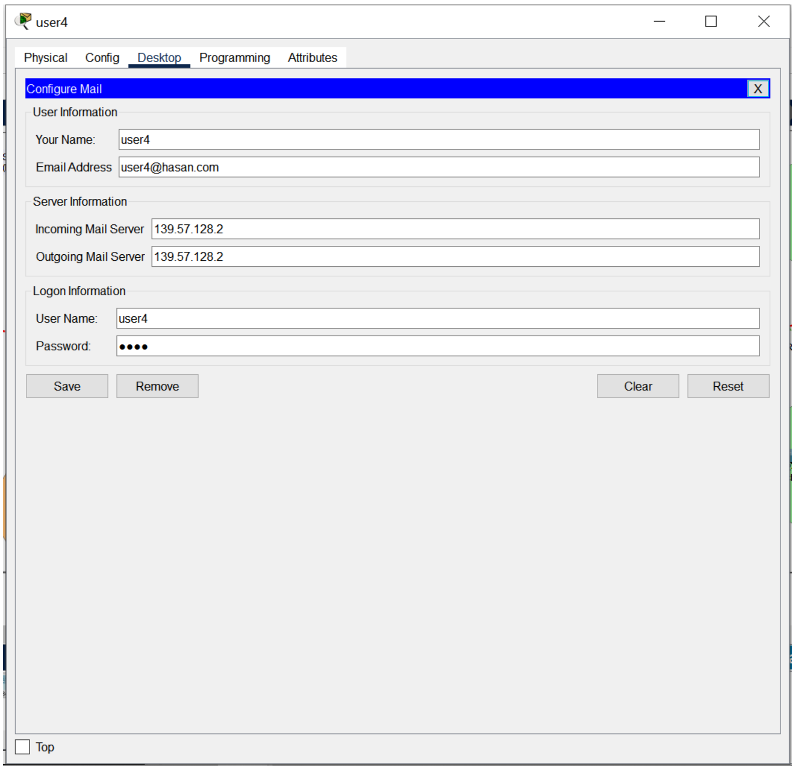



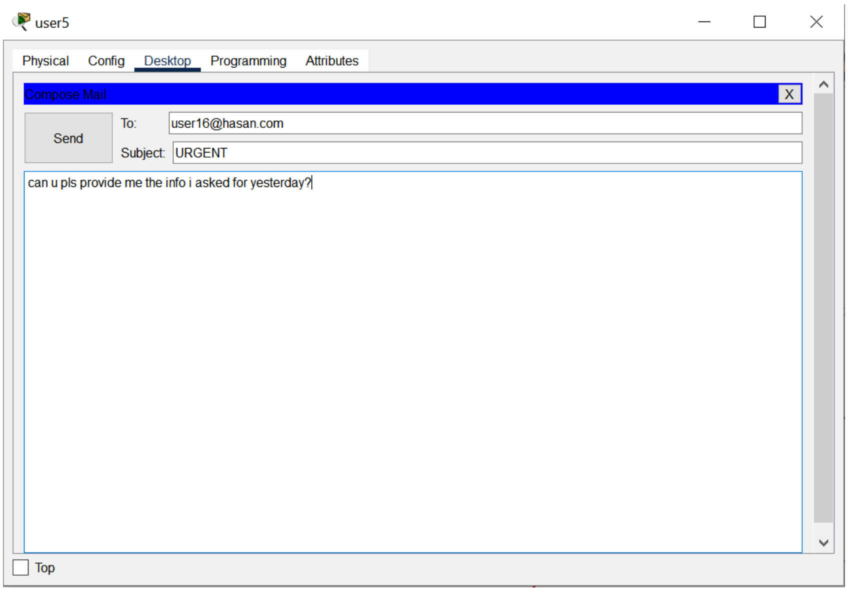
In the **Mail Server** under **Services > Email**, I assigned a domain name ***hasan.com*** and created 20 user accounts, corresponding to the 20 end devices in my topology, to enable email communication.

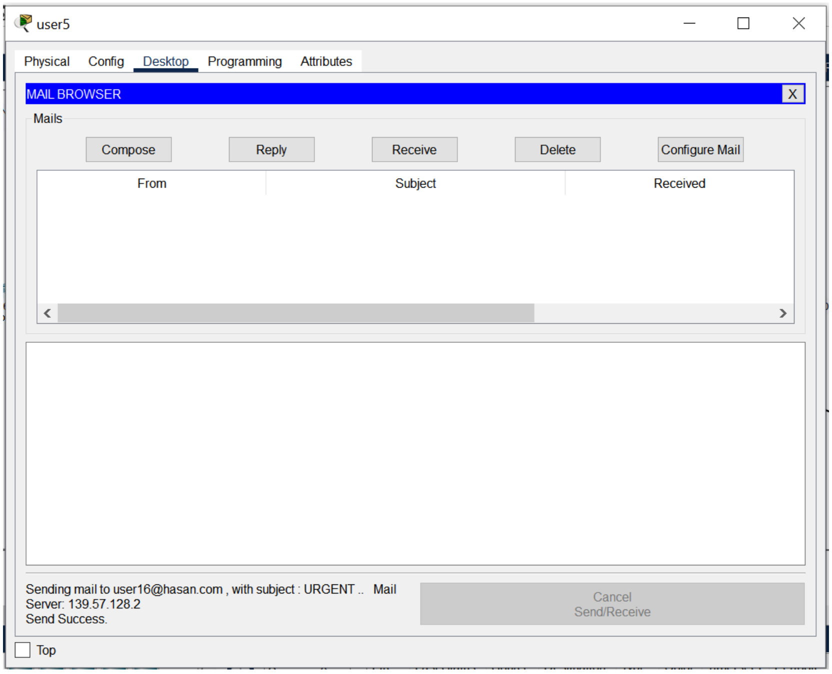


I, then, configured each PC by assigning it a unique name, email address, incoming and outgoing mail server, and password, ensuring each device was properly set up for email communication. Below is a screenshot of one PC from my topology showing its email configuration.

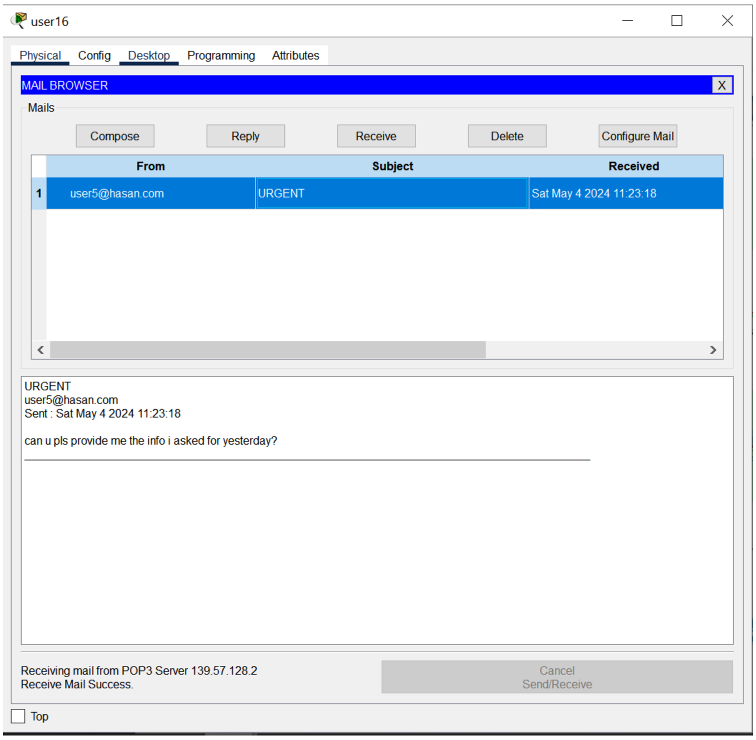


I then opened a PC or user device, composed an email, and successfully sent it to another user by using their email address.

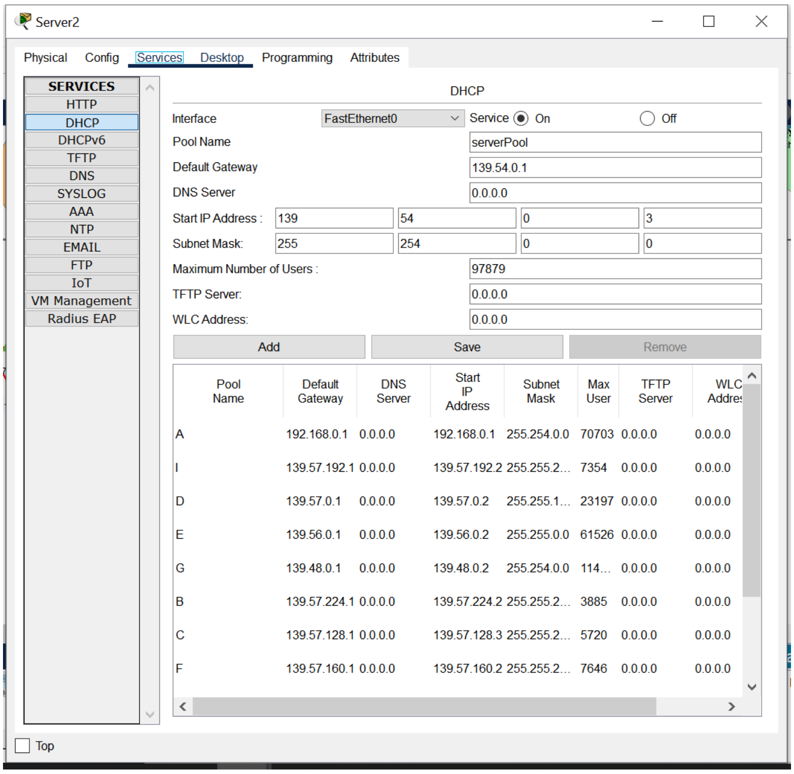




The email was successfully received by the other user, confirming the proper configuration and functionality of the email server and network.



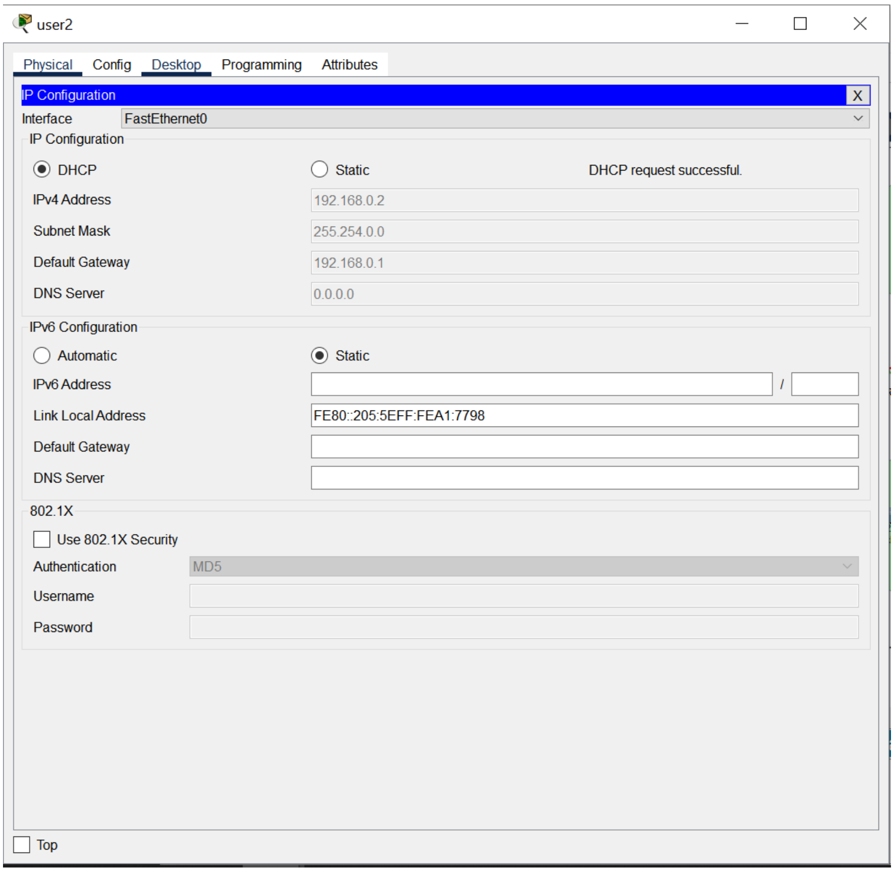
Next, I created DHCP pools for each network to enable dynamic IP address allocation for the devices within those networks.



For the DHCP requests to work across networks, I configured each router with a **helper IP address**, pointing to the DHCP server to ensure the requests were relayed properly.

```
Router>enable
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface Serial0/2/0
Router(config-if)#ip helper-address 139.54.0.2
Router(config-if)#
```

I then sent DHCP requests from all the end devices in my topology, changing their IP configurations to obtain dynamic IP addresses. The requests were successful, confirming the proper setup of the DHCP server and pools.



• Challenges and Learning

This project enhanced my understanding of network design while presenting several challenges. Calculating and assigning IP addresses with VLSM was intricate and required precision. Configuring multiple routing protocols (OSPF, RIP, EIGRP) and ensuring their seamless integration across blocks tested my knowledge of protocol-specific settings. Setting up DHCP relay with helper addresses and troubleshooting connectivity for email server functionality were also key hurdles. Despite these challenges, I learned efficient IP management, the practical implementation of routing protocols, and the integration of DHCP and email services, while significantly improving my troubleshooting and configuration skills.

• Conclusion

This project successfully established a multi-block university campus network with distinct routing protocols, DHCP, and email services. Each block was configured with its own routing protocol (OSPF, RIP, and EIGRP), and devices were set up with dynamic IP allocation through DHCP. Email communication between the networks was also successfully implemented, demonstrating the functionality of the mail server and email configuration on end devices. The outcomes of this project confirmed the effectiveness of the design and its ability to support seamless communication across different campus networks.

For future improvements, I recommend further optimization of IP address allocation through more efficient subnetting, exploring advanced routing protocol configurations for better network performance, and considering security features like firewalls and intrusion detection systems to enhance network safety. Additionally, scalability should be considered to accommodate future growth of the campus network.