National University
Of Computer and Emerging Sciences

Project Report

Branch Office Connectivity

In partial
fulfillment of the requirements
for the course of

Computer Networks Lab

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BSCS-C

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Status	Done

Objective

The goal of this project was to design and implement a hierarchical network structure in Cisco Packet Tracer, simulating a real-world branch office connectivity setup. The project aimed to ensure efficient routing between different network layers, dynamic IP management, and secure communication using NAT.

Technologies Used

- **DHCP**: To assign IP addresses dynamically to devices in the network.
- **NAT**: For translating private IP addresses to public ones, enabling secure external communication.
- **Routing Protocols**: RIP, OSPF, and EIGRP were used to route traffic efficiently between different hierarchical layers of the network.

Implementation Details

The network is designed with a hierarchical structure:

1. **Headquarters Network**: Acts as the central network hub.
2. **Branch Networks**: Two branches connected to the headquarters using EIGRP.
3. **Sub-branches**: Each branch connects to one sub-branch network using RIP.

Reasoning Behind Routing Protocol Choices

- **OSPF for Headquarters**: OSPF (Open Shortest Path First) is ideal for large and complex networks due to its ability to converge quickly and efficiently. It calculates the shortest path using the Dijkstra algorithm, making it suitable for the HQ network with multiple routers.
- **EIGRP for Branches**: EIGRP (Enhanced Interior Gateway Routing Protocol) is chosen for its flexibility and fast convergence in mid-sized networks. Its support for unequal cost load balancing ensures reliable communication with HQ.
- **RIP for Sub-branches**: RIP (Routing Information Protocol) is better suited for smaller networks with fewer devices because it is simple to configure and has low resource requirements.

Headquarters Network

This network consists of **three routers** connected using OSPF.

- **DHCP Server**: A dedicated DHCP server dynamically assigns IP addresses to devices.
- **Subnetting**: To minimize IP wastage, subnetting is implemented with the range `192.168.0.0/28` to `192.168.0.84/30`.

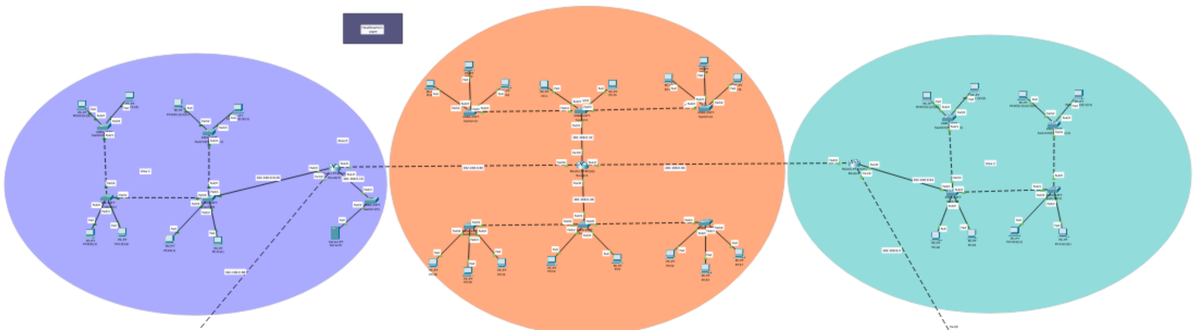
Used Subnets

- **192.168.0.0/28**
- **192.168.0.16/28**
- **192.168.0.32/28**
- **192.168.0.48/28**
- **192.168.0.64/28**
- **192.168.0.80/30**
- **192.168.0.84/30**

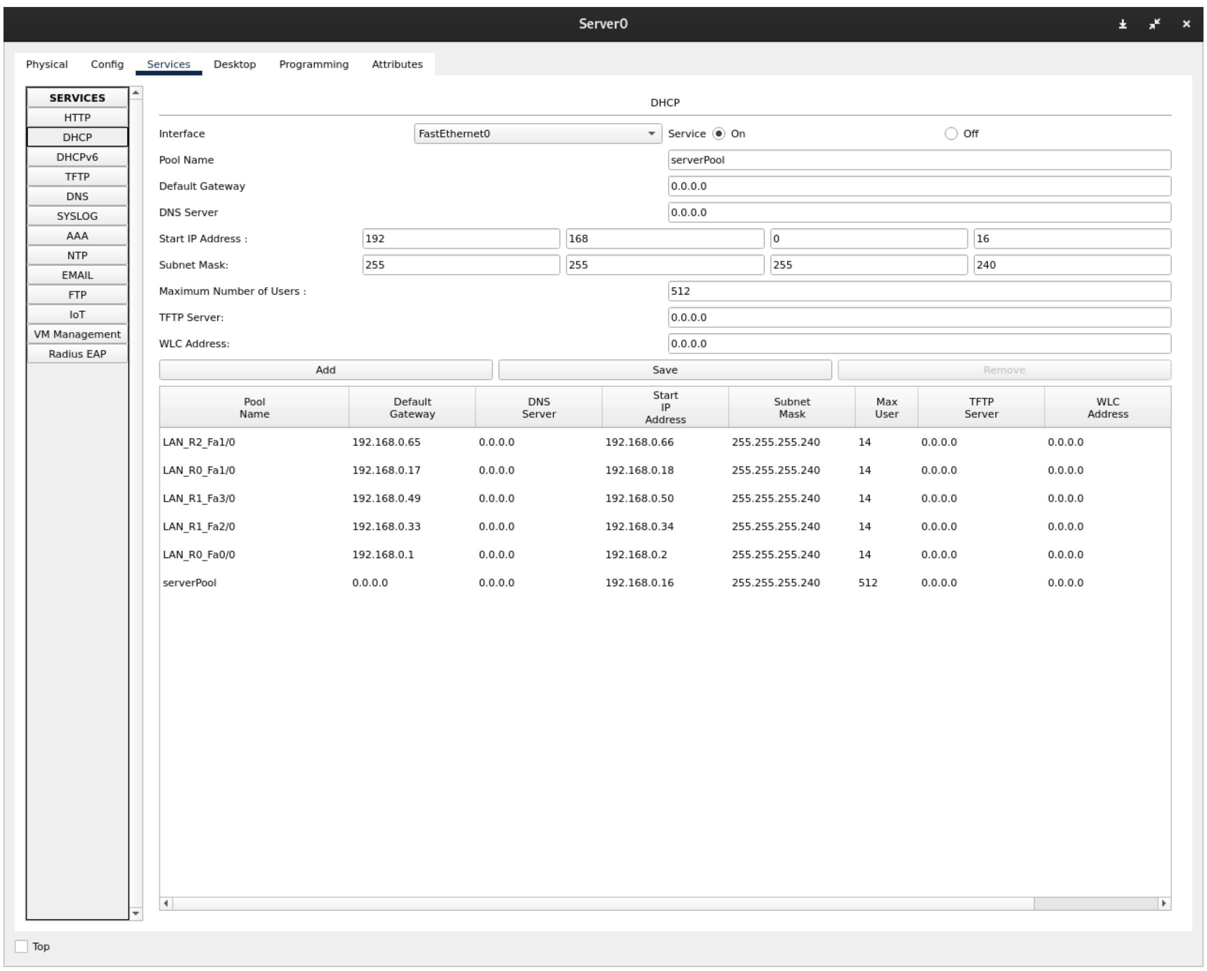
Serial links between routers use a `/30` prefix, while other networks use `/28`.

First IP Address: 192.168.0.1

Last IP Address: 192.168.0.86



Server Configuration



Branch-01

The Branch-01 network includes **three routers**, configured with EIGRP.

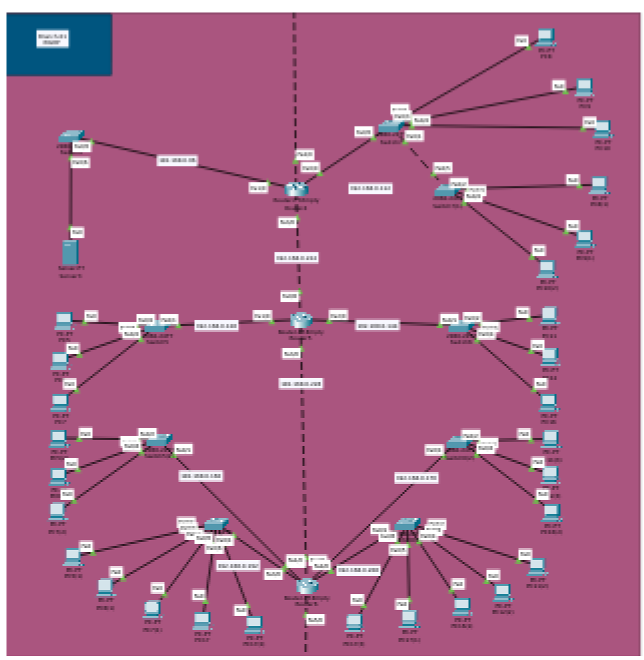
- **DHCP Server**: Dynamically assigns IPs to local devices.
- **Subnetting**: The subnet range spans `192.168.0.96/28` to `192.168.0.228/30`.

Used Subnets

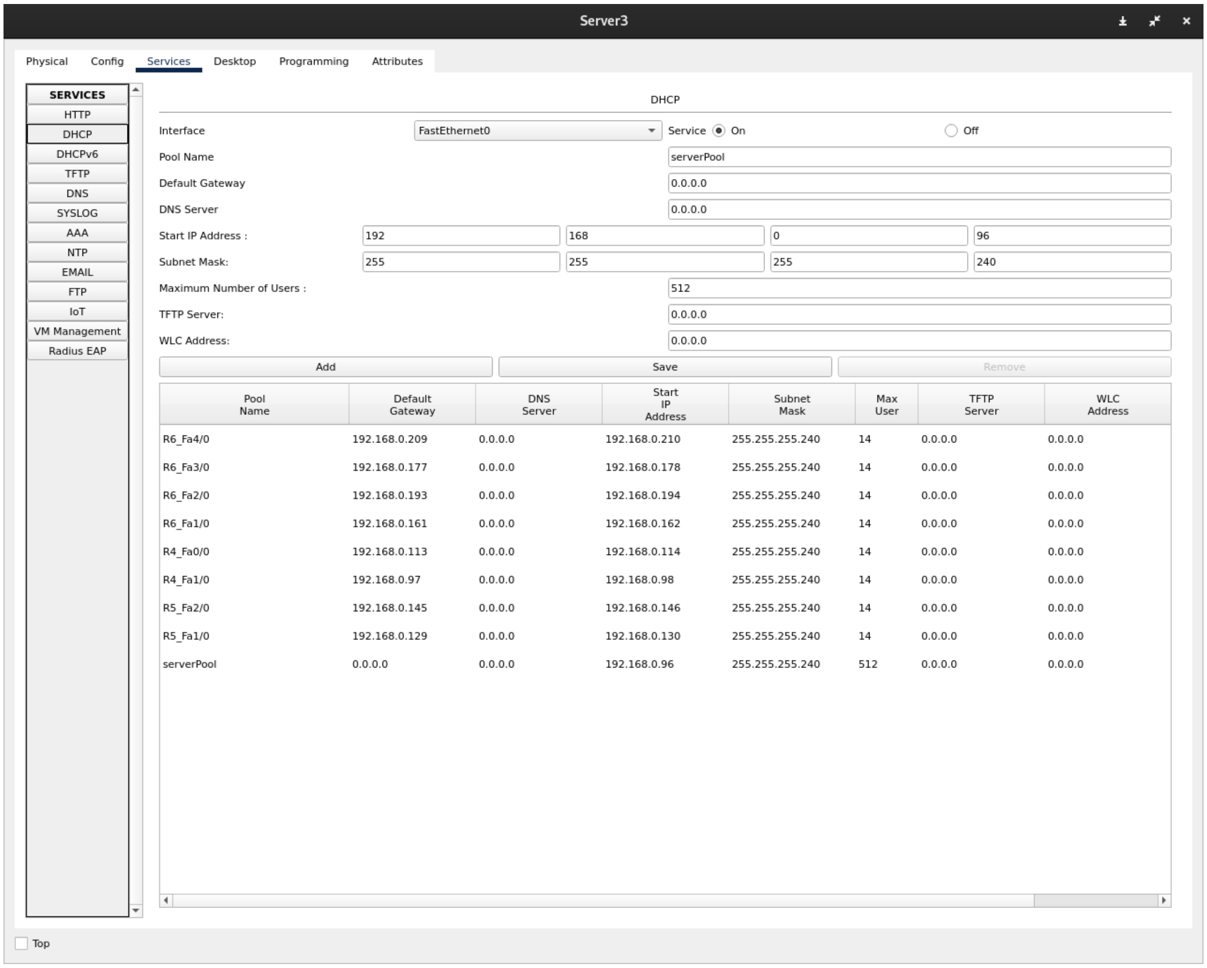
- 192.168.0.96/28
- 192.168.0.112/28
- 192.168.0.128/28
- 192.168.0.144/28
- 192.168.0.160/28
- 192.168.0.176/28
- 192.168.0.192/28
- 192.168.0.208/28
- 192.168.0.224/30
- 192.168.0.228/30

First IP Address: 192.168.0.97

Last IP Address: 192.168.0.110



Server configuration



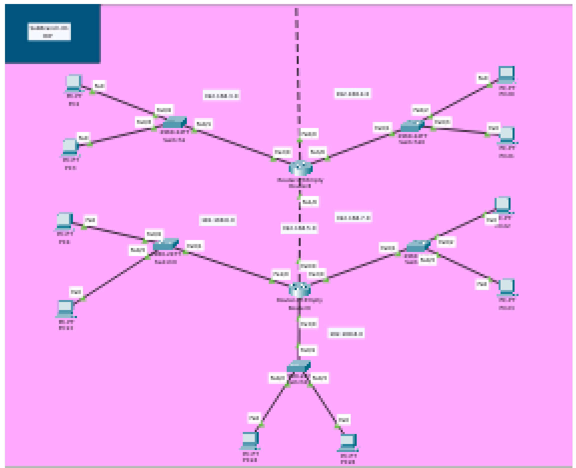
Sub-Branch-01

This network contains **two routers** and uses RIP for routing.

Used Networks

- 192.168.3.0
- 192.168.4.0
- 192.168.5.0
- 192.168.6.0
- 192.168.7.0

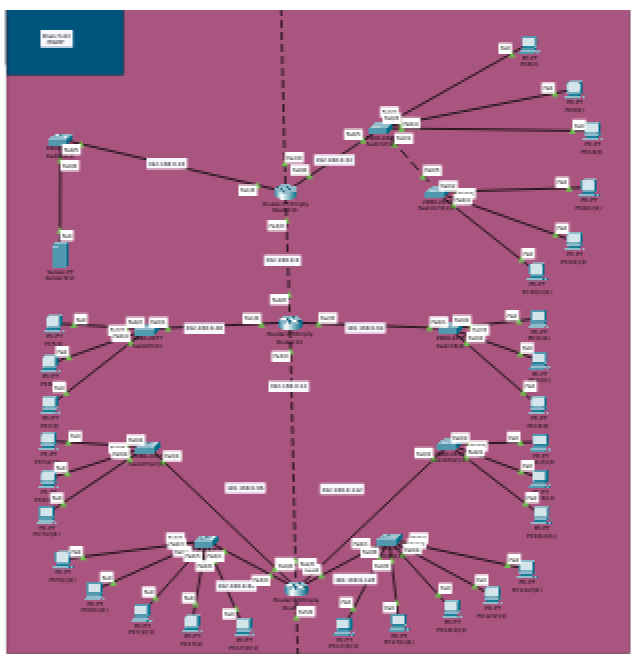
- 192.168.8.0



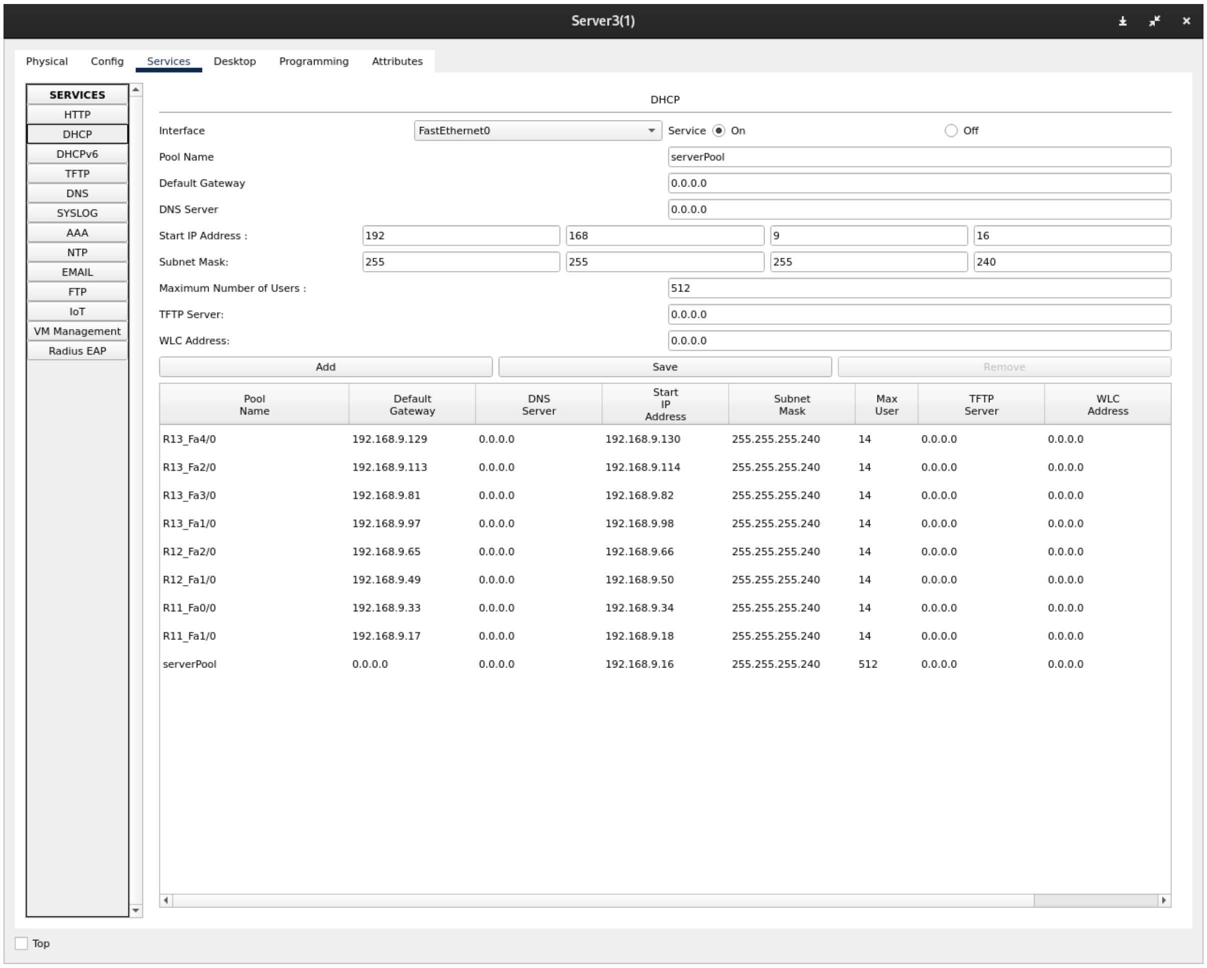
Branch-02

Branch-02 has a structure similar to Branch-01, with **three routers** and EIGRP.

- **Subnet Range**: 192.168.9.8/30 to 192.168.9.128/28.



Server Configuration



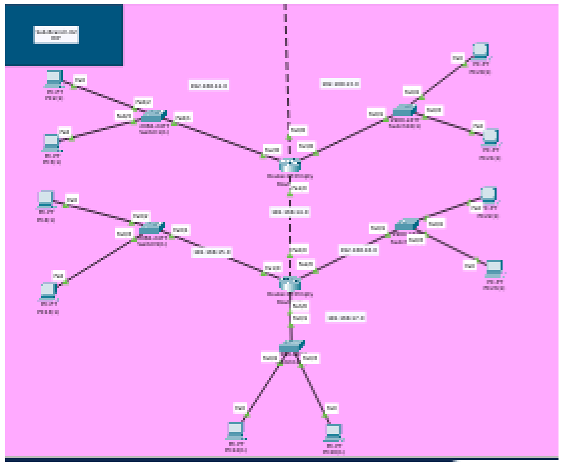
Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User	TFTP Server	WLC Address
R13_Fa4/0	192.168.9.129	0.0.0.0	192.168.9.130	255.255.255.240	14	0.0.0.0	0.0.0.0
R13_Fa2/0	192.168.9.113	0.0.0.0	192.168.9.114	255.255.255.240	14	0.0.0.0	0.0.0.0
R13_Fa3/0	192.168.9.81	0.0.0.0	192.168.9.82	255.255.255.240	14	0.0.0.0	0.0.0.0
R13_Fa1/0	192.168.9.97	0.0.0.0	192.168.9.98	255.255.255.240	14	0.0.0.0	0.0.0.0
R12_Fa2/0	192.168.9.65	0.0.0.0	192.168.9.66	255.255.255.240	14	0.0.0.0	0.0.0.0
R12_Fa1/0	192.168.9.49	0.0.0.0	192.168.9.50	255.255.255.240	14	0.0.0.0	0.0.0.0
R11_Fa0/0	192.168.9.33	0.0.0.0	192.168.9.34	255.255.255.240	14	0.0.0.0	0.0.0.0
R11_Fa1/0	192.168.9.17	0.0.0.0	192.168.9.18	255.255.255.240	14	0.0.0.0	0.0.0.0
serverPool	0.0.0.0	0.0.0.0	192.168.9.16	255.255.255.240	512	0.0.0.0	0.0.0.0

Sub-Branch-02

This network mirrors Sub-Branch-01, using RIP.

Used Networks

- 192.168.12.0
- 192.168.13.0
- 192.168.14.0
- 192.168.15.0
- 192.168.16.0
- 192.168.17.0



NAT

NAT is configured on redistribution routers to enable secure communication between private networks and external networks.

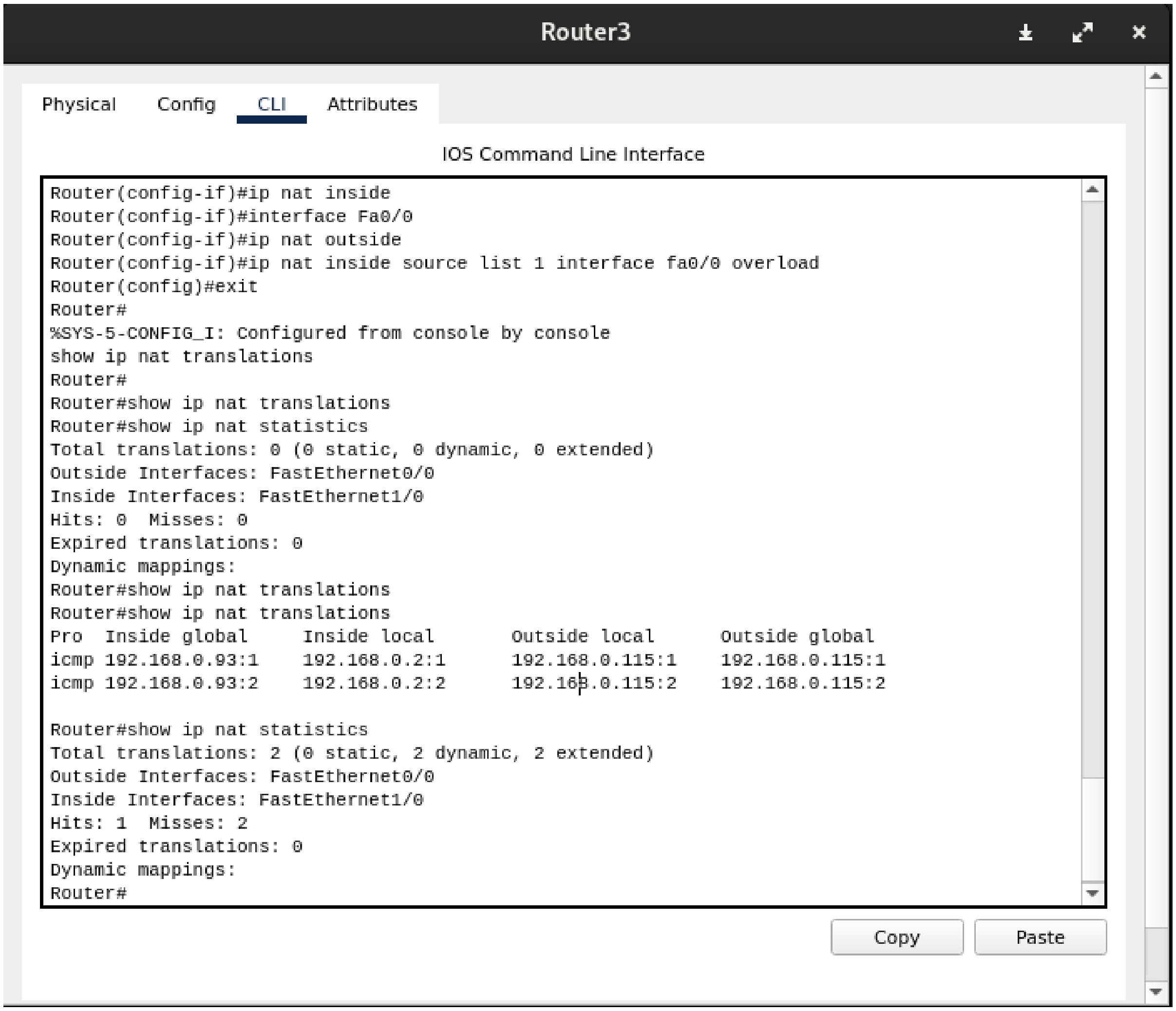
Benefits of NAT

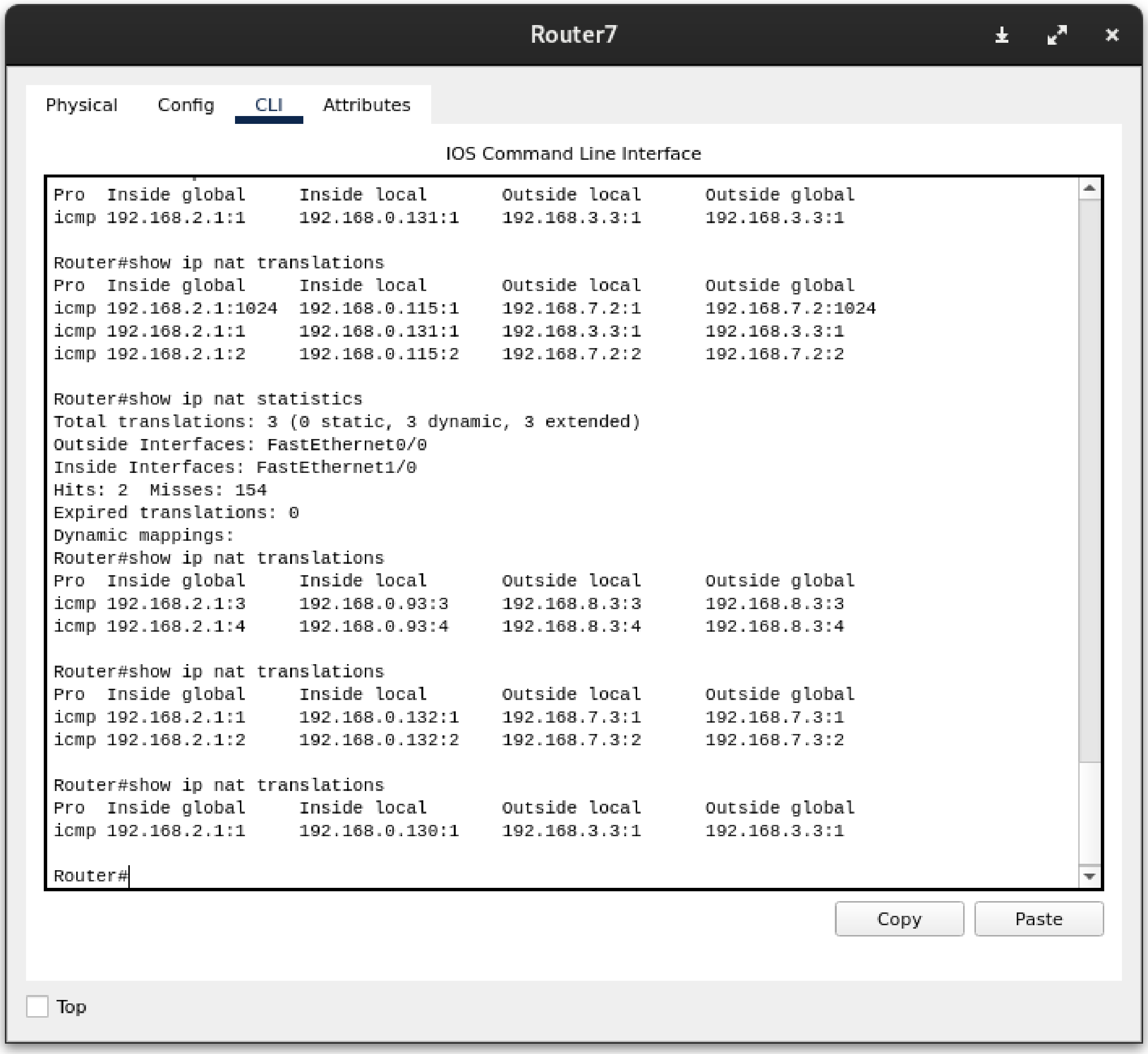
1. **Enhanced Security**: Hides internal network details from external networks.
2. **IP Conservation**: Allows multiple devices to share a single public IP.

▼ Results and Testing

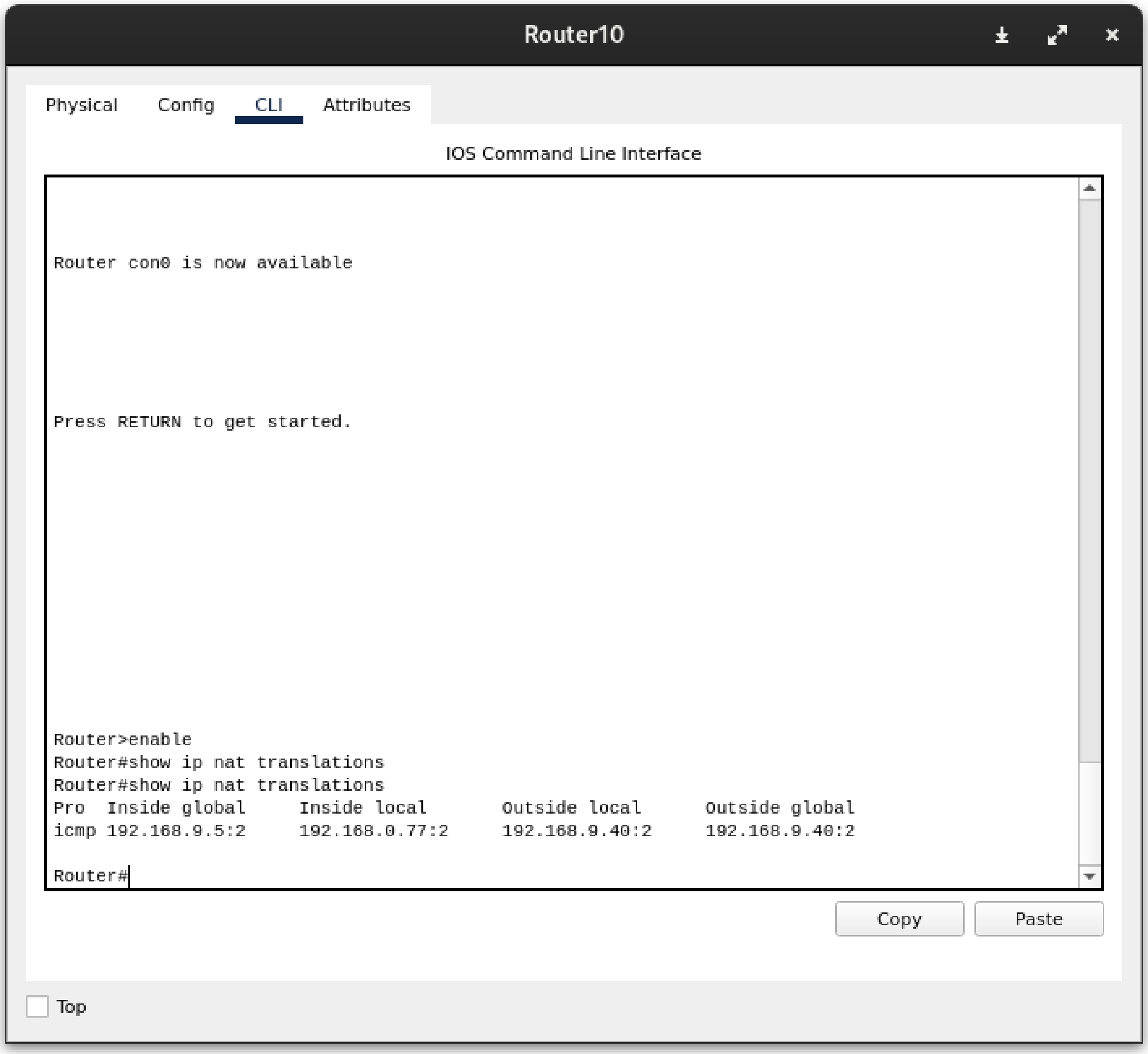
NAT Functionality:

NAT successfully translated private IPs of the HQ and branch networks, ensuring secure communication with external entities.


Router3
Physical
Config
CLI
Attributes
IOS Command Line Interface
Router(config-if)#ip nat inside
Router(config-if)#interface Fa0/0
Router(config-if)#ip nat outside
Router(config-if)#ip nat inside source list 1 interface fa0/0 overload
Router(config)#exit
Router#
%SYS-5-CONFIG_I: Configured from console by console
show ip nat translations
Router#
Router#show ip nat translations
Router#show ip nat statistics
Total translations: 0 (0 static, 0 dynamic, 0 extended)
Outside Interfaces: FastEthernet0/0
Inside Interfaces: FastEthernet1/0
Hits: 0 Misses: 0
Expired translations: 0
Dynamic mappings:
Router#show ip nat translations
Router#show ip nat translations
Pro Inside global   Inside local   Outside local   Outside global
icmp 192.168.0.93:1   192.168.0.2:1   192.168.0.115:1   192.168.0.115:1
icmp 192.168.0.93:2   192.168.0.2:2   192.168.0.115:2   192.168.0.115:2
Router#show ip nat statistics
Total translations: 2 (0 static, 2 dynamic, 2 extended)
Outside Interfaces: FastEthernet0/0
Inside Interfaces: FastEthernet1/0
Hits: 1 Misses: 2
Expired translations: 0
Dynamic mappings:
Router#
Copy
Paste




```
Pro  Inside global     Inside local       Outside local      Outside global
icmp 192.168.2.1:1     192.168.0.131:1    192.168.3.3:1      192.168.3.3:1

Router#show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
icmp 192.168.2.1:1024  192.168.0.115:1    192.168.7.2:1      192.168.7.2:1024
icmp 192.168.2.1:1     192.168.0.131:1    192.168.3.3:1      192.168.3.3:1
icmp 192.168.2.1:2     192.168.0.115:2    192.168.7.2:2      192.168.7.2:2

Router#show ip nat statistics
Total translations: 3 (0 static, 3 dynamic, 3 extended)
Outside Interfaces: FastEthernet0/0
Inside Interfaces: FastEthernet1/0
Hits: 2  Misses: 154
Expired translations: 0
Dynamic mappings:
Router#show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
icmp 192.168.2.1:3     192.168.0.93:3     192.168.8.3:3      192.168.8.3:3
icmp 192.168.2.1:4     192.168.0.93:4     192.168.8.3:4      192.168.8.3:4

Router#show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
icmp 192.168.2.1:1     192.168.0.132:1    192.168.7.3:1      192.168.7.3:1
icmp 192.168.2.1:2     192.168.0.132:2    192.168.7.3:2      192.168.7.3:2

Router#show ip nat translations
Pro  Inside global     Inside local       Outside local      Outside global
icmp 192.168.2.1:1     192.168.0.130:1    192.168.3.3:1      192.168.3.3:1

Router#
```


Router10
Physical
Config
CLI
Attributes
IOS Command Line Interface
Router con0 is now available
Press RETURN to get started.
Router>enable
Router#show ip nat translations
Router#show ip nat translations
Pro Inside global   Inside local   Outside local   Outside global
icmp 192.168.9.5:2   192.168.0.77:2   192.168.9.40:2   192.168.9.40:2
Router#
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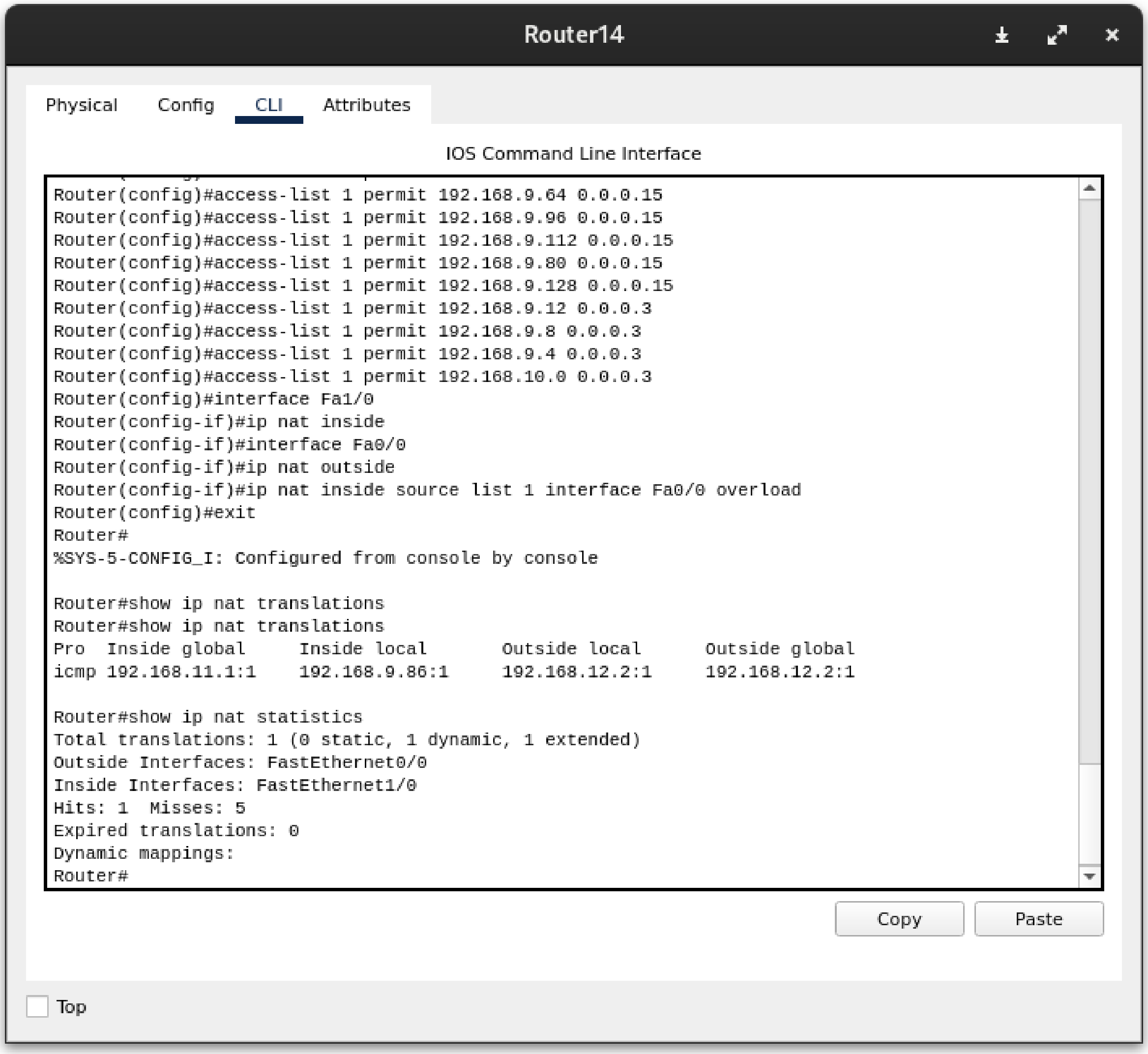
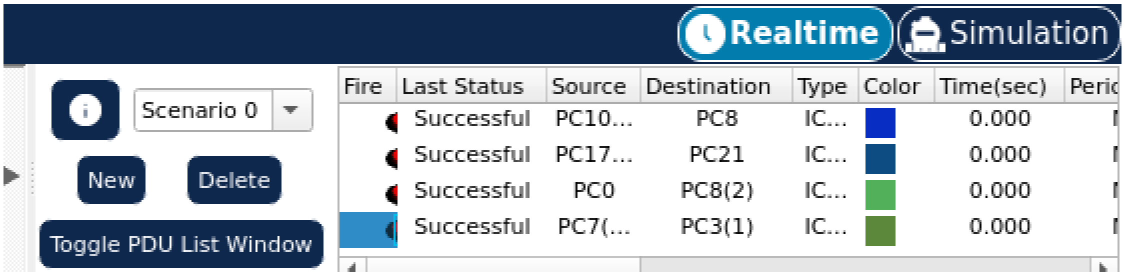


Routing Protocol Redistribution

Message passing OSPF to EIGRP (HQ to Branch-01)
Message passing EIGRP to RIP (Branch-01 to Sub-Branch-01)

Message passing OSPF to EIGRP (HQ to Branch-02)
Message passing EIGRP to RIP (Branch-02 to Sub-Branch-02)



Challenges and Learning

Routing Protocol Redistribution

- **Challenges**: Configuring redistribution between different routing protocols (OSPF, EIGRP, and RIP) was initially challenging, as mismatched settings caused communication failures.
- **Learning**: Using the appropriate redistribution command tailored for each protocol solved the issue. This reinforced the importance of understanding protocol-specific metrics and configurations.

NAT

- **Challenges**: Configuring NAT on redistribution routers required careful mapping of internal private IPs to external public IPs. Misconfigurations led to translation errors, affecting connectivity between subnets.
- **Learning**: Correctly applying the `ip nat inside` and `ip nat outside` interfaces, combined with setting up accurate access control lists (ACLs), ensured successful address translation. This exercise highlighted NAT's role in improving security and conserving IP addresses.

DHCP

- **Challenges**: While configuring DHCP, some devices were unable to acquire IP addresses due to incorrect DHCP pool settings or overlapping subnets. Diagnosing these issues involved extensive troubleshooting.

- **Learning**: Ensuring accurate subnet masks and defining specific ranges for each DHCP pool eliminated conflicts. This experience demonstrated the importance of careful planning and testing for efficient network automation.

▼ Conclusion

The project achieved seamless communication between hierarchical networks using different routing protocols. Future recommendations include incorporating VPN for enhanced security and exploring dynamic VLANs to optimize performance further.