# COMSATS University Islamabad

# Lahore Campus


## Complex Engineering Problem Report

## CPE314 - Data Communication and Computer Networks

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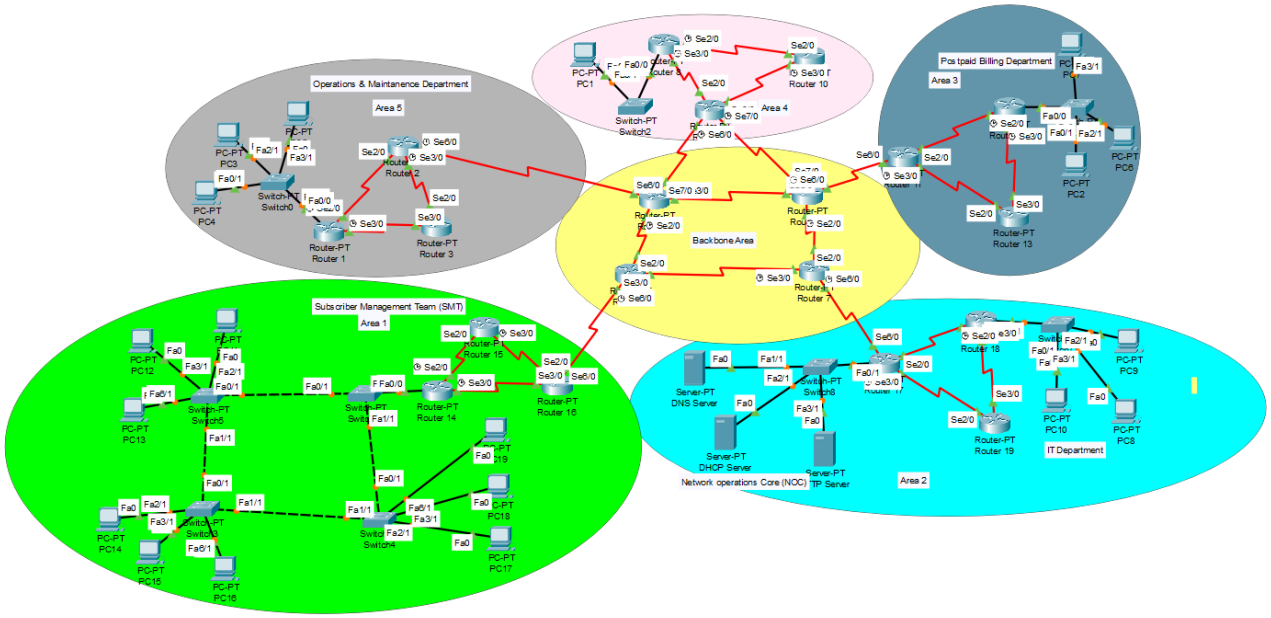
## 1. Network Topology




## 2. Variable Subnetting Scheme

The subnetting plan was tailored to fulfill the unique host requirements of each department and inter-router connections.

| Subnet Name | Hosts Available | Network Address | Slash | Subnet Mask | Usable Range | Broadcast | Area |
|---|---|---|---|---|---|---|---|
| SMT VLAN10 | 6 | 192.168.26.120 | /29 | 255.255.255.248 | 192.168.26.121 - 192.168.26.126 | 192.168.26.127 | 1 |
| SMT VLAN20 | 6 | 192.168.26.128 | /29 | 255.255.255.248 | 192.168.26.129 – 192.168.26.134 | 192.168.26.135 | 1 |
| NOC LAN | 6 | 192.168.26.0 | /29 | 255.255.255.248 | 192.168.26.1 - 192.168.26.6 | 192.168.26.7 | 2 |
| IT LAN | 6 | 192.168.26.8 | /29 | 255.255.255.248 | 192.168.26.9 - 192.168.26.14 | 192.168.26.15 | 2 |
| PBD LAN | 6 | 192.168.26.48 | /29 | 255.255.255.248 | 192.168.26.49 -192.168.26.54 | 192.168.26.55 | 3 |
| Area4 LAN | 2 | 192.168.26.72 | /30 | 255.255.255.252 | 192.168.26.73 - 192.168.26.74 | 192.168.26.75 | 4 |
| OMD LAN | 6 | 192.168.26.96 | /29 | 255.255.255.248 | 192.168.26.97 - 192.168.26.102 | 192.168.26.103 | 5 |
| R 7-6 | 2 | 192.168.26.32 | /30 | 255.255.255.252 | 192.168.26.33 -192.168.26.34 | 192.168.26.35 | 0 |
| R 7-5 | 2 | 192.168.26.36 | /30 | 255.255.255.252 | 192.168.26.37 -192.168.26.38 | 192.168.26.39 | 0 |

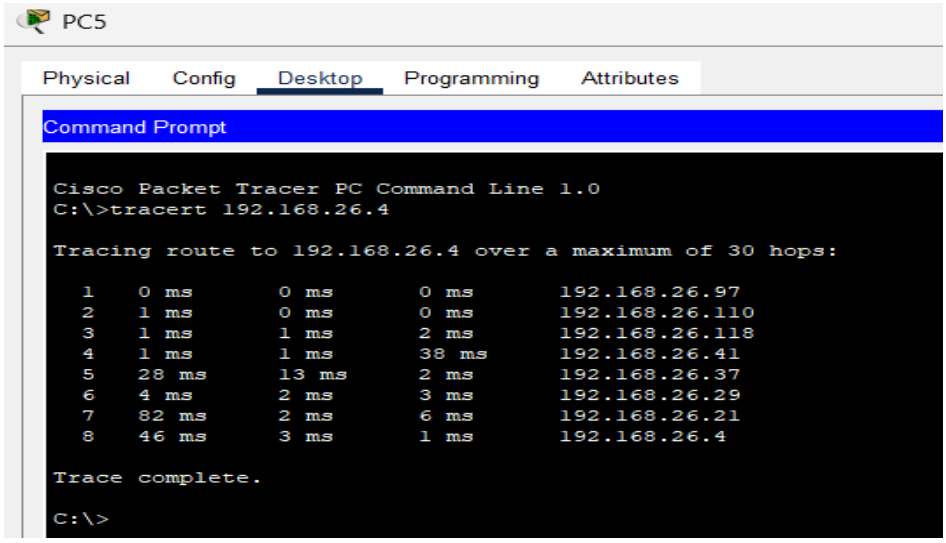
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R 6-4 | 2 | 192.168.26.40 | /30 | 255.255.255.252 | 192.168.26.41 - 192.168.26.42 | 192.168.26.43 | 0 |
| R 4-5 | 2 | 192.168.26.44 | /30 | 255.255.255.252 | 192.168.26.45 -192.168.26.46 | 192.168.26.47 | 0 |
| R 18-19 | 2 | 192.168.26.16 | /30 | 255.255.255.252 | 192.168.26.17 - 192.168.26.18 | 192.168.26.19 | 2 |
| R 18-17 | 2 | 192.168.26.20 | /30 | 255.255.255.252 | 192.168.26.21 - 192.168.26.22 | 192.168.26.23 | 2 |
| R 17 -19 | 2 | 192.168.26.24 | /30 | 255.255.255.252 | 192.168.26.25 - 192.168.26.26 | 192.168.26.27 | 2 |
| R 17-7 | 2 | 192.168.26.28 | /30 | 255.255.255.252 | 192.168.26.29 - 192.168.26.30 | 192.168.26.31 | 0 |
| R 12-13 | 2 | 192.168.26.56 | /30 | 255.255.255.252 | 192.168.26.57 - 192.168.26.58 | 192.168.26.59 | 3 |
| R 13-11 | 2 | 192.168.26.60 | /30 | 255.255.255.252 | 192.168.26.61 - 192.168.26.62 | 192.168.26.63 | 3 |
| R 11-12 | 2 | 192.168.26.64 | /30 | 255.255.255.252 | 192.168.26.65 - 192.168.26.66 | 192.168.26.67 | 3 |
| R 11-6 | 2 | 192.168.26.68 | /30 | 255.255.255.252 | 192.168.26.69 - 192.168.26.70 | 192.168.26.71 | 0 |
| R 8-10 | 2 | 192.168.26.76 | /30 | 255.255.255.252 | 192.168.26.77 - 192.168.26.78 | 192.168.26.79 | 4 |
| R 8-9 | 2 | 192.168.26.80 | /30 | 255.255.255.252 | 192.168.26.81 - 192.168.26.82 | 192.168.26.83 | 4 |
| R 9-10 | 2 | 192.168.26.84 | /30 | 255.255.255.252 | 192.168.26.85 - 192.168.26.86 | 192.168.26.87 | 4 |
| R 9-6 | 2 | 192.168.26.88 | /30 | 255.255.255.252 | 192.168.26.89 - 192.168.26.90 | 192.168.26.91 | 0 |
| R 9-4 | 2 | 192.168.26.92 | /30 | 255.255.255.252 | 192.168.26.93 - 192.168.26.94 | 192.168.26.95 | 0 |
| R 1-3 | 2 | 192.168.26.104 | /30 | 255.255.255.252 | 192.168.26.105 - 192.168.26.106 | 192.168.26.107 | 5 |
| R 1-2 | 2 | 192.168.26.108 | /30 | 255.255.255.252 | 192.168.26.109 - 192.168.26.110 | 192.168.26.111 | 5 |
| R 2-3 | 2 | 192.168.26.112 | /30 | 255.255.255.252 | 192.168.26.113 - 192.168.26.114 | 192.168.26.115 | 5 |
| R 2-4 | 2 | 192.168.26.116 | /30 | 255.255.255.252 | 192.168.26.117 - 192.168.26.118 | 192.168.26.119 | 0 |
| R 14-15 | 2 | 192.168.26.136 | /30 | 255.255.255.252 | 192.168.26.137 - 192.168.26.138 | 192.168.26.139 | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R 15-16 | 2 | 192.168.26.140 | /30 | 255.255.255.252 | 192.168.26.141 - 192.168.26.142 | 192.168.26.143 | 1 |
| R 14-16 | 2 | 192.168.26.144 | /30 | 255.255.255.252 | 192.168.26.145 - 192.168.26.146 | 192.168.26.147 | 1 |
| R 5-16 | 2 | 192.168.26.148 | /30 | 255.255.255.252 | 192.168.26.149 - 192.168.26.150 | 192.168.26.151 | 0 |

## 3. Connectivity Verification

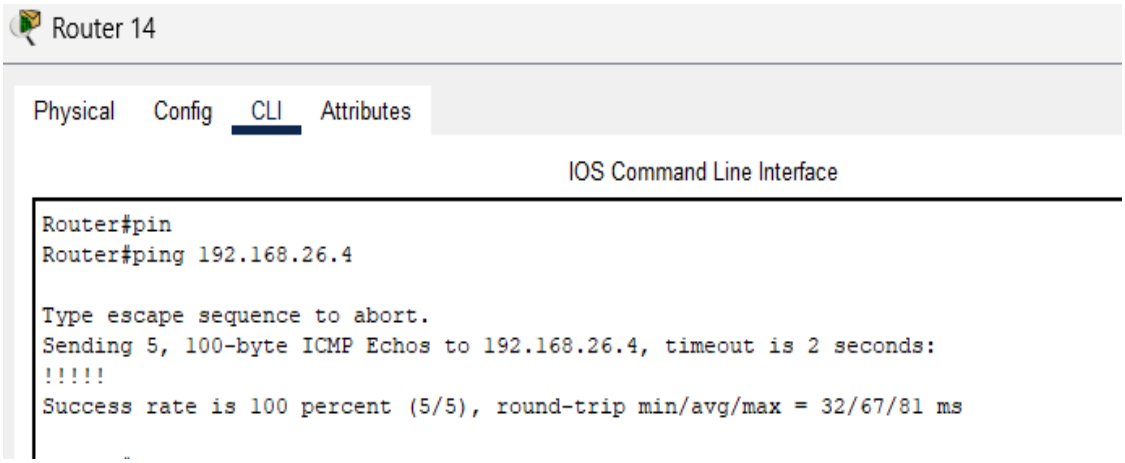
Connectivity across the network was validated using various methods. This includes traceroute and ping tests between different departments and across OSPF areas, as well as OSPF neighbor and route table checks. These tests confirmed that all devices can communicate as intended, and that routing is functioning correctly throughout the network.

### 3.1. Traceroutes



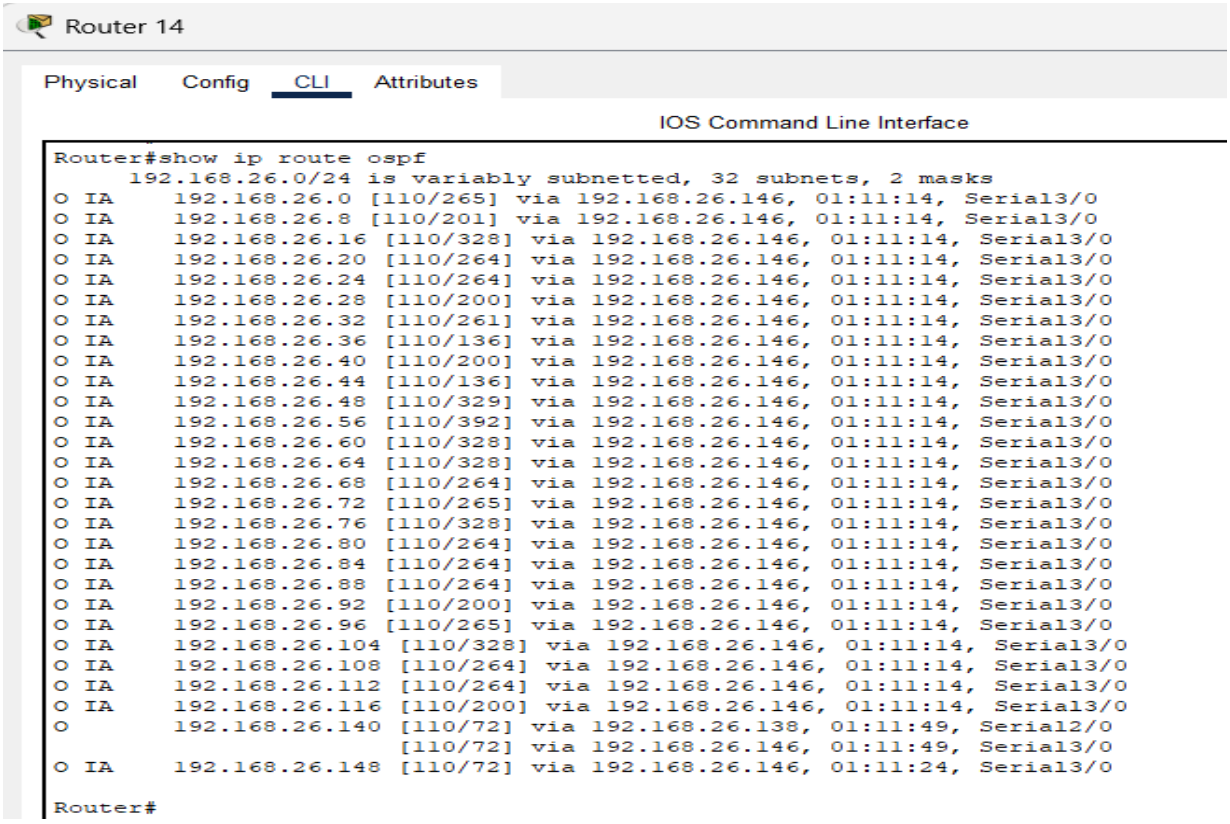

*Sample traceroute from OMD* to IT Department

### 3.2. Pings




*Sample ping from Area 1 to Area 2*

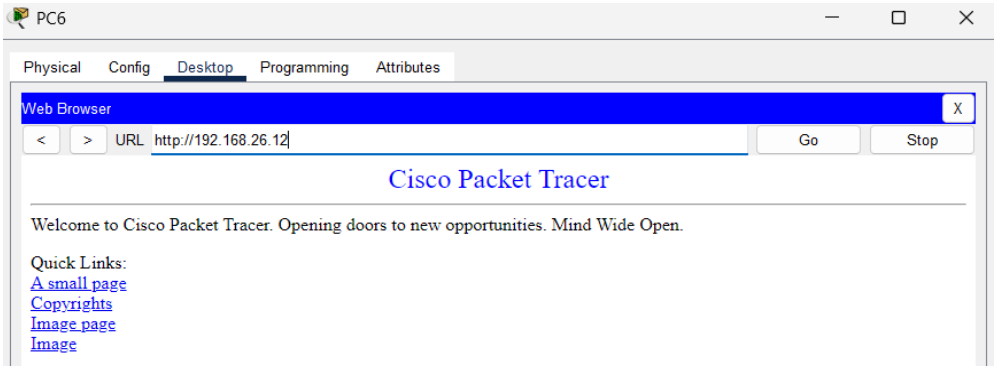
## 3.3. OSPF



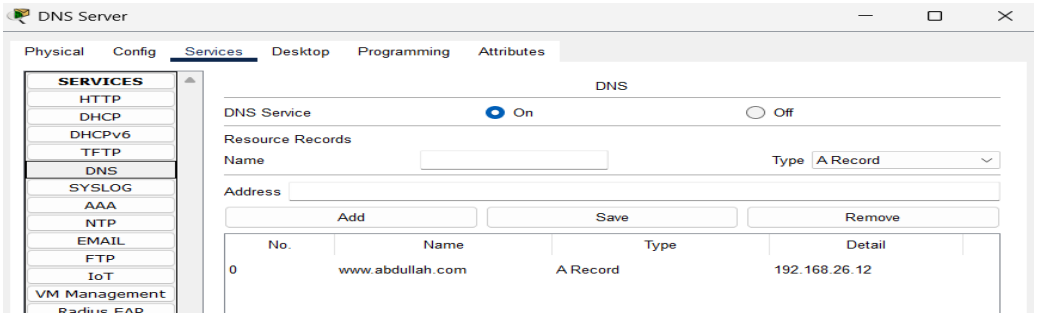
## 4. Server Operability

This section evaluates the setup and operation of major network services. Checks were performed on DNS, DHCP, and HTTP servers to confirm they are up and running and providing the proper functionality to clients in different parts of the network. Successful results show that the services are configured appropriately and well integrated with the network.

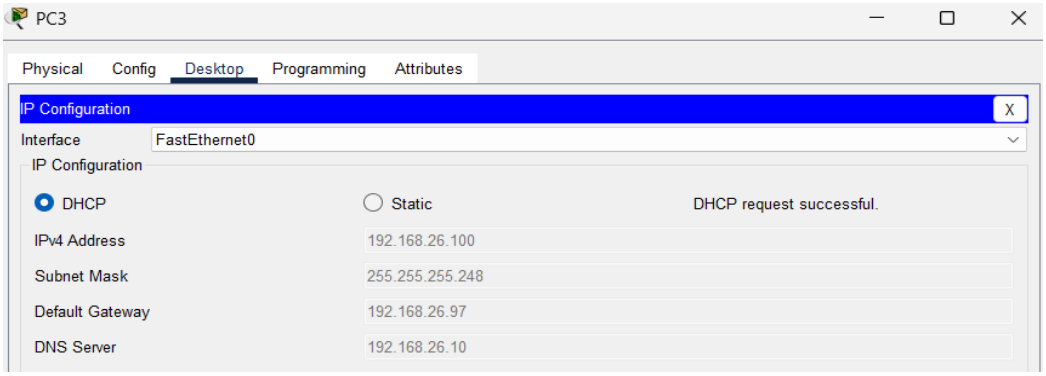
### 4.1. HTTP




### 4.2. DNS




### 4.3. DHCP

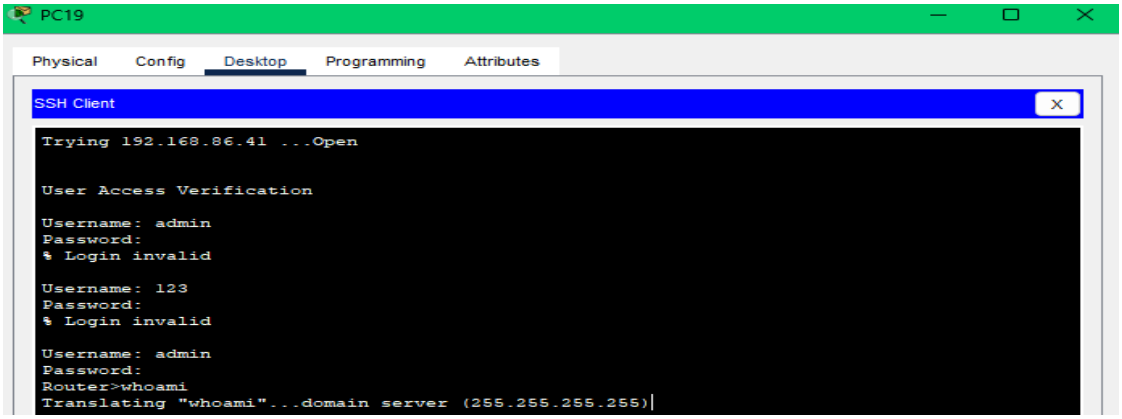



## 5. Requirement Analysis

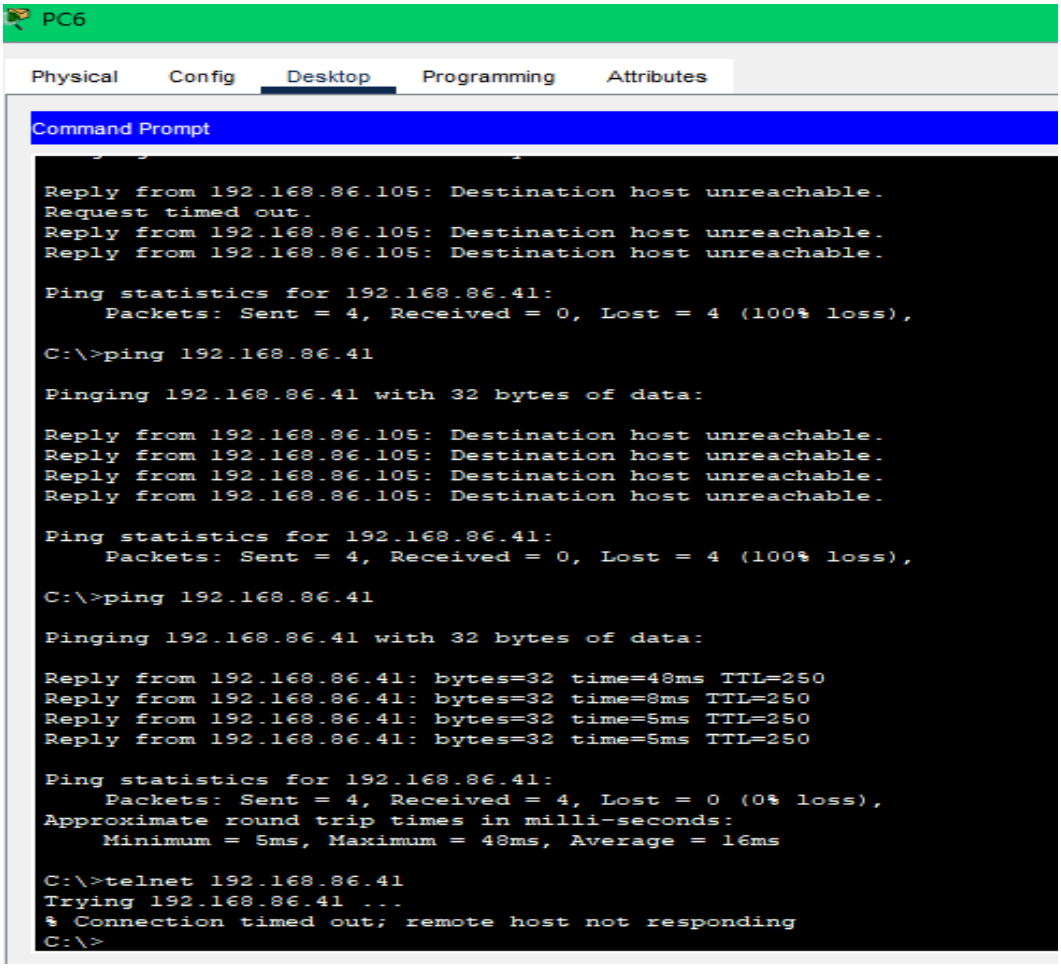
This section details how each project requirement was addressed through the network's design and setup. It outlines the specific measures taken to meet the defined objectives, including securing access, filtering traffic, establishing VLANs, configuring OSPF across various areas, efficiently managing IP address allocation, and assigning dedicated bandwidth to serial links. Each requirement is linked to its respective configuration and the results of the corresponding tests.

## R1: IT Department Network Access and Telnet Connectivity

Access Control Lists (ACLs) are set up on the virtual terminals (VTY) of all routers, permitting only the IT department's LAN (192.168.86.41/29) to establish Telnet connections to these routers. All other Telnet connection attempts are denied. In this setup, the IT department is connected to Router 18 via Telnet:

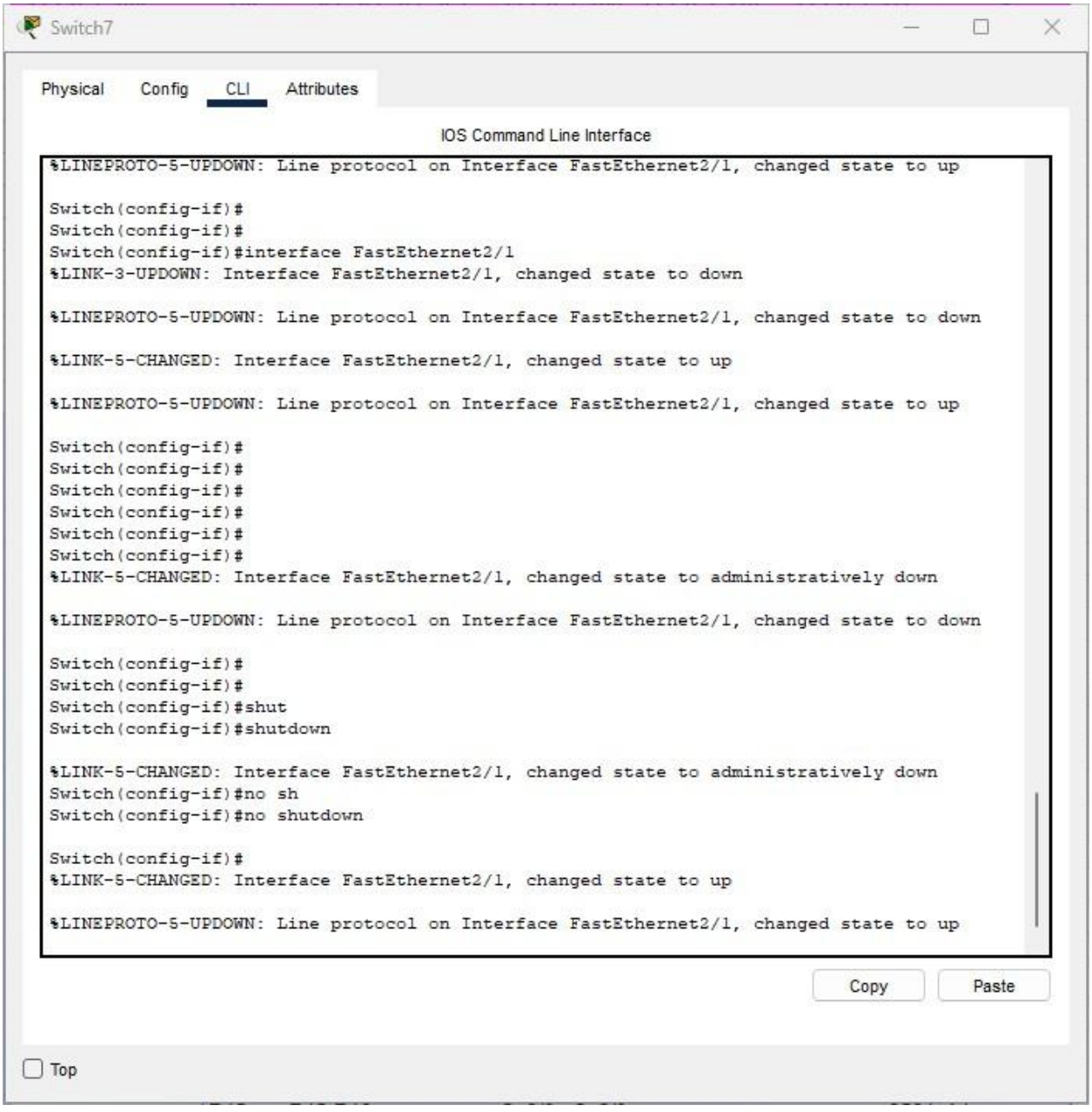



But Router 18 is refusing telnet from Postpaid Billing Department, while allowing pings.

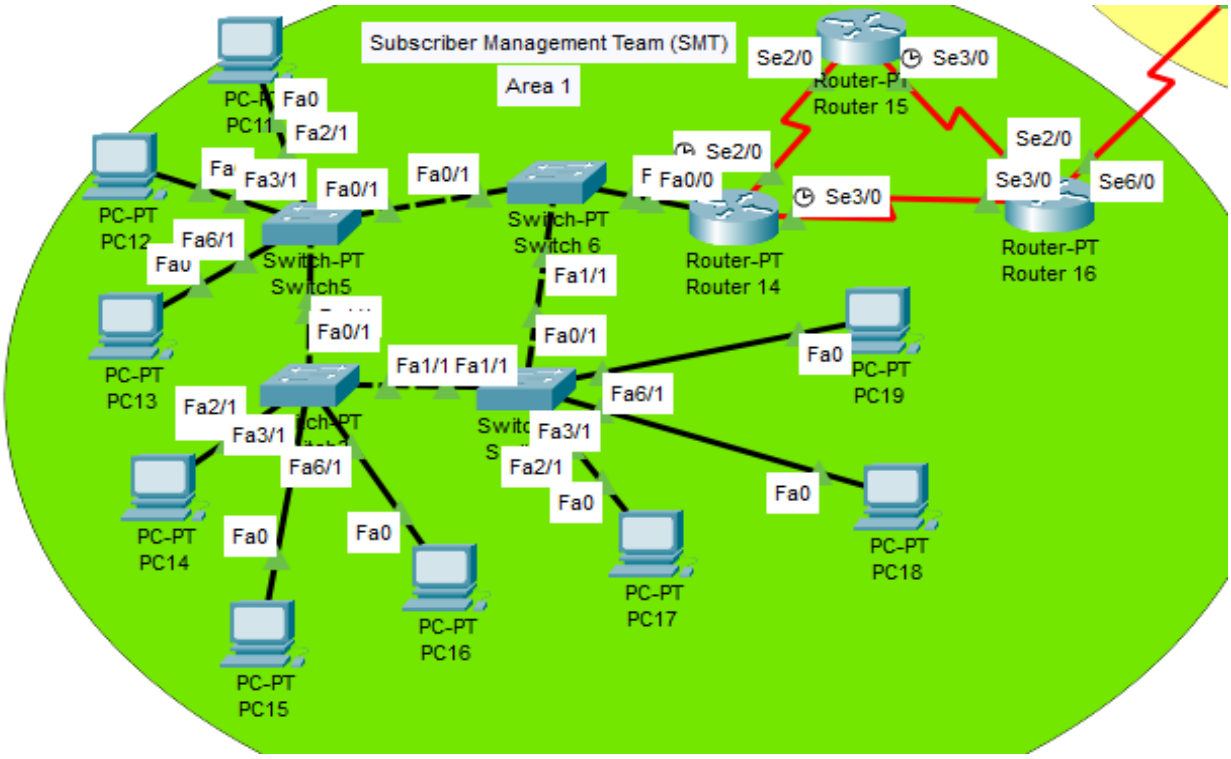


## R3: Switch Security and Intrusion Prevention in IT Department

Port security is set up on the IT department switch, shutting down any ports on a MAC address violation.



## R4: Spanning Tree Protocol (STP) Configuration and Observations in SMT Network




The output shows that Spanning Tree Protocol (STP) is active on the switch across multiple VLANs, such as VLAN 10 and VLAN 20. This protocol helps avoid Layer 2 loops by electing a root bridge and blocking redundant links in the network. Each VLAN operates its own STP instance, allowing the switch to identify root and designated ports based on the algorithm's process.

## R5: VLAN Configuration for Postpaid and Prepaid Subscriber Management in SMT Area 1

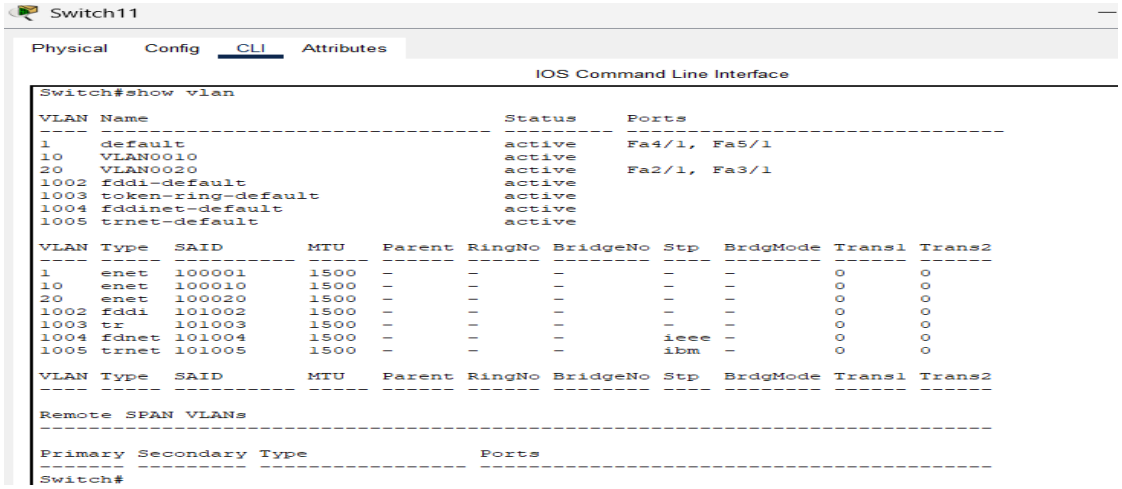
SMT department has two VLANs – VLAN 10 and VLAN 20 for Postpaid and Prepaid teams. Each VLAN is identified by a sub-interface on the first hop router and uses Dot1Q encapsulation.

Router 14

Physical Config CLI Attributes

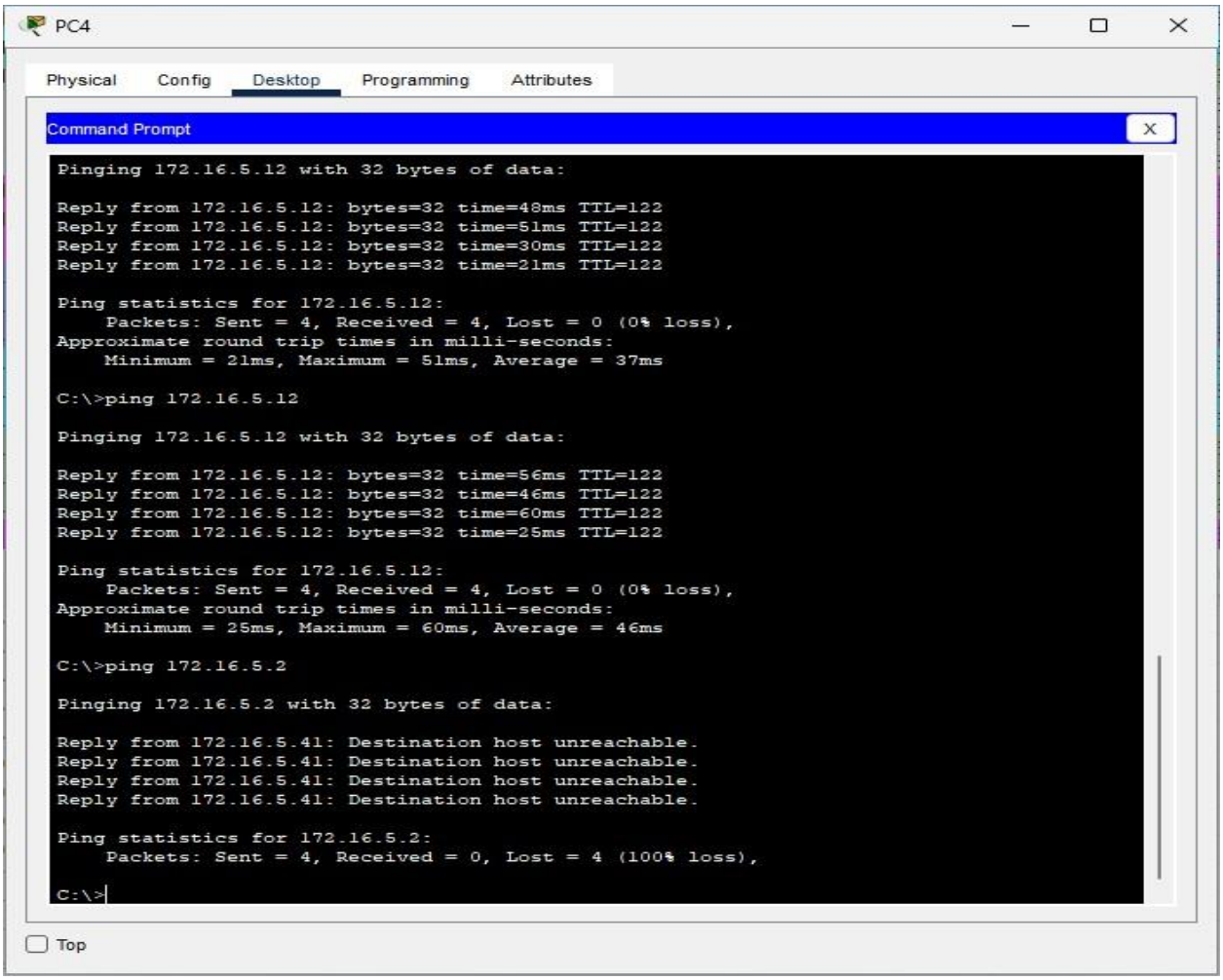
IOS Command Line Interface

```
 speed auto
!
interface FastEthernet1/0.10
 encapsulation dot1Q 10
 ip address 192.168.26.121 255.255.255.248
 ip helper-address 192.168.26.11
!
interface FastEthernet1/0.20
 encapsulation dot1Q 20
 ip address 192.168.26.129 255.255.255.248
 ip helper-address 192.168.26.11
!
interface Serial2/0
 bandwidth 11500
 ip address 192.168.26.137 255.255.255.252
 clock rate 2000000
!
interface Serial3/0
 bandwidth 11400
 ip address 192.168.26.145 255.255.255.252
 clock rate 2000000
!
interface FastEthernet4/0
 no ip address
 shutdown
!
```



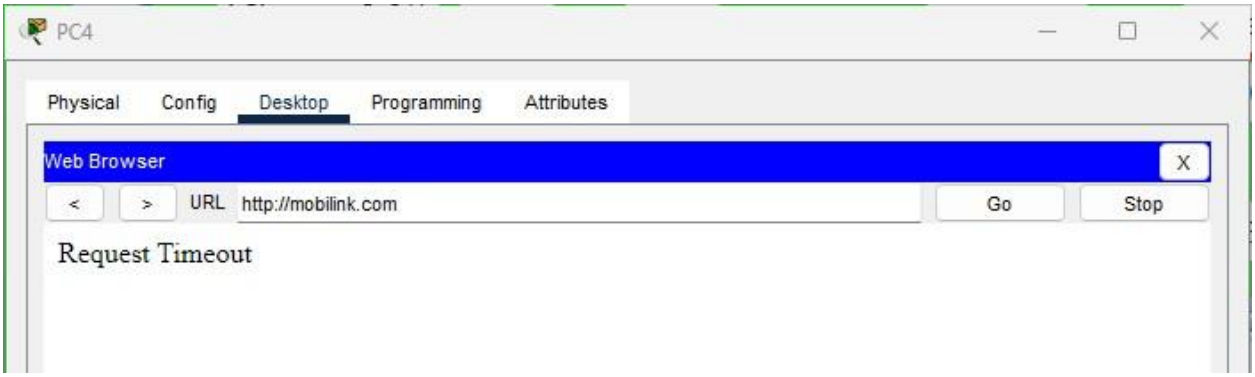

## R6: Access Control Between OMD and Postpaid Subscriber Management Team

OMD can connect to the Prepaid Subscriber Management Team, but access is restricted for Postpaid Team – defined by an ACL at the OMD first hop router.



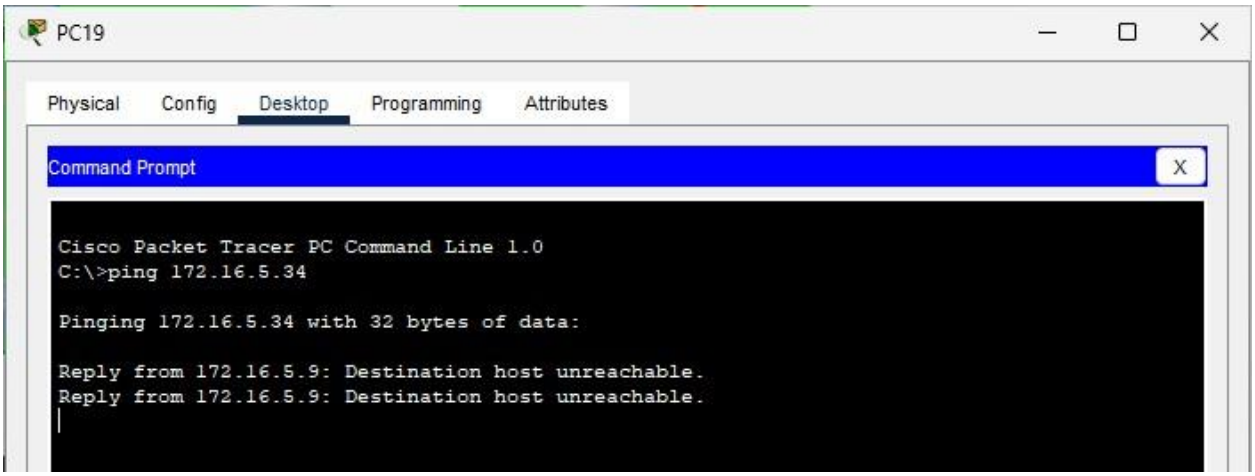
## R7: Restricting OMD Access to NOC Webserver

ACL on OMD ABR denies access to the webserver at NOC.



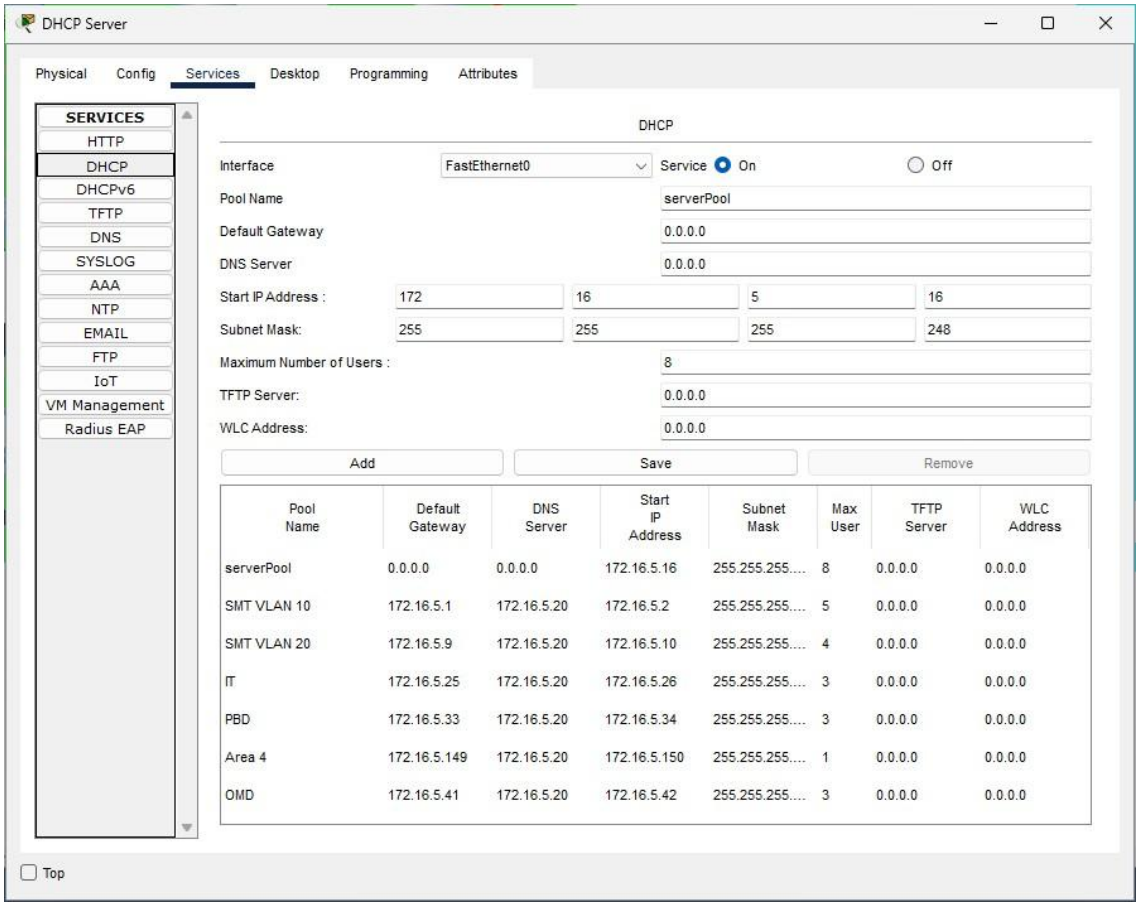

## R8: Access Restrictions Between Postpaid Billing and Prepaid Subscriber Management Teams

ACL configured on first hop router in SMT blocks inter VLAN communication.



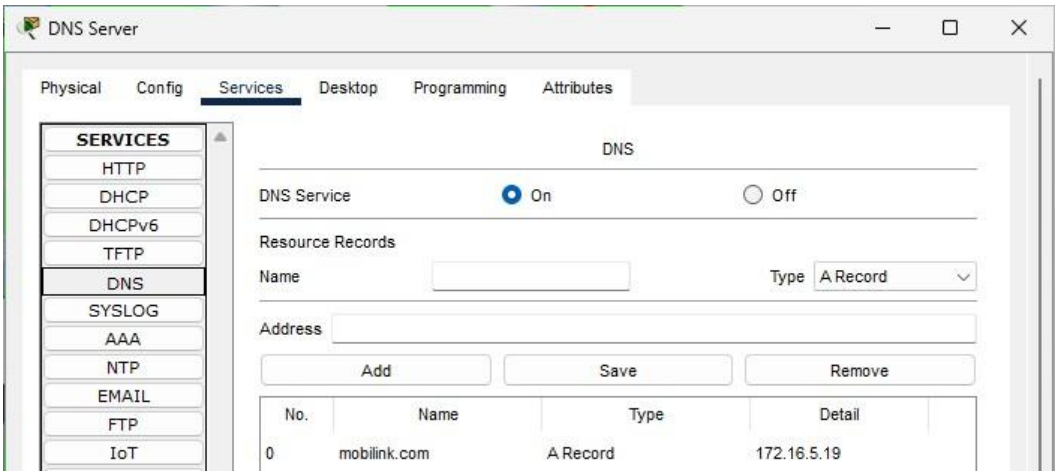
## R9: DHCP Configuration for IPv4 Address Allocation Across Departments

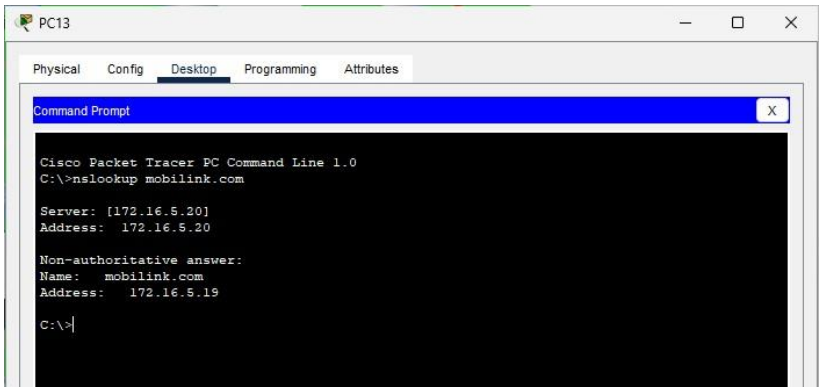
DHCP server offers these pools for the configured areas, as well as DNS.




## R10: DNS Service Configuration and Accessibility

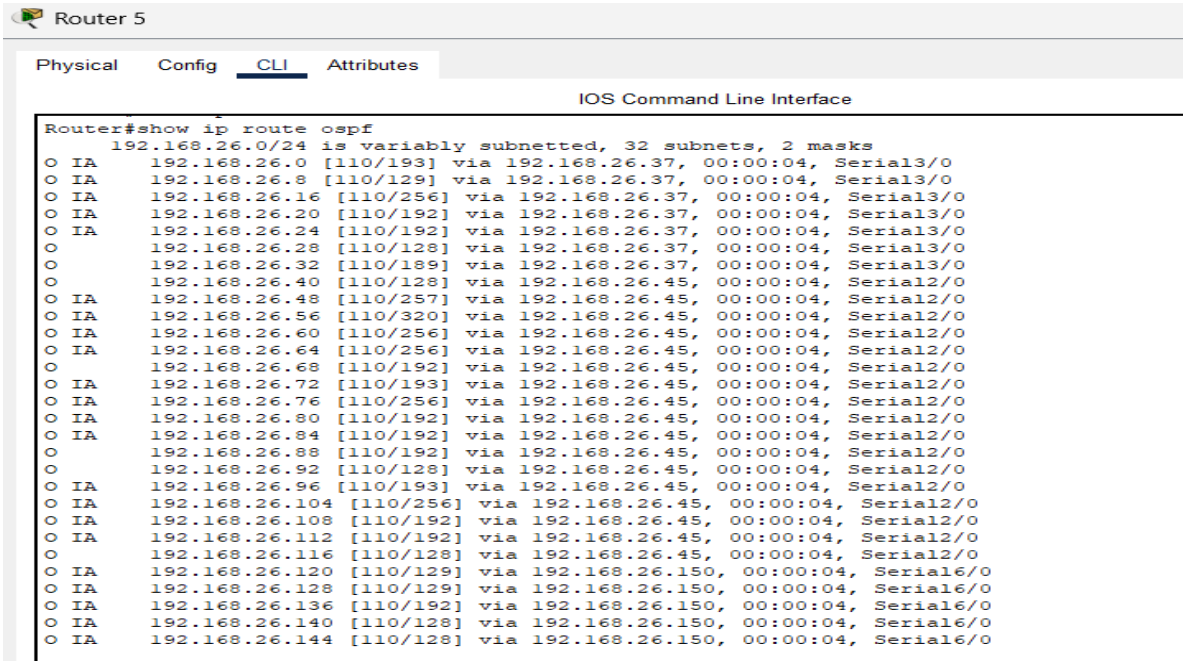
DNS server translates Mobilink.com to the HTTP server IPv4 address.






## R11: Multi-Area OSPF Implementation and Route Summarization

Multi-area OSPF was implemented to improve scalability and manageability. Route summarization was planned at area border routers to reduce the size of routing tables and limit the propagation of detailed network information between areas. However, effective summarization was only possible for Area 1 due to its contiguous subnet allocation.




## R12: Efficient IP Address Allocation and Minimization of Wastage

Refer to VLSM scheme provided above.

## R13: Ensuring Unique Bandwidth Allocation for Serial Links

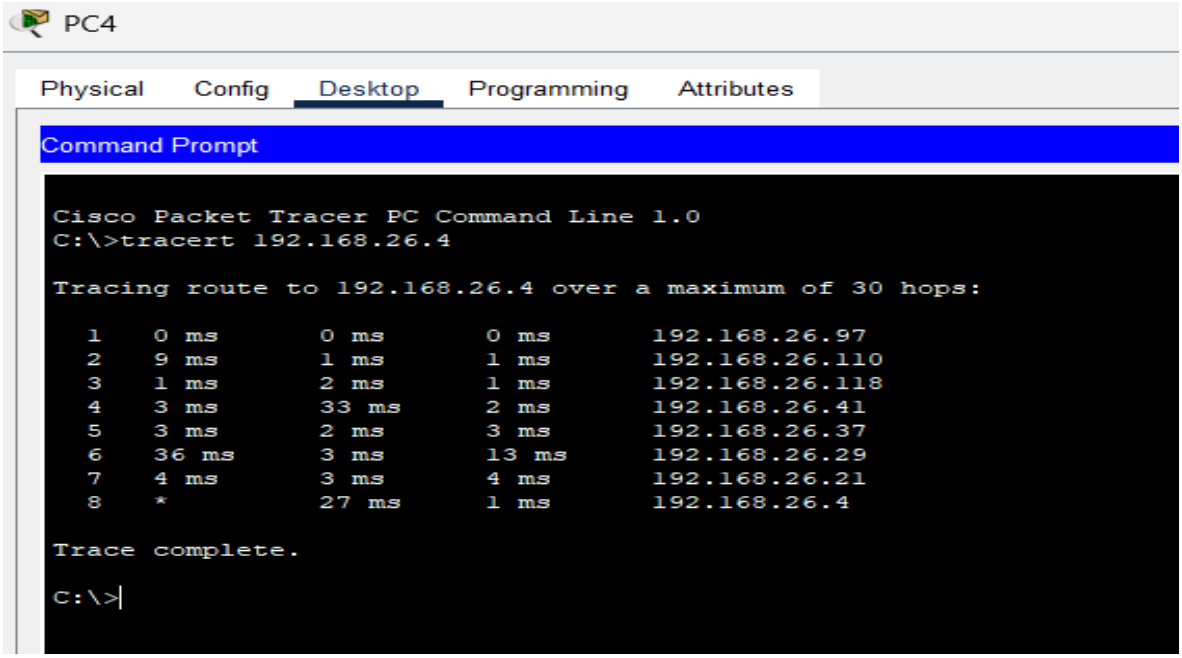
Following table provides details on each link and its bandwidth.

| Router | Link | Interface | Bandwith | Description |
|---|---|---|---|---|
| R1 | R1-R2 | Se2/0 - Se2/0 | 10240 | A5 |

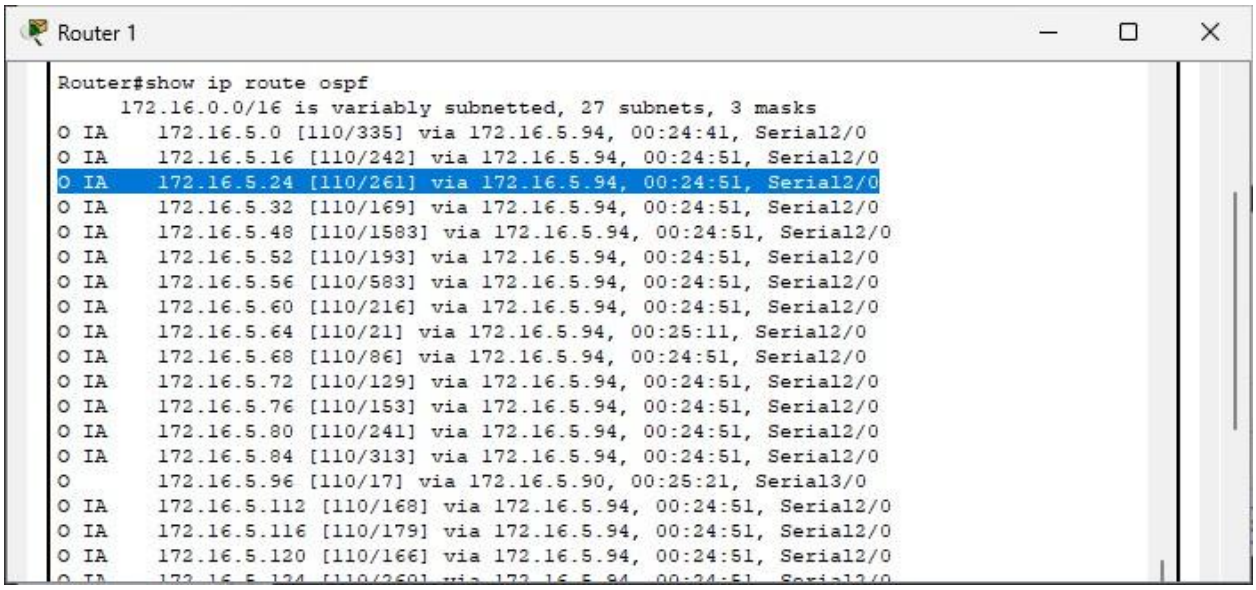
| | | | | |
|---|---|---|---|---|
| R2 | R2-R3 | Se3/0 - Se2/0 | 10752 | A5 |
| R3 | R3-R1 | Se3/0 - Se3/0 | 11264 | A5 |
| R4 | R4-R2 | Se6/0 - Se6/0 | 8192 | A5 ABR |
| | R4-R6 | Se3/0 - Se3/0 | 64 | BB |
| | R4-R9 | Se7/0 - Se6/0 | 1536 | A4 ABR |
| R5 | R5-R16 | Se6/0 - Se6/0 | 1024 | A1 ABR |
| | R5-R4 | Se2/0 - Se2/0 | 512 | BB |
| R6 | R6-R11 | Se6/0 - Se6/0 | 4096 | A3 ABR |
| | R6-R7 | Se2/0 - Se2/0 | 128 | BB |
| | R6-R9 | Se7/0 - Se7/0 | 2304 | A4 ABR |
| R7 | R7-R17 | Se6/0 - Se6/0 | 2048 | A2 ABR |
| | R7-R5 | Se3/0 - Se3/0 | 256 | BB |
| R8 | R8-R9 | Se3/0 - Se2/0 | 8704 | A4 |
| R9 | R9-R10 | Se3/0 - Se3/0 | 9216 | A4 |
| R10 | R10-R8 | Se2/0 - Se2/0 | 9728 | A4 |
| R11 | R11-R12 | Se2/0 - Se2/0 | 6656 | A3 |
| R12 | R12-R13 | Se3/0 - Se3/0 | 7168 | A3 |
| R13 | R13-R11 | Se2/0 - Se3/0 | 7680 | A3 |
| R14 | R14-R15 | Se2/0 - Se2/0 | 3072 | A1 |
| R15 | R15-R16 | Se3/0 - Se2/0 | 3584 | A1 |
| R16 | R16-R14 | Se3/0 - Se3/0 | 4608 | A1 |
| R17 | R17-R18 | Se2/0 - Se2/0 | 5120 | A2 |
| R18 | R18-R19 | Se3/0 - Se3/0 | 5632 | A2 |
| R19 | R19-R17 | Se2/0 - Se3/0 | 6144 | A2 |

## R14: Cost Analysis of Selected Network Routes

1. PC4 to PC10




The route is R1 – R2 – R4 – R9 – R6 – R7 – R7 – R18. The sum of OSPF costs is 9 + 12 + 65 + 43 + 64 + 49 + 19 = 261, as confirmed by the router.




## 6. Challenges

Due to inefficient subnetting in the network design, I was only able to tightly summarize the routes within OSPF Area 1. The subnets in Area 1 were contiguous and aligned in such a way that they could be aggregated into a single summary address without including unrelated subnets. However, the subnets in the rest of the network were fragmented and not contiguous, making it impossible to summarize them effectively without causing overlap with other subnets.

Router 18

Router(config)#int fa 0/0

Router(config-if)#ip addr 192.168.26.1 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.21 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.21 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.0 0.0.0.7 area 2

Router(config-router)#network 192.168.26.16 0.0.0.3 area 2

Router(config-router)#network 192.168.26.20 0.0.0.3 area 2

Router(config-router)#exit

Router(config)#int fa 0/0

Router(config-if)#ip helper-address 192.168.26.11

Router(config-if)#exit

==========

--Router 19

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.18 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.26 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.16 0.0.0.3 area 2

Router(config-router)#network 192.168.26.24 0.0.0.3 area 2

Router(config-router)#exit

==========

--Router 17

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.25 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.22 255.255.255.252

Router(config-if)#no shut

```
Router(config)#int se 6/0
Router(config-if)#ip addr 192.168.26.29 255.255.255.252
Router(config-if)#no shut

Router(config)#int fa 0/0
Router(config-if)#ip addr 192.168.26.9 255.255.255.248
Router(config-if)#no shut

--OSPF
Router(config)#router ospf 1
Router(config-router)#network 192.168.26.8 0.0.0.7 area 2
Router(config-router)#network 192.168.26.20 0.0.0.3 area 2
Router(config-router)#network 192.168.26.20 0.0.0.3 area 2
Router(config-router)#network 192.168.26.28 0.0.0.3 area 0
Router(config-router)#exit

enable
configure terminal
enable password 123
username admin password 123
line vty 0 4
 password 123
 login local
exit
line console 0
 password 123
```

login local

exit

exit

wr

--ACL

Router(config)#access-list 105 den

Router(config)#access-list 105 deny tcp 192.168.26.96 0.0.0.7 host 192.168.26.12 eq 80

Router(config)#access-list 105 deny tcp 192.168.26.96 0.0.0.7 host 192.168.26.12 eq 443

Router(config)#access-list 105 permit ip any any

Router(config)#int fa 0/0

Router(config-if)#ip access-group 105 in

Router(config-if)#exit

==========

--Router 7

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.30 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.33 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.37 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.32 0.0.0.7 area 0

Router(config-router)#network 192.168.26.36 0.0.0.7 area 0

Router(config-router)#network 192.168.26.28 0.0.0.7 area 0

Router(config-router)#exit

==========

--Router 5

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.38 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.46 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.149 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.148 0.0.0.3 area 0

Router(config-router)#network 192.168.26.44 0.0.0.3 area 0

Router(config-router)#network 192.168.26.36 0.0.0.3 area 0

Router(config-router)#exit

==========

--Router 4

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.45 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.42 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 7/0

Router(config-if)#ip addr 192.168.26.94 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.116 0.0.0.3 area 0

Router(config-router)#network 192.168.26.40 0.0.0.3 area 0

Router(config-router)#network 192.168.26.44 0.0.0.3 area 0

Router(config-router)#network 192.168.26.92 0.0.0.3 area 0

Router(config-router)#exit

==========

--Router 6

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.41 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.34 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.70 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 7/0

Router(config-if)#ip addr 192.168.26.90 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.68 0.0.0.7 area 0

Router(config-router)#network 192.168.26.40 0.0.0.7 area 0

Router(config-router)#network 192.168.26.32 0.0.0.7 area 0

Router(config-router)#exit

==========

--Router 12

Router(config)#int fa 0/0

Router(config-if)#ip addr 192.168.26.49 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.57 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.66 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.48 0.0.0.7 area 3

Router(config-router)#network 192.168.26.56 0.0.0.3 area 3

Router(config-router)#network 192.168.26.64 0.0.0.3 area 3

Router(config-router)#exit

Router(config)#int fa 0/0

Router(config-if)#ip helper-address 192.168.26.11

Router(config-if)#exit

==========

--Router 13

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.58 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.61 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.56 0.0.0.3 area 3

Router(config-router)#network 192.168.26.60 0.0.0.3 area 3

Router(config-router)#exit

==========

--Router 11

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.65 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.62 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.69 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.60 0.0.0.3 area 3

Router(config-router)#network 192.168.26.64 0.0.0.3 area 3

Router(config-router)#network 192.168.26.68 0.0.0.3 area 0

Router(config-router)#exit

enable

configure terminal

enable password 123

username admin password 123

line vty 0 4

 password 123

 login local

exit

line console 0

 password 123

 login local

exit

exit

wr

==========

--Router 8

Router(config)#int fa 0/0

Router(config-if)#ip addr 192.168.26.73 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.77 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.81 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.76 0.0.0.3 area 4

Router(config-router)#network 192.168.26.72 0.0.0.3 area 4

Router(config-router)#network 192.168.26.80 0.0.0.3 area 4

Router(config-router)#exit

Router(config)#int fa 0/0

Router(config-if)#ip helper-address 192.168.26.11

Router(config-if)#exit

==========

--Router 9

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.82 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

```
Router(config-if)#ip addr 192.168.26.85 255.255.255.252
Router(config-if)#no shut

Router(config)#int se 7/0
Router(config-if)#ip addr 192.168.26.89 255.255.255.252
Router(config-if)#no shut

Router(config)#int se 6/0
Router(config-if)#ip addr 192.168.26.93 255.255.255.252
Router(config-if)#no shut

--OSPF
Router(config)#router ospf 1
Router(config-router)#network 192.168.26.84 0.0.0.3 area 4
Router(config-router)#network 192.168.26.80 0.0.0.3 area 4
Router(config-router)#network 192.168.26.88 0.0.0.3 area 0
Router(config-router)#network 192.168.26.92 0.0.0.3 area 0
Router(config-router)#exit

enable
configure terminal
enable password 123
username admin password 123
line vty 0 4
 password 123
 login local
exit
```

```
line console 0
 password 123
 login local
exit
exit
wr
```

==========

```
--Router 10
Router(config)#int se 3/0
Router(config-if)#ip addr 192.168.26.86 255.255.255.252
Router(config-if)#no shut

Router(config)#int se 2/0
Router(config-if)#ip addr 192.168.26.78 255.255.255.252
Router(config-if)#no shut

--OSPF
Router(config)#router ospf 1
Router(config-router)#network 192.168.26.76 0.0.0.3 area 4
Router(config-router)#network 192.168.26.84 0.0.0.3 area 4
Router(config-router)#exit
```

==========

```
--Router 1
Router(config)#int fa 0/0
Router(config-if)#ip addr 192.168.26.97 255.255.255.248
```

Router(config-if)#no shut

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.105 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.109 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.96 0.0.0.7 area 5

Router(config-router)#network 192.168.26.104 0.0.0.3 area 5

Router(config-router)#network 192.168.26.108 0.0.0.3 area 5

Router(config)#int fa 0/0

Router(config-if)#ip helper-address 192.168.26.11

Router(config-if)#exit

==========

--Router 2

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.110 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 3/0

```
Router(config-if)#ip addr 192.168.26.113 255.255.255.252
Router(config-if)#no shut

Router(config)#int se 6/0
Router(config-if)#ip addr 192.168.26.117 255.255.255.252
Router(config-if)#no shut

--OSPF
Router(config)#router ospf 1
Router(config-router)#network 192.168.26.108 0.0.0.3 area 5
Router(config-router)#network 192.168.26.112 0.0.0.3 area 5
Router(config-router)#network 192.168.26.116 0.0.0.3 area 0
Router(config-router)#exit

enable
configure terminal
enable password 123
username admin password 123
line vty 0 4
 password 123
 login local
exit
line console 0
 password 123
 login local
exit
exit
```

wr

==========

--Router 3

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.106 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.114 255.255.255.252

Router(config-if)#no shut

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.118 255.255.255.252

Router(config-if)#no shut

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.104 0.0.0.3 area 5

Router(config-router)#network 192.168.26.112 0.0.0.3 area 5

==========

--Router 16

Router(config)#int se 6/0

Router(config-if)#ip addr 192.168.26.150 255.255.255.252

Router(config-if)#no shut

```
Router(config)#int se 3/0
Router(config-if)#ip addr 192.168.26.146 255.255.255.252
Router(config-if)#no shut

Router(config)#int se 2/0
Router(config-if)#ip addr 192.168.26.142 255.255.255.252
Router(config-if)#no shut

--OSPF
Router(config)#router ospf 1
Router(config-router)#network 192.168.26.140 0.0.0.3 area 1
Router(config-router)#network 192.168.26.144 0.0.0.3 area 1
Router(config-router)#network 192.168.26.148 0.0.0.3 area 0
Router(config-router)#exit

enable
configure terminal
enable password 123
username admin password 123
line vty 0 4
 password 123
 login local
exit
line console 0
 password 123
 login local
exit
```

exit

wr

==========

--Router 14

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.137 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.145 255.255.255.252

Router(config-if)#no shut

Router(config)#int fa 0/0.1

Router(config-subif)#encapsulation dot1Q 10

Router(config-subif)#ip addr 192.168.26.121 255.255.255.248

Router(config-subif)#no shut

Router(config-subif)#exit

Router(config)#int fa 0/0.2

Router(config-subif)#encapsulation dot1Q 20

Router(config-subif)#ip addr 192.168.26.129 255.255.255.248

Router(config-subif)#no shut

Router(config-subif)#exit

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.136 0.0.0.3 area 1

Router(config-router)#network 192.168.26.144 0.0.0.3 area 1

Router(config-router)#network 192.168.26.128 0.0.0.7 area 1

Router(config-router)#network 192.168.26.120 0.0.0.7 area 1

Router(config-router)#exit

Router(config)#int fa 0/0.1

Router(config-subif)#ip helper-address 192.168.26.11

Router(config-subif)#exit

Router(config)#int fa 0/0.2

Router(config-subif)#exit

Router(config)#int fa 0/0.2

Router(config-subif)#ip helper-address 192.168.26.11

Router(config-subif)#exit

==========

--Router 15

Router(config)#int se 2/0

Router(config-if)#ip addr 192.168.26.138 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

Router(config)#int se 3/0

Router(config-if)#ip addr 192.168.26.141 255.255.255.252

Router(config-if)#no shut

Router(config-if)#exit

--OSPF

Router(config)#router ospf 1

Router(config-router)#network 192.168.26.140 0.0.0.3 area 1

Router(config-router)#network 192.168.26.136 0.0.0.3 area 1

Router(config-router)#exit

==========

--Switch 5

Switch(config)#vlan 10

Switch(config-vlan)#name postpaid

Switch(config-vlan)#exit

Switch(config)#vlan 20

Switch(config-vlan)#name prepaid

Switch(config-vlan)#exit

Switch(config)#int range fa 0/1, fa 1/1

Switch(config-if-range)#switchport mode trunk

Switch(config-if-range)#no shutdown

Switch(config-if-range)#exit

Switch(config)#int range fa 2/1, fa 3/1, fa 6/1

Switch(config-if-range)#switchport mode access

Switch(config-if-range)#switchport access vlan 10

Switch(config-if-range)#no shutdown

Switch(config-if-range)#exit

Switch(config)#interface vlan 10

Switch(config-if)#ip addr 192.168.26.121 255.255.255.248

Switch(config-if)#no shut

Switch(config-if)#no shutdown

Switch(config-if)#exit

Switch(config)#interface vlan 20

Switch(config-if)#ip addr 192.168.26.129 255.255.255.248

Switch(config-if)#no shutdown

Switch(config-if)#exit

Switch(config-if)# switchport port-security

Switch(config-if)# switchport port-security maximum 1

Switch(config-if)# switchport port-security violation shutdown

Switch(config-if)# switchport port-security mac-address sticky

Switch(config)#spanning-tree mode pvst

Switch(config)#spanning-tree vlan 10 priority 8192

Switch(config)#spanning-tree vlan 20 priority 8192

Switch(config)#exit

==========

--Switch 3

Switch(config)#vlan 10

Switch(config-vlan)#name postpaid

```
Switch(config-vlan)#exit

Switch(config)#vlan 20
Switch(config-vlan)#name prepaid
Switch(config-vlan)#exit

Switch(config)#int ra fa 2/1,fa3/1
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 10
Switch(config-if-range)#no shutdown
Switch(config-if-range)#exit

Switch(config)#int fa 6/1
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 20
Switch(config-if)#no shutdown
Switch(config-if)#exit

Switch(config)#int vlan 10
Switch(config-if)#ip addr 192.168.26.121 255.255.255.248
Switch(config-if)#no shutdown
Switch(config-if)#exit

Switch(config)#int vlan 20
Switch(config-if)#ip addr 192.168.26.129 255.255.255.248
Switch(config-if)#no shutdown
Switch(config-if)#exit
```

Switch(config)#int ra fa 0/1,fa 1/1

Switch(config-if-range)#switchport mode trunk

Switch(config-if-range)#no shutdown

Switch(config-if-range)#exit

==========

Switch(config-if)# switchport port-security

Switch(config-if)# switchport port-security maximum 1

Switch(config-if)# switchport port-security violation shutdown

Switch(config-if)# switchport port-security mac-address sticky

Switch(config)#spanning-tree mode pvst

Switch(config)#spanning-tree vlan 10 priority 4096

Switch(config)#spanning-tree vlan 20 priority 4096

Switch(config)#exit

==========

--Switch 4

Switch(config)#vlan 10

Switch(config-vlan)#name postpaid

Switch(config-vlan)#exit

Switch(config)#vlan 20

Switch(config-vlan)#name prepaid

Switch(config-vlan)#exit

```
Switch(config)#int ra fa0/1,fa1/1
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
Switch(config-if-range)#exit

Switch(config)#int ra fa2/1,fa3/1,fa6/1
Switch(config-if-range)#switchport mode access
Switch(config-if-range)#switchport access vlan 20
Switch(config-if-range)#no shutdown
Switch(config-if-range)#exit

Switch(config)#int vlan 10
Switch(config-if)#ip addr 192.168.26.121 255.255.255.248
Switch(config-if)#no shutdown
Switch(config-if)#exit

Switch(config)#int vlan 20
Switch(config-if)#ip addr 192.168.26.129 255.255.255.248
Switch(config-if)#no shutdown
Switch(config-if)#exit
==========
Switch(config-if)#  switchport port-security
Switch(config-if)# switchport port-security maximum 1
Switch(config-if)# switchport port-security violation shutdown
Switch(config-if)# switchport port-security mac-address sticky
Switch(config-if)# exit
```

Switch(config)#spanning-tree mode pvst

Switch(config)#spanning-tree vlan 10 priority 8192

Switch(config)#spanning-tree vlan 20 priority 8192

Switch(config)#exit

==========

--Switch 6

Switch(config)#vlan 10

Switch(config-vlan)#name postpaid

Switch(config-vlan)#exit

Switch(config)#vlan 20

Switch(config-vlan)#name prepaid

Switch(config-vlan)#exit

Switch(config)#interface vlan 10

Switch(config-if)#ip addr 192.168.26.121 255.255.255.248

Switch(config-if)#no shutdown

Switch(config-if)#exit

Switch(config)#interface vlan 20

Switch(config-if)#ip addr 192.168.26.129 255.255.255.248

Switch(config-if)#no shutdown

Switch(config-if)#exit

Switch(config)#int ra fa 0/1,fa1/1,fa 2/1

```
Switch(config-if-range)#switchport mode trunk
Switch(config-if-range)#no shutdown
Switch(config-if-range)#exit
```