

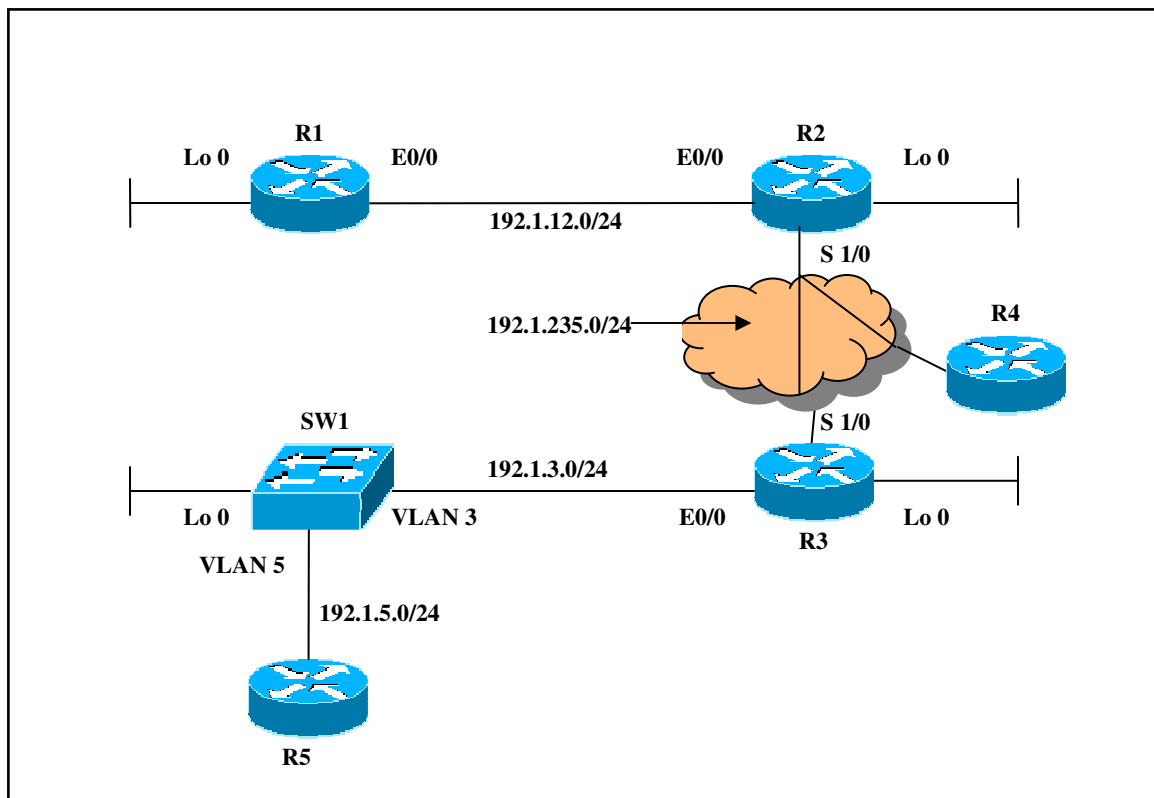
*Tech Labs*

# **MPLS Course**

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# **Module 1 – OSPF and IS-IS Routing**

# Lab 1 – Basic OSPF Configuration



## Interface IP Address Configuration

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.0.0.0
E 0/0	192.1.12.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
E 0/0	192.1.12.2	255.255.255.0
S 1/0	192.1.234.2	255.255.255.0
Loopback 0	2.2.2.2	255.0.0.0

### R3

Interface	IP Address	Subnet Mask
S 1/0	192.1.234.3	255.255.255.0
E 0/0	192.1.3.3	255.255.255.0
Loopback 0	3.3.3.3	255.0.0.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.0.0.0
S 1/0	192.1.234.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.0.0.0
E 0/0	192.1.5.5	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	55.55.55.55	255.0.0.0
VLAN 3	192.1.3.33	255.255.255.0
VLAN 5	192.1.5.55	255.255.255.0

**Interface Configuration**

<p><b>R1</b></p> <pre>interface Loopback0 ip address 1.1.1.1 255.0.0.0 ! interface Ethernet0/0 ip address 192.1.12.1 255.255.255.0 no shutdown</pre>	<p><b>R2</b></p> <pre>interface Loopback0 ip address 2.2.2.2 255.0.0.0 ! interface Ethernet0/0 ip address 192.1.12.2 255.255.255.0 no shut down ! interface Serial1/0 ip address 192.1.234.2 255.255.255.0 encapsulation frame-relay frame-relay map ip 192.1.234.3 203 broadcast frame-relay map ip 192.1.234.4 204 broadcast no frame-relay inverse-arp no shutdown</pre>
<p><b>R3</b></p> <pre>interface Loopback0 ip address 3.3.3.3 255.0.0.0 ! interface Ethernet0/0 ip address 192.1.3.3 255.255.255.0 no shutdown ! interface Serial1/0 ip address 192.1.234.3 255.255.255.0</pre>	<p><b>R4</b></p> <pre>interface Loopback0 ip address 4.4.4.4 255.0.0.0 ! interface Serial1/0 ip address 192.1.234.4 255.255.255.0 encapsulation frame-relay frame-relay map ip 192.1.234.2 402 broadcast frame-relay map ip 192.1.234.3 403 no frame-relay inverse-arp</pre>

<pre>encapsulation frame-relay frame-relay map ip 192.1.234.2 302 broadcast frame-relay map ip 192.1.234.4 304 no frame-relay inverse-arp no shutdown</pre>	<pre>no shutdown</pre>
<p><b>R5</b></p> <pre>interface Loopback0 ip address 5.5.5.5 255.0.0.0 ! interface Ethernet0/0 ip address 192.1.5.5 255.255.255.0 no shutdown</pre>	<p><b>SW1</b></p> <pre>interface Loopback0 ip address 55.55.55.55 255.0.0.0 ! interface Vlan3 ip address 192.1.3.33 255.255.255.0 no shutdown ! interface Vlan5 ip address 192.1.5.55 255.255.255.0 no shutdown</pre>

**Lab Objective:**

**Configure the Interface IP addresses based on the above table**

**Task 1**

Run OSPF as your Routing Protocol on all Routers and the Switch. Advertise the networks in the following areas:

**Area 0** – R1 Loopback 0, R1 E 0/0, R2 E 0/0, R2 Loopback 0

**Area 10** – R2 S 1/0, R3 S 1/0, R3 Loopback 0, R4 S 1/0, R4 Loopback 0

**Area 100** – R3 E 0/0, SW1 VLAN 3, SW1 VLAN 5, SW1 Loopback 0, R5 E 0/0, R5 Loopback 0

<p><b>R1</b></p> <pre>router ospf 1 network 1.0.0.0 0.255.255.255 area 0 network 192.1.12.0 0.0.0.255 area 0</pre>	<p><b>R2</b></p> <pre>router ospf 1 router-id 2.2.2.2 network 2.0.0.0 0.255.255.255 area 0 network 192.1.12.0 0.0.0.255 area 0 network 192.1.234.0 0.0.0.255 area 10 neighbor 192.1.234.3 neighbor 192.1.234.4</pre>
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<b>R3</b> router ospf 1 router-id 3.3.3.3 network 3.0.0.0 0.255.255.255 area 10 network 192.1.3.0 0.0.0.255 area 100 network 192.1.234.0 0.0.0.255 area 10	<b>R4</b> router ospf 1 network 4.0.0.0 0.255.255.255 area 10 network 192.1.234.0 0.0.0.255 area 10 !
<b>R5</b> router ospf 1 network 5.0.0.0 0.255.255.255 area 100 network 192.1.5.0 0.0.0.255 area 100	<b>SW1</b> router ospf 1 network 55.0.0.0 0.255.255.255 area 100 network 192.1.3.0 0.0.0.255 area 100 network 192.1.5.0 0.0.0.255 area 100

## Task 2

Configure the routers such that R2 becomes the DR and R3 the BDR on area 10.

<b>R2</b> Interface S1/0 Ip ospf priority 255	<b>R3</b> Interface S 1/0 Ip ospf priority 50
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**Note:** Issue the **Clear ip ospf process** command to reset the OSPF process for the change to take effect.

## Lab 2 – Virtual Link

*(Builds on previous lab)*

### Lab Objective:

#### Task 1

Run OSPF as your Routing Protocol on all Routers and the Switch. Advertise the networks in the following areas:

**Area 0** – R1 Loopback 0, R1 E 0/0, R2 E 0/0, R2 Loopback 0

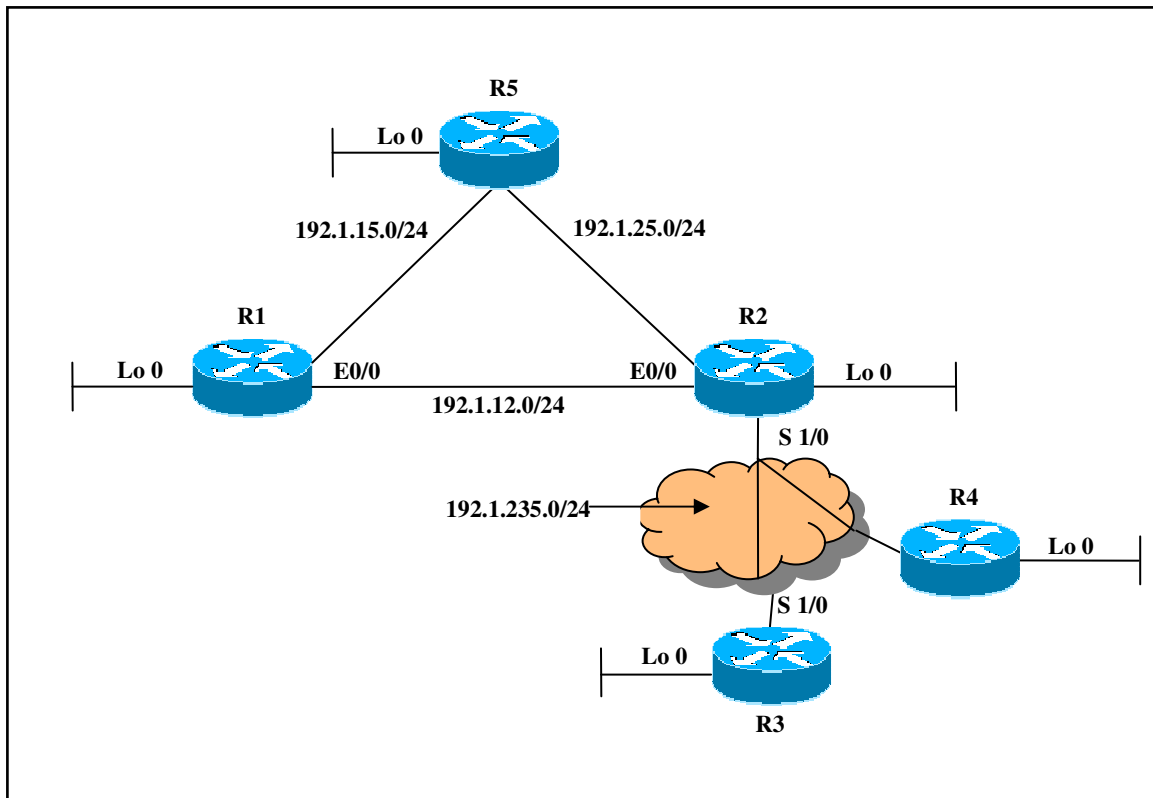
**Area 10** – R2 S 1/0, R3 S 1/0, R3 Loopback 0, R4 S 1/0, R4 Loopback 0

**Area 100** – R3 E 0/0, SW1 VLAN 3, SW1 VLAN 5, SW1 Loopback 0, R5 E 0/0, R5 Loopback 0

Configure a Virtual Link between the appropriate devices.

<b>R1</b>  router ospf 1 network 1.0.0.0 0.255.255.255 area 0 network 192.1.12.0 0.0.0.255 area 0	<b>R2</b>  router ospf 1 router-id 2.2.2.2 area 10 virtual-link 3.3.3.3 network 2.0.0.0 0.255.255.255 area 0 network 192.1.12.0 0.0.0.255 area 0 network 192.1.234.0 0.0.0.255 area 10
<b>R3</b>  router ospf 1 router-id 3.3.3.3 area 10 virtual-link 2.2.2.2 network 3.0.0.0 0.255.255.255 area 10 network 192.1.3.0 0.0.0.255 area 100 network 192.1.234.0 0.0.0.255 area 10 !	<b>R4</b>  router ospf 1 network 4.0.0.0 0.255.255.255 area 10 network 192.1.234.0 0.0.0.255 area 10 !
<b>R5</b>  router ospf 1 network 5.0.0.0 0.255.255.255 area 100 network 192.1.5.0 0.0.0.255 area 100	<b>SW1</b>  router ospf 1 network 55.0.0.0 0.255.255.255 area 100 network 192.1.3.0 0.0.0.255 area 100 network 192.1.5.0 0.0.0.255 area 100

# Lab 3 – Basic IS-IS Configuration



## Interface IP Address Configuration

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.0.0.0
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.12	192.1.12.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.0.0.0
S 1/0	192.1.234.2	255.255.255.0
E 0/0.12	192.1.12.2	255.255.255.0
E 0/0.25	192.1.25.2	255.255.255.0



### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.0.0.0
S 1/0	192.1.234.3	255.255.255.0

### R4

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.0.0.0
S 1/0	192.1.234.4	255.255.255.0

### R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.0.0.0
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

### Interface Configuration

R1	R2
<pre>interface Loopback0 ip address 1.1.1.1 255.0.0.0 ! Interface Ethernet0/0 no shutdown  interface Ethernet0/0.12 encapsulation dot1q 12 ip address 192.1.12.1 255.255.255.0  interface Ethernet0/0.15 encapsulation dot1q 15 ip address 192.1.15.1 255.255.255.0</pre>	<pre>interface Loopback0 ip address 2.2.2.2 255.0.0.0 ! interface Ethernet0/0 no shutdown ! interface Ethernet0/0.12 encapsulation dot1q 12 ip address 192.1.12.2 255.255.255.0  interface Ethernet0/0.25 encapsulation dot1q 25 ip address 192.1.25.2 255.255.255.0  interface Serial1/0 ip address 192.1.234.2 255.255.255.0 encapsulation frame-relay frame-relay map ip 192.1.234.3 203 broadcast frame-relay map ip 192.1.234.4 204 broadcast no frame-relay inverse-arp no shutdown</pre>

<p><b>R3</b></p> <pre>interface Loopback0 ip address 3.3.3.3 255.0.0.0  interface Serial1/0 ip address 192.1.234.3 255.255.255.0 encapsulation frame-relay frame-relay map ip 192.1.234.2 302 broadcast frame-relay map ip 192.1.234.4 304 no frame-relay inverse-arp no shutdown</pre>	<p><b>R4</b></p> <pre>interface Loopback0 ip address 4.4.4.4 255.0.0.0  interface Serial1/0 ip address 192.1.234.4 255.255.255.0 encapsulation frame-relay frame-relay map ip 192.1.234.2 402 broadcast frame-relay map ip 192.1.234.3 403 no frame-relay inverse-arp no shutdown</pre>
<p><b>R5</b></p> <pre>interface Loopback0 ip address 5.5.5.5 255.0.0.0  Interface Fa0/0 no shutdown  interface Fa0/0.15 encapsulation dot1q 15 ip address 192.1.15.5 255.255.255.0  interface Fa0/0.25 encapsulation dot1q 25 ip address 192.1.25.5 255.255.255.0</pre>	<p><b>SW1</b></p> <pre>Vlan database Vlan 12 name VLAN_12 Vlan 15 name VLAN_15 Vlan 25 name VLAN_25 Apply Exit  Interface range fa1/1 - 2 , fa1/5 Switchport trunk encapsulation dot1q Switchport mode trunk</pre>

**Lab Objective:**

**Configure the Interface IP addresses based on the above table**

**Task 1**

Configure IS-IS between R5, R1 and R2. Make sure you configure **only Level-1** adjacency on R5 links towards R1 and R2 using only one command, the IS-IS area **NET** should be **49.000X.000X.000X.00** (*X being your Router number*).

Only a **Level-2** should be established between **R1** and **R2**.

You also want to enable logging for any changing in the IS-IS adjacency and advertise the loopback 0 of R1, R2 and R5 using the best practise.

<p><b>R1</b></p> <pre>interface Ethernet0/0.12 ip address 192.1.12.1 255.255.255.0 ip router isis isis circuit-type level-2-only ! interface Ethernet0/0.15 ip address 192.1.15.1 255.255.255.0 ip router isis  router isis net 49.0001.0001.0001.00 log-adjacency-changes all passive-interface Loopback0</pre>	<p><b>R2</b></p> <pre>interface Ethernet0/0.12 ip address 192.1.12.2 255.255.255.0 ip router isis isis circuit-type level-2-only ! interface Ethernet0/0.25 ip address 192.1.25.2 255.255.255.0 ip router isis  router isis net 49.0002.0002.0002.00 log-adjacency-changes all passive-interface Loopback0</pre>
<p><b>R5</b></p> <pre>interface FastEthernet0/0.15 ip address 192.1.15.5 255.255.255.0 ip router isis  ! interface FastEthernet0/0.25 ip address 192.1.25.5 255.255.255.0 ip router isis  router isis net 49.0005.0005.0005.00 passive-interface Loopback0 is-type level-1</pre>	

## Task 2

Configure IS-IS between R2, R3 and R4, the IS-IS area **NET** should be **49.000X.000X.000X.00** (*X being your Router number*).

You also want to enable logging for any changing in the IS-IS adjacency and advertise the loopback 0 of R2, R3 and R4 using the best practise.

<p><b>R2</b></p> <pre>interface Serial1/0 ip address 192.1.234.2 255.255.255.0 ip router isis</pre>	<p><b>R3</b></p> <pre>interface Serial1/0 ip address 192.1.234.3 255.255.255.0 ip router isis</pre>
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<pre> frame-relay map clns 204 broadcast frame-relay map clns 203 broadcast  router isis net 49.0002.0002.0002.00 log-adjacency-changes all passive-interface Loopback0 </pre>	<pre> frame-relay map clns 304 broadcast frame-relay map clns 302 broadcast  router isis net 49.0003.0003.0003.00 log-adjacency-changes all passive-interface Loopback0 </pre>
<p><b>R4</b></p> <pre> interface Serial1/0 ip address 192.1.234.4 255.255.255.0 ip router isis frame-relay map clns 403 broadcast frame-relay map clns 402 broadcast  router isis net 49.0004.0004.0004.00 log-adjacency-changes all passive-interface Loopback0 </pre>	

### Task 3

As the IS-IS normal behavior **Level-2 routes** can get to **Level-1 routes**, but not the another way around. Change this behavior allowing R5 to see the **Level-2 inter area** routes for the Level-2 link between R1 and R2.

You are not allowed to change the **Level type** on any of the routers to accomplish that.

<p><b>R1</b></p> <pre> router isis redistribute isis ip level-2 into level-1 distribute-list 140  access-list 140 permit ip any any </pre>	<p><b>R2</b></p> <pre> router isis redistribute isis ip level-2 into level-1 distribute-list 140  access-list 140 permit ip any any </pre>
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### Task 3

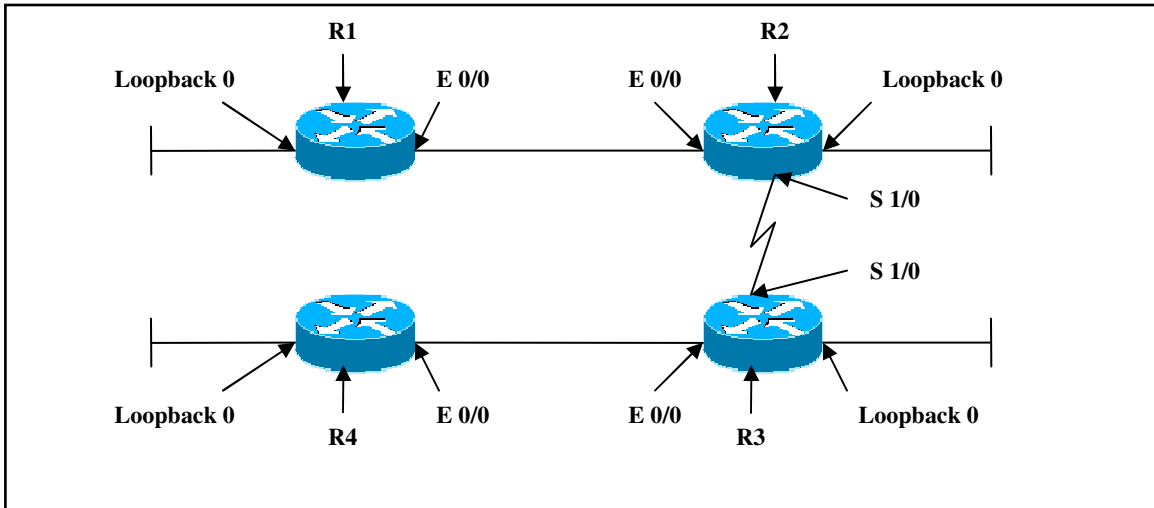
In a near future your department is planning to configure TE on the R1, R2 and R5 routers. Change the **TLV style** under the ISIS routing protocol to let Traffic Engineering to happen in the future.

<b>R1</b> Router isis Metric-style wide	<b>R2</b> Router isis Metric-style wide
<b>R5</b> Router isis Metric-style wide	

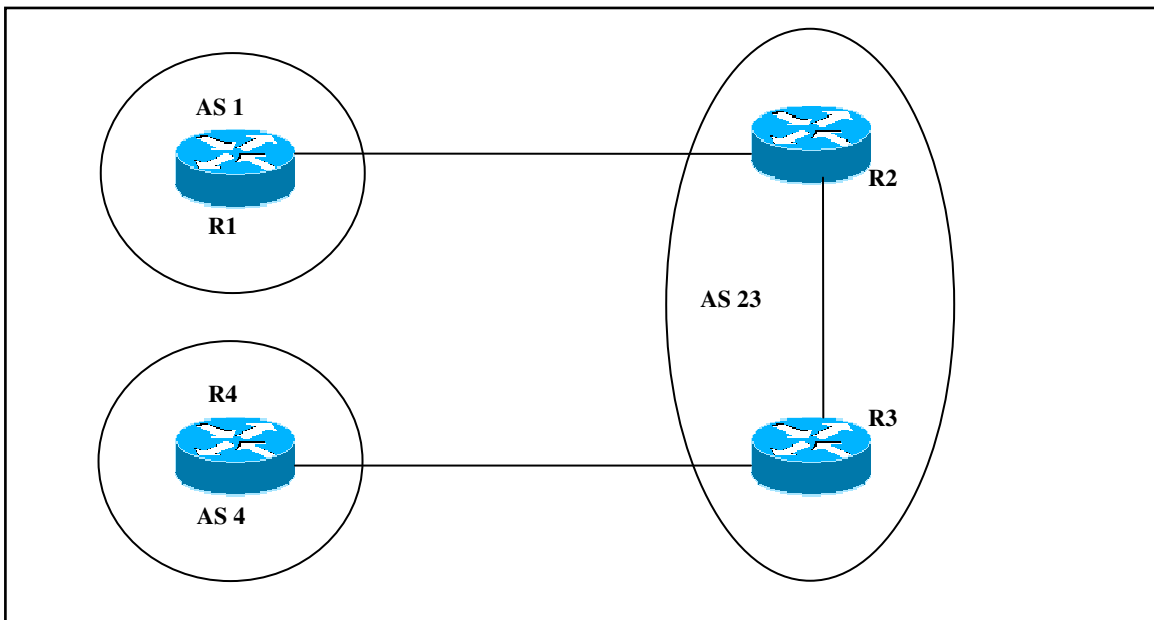
# **Module 2 – BGP**

# Lab 1 – Connecting 2 Autonomous Systems using Transit AS and iBGP

## Physical Layout



## Logical Layout



## Interface IP Address Configuration

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.0.0.0
Loopback 1	11.1.0.1	255.255.0.0
E 0/0	192.1.12.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.0.0.0
Loopback 1	12.1.0.1	255.255.0.0
E 0/0	192.1.12.2	255.255.255.0
S 1/0	192.1.23.2	255.255.255.0

### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.0.0.0
Loopback 1	13.1.0.1	255.255.0.0
S 1/0	192.1.23.3	255.255.255.0
E 0/0	192.1.34.3	255.255.255.0

### R4

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.0.0.0
Loopback 1	14.1.0.1	255.255.0.0
E 0/0	192.1.34.4	255.255.255.0

### Lab Objective:

#### Task 1

Configure a neighbor relationship between R1 and R2 based on the Logical diagram. Advertise the Loopback networks on both Routers. Hard-code the Router ID for the BGP routers as 11.11.11.11 for R1 and 22.22.22.22 for R2.

<b>R1</b>	<b>R2</b>
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<b>Router BGP 1</b> no auto-summary no sync bgp router-id 11.11.11.11 Network 1.0.0.0 Network 11.1.0.0 mask 255.255.0.0 Neighbor 192.1.12.2 remote-as 23	<b>Router BGP 23</b> no auto-summary no sync bgp router-id 22.22.22.22 Network 2.0.0.0 Network 12.1.0.0 mask 255.255.0.0 Neighbor 192.1.12.1 remote-as 1
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### Task 2

Configure a neighbor relationship between R3 and R4 based on the Logical diagram. Advertise the Loopback networks on both Routers. Hard-code the Router ID for the BGP routers as 33.33.33 for R3 and 44.44.44.44 for R4.

<b>R3</b>  Router BGP 23 no auto-summary no sync bgp router-id 33.33.33.33 Network 3.0.0.0 Network 13.1.0.0 mask 255.255.0.0 Neighbor 192.1.34.4 remote-as 4	<b>R4</b>  Router BGP 4 no auto-summary no sync bgp router-id 44.44.44.44 Network 4.0.0.0 Network 14.1.0.0 mask 255.255.0.0 Neighbor 192.1.34.3 remote-as 23
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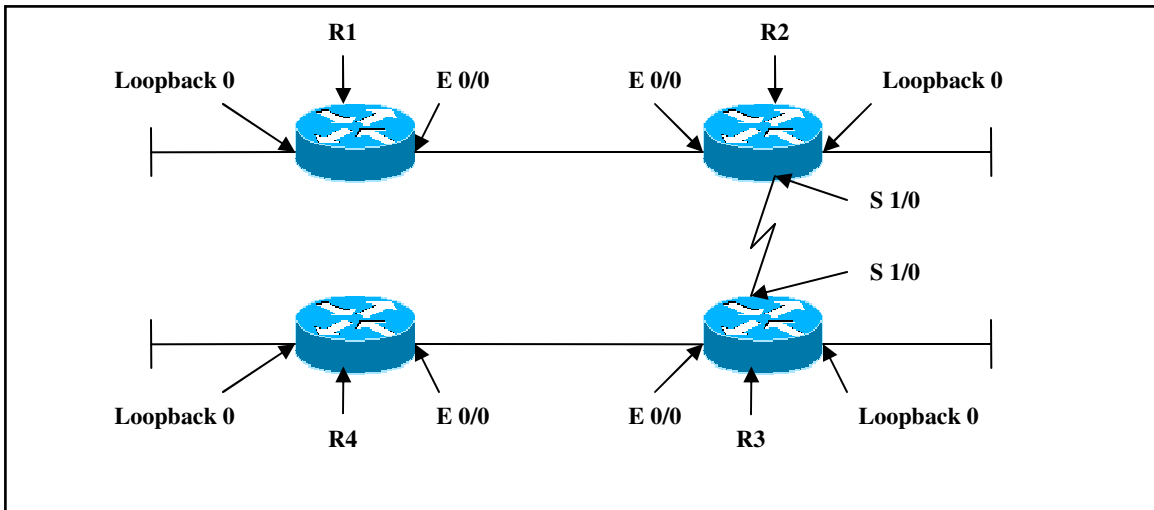
### Task 3

Configure a neighbor relationship between R2 and R3 based on the Logical diagram. When R2 sends routes that it learns from R1, it should sent 192.1.23.2 as the next hop for those routes. When R3 sends routes that it learns from R4, it should sent 192.1.23.3 as the next hop for those routes.

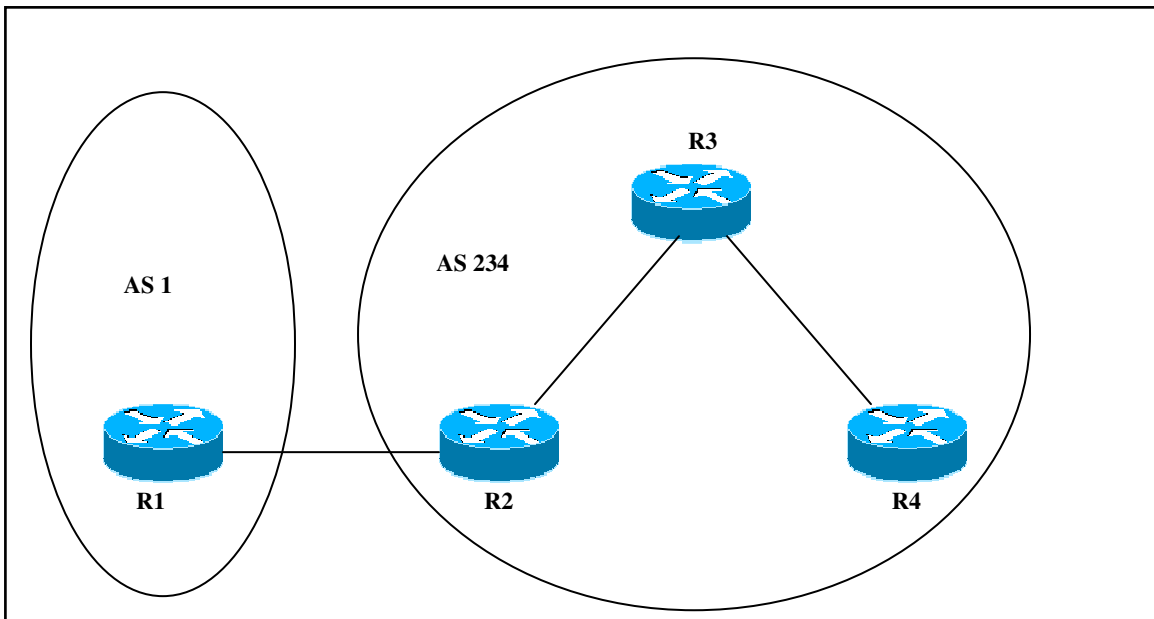
<b>R2</b>  Router BGP 23 Neighbor 192.1.23.3 remote-as 23 Neighbor 192.1.23.3 next-hop-self	<b>R3</b>  Router BGP 23 Neighbor 192.1.23.2 remote-as 23 Neighbor 192.1.23.2 next-hop-self
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# Lab 2 – Configuring Route Reflectors

## Physical Layout



## Logical Layout



## Interface IP Address Configuration

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.0.0.0
Loopback 1	11.1.0.1	255.255.0.0
E 0/0	192.1.12.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.0.0.0
Loopback 1	12.1.0.1	255.255.0.0
E 0/0	192.1.12.2	255.255.255.0
S 1/0	192.1.23.2	255.255.255.0

### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.0.0.0
Loopback 1	13.1.0.1	255.255.0.0
S 1/0	192.1.23.3	255.255.255.0
E 0/0	192.1.34.3	255.255.255.0

### R4

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.0.0.0
Loopback 1	14.1.0.1	255.255.0.0
E 0/0	192.1.34.4	255.255.255.0

### Lab Objective:

#### Task 1

Configure a neighbor relationship between R1 and R2 based on the Logical diagram. Advertise the Loopback networks on both Routers. Hard-code the Router ID for the BGP routers as 11.11.11.11 for R1 and 22.22.22.22 for R2.

R1	R2
Router BGP 1 no auto-summary	Router BGP 234 no auto-summary

no sync bgp router-id 11.11.11.11 Network 1.0.0.0 Network 11.1.0.0 mask 255.255.0.0 Neighbor 192.1.12.2 remote-as 234	no sync bgp router-id 22.22.22.22 Network 2.0.0.0 Network 12.1.0.0 mask 255.255.0.0 Neighbor 192.1.12.1 remote-as 1
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## Task 2

Configure RIP V2 as the routing protocol within AS 234. Advertise all loopback networks under RIP. Do not advertise the link between R1 and R2 in RIP.

<b>R2</b>  Router RIP no auto-summary Network 2.0.0.0 Network 12.0.0.0 Network 192.1.23.0	<b>R3</b>  Router RIP no auto-summary Network 3.0.0.0 Network 13.0.0.0 Network 192.1.23.0 Network 192.1.34.0
<b>R4</b>  Router RIP no auto-summary Network 4.0.0.0 Network 14.0.0.0 Network 192.1.34.0	

## Task 3

Configure neighbor relationships between R2 and R3 and another one between R3 and R4. Do not configure a neighbor relationship between R2 and R4. Advertise the Loopback networks under BGP. Make sure routes from R1 can get propagated to R3 and R4. Do not use a Confederation to accomplish this.

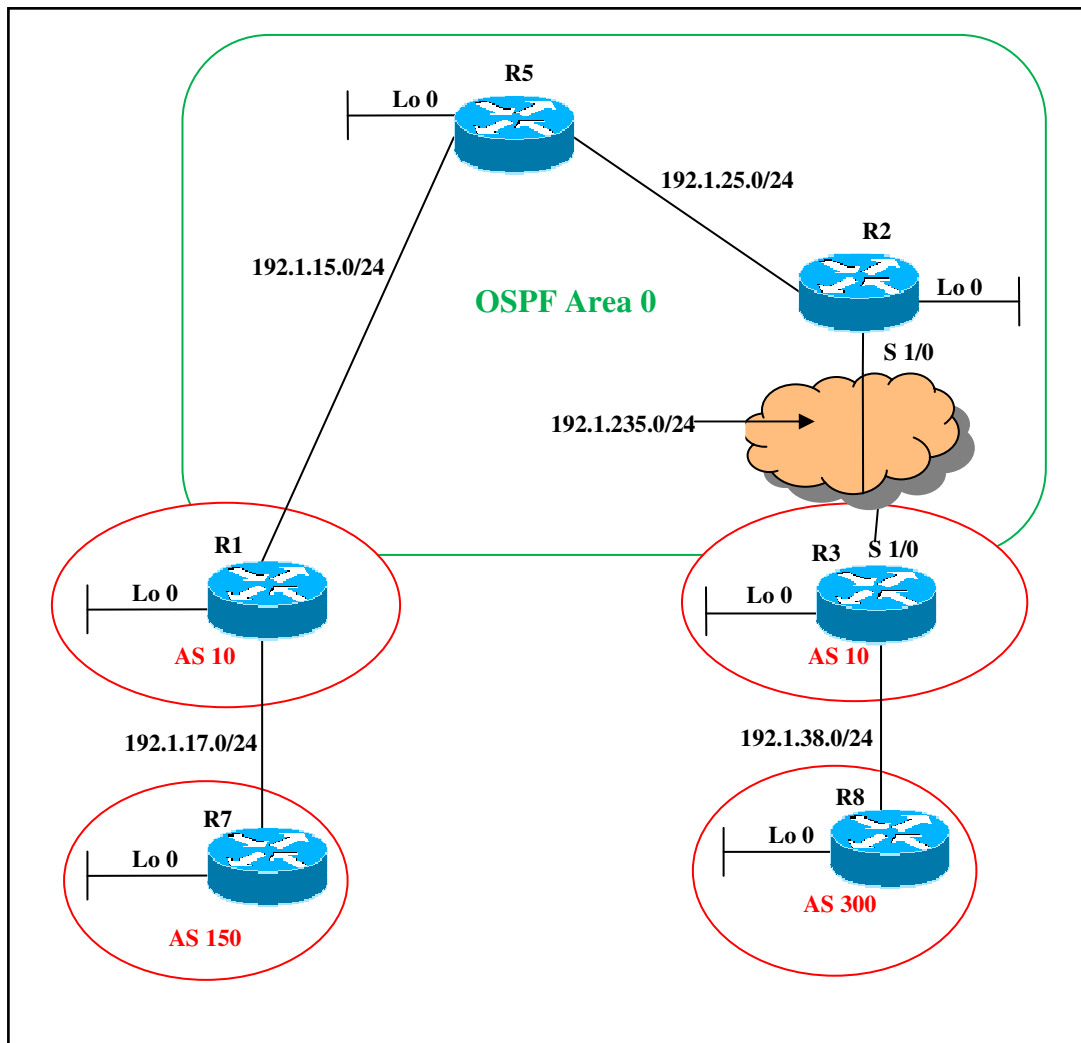
<b>R2</b>  Router BGP 234 no auto-summary no sync Network 2.0.0.0 Network 12.1.0.0 mask 255.255.0.0 Neighbor 192.1.23.3 remote-as 234 Neighbor 192.1.23.3 next-hop-self	<b>R3</b>  Router BGP 234 no auto-summary no sync Network 3.0.0.0 Network 13.1.0.0 mask 255.255.0.0 Neighbor 192.1.23.2 remote-as 234 Neighbor 192.1.23.2 route-reflector-client Neighbor 192.1.34.4 remote-as 234 Neighbor 192.1.34.4 route-reflector-client
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**R4**

```
Router BGP 234
no auto-summary
no sync
Network 4.0.0.0
Network 14.1.0.0 mask 255.255.0.0
Neighbor 192.1.34.3 remote-as 234
```

# **Module 3 – Basic MPLS Configuration**

# Lab 1 – Basic MPLS



## Interface IP Address Configuration

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.234.2	255.255.255.0
E 0/0	192.1.25.2	255.255.255.0

**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
E 0/0	192.1.38.3	255.255.255.0
S 1/0	192.1.234.3	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.17.7	255.255.255.0

**R8**

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.255
E 0/0	192.1.38.8	255.255.255.0

**Initial Configuration:**

<p><b>R1</b></p> <pre>interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! Interface Ethernet0/0 no shutdown  interface Ethernet0/0.12 encapsulation dot1q 12 ip address 192.1.12.1 255.255.255.0  interface Ethernet0/0.15 encapsulation dot1q 15 ip address 192.1.15.1 255.255.255.0</pre>	<p><b>R2</b></p> <pre>interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 no shutdown ip address 192.1.25.2 255.255.255.0  interface Serial1/0 ip address 192.1.234.2 255.255.255.0 ip ospf network point-to-multipoint encapsulation frame-relay frame-relay map ip 192.1.234.3 203 broadcast no frame-relay inverse-arp no shutdown</pre>
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<pre> router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.15.1 0.0.0.0 area 0 </pre>	<pre> router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.25.2 0.0.0.0 area 0 network 192.1.234.2 0.0.0.0 area 0 </pre>
<p><b>R3</b></p> <pre> interface Loopback0 ip address 3.3.3.3 255.255.255.255  interface Ethernet0/0 no shutdown ip address 192.1.38.3 255.255.255.0  interface Serial1/0 ip address 192.1.234.3 255.255.255.0 ip ospf network point-to-multipoint encapsulation frame-relay frame-relay map ip 192.1.234.2 302 broadcast no frame-relay inverse-arp no shutdown  router ospf 1 router-id 3.3.3.3 network 3.3.3.3 0.0.0.0 area 0 network 192.1.234.3 0.0.0.0 area 0 </pre>	<p><b>R5</b></p> <pre> interface Loopback0 ip address 5.5.5.5 255.255.255.255  interface Fa0/0 no shutdown  interface Fa0/0.15 encapsulation dot1q 15 ip address 192.1.15.5 255.255.255.0  interface Fa0/0.25 encapsulation dot1q 25 ip address 192.1.25.5 255.255.255.0  router ospf 1 router-id 5.5.5.5 network 5.5.5.5 0.0.0.0 area 0 network 192.1.15.5 0.0.0.0 area 0 network 192.1.25.5 0.0.0.0 area 0 </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.255  Interface Eth0/0 no shutdown  interface Ethernet0/0 no shutdown ip address 192.1.17.7 255.255.255.0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.255  Interface Eth0/0 no shutdown  interface Ethernet0/0 no shutdown ip address 192.1.38.8 255.255.255.0 </pre>
<p><b>SW1</b></p> <pre> Vlan database Vlan 15 name VLAN_15 Vlan 17 name VLAN_17 Vlan 25 name VLAN_25 </pre>	

```

Vlan 38 name VLAN_38
Apply
Exit

Conf t

interface range fa1/1 , fa1/5
Switchport trunk encapsulation dot1q
Switchport mode trunk

Interface Fa1/2
Switchport mode access
Switchport access vlan 25

Interface range Fa1/3 , Fa1/8
Switchport mode access
Switchport access vlan 38

Interface Fa1/7
Switchport mode access
Switchport access vlan 17

```

**Lab Objective:**

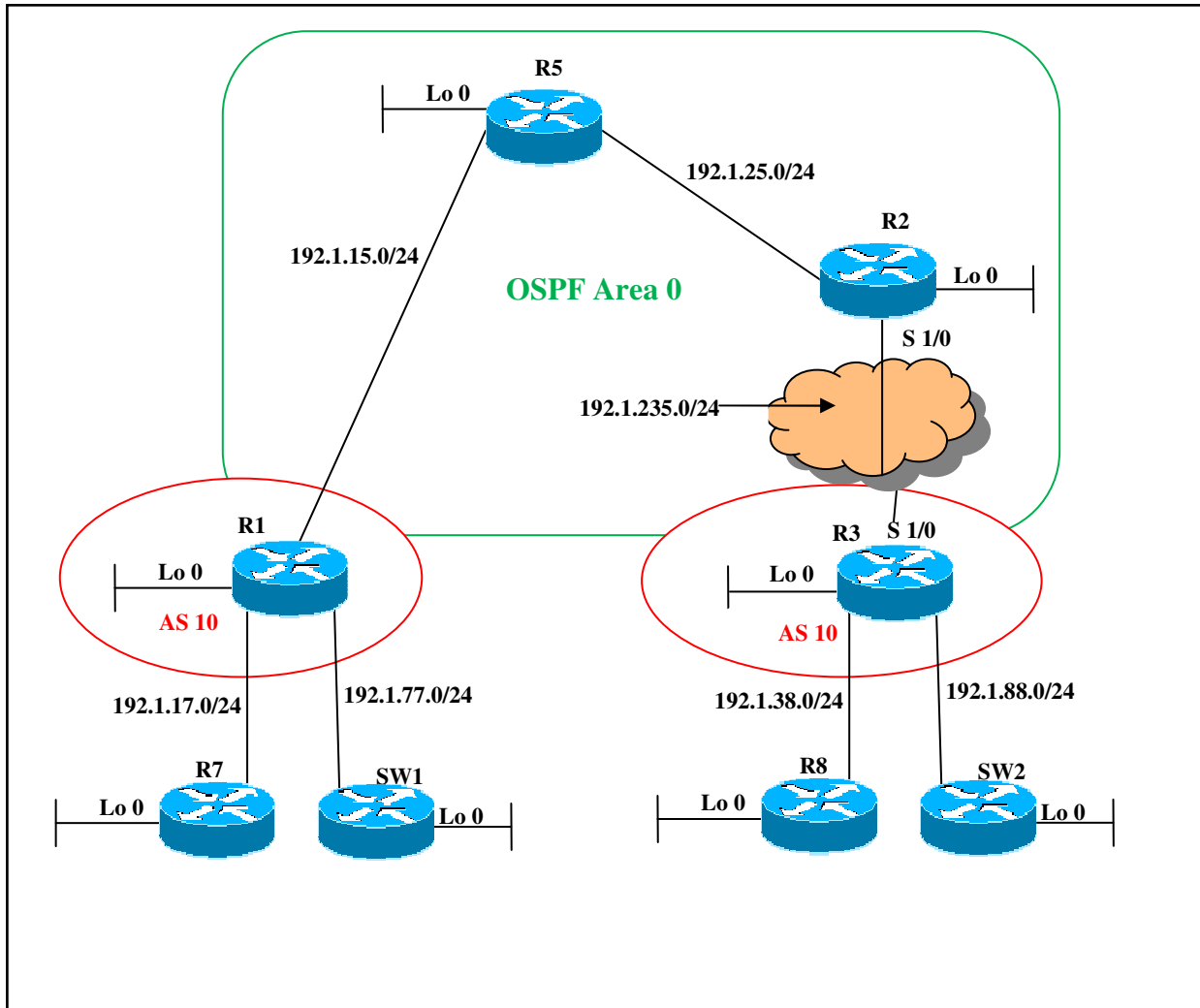
**Task 1**

Configure BGP on the routers indicated in the diagram in their respective ASs.  
 You should configure an iBGP connection between R1 and R3 using their most reliable interface as the sourcing interface.  
 Configure an eBGP connection between R1 and R7, and another eBGP connection between R3 and R8.  
 Configure MPLS inside the SP core network (make sure you use LDP as the label protocol) and you source from their Loopback 0.

<b>R1</b>	<b>R2</b>
<pre> Ip cef  Mpls ldp router-id loopback0 Mpls label protocol ldp Mpls label range 100 199 ! interface Ethernet0/0.12  mpls ip  interface Ethernet0/0.15  mpls ip </pre>	<pre> Ip cef  Mpls ldp router-id loopback0 Mpls label protocol ldp Mpls label range 200 299 ! interface Ethernet0/0  mpls ip  interface Serial1/0  mpls ip </pre>

<pre> router bgp 10 bgp router-id 1.1.1.1 no auto-summary no synchronization neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source loopback 0 neighbor 3.3.3.3 next-hop-self neighbor 192.1.17.7 remote-as 150 </pre>	
<p><b>R3</b></p> <pre> Ip cef  Mpls ldp router-id loopback0 Mpls label protocol ldp Mpls label range 300 399 ! Interface Ser1/0 Mpls ip  router bgp 10 bgp router-id 3.3.3.3 no auto-summary no synchronization neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source loopback 0 neighbor 1.1.1.1 next-hop-self neighbor 192.1.38.8 remote-as 300 </pre>	<p><b>R5</b></p> <pre> Ip cef  Mpls ldp router-id loopback0 Mpls label protocol ldp Mpls label range 500 599  interface Fa0/0 no shutdown  interface Fa0/0.15 mpls ip  interface Fa0/0.25 mpls ip </pre>
<p><b>R7</b></p> <pre> router bgp 150 bgp router-id 7.7.7.7 no auto-summary no synchronization neighbor 192.1.17.1 remote-as 10 network 7.0.0.0 mask 255.0.0.0 </pre>	<p><b>R8</b></p> <pre> router bgp 300 bgp router-id 8.8.8.8 no auto-summary no synchronization neighbor 192.1.38.3 remote-as 10 network 8.0.0.0 mask 255.0.0.0 </pre>

## Lab 2 – MPLS VPN with Static Routing



### Interface IP Address Configuration

#### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0
E 0/0.77	192.1.77.1	255.255.255.0

## R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.234.2	255.255.255.0
E 0/0	192.1.25.2	255.255.255.0

## R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.234.3	255.255.255.0
E 0/0.38	192.1.38.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0

## R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

## R7

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.17.7	255.255.255.0

## R8

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.255
E 0/0	192.1.38.8	255.255.255.0

## SW1

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

## SW2

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

### Initial Configuration:

<b>SW1</b>  interface Loopback0 ip address 77.77.77.77 255.255.255.255 ! Ip route 0.0.0.0 0.0.0.0 192.1.77.1  Interface Vlan 77 Ip address 192.1.77.7 255.255.255.0	<b>SW2</b>  interface Loopback0 ip address 88.88.88.88 255.255.255.255  ip route 0.0.0.0 0.0.0.0 192.1.88.3  Interface Vlan 88 Ip address 192.1.88.8 255.255.255.0
<b>R7</b>  interface Loopback0 ip address 7.7.7.7 255.255.255.255 ! Ip route 0.0.0.0 0.0.0.0 192.1.17.1	<b>R8</b>  interface Loopback0 ip address 8.8.8.8 255.255.255.255  ip route 0.0.0.0 0.0.0.0 192.1.38.3

### Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED** (**R1** and **R3** as being the **PE** of them respectively).  
*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>  Ip cef  ip vrf BLUE rd 10:150 route-target export 1:150 route-target import 1:150  ip vrf RED rd 10:300 route-target export 1:300 route-target import 1:300  interface Ethernet0/0.17 encapsulation dot1Q 17 ip vrf forwarding BLUE ip address 192.1.17.1 255.255.255.0	<b>R3</b>  Ip cef  ip vrf BLUE rd 10:150 route-target export 1:150 route-target import 1:150  ip vrf RED rd 10:300 route-target export 1:300 route-target import 1:300  interface Ethernet0/0.38 encapsulation dot1Q 38 ip vrf forwarding BLUE ip address 192.1.38.3 255.255.255.0
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

```

interface Ethernet0/0.77
 encapsulation dot1Q 77
 ip vrf forwarding RED
 ip address 192.1.77.1 255.255.255.0

router bgp 10
 bgp router-id 1.1.1.1
 no auto-summary
 no synchronization
 neighbor 3.3.3.3 remote-as 10
 neighbor 3.3.3.3 update-source loopback 0
 neighbor 3.3.3.3 next-hop-self

address-family vpnv4
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 send-community both

address-family ipv4 vrf BLUE
 redistribute static
 redistribute connected

address-family ipv4 vrf RED
 redistribute static
 redistribute connected

ip route vrf BLUE 7.7.7.7 255.255.255.255
 192.1.17.7
ip route vrf RED 77.77.77.77 255.255.255.255
 192.1.77.7

```

```

interface Ethernet0/0.88
 encapsulation dot1Q 88
 ip vrf forwarding RED
 ip address 192.1.88.3 255.255.255.0

router bgp 10
 bgp router-id 3.3.3.3
 no auto-summary
 no synchronization
 neighbor 1.1.1.1 remote-as 10
 neighbor 1.1.1.1 update-source loopback 0
 neighbor 1.1.1.1 next-hop-self

address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community both

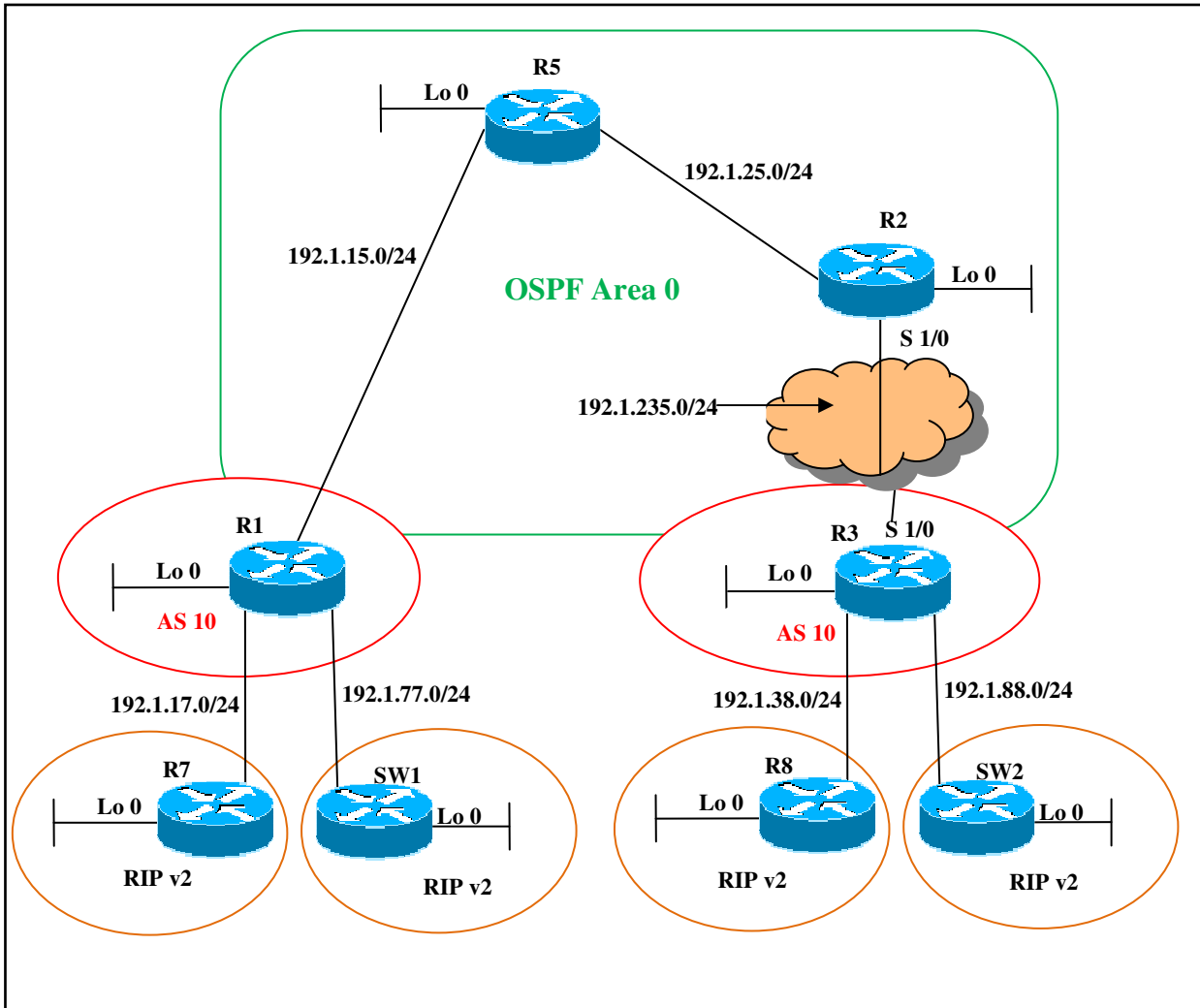
address-family ipv4 vrf BLUE
 redistribute static
 redistribute connected

address-family ipv4 vrf RED
 redistribute static
 redistribute connected

ip route vrf BLUE 8.8.8.8 255.255.255.255
 192.1.38.8
ip route vrf RED 88.88.88.88 255.255.255.255
 192.1.88.8

```

# Lab 3 – MPLS VPN with RIPv2



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **RIPv2** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>  <pre>ip cef !</pre>	<b>R3</b>  <pre>ip cef !</pre>
--------------------------------------	--------------------------------------



```

ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300

router rip
!
address-family ipv4 vrf RED
redistribute bgp 10 metric 1
network 192.1.77.0
no auto-summary
version 2
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute bgp 10 metric 1
network 192.1.17.0
no auto-summary
version 2
exit-address-family

router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
neighbor 3.3.3.3 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute rip
no auto-summary
no synchronization
exit-address-family
!

```

```

ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300

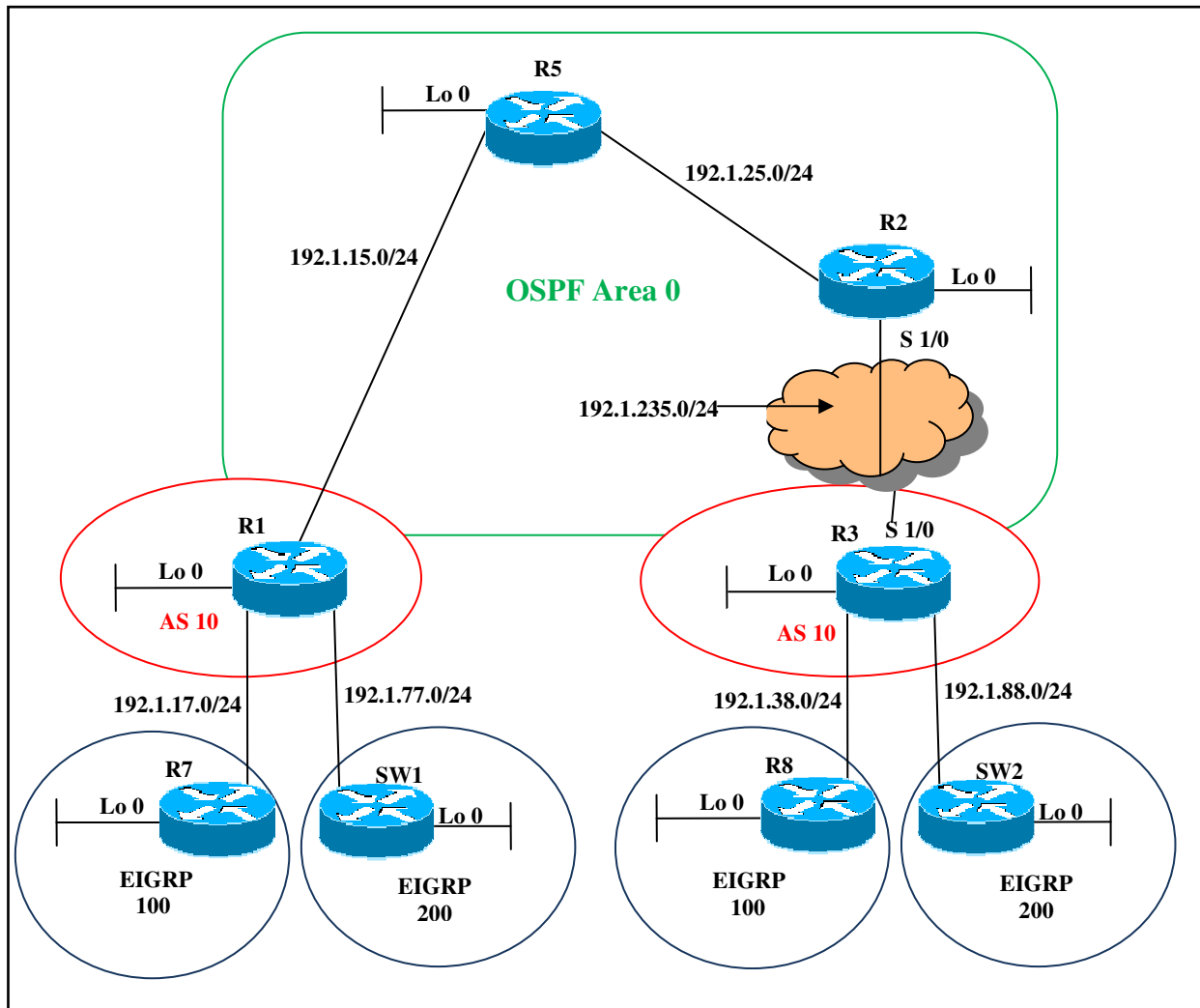
router rip
!
address-family ipv4 vrf RED
redistribute bgp 10 metric 1
network 192.1.88.0
no auto-summary
version 2
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute bgp 10 metric 1
network 192.1.38.0
no auto-summary
version 2
exit-address-family

router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 1.1.1.1 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute rip
no auto-summary
no synchronization
exit-address-family
!

```

<pre> address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family </pre>	<pre> address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> router rip version 2 network 7.0.0.0 network 192.1.17.0 no auto-summary </pre>	<p><b>R8</b></p> <pre> router rip version 2 network 8.0.0.0 network 192.1.38.0 no auto-summary </pre>
<p><b>SW1</b></p> <pre> router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary </pre>	<p><b>SW2</b></p> <pre> router rip version 2 network 88.0.0.0 network 192.1.88.0 no auto-summary </pre>

## Lab 4 – MPLS VPN with EIGRP



### Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **EIGRP** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>  ip cef	<b>R3</b>  ip cef
-------------------------	-------------------------

```

!
ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300

router eigrp 1
auto-summary
!
address-family ipv4 vrf RED
redistribute bgp 10 metric 1 1 1 1 1
network 192.1.77.1 0.0.0.0
no auto-summary
autonomous-system 200
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute bgp 10 metric 1 1 1 1 1
network 192.1.17.1 0.0.0.0
no auto-summary
autonomous-system 100
exit-address-family
!
router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
neighbor 3.3.3.3 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 200
no auto-summary
no synchronization

```

```

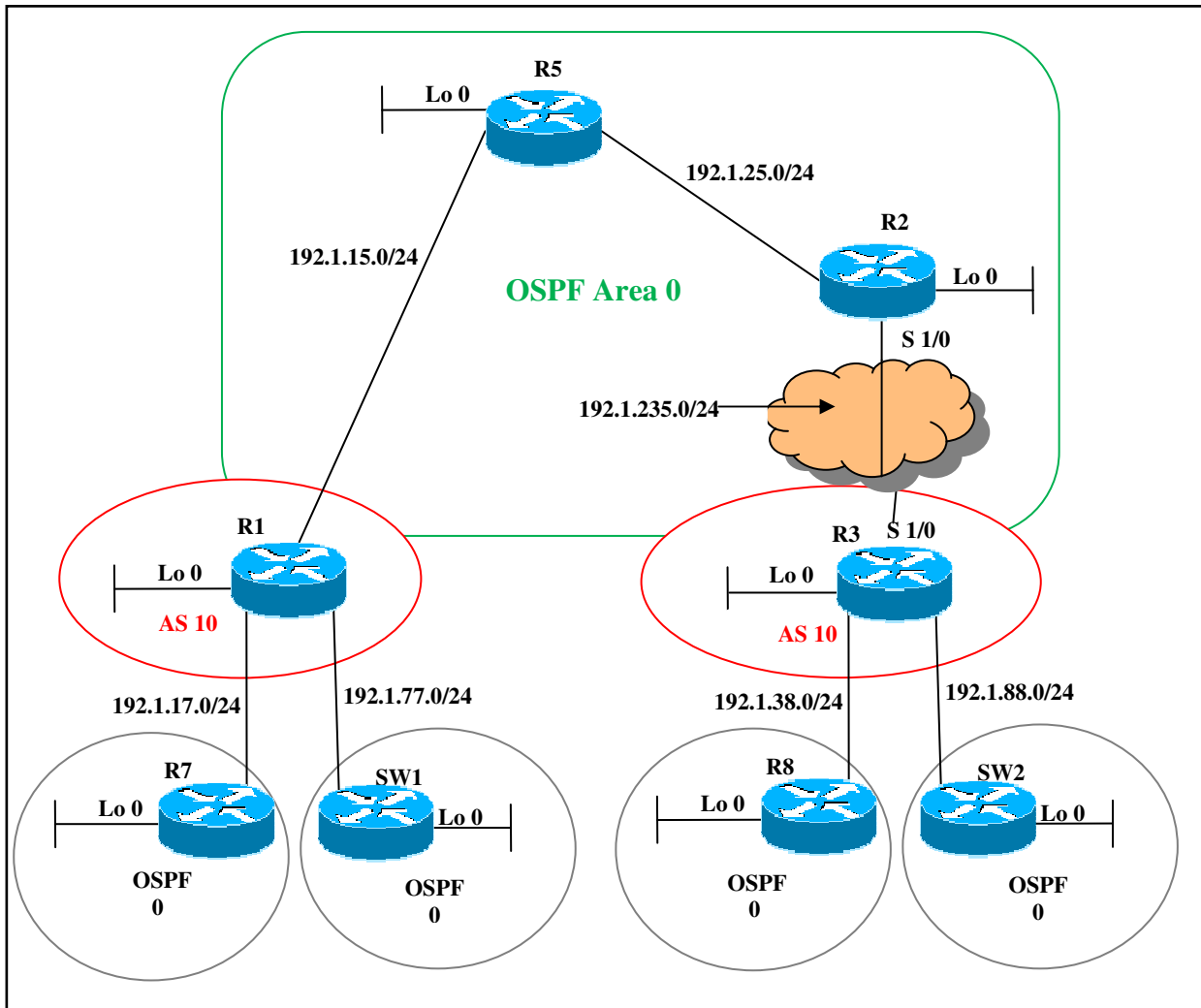
!
ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300

router eigrp 1
auto-summary
!
address-family ipv4 vrf RED
redistribute bgp 10 metric 1 1 1 1 1
network 192.1.88.3 0.0.0.0
no auto-summary
autonomous-system 200
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute bgp 10 metric 1 1 1 1 1
network 192.1.38.3 0.0.0.0
no auto-summary
autonomous-system 100
exit-address-family
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 1.1.1.1 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 200
no auto-summary
no synchronization

```

<pre> exit-address-family ! address-family ipv4 vrf BLUE redistribute eigrp 100 no auto-summary no synchronization exit-address-family </pre>	<pre> exit-address-family ! address-family ipv4 vrf BLUE redistribute eigrp 100 no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> router eigrp 100 network 7.7.7.7 0.0.0.0 network 192.1.17.7 0.0.0.0 no auto-summary </pre>	<p><b>R8</b></p> <pre> router eigrp 100 network 8.8.8.8 0.0.0.0 network 192.1.38.8 0.0.0.0 no auto-summary </pre>
<p><b>SW1</b></p> <pre> router eigrp 200 network 77.77.77.77 0.0.0.0 network 192.1.77.7 0.0.0.0 no auto-summary </pre>	<p><b>SW2</b></p> <pre> router eigrp 200 network 88.88.88.88 0.0.0.0 network 192.1.88.8 0.0.0.0 no auto-summary </pre>

# Lab 5 – MPLS VPN with OSPF



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

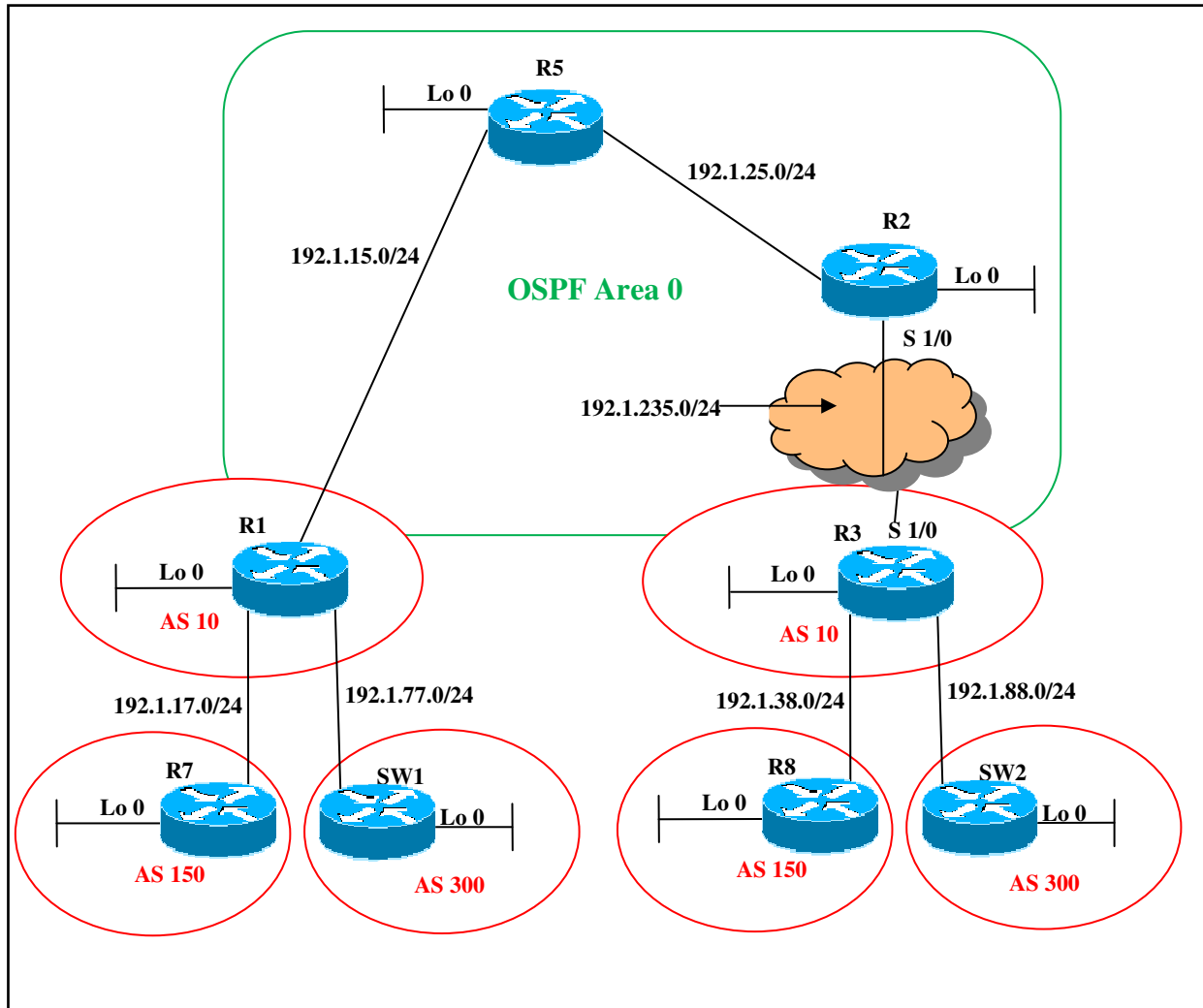
R1	R3
ip cef	ip cef
!	!
ip vrf BLUE	ip vrf BLUE

<pre> rd 10:150 route-target export 10:150 route-target import 1:150 ! ip vrf RED rd 10:300 route-target export 10:300 route-target import 10:300  router ospf 100 vrf BLUE log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 ! router ospf 200 vrf RED log-adjacency-changes redistribute bgp 10 subnets network 192.1.77.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 200 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 100 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> rd 10:150 route-target export 10:150 route-target import 10:150 ! ip vrf RED rd 10:300 route-target export 10:300 route-target import 10:300  router ospf 100 vrf BLUE log-adjacency-changes redistribute bgp 10 subnets network 192.1.38.3 0.0.0.0 area 0 ! router ospf 200 vrf RED log-adjacency-changes redistribute bgp 10 subnets network 192.1.88.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 200 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 100 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<b>R7</b> router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0	<b>R8</b> router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0
<b>SW1</b> router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0	<b>SW2</b> router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0



# Lab 6 – MPLS VPN with eBGP



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **eBGP** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

R1	R3
ip cef !	ip cef !

```

ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300

router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
neighbor 3.3.3.3 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute connected
neighbor 192.1.77.7 remote-as 300
neighbor 192.1.77.7 activate
neighbor 192.1.77.7 as-override
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute connected
neighbor 192.1.17.7 remote-as 150
neighbor 192.1.17.7 activate
neighbor 192.1.17.7 as-override
no auto-summary
no synchronization
exit-address-family

```

```

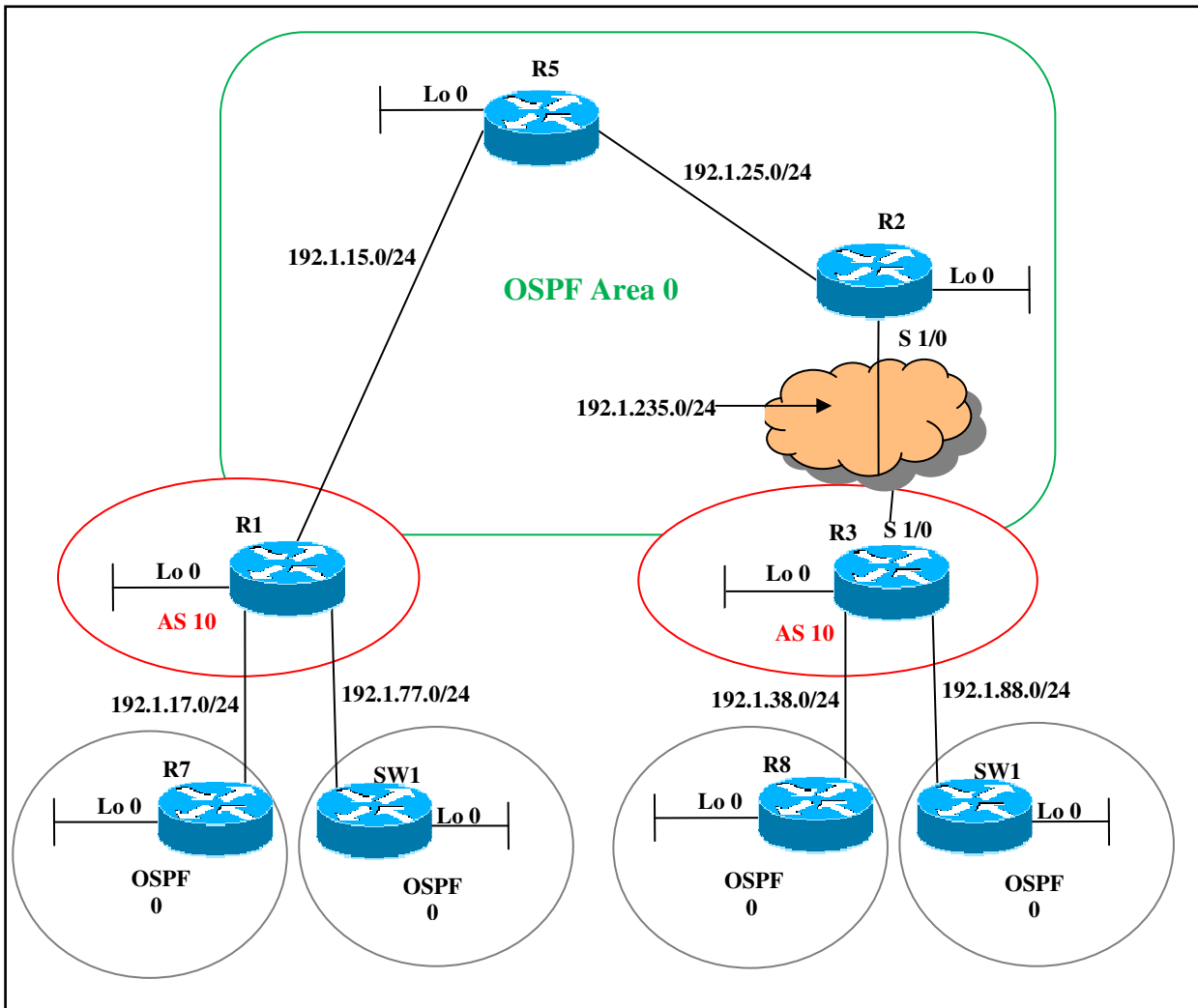
ip vrf BLUE
rd 10:150
route-target export 1:150
route-target import 1:150
!
ip vrf RED
rd 10:300
route-target export 1:300
route-target import 1:300
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 1.1.1.1 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute connected
neighbor 192.1.88.8 remote-as 300
neighbor 192.1.88.8 activate
neighbor 192.1.88.8 as-override
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute connected
neighbor 192.1.38.8 remote-as 150
neighbor 192.1.38.8 activate
neighbor 192.1.38.8 as-override
no auto-summary
no synchronization
exit-address-family

```

<p><b>R7</b></p> <pre> router bgp 150 no synchronization bgp router-id 7.7.7.7 bgp log-neighbor-changes network 7.7.7.7 mask 255.255.255.255 neighbor 192.1.17.1 remote-as 10 no auto-summary </pre>	<p><b>R8</b></p> <pre> router bgp 150 no synchronization bgp router-id 8.8.8.8 bgp log-neighbor-changes network 8.8.8.8 mask 255.255.255.255 neighbor 192.1.38.3 remote-as 10 no auto-summary </pre>
<p><b>SW1</b></p> <pre> router bgp 300 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.77 mask 255.255.255.255 neighbor 192.1.77.1 remote-as 10 no auto-summary </pre>	<p><b>SW2</b></p> <pre> router bgp 300 no synchronization bgp router-id 88.88.88.88 bgp log-neighbor-changes network 88.88.88.88 mask 255.255.255.255 neighbor 192.1.88.3 remote-as 10 no auto-summary </pre>

# **Module 4 – Advanced MPLS Configuration**

# Lab 1 – MPLS VPNs OSPF (Doman-ID)



## R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0

## R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.234.2	255.255.255.0
E 0/0	192.1.25.2	255.255.255.0

**R3**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	3.3.3.3	255.255.255.255
E 0/0	192.1.38.3	255.255.255.0
S 1/0	192.1.234.3	255.255.255.0

**R5**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

**R7**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.17.7	255.255.255.0

**R8**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	8.8.8.8	255.255.255.255
E 0/0	192.1.38.8	255.255.255.0

**SW1**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

**SW2**

<b>Interface</b>	<b>IP Address</b>	<b>Subnet Mask</b>
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Use a **unique OSPF Process-ID** and make sure the **CEs** can see these routes as **inter area routes**.

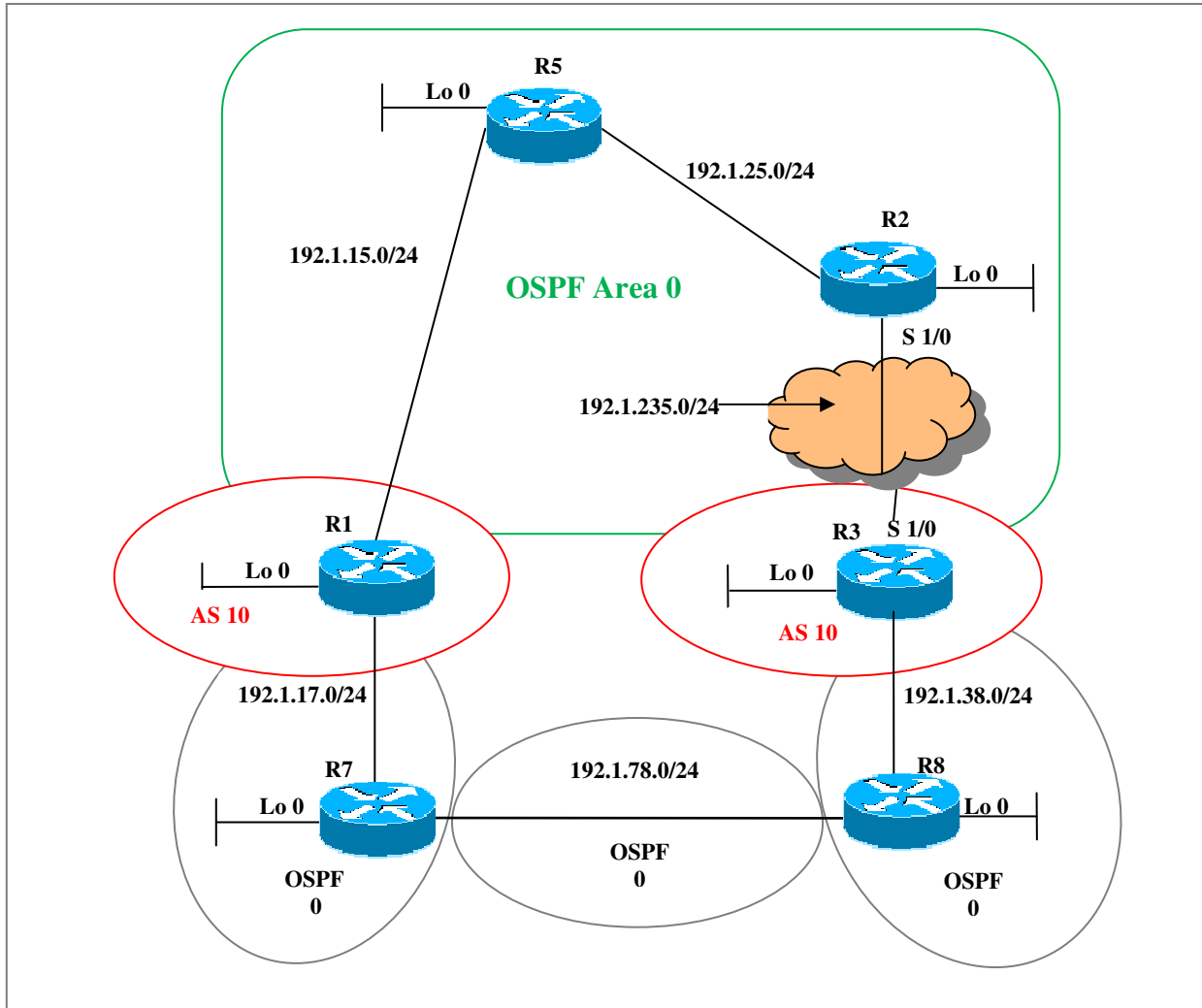
*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>	<b>R3</b>
<pre>ip cef ! ip vrf BLUE rd 10:150 route-target export 10:150 route-target import 10:150 ! ip vrf RED rd 10:300 route-target export 10:300 route-target import 10:300  router ospf 100 vrf BLUE domain-id 0.0.0.50 log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 ! router ospf 200 vrf RED domain-id 0.0.0.60 log-adjacency-changes redistribute bgp 10 subnets network 192.1.77.1 0.0.0.0 area 0 ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.15.1 0.0.0.0 area 0</pre>	<pre>ip cef ! ip vrf BLUE rd 10:150 route-target export 10:150 route-target import 10:150 ! ip vrf RED rd 10:300 route-target export 10:300 route-target import 10:300  router ospf 150 vrf BLUE domain-id 0.0.0.50 log-adjacency-changes redistribute bgp 10 subnets network 192.1.38.3 0.0.0.0 area 0 ! router ospf 300 vrf RED domain-id 0.0.0.60 log-adjacency-changes redistribute bgp 10 subnets network 192.1.88.3 0.0.0.0 area 0 ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.235.3 0.0.0.0 area 0 !</pre>

<pre> router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 200 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 100 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> router bgp 10 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 300 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 150 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0 </pre>



## Lab 2 – MPLS VPNs OSPF (Sham-Link)



### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.234.2	255.255.255.0
E 0/0	192.1.25.2	255.255.255.0

### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
E 0/0	192.1.38.3	255.255.255.0
S 1/0	192.1.234.3	255.255.255.0

### R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

### R7

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.0
E 0/0.17	192.1.17.7	255.255.255.0
E 0/0.78	192.1.78.7	255.255.255.0

### R8

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.0
E 0/0.38	192.1.38.8	255.255.255.0
E 0/0.78	192.1.78.8	255.255.255.0

### Task 1

Configure MPLS VPN to connect **R7** and **R8** (VRF **GREEN**) through AS 10 (**R1** and **R3** as being the **PE** of them respectively).

Make sure that the backdoor link is only used if the MPLS link through AS 10 is down.

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3) with the exception of SW1 and SW2 that does not exist anymore.*

R1	R3
ip cef ! ip vrf GREEN rd 10:78 route-target export 10:78 route-target import 10:78	ip cef ! ip vrf GREEN rd 10:78 route-target export 10:78 route-target import 10:78

```

!
interface Loopback10
 ip vrf forwarding GREEN
 ip address 10.10.1.1 255.255.255.255
!
interface Ethernet0/0.15
 encapsulation dot1Q 15
 ip address 192.1.15.1 255.255.255.0
 tag-switching ip
!
interface Ethernet0/0.17
 encapsulation dot1Q 17
 ip vrf forwarding GREEN
 ip address 192.1.17.1 255.255.255.0
!
router ospf 78 vrf GREEN
 log-adjacency-changes
 area 0 sham-link 10.10.1.1 10.10.3.3
 redistribute bgp 10 subnets
 network 192.1.17.1 0.0.0.0 area 0
!
router bgp 10
 no synchronization
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor 3.3.3.3 remote-as 10
 neighbor 3.3.3.3 update-source Loopback0
 neighbor 3.3.3.3 next-hop-self
 no auto-summary
!
 address-family vpnv4
 neighbor 3.3.3.3 activate
 neighbor 3.3.3.3 send-community both
 exit-address-family
!
 address-family ipv4 vrf GREEN
 redistribute connected
 redistribute ospf 78 vrf GREEN
 no auto-summary
 no synchronization
 exit-address-family

```

```

interface Loopback10
 ip vrf forwarding GREEN
 ip address 10.10.3.3 255.255.255.255
!
interface Ethernet0/0.38
 encapsulation dot1Q 38
 ip vrf forwarding GREEN
 ip address 192.1.38.3 255.255.255.0
!
router ospf 300 vrf RED
 domain-id 0.0.0.60
 log-adjacency-changes
 redistribute bgp 10 subnets
 network 192.1.88.3 0.0.0.0 area 0
!
router ospf 78 vrf GREEN
 log-adjacency-changes
 area 0 sham-link 10.10.3.3 10.10.1.1
 redistribute bgp 10 subnets
 network 192.1.38.3 0.0.0.0 area 0!
!
router bgp 10
 no synchronization
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 10
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 next-hop-self
 no auto-summary
!
 address-family vpnv4
 neighbor 1.1.1.1 activate
 neighbor 1.1.1.1 send-community both
 exit-address-family
!
 address-family ipv4 vrf GREEN
 redistribute connected
 redistribute ospf 78 vrf GREEN
 no auto-summary
 no synchronization
 exit-address-family

```

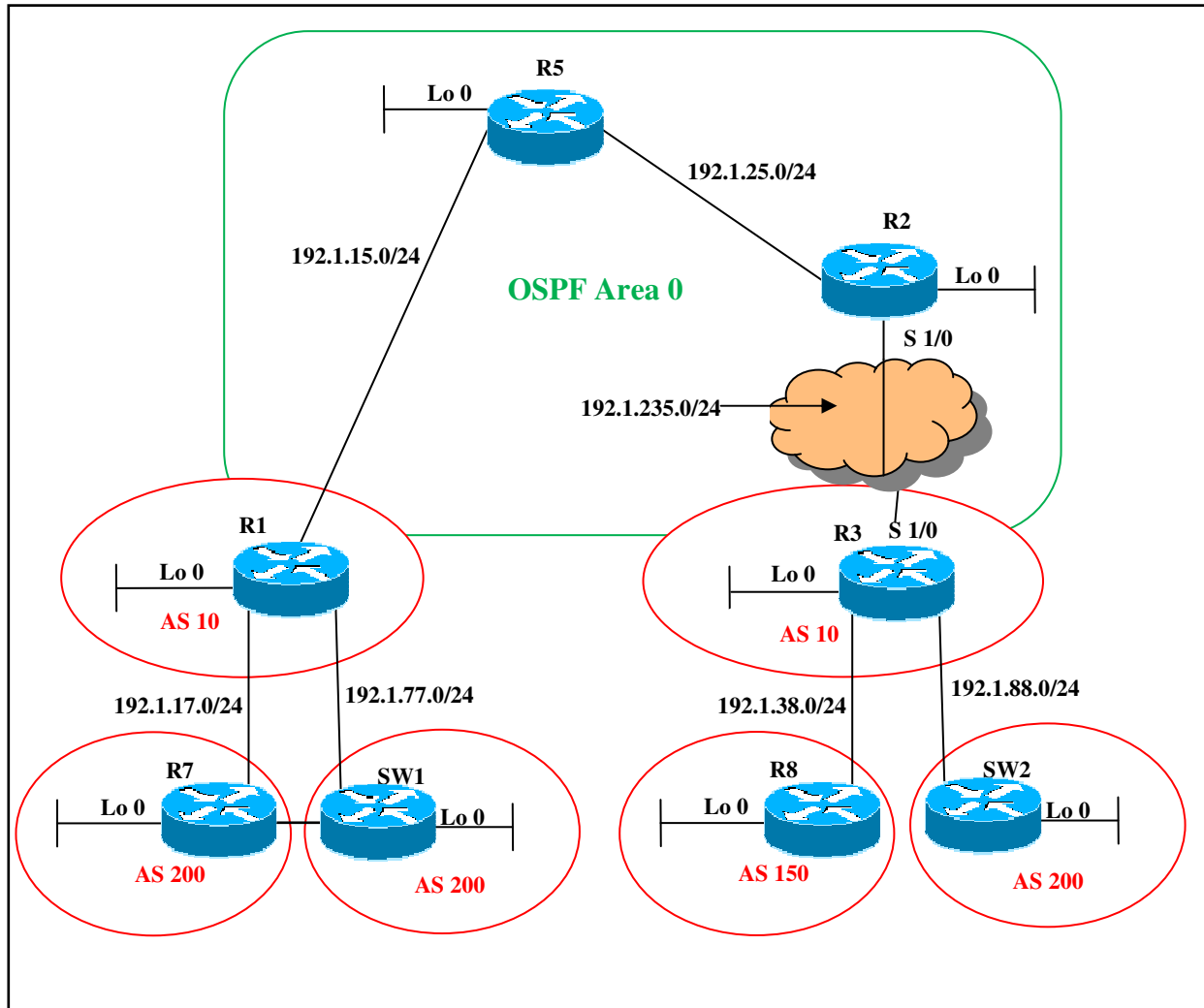
**R7**

```
router ospf 1
router-id 7.7.7.7
log-adjacency-changes
network 7.7.7.7 0.0.0.0 area 0
network 192.1.17.7 0.0.0.0 area 0
network 192.1.78.7 0.0.0.0 area 0
```

**R8**

```
router ospf 1
router-id 8.8.8.8
log-adjacency-changes
network 8.8.8.8 0.0.0.0 area 0
network 192.1.38.8 0.0.0.0 area 0
network 192.1.78.8 0.0.0.0 area 0
```

## Lab 3 – MPLS VPNs (BGP Site-of-Origin)



### Lab Guideline: Task 1

Configure MPLS VPN between **R7**, **SW1** and **SW2** in a VRF called **MARKETING**. Use **eBGP** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

There is a link between the **CEs** (between **R7** and **SW1** /network **192.1.107.0/24**), prevent looping using **BGP SOO**. Enable **RIP** on both **CEs** (**R7** and **SW1**) and send their loopbacks through this link.

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

**R1**

```
ip cef
!
ip vrf MARKETING
rd 10:200
route-target export 1:200
route-target import 1:200

interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding MARKETING
ip address 192.1.17.1 255.255.255.0
no snmp trap link-status
no cdp enable
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding MARKETING
ip address 192.1.77.1 255.255.255.0
no snmp trap link-status
no cdp enable
!
router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
neighbor 3.3.3.3 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 send-community both
exit-address-family

address-family ipv4 vrf MARKETING
neighbor 192.1.17.7 remote-as 200
neighbor 192.1.17.7 activate
neighbor 192.1.17.7 as-override
neighbor 192.1.17.7 route-map BGP_SO0
in
neighbor 192.1.77.7 remote-as 200
neighbor 192.1.77.7 activate
neighbor 192.1.77.7 as-override
```

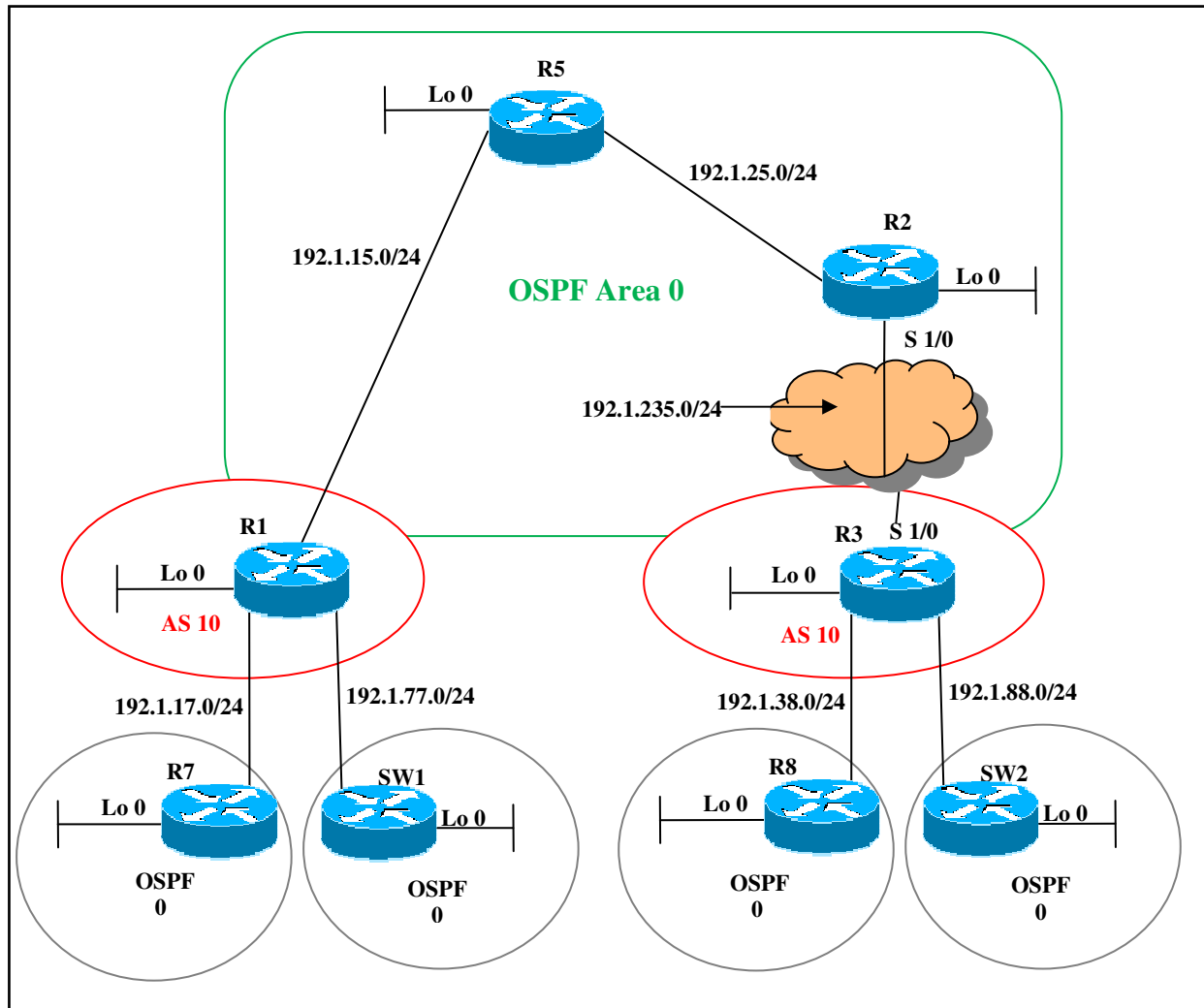
**R3**

```
ip cef
!
ip vrf MARKETING
rd 1:200
route-target export 1:200
route-target import 1:200

interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding MARKETING
ip address 192.1.38.3 255.255.255.0
no snmp trap link-status
no cdp enable
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding MARKETING
ip address 192.1.88.3 255.255.255.0
no snmp trap link-status
no cdp enable
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 1.1.1.1 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both
exit-address-family
!
address-family ipv4 vrf MARKETING
neighbor 192.1.38.8 remote-as 200
neighbor 192.1.38.8 activate
neighbor 192.1.38.8 as-override
neighbor 192.1.88.8 remote-as 200
neighbor 192.1.88.8 activate
neighbor 192.1.88.8 as-override
no auto-summary
no synchronization
```

<pre>neighbor 192.1.77.7 route-map BGP_SO0 in no auto-summary no synchronization exit-address-family  route-map BGP_SO0 permit 10 set extcommunity soo 10:200</pre>	<pre>exit-address-family</pre>
<p><b>R7</b></p> <pre>interface Ethernet0/1 ip address 192.1.107.7 255.255.255.0 half-duplex  router rip version 2 network 7.0.0.0 network 192.1.107.0 no auto-summary ! router bgp 200 no synchronization bgp router-id 7.7.7.7 bgp log-neighbor-changes network 7.7.7.7 mask 255.255.255.255 neighbor 192.1.17.1 remote-as 10 no auto-summary</pre>	<p><b>R8</b></p> <pre>router bgp 200 no synchronization bgp router-id 8.8.8.8 bgp log-neighbor-changes network 8.8.8.8 mask 255.255.255.255 neighbor 192.1.38.3 remote-as 10 no auto-summary</pre>
<p><b>SW1</b></p> <pre>interface Vlan107 ip address 192.1.107.77 255.255.255.0  router rip version 2 network 77.0.0.0 network 192.1.107.0 no auto-summary  router bgp 200 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.77 mask 255.255.255.255 neighbor 192.1.77.1 remote-as 10 no auto-summary</pre>	<p><b>SW2</b></p> <pre>router bgp 200 no synchronization bgp router-id 88.88.88.88 bgp log-neighbor-changes network 88.88.88.88 mask 255.255.255.255 neighbor 192.1.88.3 remote-as 10 no auto-summary</pre>

## Lab 4 – MPLS VPNs (Central Services)



### Task 1

Configure MPLS VPNs in a way that **R7** can access **R8**, **SW1** and **SW2** networks but they cannot have access to each other's networks.

**R7 VRF** should be called **MANAGEMENT**, **R8** (**IT**), **SW1** (**SALES**) and **SW2** (**LOGISTIC**).

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>	<b>R3</b>
ip cef	ip cef



```

!
ip vrf MANAGEMENT
rd 10:7
route-target export 10:7
route-target import 10:8
route-target import 10:77
route-target import 10:88
!
ip vrf SALES
rd 10:77
route-target export 10:77
route-target import 10:7

interface Ethernet0/0.15
encapsulation dot1Q 15
ip address 192.1.15.1 255.255.255.0
tag-switching ip
!
interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding MANAGEMENT
ip address 192.1.17.1 255.255.255.0

interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding SALES
ip address 192.1.77.1 255.255.255.0
!
router ospf 7 vrf MANAGEMENT
router-id 192.1.17.1
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0
!
router ospf 77 vrf SALES
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.15.1 0.0.0.0 area 0
!

```

```

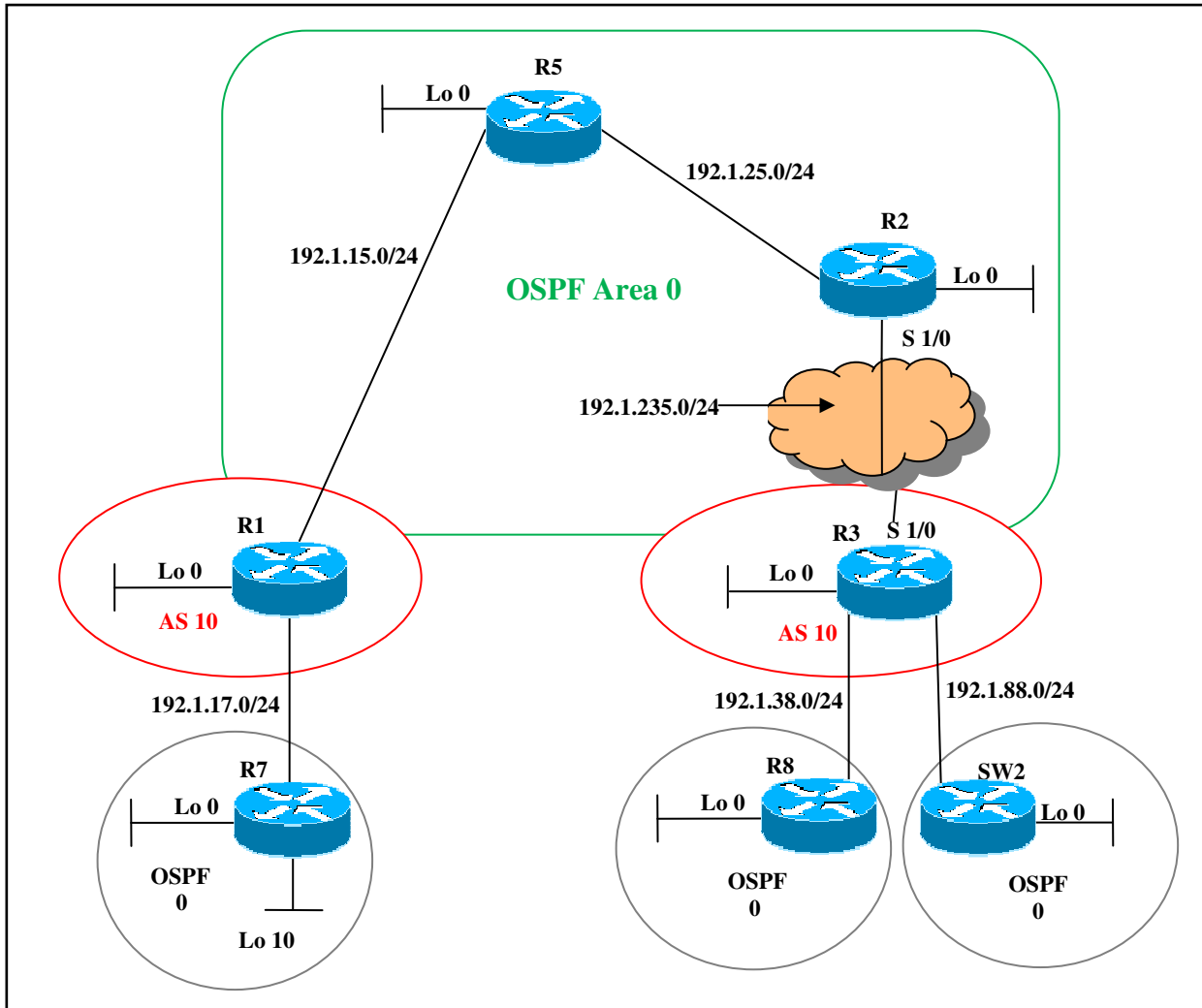
!
ip vrf IT
rd 10:8
route-target export 10:8
route-target import 10:7
!
ip vrf LOGISTIC
rd 10:88
route-target export 10:88
route-target import 10:7
!
interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding IT
ip address 192.1.38.3 255.255.255.0
no snmp trap link-status
no cdp enable
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding LOGISTIC
ip address 192.1.88.3 255.255.255.0
no snmp trap link-status
no cdp enable
!
router ospf 8 vrf IT
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.38.3 0.0.0.0 area 0
!
router ospf 88 vrf LOGISTIC
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.88.3 0.0.0.0 area 0

router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.235.3 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10

```

<pre> router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family ! address-family ipv4 vrf SALES redistribute ospf 77 vrf SALES no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf MANAGEMENT redistribute ospf 7 vrf MANAGEMENT no auto-summary no synchronization exit-address-family </pre>	<pre> neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community both exit-address-family ! address-family ipv4 vrf LOGISTIC redistribute ospf 88 vrf LOGISTIC no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf IT redistribute ospf 8 vrf IT no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>

# Lab 5 – MPLS VPNs (with VRF Export Map)



## R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
Loopback 10	10.10.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0

## R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.234.2	255.255.255.0
E 0/0	192.1.25.2	255.255.255.0

### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
E 0/0	192.1.38.3	255.255.255.0
S 1/0	192.1.234.3	255.255.255.0

### R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.15	192.1.15.5	255.255.255.0
E 0/0.25	192.1.25.5	255.255.255.0

### R7

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.0
Loopback 10	17.17.17.7	255.255.255.0
E 0/0.17	192.1.17.7	255.255.255.0

### R8

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.0
E 0/0.38	192.1.38.8	255.255.255.0

### SW2

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.0
E 0/0	192.1.88.8	255.255.255.0

### Task 1

Configure MPLS VPNs in such a way that **R8** can access **loopback 0** of **R7** but cannot access their **loopback 10**, and **SW2** can access **loopback 10** of **R7** but not their **loopback 0**.

Use an **export-map** on **R1** to accomplish that and configure a **VRF name** of **R7** for R7 interface in the **PE - R1**.

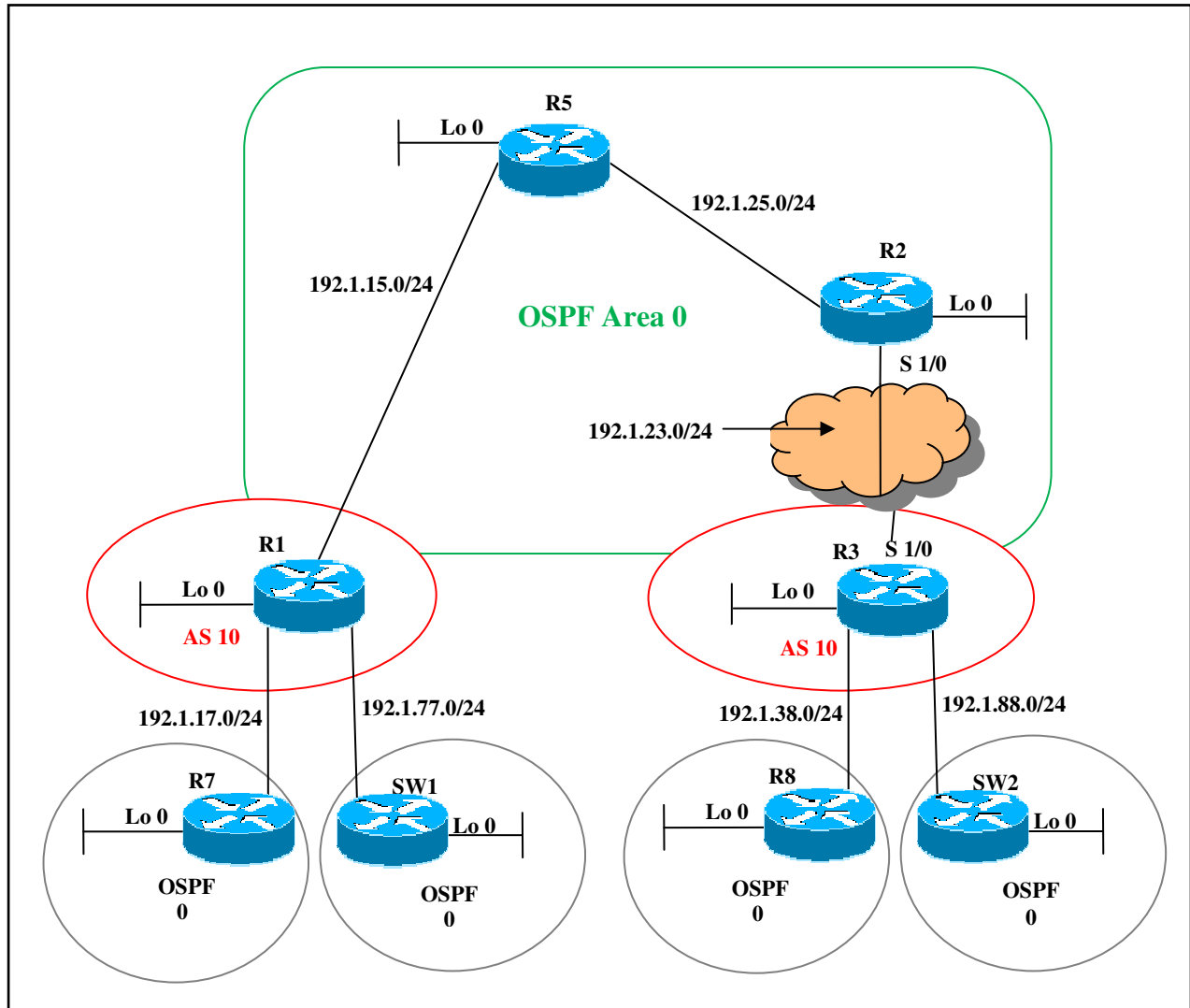
The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).

<b>R1</b>	<b>R3</b>
<pre>ip cef ! ip vrf R7 rd 10:1 export map EXPORT_MAP_R7 route-target import 10:7 route-target import 10:8  interface Ethernet0/0.15 encapsulation dot1Q 15 ip address 192.1.15.1 255.255.255.0 no snmp trap link-status tag-switching ip no cdp enable ! interface Ethernet0/0.17 encapsulation dot1Q 17 ip vrf forwarding R7 ip address 192.1.17.1 255.255.255.0  router ospf 7 vrf R7 log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.15.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary !</pre>	<pre>ip cef ! ip vrf R8 rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf SW2 rd 10:8 route-target export 10:8  interface Ethernet0/0.38 encapsulation dot1Q 38 ip vrf forwarding R8 ip address 192.1.38.3 255.255.255.0 ! interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding SW2 ip address 192.1.88.3 255.255.255.0 ! router ospf 8 vrf R8 log-adjacency-changes redistribute bgp 10 subnets network 192.1.38.3 0.0.0.0 area 0 ! router ospf 9 vrf SW2 log-adjacency-changes redistribute bgp 10 subnets network 192.1.88.3 0.0.0.0 area 0 ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.235.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 3.3.3.3</pre>

<pre> address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family ! address-family ipv4 vrf R7 redistribute ospf 7 vrf R7 no auto-summary no synchronization exit-address-family  ip prefix-list LOOPBACK_0 seq 5 permit 7.7.7.0/24 ! ip prefix-list LOOPBACK_10 seq 5 permit 17.17.17.0/24 ! route-map EXPORT_MAP_R7 permit 10 match ip address prefix-list LOOPBACK_0 set extcommunity rt 10:7 ! route-map EXPORT_MAP_R7 permit 20 match ip address prefix-list LOOPBACK_10 set extcommunity rt 10:8 </pre>	<pre> bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community both exit-address-family ! address-family ipv4 vrf SW2 redistribute ospf 9 vrf SW2 no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf R8 redistribute ospf 8 vrf R8 no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ip ospf network point-to-point ! interface Loopback10 ip address 17.17.17.7 255.255.255.0 ip ospf network point-to-point  router ospf 1 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 17.17.17.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW2</b></p> <pre> interface Vlan88 ip address 192.1.88.8 255.255.255.0 </pre>	

```
router ospf 1
router-id 88.88.88.88
log-adjacency-changes
network 88.88.88.88 0.0.0.0 area 0
network 192.1.88.8 0.0.0.0 area 0
```

## Lab 6 – MPLS VPNs (Extranets)



### Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

**R7** and **SW1** should have connectivity to each other's network through a **MPLS VPN Extranet**.

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>	<b>R3</b>
-----------	-----------



```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target export 10:70
route-target import 10:7
route-target import 10:80
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target export 10:80
route-target import 10:8
route-target import 10:70

interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.15.1 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes

```

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

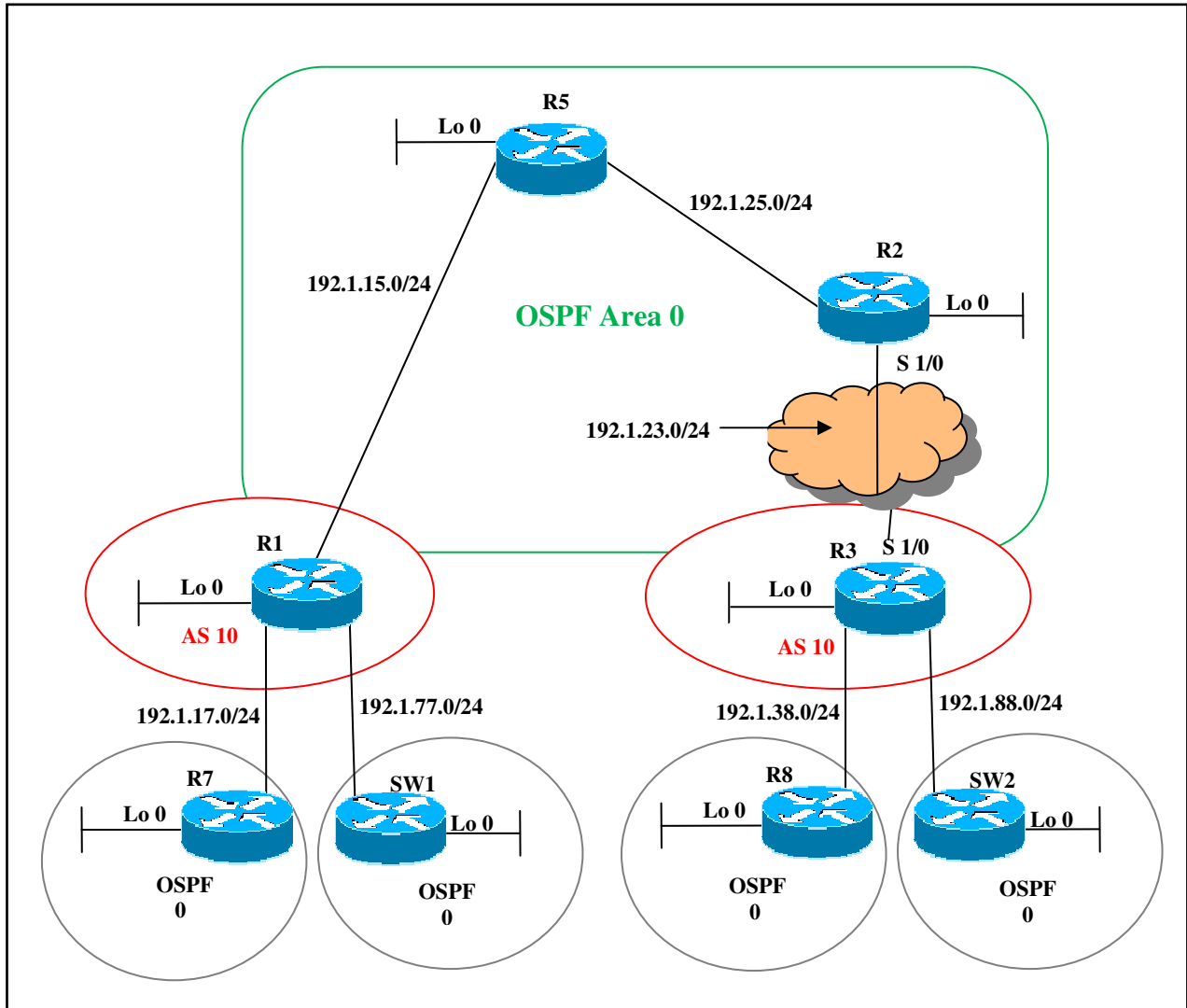
interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0

router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.235.3 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 1.1.1.1 next-hop-self
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community both
exit-address-family
!
address-family ipv4 vrf RED
redistribute ospf 8 vrf RED
no auto-summary
no synchronization

```

<pre> neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>

# Lab 7 – Controlling Label Distribution



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Make sure that **only R1 and R3 loopbacks 0 should be labeled** when sent throughout the MPLS Core network.

*The entire configuration from previous lab should stay the same (such as OSPF routing in the SP core, MPLS enabled on interfaces, iBGP for IPv4 connection between R1 and R3).*

<b>R1</b>	<b>R3</b>
-----------	-----------

```

ip cef
no ip domain lookup
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8
!

mpls label range 100 199
mpls label protocol ldp

no tag-switching advertise-tags
tag-switching advertise-tags for 20
tag-switching tdp router-id Loopback0
!

interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.15
encapsulation dot1Q 15
ip address 192.1.15.1 255.255.255.0
tag-switching ip
no cdp enable
!
interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
no cdp enable
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0
no cdp enable
!

```

```

ip cef
no ip domain lookup
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8
!

mpls label range 300 399
mpls label protocol ldp

no tag-switching advertise-tags
tag-switching advertise-tags for 20
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
!
interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
no cdp enable
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0
no cdp enable
!
interface Serial1/0
ip address 192.1.23.3 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp

```

```

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.15.1 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
no auto-summary
!
address-family vpnv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 send-community
extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute ospf 8
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute ospf 7
no auto-summary
no synchronization
exit-address-family
!
access-list 20 permit 1.1.1.1
access-list 20 permit 3.3.3.3
access-list 20 deny any

```

```

!
router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.38.3 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.88.3 0.0.0.0 area 0
!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
no auto-summary
!
address-family vpnv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 send-community
extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute ospf 8
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
redistribute ospf 7
no auto-summary
no synchronization
exit-address-family
!
access-list 20 permit 3.3.3.3
access-list 20 permit 1.1.1.1
access-list 20 deny any

```

**R2**

```
ip cef
no ip domain lookup
mpls label range 200 299
mpls label protocol ldp

no tag-switching advertise-tags
tag-switching advertise-tags for 20
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Ethernet0/0
ip address 192.1.25.2 255.255.255.0
half-duplex
tag-switching ip
!
interface Serial1/0
ip address 192.1.23.2 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.3 203
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 2.2.2.2
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.23.2 0.0.0.0 area 0
network 192.1.25.2 0.0.0.0 area 0
!
access-list 20 permit 3.3.3.3
access-list 20 permit 1.1.1.1
access-list 20 deny any
```

**R5**

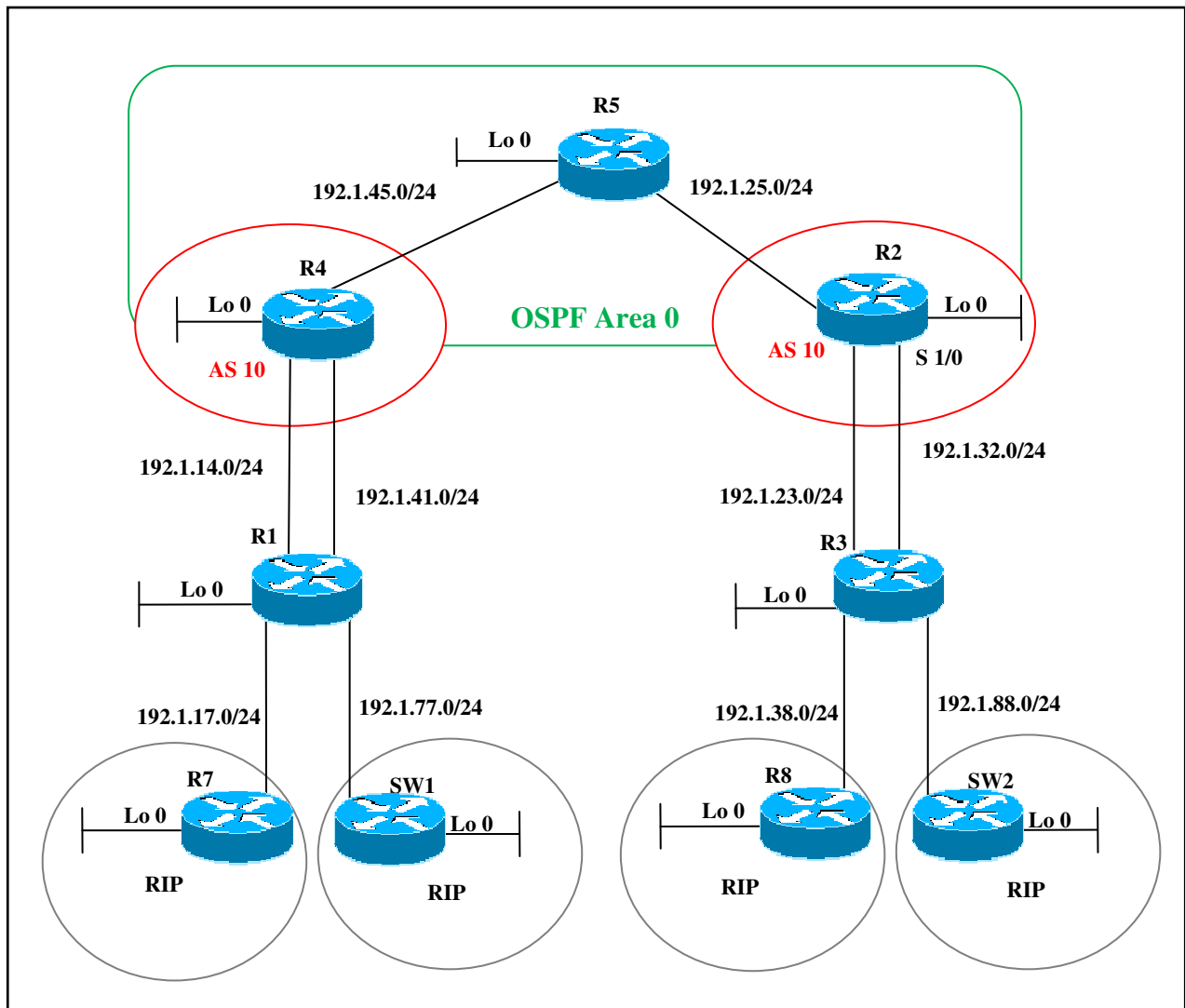
```
ip cef
no ip domain-lookup
ip ssh time-out 120

mpls label range 500 599
mpls label protocol ldp

no tag-switching advertise-tags
tag-switching advertise-tags for 20
!
interface Loopback0
ip address 5.5.5.5 255.255.255.255
no ip directed-broadcast
!
interface FastEthernet0/0
no ip address
no ip directed-broadcast
!
interface FastEthernet0/0.15
encapsulation dot1Q 15
ip address 192.1.15.5 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.25
encapsulation dot1Q 25
ip address 192.1.25.5 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
router ospf 1
router-id 5.5.5.5
log-adjacency-changes
network 5.5.5.5 0.0.0.0 area 0
network 192.1.15.5 0.0.0.0 area 0
network 192.1.25.5 0.0.0.0 area 0
!
access-list 20 permit 3.3.3.3
access-list 20 permit 1.1.1.1
access-list 20 deny any
no cdp run
```

<b>R7</b> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0	<b>R8</b> interface Loopback0 ip address 8.8.8.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0
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# Lab 8 – VRF Lite



## Task 1

Configure **Multi-VRF (VRF-Lite)** on **R1** and **R3** to transport routes from **R4** and **R2** respectively (**R7** and **R8** should be in **VRF BLUE**) and (**SW1** and **SW2** should be in **VRF RED**).

R1	R3
<pre>ip cef no ip domain lookup ip vrf BLUE rd 10:7 !</pre>	<pre>ip cef no ip domain lookup ip vrf BLUE rd 10:7 !</pre>



```

ip vrf RED
rd 10:8
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.14
encapsulation dot1Q 14
ip vrf forwarding BLUE
ip address 192.1.14.1 255.255.255.0
!
interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
!
interface Ethernet0/0.41
encapsulation dot1Q 41
ip vrf forwarding RED
ip address 192.1.41.1 255.255.255.0
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0
!
router rip
!
address-family ipv4 vrf RED
network 192.1.41.0
network 192.1.77.0
no auto-summary
version 2
exit-address-family
!
address-family ipv4 vrf BLUE
network 192.1.14.0
network 192.1.17.0
no auto-summary
version 2
exit-address-family
!

```

```

ip vrf RED
rd 10:8
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.23
encapsulation dot1Q 23
ip vrf forwarding BLUE
ip address 192.1.23.3 255.255.255.0
!
interface Ethernet0/0.32
encapsulation dot1Q 32
ip vrf forwarding RED
ip address 192.1.32.3 255.255.255.0
!
interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0
no cdp enable
!
router rip
!
address-family ipv4 vrf RED
network 192.1.32.0
network 192.1.88.0
no auto-summary
version 2
exit-address-family
!
address-family ipv4 vrf BLUE
network 192.1.23.0
network 192.1.38.0
no auto-summary
version 2
exit-address-family
!

```

<pre> <b>R2</b>  ip cef  ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8 ! mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.23 encapsulation dot1Q 23 ip vrf forwarding BLUE ip address 192.1.23.2 255.255.255.0 ! interface Ethernet0/0.25 encapsulation dot1Q 25 ip address 192.1.25.2 255.255.255.0 tag-switching ip ! interface Ethernet0/0.32 encapsulation dot1Q 32 ip vrf forwarding RED ip address 192.1.32.2 255.255.255.0 ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.25.2 0.0.0.0 area 0 ! </pre>	<pre> <b>R4</b>  ip cef no ip domain lookup ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8 ! mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.14 encapsulation dot1Q 14 ip vrf forwarding BLUE ip address 192.1.14.4 255.255.255.0 ! interface Ethernet0/0.41 encapsulation dot1Q 41 ip vrf forwarding RED ip address 192.1.41.4 255.255.255.0 ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 tag-switching ip ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! </pre>
---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<pre> router rip ! address-family ipv4 vrf RED redistribute bgp 10 metric 1 network 192.1.32.0 no auto-summary version 2 exit-address-family ! address-family ipv4 vrf BLUE redistribute bgp 10 metric 1 network 192.1.23.0 no auto-summary version 2 exit-address-family ! router bgp 10 no synchronization bgp router-id 2.2.2.2 bgp log-neighbor-changes neighbor 4.4.4.4 remote-as 10 neighbor 4.4.4.4 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 4.4.4.4 activate neighbor 4.4.4.4 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute rip no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family ! </pre>	<pre> router rip ! address-family ipv4 vrf RED redistribute bgp 10 metric 1 network 192.1.41.0 no auto-summary version 2 exit-address-family ! address-family ipv4 vrf BLUE redistribute bgp 10 metric 1 network 192.1.14.0 no auto-summary version 2 exit-address-family ! router bgp 10 no synchronization bgp router-id 4.4.4.4 bgp log-neighbor-changes neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 2.2.2.2 activate neighbor 2.2.2.2 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute rip no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family ! </pre>
<p><b>R5</b></p> <pre> ip cef  mpls label range 500 599 </pre>	<p><b>R7</b></p> <pre> ip cef  interface Loopback0 </pre>

<pre> mpls label protocol ldp ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 25 ip address 192.1.25.5 255.255.255.0 no ip directed-broadcast tag-switching ip ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.5 255.255.255.0 no ip directed-broadcast tag-switching ip ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.25.5 0.0.0.0 area 0 network 192.1.45.5 0.0.0.0 area 0 ! ip classless  tag-switching tdp router-id Loopback0 </pre>	<pre> ip address 7.7.7.7 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0 half-duplex ! router rip version 2 network 7.0.0.0 network 192.1.17.0 no auto-summary </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0 ! interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary </pre>	<p><b>R8</b></p> <pre> interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  interface Loopback0 ip address 8.8.8.8 255.255.255.0  router rip version 2 network 8.0.0.0 network 192.1.38.0 no auto-summary </pre>

## SW2

```
interface Loopback0  
ip address 88.88.88.88 255.255.255.0
```

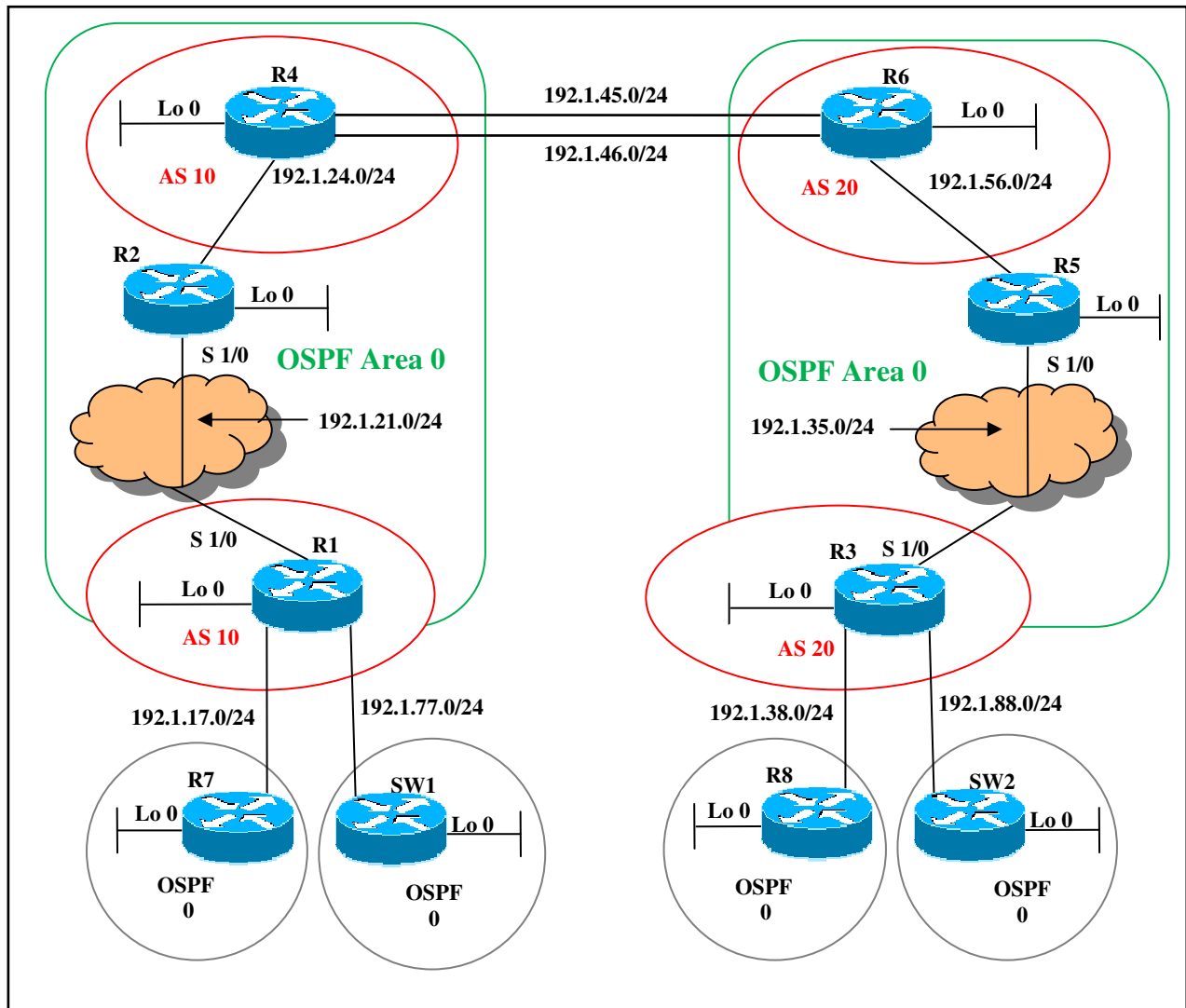
```
interface Vlan88  
ip address 192.1.88.8 255.255.255.0
```

```
router rip  
version 2  
network 88.0.0.0  
network 192.1.88.0  
no auto-summary
```

# **Module 5 – Inter-AS in MPLS VPNs**

# Lab 1 – Inter-AS with Back-to-Back VRF

*Also called Inter-AS Option 1*



### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.15	192.1.15.1	255.255.255.0
E 0/0.17	192.1.17.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.21.2	255.255.255.0
E 0/0	192.1.24.2	255.255.255.0

**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
E 0/0.38	192.1.38.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0
S 1/0	192.1.35.3	255.255.255.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.45	192.1.45.4	255.255.255.0
E 0/0.45	192.1.46.4	255.255.255.0
E 0/0.24	192.1.24.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0	192.1.56.5	255.255.255.0
S 1/0	192.1.35.5	255.255.255.0

**R6**

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.45	192.1.45.6	255.255.255.0
E 0/0.46	192.1.46.6	255.255.255.0
E 0/0.56	192.1.56.6	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.17.7	255.255.255.0

**R8**

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.255
E 0/0	192.1.38.8	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0



## SW2

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

### Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Also configure **VPN transit** between **AS 10** and **20** using the **Inter-AS Back-to-Back VRF** method.

*Change the SP core network to match the diagram above, using MPLS and OSPF as the Core routing protocol in both Providers AS10 and AS20.*

R1	R3
<pre>ip cef ! ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8  interface Ethernet0/0.17 encapsulation dot1Q 17 ip vrf forwarding BLUE ip address 192.1.17.1 255.255.255.0 ! interface Ethernet0/0.77 encapsulation dot1Q 77 ip vrf forwarding RED ip address 192.1.77.1 255.255.255.0  router ospf 7 vrf BLUE log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 !</pre>	<pre>ip cef ! ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8  interface Ethernet0/0.38 encapsulation dot1Q 38 ip vrf forwarding BLUE ip address 192.1.38.3 255.255.255.0 no snmp trap link-status no cdp enable ! interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding RED ip address 192.1.88.3 255.255.255.0  router ospf 7 vrf BLUE log-adjacency-changes redistribute bgp 20 subnets network 192.1.38.3 0.0.0.0 area 0 !</pre>

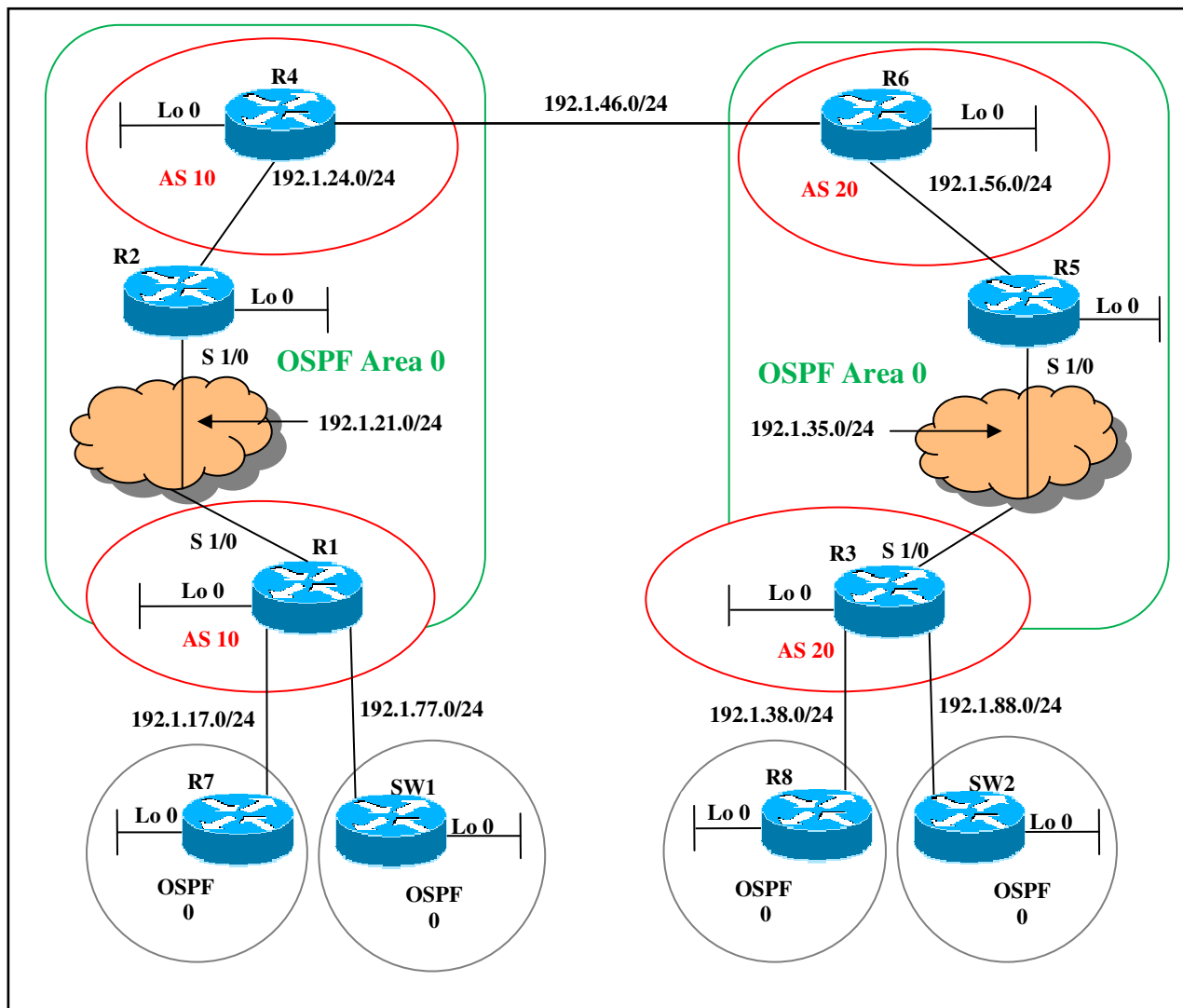
<pre> router ospf 8 vrf RED log-adjacency-changes redistribute bgp 10 subnets network 192.1.77.1 0.0.0.0 area 0 ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 4.4.4.4 remote-as 10 neighbor 4.4.4.4 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 4.4.4.4 activate neighbor 4.4.4.4 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> router ospf 8 vrf RED log-adjacency-changes redistribute bgp 20 subnets network 192.1.88.3 0.0.0.0 area 0 ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 20 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 6.6.6.6 remote-as 20 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community both exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 </pre>	<p><b>R6</b></p> <pre> ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 </pre>

<pre> route-target import 10:8  interface Ethernet0/0.24  encapsulation dot1Q 24  ip address 192.1.24.4 255.255.255.0  no snmp trap link-status  tag-switching ip  no cdp enable ! interface Ethernet0/0.45  encapsulation dot1Q 45  ip vrf forwarding BLUE  ip address 192.1.45.4 255.255.255.0  interface Ethernet0/0.46  encapsulation dot1Q 46  ip vrf forwarding RED  ip address 192.1.46.4 255.255.255.0  router ospf 1  router-id 4.4.4.4  log-adjacency-changes  network 4.4.4.4 0.0.0.0 area 0  network 192.1.24.4 0.0.0.0 area 0  network 192.1.45.4 0.0.0.0 area 0 ! router bgp 10  no synchronization  bgp router-id 4.4.4.4  bgp log-neighbor-changes  neighbor 1.1.1.1 remote-as 10  neighbor 1.1.1.1 update-source Loopback0  no auto-summary ! address-family vpnv4  neighbor 1.1.1.1 activate  neighbor 1.1.1.1 send-community both  exit-address-family ! address-family ipv4 vrf RED  neighbor 192.1.46.6 remote-as 20  neighbor 192.1.46.6 activate  no auto-summary  no synchronization  exit-address-family ! </pre>	<pre> route-target import 10:8  interface FastEthernet0/0.45  encapsulation dot1Q 45  ip vrf forwarding BLUE  ip address 192.1.45.6 255.255.255.0  no cdp enable ! interface FastEthernet0/0.46  encapsulation dot1Q 46  ip vrf forwarding RED  ip address 192.1.46.6 255.255.255.0  no cdp enable ! interface FastEthernet0/0.56  encapsulation dot1Q 56  ip address 192.1.56.6 255.255.255.0  tag-switching ip  outer ospf 1  router-id 6.6.6.6  log-adjacency-changes  network 6.6.6.6 0.0.0.0 area 0  network 192.1.56.6 0.0.0.0 area 0 ! router bgp 20  no synchronization  bgp router-id 6.6.6.6  bgp log-neighbor-changes  neighbor 3.3.3.3 remote-as 20  neighbor 3.3.3.3 update-source Loopback0  no auto-summary ! address-family vpnv4  neighbor 3.3.3.3 activate  neighbor 3.3.3.3 send-community both  no auto-summary  exit-address-family ! address-family ipv4 vrf RED  neighbor 192.1.46.4 remote-as 10  neighbor 192.1.46.4 activate  no auto-summary  no synchronization  exit-address-family ! </pre>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<pre> address-family ipv4 vrf BLUE neighbor 192.1.45.6 remote-as 20 neighbor 192.1.45.6 activate no auto-summary no synchronization exit-address-family </pre>	<pre> address-family ipv4 vrf BLUE neighbor 192.1.45.4 remote-as 10 neighbor 192.1.45.4 activate no auto-summary no synchronization exit-address-family </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0 </pre>

# Lab 1 – Inter-AS MP-eBGP with Next-Hop-Self

Also called Inter-AS Option 2a



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Also configure **VPN transit** between **AS 10** and **20** using the **MP-eBGP VPNv4 with Next-hop-self** method.

Change the **SP** core network to match the diagram above, using **MPLS** and **OSPF** as the **Core** routing protocol in both **Providers AS10** and **AS20**.

<b>R1</b>	<b>R3</b>
-----------	-----------

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0

router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.21.1 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp log-neighbor-changes
neighbor 4.4.4.4 remote-as 10
neighbor 4.4.4.4 update-source Loopback0
no auto-summary
!

```

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.38.3 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.88.3 0.0.0.0 area 0
!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.35.3 0.0.0.0 area 0
!
router bgp 20
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 6.6.6.6 remote-as 20
neighbor 6.6.6.6 update-source Loopback0
no auto-summary
!

```

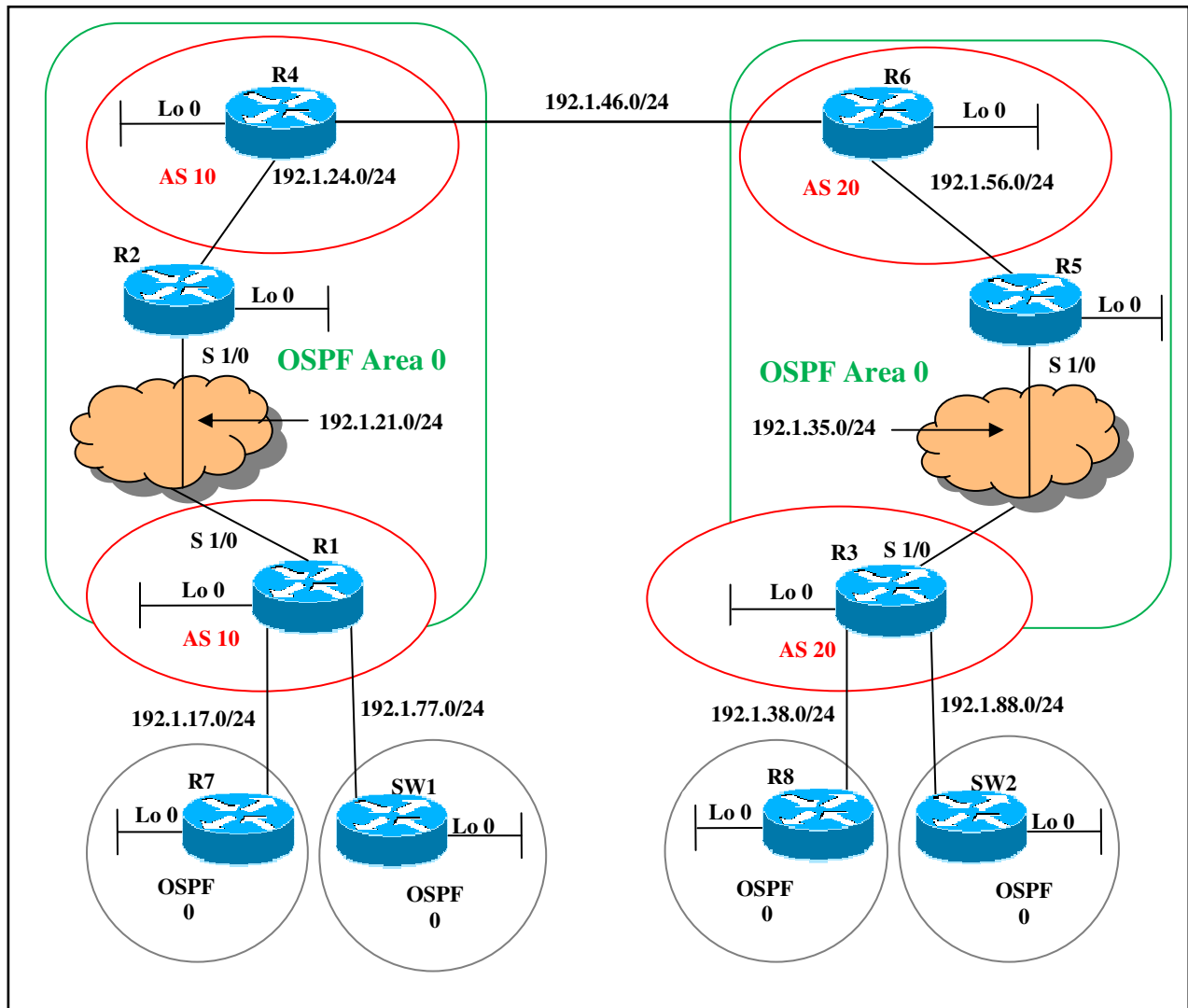
<pre> address-family vpnv4 neighbor 4.4.4.4 activate neighbor 4.4.4.4 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> address-family vpnv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 tag-switching ip ! interface Ethernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.4 255.255.255.0  router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 4.4.4.4 no bgp default route-target filter bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 192.1.46.6 remote-as 20 no auto-summary ! </pre>	<p><b>R6</b></p> <pre> interface FastEthernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.6 255.255.255.0 ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 tag-switching ip  router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! router bgp 20 no synchronization bgp router-id 6.6.6.6 no bgp default route-target filter bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 20 neighbor 3.3.3.3 update-source Loopback0 neighbor 192.1.46.4 remote-as 10 no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate </pre>

<pre> address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 1.1.1.1 next-hop-self neighbor 192.1.46.6 activate neighbor 192.1.46.6 send-community extended exit-address-family </pre>	<pre> neighbor 3.3.3 next-hop-self neighbor 3.3.3 send-community extended neighbor 192.1.46.4 activate neighbor 192.1.46.4 send-community extended no auto-summary exit-address-family </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0 </pre>



# Lab 3 – Inter-AS MP-eBGP with Redistribute Connected

Also called Inter-AS Option 2b



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Also configure **VPN transit** between **AS 10** and **20** using the **MP-eBGP VPNv4 with redistribute connected** method.

Change the **SP core network** to match the diagram above, using **MPLS** and **OSPF** as the **Core routing protocol** in both **Providers AS10 and AS20**.

<b>R1</b>	<b>R3</b>
-----------	-----------

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0

router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.21.1 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp log-neighbor-changes
neighbor 4.4.4.4 remote-as 10
neighbor 4.4.4.4 update-source Loopback0
no auto-summary
!

```

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.38.3 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.88.3 0.0.0.0 area 0
!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.35.3 0.0.0.0 area 0
!
router bgp 20
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 6.6.6.6 remote-as 20
neighbor 6.6.6.6 update-source Loopback0
no auto-summary
!

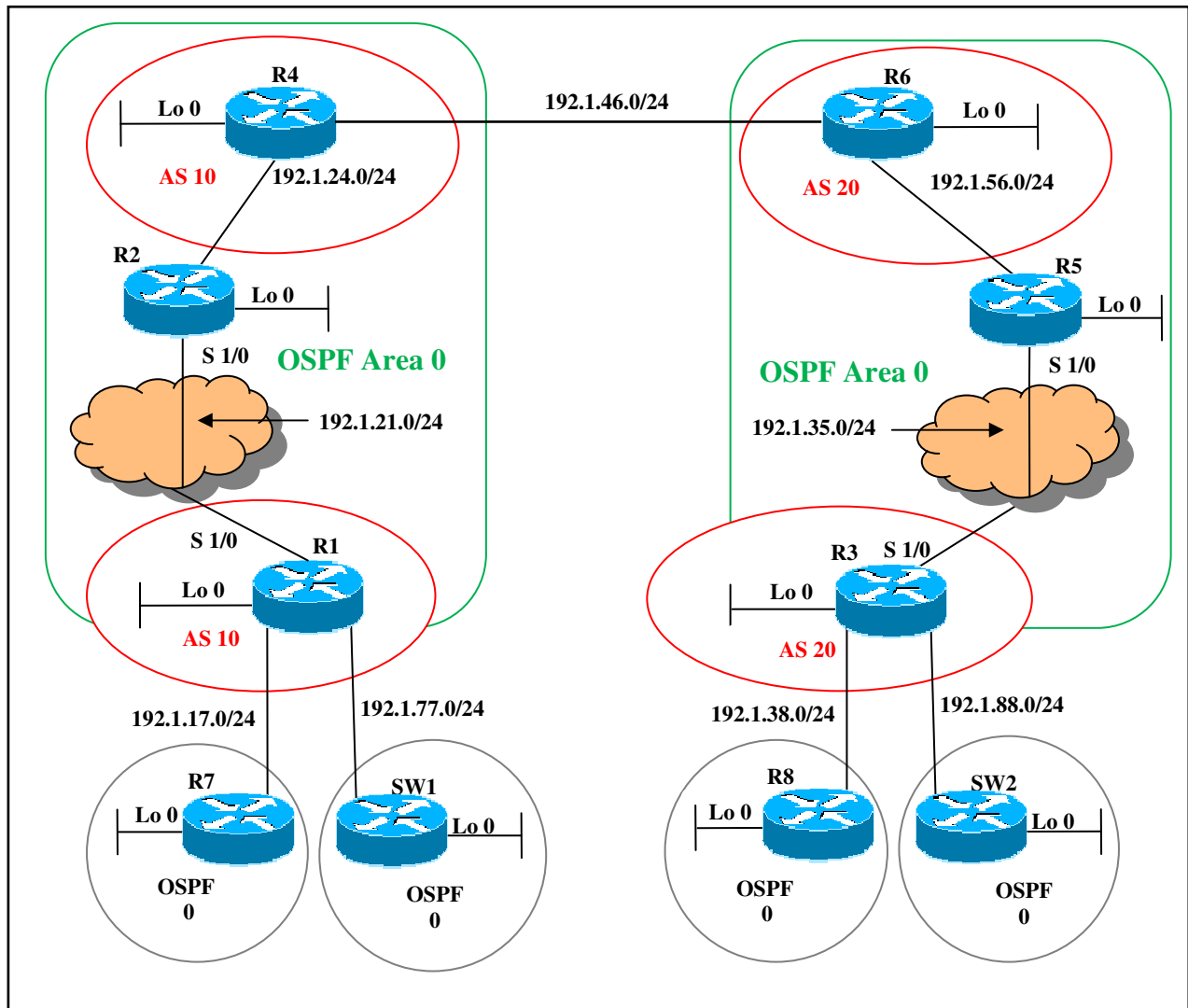
```

<pre> address-family vpvv4 neighbor 4.4.4.4 activate neighbor 4.4.4.4 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> address-family vpvv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 tag-switching ip ! interface Ethernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.4 255.255.255.0  router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 redistribute connected subnets route-map CONNECTED_192.1.46 ! router bgp 10 no synchronization bgp router-id 4.4.4.4 no bgp default route-target filter bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 192.1.46.6 remote-as 20 no auto-summary </pre>	<p><b>R6</b></p> <pre> interface FastEthernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.6 255.255.255.0 ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 tag-switching ip  router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 redistribute connected subnets route-map CONNECTED_192.1.46 ! router bgp 20 no synchronization bgp router-id 6.6.6.6 no bgp default route-target filter bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 20 neighbor 3.3.3.3 update-source Loopback0 neighbor 192.1.46.4 remote-as 10 no auto-summary </pre>

<pre> ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 192.1.46.6 activate neighbor 192.1.46.6 send-community extended exit-address-family  ip access-list standard CONNECTED_192.1.46 permit 192.1.46.0 0.0.0.6 ! route-map CONNECTED_192.1.46 permit 10 match ip address CONNECTED_192.1.46 </pre>	<pre> ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 192.1.46.4 activate neighbor 192.1.46.4 send-community extended no auto-summary exit-address-family  ip access-list standard CONNECTED_192.1.46 permit 192.1.46.0 0.0.0.4  route-map CONNECTED_192.1.46 permit 10 match ip address CONNECTED_192.1.46 </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0 </pre>

# Lab 4 – Inter-AS MP-eBGP Multihop

*Also called Inter-AS Option 2c*



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Also configure **VPN transit** between **AS 10** and **20** using the **MP-eBGP VPNv4 with Multihop** method between **R4** and **R6**.

*Change the SP core network to match the diagram above, using **MPLS** and **OSPF** as the Core routing protocol in both Providers **AS10** and **AS20**.*

<b>R1</b>	<b>R3</b>
-----------	-----------

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.17
encapsulation dot1Q 17
ip vrf forwarding BLUE
ip address 192.1.17.1 255.255.255.0
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding RED
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.17.1 0.0.0.0 area 0

router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 10 subnets
network 192.1.77.1 0.0.0.0 area 0
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.21.1 0.0.0.0 area 0
!
router bgp 10
no synchronization
bgp log-neighbor-changes
neighbor 4.4.4.4 remote-as 10
neighbor 4.4.4.4 update-source Loopback0
no auto-summary
!

```

```

ip cef
!
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip vrf RED
rd 10:8
route-target export 10:8
route-target import 10:8

interface Ethernet0/0.38
encapsulation dot1Q 38
ip vrf forwarding BLUE
ip address 192.1.38.3 255.255.255.0
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding RED
ip address 192.1.88.3 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.38.3 0.0.0.0 area 0
!
router ospf 8 vrf RED
log-adjacency-changes
redistribute bgp 20 subnets
network 192.1.88.3 0.0.0.0 area 0
!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.35.3 0.0.0.0 area 0
!
router bgp 20
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 6.6.6.6 remote-as 20
neighbor 6.6.6.6 update-source Loopback0
no auto-summary
!

```

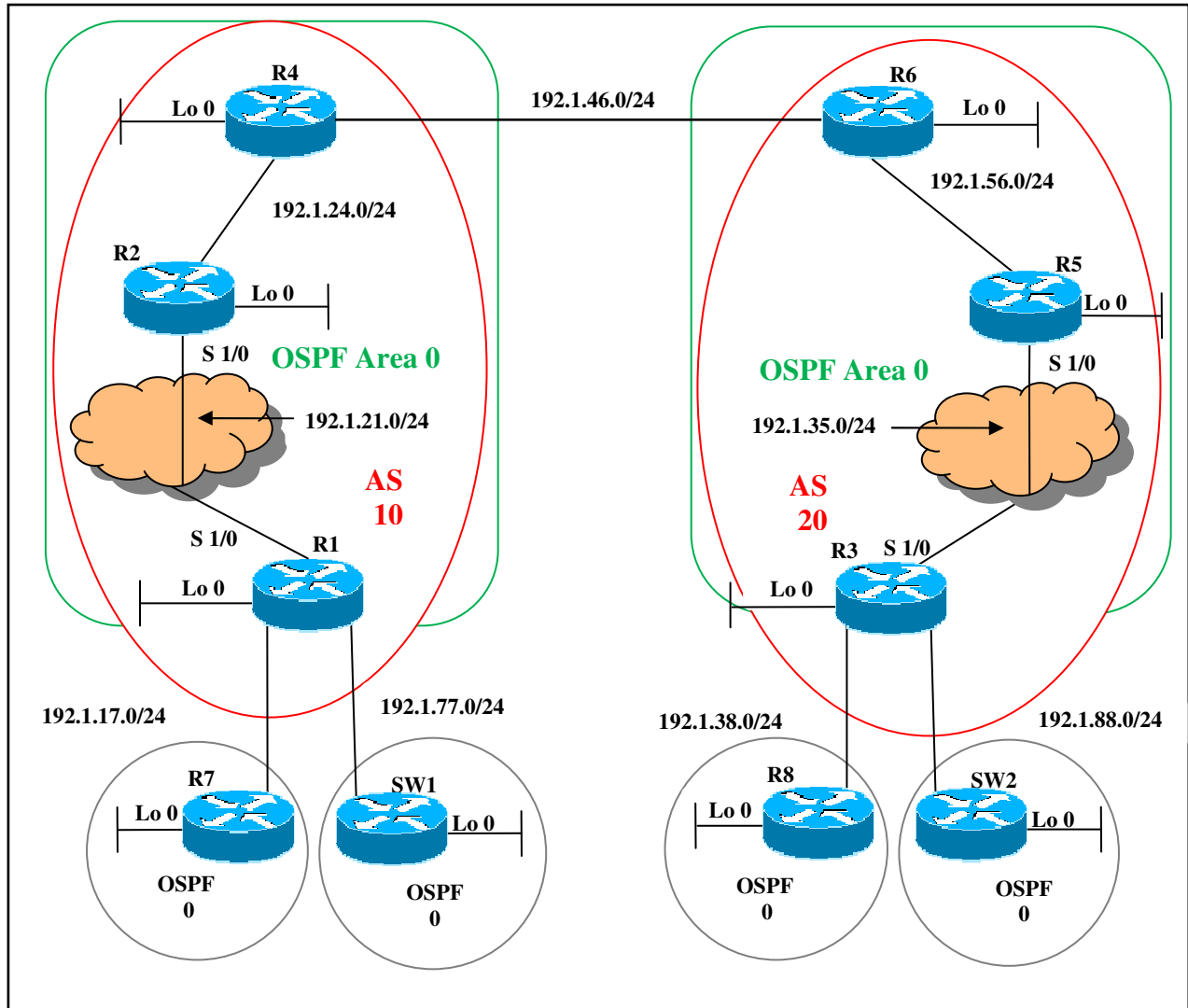
<pre> address-family vpnv4 neighbor 4.4.4.4 activate neighbor 4.4.4.4 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> address-family vpnv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> interface Loopback10 ip address 44.44.44.44 255.255.255.255  interface Ethernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.4 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip  router ospf 1 router-id 4.4.4.4 log-adjacency-changes redistribute static subnets network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 4.4.4.4 no bgp default route-target filter bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 66.66.66.66 remote-as 20 neighbor 66.66.66.66 ebgp-multihop 2 </pre>	<p><b>R6</b></p> <pre> interface Loopback10 ip address 66.66.66.66 255.255.255.255  interface FastEthernet0/0.46 encapsulation dot1Q 46 ip address 192.1.46.6 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip  router ospf 1 router-id 6.6.6.6 log-adjacency-changes redistribute static subnets network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! router bgp 20 no synchronization bgp router-id 6.6.6.6 no bgp default route-target filter bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 20 neighbor 3.3.3.3 update-source Loopback0 neighbor 44.44.44.44 remote-as 10 neighbor 44.44.44.44 ebgp-multihop 2 </pre>

<pre>neighbor 66.66.66.66 update-source Loopback10 neighbor 192.1.46.6 remote-as 20 no auto-summary !  address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 66.66.66.66 activate neighbor 66.66.66.66 send-community extended neighbor 192.1.46.6 activate neighbor 192.1.46.6 send-community extended exit-address-family ! ip route 66.66.66.66 255.255.255.255 192.1.46.6</pre>	<pre>neighbor 44.44.44.44 update-source Loopback10 neighbor 192.1.46.4 remote-as 10 no auto-summary !  address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 44.44.44.44 activate neighbor 44.44.44.44 send-community extended neighbor 192.1.46.4 activate neighbor 192.1.46.4 send-community extended no auto-summary exit-address-family ! ip route 44.44.44.44 255.255.255.255 192.1.46.4</pre>
<p><b>R7</b></p> <pre>interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0</pre>	<p><b>R8</b></p> <pre>interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0</pre>
<p><b>SW1</b></p> <pre>interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0</pre>	<p><b>SW2</b></p> <pre>interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0</pre>



# Lab 5 – Inter-AS MP-eBGP RR Multihop

*Also called Inter-AS Option 3*



## Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **BLUE**, and between **SW1** and **SW2** in a VRF called **RED**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Configure **R2** inside **BGP 10** and make it **RR** for **VPNv4** of **R1** and **R4**.

Configure **R5** inside **BGP 20** and make it **RR** for **VPNv4** of **R3** and **R6**.

Also configure **VPN transit** between **AS 10** and **20** using the **MP-eBGP VPNv4** between the **Route Reflector with Multihop** method between **R4** and **R6**.

*Change the SP core network to match the diagram above, using **MPLS** and **OSPF** as the Core routing protocol in both Providers **AS10** and **AS20**.*

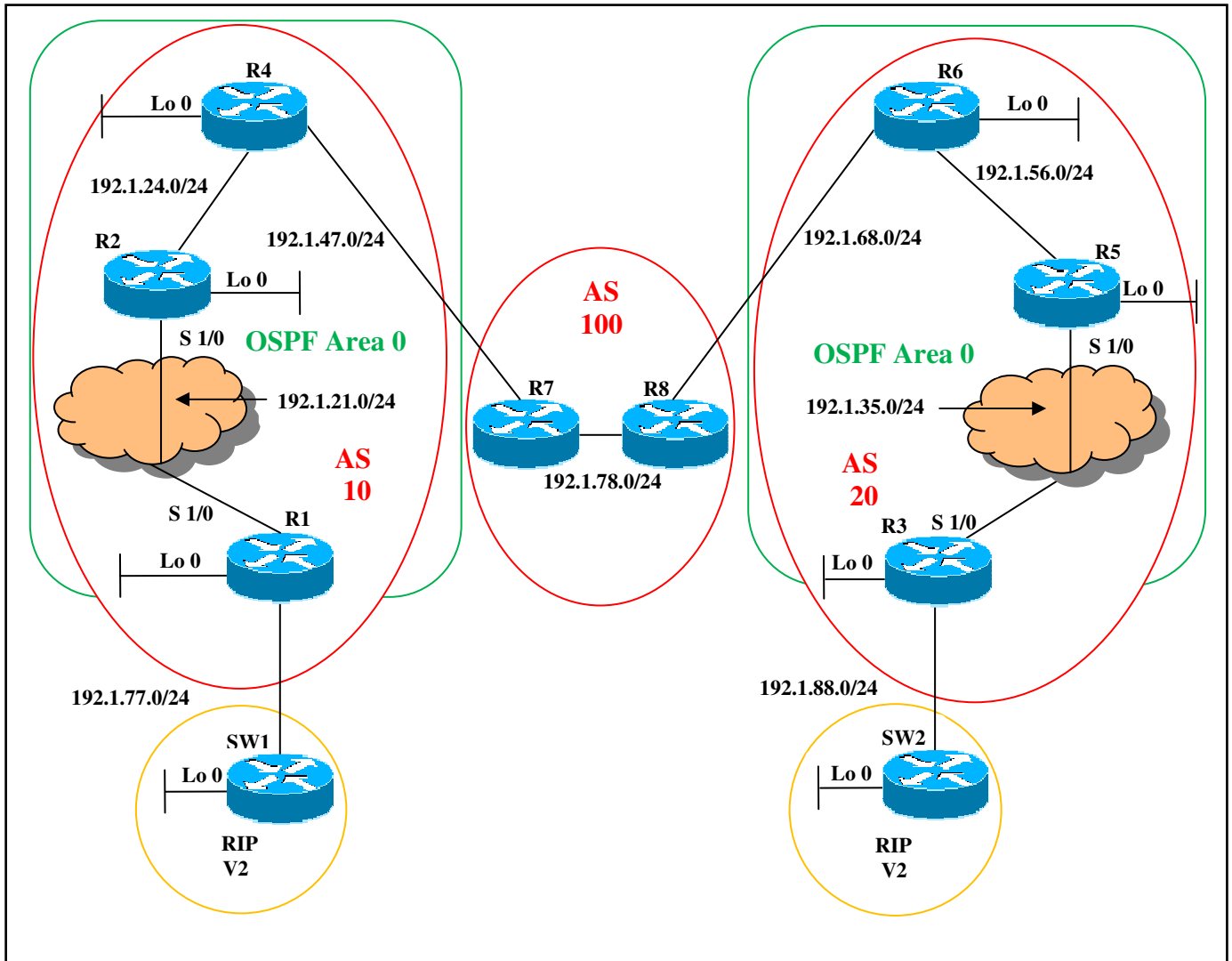
<p><b>R1</b></p> <pre> ip cef ! ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8  interface Ethernet0/0.17 encapsulation dot1Q 17 ip vrf forwarding BLUE ip address 192.1.17.1 255.255.255.0 ! interface Ethernet0/0.77 encapsulation dot1Q 77 ip vrf forwarding RED ip address 192.1.77.1 255.255.255.0  router ospf 7 vrf BLUE log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 ! router ospf 8 vrf RED log-adjacency-changes redistribute bgp 10 subnets network 192.1.77.1 0.0.0.0 area 0 ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no bgp default ipv4-unicast bgp log-neighbor-changes neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 ! </pre>	<p><b>R3</b></p> <pre> ip cef ! ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip vrf RED rd 10:8 route-target export 10:8 route-target import 10:8  interface Ethernet0/0.38 encapsulation dot1Q 38 ip vrf forwarding BLUE ip address 192.1.38.3 255.255.255.0  interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding RED ip address 192.1.88.3 255.255.255.0  router ospf 7 vrf BLUE log-adjacency-changes redistribute bgp 20 subnets network 192.1.38.3 0.0.0.0 area 0 ! router ospf 8 vrf RED log-adjacency-changes redistribute bgp 20 subnets network 192.1.88.3 0.0.0.0 area 0 ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 20 bgp router-id 3.3.3.3 no bgp default ipv4-unicast bgp log-neighbor-changes neighbor 5.5.5.5 remote-as 20 neighbor 5.5.5.5 update-source Loopback0 ! </pre>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<pre> address-family vpnv4 neighbor 2.2.2.2 activate neighbor 2.2.2.2 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>	<pre> ! address-family vpnv4 neighbor 5.5.5.5 activate neighbor 5.5.5.5 send-community extended exit-address-family ! address-family ipv4 vrf RED redistribute ospf 8 vrf RED no auto-summary no synchronization exit-address-family ! address-family ipv4 vrf BLUE redistribute ospf 7 vrf BLUE no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> router ospf 1 router-id 4.4.4.4 log-adjacency-changes redistribute bgp 10 subnets route-map FROM_BGP_TO_OSPF network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 4.4.4.4 no bgp default route-target filter bgp log-neighbor-changes network 1.1.1.1 mask 255.255.255.255 network 2.2.2.2 mask 255.255.255.255 neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 neighbor 192.1.46.6 remote-as 20 neighbor 192.1.46.6 send-label no auto-summary ! ip prefix-list LOOPBACK seq 5 permit 5.5.5.5/32 </pre>	<p><b>R6</b></p> <pre> router ospf 1 router-id 6.6.6.6 log-adjacency-changes redistribute bgp 20 subnets route-map FROM_BGP_TO_OSPF network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! router bgp 20 bgp router-id 6.6.6.6 no bgp default route-target filter bgp log-neighbor-changes neighbor 192.1.46.4 remote-as 10 ! address-family ipv4 neighbor 192.1.46.4 activate neighbor 192.1.46.4 send-label no auto-summary no synchronization network 3.3.3.3 mask 255.255.255.255 network 5.5.5.5 mask 255.255.255.255 exit-address-family ! ip prefix-list LOOPBACK seq 5 permit 2.2.2.2/32 </pre>

<pre> ip prefix-list LOOPBACK seq 10 permit 3.3.3.3/32 no cdp run ! route-map FROM_BGP_TO_OSPF permit 10 match ip address prefix-list LOOPBACK </pre>	<pre> ip prefix-list LOOPBACK seq 10 permit 1.1.1.1/32 ! route-map FROM_BGP_TO_OSPF permit 10 match ip address prefix-list LOOPBACK </pre>
<p><b>R7</b></p> <pre> interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router ospf 1 router-id 77.77.77.77 log-adjacency-changes network 77.77.77.77 0.0.0.0 area 0 network 192.1.77.7 0.0.0.0 area 0 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router ospf 1 router-id 88.88.88.88 log-adjacency-changes network 88.88.88.88 0.0.0.0 area 0 network 192.1.88.8 0.0.0.0 area 0 </pre>

# Lab 6 – Inter-AS (Non-VPN Transit Provider)

*Also called Inter-AS Option4*



## Task 1

Configure MPLS VPN between **SW1** and **SW2** in a VRF called **YELLOW**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

Configure **R2** inside **BGP 10** and make it **RR** for **IPv4** of **R1** and **R4**.

Configure **R5** inside **BGP 20** and make it **RR** for **IPv4** of **R3** and **R6**.

Also configure **AS 200** as a **Non-VPN transit Provider** between **AS 10** and **AS 20**.

*Change the SP core network to match the diagram above, using **MPLS** and **OSPF** as the Core routing protocol in both Providers **AS10** and **AS20**.*

<b>R1</b>	<b>R3</b>
<pre> ip cef ! ip vrf YELLOW rd 10:1 route-target export 10:1 route-target import 10:1 ! interface Ethernet0/0 ip vrf forwarding YELLOW ip address 192.1.77.1 255.255.255.0  router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf YELLOW redistribute bgp 10 metric 1 network 192.1.77.0 no auto-summary version 2 exit-address-family  ! router bgp 10 no bgp default ipv4-unicast bgp log-neighbor-changes neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 ! address-family ipv4 neighbor 2.2.2.2 activate neighbor 2.2.2.2 next-hop-self no auto-summary no synchronization exit-address-family !  address-family vpnv4 neighbor 2.2.2.2 activate </pre>	<pre> ip cef ! ip vrf YELLOW rd 10:1 route-target export 10:1 route-target import 10:1  interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding YELLOW ip address 192.1.88.3 255.255.255.0 ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf YELLOW redistribute bgp 20 metric 1 network 192.1.88.0 no auto-summary version 2 exit-address-family  ! router bgp 20 bgp router-id 3.3.3.3 no bgp default ipv4-unicast bgp log-neighbor-changes neighbor 5.5.5.5 remote-as 20 neighbor 5.5.5.5 update-source Loopback0 ! address-family ipv4 neighbor 5.5.5.5 activate neighbor 5.5.5.5 next-hop-self neighbor 5.5.5.5 send-label no auto-summary no synchronization exit-address-family !  address-family vpnv4 neighbor 5.5.5.5 activate </pre>

<pre>neighbor 2.2.2.2 send-community extended exit-address-family ! address-family ipv4 vrf YELLOW redistribute rip no auto-summary no synchronization exit-address-family</pre>	<pre>neighbor 5.5.5.5 send-community extended exit-address-family ! address-family ipv4 vrf YELLOW redistribute rip no auto-summary no synchronization exit-address-family</pre>
<p><b>R4</b></p> <pre>interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 no snmp trap link-status tag-switching ip  router ospf 1 router-id 4.4.4.4 log-adjacency-changes redistribute bgp 10 subnets route-map FROM_BGP_TO_OSPF network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 4.4.4.4 bgp log-neighbor-changes network 1.1.1.1 mask 255.255.255.255 network 2.2.2.2 mask 255.255.255.255 network 4.4.4.4 mask 255.255.255.255 neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 neighbor 2.2.2.2 next-hop-self neighbor 2.2.2.2 send-label neighbor 192.1.47.7 remote-as 100 neighbor 192.1.47.7 send-label no auto-summary  ip prefix-list LOOPBACK seq 5 permit 5.5.5.5/32 ip prefix-list LOOPBACK seq 10 permit 3.3.3.3/32</pre>	<p><b>R6</b></p> <pre>interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 tag-switching ip ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes redistribute bgp 20 subnets route-map FROM_BGP_TO_OSPF network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! router bgp 20 bgp router-id 6.6.6.6 bgp log-neighbor-changes neighbor 5.5.5.5 remote-as 20 neighbor 5.5.5.5 update-source Loopback0 neighbor 192.1.68.8 remote-as 100 ! address-family ipv4 neighbor 5.5.5.5 activate neighbor 5.5.5.5 send-label neighbor 5.5.5.5 next-hop-self neighbor 192.1.68.8 activate neighbor 192.1.68.8 send-label no auto-summary no synchronization network 3.3.3.3 mask 255.255.255.255 network 5.5.5.5 mask 255.255.255.255 network 6.6.6.6 mask 255.255.255.255 exit-address-family ! ip prefix-list LOOPBACK seq 5 permit</pre>

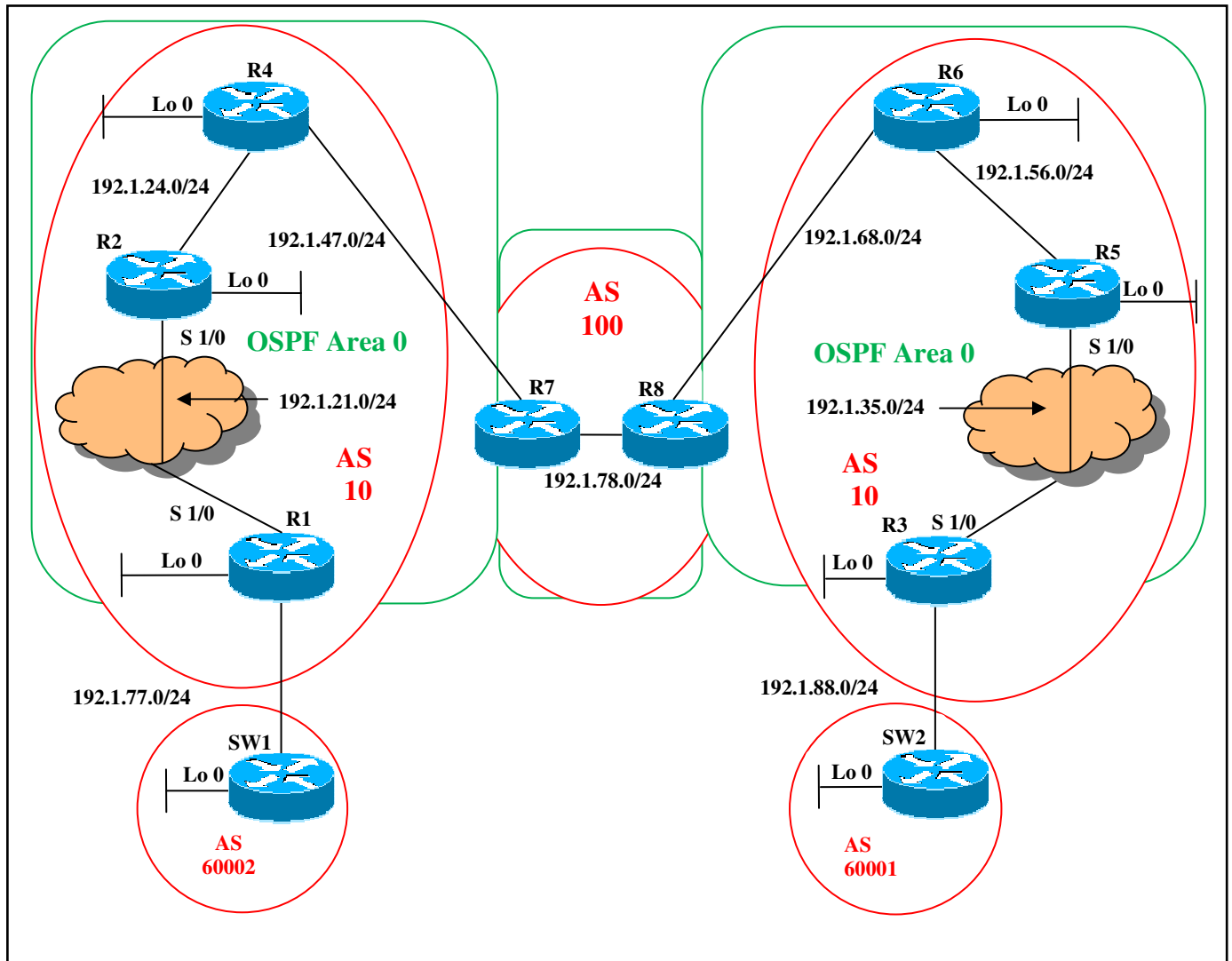
<pre> ip prefix-list LOOPBACK seq 15 permit 7.7.7.7/32 ip prefix-list LOOPBACK seq 20 permit 8.8.8.8/32 ip prefix-list LOOPBACK seq 25 permit 6.6.6.6/32 ! route-map FROM_BGP_TO_OSPF permit 10 match ip address prefix-list LOOPBACK </pre>	<pre> 2.2.2.2/32 ip prefix-list LOOPBACK seq 10 permit 1.1.1.1/32 ip prefix-list LOOPBACK seq 15 permit 7.7.7.7/32 ip prefix-list LOOPBACK seq 20 permit 8.8.8.8/32 ip prefix-list LOOPBACK seq 25 permit 4.4.4.4/32 ! route-map FROM_BGP_TO_OSPF permit 10 match ip address prefix-list LOOPBACK </pre>
<p><b>R7</b></p> <pre> interface Ethernet0/0.47 encapsulation dot1Q 47 ip address 192.1.47.7 255.255.255.0 ! interface Ethernet0/0.78 encapsulation dot1Q 78 ip address 192.1.78.7 255.255.255.0 no snmp trap link-status  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.78.7 0.0.0.0 area 0 ! router bgp 100 no synchronization bgp router-id 7.7.7.7 bgp log-neighbor-changes network 7.7.7.7 mask 255.255.255.255 neighbor 8.8.8.8 remote-as 100 neighbor 8.8.8.8 update-source Loopback0 neighbor 8.8.8.8 next-hop-self neighbor 8.8.8.8 send-label neighbor 192.1.47.4 remote-as 10 neighbor 192.1.47.4 send-label no auto-summary </pre>	<p><b>R8</b></p> <pre> interface Ethernet0/0.68 encapsulation dot1Q 68 ip address 192.1.68.8 255.255.255.0 ! interface Ethernet0/0.78 encapsulation dot1Q 78 ip address 192.1.78.8 255.255.255.0  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 network 192.1.78.8 0.0.0.0 area 0 ! router bgp 100 no synchronization bgp router-id 8.8.8.8 bgp log-neighbor-changes network 8.8.8.8 mask 255.255.255.255 neighbor 7.7.7.7 remote-as 100 neighbor 7.7.7.7 update-source Loopback0 neighbor 7.7.7.7 next-hop-self neighbor 7.7.7.7 send-label neighbor 192.1.68.6 remote-as 20 neighbor 192.1.68.6 send-label no auto-summary </pre>



SW1	SW2
<pre>interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary</pre>	<pre>interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router rip version 2 network 88.0.0.0 network 192.1.88.0 no auto-summary</pre>

# **Module 6 – Carrier Supporting Carrier**

# Lab 1 – CSC – Only IP Customer Carrier



## Task 1

Configure **MPLS Carrier Supporting Carrier**, AS 100 will be the **backbone carrier** and AS 10 the **customer carrier** providing transit between the ASs 60002 and 60001. Configure a VRF called **CSC** in the **backbone carrier** routers R7 and R8.

R1	R3
<pre> ip cef no ip domain lookup tag-switching tdp router-id Loopback0 ! interface Loopback0                     </pre>	<pre> ip cef no ip domain lookup tag-switching tdp router-id Loopback0 ! interface Loopback0                     </pre>

<pre> ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.77.1 255.255.255.0 half-duplex ! interface Serial1/0 ip address 192.1.21.1 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point serial restart-delay 0 frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 2.2.2.2 remote-as 10 neighbor 2.2.2.2 update-source Loopback0 neighbor 2.2.2.2 next-hop-self neighbor 192.1.77.7 remote-as 60002 no auto-summary </pre>	<pre> ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.88.3 255.255.255.0 half-duplex ! ! interface Serial1/0 ip address 192.1.35.3 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point serial restart-delay 0 frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 5.5.5.5 remote-as 10 neighbor 5.5.5.5 update-source Loopback0 neighbor 5.5.5.5 next-hop-self neighbor 192.1.88.8 remote-as 60001 no auto-summary </pre>
<p><b>R4</b></p> <pre> ip cef no ip domain lookup mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup mpls label range 600 699 mpls label protocol ldp ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! </pre>

<pre> interface Ethernet0/0.24  encapsulation dot1Q 24  ip address 192.1.24.4 255.255.255.0  tag-switching ip  no cdp enable  ! interface Ethernet0/0.47  encapsulation dot1Q 47  ip address 192.1.47.4 255.255.255.0  mpls ldp discovery transport-address interface  tag-switching ip  no cdp enable  ! router ospf 1  router-id 4.4.4.4  log-adjacency-changes  network 4.4.4.4 0.0.0.0 area 0  network 192.1.24.4 0.0.0.0 area 0  network 192.1.47.4 0.0.0.0 area 0  ! router bgp 10  no synchronization  bgp router-id 4.4.4.4  bgp log-neighbor-changes  neighbor 2.2.2.2 remote-as 10  neighbor 2.2.2.2 update-source Loopback0  neighbor 2.2.2.2 route-reflector-client  neighbor 6.6.6.6 remote-as 10  neighbor 6.6.6.6 update-source Loopback0  neighbor 6.6.6.6 route-reflector-client  no auto-summary </pre>	<pre> interface FastEthernet0/0.56  encapsulation dot1Q 56  ip address 192.1.56.6 255.255.255.0  no ip directed-broadcast  tag-switching ip  no cdp enable  ! interface FastEthernet0/0.68  encapsulation dot1Q 68  ip address 192.1.68.6 255.255.255.0  no ip directed-broadcast  mpls ldp discovery transport-address interface  tag-switching ip  no cdp enable  ! router ospf 1  router-id 6.6.6.6  log-adjacency-changes  network 6.6.6.6 0.0.0.0 area 0  network 192.1.56.6 0.0.0.0 area 0  network 192.1.68.6 0.0.0.0 area 0  ! router bgp 10  no synchronization  bgp router-id 6.6.6.6  bgp log-neighbor-changes  neighbor 4.4.4.4 remote-as 10  neighbor 4.4.4.4 update-source Loopback0  neighbor 4.4.4.4 route-reflector-client  neighbor 5.5.5.5 remote-as 10  neighbor 5.5.5.5 update-source Loopback0  neighbor 5.5.5.5 route-reflector-client  no auto-summary </pre>
<pre> <b>R2</b>  ip cef no ip domain lookup tag-switching tdp router-id Loopback0 ! interface Loopback0  ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0  ip address 192.1.24.2 255.255.255.0  half-duplex </pre>	<pre> <b>R5</b>  ip cef no ip domain-lookup  interface Loopback0  ip address 5.5.5.5 255.255.255.255  no ip directed-broadcast  ! interface FastEthernet0/0  ip address 192.1.56.5 255.255.255.0  no ip directed-broadcast </pre>

<pre> ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point serial restart-delay 0 frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 2.2.2.2 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 route-reflector-client neighbor 4.4.4.4 remote-as 10 neighbor 4.4.4.4 update-source Loopback0 neighbor 4.4.4.4 route-reflector-client no auto-summary </pre>	<pre> ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 no ip directed-broadcast encapsulation frame-relay ip ospf network point-to-point serial restart-delay 0 frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 5.5.5.5 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 route-reflector-client neighbor 6.6.6.6 remote-as 10 neighbor 6.6.6.6 update-source Loopback0 neighbor 6.6.6.6 route-reflector-client no auto-summary ! tag-switching tdp router-id Loopback0 </pre>
<p><b>R7</b></p> <pre> ip cef no ip domain lookup ip vrf CSC rd 100:78 route-target export 100:78 route-target import 100:78 ! mpls label range 700 799 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 7.7.7.7 255.255.255.255 </pre>	<p><b>R8</b></p> <pre> ip cef no ip domain lookup ip vrf CSC rd 100:78 route-target export 100:78 route-target import 100:78 ! mpls label range 800 899 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 8.8.8.8 255.255.255.255 </pre>

```

!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.47
encapsulation dot1Q 47
ip vrf forwarding CSC
ip address 192.1.47.7 255.255.255.0
mpls ldp discovery transport-address
interface
tag-switching ip
no cdp enable
!
interface Ethernet0/0.78
encapsulation dot1Q 78
ip address 192.1.78.7 255.255.255.0
tag-switching ip
no cdp enable
!
router ospf 1
router-id 7.7.7.7
log-adjacency-changes
network 7.7.7.7 0.0.0.0 area 0
network 192.1.78.7 0.0.0.0 area 0
!
router ospf 2 vrf CSC
log-adjacency-changes
redistribute bgp 100 subnets
network 192.1.47.7 0.0.0.0 area 0
!
router bgp 100
no synchronization
bgp router-id 7.7.7.7
bgp log-neighbor-changes
neighbor 8.8.8.8 remote-as 100
neighbor 8.8.8.8 update-source Loopback0
no auto-summary
!
address-family vpnv4
neighbor 8.8.8.8 activate
neighbor 8.8.8.8 send-community both
exit-address-family
!
address-family ipv4 vrf CSC
redistribute ospf 2

```

```

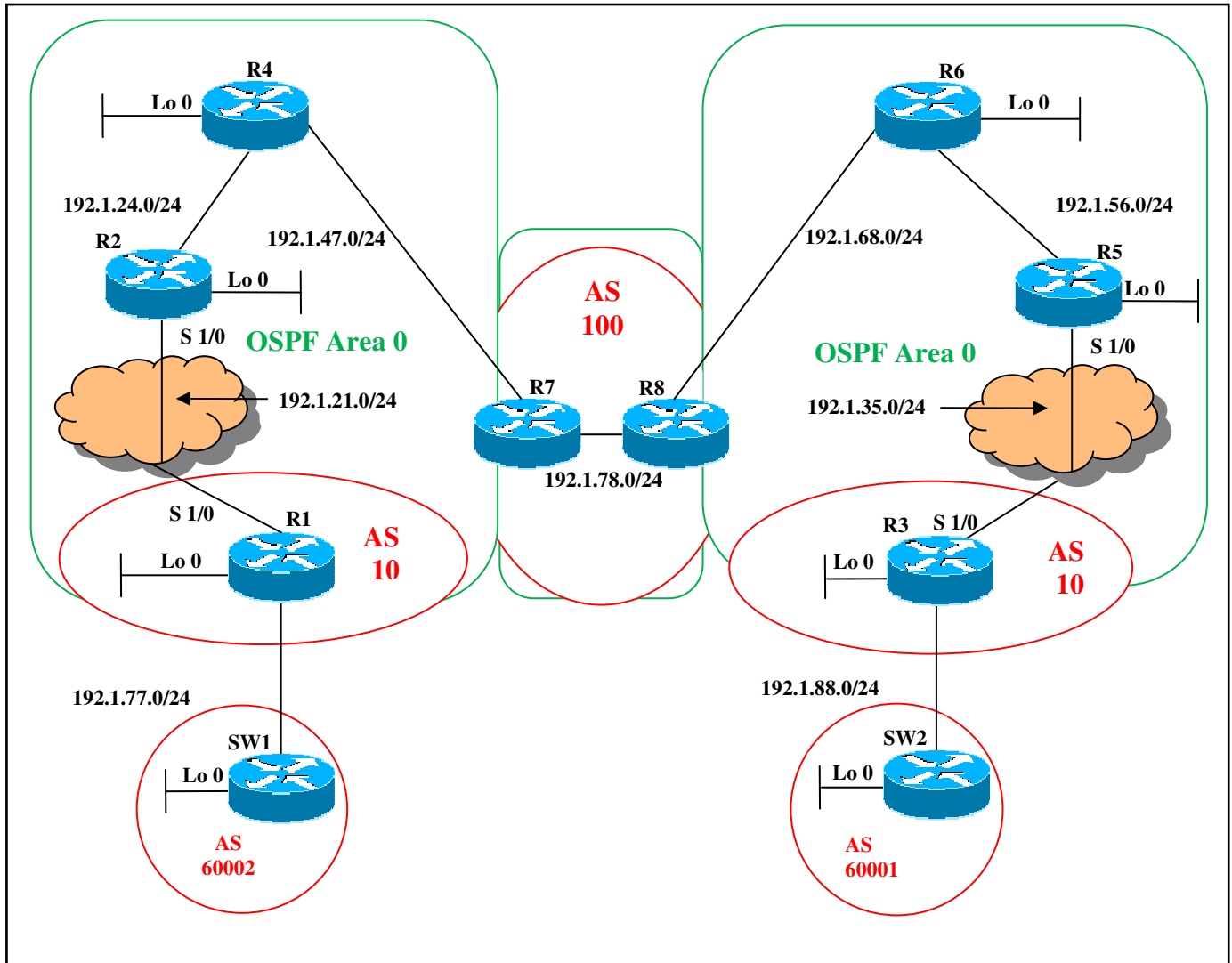
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.68
encapsulation dot1Q 68
ip vrf forwarding CSC
ip address 192.1.68.8 255.255.255.0
mpls ldp discovery transport-address
interface
tag-switching ip
no cdp enable
!
interface Ethernet0/0.78
encapsulation dot1Q 78
ip address 192.1.78.8 255.255.255.0
tag-switching ip
no cdp enable
!
router ospf 1
router-id 8.8.8.8
log-adjacency-changes
network 8.8.8.8 0.0.0.0 area 0
network 192.1.78.8 0.0.0.0 area 0
!
router ospf 2 vrf CSC
log-adjacency-changes
redistribute bgp 100 subnets
network 192.1.68.8 0.0.0.0 area 0
!
router bgp 100
no synchronization
bgp router-id 8.8.8.8
bgp log-neighbor-changes
neighbor 7.7.7.7 remote-as 100
neighbor 7.7.7.7 update-source Loopback0
no auto-summary
!
address-family vpnv4
neighbor 7.7.7.7 activate
neighbor 7.7.7.7 send-community both
exit-address-family
!
address-family ipv4 vrf CSC
redistribute ospf 2

```

no auto-summary no synchronization exit-address-family	no auto-summary no synchronization exit-address-family
<b>SW1</b>  interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router bgp 60002 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.0 mask 255.255.255.0 neighbor 192.1.77.1 remote-as 10 no auto-summary	<b>SW2</b>  interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router bgp 60001 no synchronization bgp router-id 88.88.88.88 bgp log-neighbor-changes network 88.88.88.0 mask 255.255.255.0 neighbor 192.1.88.3 remote-as 10 no auto-summary



# Lab 2 – CSC – MPLS Enabled Customer Carrier



## Task 1

Configure **MPLS Carrier Supporting Carrier**, AS 100 will be the **backbone carrier** and AS 10 as being the **MPLS customer carrier** providing transit between the ASs **60002** and **60001**.

Configure a VRF called **CSC** in the **backbone carrier** routers **R7** and **R8**.

R1	R3
<pre>ip cef no ip domain lookup mpls label range 100 199 mpls label protocol ldp</pre>	<pre>ip cef no ip domain lookup mpls label range 300 399 mpls label protocol ldp</pre>

<pre> tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.77.1 255.255.255.0 half-duplex !! interface Serial1/0 ip address 192.1.21.1 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self neighbor 192.1.77.7 remote-as 60002 no auto-summary </pre>	<pre> tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.88.3 255.255.255.0 half-duplex ! interface Serial1/0 ip address 192.1.35.3 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self neighbor 192.1.88.8 remote-as 60001 no auto-summary </pre>
<p><b>R4</b></p> <pre> ip cef no ip domain lookup mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup  mpls label range 600 699 mpls label protocol ldp ! ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 no ip directed-broadcast </pre>

<pre> no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 tag-switching ip no cdp enable ! interface Ethernet0/0.47 encapsulation dot1Q 47 ip address 192.1.47.4 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip no cdp enable ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.47.4 0.0.0.0 area 0 </pre>	<pre> ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.68 encapsulation dot1Q 68 ip address 192.1.68.6 255.255.255.0 no ip directed-broadcast mpls ldp discovery transport-address interface tag-switching ip no cdp enable ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 network 192.1.68.6 0.0.0.0 area 0 </pre>
<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 half-duplex tag-switching ip ! ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 </pre>	<p><b>R5</b></p> <pre> ip cef no ip domain-lookup  mpls label range 500 599 mpls label protocol ldp ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 no ip directed-broadcast tag-switching ip ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 </pre>

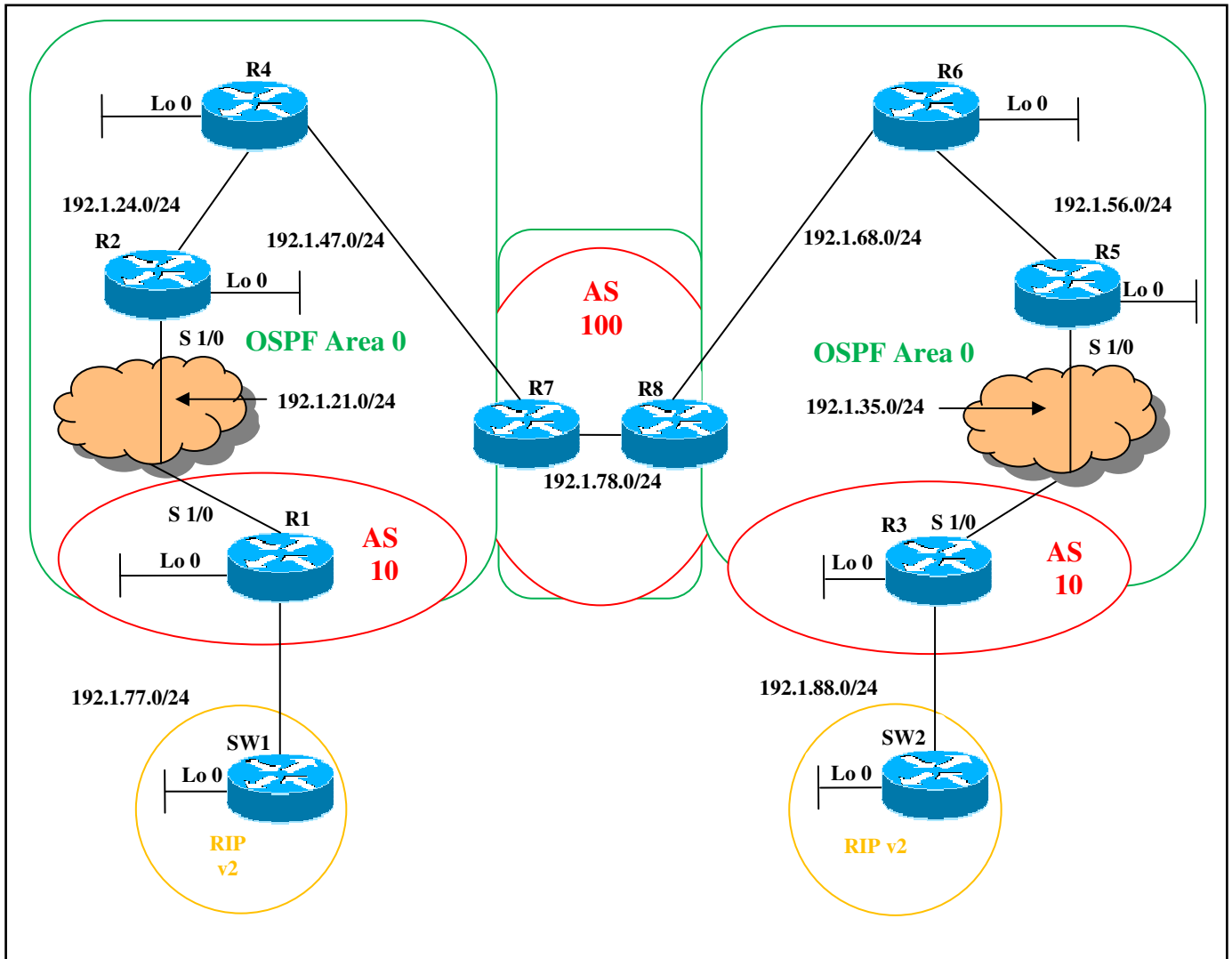
<pre> encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 ! </pre>	<pre> no ip directed-broadcast encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0 </pre>
<p><b>R7</b></p> <pre> ip cef no ip domain lookup ip vrf CSC rd 100:78 route-target export 100:78 route-target import 100:78 ! mpls label range 700 799 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 7.7.7.7 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.47 encapsulation dot1Q 47 ip vrf forwarding CSC ip address 192.1.47.7 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip </pre>	<p><b>R8</b></p> <pre> ip cef no ip domain lookup ip vrf CSC rd 100:78 route-target export 100:78 route-target import 100:78 ! mpls label range 800 899 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 8.8.8.8 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.68 encapsulation dot1Q 68 ip vrf forwarding CSC ip address 192.1.68.8 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip </pre>

<pre> no cdp enable ! interface Ethernet0/0.78 encapsulation dot1Q 78 ip address 192.1.78.7 255.255.255.0 tag-switching ip no cdp enable ! router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.78.7 0.0.0.0 area 0 ! router ospf 2 vrf CSC log-adjacency-changes redistribute bgp 100 subnets network 192.1.47.7 0.0.0.0 area 0 ! router bgp 100 no synchronization bgp router-id 7.7.7.7 bgp log-neighbor-changes neighbor 8.8.8.8 remote-as 100 neighbor 8.8.8.8 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 8.8.8.8 activate neighbor 8.8.8.8 send-community both exit-address-family ! address-family ipv4 vrf CSC redistribute ospf 2 no auto-summary no synchronization exit-address-family </pre>	<pre> no cdp enable ! interface Ethernet0/0.78 encapsulation dot1Q 78 ip address 192.1.78.8 255.255.255.0 tag-switching ip no cdp enable ! router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.78.8 0.0.0.0 area 0 ! router ospf 2 vrf CSC log-adjacency-changes redistribute bgp 100 subnets network 192.1.68.8 0.0.0.0 area 0 ! router bgp 100 no synchronization bgp router-id 8.8.8.8 bgp log-neighbor-changes neighbor 7.7.7.7 remote-as 100 neighbor 7.7.7.7 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 7.7.7.7 activate neighbor 7.7.7.7 send-community both exit-address-family ! address-family ipv4 vrf CSC redistribute ospf 2 no auto-summary no synchronization exit-address-family </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router bgp 60002 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router bgp 60001 </pre>

```
no synchronization
bgp router-id 77.77.77.77
bgp log-neighbor-changes
network 77.77.77.0 mask 255.255.255.0
neighbor 192.1.77.1 remote-as 10
no auto-summary
```

```
no synchronization
bgp router-id 88.88.88.88
bgp log-neighbor-changes
network 88.88.88.0 mask 255.255.255.0
neighbor 192.1.88.3 remote-as 10
no auto-summary
```

# Lab 3 – CSC – MPLS Hierarchical VPNs



## Task 1

Configure **MPLS Carrier Supporting Carrier**, AS 100 will be the **backbone carrier** and AS 10 as being the **MPLS customer carrier** providing transit between the ASs 60002 and 60001.

Configure a VRF called **CSC** in the **backbone carrier** routers R7 and R8.

Configure a VRF in the **PEs** R1 and R3 called **MARKETING** and make sure SW1 and SW2 can see their loopbacks through RIP.

R1	R3
<pre>ip cef no ip domain lookup</pre>	<pre>ip cef no ip domain lookup</pre>

```

ip vrf MARKETING
rd 10:80
route-target export 10:80
route-target import 10:80
!
mpls label range 100 199
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
ip vrf forwarding MARKETING
ip address 192.1.77.1 255.255.255.0
half-duplex
!
interface Serial1/0
ip address 192.1.21.1 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.21.2 102
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.21.1 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf MARKETING
redistribute bgp 10 metric 1
network 192.1.77.0
no auto-summary
version 2
exit-address-family
!
router bgp 10
no synchronization
bgp router-id 1.1.1.1
bgp log-neighbor-changes

```

```

ip vrf MARKETING
rd 10:80
route-target export 10:80
route-target import 10:80
!
mpls label range 300 399
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
ip vrf forwarding MARKETING
ip address 192.1.88.3 255.255.255.0
half-duplex
!
interface Serial1/0
ip address 192.1.35.3 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.35.5 305
broadcast
no frame-relay inverse-arp
!!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.35.3 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf MARKETING
redistribute bgp 10 metric 1
network 192.1.88.0
no auto-summary
version 2
exit-address-family
!
router bgp 10
no synchronization
bgp router-id 3.3.3.3
bgp log-neighbor-changes

```



<pre> neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended exit-address-family ! address-family ipv4 vrf MARKETING redistribute rip no auto-summary no synchronization exit-address-family </pre>	<pre> neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf MARKETING redistribute rip no auto-summary no synchronization exit-address-family </pre>
<p><b>R4</b></p> <pre> ip cef no ip domain lookup mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 tag-switching ip no cdp enable ! interface Ethernet0/0.47 encapsulation dot1Q 47 ip address 192.1.47.4 255.255.255.0 mpls ldp discovery transport-address interface tag-switching ip no cdp enable ! </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup  mpls label range 600 699 mpls label protocol ldp ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.68 encapsulation dot1Q 68 ip address 192.1.68.6 255.255.255.0 no ip directed-broadcast mpls ldp discovery transport-address interface tag-switching ip </pre>

<pre> router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.47.4 0.0.0.0 area 0 !</pre>	<pre> no cdp enable ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 network 192.1.68.6 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0</pre>
<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 half-duplex tag-switching ip ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0!</pre>	<p><b>R5</b></p> <pre> ip cef no ip domain-lookup  mpls label range 500 599 mpls label protocol ldp ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 no ip directed-broadcast tag-switching ip ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 no ip directed-broadcast encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0</pre>

**R7**

```
ip cef
no ip domain lookup
ip vrf CSC
rd 100:78
route-target export 100:78
route-target import 100:78
!
mpls label range 700 799
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 7.7.7.7 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.47
encapsulation dot1Q 47
ip vrf forwarding CSC
ip address 192.1.47.7 255.255.255.0
mpls ldp discovery transport-address
interface
tag-switching ip
no cdp enable
!
interface Ethernet0/0.78
encapsulation dot1Q 78
ip address 192.1.78.7 255.255.255.0
tag-switching ip
no cdp enable
!
router ospf 1
router-id 7.7.7.7
log-adjacency-changes
network 7.7.7.7 0.0.0.0 area 0
network 192.1.78.7 0.0.0.0 area 0
!
router ospf 2 vrf CSC
log-adjacency-changes
redistribute bgp 100 subnets
network 192.1.47.7 0.0.0.0 area 0
!
```

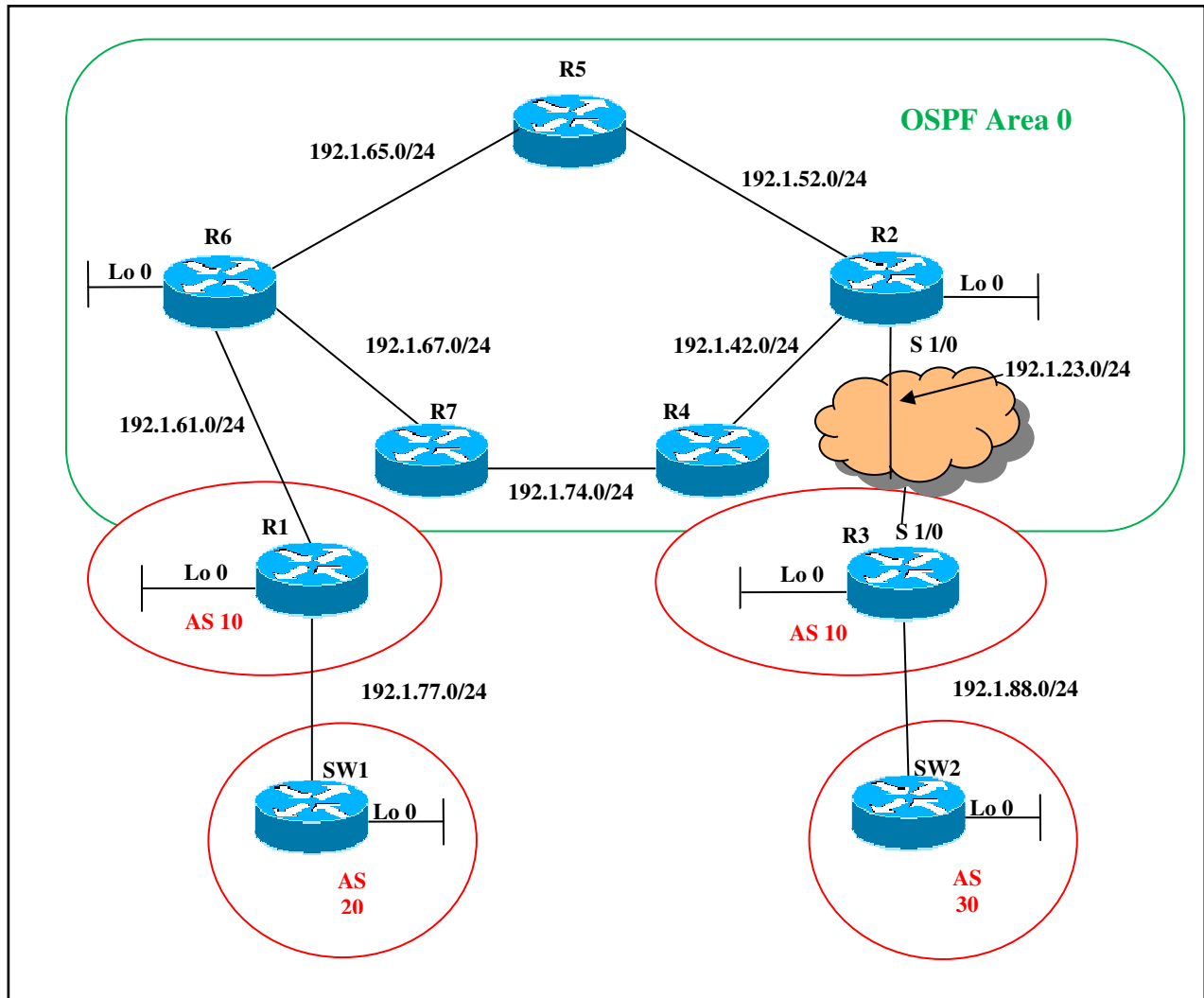
**R8**

```
ip cef
no ip domain lookup
ip vrf CSC
rd 100:78
route-target export 100:78
route-target import 100:78
!
mpls label range 800 899
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 8.8.8.8 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.68
encapsulation dot1Q 68
ip vrf forwarding CSC
ip address 192.1.68.8 255.255.255.0
mpls ldp discovery transport-address
interface
tag-switching ip
no cdp enable
!
interface Ethernet0/0.78
encapsulation dot1Q 78
ip address 192.1.78.8 255.255.255.0
tag-switching ip
no cdp enable
!
router ospf 1
router-id 8.8.8.8
log-adjacency-changes
network 8.8.8.8 0.0.0.0 area 0
network 192.1.78.8 0.0.0.0 area 0
!
router ospf 2 vrf CSC
log-adjacency-changes
redistribute bgp 100 subnets
network 192.1.68.8 0.0.0.0 area 0
!
```

<pre> router bgp 100 no synchronization bgp router-id 7.7.7.7 bgp log-neighbor-changes neighbor 8.8.8.8 remote-as 100 neighbor 8.8.8.8 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 8.8.8.8 activate neighbor 8.8.8.8 send-community both exit-address-family ! address-family ipv4 vrf CSC redistribute ospf 2 no auto-summary no synchronization exit-address-family </pre>	<pre> router bgp 100 no synchronization bgp router-id 8.8.8.8 bgp log-neighbor-changes neighbor 7.7.7.7 remote-as 100 neighbor 7.7.7.7 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 7.7.7.7 activate neighbor 7.7.7.7 send-community both exit-address-family ! address-family ipv4 vrf CSC redistribute ospf 2 no auto-summary no synchronization exit-address-family </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router rip version 2 network 88.0.0.0 network 192.1.88.0 no auto-summary </pre>

# **Module 7 – MPLS Traffic Engineering**

# Lab 1 – Dynamic PE to PE Tunnel



## Interface Configuration:

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.61	192.1.61.1	255.255.255.0
E 0/0.77	192.1.77.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.23.2	255.255.255.0
E 0/0.42	192.1.42.2	255.255.255.0
E 0/0.52	192.1.52.2	255.255.255.0

**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.23.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.42	192.1.42.4	255.255.255.0
E 0/0.74	192.1.74.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0	192.1.56.5	255.255.255.0
S 1/0	192.1.35.5	255.255.255.0

**R6**

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.52	192.1.52.6	255.255.255.0
E 0/0.65	192.1.65.6	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0.67	192.1.67.7	255.255.255.0
E 0/0.74	192.1.74.7	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

**SW2**

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

## Task 1

Enable support for MPLS Traffic Engineering on all possible transit interfaces in the MPLS network; also make sure RSVP is enabled on all the transit interfaces.

A tunnel needs to be created in the PEs (**R1** and **R3**) and should source from their loopbacks to transport the VPNv4 routes from the CEs (SW1 and SW2).

You need to configure the PEs in such a way that a path for this **tunnel is dynamically** selected whenever the Tunnel is up and running.

Also the path throughout the MPLS network should be selected dynamically by the Tunnel.

Also configure the tunnel with a **priority of 1** and **reserve 4 Mbps** in the MPLS network for this Tunnel.

*Note that the serial connection between R2 and R3 is a SONET – OC1 (51 Mbps).*

R1	R3
<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! mpls label range 100 199 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Tunnel0 ip unnumbered Loopback0 tunnel destination 3.3.3.3 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 dynamic no routing dynamic ! interface Loopback0 ip address 1.1.1.1 255.255.255.255  interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.61 encapsulation dot1Q 61</pre>	<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7  mpls label range 300 399 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  Interface Tunnel0 ip unnumbered Loopback0 tunnel destination 1.1.1.1 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 dynamic no routing dynamic ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.88 encapsulation dot1Q 88</pre>



```

ip address 192.1.61.1 255.255.255.0
mpls traffic-eng tunnels
tag-switching ip
ip rsvp bandwidth 10000 10000
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding BLUE
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
network 192.1.17.1 0.0.0.0 area 0
!
router ospf 1
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 0
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.61.1 0.0.0.0 area 0
!
router bgp 10
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
!
address-family ipv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 next-hop-self
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
neighbor 192.1.77.7 remote-as 20
neighbor 192.1.77.7 activate
no auto-summary
no synchronization
exit-address-family

```

```

ip vrf forwarding BLUE
ip address 192.1.88.3 255.255.255.0
no cdp enable
!
interface Serial1/0
bandwidth 51000
ip address 192.1.23.3 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
mpls traffic-eng tunnels
tag-switching ip
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp
ip rsvp bandwidth 51000 51000

router ospf 1
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 0
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router bgp 10
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 192.1.88.8 remote-as 30
!
address-family ipv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 next-hop-self
no neighbor 192.1.88.8 activate
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
neighbor 192.1.88.8 remote-as 30
neighbor 192.1.88.8 activate
no auto-summary
no synchronization
exit-address-family

```

**R4**

```
mpls label range 400 499
mpls label protocol ldp
mpls traffic-eng tunnels
tag-switching tdp router-id Loopback0
no ftp-server write-enable
!
interface Loopback0
 ip address 4.4.4.4 255.255.255.255
!
interface Ethernet0/0
 no ip address
 half-duplex
!
interface Ethernet0/0.42
 encapsulation dot1Q 42
 ip address 192.1.42.4 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 no cdp enable
 ip rsvp bandwidth 10000 10000
!
interface Ethernet0/0.74
 encapsulation dot1Q 74
 ip address 192.1.74.4 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 no cdp enable
 ip rsvp bandwidth 10000 10000

router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 4.4.4.4
 log-adjacency-changes
 network 4.4.4.4 0.0.0.0 area 0
 network 192.1.42.4 0.0.0.0 area 0
 network 192.1.74.4 0.0.0.0 area 0
```

**R6**

```
mpls label range 600 699
mpls label protocol ldp
mpls ldp logging neighbor-changes
mpls traffic-eng tunnels
tag-switching tdp router-id Loopback0
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
!
interface FastEthernet0/0
!
interface FastEthernet0/0.61
 encapsulation dot1Q 61
 ip address 192.1.61.6 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 no cdp enable
 ip rsvp bandwidth 100000 100000
!
interface FastEthernet0/0.65
 encapsulation dot1Q 65
 ip address 192.1.65.6 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 no cdp enable
 ip rsvp bandwidth 100000 100000
!
interface FastEthernet0/0.67
 encapsulation dot1Q 67
 ip address 192.1.67.6 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 no cdp enable
 ip rsvp bandwidth 100000 100000

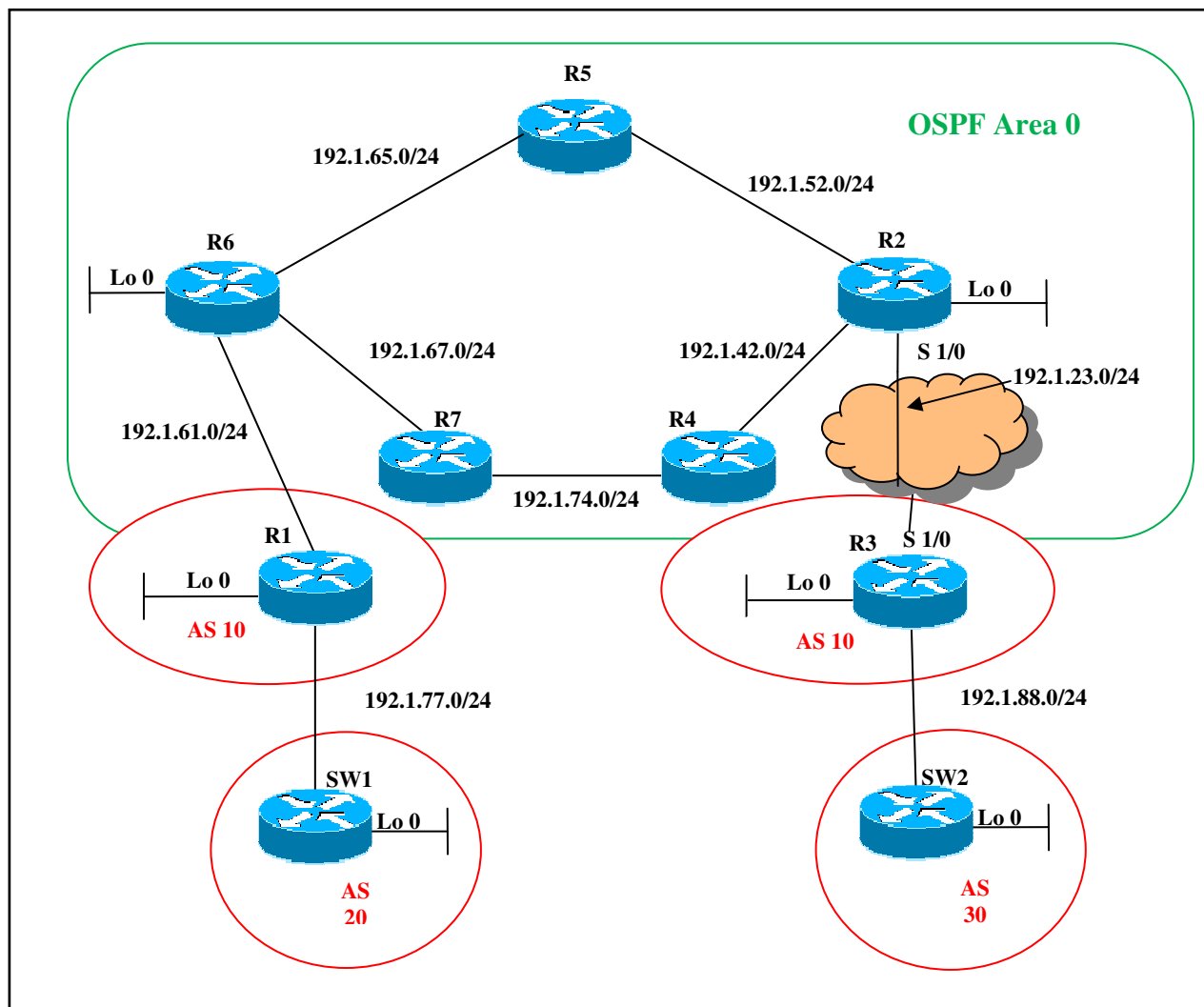
router ospf 1
 router-id 6.6.6.6
 log-adjacency-changes
 network 6.6.6.6 0.0.0.0 area 0
 network 192.1.61.6 0.0.0.0 area 0
 network 192.1.65.6 0.0.0.0 area 0
 network 192.1.67.6 0.0.0.0 area 0
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
```

<p><b>R7</b></p> <pre> mpls label range 700 799 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.74 encapsulation dot1Q 74 ip address 192.1.74.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.67.7 0.0.0.0 area 0 network 192.1.74.7 0.0.0.0 area 0 </pre>	<p><b>R5</b></p> <pre> mpls label range 500 599 mpls label protocol ldp mpls ldp logging neighbor-changes mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000  router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 </pre>
<p><b>R2</b></p> <pre> mpls label range 200 299 mpls label protocol ldp mpls traffic-eng tunnels </pre>	<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0 </pre>

<pre> tag-switching tdp router-id Loopback0  interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.42 encapsulation dot1Q 42 ip address 192.1.42.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.23.2 0.0.0.0 area 0 network 192.1.42.2 0.0.0.0 area 0 network 192.1.52.2 0.0.0.0 area 0 </pre>	<pre> interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router bgp 20 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.0 mask 255.255.255.0 neighbor 192.1.77.1 remote-as 10 no auto-summary ! ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>
<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router bgp 30 no synchronization bgp router-id 88.88.88.88 </pre>	

```
bgp log-neighbor-changes
network 88.88.88.0 mask 255.255.255.0
neighbor 192.1.88.3 remote-as 10
no auto-summary
!
ip route 0.0.0.0 0.0.0.0 192.1.88.3
```

## Lab 2 – Explicit PE to PE Tunnel



### Interface Configuration:

#### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.61	192.1.61.1	255.255.255.0
E 0/0.77	192.1.77.1	255.255.255.0

#### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.23.2	255.255.255.0
E 0/0.42	192.1.42.2	255.255.255.0
E 0/0.52	192.1.52.2	255.255.255.0

**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.23.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.42	192.1.42.4	255.255.255.0
E 0/0.74	192.1.74.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0	192.1.56.5	255.255.255.0
S 1/0	192.1.35.5	255.255.255.0

**R6**

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.52	192.1.52.6	255.255.255.0
E 0/0.65	192.1.65.6	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0.67	192.1.67.7	255.255.255.0
E 0/0.74	192.1.74.7	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

**SW2**

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

## Task 1

Enable support for MPLS Traffic Engineering on all possible transit interfaces in the MPLS network; also make sure RSVP is enabled on all the transit interfaces.

A tunnel needs to be created in the PEs (**R1** and **R3**) and should source from their loopbacks to transport the VPNv4 routes from the **CEs** (**SW1** and **SW2**).

You need to configure the **PEs** in such a way that the following path should be explicit selected by the tunnel whenever the Tunnel is up and running (**Traffic should go from R1 to R6, R7, R4, R2 and R3**, make sure to configure the same path to the way back). Also the path throughout the MPLS network should be selected dynamically by the Tunnel.

Also configure the tunnel with a **priority of 1** and **reserve 4 Mbps** in the MPLS network for this Tunnel.

*Note that the serial connection between R2 and R3 is a SONET – OC1 (51 Mbps).*

<b>R1</b>	<b>R3</b>
<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! mpls label range 100 199 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Tunnel0 ip unnumbered Loopback0 tunnel destination 3.3.3.3 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 explicit name FROM_R1_TO_R3_LONG_PATH no routing dynamic ! interface Loopback0 ip address 1.1.1.1 255.255.255.255  interface Ethernet0/0 no ip address half-duplex</pre>	<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7  mpls label range 300 399 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Tunnel0 ip unnumbered Loopback0 tunnel destination 1.1.1.1 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 explicit name FROM_R3_TO_R1_LONG_PATH no routing dynamic ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex</pre>



```

!
interface Ethernet0/0.61
 encapsulation dot1Q 61
 ip address 192.1.61.1 255.255.255.0
 mpls traffic-eng tunnels
 tag-switching ip
 ip rsvp bandwidth 10000 10000
!
interface Ethernet0/0.77
 encapsulation dot1Q 77
 ip vrf forwarding BLUE
 ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
 log-adjacency-changes
 network 192.1.17.1 0.0.0.0 area 0
!
router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 1.1.1.1
 log-adjacency-changes
 network 1.1.1.1 0.0.0.0 area 0
 network 192.1.61.1 0.0.0.0 area 0
!
router bgp 10
 bgp router-id 1.1.1.1
 bgp log-neighbor-changes
 neighbor 3.3.3.3 remote-as 10
 neighbor 3.3.3.3 update-source Loopback0
!
 address-family ipv4
  neighbor 3.3.3.3 activate
  neighbor 3.3.3.3 next-hop-self
 no auto-summary
 no synchronization
 exit-address-family
!
 address-family ipv4 vrf BLUE
  neighbor 192.1.77.7 remote-as 20
  neighbor 192.1.77.7 activate
 no auto-summary
 no synchronization
 exit-address-family

ip explicit-path name

```

```

!
interface Ethernet0/0.88
 encapsulation dot1Q 88
 ip vrf forwarding BLUE
 ip address 192.1.88.3 255.255.255.0
 no cdp enable
!
interface Serial1/0
 bandwidth 51000
 ip address 192.1.23.3 255.255.255.0
 encapsulation frame-relay
 ip ospf network point-to-multipoint
 mpls traffic-eng tunnels
 tag-switching ip
 frame-relay map ip 192.1.23.2 302
 broadcast
 no frame-relay inverse-arp
 ip rsvp bandwidth 51000 51000

router ospf 1
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng area 0
 router-id 3.3.3.3
 log-adjacency-changes
 network 3.3.3.3 0.0.0.0 area 0
 network 192.1.23.3 0.0.0.0 area 0
!
router bgp 10
 bgp router-id 3.3.3.3
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 10
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 192.1.88.8 remote-as 30
!
 address-family ipv4
  neighbor 1.1.1.1 activate
  neighbor 1.1.1.1 next-hop-self
 no neighbor 192.1.88.8 activate
 no auto-summary
 no synchronization
 exit-address-family
!
 address-family ipv4 vrf BLUE
  neighbor 192.1.88.8 remote-as 30
  neighbor 192.1.88.8 activate
 no auto-summary

```

<pre>FROM_R1_TO_R3_LONG_PATH enable next-address 192.1.61.6 next-address 192.1.67.7 next-address 192.1.74.4 next-address 192.1.42.2 next-address 192.1.23.3 next-address 3.3.3.3</pre>	<pre>no synchronization exit-address-family  ip explicit-path name FROM_R3_TO_R1_LONG_PATH enable next-address 192.1.23.2 next-address 192.1.42.4 next-address 192.1.74.7 next-address 192.1.67.6 next-address 192.1.61.1 next-address 1.1.1.1</pre>
<pre><b>R4</b>  mpls label range 400 499 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0 no ftp-server write-enable ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.42 encapsulation dot1Q 42 ip address 192.1.42.4 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.74 encapsulation dot1Q 74 ip address 192.1.74.4 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 4.4.4.4</pre>	<pre><b>R6</b>  mpls label range 600 699 mpls label protocol ldp mpls ldp logging neighbor-changes mpls traffic-eng tunnels tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 ! interface FastEthernet0/0.61 encapsulation dot1Q 61 ip address 192.1.61.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable</pre>

<pre>log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.42.4 0.0.0.0 area 0 network 192.1.74.4 0.0.0.0 area 0</pre>	<pre>ip rsvp bandwidth 100000 100000  router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.61.6 0.0.0.0 area 0 network 192.1.65.6 0.0.0.0 area 0 network 192.1.67.6 0.0.0.0 area 0 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0</pre>
<p><b>R7</b></p> <pre>mpls label range 700 799 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.74 encapsulation dot1Q 74 ip address 192.1.74.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0</pre>	<p><b>R5</b></p> <pre>mpls label range 500 599 mpls label protocol ldp mpls ldp logging neighbor-changes mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000  router ospf 1 router-id 5.5.5.5 log-adjacency-changes</pre>

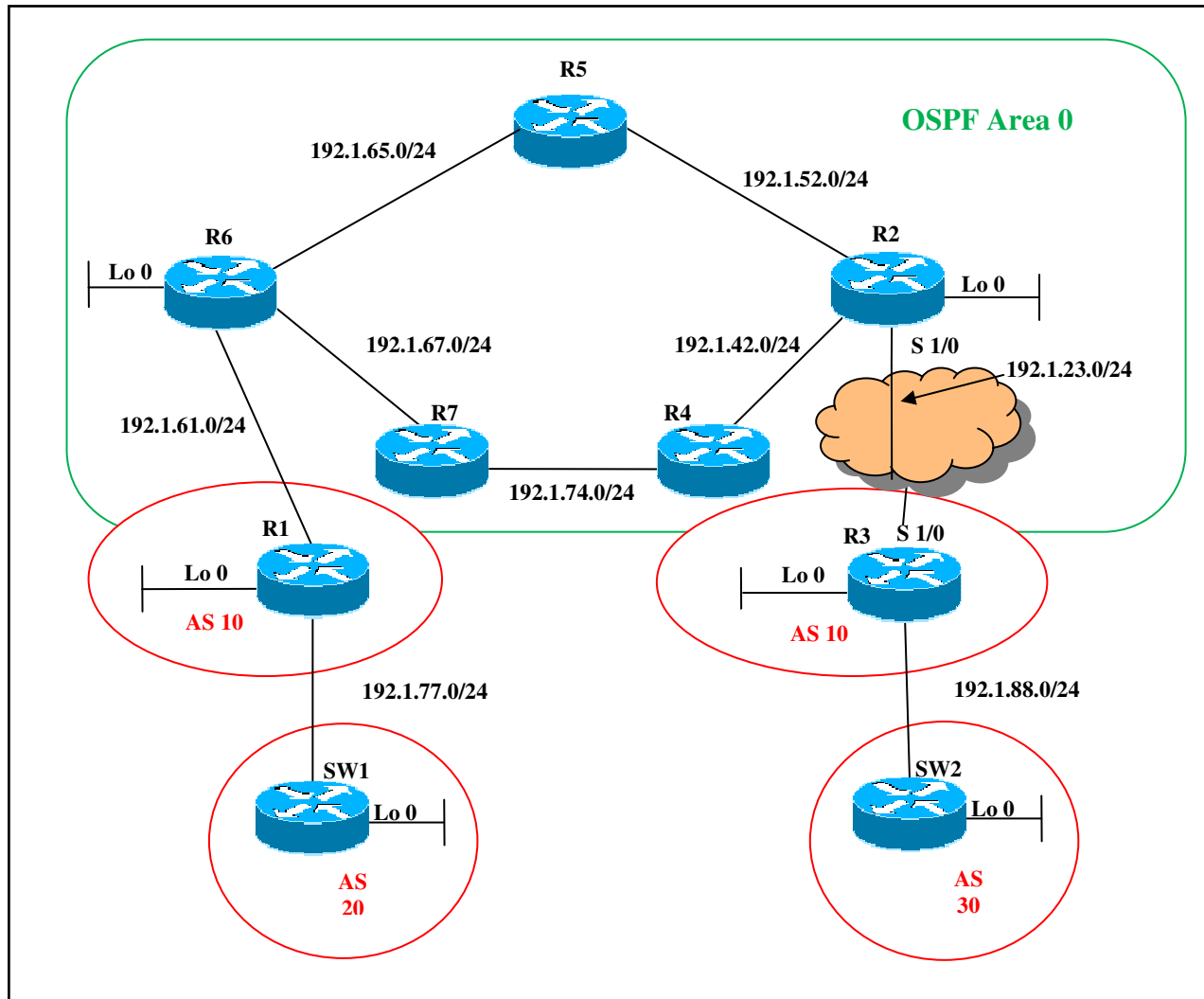
<pre> router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.67.7 0.0.0.0 area 0 network 192.1.74.7 0.0.0.0 area 0 </pre>	<pre> network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 </pre>
<p><b>R2</b></p> <pre> mpls label range 200 299 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.42 encapsulation dot1Q 42 ip address 192.1.42.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.23.2 0.0.0.0 area 0 network 192.1.42.2 0.0.0.0 area 0 network 192.1.52.2 0.0.0.0 area 0 </pre>	<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router bgp 20 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.0 mask 255.255.255.0 neighbor 192.1.77.1 remote-as 10 no auto-summary ! ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>

## SW2

```
interface Loopback0
ip address 88.88.88.88 255.255.255.0

interface Vlan88
ip address 192.1.88.8 255.255.255.0
!
router bgp 30
no synchronization
bgp router-id 88.88.88.88
bgp log-neighbor-changes
network 88.88.88.0 mask 255.255.255.0
neighbor 192.1.88.3 remote-as 10
no auto-summary
!
ip route 0.0.0.0 0.0.0.0 192.1.88.3
```

# Lab 3 – Unequal Cost Load Balancing



## Interface Configuration:

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.61	192.1.61.1	255.255.255.0
E 0/0.77	192.1.77.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.23.2	255.255.255.0
E 0/0.42	192.1.42.2	255.255.255.0
E 0/0.52	192.1.52.2	255.255.255.0

**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.23.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.42	192.1.42.4	255.255.255.0
E 0/0.74	192.1.74.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0	192.1.56.5	255.255.255.0
S 1/0	192.1.35.5	255.255.255.0

**R6**

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.52	192.1.52.6	255.255.255.0
E 0/0.65	192.1.65.6	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0.67	192.1.67.7	255.255.255.0
E 0/0.74	192.1.74.7	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

**SW2**

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

## Task 1

Enable support for MPLS Traffic Engineering on all possible transit interfaces in the MPLS network; also make sure RSVP is enabled on all the transit interfaces.

A tunnel needs to be created in the PEs (**R1** and **R3**) and should source from their loopbacks to transport the VPNv4 routes from the **CEs** (**SW1** and **SW2**).

You need to configure the **PEs** in such a way that **One-Fourth** of the traffic transmitted from **PEs** carrying the VPNv4 routes go through routers **R7** and **R4**.

Also configure the tunnel with a **priority of 1**.

*Note that the serial connection between R2 and R3 is a SONET – OC1 (51 Mbps).*

<b>R1</b>	<b>R3</b>
<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! mpls label range 100 199 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Tunnel0 ip unnumbered Loopback0 tunnel destination 3.3.3.3 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 explicit name FROM_R1_TO_R3_LONG_PATH no routing dynamic ! interface Tunnel1 ip unnumbered Loopback0 tunnel destination 3.3.3.3 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 1000 tunnel mpls traffic-eng path-option 1 dynamic no routing dynamic</pre>	<pre>ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7  mpls label range 300 399 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Tunnel0 ip unnumbered Loopback0 tunnel destination 1.1.1.1 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 4000 tunnel mpls traffic-eng path-option 1 explicit name FROM_R3_TO_R1_LONG_PATH no routing dynamic ! interface Tunnel1 ip unnumbered Loopback0 tunnel destination 1.1.1.1 tunnel mode mpls traffic-eng tunnel mpls traffic-eng autoroute announce tunnel mpls traffic-eng priority 1 1 tunnel mpls traffic-eng bandwidth 1000 tunnel mpls traffic-eng path-option 1 dynamic no routing dynamic</pre>



```

interface Loopback0
ip address 1.1.1.1 255.255.255.255

interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.1 255.255.255.0
mpls traffic-eng tunnels
tag-switching ip
ip rsvp bandwidth 10000 10000
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding BLUE
ip address 192.1.77.1 255.255.255.0

router ospf 7 vrf BLUE
log-adjacency-changes
network 192.1.17.1 0.0.0.0 area 0
!
router ospf 1
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 0
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.61.1 0.0.0.0 area 0
!
router bgp 10
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 10
neighbor 3.3.3.3 update-source Loopback0
!
address-family ipv4
neighbor 3.3.3.3 activate
neighbor 3.3.3.3 next-hop-self
no auto-summary
no synchronization
exit-address-family
!
address-family ipv4 vrf BLUE
neighbor 192.1.77.7 remote-as 20

```

```

interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding BLUE
ip address 192.1.88.3 255.255.255.0
no cdp enable
!
interface Serial1/0
bandwidth 51000
ip address 192.1.23.3 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-multipoint
mpls traffic-eng tunnels
tag-switching ip
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp
ip rsvp bandwidth 51000 51000

router ospf 1
mpls traffic-eng router-id Loopback0
mpls traffic-eng area 0
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router bgp 10
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 10
neighbor 1.1.1.1 update-source Loopback0
neighbor 192.1.88.8 remote-as 30
!
address-family ipv4
neighbor 1.1.1.1 activate
neighbor 1.1.1.1 next-hop-self
no neighbor 192.1.88.8 activate
no auto-summary
no synchronization

```

<pre> neighbor 192.1.77.7 activate no auto-summary no synchronization exit-address-family  ip explicit-path name FROM_R1_TO_R3_LONG_PATH enable next-address 192.1.61.6 next-address 192.1.67.7 next-address 192.1.74.4 next-address 192.1.42.2 next-address 192.1.23.3 next-address 3.3.3.3 </pre>	<pre> exit-address-family ! address-family ipv4 vrf BLUE neighbor 192.1.88.8 remote-as 30 neighbor 192.1.88.8 activate no auto-summary no synchronization exit-address-family  ip explicit-path name FROM_R3_TO_R1_LONG_PATH enable next-address 192.1.23.2 next-address 192.1.42.4 next-address 192.1.74.7 next-address 192.1.67.6 next-address 192.1.61.1 next-address 1.1.1.1 </pre>
<p><b>R4</b></p> <pre> mpls label range 400 499 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0 no ftp-server write-enable ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.42 encapsulation dot1Q 42 ip address 192.1.42.4 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.74 encapsulation dot1Q 74 ip address 192.1.74.4 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable </pre>	<p><b>R6</b></p> <pre> mpls label range 600 699 mpls label protocol ldp mpls ldp logging neighbor-changes mpls traffic-eng tunnels tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 ! interface FastEthernet0/0.61 encapsulation dot1Q 61 ip address 192.1.61.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! </pre>

<pre> ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.42.4 0.0.0.0 area 0 network 192.1.74.4 0.0.0.0 area 0 </pre>	<pre> interface FastEthernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.6 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000  router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.61.6 0.0.0.0 area 0 network 192.1.65.6 0.0.0.0 area 0 network 192.1.67.6 0.0.0.0 area 0 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 </pre>
<p><b>R7</b></p> <pre> mpls label range 700 799 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.74 encapsulation dot1Q 74 ip address 192.1.74.7 255.255.255.0 no snmp trap link-status mpls traffic-eng tunnels tag-switching ip </pre>	<p><b>R5</b></p> <pre> mpls label range 500 599 mpls label protocol ldp mpls ldp logging neighbor-changes mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 100000 100000 ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable </pre>

<pre> no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.67.7 0.0.0.0 area 0 network 192.1.74.7 0.0.0.0 area 0 </pre>	<pre> ip rsvp bandwidth 100000 100000  router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 </pre>
<p><b>R2</b></p> <pre> mpls label range 200 299 mpls label protocol ldp mpls traffic-eng tunnels tag-switching tdp router-id Loopback0  interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.42 encapsulation dot1Q 42 ip address 192.1.42.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000 ! interface Ethernet0/0.52 encapsulation dot1Q 52 ip address 192.1.52.2 255.255.255.0 mpls traffic-eng tunnels tag-switching ip no cdp enable ip rsvp bandwidth 10000 10000  router ospf 1 mpls traffic-eng router-id Loopback0 mpls traffic-eng area 0 router-id 2.2.2.2 </pre>	<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router bgp 20 no synchronization bgp router-id 77.77.77.77 bgp log-neighbor-changes network 77.77.77.0 mask 255.255.255.0 neighbor 192.1.77.1 remote-as 10 no auto-summary ! ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>

```
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.23.2 0.0.0.0 area 0
network 192.1.42.2 0.0.0.0 area 0
network 192.1.52.2 0.0.0.0 area 0
```

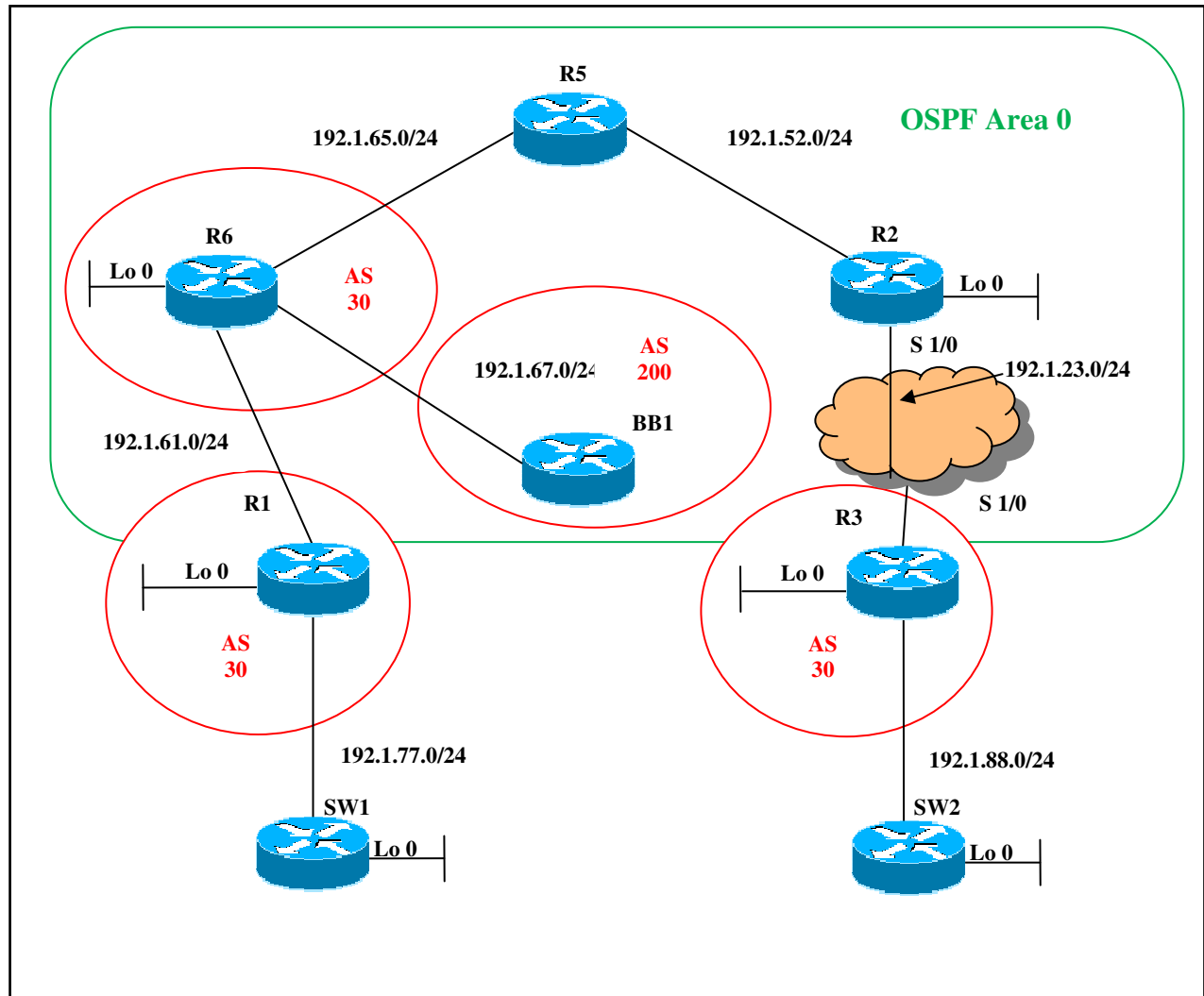
## SW2

```
interface Loopback0
ip address 88.88.88.88 255.255.255.0

interface Vlan88
ip address 192.1.88.8 255.255.255.0
!
router bgp 30
no synchronization
bgp router-id 88.88.88.88
bgp log-neighbor-changes
network 88.88.88.0 mask 255.255.255.0
neighbor 192.1.88.3 remote-as 10
no auto-summary
!
ip route 0.0.0.0 0.0.0.0 192.1.88.3
```

# **Module 8 – Internet Access in MPLS**

# Lab 1 – Central Services Internet Access



## Interface Configuration:

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0.61	192.1.61.1	255.255.255.0
E 0/0.77	192.1.77.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.23.2	255.255.255.0
E 0/0	192.1.52.2	255.255.255.0

### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.23.3	255.255.255.0
E 0/0.88	192.1.88.3	255.255.255.0

### R4

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.42	192.1.42.4	255.255.255.0
E 0/0.74	192.1.74.4	255.255.255.0

### R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0.52	192.1.52.5	255.255.255.0
E0/0.65	192.1.65.5	255.255.255.0

### R6

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.61	192.1.61.6	255.255.255.0
E 0/0.65	192.1.65.6	255.255.255.0
E 0/0.67	192.1.67.6	255.255.255.0

### SW1

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

### SW2

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

### Task 1

**R6** is receiving Internet access from **BB1**, make sure **SW1** and **SW2** gets this Internet routes from **R6**. Configure a **VRF** in **R6** called **MPLS\_INTERNET** for the Internet routes. On **R1** and **R3** configure a **VRF** called **BLUE** and make sure you install the Internet routes from **MPLS\_INTERNET** VRF table received from **R6**.



<b>R1</b>	<b>R3</b>
<pre> ip cef no ip domain lookup ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 route-target import 200:30 ! mpls label range 100 199 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.61 encapsulation dot1Q 61 ip address 192.1.61.1 255.255.255.0 tag-switching ip no cdp enable ! interface Ethernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.1 255.255.255.0 tag-switching ip no cdp enable ! interface Ethernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.1 255.255.255.0 tag-switching ip no cdp enable ! interface Ethernet0/0.77 encapsulation dot1Q 77 ip vrf forwarding BLUE ip address 192.1.77.1 255.255.255.0 no cdp enable ! </pre>	<pre> ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 route-target import 200:30 ! mpls label range 300 399 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding BLUE ip address 192.1.88.3 255.255.255.0 no cdp enable ! interface Serial1/0 ip address 192.1.23.3 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.23.2 302 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.23.3 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf BLUE redistribute bgp 30 metric 1 network 192.1.88.0 </pre>

<pre> router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.61.1 0.0.0.0 area 0 network 192.1.65.1 0.0.0.0 area 0 network 192.1.67.1 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf BLUE redistribute bgp 30 metric 1 network 192.1.77.0 no auto-summary version 2 exit-address-family ! router bgp 30 bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 ! address-family ipv4 no neighbor 6.6.6.6 activate no auto-summary no synchronization exit-address-family ! address-family vpnv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family </pre>	<pre> no auto-summary version 2 exit-address-family ! router bgp 30 bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 ! address-family ipv4 no neighbor 6.6.6.6 activate no auto-summary no synchronization exit-address-family ! address-family vpnv4 neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family </pre>
<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup ip vrf MPLS_INTERNET rd 200:30 </pre>

```

tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Ethernet0/0
ip address 192.1.52.2 255.255.255.0
half-duplex
tag-switching ip
!
interface Serial1/0
ip address 192.1.23.2 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.3 203
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 2.2.2.2
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.23.2 0.0.0.0 area 0
network 192.1.52.2 0.0.0.0 area 0
!

```

```

route-target export 200:30
route-target import 10:7

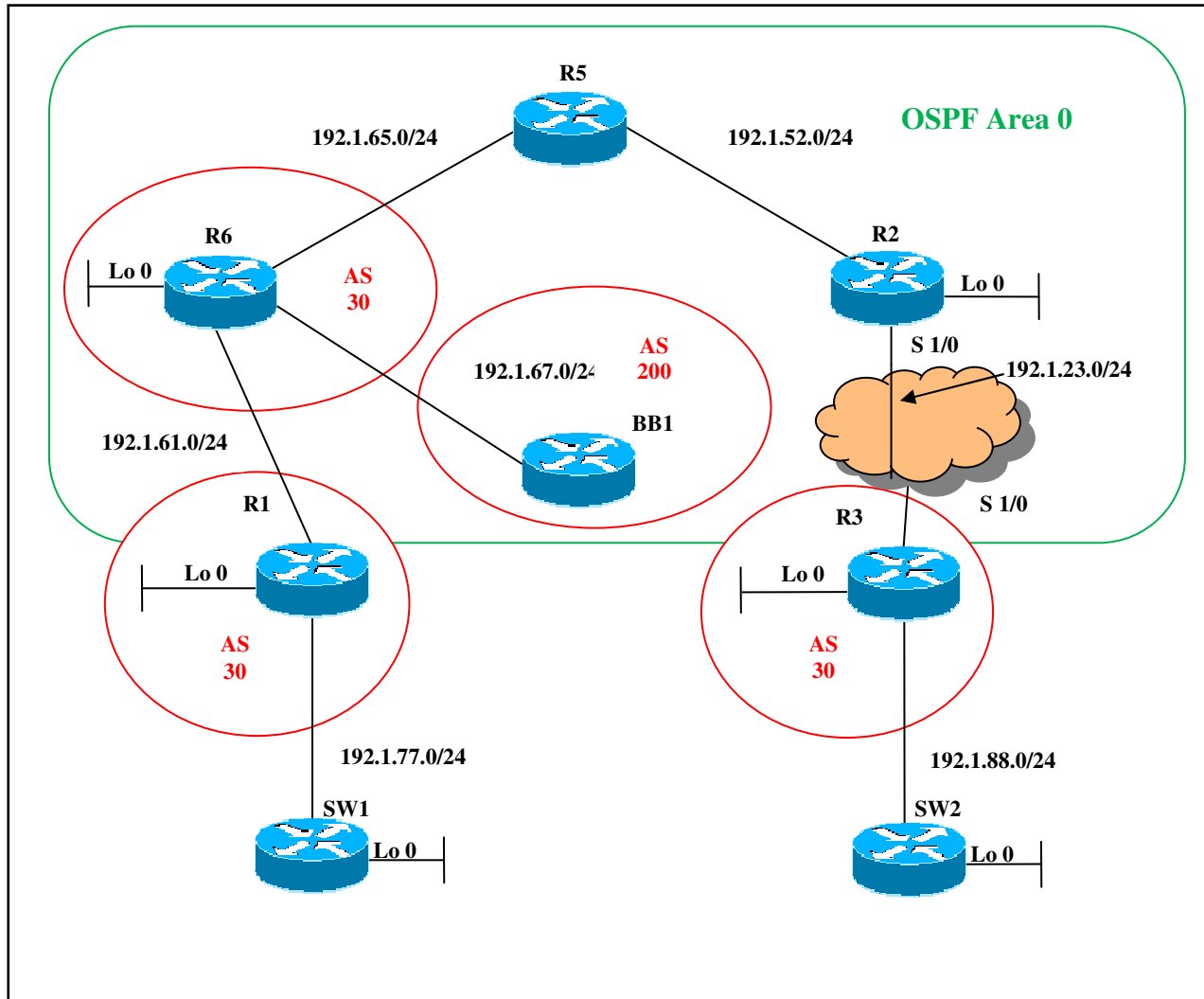
mpls label range 600 699
mpls label protocol ldp
!
interface Loopback0
ip address 6.6.6.6 255.255.255.255
no ip directed-broadcast
!
interface FastEthernet0/0
no ip address
no ip directed-broadcast
!
interface FastEthernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.65
encapsulation dot1Q 65
ip address 192.1.65.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.67
encapsulation dot1Q 67
ip vrf forwarding MPLS_INTERNET
ip address 192.1.67.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
router ospf 1
router-id 6.6.6.6
log-adjacency-changes
network 6.6.6.6 0.0.0.0 area 0
network 192.1.61.6 0.0.0.0 area 0
network 192.1.65.6 0.0.0.0 area 0
!
router bgp 30
bgp router-id 6.6.6.6
bgp log-neighbor-changes

```

	<pre> neighbor 1.1.1.1 remote-as 30 neighbor 1.1.1.1 update-source Loopback0 neighbor 3.3.3.3 remote-as 30 neighbor 3.3.3.3 update-source Loopback0 ! address-family ipv4 no neighbor 1.1.1.1 activate no neighbor 3.3.3.3 activate no auto-summary no synchronization exit-address-family ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 1.1.1.1 route-reflector-client neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 3.3.3.3 route-reflector-client exit-address-family ! address-family ipv4 vrf MPLS_INTERNET redistribute connected neighbor 192.1.67.100 remote-as 200 neighbor 192.1.67.100 activate no synchronization exit-address-family ! tag-switching tdp router-id Loopback0 </pre>
<p><b>R5</b></p> <pre> ip cef no ip domain-lookup  mpls label range 500 599 mpls label protocol ldp ! ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 </pre>	<p><b>BB1</b></p> <pre> interface Loopback0 ip address 99.99.99.99 255.255.255.0 ! interface Loopback10 ip address 198.10.10.10 255.255.255.0 ! interface Loopback11 ip address 192.11.11.11 255.255.255.0 ! interface Loopback12 ip address 192.12.12.12 255.255.255.0 ! </pre>

<pre> no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.45 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0 control-plane </pre>	<pre> interface Loopback13 ip address 192.13.13.13 255.255.255.0 ! interface Loopback14 ip address 192.14.14.14 255.255.255.0 ! interface Loopback15 ip address 192.15.15.15 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.67.100 255.255.255.0 half-duplex  router bgp 200 no synchronization bgp router-id 99.99.99.99 bgp log-neighbor-changes network 99.99.99.0 mask 255.255.255.0 network 192.10.10.0 network 192.11.11.0 network 192.12.12.0 network 192.13.13.0 network 192.14.14.0 network 192.15.15.0 neighbor 192.1.67.6 remote-as 30 no auto-summary ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.67.6 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router rip version 2 network 88.0.0.0 network 192.1.88.0 no auto-summary </pre>

# Lab 2 – Internet Access through Global Routing



## Task 1

**R6** is receiving Internet access from **BB1**, make sure **SW1** and **SW2** gets this Internet routes from **R6**. Configure BGP peering between **R1**, **R6** and **R3** and make sure **BB1** has access to **R1** and **R3**'s loopback 0. All the traffic coming from the **CE**'s **SW1** and **SW2** should be natted on their local **PE**s (**R1** and **R3** respectively).

Configure a static default route on the **CE**s pointing towards their **PE**s and make sure the NAT is working. Ping any Loopback received from **BB1** from the **CE**s and make sure it goes through.

R1	R3
ip cef no ip domain lookup	ip cef no ip domain lookup

```

ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 100 199
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.1 255.255.255.0
ip nat outside
tag-switching ip
no cdp enable
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding BLUE
ip address 192.1.77.1 255.255.255.0
ip nat inside
no cdp enable
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.61.1 0.0.0.0 area 0
network 192.1.65.1 0.0.0.0 area 0
network 192.1.67.1 0.0.0.0 area 0
!
router bgp 30
bgp router-id 1.1.1.1
bgp log-neighbor-changes
neighbor 3.3.3.3 remote-as 30
neighbor 3.3.3.3 update-source Loopback0
neighbor 6.6.6.6 remote-as 30
neighbor 6.6.6.6 update-source Loopback0
!

```

```

ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 300 399
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding BLUE
ip address 192.1.88.3 255.255.255.0
ip nat inside
!
interface Serial1/0
ip address 192.1.23.3 255.255.255.0
ip nat outside
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router bgp 30
bgp router-id 3.3.3.3
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 30
neighbor 1.1.1.1 update-source Loopback0
neighbor 6.6.6.6 remote-as 30
neighbor 6.6.6.6 update-source Loopback0
!

```

<pre> address-family ipv4 neighbor 3.3.3.3 activate neighbor 6.6.6.6 activate no auto-summary no synchronization network 1.1.1.1 mask 255.255.255.255 exit-address-family ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected redistribute rip no auto-summary no synchronization exit-address-family ! ip nat pool POOL_VPN 1.1.1.1 1.1.1.1 netmask 255.255.255.0 ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload no ip http server ip classless ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global ! ! access-list 140 permit ip 192.1.77.0 0.0.0.255 any no cdp run route-map RM_NAT permit 10 match ip address 140 </pre>	<pre> ! address-family ipv4 neighbor 1.1.1.1 activate neighbor 6.6.6.6 activate no auto-summary no synchronization network 3.3.3.3 mask 255.255.255.255 exit-address-family ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute rip no auto-summary no synchronization exit-address-family ! ip nat pool POOL_VPN 3.3.3.3 3.3.3.3 netmask 255.255.255.0 ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload no ip http server ip classless ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global ! ! access-list 140 permit ip 192.1.88.0 0.0.0.255 any no cdp run route-map RM_NAT permit 10 match ip address 140 </pre>
<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup  mpls label range 600 699 mpls label protocol ldp </pre>



```

!
interface Loopback0
 ip address 2.2.2.2 255.255.255.255
!
interface Ethernet0/0
 ip address 192.1.52.2 255.255.255.0
 half-duplex
 tag-switching ip
!
interface Serial1/0
 ip address 192.1.23.2 255.255.255.0
 encapsulation frame-relay
 ip ospf network point-to-point
 tag-switching ip
 serial restart-delay 0
 frame-relay map ip 192.1.23.3 203
 broadcast
 no frame-relay inverse-arp
!
router ospf 1
 router-id 2.2.2.2
 log-adjacency-changes
 network 2.2.2.2 0.0.0.0 area 0
 network 192.1.23.2 0.0.0.0 area 0
 network 192.1.52.2 0.0.0.0 area 0
!

```

```

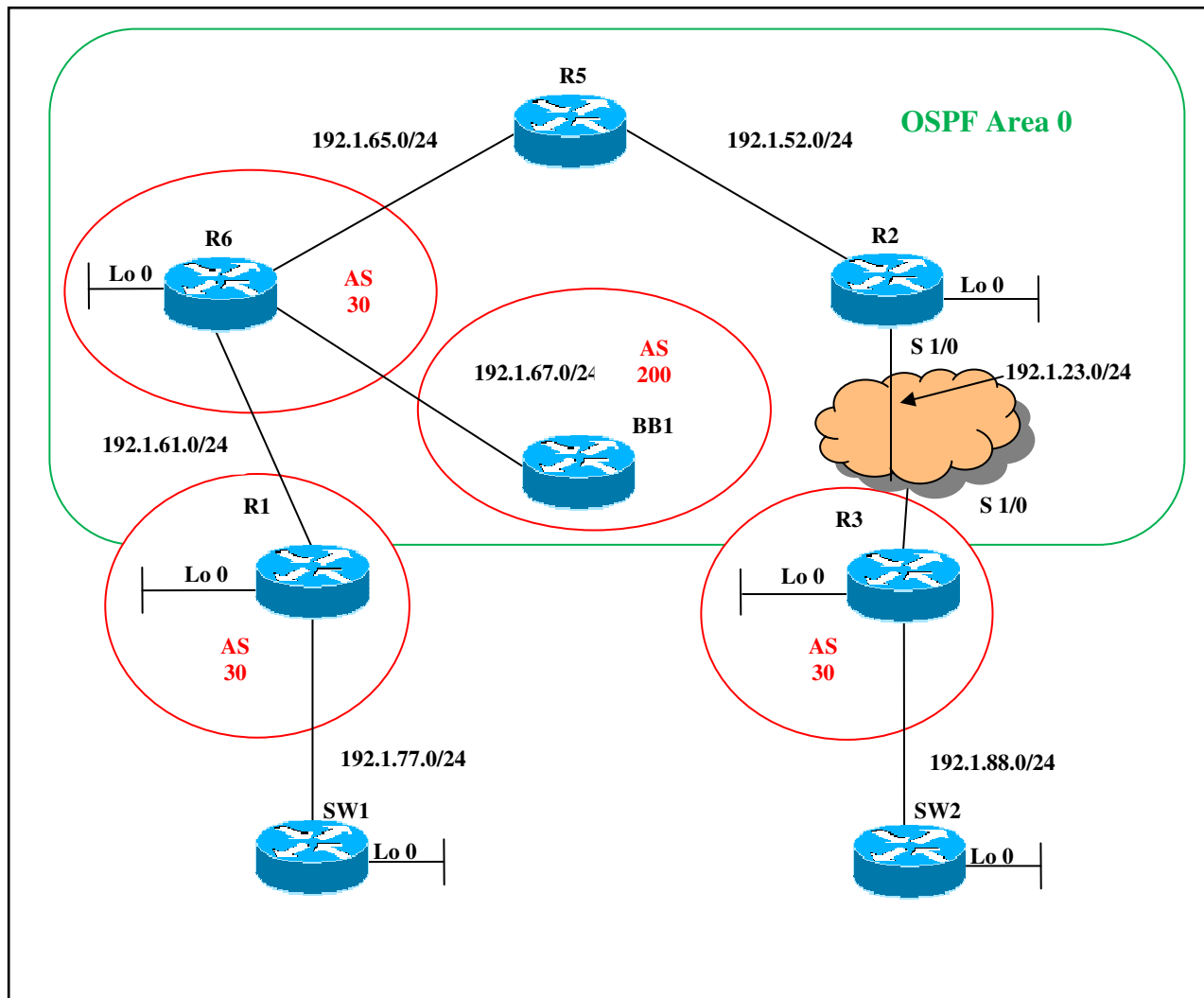
!
interface Loopback0
 ip address 6.6.6.6 255.255.255.255
 no ip directed-broadcast
!
interface FastEthernet0/0
 no ip address
 no ip directed-broadcast
!
interface FastEthernet0/0.61
 encapsulation dot1Q 61
 ip address 192.1.61.6 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 no cdp enable
!
interface FastEthernet0/0.65
 encapsulation dot1Q 65
 ip address 192.1.65.6 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 no cdp enable
!
interface FastEthernet0/0.67
 encapsulation dot1Q 67
 ip address 192.1.67.6 255.255.255.0
 no ip directed-broadcast
 tag-switching ip
 no cdp enable
!
router ospf 1
 router-id 6.6.6.6
 log-adjacency-changes
 network 6.6.6.6 0.0.0.0 area 0
 network 192.1.61.6 0.0.0.0 area 0
 network 192.1.65.6 0.0.0.0 area 0
!
router bgp 30
 no synchronization
 bgp router-id 6.6.6.6
 no bgp default route-target filter
 bgp log-neighbor-changes
 neighbor 1.1.1.1 remote-as 30
 neighbor 1.1.1.1 update-source Loopback0
 neighbor 1.1.1.1 route-reflector-client
 neighbor 1.1.1.1 next-hop-self

```

	<pre> neighbor 3.3.3.3 remote-as 30 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 route-reflector-client neighbor 3.3.3.3 next-hop-self neighbor 192.1.67.100 remote-as 200 no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended exit-address-family ! tag-switching tdp router-id Loopback0 </pre>
<pre> <b>R5</b>  ip cef no ip domain-lookup  mpls label range 500 599 mpls label protocol ldp ! ! ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.45 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 </pre>	<pre> <b>BB1</b>  interface Loopback0 ip address 99.99.99.99 255.255.255.0 ! interface Loopback10 ip address 198.10.10.10 255.255.255.0 ! interface Loopback11 ip address 192.11.11.11 255.255.255.0 ! interface Loopback12 ip address 192.12.12.12 255.255.255.0 ! interface Loopback13 ip address 192.13.13.13 255.255.255.0 ! interface Loopback14 ip address 192.14.14.14 255.255.255.0 ! interface Loopback15 ip address 192.15.15.15 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.67.100 255.255.255.0 half-duplex  router bgp 200 </pre>

<pre> no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0 </pre>	<pre> no synchronization bgp router-id 99.99.99.99 bgp log-neighbor-changes network 99.99.99.0 mask 255.255.255.0 network 192.10.10.0 network 192.11.11.0 network 192.12.12.0 network 192.13.13.0 network 192.14.14.0 network 192.15.15.0 neighbor 192.1.67.6 remote-as 30 no auto-summary ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.67.6 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.88.3 </pre>

# Lab 3 – Internet Access – VRF Aware NAT at Local PE



## Task 1

**R6** is receiving Internet access from **BB1**, make sure **SW1** and **SW2** gets this Internet routes from **R6**. Configure BGP peering between **R1**, **R6** and **R3** and make sure **BB1** has access to **R1** and **R3**'s loopback 0. All the traffic coming from the **CE**'s **SW1** and **SW2** should be natted on their local **PE**s (**R1** and **R3** respectively).

**Don't establish IPv4 unicast peering between R1, R6 and R4.**

Configure a static default route on the **CE**'s pointing towards their **PE**s and make sure the NAT is working. Ping any Loopback received from **BB1** from the **CE**s and make sure it goes through.

R1	R3
ip cef	ip cef

```

no ip domain lookup
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 100 199
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.1 255.255.255.0
ip nat outside
tag-switching ip
no cdp enable
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding BLUE
ip address 192.1.77.1 255.255.255.0
ip nat inside
no cdp enable
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.61.1 0.0.0.0 area 0
network 192.1.65.1 0.0.0.0 area 0
network 192.1.67.1 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf BLUE
network 192.1.77.0
no auto-summary
version 2
exit-address-family

```

```

no ip domain lookup
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 300 399
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding BLUE
ip address 192.1.88.3 255.255.255.0
ip nat inside
no cdp enable
!
interface Serial1/0
ip address 192.1.23.3 255.255.255.0
ip nat outside
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp

router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf BLUE
network 192.1.88.0
no auto-summary

```

<pre> ! router bgp 30 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 30 neighbor 3.3.3.3 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family ! ip nat pool POOL_VPN 1.1.1.1 1.1.1.1 netmask 255.255.255.0 ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload no ip http server ip classless ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global ! ! access-list 140 permit ip 192.1.77.0 0.0.0.255 any  route-map RM_NAT permit 10 match ip address 140 </pre>	<pre> version 2 exit-address-family ! router bgp 30 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 30 neighbor 1.1.1.1 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family ! ip nat pool POOL_VPN 3.3.3.3 3.3.3.3 netmask 255.255.255.0 ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload no ip http server ip classless ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global ! ! access-list 140 permit ip 192.1.88.0 0.0.0.255 any  route-map RM_NAT permit 10 match ip address 140 </pre>
<p><b>R2</b></p> <pre> ip cef </pre>	<p><b>R6</b></p> <pre> ip cef </pre>

```

no ip domain lookup
mpls label range 200 299
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 2.2.2.2 255.255.255.255
!
interface Ethernet0/0
ip address 192.1.52.2 255.255.255.0
half-duplex
tag-switching ip
!
interface Serial1/0
ip address 192.1.23.2 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.3 203
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 2.2.2.2
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.23.2 0.0.0.0 area 0
network 192.1.52.2 0.0.0.0 area 0

```

```

no ip domain-lookup
ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
ip ssh time-out 120
ip ssh authentication-retries 3
mpls label range 600 699
mpls label protocol ldp
!
interface Loopback0
ip address 6.6.6.6 255.255.255.255
no ip directed-broadcast
!
interface FastEthernet0/0
no ip address
no ip directed-broadcast
!
interface FastEthernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.65
encapsulation dot1Q 65
ip address 192.1.65.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.67
encapsulation dot1Q 67
ip address 192.1.67.6 255.255.255.0
no ip directed-broadcast
tag-switching ip
no cdp enable
!
router ospf 1
router-id 6.6.6.6
log-adjacency-changes
network 6.6.6.6 0.0.0.0 area 0
network 192.1.61.6 0.0.0.0 area 0
network 192.1.65.6 0.0.0.0 area 0

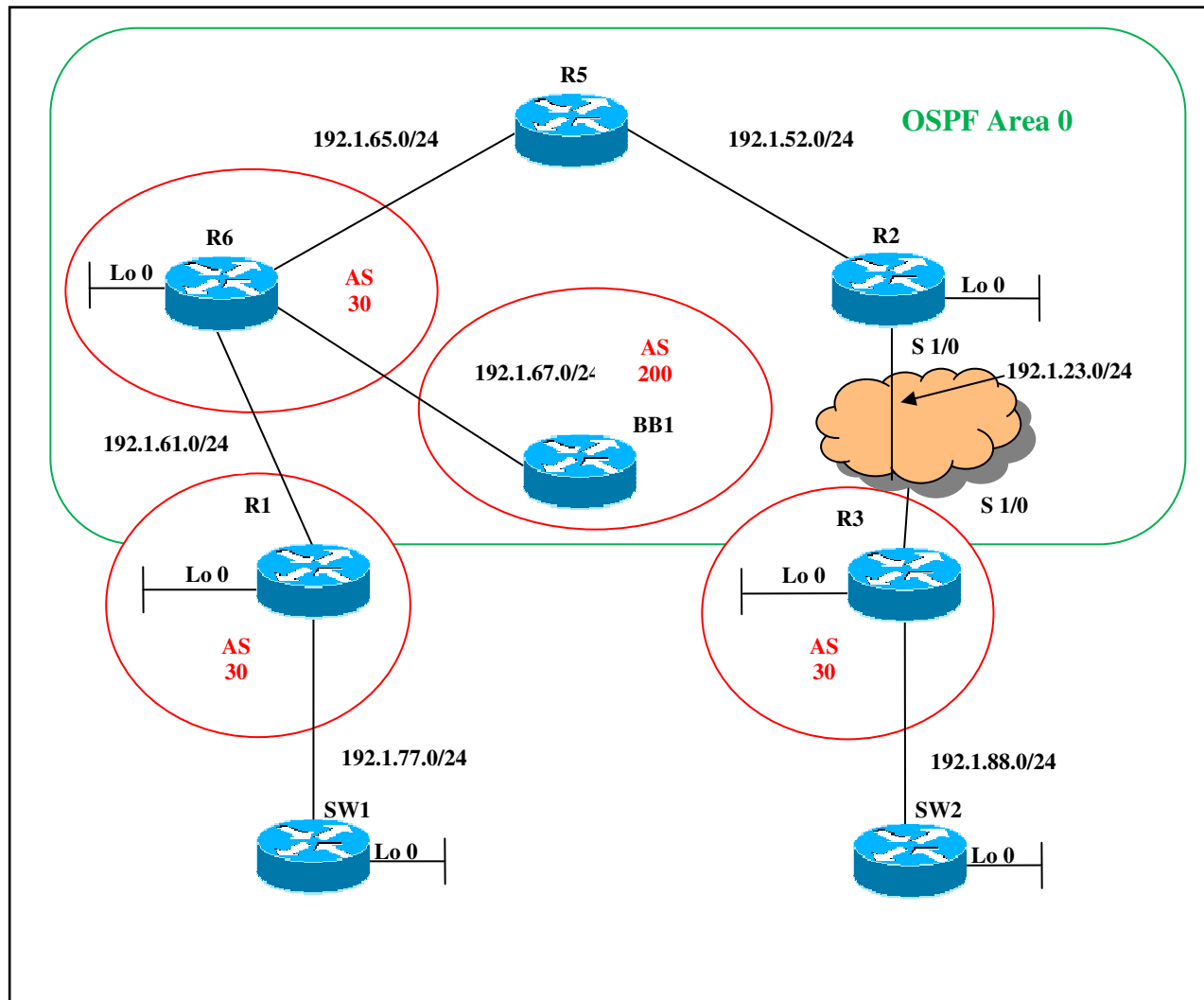
```

	<pre> ! router bgp 30   bgp router-id 6.6.6.6   bgp log-neighbor-changes   neighbor 1.1.1.1 remote-as 30   neighbor 1.1.1.1 update-source Loopback0   neighbor 3.3.3.3 remote-as 30   neighbor 3.3.3.3 update-source Loopback0   neighbor 192.1.67.100 remote-as 200 !   address-family ipv4     neighbor 1.1.1.1 activate     neighbor 3.3.3.3 activate     neighbor 192.1.67.100 activate   no auto-summary   no synchronization   exit-address-family !   address-family vpnv4     neighbor 1.1.1.1 activate     neighbor 1.1.1.1 send-community   extended     neighbor 3.3.3.3 activate     neighbor 3.3.3.3 send-community   extended   exit-address-family !   address-family ipv4 vrf BLUE   redistribute static   default-information originate   no synchronization   exit-address-family  tag-switching tdp router-id Loopback0 </pre>
<pre> <b>R5</b>  ip cef no ip domain-lookup ip ssh time-out 120 ip ssh authentication-retries 3 mpls label range 500 599 mpls label protocol ldp ! interface Loopback0   ip address 5.5.5.5 255.255.255.255   no ip directed-broadcast </pre>	<pre> <b>BB1</b>  interface Loopback0   ip address 99.99.99.99 255.255.255.0 ! interface Loopback10   ip address 198.10.10.10 255.255.255.0 ! interface Loopback11   ip address 192.11.11.11 255.255.255.0 ! interface Loopback12 </pre>



<pre> ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.45 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0 </pre>	<pre> ip address 192.12.12.12 255.255.255.0 ! interface Loopback13 ip address 192.13.13.13 255.255.255.0 ! interface Loopback14 ip address 192.14.14.14 255.255.255.0 ! interface Loopback15 ip address 192.15.15.15 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.67.100 255.255.255.0 half-duplex  router bgp 200 no synchronization bgp router-id 99.99.99.99 bgp log-neighbor-changes network 99.99.99.0 mask 255.255.255.0 network 192.10.10.0 network 192.11.11.0 network 192.12.12.0 network 192.13.13.0 network 192.14.14.0 network 192.15.15.0 neighbor 192.1.67.6 remote-as 30 no auto-summary ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.67.6 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! no ip http server ip classless ip route 0.0.0.0 0.0.0.0 192.1.88.3 </pre>

# Lab 4 – Internet Access – VRF Aware NAT at Central P



## Task 1

**R6** is receiving Internet access from **BB1**, make sure **SW1** and **SW2** gets this Internet routes from **R6**. Configure BGP peering between **R1**, **R6** and **R3** and make sure **BB1** has access to **R1** and **R3**'s loopback 0. All the traffic coming from the **CE**'s **SW1** and **SW2** should be natted on the **P** router **R6**.

Configure a static default route on the **CE**s pointing towards their **PE**s and make sure the NAT is working. Ping any Loopback received from **BB1** from the **CE**s and make sure it goes through.

R1	R3
ip cef no ip domain lookup	ip cef no ip domain lookup

```

ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 100 199
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 1.1.1.1 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.1 255.255.255.0
ip nat outside
tag-switching ip
no cdp enable
!
interface Ethernet0/0.77
encapsulation dot1Q 77
ip vrf forwarding BLUE
ip address 192.1.77.1 255.255.255.0
ip nat inside
no cdp enable
!
router ospf 1
router-id 1.1.1.1
log-adjacency-changes
network 1.1.1.1 0.0.0.0 area 0
network 192.1.61.1 0.0.0.0 area 0
network 192.1.65.1 0.0.0.0 area 0
network 192.1.67.1 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf BLUE
network 192.1.77.0
no auto-summary
version 2
exit-address-family
!

```

```

ip vrf BLUE
rd 10:7
route-target export 10:7
route-target import 10:7
!
mpls label range 300 399
mpls label protocol ldp
tag-switching tdp router-id Loopback0
!
interface Loopback0
ip address 3.3.3.3 255.255.255.255
!
interface Ethernet0/0
no ip address
half-duplex
!
interface Ethernet0/0.88
encapsulation dot1Q 88
ip vrf forwarding BLUE
ip address 192.1.88.3 255.255.255.0
ip nat inside
no cdp enable
!
interface Serial1/0
ip address 192.1.23.3 255.255.255.0
ip nat outside
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.2 302
broadcast
no frame-relay inverse-arp

router ospf 1
router-id 3.3.3.3
log-adjacency-changes
network 3.3.3.3 0.0.0.0 area 0
network 192.1.23.3 0.0.0.0 area 0
!
router rip
!
address-family ipv4 vrf BLUE
network 192.1.88.0
no auto-summary
version 2

```

<pre> router bgp 30 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 30 neighbor 3.3.3.3 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family ! ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global ! </pre>	<pre> exit-address-family ! router bgp 30 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 30 neighbor 1.1.1.1 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family ! ip route vrf BLUE 0.0.0.0 0.0.0.0 6.6.6.6 global </pre>
<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.52.2 255.255.255.0 half-duplex tag-switching ip </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip ssh time-out 120 ip ssh authentication-retries 3 mpls label range 600 699 mpls label protocol ldp ! interface Loopback0 </pre>

```

!
interface Serial1/0
ip address 192.1.23.2 255.255.255.0
encapsulation frame-relay
ip ospf network point-to-point
tag-switching ip
serial restart-delay 0
frame-relay map ip 192.1.23.3 203
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 2.2.2.2
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.23.2 0.0.0.0 area 0
network 192.1.52.2 0.0.0.0 area 0

```

```

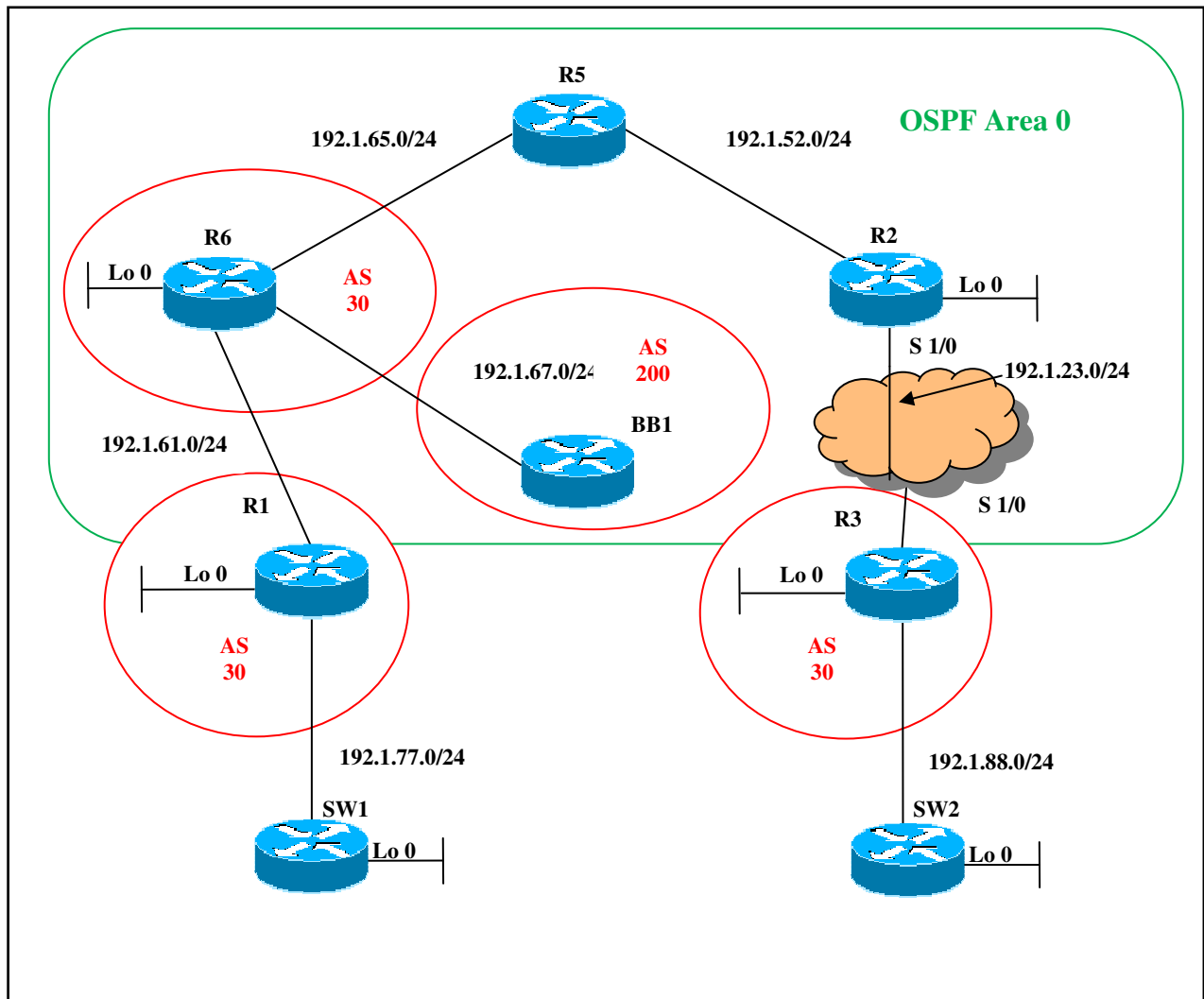
ip address 6.6.6.6 255.255.255.255
no ip directed-broadcast
!
interface FastEthernet0/0
no ip address
no ip directed-broadcast
!
interface FastEthernet0/0.61
encapsulation dot1Q 61
ip address 192.1.61.6 255.255.255.0
ip nat inside
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.65
encapsulation dot1Q 65
ip address 192.1.65.6 255.255.255.0
ip nat inside
tag-switching ip
no cdp enable
!
interface FastEthernet0/0.67
encapsulation dot1Q 67
ip address 192.1.67.6 255.255.255.0
ip nat outside
no ip directed-broadcast
tag-switching ip
no cdp enable
!
router ospf 1
router-id 6.6.6.6
log-adjacency-changes
network 6.6.6.6 0.0.0.0 area 0
network 192.1.61.6 0.0.0.0 area 0
network 192.1.65.6 0.0.0.0 area 0
router bgp 30
bgp router-id 6.6.6.6
bgp log-neighbor-changes
neighbor 1.1.1.1 remote-as 30
neighbor 1.1.1.1 update-source Loopback0
neighbor 3.3.3.3 remote-as 30
neighbor 3.3.3.3 update-source Loopback0
neighbor 192.1.67.100 remote-as 200
!
address-family ipv4
neighbor 1.1.1.1 activate

```

	<pre> neighbor 3.3.3.3 activate neighbor 192.1.67.100 activate no auto-summary no synchronization exit-address-family ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute static default-information originate no synchronization exit-address-family  tag-switching tdp router-id Loopback0  ip route vrf BLUE 0.0.0.0 0.0.0.0 192.1.67.100 global ! ip nat pool VPNPOOL 6.6.6.6 6.6.6.6 netmask 255.255.255.0  ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload ! access-list 140 permit ip 192.1.77.0 0.255.255.255 any access-list 140 permit ip 192.1.88.0 0.255.255.255 any ! route-map RM_NAT permit 10 match ip address 140 </pre>
<p><b>R5</b></p> <pre> ip cef no ip domain-lookup  mpls label range 500 599 </pre>	<p><b>BB1</b></p> <pre> interface Loopback0 ip address 99.99.99.99 255.255.255.0 ! interface Loopback10 </pre>

<pre> mpls label protocol ldp ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.45 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 ! tag-switching tdp router-id Loopback0 </pre>	<pre> ip address 198.10.10.10 255.255.255.0 ! interface Loopback11 ip address 192.11.11.11 255.255.255.0 ! interface Loopback12 ip address 192.12.12.12 255.255.255.0 ! interface Loopback13 ip address 192.13.13.13 255.255.255.0 ! interface Loopback14 ip address 192.14.14.14 255.255.255.0 ! interface Loopback15 ip address 192.15.15.15 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.67.100 255.255.255.0 half-duplex  router bgp 200 no synchronization bgp router-id 99.99.99.99 bgp log-neighbor-changes network 99.99.99.0 mask 255.255.255.0 network 192.10.10.0 network 192.11.11.0 network 192.12.12.0 network 192.13.13.0 network 192.14.14.0 network 192.15.15.0 neighbor 192.1.67.6 remote-as 30 no auto-summary ! ip route 0.0.0.0 0.0.0.0 192.1.67.6 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! ip route 0.0.0.0 0.0.0.0 192.1.77.1 </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! ip route 0.0.0.0 0.0.0.0 192.1.88.3 </pre>

# Lab 5 – Internet Access – GRE Tunnel between PE-CE



## Task 1

**R6** is receiving Internet access from **BB1**, make sure **SW1** and **SW2** gets this Internet routes from **R6**. Configure BGP peering between **R1**, **R6** and **R3** and make sure **BB1** has access to **R1** and **R3**'s loopback 0. All the traffic coming from the **CE**'s **SW1** and **SW2** should be natted on their local **PE**s (**R1** and **R3** respectively).

Configure a static default route on the **CE**s pointing towards their **PE**s and make sure the NAT is working. Ping any Loopback received from **BB1** from the **CE**s and make sure it goes through.

R1	R3
ip cef no ip domain lookup	ip cef ip vrf BLUE



<pre> ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! mpls label range 100 199 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.61 encapsulation dot1Q 61 ip address 192.1.61.1 255.255.255.0 ip nat outside tag-switching ip no cdp enable ! interface Ethernet0/0.77 encapsulation dot1Q 77 ip vrf forwarding BLUE ip address 192.1.77.1 255.255.255.0 ip nat inside no cdp enable ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.61.1 0.0.0.0 area 0 network 192.1.65.1 0.0.0.0 area 0 network 192.1.67.1 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf BLUE network 192.1.77.0 no auto-summary version 2 exit-address-family ! </pre>	<pre> rd 10:7 route-target export 10:7 route-target import 10:7 ! mpls label range 300 399 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 no ip address ! interface Ethernet0/0.88 encapsulation dot1Q 88 ip vrf forwarding BLUE ip address 192.1.88.3 255.255.255.0 ip nat inside no cdp enable ! interface Serial1/0 ip address 192.1.23.3 255.255.255.0 ip nat outside encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.23.2 302 broadcast no frame-relay inverse-arp  router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.23.3 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf BLUE network 192.1.88.0 no auto-summary version 2 exit-address-family ! </pre>
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<pre> router bgp 30 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 30 neighbor 3.3.3.3 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family ! ! ip nat pool POOL_VPN 1.1.1.1 1.1.1.1 netmask 255.255.255.0  ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload ! access-list 140 permit ip any any  route-map RM_NAT permit 10 match ip address 140  interface Tunnel10 ip address 61.1.1.1 255.255.255.0 ip nat inside tunnel source Ethernet0/0.77 tunnel destination 192.1.77.7 tunnel vrf BLUE </pre>	<pre> router bgp 30 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 30 neighbor 1.1.1.1 update-source Loopback0 neighbor 6.6.6.6 remote-as 30 neighbor 6.6.6.6 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended neighbor 6.6.6.6 activate neighbor 6.6.6.6 send-community extended exit-address-family ! address-family ipv4 vrf BLUE redistribute connected no auto-summary no synchronization exit-address-family  ip nat pool POOL_VPN 3.3.3.3 3.3.3.3 netmask 255.255.255.0  ip nat inside source route-map RM_NAT pool POOL_VPN vrf BLUE overload ! access-list 140 permit ip any any  route-map RM_NAT permit 10 match ip address 140  interface Tunnel10 ip address 62.1.1.1 255.255.255.0 ip nat inside tunnel source Ethernet0/0.88 tunnel destination 192.1.88.8 tunnel vrf BLUE </pre>
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<p><b>R2</b></p> <pre> ip cef no ip domain lookup mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.52.2 255.255.255.0 half-duplex tag-switching ip ! interface Serial1/0 ip address 192.1.23.2 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.23.3 203 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.23.2 0.0.0.0 area 0 network 192.1.52.2 0.0.0.0 area 0 </pre>	<p><b>R6</b></p> <pre> ip cef no ip domain-lookup ip vrf BLUE rd 10:7 route-target export 10:7 route-target import 10:7 ! ip ssh time-out 120 ip ssh authentication-retries 3 mpls label range 600 699 mpls label protocol ldp ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.61 encapsulation dot1Q 61 ip address 192.1.61.6 255.255.255.0 ip nat inside tag-switching ip no cdp enable ! interface FastEthernet0/0.65 encapsulation dot1Q 65 ip address 192.1.65.6 255.255.255.0 ip nat inside tag-switching ip no cdp enable ! interface FastEthernet0/0.67 encapsulation dot1Q 67 ip address 192.1.67.6 255.255.255.0 ip nat outside no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 6.6.6.6 </pre>
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```

log-adjacency-changes
network 6.6.6.6 0.0.0.0 area 0
network 192.1.61.6 0.0.0.0 area 0
network 192.1.65.6 0.0.0.0 area 0
router bgp 30
  bgp router-id 6.6.6.6
  bgp log-neighbor-changes
  neighbor 1.1.1.1 remote-as 30
  neighbor 1.1.1.1 update-source Loopback0
  neighbor 3.3.3.3 remote-as 30
  neighbor 3.3.3.3 update-source Loopback0
  neighbor 192.1.67.100 remote-as 200
  !
  address-family ipv4
    neighbor 1.1.1.1 activate
    neighbor 3.3.3.3 activate
    neighbor 192.1.67.100 activate
    no auto-summary
    no synchronization
    exit-address-family
  !
  address-family vpnv4
    neighbor 1.1.1.1 activate
    neighbor 1.1.1.1 send-community
    extended
    neighbor 3.3.3.3 activate
    neighbor 3.3.3.3 send-community
    extended
    exit-address-family
  !
  address-family ipv4 vrf BLUE
    redistribute static
    default-information originate
    no synchronization
    exit-address-family

tag-switching tdp router-id Loopback0

ip route vrf BLUE 0.0.0.0 0.0.0.0
192.1.67.100 global
!
ip nat pool VPNPOOL 6.6.6.6 6.6.6.6
netmask 255.255.255.0

ip nat inside source route-map RM_NAT
pool POOL_VPN vrf BLUE overload

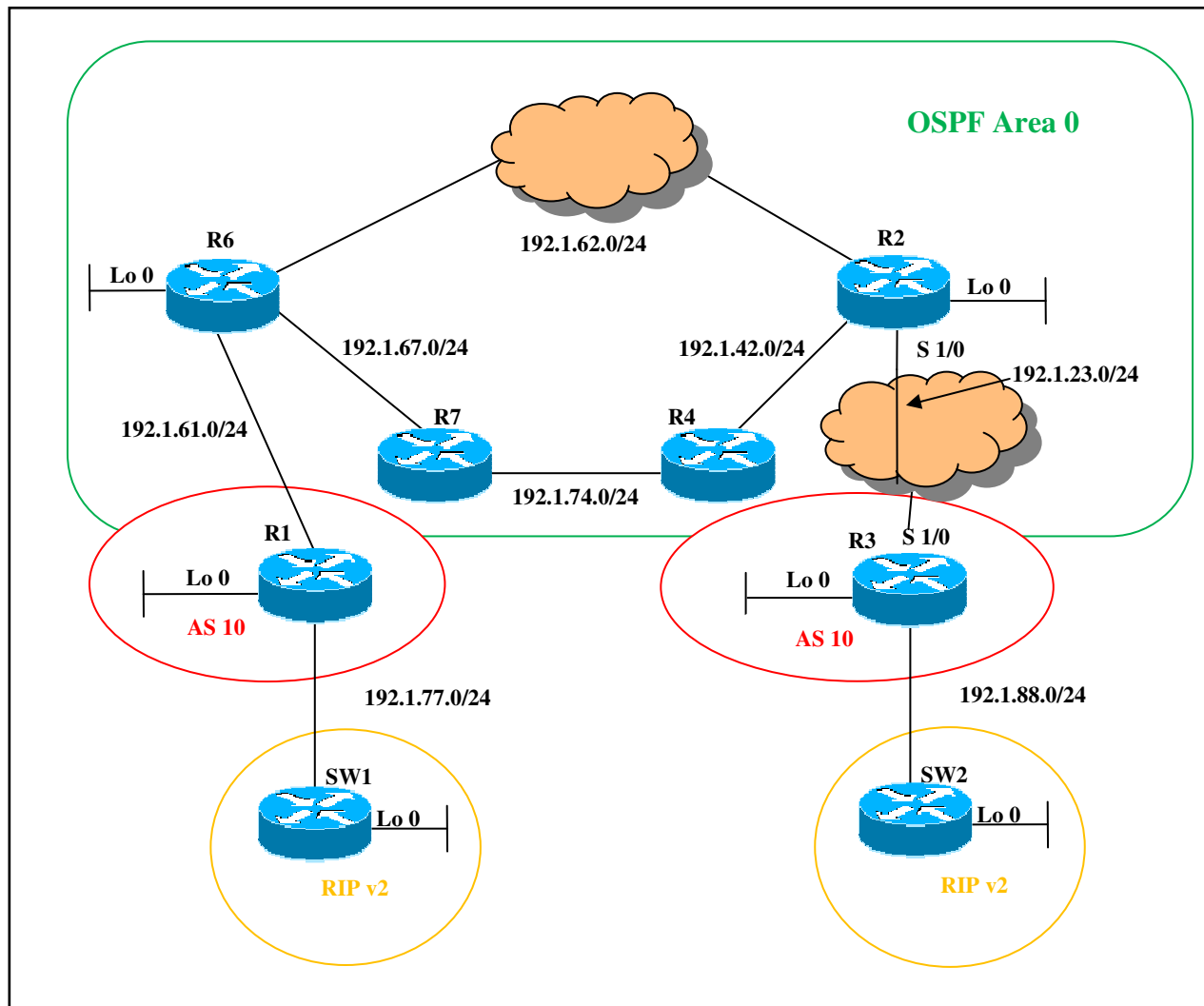
```

	<pre> ! access-list 140 permit ip 192.1.77.0 0.255.255.255 any access-list 140 permit ip 192.1.88.0 0.255.255.255 any ! route-map RM_NAT permit 10 match ip address 140 </pre>
<pre> <b>R5</b>  ip cef no ip domain-lookup  mpls label range 500 599 mpls label protocol ldp ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 no ip directed-broadcast ! interface FastEthernet0/0 no ip address no ip directed-broadcast ! interface FastEthernet0/0.25 encapsulation dot1Q 52 ip address 192.1.52.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! interface FastEthernet0/0.45 encapsulation dot1Q 65 ip address 192.1.65.5 255.255.255.0 no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.52.5 0.0.0.0 area 0 network 192.1.65.5 0.0.0.0 area 0 ! </pre>	<pre> <b>BB1</b>  interface Loopback0 ip address 99.99.99.99 255.255.255.0 ! interface Loopback10 ip address 198.10.10.10 255.255.255.0 ! interface Loopback11 ip address 192.11.11.11 255.255.255.0 ! interface Loopback12 ip address 192.12.12.12 255.255.255.0 ! interface Loopback13 ip address 192.13.13.13 255.255.255.0 ! interface Loopback14 ip address 192.14.14.14 255.255.255.0 ! interface Loopback15 ip address 192.15.15.15 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.67.100 255.255.255.0 half-duplex  router bgp 200 no synchronization bgp router-id 99.99.99.99 bgp log-neighbor-changes network 99.99.99.0 mask 255.255.255.0 network 192.10.10.0 network 192.11.11.0 network 192.12.12.0 network 192.13.13.0 network 192.14.14.0 </pre>

tag-switching tdp router-id Loopback0	network 192.15.15.0 neighbor 192.1.67.6 remote-as 30 no auto-summary ! ip route 0.0.0.0 0.0.0.0 192.1.67.6
<b>SW1</b>  interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0  interface Tunnel10 ip address 61.1.1.10 255.255.255.0 tunnel source Vlan 77 tunnel destination 192.1.77.1 tunnel vrf BLUE  ip route 0.0.0.0 0.0.0.0 tunnel10	<b>SW2</b>  interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0  interface Tunnel10 ip address 62.1.1.10 255.255.255.0 tunnel source Vlan 88 tunnel destination 192.1.88.3 tunnel vrf BLUE  ip route 0.0.0.0 0.0.0.0 tunnel10

# Module 9 – MPLS QoS

# Lab 1 – QoS in MPLS



## Interface Configuration:

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
E 0/0	192.1.61.1	255.255.255.0
E 0/1	192.1.77.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.23.2	255.255.255.0
S 1/0	192.1.62.2	255.255.255.0
E 0/0	192.1.42.2	255.255.255.0



**R3**

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.23.3	255.255.255.0
E 0/0	192.1.88.3	255.255.255.0

**R4**

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0	192.1.42.4	255.255.255.0
E 0/1	192.1.74.4	255.255.255.0

**R5**

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
E 0/0	192.1.56.5	255.255.255.0
S 1/0	192.1.35.5	255.255.255.0

**R6**

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0	192.1.61.6	255.255.255.0
E 0/1	192.1.67.6	255.255.255.0
S 1/0	192.1.62.6	255.255.255.0

**R7**

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.67.7	255.255.255.0
E 0/1	192.1.74.7	255.255.255.0

**SW1**

Interface	IP Address	Subnet Mask
Loopback 0	77.77.77.77	255.255.255.255
E 0/0	192.1.77.7	255.255.255.0

**SW2**

Interface	IP Address	Subnet Mask
Loopback 0	88.88.88.88	255.255.255.255
E 0/0	192.1.88.8	255.255.255.0

## Task 1

Configure your MPLS network in such a way that all the **WWW** and **SMTP** traffic between **SW1** and **SW2** will be prioritized at **512 Kbps** throughout your MPLS network end-to-end. Also mark them as **qos-group of 5** and you should mark these as **MPLS EXP of 5** when sending them throughout your MPLS network.

<b>R1</b>	<b>R3</b>
<pre>ip cef  ip vrf CENTRAL rd 10:1 route-target export 10:1 route-target import 10:1 ! mpls label range 100 199 mpls label protocol ldp tag-switching tdp router-id Loopback0  class-map match-all SMTP match protocol smtp class-map match-all QoS_MPLS match mpls experimental topmost 5 class-map match-all WWW match protocol http class-map match-all GROUP_QoS match qos-group 5 ! ! policy-map QoS&lt;-P class QoS_MPLS set qos-group 5  policy-map QoS-&gt;P class QoS_MPLS priority 512  policy-map QoS-&gt;CE class GROUP_QoS priority 512  policy-map QoS&lt;-CE class SMTP set qos-group 5</pre>	<pre>ip cef  ip vrf CENTRAL rd 10:1 route-target export 10:1 route-target import 10:1 ! mpls label range 300 399 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! class-map match-all SMTP match protocol smtp class-map match-all QoS_MPLS match mpls experimental topmost 5 class-map match-all WWW match protocol http class-map match-all GROUP_QoS match qos-group 5 ! ! policy-map QoS&lt;-P class QoS_MPLS set qos-group 5  policy-map QoS-&gt;P class QoS_MPLS priority 512  policy-map QoS-&gt;CE class GROUP_QoS priority 512  policy-map QoS&lt;-CE class SMTP set qos-group 5</pre>

<pre> set mpls experimental imposition 5 class WWW set mpls experimental imposition 5 set qos-group 5  interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.61.1 255.255.255.0 tag-switching ip service-policy input QoS&lt;-P service-policy output QoS-&gt;P ! interface Ethernet0/1 ip vrf forwarding CENTRAL ip address 192.1.77.1 255.255.255.0 service-policy input QoS&lt;-CE service-policy output QoS-&gt;CE ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.61.1 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf CENTRAL redistribute bgp 10 metric 1 network 192.1.77.0 no auto-summary version 2 exit-address-family ! router bgp 10 no synchronization bgp router-id 1.1.1.1 neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community both exit-address-family </pre>	<pre> set mpls experimental imposition 5 class WWW set mpls experimental imposition 5 set qos-group 5 ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 ip vrf forwarding CENTRAL ip address 192.1.88.3 255.255.255.0 service-policy input QoS&lt;-CE service-policy output QoS-&gt;CE ! interface Serial1/0 ip address 192.1.23.3 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip frame-relay map ip 192.1.23.2 302 broadcast no frame-relay inverse-arp service-policy input QoS&lt;-P service-policy output QoS-&gt;P ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.23.3 0.0.0.0 area 0 ! router rip ! address-family ipv4 vrf CENTRAL redistribute bgp 10 metric 1 network 192.1.88.0 no auto-summary version 2 exit-address-family ! router bgp 10 no synchronization bgp router-id 3.3.3.3 bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 </pre>
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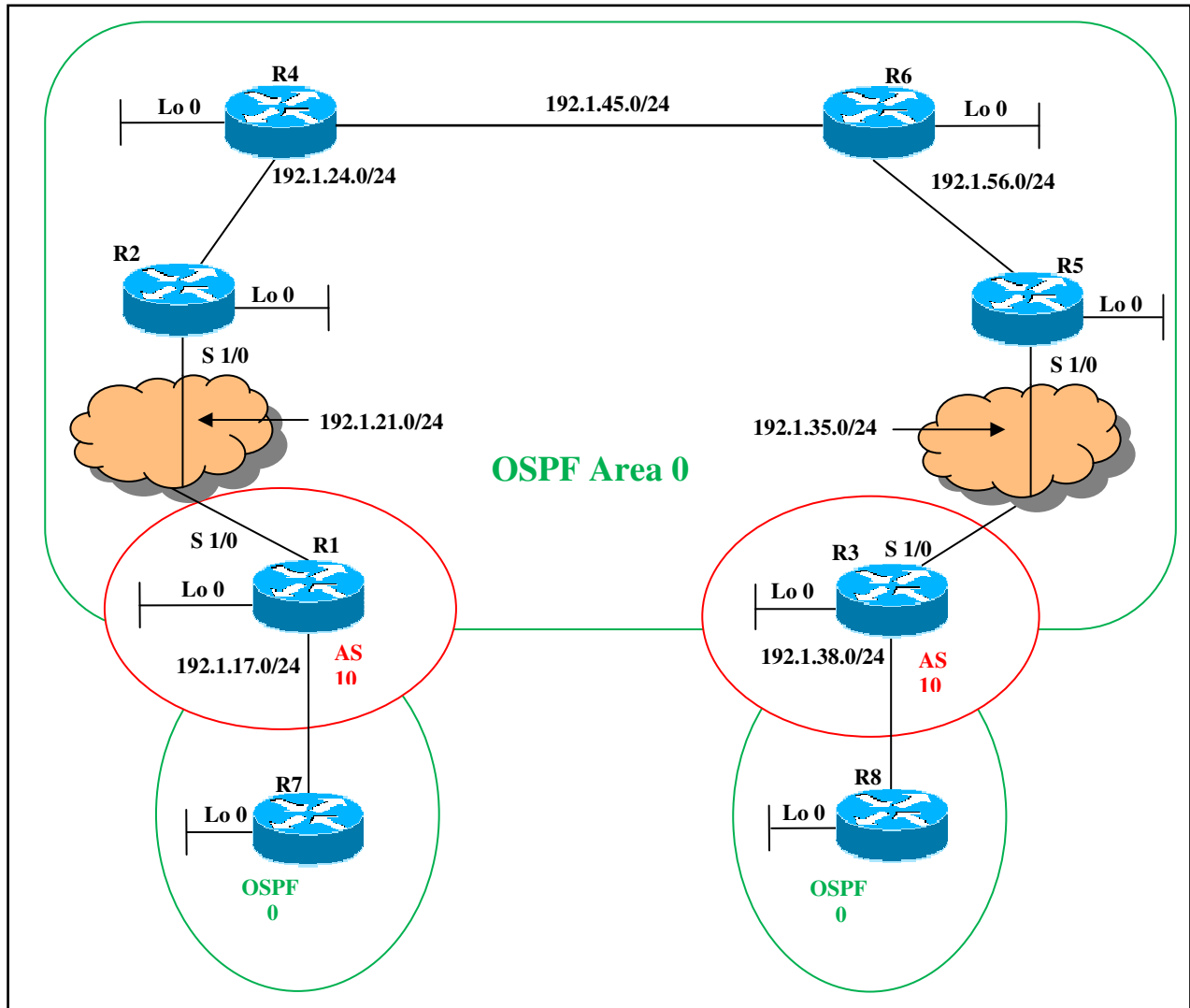
<pre> ! address-family ipv4 vrf CENTRAL redistribute rip no auto-summary no synchronization exit-address-family </pre>	<pre> no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community both exit-address-family ! address-family ipv4 vrf CENTRAL redistribute rip no auto-summary no synchronization exit-address-family </pre>
<pre> <b>R2</b>  ip cef  mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! class-map match-all QoS_MPLS   match mpls experimental topmost 5 ! policy-map QoS-&gt;P   class QoS_MPLS     priority 512 policy-map QoS-&gt;PE   class QoS_MPLS     priority 512 ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.42.2 255.255.255.0 service-policy output QoS-&gt;P tag-switching ip no cdp enable ! interface Ethernet0/1 ip address 192.1.52.2 255.255.255.0 service-policy output QoS-&gt;P tag-switching ip no cdp enable ! interface Serial1/0 </pre>	<pre> <b>R6</b>  ip cef ! class-map match-all QoS_MPLS   match mpls experimental 5 ! policy-map QoS-&gt;P   class QoS_MPLS     priority 512  policy-map QoS-&gt;PE   class QoS_MPLS     priority 512 ! mpls label range 600 699 mpls label protocol ldp ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 no ip directed-broadcast ! Interface Ser1/0 Ip address 192.1.62.6 255.255.255.0 Encapsulation frame-relay No frame-relay inverse-arp Frame-relay map ip 192.1.62.2 602 bro Service-policy output QoS-&gt;P  interface FastEthernet0/0 ip address 192.1.61.6 255.255.255.0 service-policy output QoS-&gt;PE tag-switching ip no cdp enable </pre>

<pre> ip address 192.1.23.2 255.255.255.0 encapsulation frame-relay ip ospf network point-to-point tag-switching ip serial restart-delay 0 frame-relay map ip 192.1.23.3 203 broadcast service-policy output QoS-&gt;PE no frame-relay inverse-arp  Interface Ser1/1 Ip address 192.1.62.2 255.255.255.0 Encapsulation frame-relay No frame-relay inverse-arp Frame-relay map ip 192.1.62.6 206 bro Service-policy ouput QoS-&gt;P  ! router ospf 1 router-id 2.2.2.2 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.23.2 0.0.0.0 area 0 network 192.1.42.2 0.0.0.0 area 0 network 192.1.52.2 0.0.0.0 area 0 </pre>	<pre> ! interface FastEthernet0/1 ip address 192.1.67.6 255.255.255.0 service-policy output QoS-&gt;P no ip directed-broadcast tag-switching ip no cdp enable ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.61.6 0.0.0.0 area 0 network 192.1.65.6 0.0.0.0 area 0 network 192.1.67.6 0.0.0.0 area 0 </pre>
<pre> <b>R7</b>  ip cef no ip domain lookup  mpls label range 700 799 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! class-map match-all QoS_MPLS match mpls experimental topmost 5 ! policy-map QoS-&gt;P class QoS_MPLS priority 512 ! ! interface Loopback0 ip address 7.7.7.7 255.255.255.255 ! interface Ethernet0/0 </pre>	<pre> <b>R4</b>  ip cef no ip domain lookup mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! class-map match-all QoS_MPLS match mpls experimental topmost 5 ! policy-map QoS-&gt;P class QoS_MPLS priority 512 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.42.4 255.255.255.0 service-policy ouput QoS-&gt;P </pre>

<pre> ip address 192.1.67.7 255.255.255.0 service-policy ouput QoS-&gt;P tag-switching ip no cdp enable ! interface Ethernet0/1 ip address 192.1.74.7 255.255.255.0 service-policy ouput QoS-&gt;P tag-switching ip no cdp enable ! router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.67.7 0.0.0.0 area 0 network 192.1.74.7 0.0.0.0 area 0 ! </pre>	<pre> tag-switching ip no cdp enable  interface Ethernet0/1 ip address 192.1.74.4 255.255.255.0 service-policy ouput QoS-&gt;P tag-switching ip no cdp enable ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.42.4 0.0.0.0 area 0 network 192.1.74.4 0.0.0.0 area 0 </pre>
<p><b>SW1</b></p> <pre> interface Loopback0 ip address 77.77.77.77 255.255.255.0  interface Vlan77 ip address 192.1.77.7 255.255.255.0 ! router rip version 2 network 77.0.0.0 network 192.1.77.0 no auto-summary </pre>	<p><b>SW2</b></p> <pre> interface Loopback0 ip address 88.88.88.88 255.255.255.0  interface Vlan88 ip address 192.1.88.8 255.255.255.0 ! router rip version 2 network 88.0.0.0 network 192.1.88.0 no auto-summary </pre>

# **Module 10 – Multicast**

# Lab 1 – Multicast over MPLS VPNs



## Interface Configuration:

### R1

Interface	IP Address	Subnet Mask
Loopback 0	1.1.1.1	255.255.255.255
S 1/0	192.1.21.1	255.255.255.0
E 0/0	192.1.17.1	255.255.255.0

### R2

Interface	IP Address	Subnet Mask
Loopback 0	2.2.2.2	255.255.255.255
S 1/0	192.1.21.2	255.255.255.0
E 0/0	192.1.24.2	255.255.255.0



### R3

Interface	IP Address	Subnet Mask
Loopback 0	3.3.3.3	255.255.255.255
S 1/0	192.1.35.3	255.255.255.0
E 0/0	192.1.38.3	255.255.255.0

### R4

Interface	IP Address	Subnet Mask
Loopback 0	4.4.4.4	255.255.255.255
E 0/0.45	192.1.45.4	255.255.255.0
E 0/0.24	192.1.24.4	255.255.255.0

### R5

Interface	IP Address	Subnet Mask
Loopback 0	5.5.5.5	255.255.255.255
S 1/0	192.1.35.5	255.255.255.0
E 0/0	192.1.56.5	255.255.255.0

### R6

Interface	IP Address	Subnet Mask
Loopback 0	6.6.6.6	255.255.255.255
E 0/0.45	192.1.45.6	255.255.255.0
E 0/0.56	192.1.56.6	255.255.255.0

### R7

Interface	IP Address	Subnet Mask
Loopback 0	7.7.7.7	255.255.255.255
E 0/0	192.1.17.7	255.255.255.0

### R8

Interface	IP Address	Subnet Mask
Loopback 0	8.8.8.8	255.255.255.255
E 0/0	192.1.38.8	255.255.255.0

### Task 1

Configure MPLS VPN between **R7** and **R8** in a VRF called **VIDEO**. Use **OSPF** as the PE-CE routing protocol (**R1** and **R3** as being the **PE** of them respectively).

There is a multicast feed on R7, make sure you configure your MPLS Core so the multicast traffic from R7 can be seen on R8.

Use a **MDT Default group** of **232.10.1.1** to handle the Control and Data packets in the **m-VRF** and also a **MDT Data range group** of **232.0.0.0/24** whenever you receive a High Multicast bandwidth (**anything above 100 Kbps**).

Configure **PIM-SM** with **R8** being the **RP** address and also a multicast group under the Ethernet interface of **224.10.10.10** and make sure R7 can reach this multicast group.

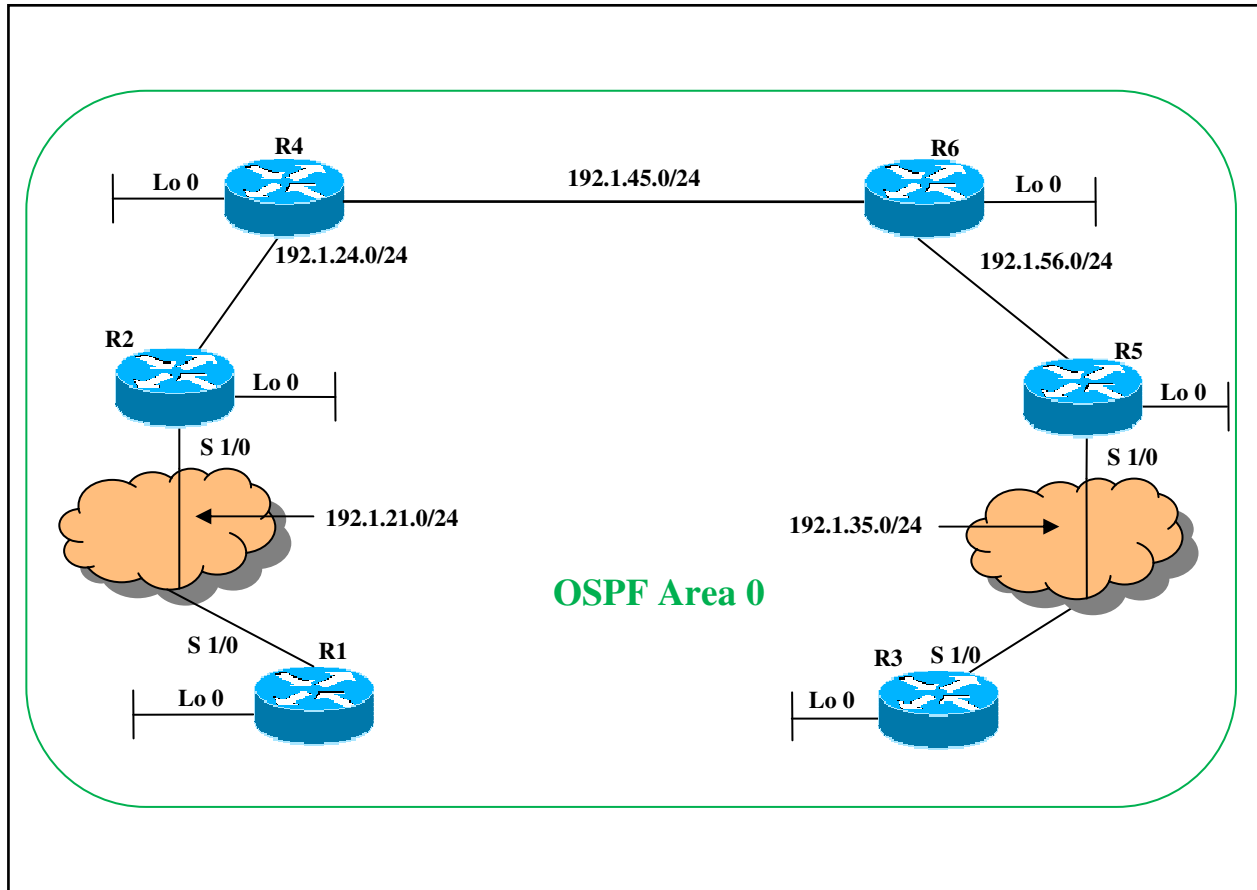
<b>R1</b>	<b>R3</b>
<pre> ip cef ! ip vrf VIDEO rd 10:1 route-target export 10:1 route-target import 10:1 mdt default 232.10.1.1 mdt data 232.0.0.0 0.0.0.255 threshold 100  ip multicast-routing ip multicast-routing vrf VIDEO  mpls label range 100 199 mpls label protocol ldp tag-switching tdp router-id Loopback0  interface Loopback0 ip address 1.1.1.1 255.255.255.255 ip pim sparse-mode ! interface Ethernet0/0 ip vrf forwarding VIDEO ip address 192.1.17.1 255.255.255.0 ip pim sparse-mode  router ospf 7 vrf BLUE log-adjacency-changes redistribute bgp 10 subnets network 192.1.17.1 0.0.0.0 area 0 ! interface Serial1/0 ip address 192.1.21.1 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint tag-switching ip frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp  router ospf 7 vrf VIDEO router-id 192.1.17.1 log-adjacency-changes redistribute bgp 10 subnets </pre>	<pre> ip cef ! ip vrf VIDEO rd 10:1 route-target export 10:1 route-target import 10:1 mdt default 232.10.1.1 mdt data 232.0.0.0 0.0.0.255 threshold 100 ! ip multicast-routing ip multicast-routing vrf VIDEO ! mpls label range 300 399 mpls label protocol ldp tag-switching tdp router-id Loopback0 interface Loopback0 ip address 3.3.3.3 255.255.255.255 ip pim sparse-mode ! interface Ethernet0/0 ip vrf forwarding VIDEO ip address 192.1.38.3 255.255.255.0 ip pim sparse-mode  interface Serial1/0 ip address 192.1.35.3 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint tag-switching ip frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp  router ospf 8 vrf VIDEO router-id 192.1.38.3 log-adjacency-changes redistribute bgp 10 subnets network 192.1.38.3 0.0.0.0 area 0 !  router ospf 1 router-id 3.3.3.3 log-adjacency-changes </pre>

<pre> network 192.1.17.1 0.0.0.0 area 0 ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended exit-address-family ! address-family ipv4 vrf VIDEO redistribute ospf 7 vrf VIDEO no auto-summary no synchronization exit-address-family ! ip pim ssm default ip pim vrf VIDEO rp-address 192.1.38.8 </pre>	<pre> network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended exit-address-family ! address-family ipv4 vrf VIDEO redistribute ospf 8 vrf VIDEO no auto-summary no synchronization exit-address-family ! no ip http server no ip http secure-server ip classless ! ! ip pim ssm default ip pim vrf VIDEO rp-address 192.1.38.8 </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! mpls label range 400 499 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex </pre>	<p><b>R6</b></p> <pre> ip multicast-routing  mpls label range 600 699 mpls label protocol ldp mpls ldp logging neighbor-changes tag-switching tdp router-id Loopback0 ! interface Loopback0 ip address 6.6.6.6 255.255.255.255  interface FastEthernet0/0 no ip address </pre>

<pre> ! interface Ethernet0/0.24  encapsulation dot1Q 24  ip address 192.1.24.4 255.255.255.0  ip pim sparse-mode  tag-switching ip  no cdp enable ! interface Ethernet0/0.45  encapsulation dot1Q 45  ip address 192.1.45.4 255.255.255.0  ip pim sparse-mode  tag-switching ip  no cdp enable ! router ospf 1  router-id 4.4.4.4  log-adjacency-changes  network 4.4.4.4 0.0.0.0 area 0  network 192.1.24.4 0.0.0.0 area 0  network 192.1.45.4 0.0.0.0 area 0  ip classless ! ip pim ssm default </pre>	<pre> duplex half ! interface FastEthernet0/0.45  encapsulation dot1Q 45  ip address 192.1.45.6 255.255.255.0  ip pim sparse-mode  tag-switching ip  no cdp enable ! interface FastEthernet0/0.56  encapsulation dot1Q 56  ip address 192.1.56.6 255.255.255.0  ip pim sparse-mode  tag-switching ip  no cdp enable router ospf 1  router-id 6.6.6.6  log-adjacency-changes  network 6.6.6.6 0.0.0.0 area 0  network 192.1.45.6 0.0.0.0 area 0  network 192.1.56.6 0.0.0.0 area 0 ! ip classless  ip pim ssm default </pre>
<pre> <b>R2</b>  ip multicast-routing ! mpls label range 200 299 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0  ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0  ip address 192.1.24.2 255.255.255.0  ip pim sparse-mode  tag-switching ip ! interface Serial1/0  ip address 192.1.21.2 255.255.255.0  ip pim sparse-mode  encapsulation frame-relay </pre>	<pre> <b>R5</b>  ip multicast-routing mpls label range 500 599 mpls label protocol ldp tag-switching tdp router-id Loopback0 ! interface Loopback0  ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0  ip address 192.1.56.5 255.255.255.0  ip pim sparse-mode  tag-switching ip ! interface Serial2/0  ip address 192.1.35.5 255.255.255.0  ip pim sparse-mode  encapsulation frame-relay  ip ospf network point-to-multipoint </pre>

<pre> ip ospf network point-to-multipoint tag-switching ip frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 ! ip pim ssm default </pre>	<pre> tag-switching ip frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 ! ip pim ssm default </pre>
<p><b>R7</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 7.7.7.7 255.255.255.0  interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0 ip pim sparse-mode  router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 ! ip pim rp-address 192.1.38.8 </pre>	<p><b>R8</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.10.10.10  router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 ! ip pim rp-address 192.1.38.8 </pre>

## Lab 2 – PIM Sparse Mode



### Task 1

Configure **PIM Sparse Mode** in your **MPLS Core**, **R5** being the **Rendevouz Point** (**sourcing from its most reliable interface**).

Also configure a multicast group of **224.50.50.50** under **R5's FastEthernet0/0** interface and make everybody in the MPLS Core can reach this multicast group.

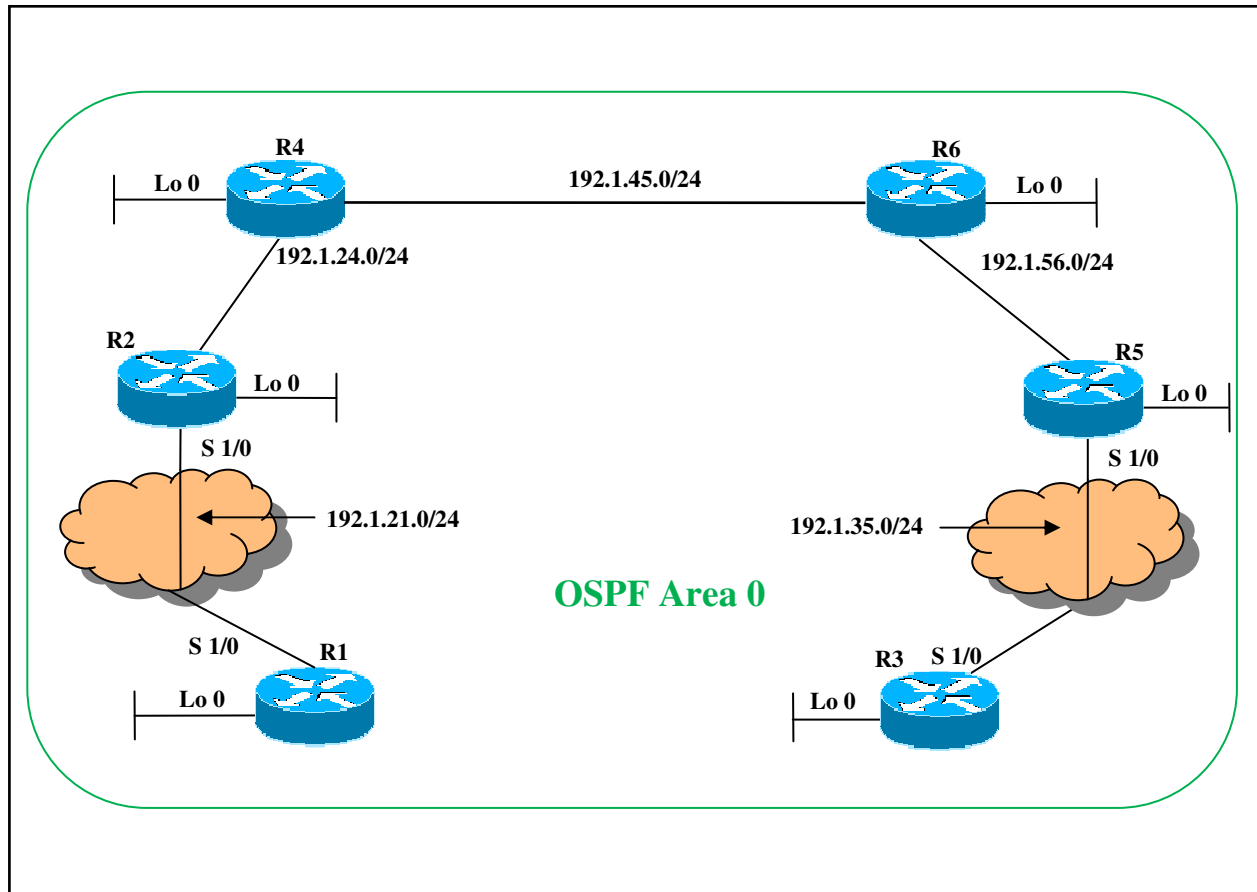
R1	R3
<pre>ip cef ! ip multicast-routing  interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Serial1/0 ip address 192.1.21.1 255.255.255.0</pre>	<pre>ip cef ! ip multicast-routing ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Serial1/0 ip address 192.1.35.3 255.255.255.0</pre>

<pre> ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! Ip pim rp-address 5.5.5.5 </pre>	<pre> ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp  router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! Ip pim rp-address 5.5.5.5 </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 4.4.4.4 255.255.255.255  interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 ip pim sparse-mode no cdp enable ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim sparse-mode no cdp enable </pre>	<p><b>R6</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 6.6.6.6 255.255.255.255  interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.6 255.255.255.0 ip pim sparse-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim sparse-mode no cdp enable </pre>

<pre> router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0  ip classless ! ip pim rp-address 5.5.5.5 </pre>	<pre> router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.45.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! ip classless  ip pim rp-address 5.5.5.5 </pre>
<p><b>R2</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 ip pim sparse-mode ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp !  router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0  ip pim rp-address 5.5.5.5 </pre>	<p><b>R5</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 ip pim sparse-mode ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 ip igmp join-group 224.50.50.50 ip pim sparse-mode ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp !  router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0  ip pim rp-address 5.5.5.5 </pre>



# Lab 3 – PIM Dense Mode



## Task 1

Configure **PIM Dense Mode** in your MPLS Core, **R2** being the **Rendevouz Point** (sourcing from its most reliable interface).

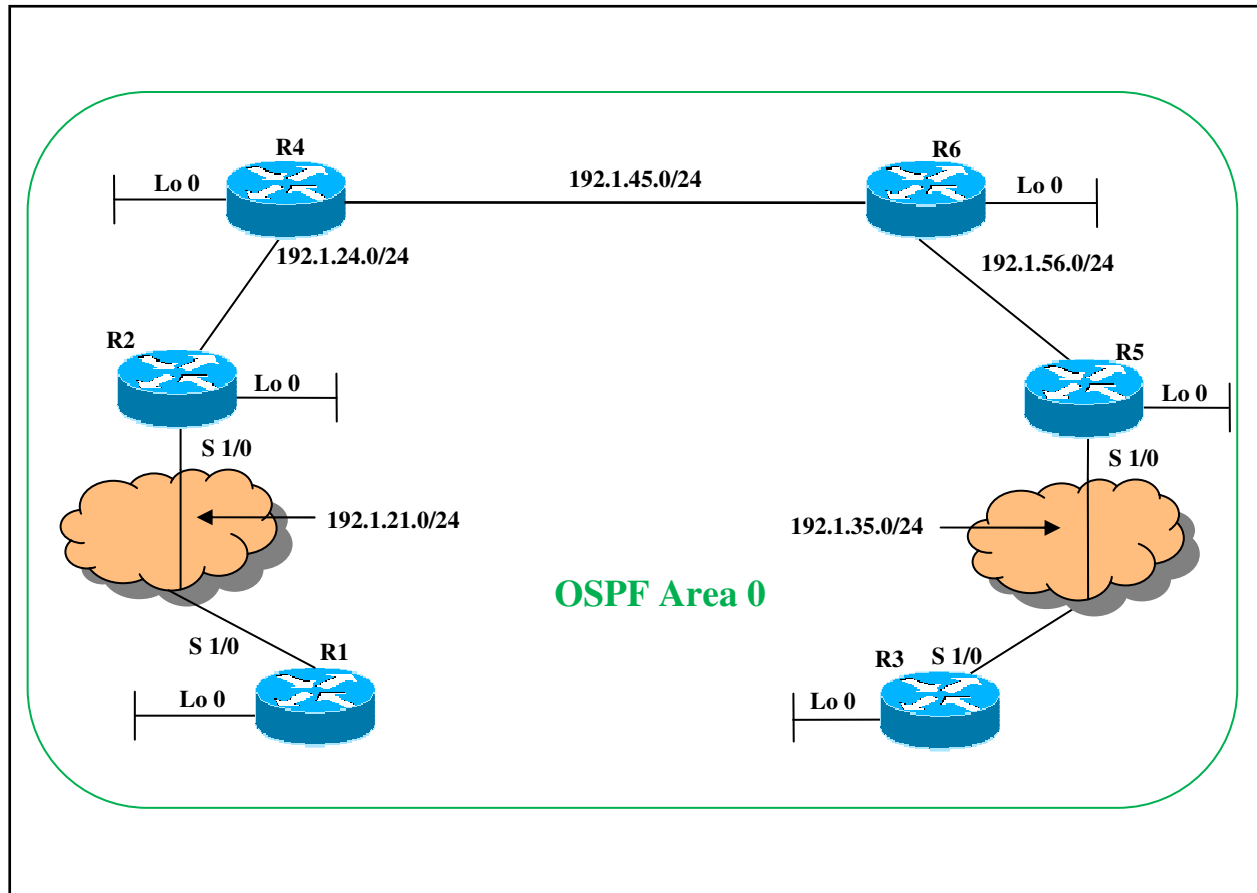
Also configure a multicast group of **224.20.20.20** under **R2's Ethernet0/0** interface and make everybody in the MPLS Core can reach this multicast group.

<b>R1</b>	<b>R3</b>
<pre> ip cef ! ip multicast-routing  interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Serial1/0                     </pre>	<pre> ip cef ! ip multicast-routing ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Serial1/0                     </pre>

<pre> ip address 192.1.21.1 255.255.255.0 ip pim dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! </pre>	<pre> ip address 192.1.35.3 255.255.255.0 ip pim dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 4.4.4.4 255.255.255.255  interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 ip pim dense-mode no cdp enable ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim dense-mode no cdp enable ! </pre>	<p><b>R6</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 6.6.6.6 255.255.255.255  interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.6 255.255.255.0 ip pim dense-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim dense-mode no cdp enable router ospf 1 </pre>

<pre> router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 </pre>	<pre> router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.45.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 </pre>
<pre> <b>R2</b>  ip multicast-routing ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ip pim dense-mode ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 ip pim dense-mode ip igmp join-group 224.20.20.20 ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 ip pim dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 </pre>	<pre> <b>R5</b>  ip multicast-routing ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 ip igmp join-group 224.50.50.50 ip pim dense-mode ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 ip pim dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp !  router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 </pre>

## Lab 4 – Auto-RP



### Task 1

Configure **PIM Sparse-Dense Mode** in your **MPLS Core**, **R2** being the **Rendevouz Point** (sourcing from its most reliable interface).

Also configure a multicast group of **224.20.20.20** under **R2's Ethernet0/0** interface and make everybody in the **MPLS Core** can reach this multicast group.

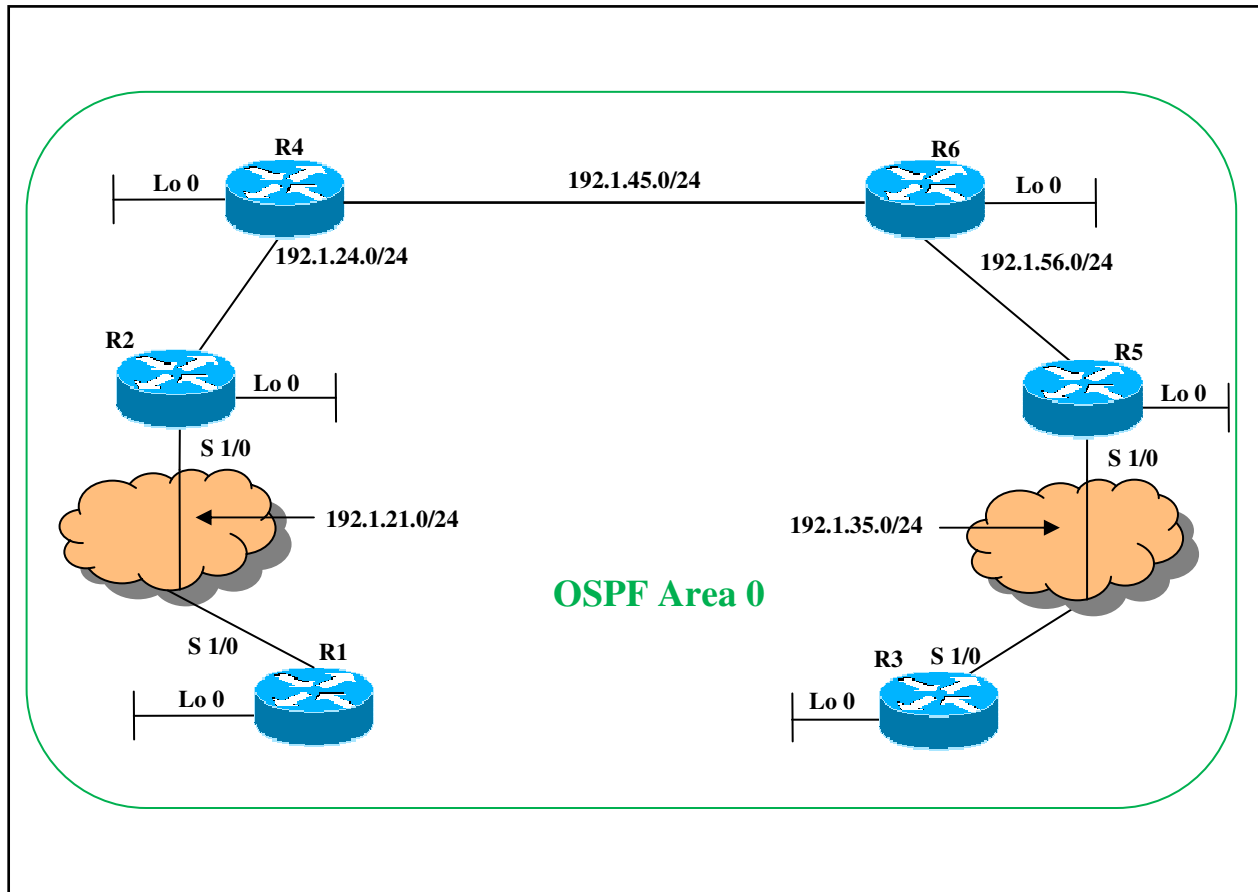
**R2** should **announce** himself as the **Auto-RP** and **R6** should be the **mapping agent** (sourcing from its most reliable interface).

R1	R3
<pre>ip cef ! ip multicast-routing  interface Loopback0 ip address 1.1.1.1 255.255.255.255 !</pre>	<pre>ip cef ! ip multicast-routing ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 !</pre>

<pre> interface Serial1/0 ip address 192.1.21.1 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! </pre>	<pre> interface Serial1/0 ip address 192.1.35.3 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp  router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 4.4.4.4 255.255.255.255  interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 ip pim sparse-dense-mode no cdp enable ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim sparse-dense-mode no cdp enable </pre>	<p><b>R6</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 6.6.6.6 255.255.255.255 interface FastEthernet0/0 ip pim sparse-dense-mode no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.6 255.255.255.0 ip pim sparse-dense-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim sparse-dense-mode no cdp enable </pre>

<pre> ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 </pre>	<pre> router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.45.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0  ip pim send-rp-discovery loopback 0 scope 16 </pre>
<pre> <b>R2</b>  ip multicast-routing ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ip pim sparse-dense-mode ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 ip pim sparse-dense-mode ip igmp join-group 224.20.20.20 ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0  ip pim send-rp-announce loopback 0 scope 16 </pre>	<pre> <b>R5</b>  ip multicast-routing ! interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 ip igmp join-group 224.50.50.50 ip pim sparse-dense-mode ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 </pre>

## Lab 5 – Auto-RPs Methods



### Task 1

Configure **PIM Sparse-Dense Mode** in your **MPLS Core**.

**R2** should be the **Auto-RP** for group **224.22.22.22** and **R5** being the **Auto-RP** for group **224.55.55.55** (both of them should source from its most reliable interface).

Configure a multicast group of **224.22.22.22** and **224.55.55.55** under **R2** and **R5 Ethernet0/0** respectively, and make sure everybody in the MPLS Core can reach these groups.

**R4** should be the **mapping agent** and for security purposes make sure **R4** doesn't accept any other **Auto-RP announcement** rather than **R2** and **R5**.

<b>R1</b>	<b>R3</b>
<pre>ip multicast-routing ! ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 !</pre>	<pre>ip multicast-routing  interface Loopback0 ip address 3.3.3.3 255.255.255.255 ip pim sparse-dense-mode !</pre>

<pre> interface Serial1/0 ip address 192.1.21.1 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint serial restart-delay 0 no dce-terminal-timing-enable frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.17.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! </pre>	<pre> interface Serial1/0 ip address 192.1.35.3 255.255.255.0 ip pim sparse-dense-mode encapsulation frame-relay ip ospf network point-to-multipoint serial restart-delay 0 no dce-terminal-timing-enable frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 network 192.1.38.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ip pim sparse-dense-mode ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 ip pim sparse-dense-mode no snmp trap link-status no cdp enable ! </pre>	<p><b>R6</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.6 255.255.255.0 ip pim sparse-dense-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 </pre>



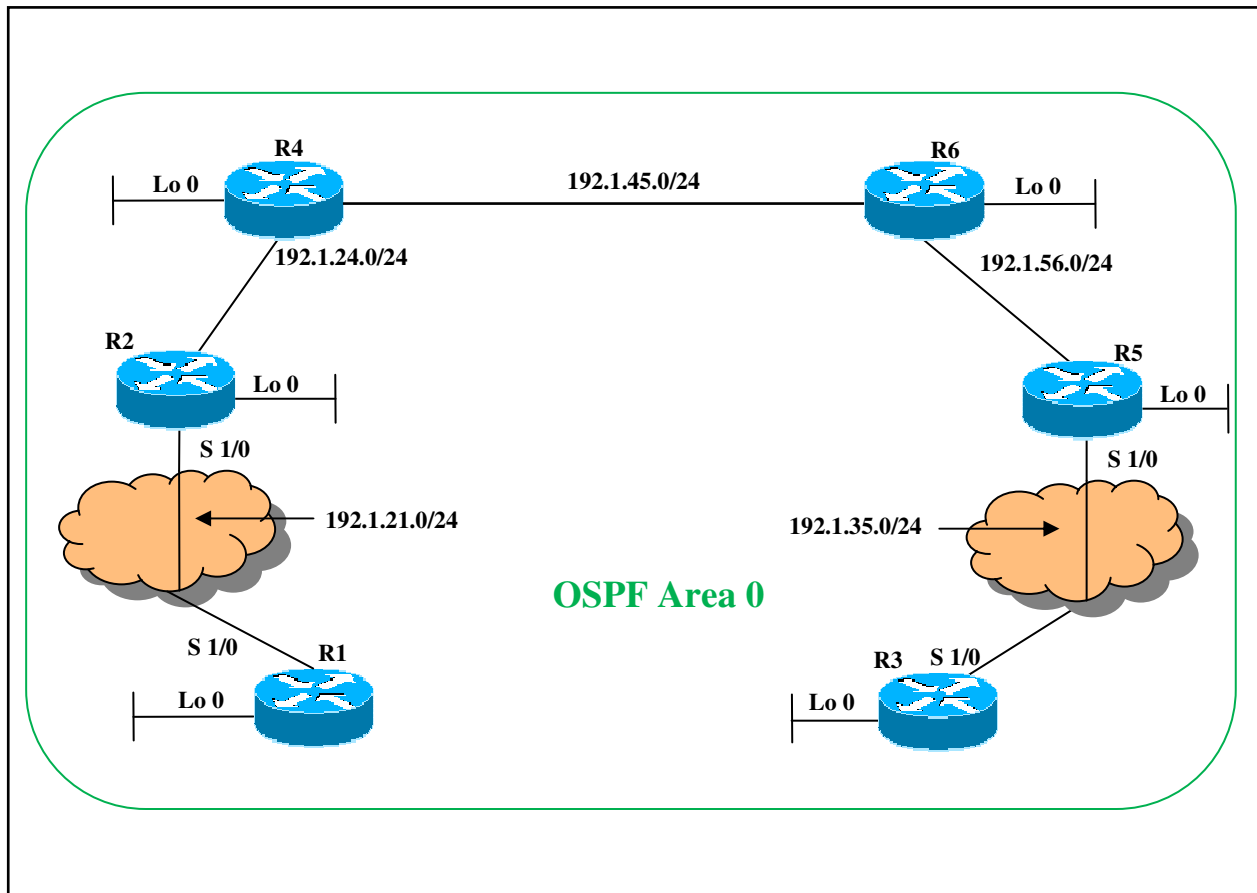
<pre> interface Ethernet0/0.45  encapsulation dot1Q 45  ip address 192.1.45.4 255.255.255.0  ip pim sparse-dense-mode  no snmp trap link-status  no cdp enable  ! router ospf 1  router-id 4.4.4.4  log-adjacency-changes  network 4.4.4.4 0.0.0.0 area 0  network 192.1.24.4 0.0.0.0 area 0  network 192.1.45.4 0.0.0.0 area 0  ! no ip http server no ip http secure-server ip classless ! ip pim send-rp-discovery Loopback0 scope 16 ip pim rp-announce-filter rp-list 20 group- list 10 ip pim rp-announce-filter rp-list 15 group- list 5 ! access-list 5 permit 224.22.22.22 access-list 10 permit 224.55.55.55 access-list 15 permit 2.2.2.2 access-list 20 permit 5.5.5.5 </pre>	<pre> ip address 192.1.56.6 255.255.255.0 ip pim sparse-dense-mode no cdp enable ! router ospf 1  router-id 6.6.6.6  log-adjacency-changes  network 6.6.6.6 0.0.0.0 area 0  network 192.1.45.6 0.0.0.0 area 0  network 192.1.56.6 0.0.0.0 area 0  ! </pre>
<p><b>R2</b></p> <pre> ip multicast-routing ! interface Loopback0  ip address 2.2.2.2 255.255.255.255  ip pim sparse-mode ! interface Ethernet0/0  ip address 192.1.24.2 255.255.255.0  ip pim sparse-dense-mode  ip igmp join-group 224.22.22.22  half-duplex ! interface Serial1/0  ip address 192.1.21.2 255.255.255.0 </pre>	<p><b>R5</b></p> <pre> ip multicast-routing  interface Loopback0  ip address 5.5.5.5 255.255.255.255  ip pim sparse-dense-mode ! interface FastEthernet0/0  ip address 192.1.56.5 255.255.255.0  ip pim sparse-dense-mode  ip igmp join-group 224.50.50.50  ip igmp join-group 224.55.55.55  duplex half ! </pre>

```
ip pim sparse-dense-mode
encapsulation frame-relay
ip ospf network point-to-multipoint
serial restart-delay 0
no dce-terminal-timing-enable
frame-relay map ip 192.1.21.1 201
broadcast
no frame-relay inverse-arp
!
router ospf 1
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 192.1.21.2 0.0.0.0 area 0
network 192.1.24.2 0.0.0.0 area 0
!
no ip http server
no ip http secure-server
ip classless
!
ip pim send-rp-announce Loopback0 scope
16 group-list 5
!
access-list 5 permit 224.22.22.22
```

```
interface Serial2/0
ip address 192.1.35.5 255.255.255.0
ip pim sparse-dense-mode
encapsulation frame-relay
ip ospf network point-to-multipoint
serial restart-delay 0
frame-relay map ip 192.1.35.3 503
broadcast
no frame-relay inverse-arp
!
router ospf 1
router-id 5.5.5.5
log-adjacency-changes
network 5.5.5.5 0.0.0.0 area 0
network 192.1.35.5 0.0.0.0 area 0
network 192.1.56.5 0.0.0.0 area 0
!
ip classless
no ip http server
no ip http secure-server
ip pim send-rp-announce Loopback0 scope
16 group-list 15
!
access-list 15 permit 224.55.55.55
```

# Lab 6 – Bootstrap Router (BSR)

*Also known as PIMv2*



## Task 1

Configure **PIM Sparse Mode** and **PIM v2** in your **MPLS Core**.

**R1** should be the **RP** for **224.11.11.11** group (**sourcing from its most reliable interface**) and **R3** the **BSR**.

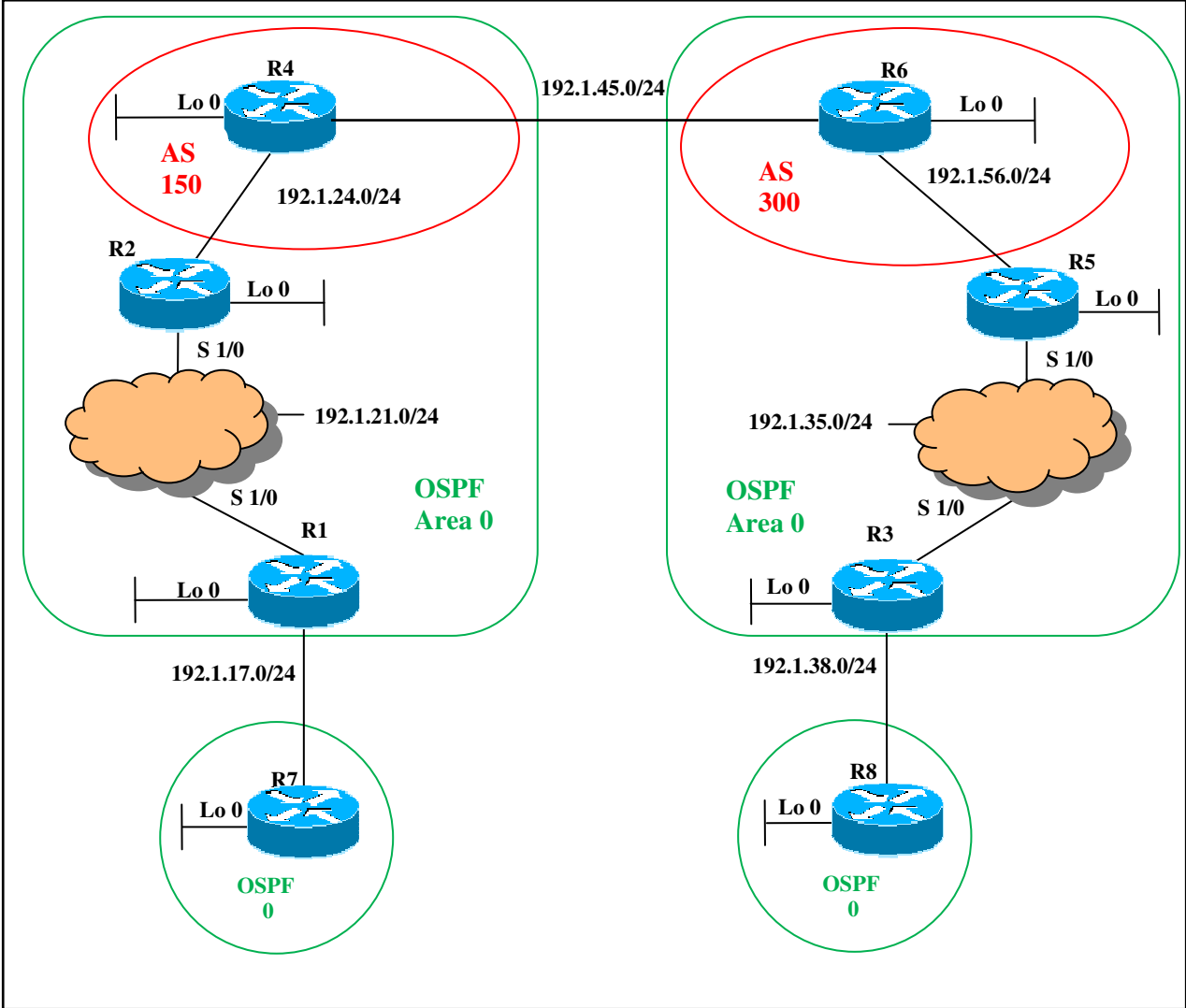
Configure the multicast group of **224.11.11.11** under **R1 Serial1/0**, and make sure everybody in the MPLS Core can reach this group.

<b>R1</b>	<b>R3</b>
<pre> ip multicast-routing ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ip pim sparse-mode ! interface Serial1/0                     </pre>	<pre> ip multicast-routing  interface Loopback0 ip address 3.3.3.3 255.255.255.255 ip pim sparse-mode ! interface Serial1/0                     </pre>

<pre> ip address 192.1.21.1 255.255.255.0 ip igmp join-group 224.11.11.11 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.17.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp router-id 1.1.1.1 bgp log-neighbor-changes neighbor 3.3.3.3 remote-as 10 neighbor 3.3.3.3 update-source Loopback0 neighbor 3.3.3.3 next-hop-self no auto-summary ! address-family vpnv4 neighbor 3.3.3.3 activate neighbor 3.3.3.3 send-community extended exit-address-family  ip pim rp-candidate loopback 0 </pre>	<pre> ip address 192.1.35.3 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 network 192.1.38.3 0.0.0.0 area 0 ! router bgp 10 no synchronization bgp log-neighbor-changes neighbor 1.1.1.1 remote-as 10 neighbor 1.1.1.1 update-source Loopback0 neighbor 1.1.1.1 next-hop-self no auto-summary ! address-family vpnv4 neighbor 1.1.1.1 activate neighbor 1.1.1.1 send-community extended exit-address-family  ip pim bsr-candidate loopback 0 </pre>
<p><b>R4</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 </pre>	<p><b>R6</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 </pre>

<pre> ip address 192.1.24.4 255.255.255.0 ip pim sparse-mode ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim sparse-mode no snmp trap link-status ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 network 192.1.45.4 0.0.0.0 area 0 ! </pre>	<pre> ip address 192.1.45.6 255.255.255.0 ip pim sparse-mode ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim sparse-mode ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.45.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 ! </pre>
<p><b>R2</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.22.22.22  interface Serial1/0 ip address 192.1.21.2 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 </pre>	<p><b>R5</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.50.50.50 ip igmp join-group 224.55.55.55 ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 </pre>

# Lab 7 – Multicast Source Distribution Protocol



### Task 1

Configure **MSDP** between **R4** and **R6** and make sure that multicast traffic from **R8** can be received on **R7** and vice versa, crossing the two ASes.

Make sure that when **R7** sends traffic for **224.88.88.88**, **R4** informs **R6** with a **SA message**.

**R4** should be the **RP** for **R1**, **R2** and **R7**.

**R6** should be the **RP** for **R3**, **R5** and **R8**.

Configure the multicast group of **224.77.77.77** under **R7 Ethernet0/0** interface, and group **224.88.88.88** under **R8 Ethernet0/0** make sure everybody in the MPLS Core can reach this group.

Generate a **default route** under **OSPF** on **R4** and **R6** to avoid reachability problems and RPF Failures.

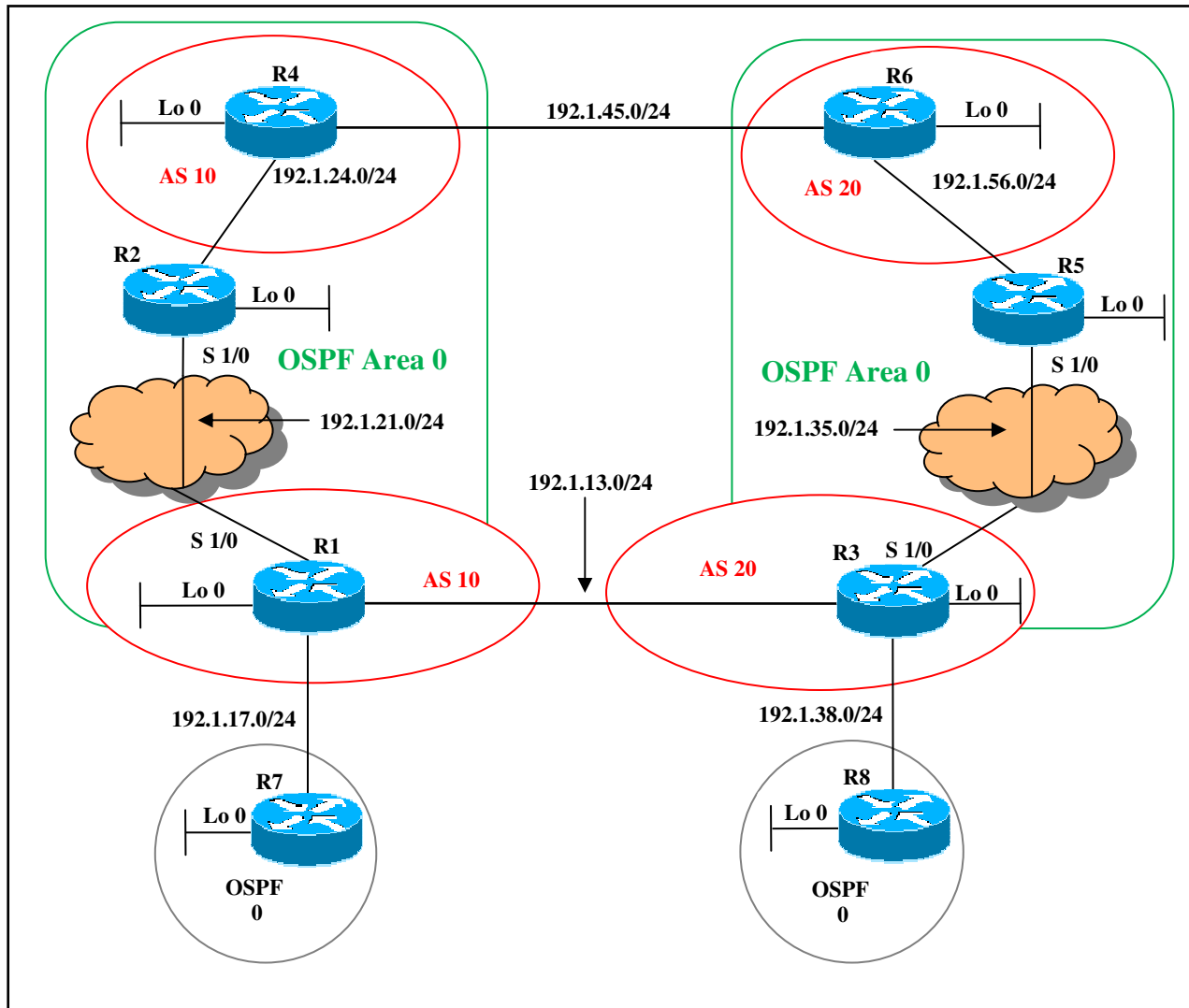
<pre> <b>R1</b>  ip multicast-routing ! ! interface Loopback0 ip address 1.1.1.1 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.17.1 255.255.255.0 ip pim sparse-mode half-duplex ! interface Serial1/0 ip address 192.1.21.1 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.21.2 102 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 1.1.1.1 log-adjacency-changes network 1.1.1.1 0.0.0.0 area 0 network 192.1.17.1 0.0.0.0 area 0 network 192.1.21.1 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.4 </pre>	<pre> <b>R3</b>  ip multicast-routing ! ! interface Loopback0 ip address 3.3.3.3 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.38.3 255.255.255.0 ip pim sparse-mode half-duplex ! interface Serial1/0 ip address 192.1.35.3 255.255.255.0 ip pim sparse-mode encapsulation frame-relay ip ospf network point-to-multipoint frame-relay map ip 192.1.35.5 305 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 3.3.3.3 log-adjacency-changes network 3.3.3.3 0.0.0.0 area 0 network 192.1.35.3 0.0.0.0 area 0 network 192.1.38.3 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.6 </pre>
<pre> <b>R4</b>  ip multicast-routing no ip ips deny-action ips-interface ! interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 </pre>	<pre> <b>R6</b>  ip multicast-routing no mpls ldp logging neighbor-changes ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 </pre>

<pre> ip address 192.1.24.4 255.255.255.0 ip pim sparse-mode no snmp trap link-status no cdp enable ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim sparse-mode no snmp trap link-status no cdp enable ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 default-information originate always ! router bgp 150 no synchronization bgp router-id 4.4.4.4 bgp log-neighbor-changes redistribute ospf 1 neighbor 192.1.45.6 remote-as 300 no auto-summary ! ip pim rp-address 192.1.45.4 ip msdp peer 192.1.45.6 remote-as 300 ! </pre>	<pre> ip address 192.1.45.6 255.255.255.0 ip pim sparse-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim sparse-mode no cdp enable ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes network 6.6.6.6 0.0.0.0 area 0 network 192.1.56.6 0.0.0.0 area 0 default-information originate always ! router bgp 300 no synchronization bgp router-id 3.3.3.3 bgp cluster-id 101058054 bgp log-neighbor-changes redistribute ospf 1 neighbor 192.1.45.4 remote-as 150 no auto-summary  ip pim rp-address 192.1.45.6 ip msdp peer 192.1.45.4 remote-as 150 </pre>
<p><b>R2</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 2.2.2.2 255.255.255.255 ! interface Ethernet0/0 ip address 192.1.24.2 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.22.22.22 half-duplex ! interface Serial1/0 ip address 192.1.21.2 255.255.255.0 ip pim sparse-mode </pre>	<p><b>R5</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 5.5.5.5 255.255.255.255 ! interface FastEthernet0/0 ip address 192.1.56.5 255.255.255.0 ip pim sparse-mode duplex half ! interface Serial2/0 ip address 192.1.35.5 255.255.255.0 ip pim sparse-mode encapsulation frame-relay </pre>



<pre> encapsulation frame-relay ip ospf network point-to-multipoint serial restart-delay 0 no dce-terminal-timing-enable frame-relay map ip 192.1.21.1 201 broadcast no frame-relay inverse-arp ! router ospf 1 log-adjacency-changes network 2.2.2.2 0.0.0.0 area 0 network 192.1.21.2 0.0.0.0 area 0 network 192.1.24.2 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.4 ! </pre>	<pre> ip ospf network point-to-multipoint serial restart-delay 0 frame-relay map ip 192.1.35.3 503 broadcast no frame-relay inverse-arp ! router ospf 1 router-id 5.5.5.5 log-adjacency-changes network 5.5.5.5 0.0.0.0 area 0 network 192.1.35.5 0.0.0.0 area 0 network 192.1.56.5 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.6 </pre>
<p><b>R7</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 7.7.7.7 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.17.7 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.77.77.77 half-duplex ! router ospf 1 router-id 7.7.7.7 log-adjacency-changes network 7.7.7.7 0.0.0.0 area 0 network 192.1.17.7 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.4 </pre>	<p><b>R8</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 8.8.8.8 255.255.255.0 ! interface Ethernet0/0 ip address 192.1.38.8 255.255.255.0 ip pim sparse-mode ip igmp join-group 224.88.88.88 half-duplex ! router ospf 1 router-id 8.8.8.8 log-adjacency-changes network 8.8.8.8 0.0.0.0 area 0 network 192.1.38.8 0.0.0.0 area 0 ! ip pim rp-address 192.1.45.6 </pre>

## Lab 8 – Multicast BGP (M-BGP)



### Task 1

Configure **PIM Dense Mode** inside your two Core Networks.

Configure an **iBGP IPv4 peer** between **R3** and **R6** in **AS 20** and **R1** and **R4** in **AS 10**.

Configure an **eBGP IPv4 peer** between **R4** and **R6**.

Also configure a **MBGP peer** between **R1** and **R3** using its directed interface (192.1.13.0/24).

Configure the multicast group of **224.77.77.77** under **R7 Ethernet0/0** interface, and group **224.88.88.88** under **R8 Ethernet0/0**.

**R7** and **R8** should be able to reach each other's multicast group sourcing from their respective loopbacks.

Generate a **default route** under **OSPF** on **R4** and **R6** to avoid reachability.

<p><b>R1</b></p> <pre> ip multicast-routing  interface Loopback0  ip address 1.1.1.1 255.255.255.255  ! interface Ethernet0/0  no ip address  half-duplex  ! interface Ethernet0/0.13  encapsulation dot1Q 13  ip address 192.1.13.1 255.255.255.0  ip pim dense-mode  no snmp trap link-status  no cdp enable  ! interface Ethernet0/0.17  encapsulation dot1Q 17  ip address 192.1.17.1 255.255.255.0  ip pim dense-mode  no snmp trap link-status  no cdp enable  ! interface Serial1/0  ip address 192.1.21.1 255.255.255.0  ip pim sparse-mode  encapsulation frame-relay  ip ospf network point-to-multipoint  frame-relay map ip 192.1.21.2 102  broadcast  no frame-relay inverse-arp  ! router ospf 1  router-id 1.1.1.1  log-adjacency-changes  network 1.1.1.1 0.0.0.0 area 0  network 192.1.17.1 0.0.0.0 area 0  network 192.1.21.1 0.0.0.0 area 0  ! router bgp 10  bgp router-id 1.1.1.1  bgp log-neighbor-changes  neighbor 4.4.4.4 remote-as 10 </pre>	<p><b>R3</b></p> <pre> ip multicast-routing  ! interface Loopback0  ip address 3.3.3.3 255.255.255.255  ! interface Ethernet0/0  no ip address  half-duplex  ! interface Ethernet0/0.13  encapsulation dot1Q 13  ip address 192.1.13.3 255.255.255.0  ip pim dense-mode  no snmp trap link-status  no cdp enable  ! interface Ethernet0/0.38  encapsulation dot1Q 38  ip address 192.1.38.3 255.255.255.0  ip pim dense-mode  no snmp trap link-status  no cdp enable  ! interface Serial1/0  ip address 192.1.35.3 255.255.255.0  ip pim sparse-mode  encapsulation frame-relay  ip ospf network point-to-multipoint  frame-relay map ip 192.1.35.5 305  broadcast  no frame-relay inverse-arp  ! router ospf 1  router-id 3.3.3.3  log-adjacency-changes  network 3.3.3.3 0.0.0.0 area 0  network 192.1.35.3 0.0.0.0 area 0  network 192.1.38.3 0.0.0.0 area 0  ! router bgp 20  bgp router-id 3.3.3.3  bgp log-neighbor-changes  neighbor 6.6.6.6 remote-as 20 </pre>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

<pre> neighbor 4.4.4.4 update-source Loopback0 neighbor 192.1.13.3 remote-as 20 ! address-family ipv4 neighbor 4.4.4.4 activate neighbor 192.1.13.3 activate no auto-summary no synchronization network 7.7.7.0 mask 255.255.255.0 exit-address-family ! address-family ipv4 multicast neighbor 192.1.13.3 activate no auto-summary no synchronization network 7.7.7.0 mask 255.255.255.0 exit-address-family </pre>	<pre> neighbor 6.6.6.6 update-source Loopback0 neighbor 192.1.13.1 remote-as 10 ! address-family ipv4 neighbor 6.6.6.6 activate neighbor 192.1.13.1 activate no auto-summary no synchronization network 8.8.8.0 mask 255.255.255.0 exit-address-family ! address-family ipv4 multicast neighbor 192.1.13.1 activate no auto-summary no synchronization network 8.8.8.0 mask 255.255.255.0 exit-address-family </pre>
<p><b>R4</b></p> <pre> ip multicast-routing  interface Loopback0 ip address 4.4.4.4 255.255.255.255 ! interface Ethernet0/0 no ip address half-duplex ! interface Ethernet0/0.24 encapsulation dot1Q 24 ip address 192.1.24.4 255.255.255.0 ip pim dense-mode no snmp trap link-status no cdp enable ! interface Ethernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.4 255.255.255.0 ip pim dense-mode no snmp trap link-status no cdp enable ! router ospf 1 router-id 4.4.4.4 log-adjacency-changes </pre>	<p><b>R6</b></p> <pre> ip multicast-routing ! interface Loopback0 ip address 6.6.6.6 255.255.255.255 ! interface FastEthernet0/0 no ip address duplex half ! interface FastEthernet0/0.45 encapsulation dot1Q 45 ip address 192.1.45.6 255.255.255.0 ip pim dense-mode no cdp enable ! interface FastEthernet0/0.56 encapsulation dot1Q 56 ip address 192.1.56.6 255.255.255.0 ip pim dense-mode no cdp enable ! router ospf 1 router-id 6.6.6.6 log-adjacency-changes redistribute connected network 6.6.6.6 0.0.0.0 area 0 </pre>

<pre> redistribute connected network 4.4.4.4 0.0.0.0 area 0 network 192.1.24.4 0.0.0.0 area 0 default-information originate always ! router bgp 10   bgp router-id 4.4.4.4   bgp log-neighbor-changes   neighbor 1.1.1.1 remote-as 10   neighbor 1.1.1.1 update-source Loopback0   neighbor 192.1.45.6 remote-as 20   !   address-family ipv4     neighbor 1.1.1.1 activate     neighbor 1.1.1.1 next-hop-self     neighbor 192.1.45.6 activate   no auto-summary   no synchronization   exit-address-family   ! </pre>	<pre> network 192.1.56.6 0.0.0.0 area 0 default-information originate always ! router bgp 20   bgp router-id 6.6.6.6   bgp cluster-id 50529027   bgp log-neighbor-changes   neighbor 3.3.3.3 remote-as 20   neighbor 3.3.3.3 update-source Loopback0   neighbor 192.1.45.4 remote-as 10   !   address-family ipv4     neighbor 3.3.3.3 activate     neighbor 3.3.3.3 next-hop-self     neighbor 192.1.45.4 activate   no auto-summary   no synchronization   exit-address-family </pre>
<p><b>R7</b></p> <pre> ip multicast-routing ! interface Loopback0   ip address 7.7.7.7 255.255.255.0   ip ospf network point-to-point ! interface Ethernet0/0   ip address 192.1.17.7 255.255.255.0   ip pim dense-mode   ip igmp join-group 224.77.77.77   half-duplex ! router ospf 1   router-id 7.7.7.7   log-adjacency-changes   network 7.7.7.7 0.0.0.0 area 0   network 192.1.17.7 0.0.0.0 area 0 </pre>	<p><b>R8</b></p> <pre> ip multicast-routing ! interface Loopback0   ip address 8.8.8.8 255.255.255.0   ip ospf network point-to-point ! interface Ethernet0/0   ip address 192.1.38.8 255.255.255.0   ip pim dense-mode   ip igmp join-group 224.88.88.88   half-duplex ! router ospf 1   router-id 8.8.8.8   log-adjacency-changes   network 8.8.8.8 0.0.0.0 area 0   network 192.1.38.8 0.0.0.0 area 0 ! </pre>