

# COMSATS University Islamabad

## Lahore Campus



### **Complex Engineering Problem Report**

### **CPE314 - Data Communication and Computer Networks**

**Submitted To:** Sir Modassir Ishfaq

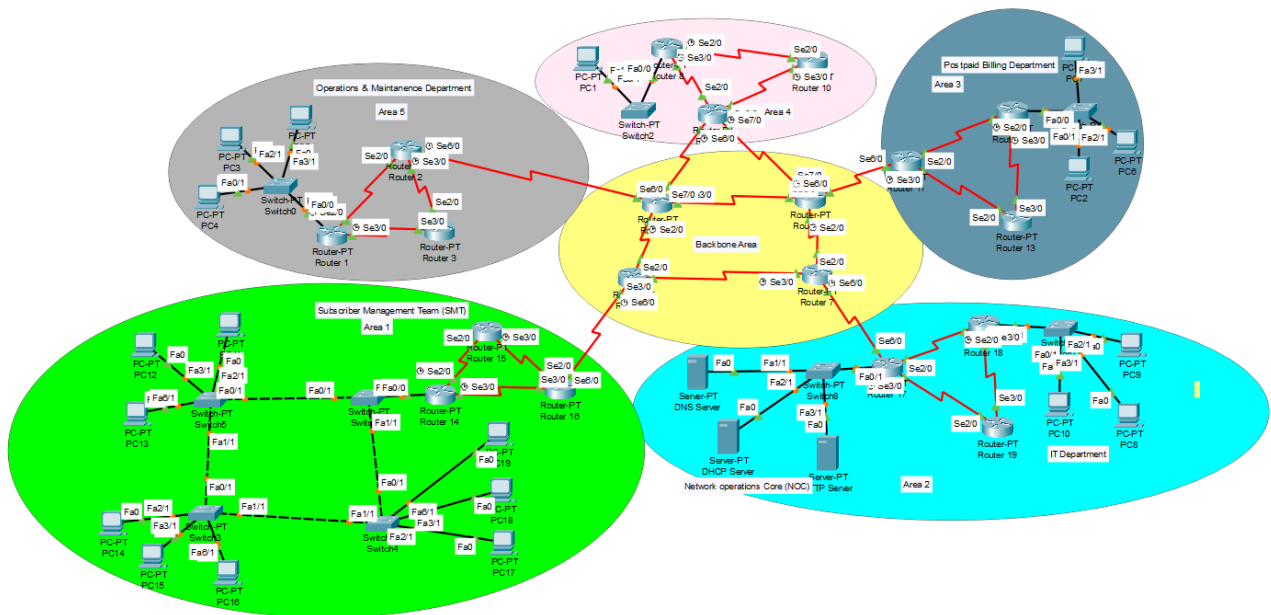
**Submitted By:** Abdullah Laeeq (FA22-BCE-026)

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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	Slas h	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

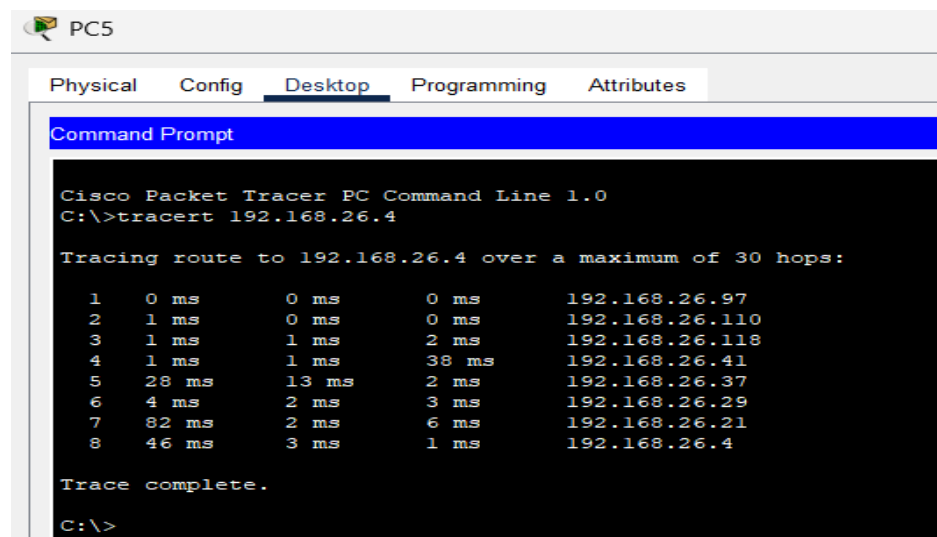
R 6-4	2	192.168.26.40	/30	255.255.255.252	192.168.26.41 - 192.168.26.42	192.168.26.43	0
R 4-5	2	192.168.26.44	/30	255.255.255.252	192.168.26.45 - 192.168.26.46	192.168.26.47	0
R 18-19	2	192.168.26.16	/30	255.255.255.252	192.168.26.17 - 192.168.26.18	192.168.26.19	2
R 18-17	2	192.168.26.20	/30	255.255.255.252	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



```

Cisco Packet Tracer PC Command Line 1.0
C:\>tracert 192.168.26.4

Tracing route to 192.168.26.4 over a maximum of 30 hops:

  0  0 ms    0 ms    0 ms    192.168.26.97
  1  1 ms    0 ms    0 ms    192.168.26.110
  2  1 ms    1 ms    2 ms    192.168.26.118
  3  1 ms    1 ms    38 ms   192.168.26.41
  4  28 ms   13 ms   2 ms    192.168.26.37
  5  4 ms    2 ms    3 ms    192.168.26.29
  6  82 ms   2 ms    6 ms    192.168.26.21
  7  46 ms   3 ms    1 ms    192.168.26.4

Trace complete.

C:\>

```

*Sample traceroute from OMD to IT Department*

#### 3.2. Pings

```
Router 14

Physical Config CLI Attributes

IOS Command Line Interface

Router#pin
Router#ping 192.168.26.4

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.26.4, timeout is 2 seconds:
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 32/67/81 ms
```

*Sample ping from Area 1 to Area 2*

### 3.3. OSPF

```
Router 14

Physical Config CLI Attributes

IOS Command Line Interface

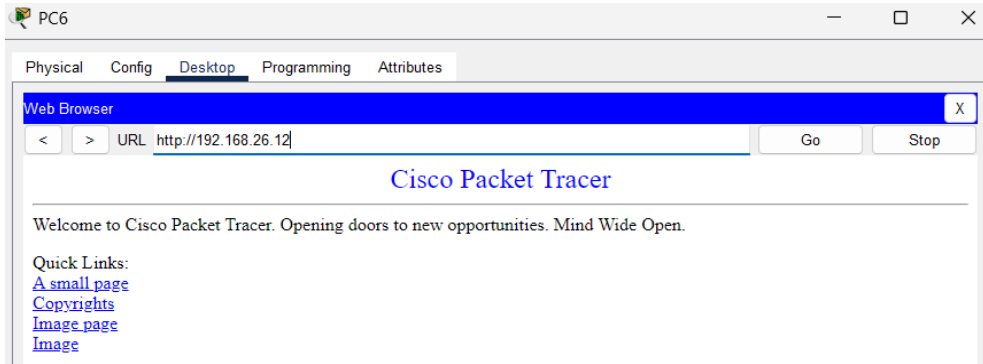
Router#show ip route ospf
192.168.26.0/24 is variably subnetted, 32 subnets, 2 masks
O IA    192.168.26.0 [110/265] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.8 [110/201] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.16 [110/328] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.20 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.24 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.28 [110/200] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.32 [110/261] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.36 [110/136] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.40 [110/200] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.44 [110/136] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.48 [110/329] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.56 [110/392] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.60 [110/328] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.64 [110/328] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.68 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.72 [110/265] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.76 [110/328] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.80 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.84 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.88 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.92 [110/200] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.96 [110/265] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.104 [110/328] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.108 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.112 [110/264] via 192.168.26.146, 01:11:14, Serial3/0
O IA    192.168.26.116 [110/200] via 192.168.26.146, 01:11:14, Serial3/0
O       192.168.26.140 [110/72] via 192.168.26.138, 01:11:49, Serial12/0
O       [110/72] via 192.168.26.146, 01:11:49, Serial3/0
O IA    192.168.26.148 [110/72] via 192.168.26.146, 01:11:24, Serial3/0

Router#
```

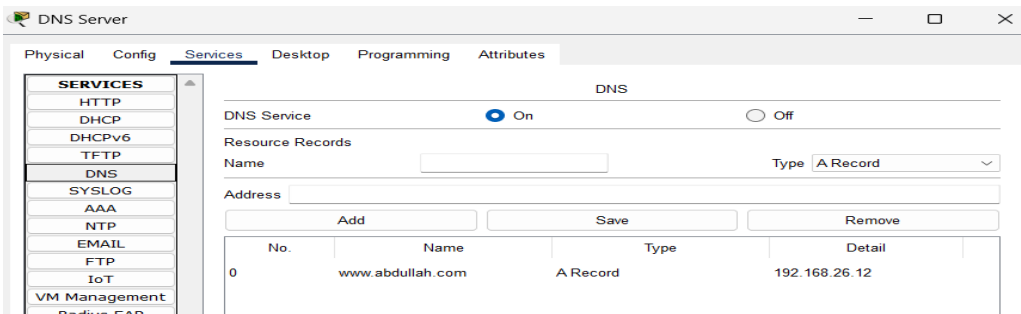
## 4. Server Operability

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.

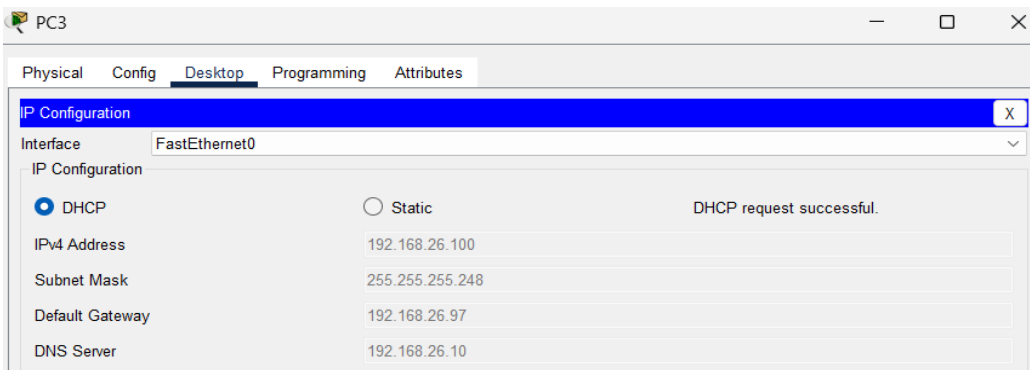
### 4.1. HTTP



### 4.2. DNS



### 4.3. DHCP

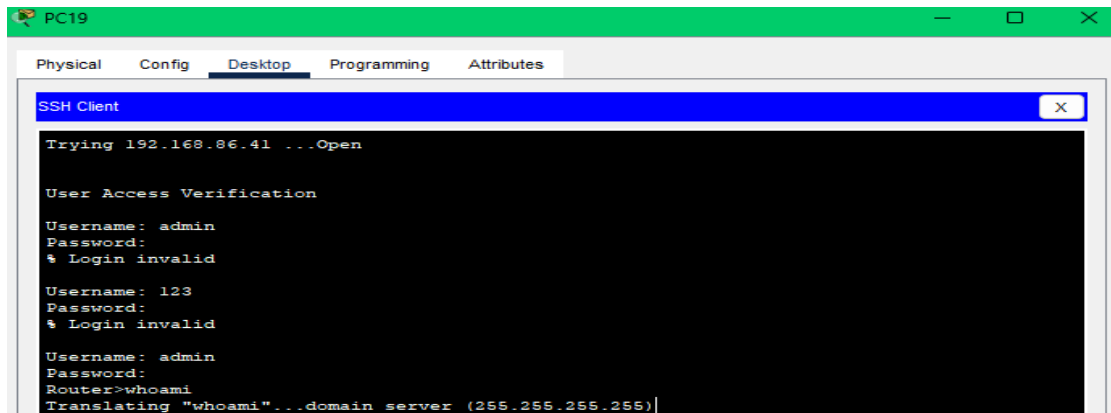


## 5. Requirement Analysis

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.

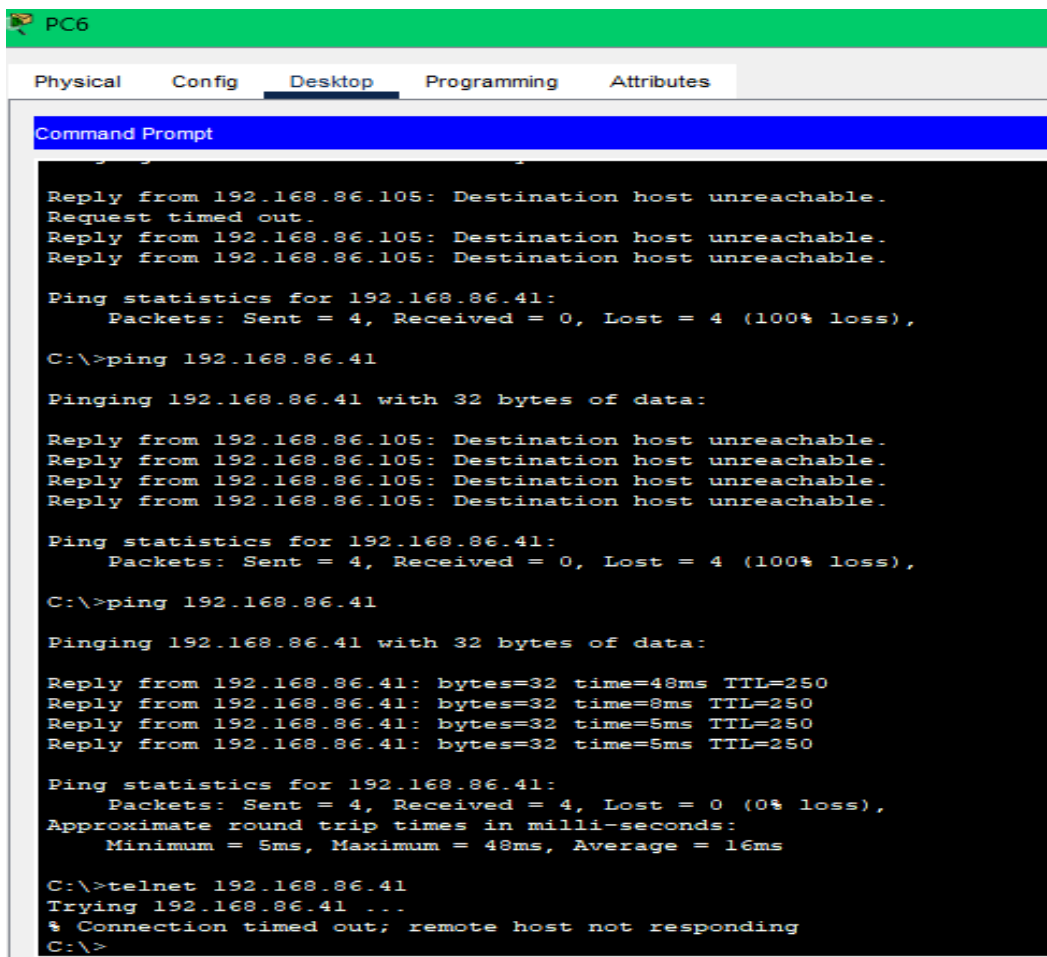
## R1: IT Department Network Access and Telnet Connectivity

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:



```
PC19
Physical Config Desktop Programming Attributes
SSH Client
Trying 192.168.86.41 ...Open
User Access Verification
Username: admin
Password:
% Login invalid
Username: 123
Password:
% Login invalid
Username: admin
Password:
Router>whoami
Translating "whoami"...domain server (255.255.255.255)|
```

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

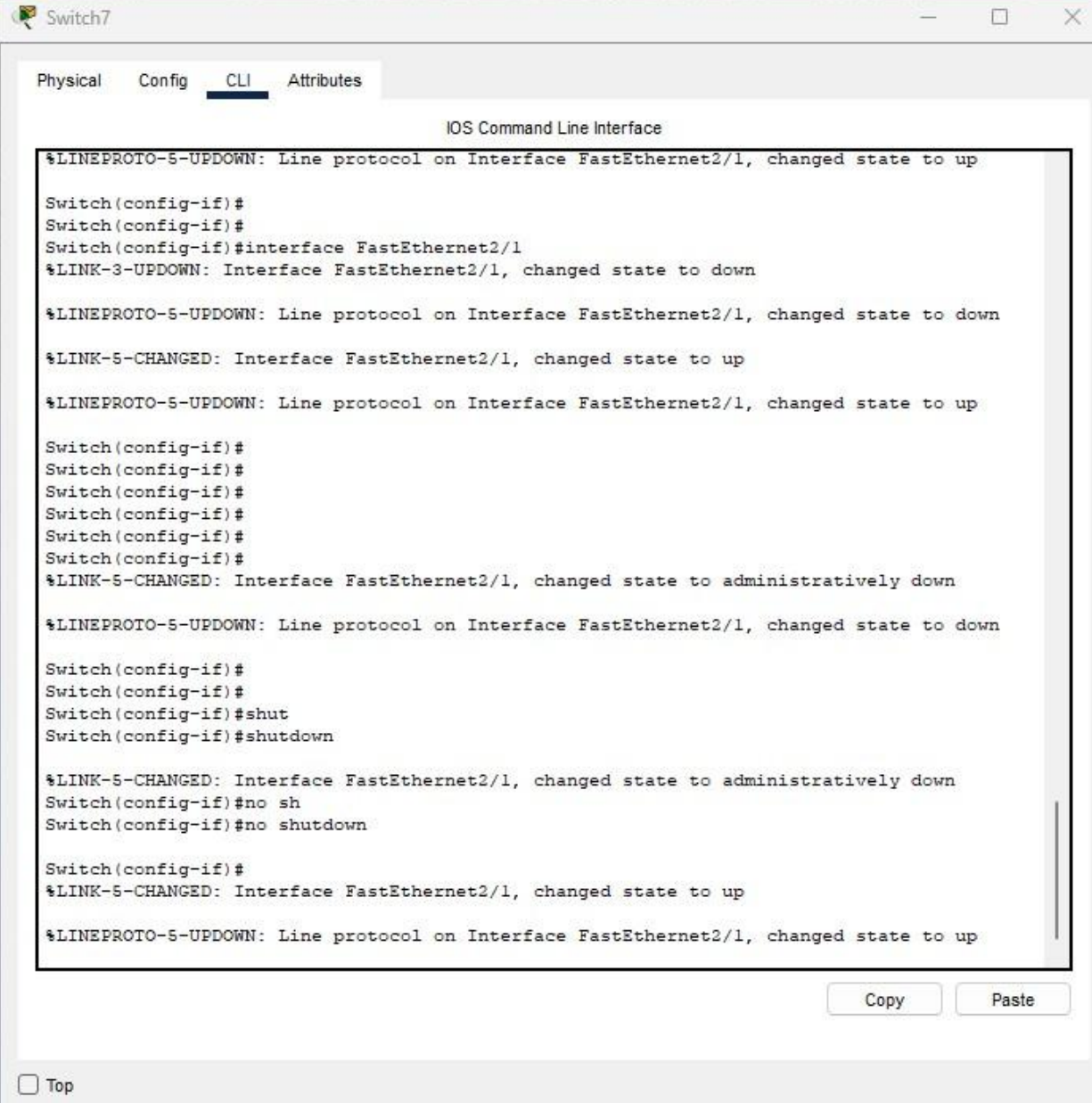


```
PC6
Physical Config Desktop Programming Attributes
Command Prompt
Reply from 192.168.86.105: Destination host unreachable.
Request timed out.
Reply from 192.168.86.105: Destination host unreachable.
Reply from 192.168.86.105: Destination host unreachable.
Ping statistics for 192.168.86.41:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
C:\>ping 192.168.86.41
Pinging 192.168.86.41 with 32 bytes of data:
Reply from 192.168.86.105: Destination host unreachable.
Reply from 192.168.86.105: Destination host unreachable.
Reply from 192.168.86.105: Destination host unreachable.
Reply from 192.168.86.105: Destination host unreachable.
Ping statistics for 192.168.86.41:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
C:\>ping 192.168.86.41
Pinging 192.168.86.41 with 32 bytes of data:
Reply from 192.168.86.41: bytes=32 time=48ms TTL=250
Reply from 192.168.86.41: bytes=32 time=8ms TTL=250
Reply from 192.168.86.41: bytes=32 time=5ms TTL=250
Reply from 192.168.86.41: bytes=32 time=5ms TTL=250
Ping statistics for 192.168.86.41:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 5ms, Maximum = 48ms, Average = 16ms
C:\>telnet 192.168.86.41
Trying 192.168.86.41 ...
% Connection timed out; remote host not responding
C:\>
```



### 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.



The screenshot shows a network switch interface titled "Switch7" with tabs for Physical, Config, CLI, and Attributes. The CLI tab is active, displaying the "IOS Command Line Interface". The terminal output shows a series of commands and system messages for interface FastEthernet2/1. The messages indicate that the line protocol and link states have changed multiple times, including administrative shutdowns. At the bottom, there are "Copy" and "Paste" buttons and a "Top" link.

```
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/1, changed state to up
Switch(config-if)#
Switch(config-if)#
Switch(config-if)#interface FastEthernet2/1
%LINK-3-UPDOWN: Interface FastEthernet2/1, changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/1, changed state to down

%LINK-5-CHANGED: Interface FastEthernet2/1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/1, changed state to up

Switch(config-if)#
Switch(config-if)#
Switch(config-if)#
Switch(config-if)#
Switch(config-if)#
Switch(config-if)#
%LINK-5-CHANGED: Interface FastEthernet2/1, changed state to administratively down

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/1, changed state to down

Switch(config-if)#
Switch(config-if)#
Switch(config-if)#shut
Switch(config-if)#shutdown

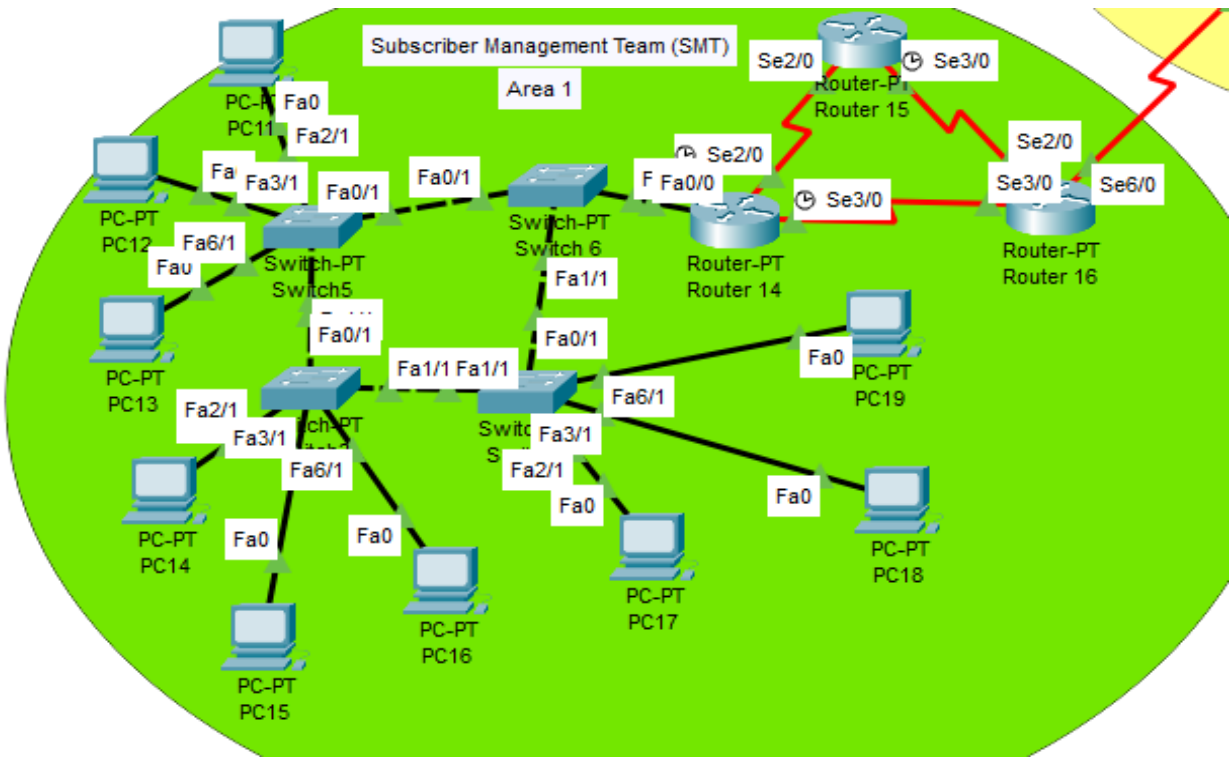
%LINK-5-CHANGED: Interface FastEthernet2/1, changed state to administratively down
Switch(config-if)#no sh
Switch(config-if)#no shutdown

Switch(config-if)#
%LINK-5-CHANGED: Interface FastEthernet2/1, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet2/1, changed state to up
```

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#### 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
!
```

Switch11

Physical Config **CLI** Attributes

IOS Command Line Interface

```
Switch#show vlan
```

VLAN	Name	Status	Ports
1	default	active	Fa4/1, Fa5/1
10	VLAN0010	active	
20	VLAN0020	active	Fa2/1, Fa3/1
1002	fddi-default	active	
1003	token-ring-default	active	
1004	fddinet-default	active	
1005	trnet-default	active	

VLAN	Type	SAID	MTU	Parent	RingNo	BridgeNo	Stp	BrdgMode	Trans1	Trans2
1	enet	100001	1500	-	-	-	-	-	0	0
10	enet	100010	1500	-	-	-	-	-	0	0
20	enet	100020	1500	-	-	-	-	-	0	0
1002	fddi	101002	1500	-	-	-	-	-	0	0
1003	tr	101003	1500	-	-	-	-	-	0	0
1004	fdnet	101004	1500	-	-	-	ieee	-	0	0
1005	trnet	101005	1500	-	-	-	ibm	-	0	0

Remote SPAN VLANs

Primary	Secondary	Type	Ports
Switch#			

## 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.

PC4

Physical Config **Desktop** Programming Attributes

Command Prompt

```
Pinging 172.16.5.12 with 32 bytes of data:

Reply from 172.16.5.12: bytes=32 time=48ms TTL=122
Reply from 172.16.5.12: bytes=32 time=51ms TTL=122
Reply from 172.16.5.12: bytes=32 time=30ms TTL=122
Reply from 172.16.5.12: bytes=32 time=21ms TTL=122

Ping statistics for 172.16.5.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 21ms, Maximum = 51ms, Average = 37ms

C:\>ping 172.16.5.12

Pinging 172.16.5.12 with 32 bytes of data:

Reply from 172.16.5.12: bytes=32 time=56ms TTL=122
Reply from 172.16.5.12: bytes=32 time=46ms TTL=122
Reply from 172.16.5.12: bytes=32 time=60ms TTL=122
Reply from 172.16.5.12: bytes=32 time=25ms TTL=122

Ping statistics for 172.16.5.12:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 25ms, Maximum = 60ms, Average = 46ms

C:\>ping 172.16.5.2

Pinging 172.16.5.2 with 32 bytes of data:

Reply from 172.16.5.41: Destination host unreachable.
Reply from 172.16.5.41: Destination host unreachable.
Reply from 172.16.5.41: Destination host unreachable.
Reply from 172.16.5.41: Destination host unreachable.

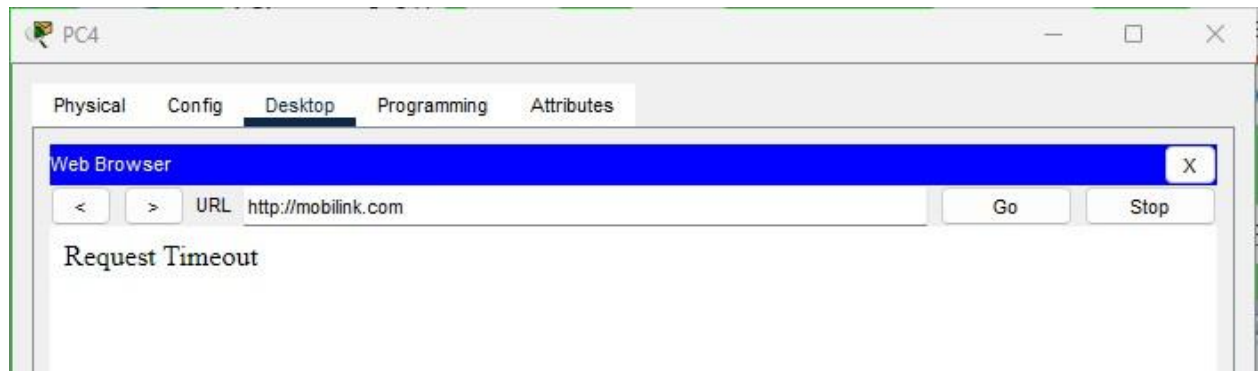
Ping statistics for 172.16.5.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

C:\>
```

☐ Top

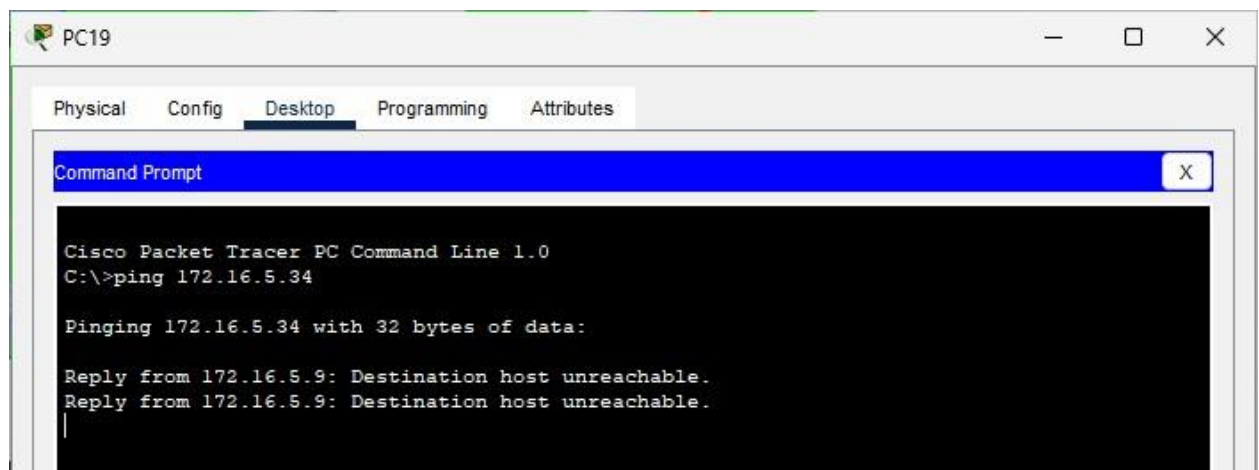
### R7: Restricting OMD Access to NOC Webserver

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

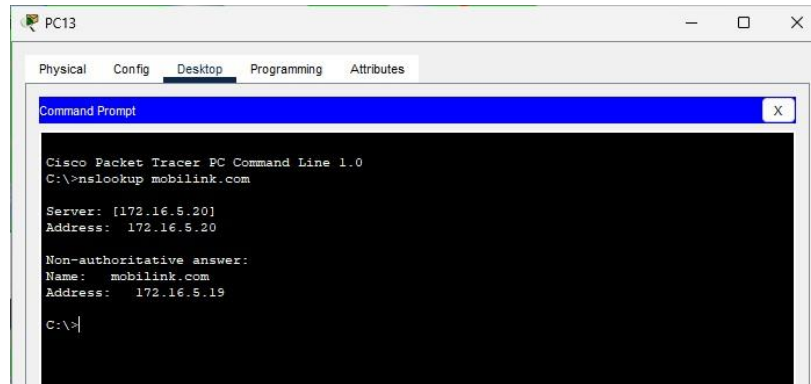
DHCP server offers these pools for the configured areas, as well as DNS.

Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User	TFTP Server	WLC Address
serverPool	0.0.0.0	0.0.0.0	172.16.5.16	255.255.255.248	8	0.0.0.0	0.0.0.0
SMT VLAN 10	172.16.5.1	172.16.5.20	172.16.5.2	255.255.255.248	5	0.0.0.0	0.0.0.0
SMT VLAN 20	172.16.5.9	172.16.5.20	172.16.5.10	255.255.255.248	4	0.0.0.0	0.0.0.0
IT	172.16.5.25	172.16.5.20	172.16.5.26	255.255.255.248	3	0.0.0.0	0.0.0.0
PBD	172.16.5.33	172.16.5.20	172.16.5.34	255.255.255.248	3	0.0.0.0	0.0.0.0
Area 4	172.16.5.149	172.16.5.20	172.16.5.150	255.255.255.248	1	0.0.0.0	0.0.0.0
OMD	172.16.5.41	172.16.5.20	172.16.5.42	255.255.255.248	3	0.0.0.0	0.0.0.0

## R10: DNS Service Configuration and Accessibility

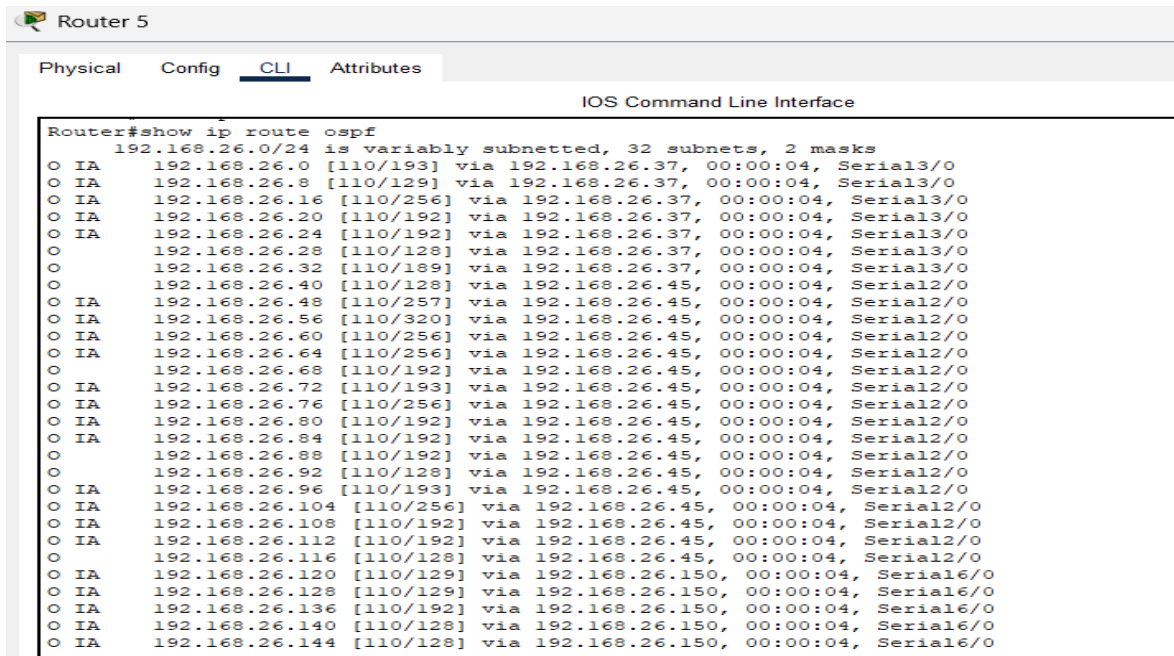
DNS server translates Mobilink.com to the HTTP server IPv4 address.

No.	Name	Type	Detail
0	mobilink.com	A Record	172.16.5.19



## 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

```
PC4
Physical Config Desktop Programming Attributes
Command Prompt
Cisco Packet Tracer PC Command Line 1.0
C:\>tracert 192.168.26.4

Tracing route to 192.168.26.4 over a maximum of 30 hops:

  1  0 ms      0 ms      0 ms      192.168.26.97
  2  9 ms      1 ms      1 ms      192.168.26.110
  3  1 ms      2 ms      1 ms      192.168.26.118
  4  3 ms      33 ms     2 ms      192.168.26.41
  5  3 ms      2 ms      3 ms      192.168.26.37
  6  36 ms     3 ms      13 ms     192.168.26.29
  7  4 ms      3 ms      4 ms      192.168.26.21
  8  *         27 ms     1 ms      192.168.26.4

Trace complete.

C:\>|
```

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.

```
Router 1
Router#show ip route ospf
172.16.0.0/16 is variably subnetted, 27 subnets, 3 masks
O IA 172.16.5.0 [110/335] via 172.16.5.94, 00:24:41, Serial2/0
O IA 172.16.5.16 [110/242] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.24 [110/261] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.32 [110/169] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.48 [110/1583] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.52 [110/193] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.56 [110/583] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.60 [110/216] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.64 [110/21] via 172.16.5.94, 00:25:11, Serial2/0
O IA 172.16.5.68 [110/86] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.72 [110/129] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.76 [110/153] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.80 [110/241] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.84 [110/313] via 172.16.5.94, 00:24:51, Serial2/0
O 172.16.5.96 [110/17] via 172.16.5.90, 00:25:21, Serial3/0
O IA 172.16.5.112 [110/168] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.116 [110/179] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.120 [110/166] via 172.16.5.94, 00:24:51, Serial2/0
O IA 172.16.5.124 [110/260] via 172.16.5.94, 00:24:51, Serial2/0
```

## 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