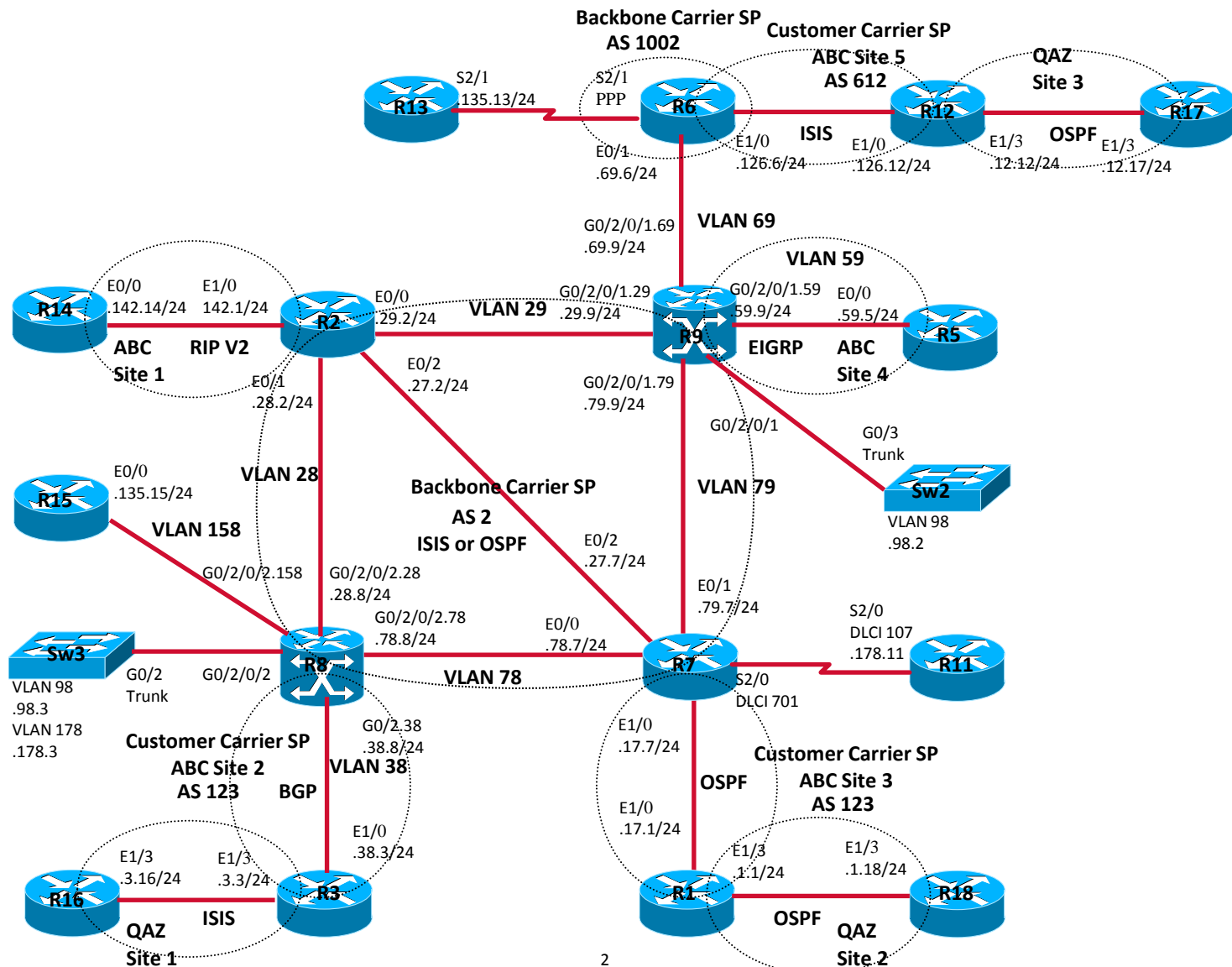# CCIE Service Provider v3.0 Sample Lab

Vincent Jun Ling Zhou

CCIE Service Provider – Product Manager

Cisco Systems

SP Sample Lab – Main Topology

Backbone Carrier SP
AS 1002

Customer Carrier SP
ABC Site 5
AS 612

QAZ
Site 3

R13 S2/1
135.13/24

S2/1
PPP

R6

E0/1
.69.6/24

E1/0
.126.6/24

ISIS

E1/0
.126.12/24

R12

E1/3
.12.12/24

OSPF

R17

E1/3
.12.17/24

G0/2/0/1.69
.69.9/24

VLAN 69

VLAN 59

R14 E0/0
.142.14/24

E1/0
142.1/24

R2 E0/0
.29.2/24

VLAN 29

G0/2/0/1.29
.29.9/24

G0/2/0/1.59
59.9/24

E0/0
.59.5/24

ABC
Site 1

RIP V2

R9

EIGRP

R5

ABC
Site 4

E0/1
.28.2/24

E0/2
.27.2/24

G0/2/0/1.79
.79.9/24

G0/2/0/1

G0/3
Trunk

R15 E0/0
.135.15/24

VLAN 28

Backbone Carrier SP

AS 2

ISIS or OSPF

VLAN 79

Sw2

VLAN 98
.98.2

VLAN 158

G0/2/0/2.158

G0/2/0/2.28
.28.8/24

E0/2
.27.7/24

E0/1
.79.7/24

S2/0
DLCI 107
.178.11

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

Sw3

R8

VLAN 78

R7

R11

VLAN 98
.98.3
VLAN 178
.178.3

G0/2
Trunk

G0/2/0/2

S2/0
DLCI 701

Customer Carrier SP
ABC Site 2
AS 123

BGP

G0/2.38
.38.8/24

VLAN 38

E1/0
.17.7/24

OSPF

Customer Carrier SP
ABC Site 3
AS 123

E1/0
.17.1/24

E1/3
.3.16/24

E1/3
.3.3/24

E1/0
.38.3/24

E1/3
.1.1/24

E1/3
.1.18/24

R16

ISIS

R3

R1

OSPF

R18

QAZ
Site 1

QAZ
Site 2

2

SP Sample Lab – Addressing Scheme

- Backbone Carrier SP network Prefix: 2.2.0.0/24, 2002:2:2::/64

- Backbone Carrier SP router Loopback0: 2.2.0.Z/32, 2002:2:2::Z/128

- Customer Carrier SP/VPN network Prefix: 172.2.0.0/24, 2002:172:2::/64

- Customer Carrier SP/VPN router Loopback0: 172.2.0.Z/32, 2002:172:2::Z/128

- End Customer VPN network Prefix: 192.2.0.0/24

- End Customer VPN router Loopback0: 192.2.0.Z/32

- L2 VPN Customer network Prefix: 172.2.0.0/24

- L2 VPN Customer router Loopback0: 172.2.0.Z/32

"Z" is router number, for example "Z" value for R12 is "12"

SP Sample Lab – Setup

- Hardware

  Two XR-12404 with two GigabitEthernet interfaces or equivalent

  Thirteen Cisco 7200 series routers with Ethernet interfaces or equivalent

  Three Cisco 3560G series or equivalent

- Software Operating System

  XR12000-iosxr-k9-3.9.1.tar

  c7200-spservices-mz.122-33.SRE2.bin

  c3560-advipservicesk9-mz.122-46.SE.bin

SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP Intra-AS VPNv4
8	MP-BGP Inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

IS-IS Overview

- IS-IS was originally designed for use as a dynamic routing protocol for the ISO Connectionless Network Protocol (CLNP)

- IS-IS is a Link State Protocol similar to the Open Shortest Path First (OSPF)

- Three network protocols play together to deliver the ISO defined Connectionless Network Service
    - CLNP
    - IS-IS
    - ES-IS

- All 3 protocols independently ride over layer 2

- Supports for IPv4 and IPv6 routing

- Supports for MPLS Traffic Engineering

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

  1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

  1.3 – Implement, Optimize and Troubleshoot IGP routing

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

IS-IS IPv4/IPv6 – Sub Topology and Question

E0/0
.29.2/24

G0/2/0/1.29
.29.9/24

E0/1
.28.2/24

E0/2
.27.2/24

G0/2/0/1.79
.79.9/24

G0/2/0/2.28
.28.8/24

E0/2
27.7/24

E0/1
.79.7/24

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

R2 R9 R8 R7
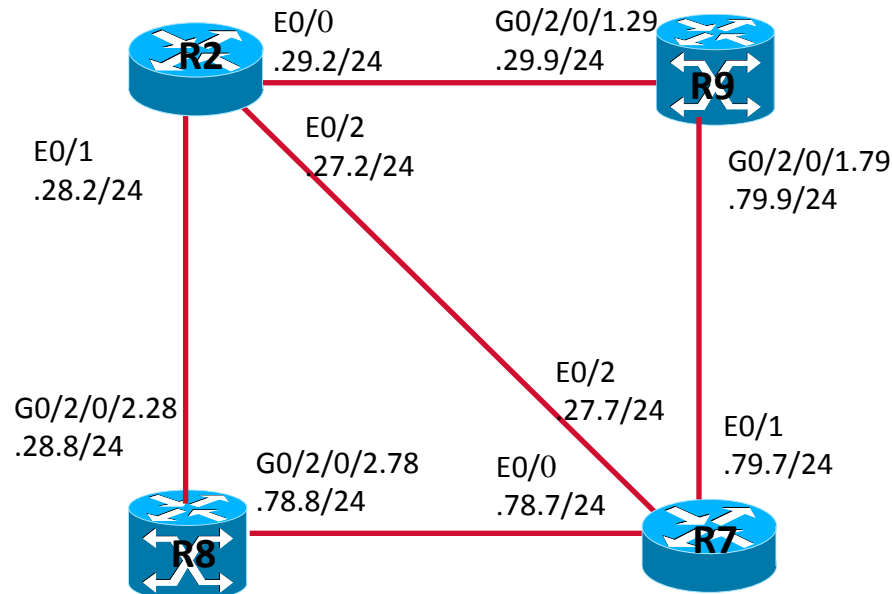
- Configure IS-IS on above routers in area of 47.0002 and put all router into level-1

- Ensure routers have IS-IS IPv4 and IPv6 routes and can ping each other

IS-IS Configuration

R2 (IOS) configuration

interface Loopback0
 ip address 2.2.0.2 255.255.255.255
 ip router isis
 ipv6 address 2002:2:2::2/128
 ipv6 router isis
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:29::2/64
 ipv6 router isis
!
interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:28::2/64
 ipv6 router isis
!

interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:27::2/64
 ipv6 router isis
!
router isis
 net 47.0002.0000.0000.0002.00
 is-type level-1
 metric-style wide
 !
 address-family ipv6
 exit-address-family
!

IS-IS Configuration (Cont.)

R8 (IOS-XR) configuration

interface Loopback0
 ipv4 address 2.2.0.8 255.255.255.255
 ipv6 address 2002:2:2::8/128
!
interface GigabitEthernet0/2/0/2.28
 ipv4 address 2.2.28.8 255.255.255.0
 ipv6 address 2002:2:2:28::8/64
 dot1q vlan 28
!
interface GigabitEthernet0/2/0/2.78
 ipv4 address 2.2.78.8 255.255.255.0
 ipv6 address 2002:2:2:78::8/64
 dot1q vlan 78
!
router isis abc
 net 47.0002.0000.0000.0008.00
 address-family ipv4 unicast
  is-type level-1
  metric-style wide
!

 address-family ipv6 unicast
  single-topology
 !
 interface Loopback0
  passive
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !
 !
 interface GigabitEthernet0/2/0/2.28
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !
 !
 interface GigabitEthernet0/2/0/2.78
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !

10

IS-IS Configuration (Cont.)

R7 (IOS) configuration

interface Loopback0
 ip address 2.2.0.7 255.255.255.255
 ip router isis
 ipv6 address 2002:2:2::7/128
 ipv6 router isis
!
interface Ethernet0/0
 ip address 2.2.78.7 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:78::7/64
 ipv6 router isis
!
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:79::7/64
 ipv6 router isis
!

interface Ethernet0/2
 ip address 2.2.27.7 255.255.255.0
 ip router isis
 ipv6 address 2002:2:2:27::7/64
 ipv6 router isis
!
router isis
 net 47.0002.0000.0000.0007.00
 is-type level-1
 metric-style wide
 !
 address-family ipv6
 exit-address-family

IS-IS Configuration (Cont.)

R9 (IOS-XR) configuration

```
interface Loopback0
 ipv4 address 2.2.0.9 255.255.255.255
 ipv6 address 2002:2:2::9/128
!
interface GigabitEthernet0/2/0/1.29
 ipv4 address 2.2.29.9 255.255.255.0
 ipv6 address 2002:2:2:29::9/64
 dot1q vlan 29
!
interface GigabitEthernet0/2/0/1.79
 ipv4 address 2.2.79.9 255.255.255.0
 ipv6 address 2002:2:2:79::9/64
 dot1q vlan 79
!
router isis abc
 is-type level-1
 net 47.0002.0000.0000.9999.00
 address-family ipv4 unicast
  metric-style wide
 !
```

```
 address-family ipv6 unicast
  single-topology
 !
 interface Loopback0
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !
 !
 interface GigabitEthernet0/2/0/1.29
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !
 !
 interface GigabitEthernet0/2/0/1.79
  address-family ipv4 unicast
  !
  address-family ipv6 unicast
  !
```

IS-IS Adjacency

R2#show clns neighbors

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
R7	Et0/2	0e00.0000.4620	Up	27	L1	IS-IS
R8	Et0/1	0015.c75c.3552	Up	24	L1	IS-IS
R9	Et0/0	0013.7fe1.c551	Up	21	L1	IS-IS

R7#show clns neighbors

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
R2	Et0/2	0e00.0000.1420	Up	29	L1	IS-IS
R8	Et0/0	0015.c75c.3552	Up	29	L1	IS-IS
R9	Et0/1	0013.7fe1.c551	Up	25	L1	IS-IS

RP/0/0/CPU0:R8#show isis neighbors

IS-IS abc neighbors:

System Id	Interface	SNPA	State	Holdtime	Type	IETF-NSF
R2	Gi0/2/0/2.28	0e00.0000.1410	Up	8	L1	Capable
R7	Gi0/2/0/2.78	0e00.0000.4600	Up	0	L1	Capable

RP/0/0/CPU0:R9#show isis neighbors

IS-IS abc neighbors:

System Id	Interface	SNPA	State	Holdtime	Type	IETF-NSF
R2	Gi0/2/0/1.29	0e00.0000.1400	Up	7	L1	Capable
R7	Gi0/2/0/1.79	0e00.0000.4610	Up	9	L1	Capable

IS-IS Database

R2 #show isis database
Tag null:
IS-IS Level-1 Link State Database:

LSPID	LSP Seq Num	LSP Checksum	LSP Holdtime	ATT/P/OL
R2.00-00	* 0x00000F08	0xAD29	1117	0/0/0
R2.02-00	* 0x00000B3E	0x14B3	417	0/0/0
R2.03-00	* 0x00000B48	0x33B4	1000	0/0/0
R7.00-00	0x0000101B	0x018A	1135	0/0/0
R7.02-00	0x00000002	0xEC43	857	0/0/0
R7.03-00	0x00000002	0xAB58	983	0/0/0
R8.00-00	0x0000205D	0x68D3	1101	0/0/0
R8.01-00	0x00001C88	0x4CC0	966	0/0/0
R9.00-00	0x000039F6	0xAAF1	1163	0/0/0

All router have same IS-IS database

IS-IS Routes

R2#show ip route isis
i L1   2.2.0.7/32 [115/20] via 2.2.27.7, Ethernet0/2
i L1   2.2.0.8/32 [115/10] via 2.2.28.8, Ethernet0/1
i L1   2.2.0.9/32 [115/10] via 2.2.29.9, Ethernet0/0
i L1   2.2.78.0/24 [115/20] via 2.2.28.8, Ethernet0/1
               [115/20] via 2.2.27.7, Ethernet0/2
i L1   2.2.79.0/24 [115/20] via 2.2.29.9, Ethernet0/0
               [115/20] via 2.2.27.7, Ethernet0/2

R2#show ipv6 route isis
I1 2002:2:2::7/128 [115/20]
    via FE80::C00:FF:FE00:4620, Ethernet0/2
I1 2002:2:2::8/128 [115/10]
    via FE80::215:C7FF:FE5C:3552, Ethernet0/1
I1 2002:2:2::9/128 [115/10]
    via FE80::213:7FFF:FEE1:C551, Ethernet0/0
I1 2002:2:2:78::/64 [115/20]
    via FE80::215:C7FF:FE5C:3552, Ethernet0/1
    via FE80::C00:FF:FE00:4620, Ethernet0/2
I1 2002:2:2:79::/64 [115/20]
    via FE80::213:7FFF:FEE1:C551, Ethernet0/0
    via FE80::C00:FF:FE00:4620, Ethernet0/2

IS-IS Routes (Cont.)

RP/0/0/CPU0:R8#show route ipv4 isis
i L1 2.2.0.2/32 [115/20] via 2.2.28.2, 00:02:47, GigabitEthernet0/2/0/2.28
i L1 2.2.0.7/32 [115/20] via 2.2.78.7, 00:02:44, GigabitEthernet0/2/0/2.78
i L1 2.2.0.9/32 [115/20] via 2.2.78.7, 00:00:16, GigabitEthernet0/2/0/2.78
         [115/20] via 2.2.28.2, 00:00:16, GigabitEthernet0/2/0/2.28
i L1 2.2.27.0/24 [115/20] via 2.2.78.7, 00:02:44, GigabitEthernet0/2/0/2.78
          [115/20] via 2.2.28.2, 00:02:44, GigabitEthernet0/2/0/2.28
i L1 2.2.29.0/24 [115/20] via 2.2.28.2, 00:02:47, GigabitEthernet0/2/0/2.28
i L1 2.2.79.0/24 [115/20] via 2.2.78.7, 00:02:44, GigabitEthernet0/2/0/2.78

RP/0/0/CPU0:R8#show route ipv6 isis
i L1 2002:2:2::2/128
    [115/20] via fe80::c00:ff:fe00:1410, 00:42:41, GigabitEthernet0/2/0/2.28
i L1 2002:2:2::7/128
    [115/20] via fe80::c00:ff:fe00:4600, 00:03:29, GigabitEthernet0/2/0/2.78
i L1 2002:2:2::9/128
    [115/20] via fe80::c00:ff:fe00:4600, 00:03:26, GigabitEthernet0/2/0/2.78
    [115/20] via fe80::c00:ff:fe00:1410, 00:03:26, GigabitEthernet0/2/0/2.28
i L1 2002:2:2:27::/64
    [115/20] via fe80::c00:ff:fe00:4600, 00:03:29, GigabitEthernet0/2/0/2.78
    [115/20] via fe80::c00:ff:fe00:1410, 00:03:29, GigabitEthernet0/2/0/2.28
i L1 2002:2:2:29::/64
    [115/20] via fe80::c00:ff:fe00:1410, 00:03:32, GigabitEthernet0/2/0/2.28
i L1 2002:2:2:79::/64
    [115/20] via fe80::c00:ff:fe00:4600, 00:03:29, GigabitEthernet0/2/0/2.78

Connectivity Verification

RP/0/0/CPU0:R8#ping 2.2.0.9 source 2.2.0.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.9, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 15/18/20 ms

R2#ping 2.2.0.8 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.8, timeout is 2 seconds:
Packet sent with a source address of 2.2.0.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/10/12 ms

RP/0/0/CPU0:R9#ping 2.2.0.7 source 2.2.0.9
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.7, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 7/11/20 ms

Connectivity Verification (Cont.)

RP/0/0/CPU0:R8#ping 2002:2:2::9 source 2002:2:2::8

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2002:2:2::9, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 4/5/6 ms

RP/0/0/CPU0:R8#ping 2002:2:2::2 source 2002:2:2::8

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2002:2:2::2, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/3 ms

RP/0/0/CPU0:R8#ping 2002:2:2::7 source 2002:2:2::8

Type escape sequence to abort.

Sending 5, 100-byte ICMP Echos to 2002:2:2::7, timeout is 2 seconds:

!!!!!

Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/3 ms

OSPF Overview

- OSPF is a link state protocol, uses Dijkstra (Shortest Path First) algorithm to find path.

- OSPF uses two-level hierarchical model

- OSPF supports for CIDR, VLSM, authentication, multipath, and IP unnumbered

- OSPF supports for IPv4 and IPv6 routing

- OSPF supports for MPLS Traffic Engineering

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

  1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

  1.3 – Implement, Optimize and Troubleshoot IGP routing

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

OSPF IPv4/IPv6 – Sub Topology and Question
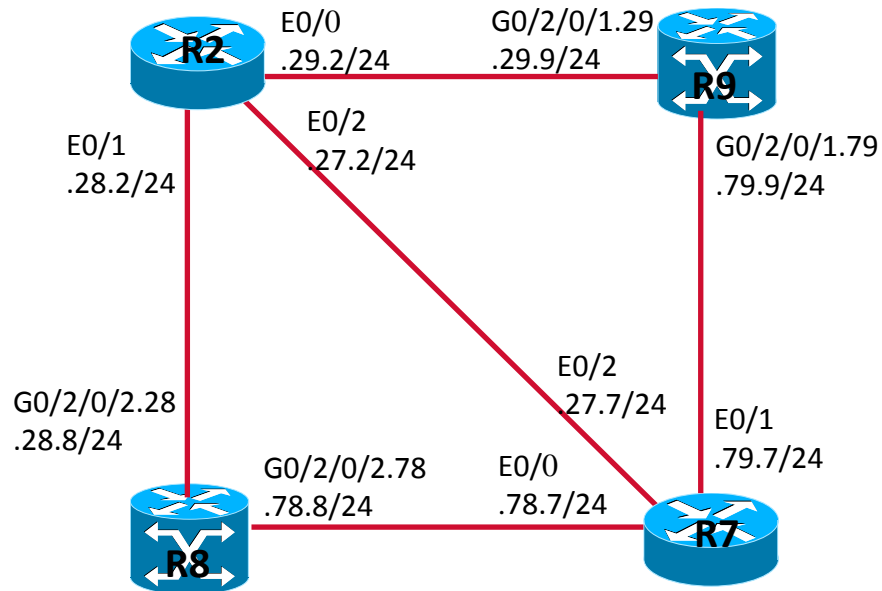
- Configure OSPF and OSPFv3 on above routers in area 0
- Ensure routers have OSPF IPv4 and IPv6 routes and can ping each other

OSPF Configuration

R2 (IOS) configuration

interface Loopback0
 ip address 2.2.0.2 255.255.255.255
 ipv6 address 2002:2:2::2/128
 ipv6 ospf 300 area 0
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 ipv6 address 2002:2:2:29::2/64
 ipv6 ospf 300 area 0
!
interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 ipv6 address 2002:2:2:28::2/64
 ipv6 ospf 300 area 0
!

interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 ipv6 address 2002:2:2:27::2/64
ipv6 ospf 300 area 0
!
router ospf 200
 network 2.2.0.0 0.0.255.255 area 0
!
ipv6 router ospf 300
 router-id 2.2.0.2
!

OSPF Configuration (Cont.)

R8 (IOS-XR) configuration

interface Loopback0
 ipv4 address 2.2.0.8 255.255.255.255
 ipv6 address 2002:2:2::8/128
!
interface GigabitEthernet0/2/0/2.28
 ipv4 address 2.2.28.8 255.255.255.0
 ipv6 address 2002:2:2:28::8/64
 dot1q vlan 28
!
interface GigabitEthernet0/2/0/2.78
 ipv4 address 2.2.78.8 255.255.255.0
 ipv6 address 2002:2:2:78::8/64
 dot1q vlan 78
!

router ospf 200
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/2/0/2.28
  !
  interface GigabitEthernet0/2/0/2.78
!
router ospfv3 300
 address-family ipv6
 area 0
  interface Loopback0
  !
  interface GigabitEthernet0/2/0/2.28
  !
  interface GigabitEthernet0/2/0/2.78
  !

Note: R7 and R9 configurations are similar to R2 and R8

OSPF Adjacency

R2#show ip ospf neighbor

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.0.7	1	FULL/DR	00:00:32	2.2.27.7	Ethernet0/2
2.2.0.8	1	FULL/DR	00:00:30	2.2.28.8	Ethernet0/1
2.2.0.9	1	FULL/DR	00:00:38	2.2.29.9	Ethernet0/0

RP/0/0/CPU0:R8#show ospf neighbor

Neighbors for OSPF 200

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.0.2	1	FULL/BDR	00:00:33	2.2.28.2	GigabitEthernet0/2/0/2.28
Neighbor is up for 00:27:46					
2.2.0.7	1	FULL/BDR	00:00:36	2.2.78.7	GigabitEthernet0/2/0/2.78
Neighbor is up for 00:27:17					

RP/0/0/CPU0:R8#show ospfv3 neighbor

Neighbors for OSPFv3 300

Neighbor ID	Pri	State	Dead Time	Address	Interface
2.2.0.2	1	FULL/BDR	00:00:31	2.2.28.2	GigabitEthernet0/2/0/2.28
Neighbor is up for 00:27:50					
2.2.0.7	1	FULL/BDR	00:00:32	2.2.78.7	GigabitEthernet0/2/0/2.78
Neighbor is up for 00:27:32					

OSPF Routes

R2#show ip route ospf
O   2.2.0.7/32 [110/11] via 2.2.27.7, 00:54:42, Ethernet0/2
O   2.2.0.8/32 [110/11] via 2.2.28.8, 00:55:37, Ethernet0/1
O   2.2.0.9/32 [110/11] via 2.2.29.9, 00:55:37, Ethernet0/0
O   2.2.78.0/24 [110/11] via 2.2.28.8, 00:55:37, Ethernet0/1
O   2.2.79.0/24 [110/11] via 2.2.29.9, 00:55:37, Ethernet0/0

R2#show ipv6 route ospf
O   2002:2:2::7/128 [110/10]
     via FE80::C00:FF:FE00:4620, Ethernet0/2
O   2002:2:2::8/128 [110/10]
     via FE80::215:C7FF:FE5C:3552, Ethernet0/1
O   2002:2:2::9/128 [110/10]
     via FE80::213:7FFF:FEE1:C551, Ethernet0/0
O   2002:2:2:78::/64 [110/11]
     via FE80::215:C7FF:FE5C:3552, Ethernet0/1
O   2002:2:2:79::/64 [110/11]
     via FE80::213:7FFF:FEE1:C551, Ethernet0/0

OSPF Routes (Cont.)

RP/0/0/CPU0:R8#show route ipv4 ospf
O   2.2.0.2/32 [110/2] via 2.2.28.2, 00:53:44, GigabitEthernet0/2/0/2.28
O   2.2.0.7/32 [110/2] via 2.2.78.7, 00:53:12, GigabitEthernet0/2/0/2.78
O   2.2.0.9/32 [110/12] via 2.2.78.7, 00:53:12, GigabitEthernet0/2/0/2.78
              [110/12] via 2.2.28.2, 00:53:12, GigabitEthernet0/2/0/2.28
O   2.2.27.0/24 [110/11] via 2.2.78.7, 00:52:44, GigabitEthernet0/2/0/2.78
               [110/11] via 2.2.28.2, 00:52:44, GigabitEthernet0/2/0/2.28
O   2.2.29.0/24 [110/11] via 2.2.28.2, 00:53:44, GigabitEthernet0/2/0/2.28
O   2.2.79.0/24 [110/11] via 2.2.78.7, 00:53:12, GigabitEthernet0/2/0/2.78

RP/0/0/CPU0:R8#show route ipv6 ospf
O   2002:2:2::2/128
    [110/1] via fe80::c00:ff:fe00:1410, 00:13:14, GigabitEthernet0/2/0/2.28
O   2002:2:2::7/128
    [110/1] via fe80::c00:ff:fe00:4600, 00:14:53, GigabitEthernet0/2/0/2.78
O   2002:2:2::9/128
    [110/11] via fe80::c00:ff:fe00:4600, 00:13:14, GigabitEthernet0/2/0/2.78
    [110/11] via fe80::c00:ff:fe00:1410, 00:13:14, GigabitEthernet0/2/0/2.28
O   2002:2:2:27::/64
    [110/11] via fe80::c00:ff:fe00:4600, 00:13:14, GigabitEthernet0/2/0/2.78
    [110/11] via fe80::c00:ff:fe00:1410, 00:13:14, GigabitEthernet0/2/0/2.28
O   2002:2:2:29::/64
    [110/11] via fe80::c00:ff:fe00:1410, 00:13:14, GigabitEthernet0/2/0/2.28
O   2002:2:2:79::/64
    [110/11] via fe80::c00:ff:fe00:4600, 00:14:53, GigabitEthernet0/2/0/2.78

Connectivity Verification

RP/0/0/CPU0:R8#ping 2.2.0.9 source 2.2.0.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.9, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 15/18/20 ms

R2#ping 2.2.0.8 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.8, timeout is 2 seconds:
Packet sent with a source address of 2.2.0.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/10/12 ms

RP/0/0/CPU0:R9#ping 2.2.0.7 source 2.2.0.9
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.7, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 7/11/20 ms

BGP Overview

- BGP scales Internet routing by connecting ISPs with globally unique AS numbers

- BGP uses TCP (with port 179) to exchange updates

- BGP is Path Vector Protocol

- BGP is composed of IBGP and EBGP

- BGP has improved to support multi protocol operation

- Note: This section describes BGP IPv4 and IPv6 unicast family

  MP-BGP will be introduced in further sections

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

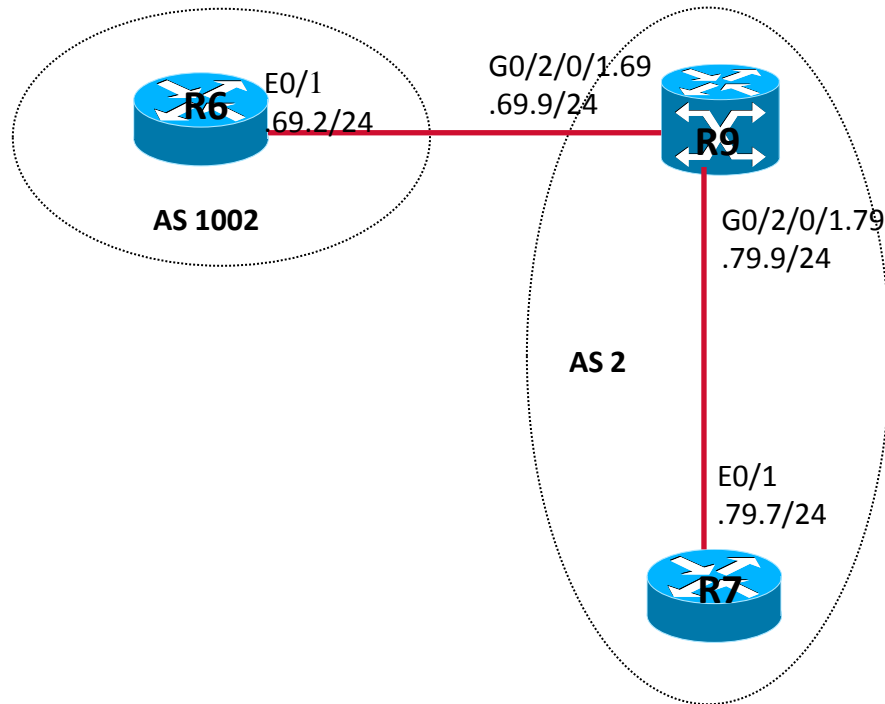 https://learningnetwork.cisco.com/docs/DOC-9991

  1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

  1.6 – Implement, Optimize and Troubleshoot BGP

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

BGP Unicast IPv4/IPv6 – Sub Topology and Question

- Configure IBGP IPv4/IPv6 unicast between R7 and R9

- Configure EBGP IPv4/IPv6 unicast between R6 and R9

- Ensure Loopback0 IPV4/IPv6 network is seen as BGP routes and they can ping each other

BGP Configuration

R7 (IOS) configuration

```
interface Loopback0
 ip address 2.2.0.7 255.255.255.255
 ipv6 address 2002:2:2::7/128
!
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 ipv6 address 2002:2:2:79::7/64
!
router bgp 2
 no bgp default ipv4-unicast
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 neighbor 2002:2:2::9 remote-as 2
 neighbor 2002:2:2::9 update-source loopback 0
 !
```

```
address-family ipv4
 no synchronization
 network 2.2.0.7 mask 255.255.255.255
 neighbor 2.2.0.2 activate
 neighbor 2.2.0.2 send-community
 no auto-summary
exit-address-family
!
address-family ipv6
 no synchronization
 network 2002:2:2::7/128
 neighbor 2002:2:2::9 activate
exit-address-family
!
```

BGP Configuration (Cont.)

R9 (IOS-XR) configuration

```
interface Loopback0
 ipv4 address 2.2.0.9 255.255.255.255
 ipv6 address 2002:2:2::9/128
!
interface GigabitEthernet0/2/0/1.69
 ipv4 address 2.2.69.9 255.255.255.0
 ipv6 address 2002:2:2:69::9/64
 dot1q vlan 69
!
router bgp 2
 address-family ipv4 unicast
  network 2.2.0.9/32
 !
 address-family ipv6 unicast
  network 2002:2:2::9/128
 !
 neighbor 2.2.0.7
  remote-as 2
  update-source Loopback0
  address-family ipv4 unicast
  next-hop-self
 !
```

```
 address-family vpnv6 unicast
  next-hop-self
  !
 neighbor 2.2.69.6
  remote-as 1002
  address-family ipv4 unicast
 route-policy default_policy_pass_all in
 route-policy default_policy_pass_all out
 !
 neighbor 2002:2:2::7
  remote-as 2
  update-source Loopback0
  address-family ipv6 unicast
  next-hop-self
  !
 neighbor 2002:2:2:69::6
  remote-as 1002
  address-family ipv6 unicast
  route-policy default_policy_pass_all in
  route-policy default_policy_pass_all out
```

Note: Configure EBGP in IOS-XR will require defining "route-policy"

BGP Configuration (Cont.)

R6 (IOS) configuration

interface Loopback0
 ip address 2.2.0.6 255.255.255.255
 ipv6 address 2002:2:2::6/128
!
interface Ethernet0/1
 ip address 2.2.69.6 255.255.255.0
 ipv6 address 2002:2:2:69::6/64
!
router bgp 1002
 no bgp default ipv4-unicast
 neighbor 2.2.69.9 remote-as 2
 neighbor 2002:2:2:69::9 remote-as 2
 !

address-family ipv4
 no synchronization
 network 2.2.0.6 mask 255.255.255.255
 neighbor 2.2.69.9 activate
 no auto-summary
exit-address-family
!
 address-family ipv6
 no synchronization
 network 2002:2:2::6/128
 neighbor 2002:2:2:69::9 activate
exit-address-family
!

BGP Adjacency

R6#show bgp ipv4 unicast summary
Neighbor   V   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down State/PfxRcd
2.2.69.9   4   2   117   120   30   0   0 01:28:24   6

R6#show bgp ipv6 unicast summary
Neighbor   V   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down State/PfxRcd
2002:2:2:69::9 4   2   90   99   5   0   0 01:25:46   2

RP/0/0/CPU0:R9#show bgp ipv4 unicast summary
Neighbor   Spk   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down St/PfxRcd
2.2.0.7   0   2   106312 101563   0   0   0   1d21h   0
2.2.69.6   0 1002 108429 100503   6635   0   0 01:30:26   7

RP/0/0/CPU0:R9#show bgp ipv6 unicast summary
Neighbor   Spk   AS MsgRcvd MsgSent   TblVer InQ OutQ Up/Down St/PfxRcd
2002:2:2::7   0   2   104763 95205   4   0   0   1d21h   1
2002:2:2:69::6 0 1002   101   92   4   0   0 01:27:59   1

BGP Routes

R6#show ip route bgp
B   2.2.0.7/32 [20/0] via 2.2.69.9, 01:25:50
B   2.2.0.9/32 [20/0] via 2.2.69.9, 01:25:50

R6#show ipv6 route bgp
B 2002:2:2::7/128 [20/0]   via FE80::213:7FFF:FEE1:C551, Ethernet0/1
B 2002:2:2::9/128 [20/0]   via FE80::213:7FFF:FEE1:C551, Ethernet0/1

RP/0/0/CPU0:R9#show route ipv4 bgp
B   2.2.0.6/32 [20/20] via 2.2.69.6, 01:25:25

RP/0/0/CPU0:R9#show route ipv6 bgp
B   2002:2:2::6/128
   [20/0] via fe80::c00:ff:fe00:3c10, 01:35:31, GigabitEthernet0/2/0/1.69

R7#show ip route bgp
B   2.2.0.6/32 [200/20] via 2.2.0.9, 01:29:36

R7#show ipv6 route bgp
B 2002:2:2::6/128 [200/0]
   via 2002:2:2::9

Connectivity Verification

R6#ping 2.2.0.9 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.9, timeout is 2 seconds:
Packet sent with a source address of 2.2.0.6
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/10/12 ms

R6#ping 2002:2:2::9 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:2:2::9, timeout is 2 seconds:
Packet sent with a source address of 2002:2:2::6
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 8/8/12 ms

R6#ping 2.2.0.7 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.7, timeout is 2 seconds:
Packet sent with a source address of 2.2.0.6
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms

R6#ping 2002:2:2::7 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:2:2::7, timeout is 2 seconds:
Packet sent with a source address of 2002:2:2::6
!!!!! 36
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/19/20 ms

SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP Intra-AS VPNv4
8	MP-BGP Inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

MPLS Overview

- Based on the label-swapping and forwarding paradigm

- As a packet enters an MPLS network, it is assigned a label based on its Forwarding Equivalence Class (FEC) as determined at the edge of the MPLS network

- FECs are groups of packets forwarded over the same Label Switched Path (LSP)

- Need a mechanism that will create and distribute labels to establish LSP paths

- Separated into two planes:

  – Control Plane—responsible for maintaining correct label tables among Label Switching Routers

  – Forwarding Plane—uses label carried by packet and label table maintained by LSR to forward the packet

Label Distribution Protocol

- LDP is a superset of the Cisco-specific Tag Distribution Protocol

- Assigns, distributes, and installs (in forwarding) labels for prefixes advertised by unicast routing protocols

  OSPF, IS-IS, EIGRP, etc.

- Also used for Pseudowire/PW (VC) signaling

  Used for L2VPN control plane signaling

- Uses UDP (port 646) for session discovery and TCP (port 646) for exchange of LDP messages

- LDP operations

  LDP Peer Discovery

  LDP Session Establishment

  MPLS Label Allocation, Distribution, and Updating MPLS forwarding

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

    https://learningnetwork.cisco.com/docs/DOC-9991
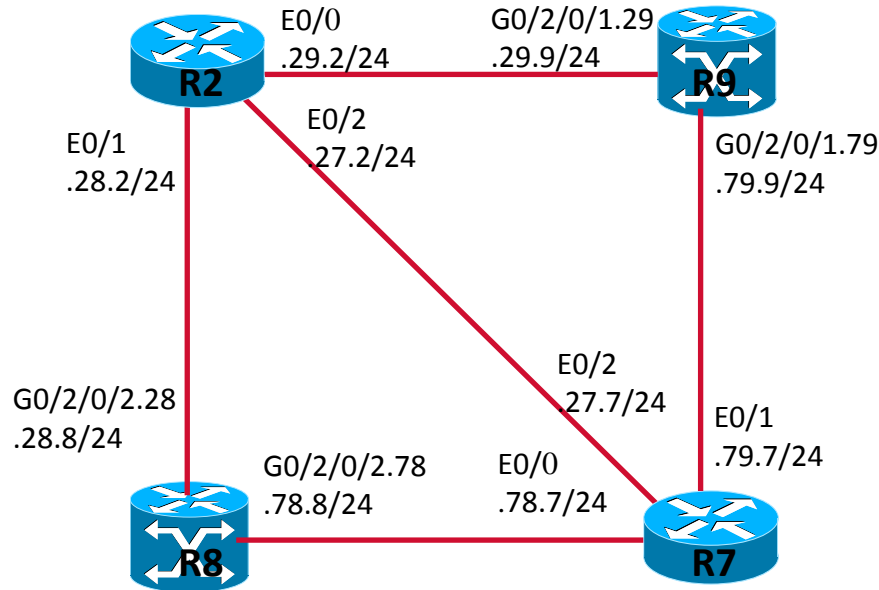
    1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

    1.4 – Implement, Optimize and Troubleshoot MPLS and LDP

- For more details, please review the Lab Exam Checklist document below;

    https://learningnetwork.cisco.com/docs/DOC-10145

MPLS LDP – Sub Topology and Question

E0/0
.29.2/24

G0/2/0/1.29
.29.9/24

R2   R9

E0/1
.28.2/24

E0/2
27.2/24

G0/2/0/1.79
.79.9/24

G0/2/0/2.28
.28.8/24

E0/2
27.7/24

E0/1
.79.7/24

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

R8   R7

- ■ Enable MPLS LDP on above routers, use loopback 0 IP address as router-id

- ■ IS-IS is acting as unicast routing protocol

MPLS LDP Configuration

R2 (IOS) configuration

mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
 ip address 2.2.0.2 255.255.255.255
 mpls ip
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 mpls ip
!
interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 mpls ip
!

interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 mpls ip
!

MPLS LDP Configuration (Cont.)

R8 (IOS-XR) configuration

interface Loopback0
 ipv4 address 2.2.0.8 255.255.255.255
 !
interface GigabitEthernet0/2/0/2.28
 ipv4 address 2.2.28.8 255.255.255.0
 dot1q vlan 28
 !
interface GigabitEthernet0/2/0/2.78
 ipv4 address 2.2.78.8 255.255.255.0
 dot1q vlan 78
!

mpls ldp
 router-id 2.2.0.8
 !
 interface GigabitEthernet0/2/0/2.28
 !
 interface GigabitEthernet0/2/0/2.78
 !
!

MPLS LDP Configuration (Cont.)

R7 (IOS) configuration

mpls label protocol ldp
mpls ldp router-id Loopback0
!
interface Loopback0
 ip address 2.2.0.7 255.255.255.255
 mpls ip
!
interface Ethernet0/0
 ip address 2.2.78.7 255.255.255.0
 mpls ip
!
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 mpls ip

interface Ethernet0/2
 ip address 2.2.27.7 255.255.255.0
 mpls ip
!

MPLS LDP Configuration (Cont.)

R9 (IOS-XR) configuration

```
interface Loopback0
 ipv4 address 2.2.0.9 255.255.255.255
!
interface GigabitEthernet0/2/0/1.29
 ipv4 address 2.2.29.9 255.255.255.0
 dot1q vlan 29
!
interface GigabitEthernet0/2/0/1.79
 ipv4 address 2.2.79.9 255.255.255.0
 dot1q vlan 79
!
```

```
mpls ldp
 router-id 2.2.0.9
 !
 interface GigabitEthernet0/2/0/1.29
 !
 interface GigabitEthernet0/2/0/1.79
 !
!
```

MPLS LDP Adjacency

R2#show mpls ldp neighbor
  Peer LDP Ident: 2.2.0.7:0; Local LDP Ident 2.2.0.2:0
    TCP connection: 2.2.0.7.56629 - 2.2.0.2.646
    State: Oper; Msgs sent/rcvd: 258/248; Downstream
    Up time: 03:19:04
    LDP discovery sources:
      Ethernet0/2, Src IP addr: 2.2.27.7
      Targeted Hello 2.2.0.2 -> 2.2.0.7, active, passive
    Addresses bound to peer LDP Ident:
      2.2.0.7   2.2.27.7   2.2.78.7   2.2.79.7
  Peer LDP Ident: 2.2.0.9:0; Local LDP Ident 2.2.0.2:0
    TCP connection: 2.2.0.9.16960 - 2.2.0.2.646
    State: Oper; Msgs sent/rcvd: 247/249; Downstream
    Up time: 03:18:59
    LDP discovery sources:
      Ethernet0/0, Src IP addr: 2.2.29.9
    Addresses bound to peer LDP Ident:
      2.2.0.9   2.2.29.9   2.2.79.9
  Peer LDP Ident: 2.2.0.8:0; Local LDP Ident 2.2.0.2:0
    TCP connection: 2.2.0.8.36575 - 2.2.0.2.646
    State: Oper; Msgs sent/rcvd: 248/243; Downstream
    Up time: 03:18:59
    LDP discovery sources:
      Ethernet0/1, Src IP addr: 2.2.28.8
    Addresses bound to peer LDP Ident: 46
      2.2.0.8   2.2.28.8   2.2.78.8

MPLS LDP Adjacency (Cont.)

RP/0/0/CPU0:R8#show mpls ldp neighbor
Peer LDP Identifier: 2.2.0.7:0
 TCP connection: 2.2.0.7:646 - 2.2.0.8:48153
 Graceful Restart: No
 Session Holdtime: 180 sec
 State: Oper; Msgs sent/rcvd: 244/245
 Up time: 03:15:48
 LDP Discovery Sources:
  Targeted Hello (2.2.0.8 -> 2.2.0.7, active/passive)
  GigabitEthernet0/2/0/2.78
 Addresses bound to this peer:
  2.2.0.7   2.2.79.7   2.2.27.7   2.2.78.7

 Peer LDP Identifier: 2.2.0.2:0
 TCP connection: 2.2.0.2:646 - 2.2.0.8:36575
 Graceful Restart: No
 Session Holdtime: 180 sec
 State: Oper; Msgs sent/rcvd: 239/244
 Up time: 03:15:47
 LDP Discovery Sources:
  GigabitEthernet0/2/0/2.28
 Addresses bound to this peer:
  2.2.0.2   2.2.29.2   2.2.27.2   2.2.28.2

MPLS forwarding table

R2#show mpls forwarding-table

Local Label	Outgoing Label or VC	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
17	Pop Label	2.2.0.9/32	362367	Et0/0	2.2.29.9
18	Pop Label	2.2.0.8/32	1042947	Et0/1	2.2.28.8
19	Pop Label	2.2.0.7/32	455	Et0/2	2.2.27.7
21	Pop Label	2.2.79.0/24	0	Et0/2	2.2.27.7
	Pop Label	2.2.79.0/24	0	Et0/0	2.2.29.9
23	Pop Label	2.2.78.0/24	0	Et0/2	2.2.27.7
	Pop Label	2.2.78.0/24	0	Et0/1	2.2.28.8

RP/0/0/CPU0:R8#show mpls forwarding

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16002	Pop	2.2.0.2/32	Gi0/2/0/2.28	2.2.28.2	173494
16003	17	2.2.0.9/32	Gi0/2/0/2.28	2.2.28.2	300861
	21	2.2.0.9/32	Gi0/2/0/2.78	2.2.78.7	330246
16004	Pop	2.2.27.0/24	Gi0/2/0/2.28	2.2.28.2	0
	Pop	2.2.27.0/24	Gi0/2/0/2.78	2.2.78.7	0
16006	Pop	2.2.79.0/24	Gi0/2/0/2.78	2.2.78.7	0
16007	Pop	2.2.29.0/24	Gi0/2/0/2.28	2.2.28.2	0
16014	Pop	2.2.0.7/32	Gi0/2/0/2.78	2.2.78.7	72967

MPLS Traffic Engineering Overview

- Introduces explicit routing

- Supports constraint-based routing

- Supports admission control

- Provides protection capabilities

- Uses RSVP-TE to establish LSPs

- Uses ISIS/OSPF extensions to advertise link attributes
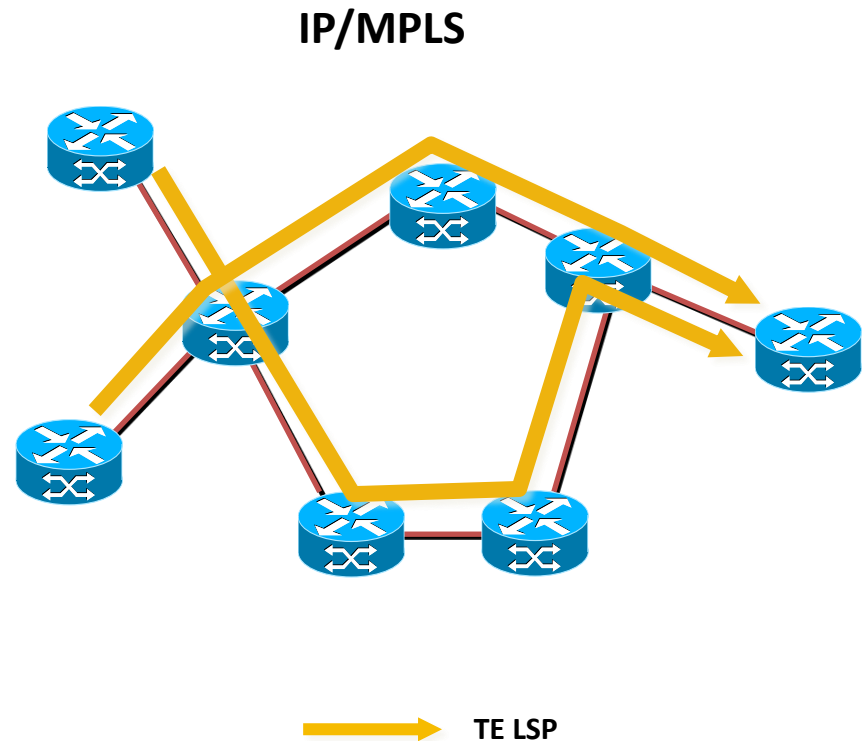
IP/MPLS

TE LSP

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

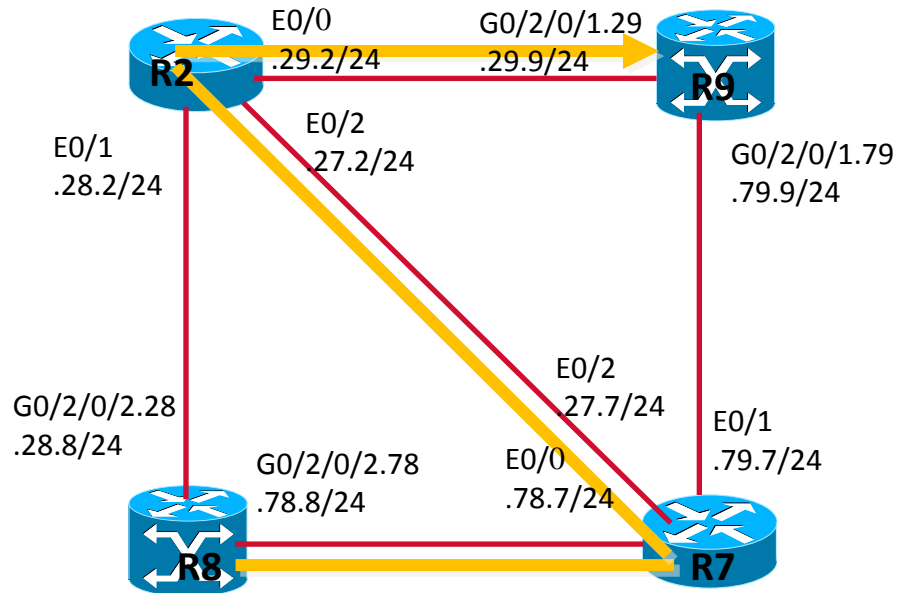 https://learningnetwork.cisco.com/docs/DOC-9991

    1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

      1.5 – Implement, Optimize and Troubleshoot MPLS Traffic Engineering

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

MPLS TE – Sub Topology and Question

- Configure MPLS TE tunnel 89 on R8, the tunnel path follows through R7 and R2 to reach R9

- Configure auto-route to follow traffic along tunnel 89

- Configure Tunnel bandwidth of 2Mbps

- Ensure traffic from R8 to R9 loopback0 follow the tunnel 89

MPLS TE Configuration

R2 (IOS) configuration

mpls traffic-eng tunnels
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!
interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!

interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!
router isis
 net 47.0002.0000.0000.0002.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
!

MPLS TE Configuration (Cont.)

R7 (IOS) configuration

mpls traffic-eng tunnels
!
interface Ethernet0/0
 ip address 2.2.78.7 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!

interface Ethernet0/2
 ip address 2.2.27.7 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls ip
 ip rsvp bandwidth 25000
!
router isis
 net 47.0002.0000.0000.0007.00
 is-type level-1
 metric-style wide
 mpls traffic-eng router-id Loopback0
 mpls traffic-eng level-1
!

MPLS TE Configuration (Cont.)

R8 (IOS-XR) configuration

explicit-path name expp_8t9
 index 10 next-address strict ipv4 unicast 2.2.78.7
 index 20 next-address strict ipv4 unicast 2.2.27.2
 index 30 next-address strict ipv4 unicast 2.2.29.9
!
interface tunnel-te89
 ipv4 unnumbered Loopback0
 priority 7 7
 autoroute announce
 signalled-bandwidth 2000
 destination 2.2.0.9
 path-option 1 explicit name expp_8t9
!

router isis abc
 is-type level-1
 net 47.0002.0000.0000.0008.00
 address-family ipv4 unicast
  metric-style wide
  mpls traffic-eng level-1
  mpls traffic-eng router-id Loopback0
!
mpls traffic-eng
 interface GigabitEthernet0/2/0/2.28
!
 interface GigabitEthernet0/2/0/2.78
 !
rsvp
 interface GigabitEthernet0/2/0/2.28
  bandwidth 80000
 !
 interface GigabitEthernet0/2/0/2.78
  bandwidth 80000

MPLS TE Configuration (Cont.)

R9 (IOS-XR) configuration

```
router isis abc
 is-type level-1
 net 47.0002.0000.0000.0009.00
 address-family ipv4 unicast
  metric-style wide
  mpls traffic-eng level-1
  mpls traffic-eng router-id Loopback0
!
mpls traffic-eng
 interface GigabitEthernet0/2/0/2.29
!
 interface GigabitEthernet0/2/0/2.79
 !
rsvp
 interface GigabitEthernet0/2/0/2.29
  bandwidth 80000
 !
 interface GigabitEthernet0/2/0/2.79
  bandwidth 80000
```

MPLS TE Tunnel

RP/0/0/CPU0:R8#show mpls traffic-eng tunnels 89
Name: tunnel-te89 Destination: 2.2.0.9
 Status:
  Admin: up Oper: up   Path: valid   Signalling: connected
  path option 1, type explicit expp_8t9 (Basis for Setup, path weight 30)
  G-PID: 0x0800 (derived from egress interface properties)
  Bandwidth Requested: 2000 kbps CT0
 Config Parameters:
  Bandwidth: 2000 kbps (CT0) Priority: 7 7 Affinity: 0x0/0xffff
  Metric Type: TE (default)
  AutoRoute: enabled LockDown: disabled   Policy class: not set
  Loadshare: 0 equal loadshares
  Auto-bw: disabled
  Direction: unidirectional
  Endpoint switching capability: unknown, encoding type: unassigned
  Transit switching capability: unknown, encoding type: unassigned
  Fast Reroute: Disabled, Protection Desired: None
 Path info (ISIS abc level-1):
 Hop0: 2.2.78.8
 Hop1: 2.2.78.7
 Hop2: 2.2.27.2
 Hop3: 2.2.29.2
 Hop4: 2.2.29.9
 Hop5: 2.2.0.9

MPLS TE Tunnel (Cont.)

R7#show mpls traffic-eng tunnels
LSP Tunnel R8_t89 is signalled, connection is up
 InLabel : Ethernet0/0, 19
 OutLabel : Ethernet0/2, 34
 RSVP Signalling Info:
    Src 2.2.0.8, Dst 2.2.0.9, Tun_Id 89, Tun_Instance 4016
  RSVP Path Info:
   My Address: 2.2.27.7
   Explicit Route: 2.2.27.2 2.2.29.2 2.2.29.9 2.2.0.9
   Record   Route: NONE
   Tspec: ave rate=2000 kbits, burst=1000 bytes, peak rate=2000 kbits
  RSVP Resv Info:
   Record   Route: 2.2.0.2(34) 2.2.0.9(3)
             2.2.29.9(3)
   Fspec: ave rate=2000 kbits, burst=1000 bytes, peak rate=2000 kbits

MPLS TE Tunnel (Cont.)

R2#show mpls traffic-eng tunnels
LSP Tunnel R8_t89 is signalled, connection is up
 InLabel : Ethernet0/2, 34
 OutLabel : Ethernet0/0, implicit-null
 FRR OutLabel : Tunnel279, implicit-null
 RSVP Signalling Info:
    Src 2.2.0.8, Dst 2.2.0.9, Tun_Id 89, Tun_Instance 4016
  RSVP Path Info:
   My Address: 2.2.29.2
   Explicit Route: 2.2.29.9 2.2.0.9
   Record Route: NONE
   Tspec: ave rate=2000 kbits, burst=1000 bytes, peak rate=2000 kbits
  RSVP Resv Info:
   Record Route: 2.2.0.9(3) 2.2.29.9(3)
   Fspec: ave rate=2000 kbits, burst=1000 bytes, peak rate=2000 kbits

MPLS TE Tunnel (Cont.)

RP/0/0/CPU0:R9#show mpls traffic-eng tunnels
LSP Tunnel 2.2.0.8 89 [4016] is signalled, connection is up
 Tunnel Name: R8_t89   Tunnel Role: Tail
 InLabel: GigabitEthernet0/2/0/1.29, implicit-null
 Signalling Info:
   Src 2.2.0.8 Dst 2.2.0.9, Tun ID 89, Tun Inst 4016, Ext ID 2.2.0.8
   Router-IDs: upstream   2.2.0.2
        local   2.2.0.9
   Path Info:
    Incoming Address: 2.2.29.9
    Incoming   Explicit Route:
     Strict, 2.2.29.9
     Strict, 2.2.0.9
    Record Route: None
    Tspec: avg rate=2000 kbits, burst=1000 bytes, peak rate=2000 kbits
    Session Attributes: Local Prot: Set, Node Prot: Not Set, BW Prot: Not Set
   Resv Info:
    Record Route: None
    Fspec: avg rate=0 kbits, burst=0 bytes, peak rate=0 kbits

Routing table and MPLS table

RP/0/0/CPU0:R8#show route ipv4 isis
i L1 2.2.0.2/32 [115/20] via 2.2.28.2, 05:06:13, GigabitEthernet0/2/0/2.28
i L1 2.2.0.7/32 [115/20] via 2.2.78.7, 05:06:13, GigabitEthernet0/2/0/2.78
i L1 2.2.0.9/32 [115/20] via 2.2.0.9, 00:42:43, tunnel-te89
i L1 2.2.27.0/24 [115/20] via 2.2.78.7, 05:06:13, GigabitEthernet0/2/0/2.78
            [115/20] via 2.2.28.2, 05:06:13, GigabitEthernet0/2/0/2.28
i L1 2.2.29.0/24 [115/20] via 2.2.28.2, 05:06:13, GigabitEthernet0/2/0/2.28
i L1 2.2.79.0/24 [115/20] via 2.2.78.7, 05:06:13, GigabitEthernet0/2/0/2.78

RP/0/0/CPU0:R8#show mpls forwarding

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16002	Pop	2.2.0.2/32	Gi0/2/0/2.28	2.2.28.2	106
16003	Pop	2.2.0.9/32	tt89	2.2.0.9	1200
16004	Pop	2.2.27.0/24	Gi0/2/0/2.28	2.2.28.2	0
	Pop	2.2.27.0/24	Gi0/2/0/2.78	2.2.78.7	0
16006	Pop	2.2.79.0/24	Gi0/2/0/2.78	2.2.78.7	0
16007	Pop	2.2.29.0/24	Gi0/2/0/2.28	2.2.28.2	0

Connection and path verification

RP/0/0/CPU0:R8#ping 2.2.0.9 source 2.2.0.8
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.0.9, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 18/19/21 ms

RP/0/0/CPU0:R8#traceroute 2.2.0.9 source 2.2.0.8
Type escape sequence to abort.
Tracing the route to 2.2.0.9

 1 2.2.78.7 [MPLS: Label 19 Exp 0] 20 msec 28 msec 18 msec
 2 2.2.27.2 [MPLS: Label 34 Exp 0] 20 msec 20 msec 18 msec
 3 2.2.29.9 22 msec * 18 msec

MPLS TE Fast Re-Route (FRR)

- Subsecond recovery against node/link failures
- Scalable 1:N protection
- Greater protection granularity
- Cost-effective alternative to optical protection
- Bandwidth protection
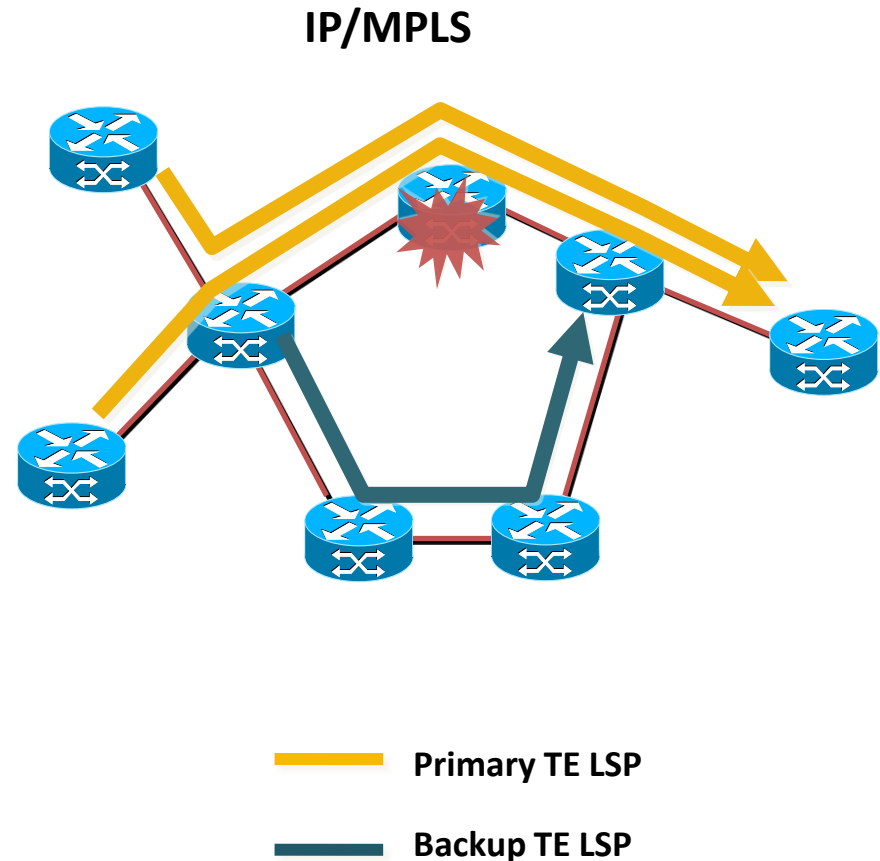
IP/MPLS

Primary TE LSP

Backup TE LSP

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

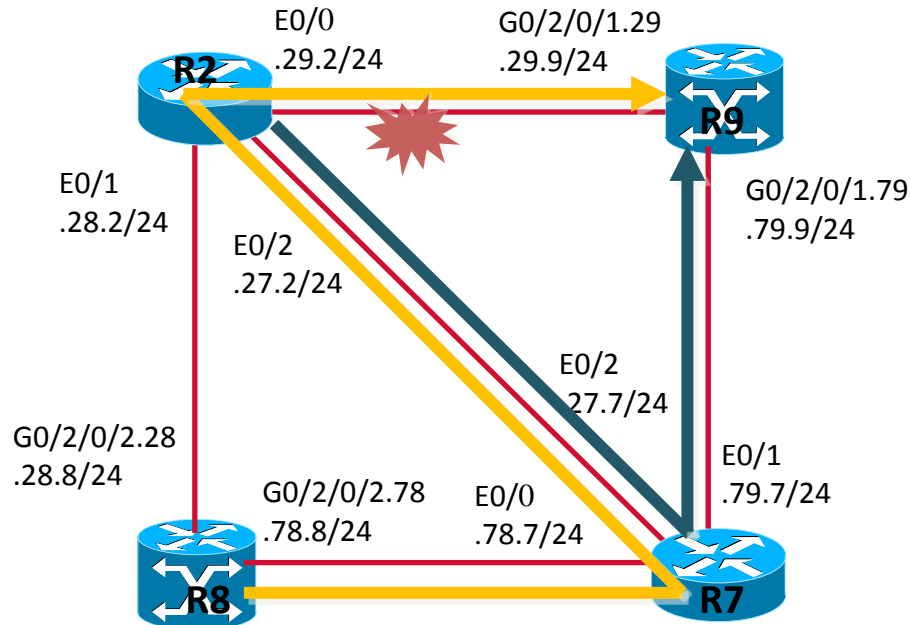 https://learningnetwork.cisco.com/docs/DOC-9991

  1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

   1.8 – Implement, Optimize and Troubleshoot High availability

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

MPLS TE FRR – Sub Topology and Question

E0/0
.29.2/24

G0/2/0/1.29
.29.9/24

R2

R9

E0/1
.28.2/24

E0/2
.27.2/24

G0/2/0/1.79
.79.9/24

E0/2
27.7/24

G0/2/0/2.28
.28.8/24

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

E0/1
.79.7/24

R8

R7

- The Primary tunnel 89 on R8 has configured in Question 5 (Refer to part 2/7)

- Configure Backup tunnel 279 on R2 to protect the Ethernet link between R2 and R9, tunnel 279 is from R2 to R9 through R7. If R2 Eth0/2 detect link problem, it switches Tunnel 89 traffic into tunnel 279

MPLS TE FRR Configuration

R2 (IOS) configuration

interface Tunnel279
 ip unnumbered Loopback0
 mpls ip
 tunnel destination 2.2.0.9
 tunnel mode mpls traffic-eng
 tunnel mpls traffic-eng path-option 10 explicit name 2t9
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 ip router isis
 mpls traffic-eng tunnels
 mpls traffic-eng backup-path Tunnel279
 mpls ip
 ip rsvp bandwidth 25000
!
ip explicit-path name 2t9 enable
 next-address 2.2.27.7
 next-address 2.2.79.9
!

MPLS TE FRR Configuration (Cont.)

R8 (IOS-XR) configuration

explicit-path name expp_8t9
 index 10 next-address strict ipv4 unicast 2.2.78.7
 index 20 next-address strict ipv4 unicast 2.2.27.2
 index 30 next-address strict ipv4 unicast 2.2.29.9
!
interface tunnel-te89
 ipv4 unnumbered Loopback0
 priority 7 7
 autoroute announce
 signalled-bandwidth 2000
 destination 2.2.0.9
 fast-reroute
 path-option 1 explicit name expp_8t9
!

MPLS TE FRR Tunnel

RP/0/0/CPU0:R8#show mpls traffic-eng tunnels 89
 Name: tunnel-te89 Destination: 2.2.0.9
  Status:
    Admin: up Oper: up   Path: valid   Signalling: connected
    path option 1, type explicit expp_8t9 (Basis for Setup, path weight 30)
    G-PID: 0x0800 (derived from egress interface properties)
    Bandwidth Requested: 2000 kbps CT0
   Config Parameters:
    Bandwidth: 2000 kbps (CT0) Priority: 7 7 Affinity: 0x0/0xffff
    Metric Type: TE (default)
    AutoRoute: enabled LockDown: disabled   Policy class: not set
    Loadshare: 0 equal loadshares
    Auto-bw: disabled
    Direction: unidirectional
    Endpoint switching capability: unknown, encoding type: unassigned
    Transit switching capability: unknown, encoding type: unassigned
    Fast Reroute: Enabled, Protection Desired: Any

MPLS TE FRR Tunnel (Cont.)

R2#show mpls traffic-eng tunnels backup
R2_t279
  LSP Head, Tunnel279, Admin: up, Oper: up
  Src 2.2.0.2, Dest 2.2.0.9, Instance 1
  Fast Reroute Backup Provided:
   Protected i/fs: Et0/0
   Protected lsps: 1 Active lsps: 0
   Backup BW: any pool unlimited; inuse: 2000 kbps

R2#show mpls traffic-eng fast-reroute database
Headend frr information:
Protected tunnel   In-label Out intf/label FRR intf/label Status

LSP midpoint frr information:
LSP identifier   In-label Out intf/label FRR intf/label Status
2.2.0.8 89 [1392]   34   Et0/0:implicit-n Tu279:implicit-n ready

Verification

Shutdown R2 Ethernet0/0, FRR takes effect, R8 traffic should follow path of R8-R7-R2-R7-R9

RP/0/0/CPU0:R8#traceroute 2.2.0.9 source 2.2.0.8
Type escape sequence to abort.
Tracing the route to 2.2.0.9

 1 2.2.78.7 [MPLS: Label 19 Exp 0] 27 msec 24 msec 18 msec
 2 2.2.27.2 [MPLS: Label 34 Exp 0] 18 msec 21 msec 21 msec
 3 2.2.27.7 [MPLS: Label 18 Exp 0] 18 msec 20 msec 19 msec
 4 2.2.79.9 21 msec * 18 msec

R2#show mpls traffic-eng tunnels backup
R2_t279
 LSP Head, Tunnel279, Admin: up, Oper: up
 Src 2.2.0.2, Dest 2.2.0.9, Instance 1
 Fast Reroute Backup Provided:
  Protected i/fs: Et0/0
  Protected lsps: 1 Active lsps: 1
  Backup BW: any pool unlimited; inuse: 2000 kbps

SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP intra-AS VPNv4
8	MP-BGP inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

MPLS VPN Terminology

- LSR: Label switch router

- LSP: Label switched path
  - The chain of labels that are swapped at each hop to get from one LSR to another

- VRF: VPN routing and forwarding
  - Mechanism in Cisco IOS® used to build per-interface RIB and FIB

- MP-BGP: Multiprotocol BGP

- PE: Provider edge router interfaces with CE routers

- P: Provider (core) router, without knowledge of VPN

- VPNv4: Address family used in BGP to carry MPLS-VPN routes

- RD: Route distinguisher
  - Distinguish same network/mask prefix in different VRFs

- RT: Route target
  - Extended community attribute used to control import and export policies of VPN routes

- LFIB: Label forwarding information base

- FIB: Forwarding information base

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

  3.0 – Implement, Optimize and Troubleshoot L3VPN Technologies

  3.1 – Implement, Optimize and Troubleshoot Intra-AS L3VPN

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

MP-BGP Intra-AS VPNv4 – Sub Topology and Question
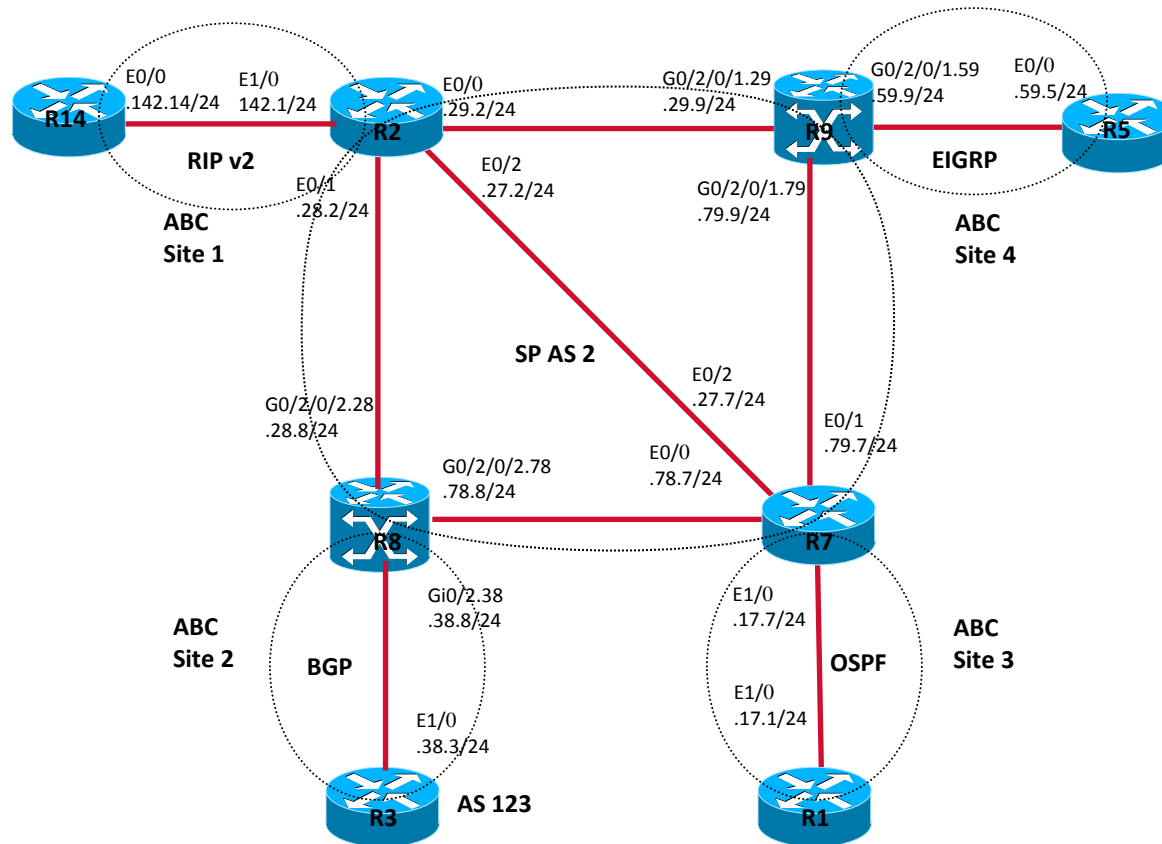
- Configure BGP VPNv4 on R2, R7, R8 and R9, configure R9 as VPNv4 Route-reflector for R2, R7 and R8

- Configure ABC sites router R14, R3, R1 and R5, ensure the Four sites can ping each other

MP-BGP VPNv4 Configuration

R2 (IOS) configuration

vrf definition ABC
 rd 2:2
 !
 address-family ipv4
 route-target export 2:2
 route-target import 2:2
 !
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 mpls ip
 !
 interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 mpls ip
 !
 interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 mpls ip
 !
interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.142.2 255.255.255.0

router rip
 version 2
 !
 address-family ipv4 vrf ABC
 redistribute bgp 2 metric 1
 network 172.2.0.0
 version 2
 exit-address-family
 !
router bgp 2
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 !
 address-family vpnv4
 neighbor 2.2.0.9 activate
 neighbor 2.2.0.9 send-community extended
 neighbor 2.2.0.9 next-hop-self
 !
 address-family ipv4 vrf ABC
 no synchronization
 redistribute rip
 exit-address-family
 !

MP-BGP VPNv4 Configuration (Cont.)

R7 (IOS) configuration

vrf definition ABC
 rd 2:2
 !
 address-family ipv4
 route-target export 2:2
 route-target import 2:2
!
interface Ethernet0/0
 ip address 2.2.78.7 255.255.255.0
 mpls ip
!
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 mpls ip
!
interface Ethernet0/2
 ip address 2.2.27.7 255.255.255.0
 mpls ip
!
interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.17.7 255.255.255.0

router ospf 100 vrf ABC
 redistribute bgp 2 subnets
 network 172.2.0.0 0.0.255.255 area 0
!
router bgp 2
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 !
 address-family vpnv4
  neighbor 2.2.0.9 activate
  neighbor 2.2.0.9 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf ABC
  no synchronization
  redistribute ospf 100 vrf ABC
 exit-address-family
 !

MP-BGP VPNv4 Configuration (Cont.)

R8 (IOS-XR) configuration

```
interface GigabitEthernet0/2/0/2.28
 ipv4 address 2.2.28.8 255.255.255.0
 dot1q vlan 28
!
interface GigabitEthernet0/2/0/2.78
 ipv4 address 2.2.78.8 255.255.255.0
 dot1q vlan 78
!
interface GigabitEthernet0/2/0/2.38
 vrf ABC
 ipv4 address 172.2.38.8 255.255.255.0
 dot1q vlan 38
!
router bgp 2
 address-family vpnv4 unicast
 !
 neighbor 2.2.0.9
  remote-as 2
  update-source Loopback0
  !
  address-family vpnv4 unicast
  !
```

```
 vrf ABC
 rd 2:2
 address-family ipv4 unicast
 allocate-label all
 !
 neighbor 172.2.38.3
  remote-as 123
  address-family ipv4 labeled-unicast
  route-policy default_policy_pass_all in
  route-policy default_policy_pass_all out
  as-override
  send-extended-community-ebgp
  !
mpls ldp
 router-id 2.2.0.8
 interface GigabitEthernet0/2/0/2.28
 !
 interface GigabitEthernet0/2/0/2.78
 !
!
vrf ABC
 address-family ipv4 unicast
 import route-target
  2:2
!
 export route-target
  2:2
```

MP-BGP VPNv4 Configuration (Cont.)

R9 (IOS-XR) configuration

```
vrf ABC
 address-family ipv4 unicast
  import route-target
   2:2
  !
  export route-target
   2:2
  !
interface GigabitEthernet0/2/0/1.29
 ipv4 address 2.2.29.9 255.255.255.0
 dot1q vlan 29
!
interface GigabitEthernet0/2/0/1.59
 vrf ABC
 ipv4 address 172.2.59.9 255.255.255.0
 dot1q vlan 59
!
interface GigabitEthernet0/2/0/1.79
 ipv4 address 2.2.79.9 255.255.255.0
 dot1q vlan 79
!
```

```
router bgp 2
 address-family vpnv4 unicast
 !
 neighbor 2.2.0.2
  remote-as 2
  update-source Loopback0
  address-family vpnv4 unicast
   route-reflector-client
!
 neighbor 2.2.0.7
  remote-as 2
  update-source Loopback0
  address-family vpnv4 unicast
   route-reflector-client
!
 neighbor 2.2.0.8
  remote-as 2
  update-source Loopback0
  address-family vpnv4 unicast
   route-reflector-client
 !
 vrf ABC
  rd 2:2
  address-family ipv4 unicast
   redistribute eigrp 100
 !
```

```
mpls ldp
 router-id 2.2.0.9
 !
 interface GigabitEthernet0/2/0/1.29
 !
 interface GigabitEthernet0/2/0/1.79
 !
router eigrp 100
 vrf ABC
  address-family ipv4
   default-metric 100000 10 250 1 1500
   autonomous-system 100
   redistribute bgp 2
   interface GigabitEthernet0/2/0/1.59
   !
!
```

MP-BGP VPNv4 Configuration (Cont.)

R14 configuration

interface Loopback0
 ip address 172.2.0.14 255.255.255.255
!
interface Ethernet0/0
 ip address 172.2.142.14 255.255.255.0
!
router rip
 version 2
 network 172.2.0.0

R1 configuration

interface Loopback0
 ip address 172.2.0.1 255.255.255.255
!
interface Ethernet1/0
 ip address 172.2.17.1 255.255.255.0
!
router ospf 100
 network 172.2.0.1 0.0.0.0 area 0
 network 172.2.17.1 0.0.0.0 area 0

R3 configuration

interface Loopback0
 ip address 172.2.0.3 255.255.255.255
!
interface Ethernet1/0
 ip address 172.2.38.3 255.255.255.0
!
router bgp 123
neighbor 172.2.38.8 remote-as 2
!
 address-family ipv4
 network 172.2.0.3 mask 255.255.255.255
 neighbor 172.2.38.8 activate

R5 configuration

interface Loopback0
 ip address 172.2.0.5 255.255.255.255
!
interface Ethernet0/0
 ip address 172.2.59.5 255.255.255.0
!
router eigrp 100
 network 172.2.0.5 0.0.0.0
 network 172.2.59.0 0.0.0.255

MP-BGP VPNv4 Adjacency

RP/0/0/CPU0:R9#show bgp vpnv4 unicast summary
BGP router identifier 2.2.0.9, local AS number 2

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.0.2	0	2	111048	108531	13904	0	0	4d02h	18
2.2.0.7	0	2	109794	104739	13904	0	0	4d01h	2
2.2.0.8	0	2	99301	108712	13904	0	0	4d02h	3

R2#show ip bgp vpnv4 all summary
BGP router identifier 2.2.0.2, local AS number 2

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.0.9	4	2	185	183	29	0	0	02:28:55	10

R7#show ip bgp vpnv4 all summary
BGP router identifier 2.2.0.7, local AS number 2

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.0.9	4	2	181	177	31	0	0	02:33:17	12

RP/0/0/CPU0:R8#show bgp vpnv4 unicast summary
BGP router identifier 2.2.0.8, local AS number 2

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.0.9	0	2	116418	107553	10590	0	0	03:44:31	11

MP-BGP VPNv4 table

R8 VPN table

RP/0/0/CPU0:R8#show bgp vpnv4 unicast vrf ABC
Route Distinguisher: 2:2 (default for vrf ABC)
```
*>i172.2.0.1/32      2.2.0.7           15   100    0 ?
*>  172.2.0.3/32     172.2.38.3         0          0 123 i
*>i172.2.0.5/32      2.2.0.9        130816   200    0 ?
*>i172.2.0.14/32     2.2.0.2            1   100    0 ?
*>i172.2.17.0/24     2.2.0.7           15   100    0 ?
*>  172.2.38.0/24    0.0.0.0            0      32768 ?
*>i172.2.59.0/24     2.2.0.9            0   200    0 ?
*>i172.2.142.0/24    2.2.0.2            0   100    0 ?
```

R9 VPN table

RP/0/0/CPU0:R9#show bgp vpnv4 unicast vrf ABC
```
*>i172.2.0.1/32      2.2.0.7           15   100    0 ?
*>i172.2.0.3/32      2.2.0.8            0   100    0 123 i
*>  172.2.0.5/32     172.2.59.5     130816      32768 ?
*>i172.2.0.14/32     2.2.0.2            1   100    0 ?
*>i172.2.17.0/24     2.2.0.7           15   100    0 ?
*>i172.2.38.0/24     2.2.0.8            0   100    0 ?
*>  172.2.59.0/24    0.0.0.0            0   32768   ?
*>i172.2.142.0/24    2.2.0.2            0   100    0 ?
```

MP-BGP VPNv4 table (Cont.)

R2 VPN table

R2#show ip bgp vpnv4 vrf ABC
Route Distinguisher: 2:2 (default for vrf ABC)
```
*>i172.2.0.1/32    2.2.0.7              15   100    0 ?
*>i172.2.0.3/32    2.2.0.8               0   100    0 123 i
*>i172.2.0.5/32    2.2.0.9          130816   200    0 ?
*> 172.2.0.14/32   172.2.142.14         1       32768 ?
*>i172.2.17.0/24   2.2.0.7              15   100    0 ?
*>i172.2.38.0/24   2.2.0.8               0   100    0 ?
*>i172.2.59.0/24   2.2.0.9               0   200    0 ?
*> 172.2.142.0/24  0.0.0.0               0       32768 ?
```

R7 VPN table

R7#show ip bgp vpnv4 vrf ABC
```
*> 172.2.0.1/32    172.2.17.1          15       32768 ?
*>i172.2.0.3/32    2.2.0.8              0   100    0 123 i
*>i172.2.0.5/32    2.2.0.9         130816   200    0 ?
*>i172.2.0.14/32   2.2.0.2              1   100    0 ?
*> 172.2.17.0/24   0.0.0.0             15       32768 ?
*>i172.2.38.0/24   2.2.0.8              0   100    0 ?
*>i172.2.59.0/24   2.2.0.9              0   200    0 ?
*>i172.2.142.0/24  2.2.0.2              0   100    0 ?
```

MPLS VPNv4 routes

R14 and R3 route

R14#show ip route rip
R   172.2.0.1/32 [120/1] via 172.2.142.2, 00:00:12, Ethernet0/0
R   172.2.0.3/32 [120/1] via 172.2.142.2, 00:00:12, Ethernet0/0
R   172.2.0.5/32 [120/1] via 172.2.142.2, 00:00:12, Ethernet0/0
R   172.2.17.0/24 [120/1] via 172.2.142.2, 00:00:19, Ethernet0/0
R   172.2.38.0/24 [120/1] via 172.2.142.2, 00:00:19, Ethernet0/0
R   172.2.59.0/24 [120/1] via 172.2.142.2, 00:00:19, Ethernet0/0

R3#show ip route bgp
B   172.2.0.1/32 [20/0] via 172.2.38.8, 01:29:23
B   172.2.0.5/32 [20/0] via 172.2.38.8, 01:26:09
B   172.2.0.14/32 [20/0] via 172.2.38.8, 01:02:08
B   172.2.17.0/24 [20/0] via 172.2.38.8, 01:41:59
B   172.2.59.0/24 [20/0] via 172.2.38.8, 01:38:45
B   172.2.142.0/24 [20/0] via 172.2.38.8, 01:16:00

MP-BGP VPNv4 routes (Cont.)

R1 and R5 routes

R1#show ip route ospf
O E2   172.2.0.3/32 [110/1] via 172.2.17.7, 01:30:15, Ethernet1/0
O E2   172.2.0.5/32 [110/130816] via 172.2.17.7, 01:27:00, Ethernet1/0
O E2   172.2.0.14/32 [110/1] via 172.2.17.7, 01:02:54, Ethernet1/0
O E2   172.2.38.0/24 [110/1] via 172.2.17.7, 01:40:49, Ethernet1/0
O E2   172.2.59.0/24 [110/1] via 172.2.17.7, 01:40:49, Ethernet1/0
O E2   172.2.142.0/24 [110/1] via 172.2.17.7, 01:14:43, Ethernet1/0

R5#show ip route eigrp
D EX   172.2.0.1/32 [170/284160] via 172.2.59.9, 01:27:05, Ethernet0/0
D EX   172.2.0.3/32 [170/284160] via 172.2.59.9, 01:27:05, Ethernet0/0
D EX   172.2.0.14/32 [170/284160] via 172.2.59.9, 01:03:55, Ethernet0/0
D EX   172.2.17.0/24 [170/284160] via 172.2.59.9, 01:38:43, Ethernet0/0
D EX   172.2.38.0/24 [170/284160] via 172.2.59.9, 01:38:43, Ethernet0/0
D EX   172.2.142.0/24 [170/284160] via 172.2.59.9, 01:16:48, Ethernet0/0

MP-BGP VPNv4 routes (Cont.)

R2 and R7 VRF ABC routes

R2#show ip route vrf ABC
B   172.2.0.1/32 [200/15] via 2.2.0.7, 01:56:52
B   172.2.0.3/32 [200/0] via 2.2.0.8, 4d01h
B   172.2.0.5/32 [200/130816] via 2.2.0.9, 01:53:36
R   172.2.0.14/32 [120/1] via 172.2.142.14, 00:00:19, Ethernet1/0
B   172.2.17.0/24 [200/15] via 2.2.0.7, 01:57:00
B   172.2.38.0/24 [200/0] via 2.2.0.8, 4d01h
B   172.2.59.0/24 [200/0] via 2.2.0.9, 01:53:45
C   172.2.142.0/24 is directly connected, Ethernet1/0
L   172.2.142.2/32 is directly connected, Ethernet1/0

R7#show ip route vrf ABC
O   172.2.0.1/32 [110/11] via 172.2.17.1, 01:58:04, Ethernet1/0
B   172.2.0.3/32 [200/0] via 2.2.0.8, 01:58:04
B   172.2.0.5/32 [200/130816] via 2.2.0.9, 01:54:41
B   172.2.0.14/32 [200/1] via 2.2.0.2, 01:30:35
C   172.2.17.0/24 is directly connected, Ethernet1/0
L   172.2.17.7/32 is directly connected, Ethernet1/0
B   172.2.38.0/24 [200/0] via 2.2.0.8, 01:58:04
B   172.2.59.0/24 [200/0] via 2.2.0.9, 01:54:53
B   172.2.142.0/24 [200/0] via 2.2.0.2, 01:31:53

MP-BGP VPNv4 routes (Cont.)

R8 and R9 VRF ABC routes

RP/0/0/CPU0:R8#show route vrf ABC ipv4
B   172.2.0.1/32 [200/15] via 2.2.0.7 (nexthop in vrf default), 01:59:19
B   172.2.0.3/32 [20/0] via 172.2.38.3, 4d03h
B   172.2.0.5/32 [200/130816] via 2.2.0.9 (nexthop in vrf default), 01:56:05
B   172.2.0.14/32 [200/1] via 2.2.0.2 (nexthop in vrf default), 01:32:04
B   172.2.17.0/24 [200/15] via 2.2.0.7 (nexthop in vrf default), 01:59:19
C   172.2.38.0/24 is directly connected, 8w4d, GigabitEthernet0/2/0/2.38
L   172.2.38.8/32 is directly connected, 8w4d, GigabitEthernet0/2/0/2.38
B   172.2.59.0/24 [200/0] via 2.2.0.9 (nexthop in vrf default), 01:56:05
B   172.2.124.0/24 [200/0] via 2.2.0.9 (nexthop in vrf default), 2d06h

RP/0/0/CPU0:R9#show route vrf ABC ipv4
B   172.2.0.1/32 [200/15] via 2.2.0.7 (nexthop in vrf default), 02:00:34
B   172.2.0.3/32 [200/0] via 2.2.0.8 (nexthop in vrf default), 4d01h
D   172.2.0.5/32 [90/130816] via 172.2.59.5, 01:59:03, GigabitEthernet0/2/0/1.59
B   172.2.0.14/32 [200/1] via 2.2.0.2 (nexthop in vrf default), 01:33:20
B   172.2.17.0/24 [200/15] via 2.2.0.7 (nexthop in vrf default), 02:00:34
B   172.2.38.0/24 [200/0] via 2.2.0.8 (nexthop in vrf default), 4d01h
C   172.2.59.0/24 is directly connected, 10w0d, GigabitEthernet0/2/0/1.59
L   172.2.59.9/32 is directly connected, 10w0d, GigabitEthernet0/2/0/1.59
B   172.2.142.0/24 [200/0] via 2.2.0.2 (nexthop in vrf default), 01:34:35

MP-BGP VPNv4 connection verification

R1#ping 172.2.0.3 source loopback 0
Sending 5, 100-byte ICMP Echos to 172.2.0.3, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/19/20 ms

R1#ping 172.2.0.5 source loopback 0
Sending 5, 100-byte ICMP Echos to 172.2.0.5, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/20/24 ms

R1#ping 172.2.0.14 source loopback 0
Sending 5, 100-byte ICMP Echos to 172.2.0.14, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
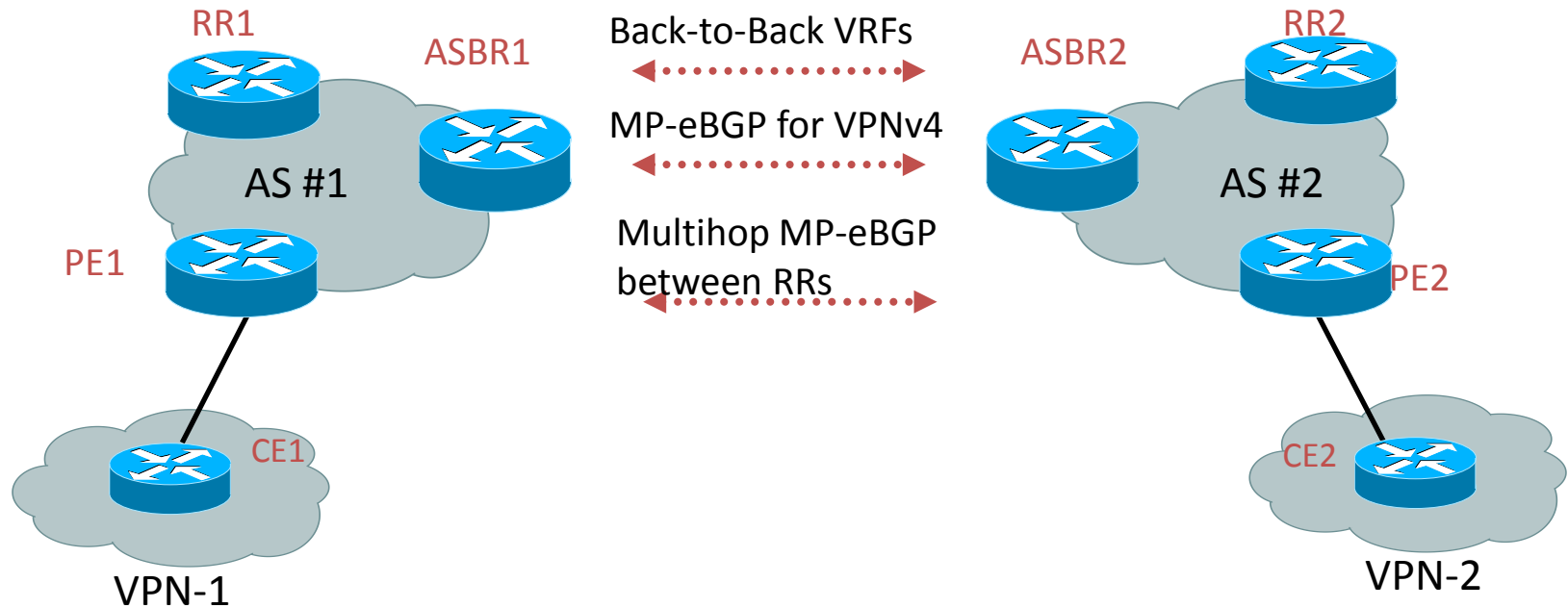
R3#ping 172.2.0.5 source loopback 0
Sending 5, 100-byte ICMP Echos to 172.2.0.5, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/40/44 ms

MP-BGP Inter-AS VPNv4 Distribution Options

VPN Sites Attached to Different MPLS VPN Service Providers

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

  3.0 – Implement, Optimize and Troubleshoot L3VPN Technologies

  3.2 – Implement, Optimize and Troubleshoot Inter-AS L3VPN

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

MP-BGP Inter-AS VPNv4 – Sub Topology and Question

- Configure Inter-AS BGP VPNv4 unicast on R6 and R9, ensure they can exchange VPNv4 unicast information

- Configure VPN site 2, 3, 4 and 5. Ensure these sites have full reach ability between each other

- You are permitted to define static host route on R9
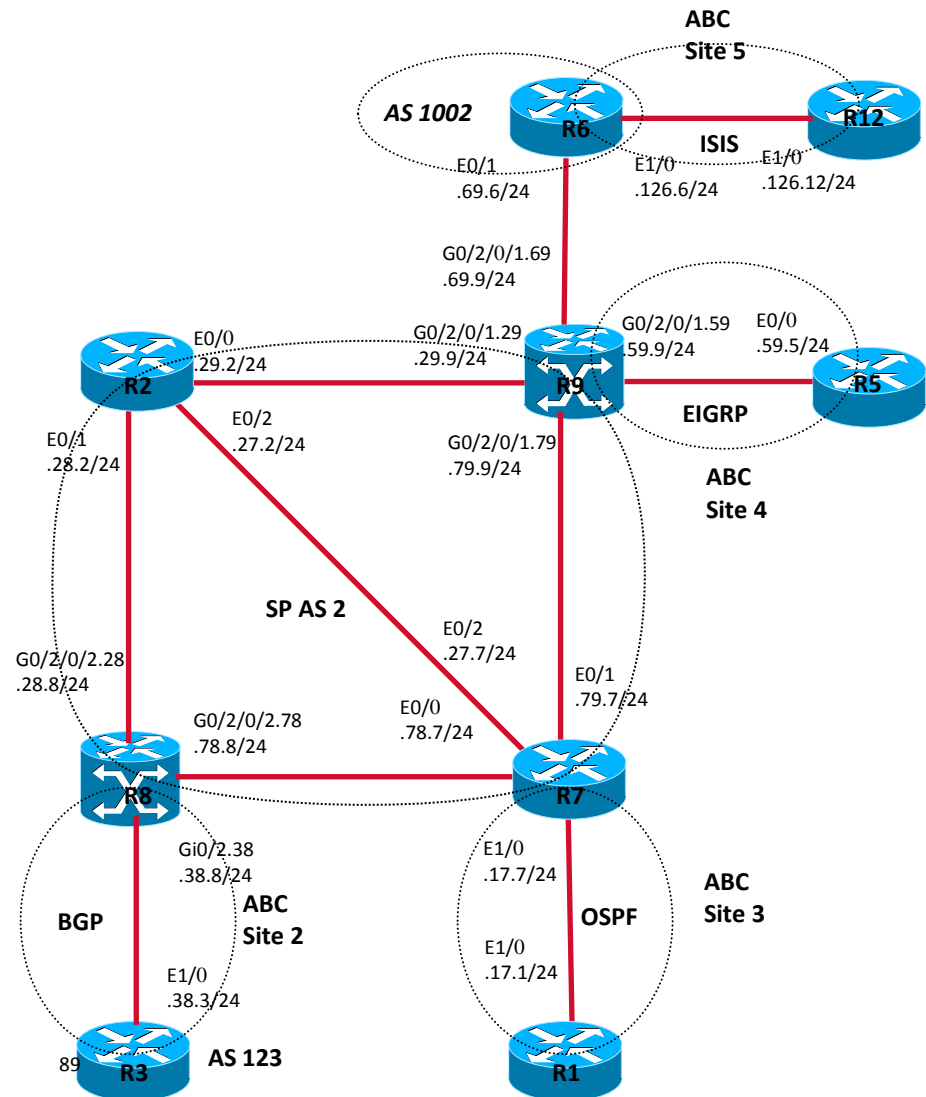
MP-BGP VPNv4 Configuration

R6 (IOS) configuration

vrf definition ABC
 rd 1002:2
 !
 address-family ipv4
 route-target export 1002:2
 route-target import 1002:2
 route-target import 2:2
 !
interface Ethernet0/1
 ip address 2.2.69.6 255.255.255.0
 !
interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.126.6 255.255.255.0
 !
router isis ABC
 vrf ABC
 net 47.0172.0000.0000.0006.00
 metric-style wide
 redistribute bgp 1002
 !

router bgp 1002
 no bgp default route-target filter
 neighbor 2.2.69.9 remote-as 2
 !
 address-family vpnv4
  neighbor 2.2.69.9 activate
  neighbor 2.2.69.9 send-community extended
 exit-address-family
 !
 address-family ipv4 vrf ABC
  no synchronization
  redistribute isis ABC level-1-2
 exit-address-family

MP-BGP VPNv4 Configuration (Cont.)

R9 (IOS-XR) configuration

```
vrf ABC
 address-family ipv4 unicast
  import route-target
   2:2
   1002:2
  !
  export route-target
   2:2
  !
 !
router bgp 2
 address-family vpnv4 unicast
  !
 neighbor 2.2.69.6
  remote-as 1002
  address-family vpnv4 unicast
   route-policy default_policy_pass_all in
   route-policy default_policy_pass_all out
  !
```

```
vrf ABC
 rd 2:2
  address-family ipv4 unicast
   redistribute eigrp 100
  !
router eigrp 100
 vrf ABC
  address-family ipv4
   default-metric 100000 10 250 1 1500
   autonomous-system 100
   redistribute bgp 2
   interface GigabitEthernet0/2/0/1.59
   !
router static
 address-family ipv4 unicast
  2.2.69.6/32 GigabitEthernet0/2/0/1.69
 !
```

Note: IOS-XR does not automatically learn directly connected host route, static host route request to ensure MPLS forwarding

MP-BGP VPNv4 Configuration (Cont.)

R12 configuration

interface Loopback0
 ip address 172.2.0.12 255.255.255.255
 ip router isis
 !
interface Ethernet1/0
 ip address 172.2.126.12 255.255.255.0
 ip pim sparse-mode
 ip router isis
 !
router isis
 net 47.0172.0000.0000.0012.00
 metric-style wide
 !

R2 and R7 configuration

vrf definition ABC
 rd 2:2
 !
 address-family ipv4
 route-target export 2:2
 route-target import 2:2
 route-target import 1002:2
 exit-address-family
 !

R8 configuration

vrf ABC
 address-family ipv4 unicast
 import route-target
  2:2
  1002:2
 !
 export route-target
  2:2
 !

MP-BGP VPNv4 Adjacency

R9 VPNv4 neighbor

RP/0/0/CPU0:R9#show bgp vpnv4 unicast summary
BGP router identifier 2.2.0.9, local AS number 2

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.0.2	0	2	111048	108531	13904	0	0	4d02h	18
2.2.0.7	0	2	109794	104739	13904	0	0	4d01h	2
2.2.0.8	0	2	99301	108712	13904	0	0	4d02h	3
2.2.69.6	0	1002	112963	104627	13918	0	0	2d22h	2

R6 VPNv4 neighbor

R6#show ip bgp vpnv4 all summary
BGP router identifier 2.2.0.6, local AS number 1002
BGP table version is 158, main routing table version 158

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.69.9	4	2	4245	4658	158	0	0	2d22h	26

MP-BGP VPNv4 table

R6 VPNv4 table

R6#show ip bgp vpnv4 vrf ABC
BGP table version is 158, local router ID is 2.2.0.6
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
       r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? – incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 1002:2 (default for vrf ABC)					
*> 172.2.0.1/32	2.2.69.9			0	2 ?
*> 172.2.0.3/32	2.2.69.9			0	2 123 i
*> 172.2.0.5/32	2.2.69.9	130816		0	2 ?
*> 172.2.0.12/32	172.2.126.12	20		32768	?
*> 172.2.17.0/24	2.2.69.9			0	2 ?
*> 172.2.38.0/24	2.2.69.9			0	2 ?
*> 172.2.59.0/24	2.2.69.9	0		0	2 ?
*> 172.2.126.0/24	0.0.0.0	0		32768	?

MP-BGP VPNv4 table (Cont.)

R9 VPNv4 table

RP/0/0/CPU0:R9#show bgp vpnv4 unicast vrf ABC
BGP router identifier 2.2.0.9, local AS number 2
BGP generic scan interval 60 secs
Status codes: s suppressed, d damped, h history, * valid, > best
        i - internal, S stale
Origin codes: i - IGP, e - EGP, ? - incomplete

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 2:2 (default for vrf ABC)					
*>i172.2.0.1/32	2.2.0.7	15	100	0	?
*>i172.2.0.3/32	2.2.0.8	0	100	0	123 i
*> 172.2.0.5/32	172.2.59.5	130816		32768	?
*> 172.2.0.12/32	2.2.69.6	20		0	1002 ?
*>i172.2.17.0/24	2.2.0.7	15	100	0	?
*>i172.2.38.0/24	2.2.0.8	0	100	0	?
*> 172.2.59.0/24	0.0.0.0	0		32768	?
*> 172.2.126.0/24	2.2.69.6	0		0	1002 ?

MP-BGP VPNv4 table (Cont.)

R7 VPNv4 table

R7#show ip bgp vpnv4 vrf ABC
BGP table version is 342, local router ID is 2.2.0.7
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
        r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

```
   Network        Next Hop        Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf ABC)
*> 172.2.0.1/32    172.2.17.1          15        32768 ?
*>i172.2.0.3/32    2.2.0.8            0   100     0 123 i
*>i172.2.0.5/32    2.2.0.9         130816   200     0 ?
*>i172.2.0.12/32   2.2.0.9            20   200     0 1002 ?
*> 172.2.17.0/24   0.0.0.0           15        32768 ?
*>i172.2.38.0/24   2.2.0.8            0   100     0 ?
*>i172.2.59.0/24   2.2.0.9            0   200     0 ?
*>i172.2.126.0/24  2.2.0.9            0   200     0 1002 ?
```

VPNv4 routes

R12 and R5 route

R12#show ip route isis

i L2   172.2.0.1/32 [115/10] via 172.2.126.6, Ethernet1/0
i L2   172.2.0.3/32 [115/10] via 172.2.126.6, Ethernet1/0
i L2   172.2.0.5/32 [115/10] via 172.2.126.6, Ethernet1/0
i L2   172.2.17.0/24 [115/10] via 172.2.126.6, Ethernet1/0
i L2   172.2.38.0/24 [115/10] via 172.2.126.6, Ethernet1/0
i L2   172.2.59.0/24 [115/10] via 172.2.126.6, Ethernet1/0

R5#show ip route eigrp

D EX   172.2.0.1/32 [170/284160] via 172.2.59.9, 17:31:10, Ethernet0/0
D EX   172.2.0.3/32 [170/284160] via 172.2.59.9, 17:31:10, Ethernet0/0
D EX   172.2.0.12/32 [170/284160] via 172.2.59.9, 00:40:57, Ethernet0/0
D EX   172.2.17.0/24 [170/284160] via 172.2.59.9, 17:31:10, Ethernet0/0
D EX   172.2.38.0/24 [170/284160] via 172.2.59.9, 17:31:10, Ethernet0/0
D EX   172.2.126.0/24 [170/284160] via 172.2.59.9, 00:41:27, Ethernet0/0

VPNv4 routes (Cont.)

R1 and R3 routes

R1#show ip route ospf

O E2   172.2.0.3/32 [110/1] via 172.2.17.7, 17:35:44, Ethernet1/0
O E2   172.2.0.5/32 [110/130816] via 172.2.17.7, 17:32:29, Ethernet1/0
O E2   172.2.0.12/32 [110/20] via 172.2.17.7, 00:41:31, Ethernet1/0
O E2   172.2.38.0/24 [110/1] via 172.2.17.7, 17:35:44, Ethernet1/0
O E2   172.2.59.0/24 [110/1] via 172.2.17.7, 17:35:44, Ethernet1/0
O E2   172.2.126.0/24 [110/1] via 172.2.17.7, 00:42:01, Ethernet1/0

R3#show ip route bgp

B   172.2.0.1/32 [20/0] via 172.2.38.8, 17:48:55
B   172.2.0.5/32 [20/0] via 172.2.38.8, 17:45:41
B   172.2.0.12/32 [20/0] via 172.2.38.8, 00:54:38
B   172.2.17.0/24 [20/0] via 172.2.38.8, 17:48:55
B   172.2.59.0/24 [20/0] via 172.2.38.8, 17:45:41
B   172.2.126.0/24 [20/0] via 172.2.38.8, 00:55:08

VPNv4 routes (Cont.)

R6 and R9 VRF route

R6#show ip route vrf ABC
B   172.2.0.1/32 [20/0] via 2.2.69.9, 15:04:01
B   172.2.0.3/32 [20/0] via 2.2.69.9, 15:04:01
B   172.2.0.5/32 [20/130816] via 2.2.69.9, 15:04:01
i L1   172.2.0.12/32 [115/20] via 172.2.126.12, Ethernet1/0
B   172.2.17.0/24 [20/0] via 2.2.69.9, 15:04:01
B   172.2.38.0/24 [20/0] via 2.2.69.9, 15:04:01
B   172.2.59.0/24 [20/0] via 2.2.69.9, 15:04:01
C   172.2.126.0/24 is directly connected, Ethernet1/0
L   172.2.126.6/32 is directly connected, Ethernet1/0

RP/0/0/CPU0:R9#show route vrf ABC ipv4
B   172.2.0.1/32 [200/15] via 2.2.0.7 (nexthop in vrf default), 17:36:28
B   172.2.0.3/32 [200/0] via 2.2.0.8 (nexthop in vrf default), 4d17h
D   172.2.0.5/32 [90/130816] via 172.2.59.5, 17:34:57, GigabitEthernet0/2/0/1.59
B   172.2.0.12/32 [20/20] via 2.2.69.6 (nexthop in vrf default), 00:42:30
B   172.2.17.0/24 [200/15] via 2.2.0.7 (nexthop in vrf default), 17:36:28
B   172.2.38.0/24 [200/0] via 2.2.0.8 (nexthop in vrf default), 4d17h
C   172.2.59.0/24 is directly connected, 10w1d, GigabitEthernet0/2/0/1.59
L   172.2.59.9/32 is directly connected, 10w1d, GigabitEthernet0/2/0/1.59
B   172.2.126.0/24 [20/0] via 2.2.69.6 (nexthop in vrf default), 00:43:00

MPLS forwarding table

R6 MPLS label table

R6#show mpls forwarding-table vrf ABC
Local Outgoing   Prefix   Bytes Label Outgoing   Next Hop
Label Label or VC   or Tunnel Id   Switched   interface
16003 16026   172.2.0.1/32[V]   194740   Et0/1   2.2.69.9
16021 No Label   172.2.0.12/32[V] 3360895   Et1/0   172.2.126.12
16022 No Label   172.2.126.0/24[V] 98070   aggregate/ABC
16037 16011   172.2.0.5/32[V]   118   Et0/1   2.2.69.9
16038 16015   172.2.0.3/32[V]   10478523   Et0/1   2.2.69.9
16042 16027   172.2.17.0/24[V] 0   Et0/1   2.2.69.9
16043 16052   172.2.38.0/24[V] 0   Et0/1   2.2.69.9
16044 16029   172.2.59.0/24[V] 118   Et0/1   2.2.69.9

MPLS forwarding table (Cont.)

R9 MPLS label table

RP/0/0/CPU0:R9#show mpls forwarding

```
Local  Outgoing    Prefix            Outgoing      Next Hop        Bytes
Label  Label       or ID             Interface                   Switched
------ ----------- ----------------- ------------ --------------- ------------
16011  Unlabelled  172.2.0.5/32[V]   Gi0/2/0/1.59 172.2.59.5      516064
16015  16009        172.2.0.3/32[V]               2.2.0.8         0
16026  62           172.2.0.1/32[V]               2.2.0.7         884
16027  27           172.2.17.0/24[V]              2.2.0.7         0
16028  16022       1002:2:172.2.126.0/24  \
                         Gi0/2/0/1.69 2.2.69.6       0
16048  16021       1002:2:172.2.0.12/32  \
                         Gi0/2/0/1.69 2.2.69.6       3156
16052  16019       172.2.38.0/24[V]              2.2.0.8         0
```

MPLS forwarding table (Cont.)

R8 MPLS label table

```
RP/0/0/CPU0:R8#show mpls forwarding vrf ABC
Local  Outgoing   Prefix            Outgoing      Next Hop      Bytes
Label  Label      or ID             Interface                  Switched
------ ---------- ----------------- ------------- ------------- ------------
16001  Pop        172.2.38.3/32[V]  Gi0/2/0/2.38  172.2.38.3    56468989
16013  Pop        172.2.0.3/32[V]   Gi0/2/0/2.38  172.2.38.3    1650
16018  30         172.2.0.1/32[V]                 2.2.0.7       0
16020  16015      172.2.0.5/32[V]                 2.2.0.9       0
16022  29         172.2.17.0/24[V]                2.2.0.7       0
16023  16029      172.2.59.0/24[V]                2.2.0.9       0
16024  16028      172.2.0.12/32[V]                2.2.0.9       2547
16025  16030      172.2.126.0/24[V]               2.2.0.9       0
```

Connection verification

R3#ping 172.2.0.12 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.0.12, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/40/44 ms

R3#traceroute 172.2.0.12 source loopback 0
Type escape sequence to abort.
Tracing the route to 172.2.0.12

 1 172.2.38.8 [AS 2] [MPLS: Label 16024 Exp 0] 40 msec 40 msec 40 msec
 2 2.2.28.2 [MPLS: Labels 17/16028 Exp 0] 40 msec 40 msec 40 msec
 3 2.2.29.9 [MPLS: Label 16028 Exp 0] 40 msec 40 msec 40 msec
 4 172.2.126.6 [AS 1002] [MPLS: Label 16004 Exp 0] 40 msec 40 msec 40 msec
 5 172.2.126.12 [AS 1002] 36 msec * 40 msec

SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP intra-AS VPNv4
8	MP-BGP inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

CSC Building Blocks
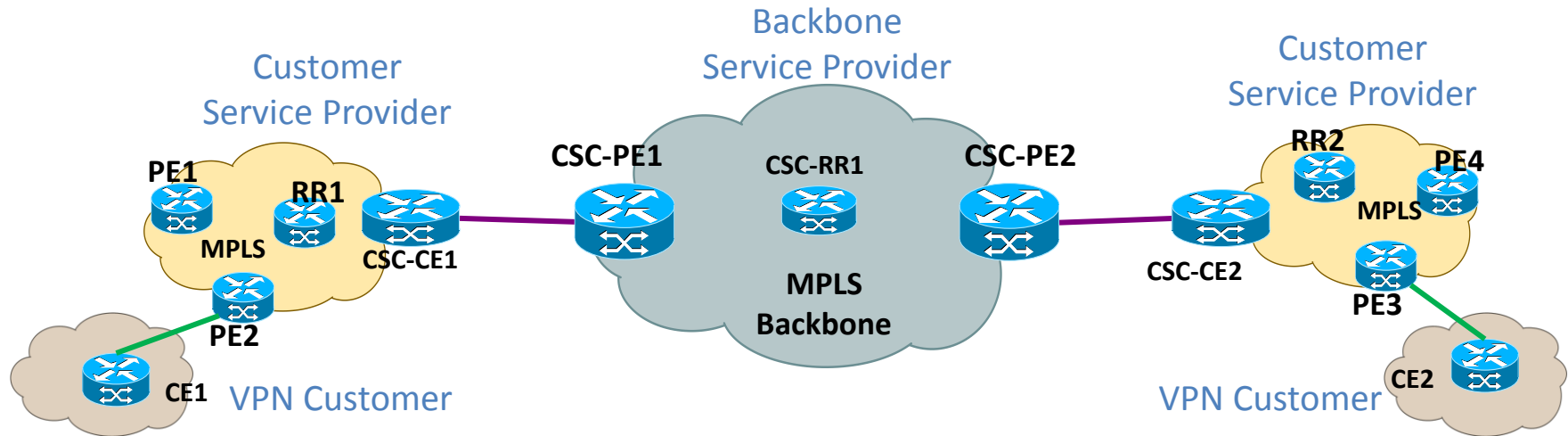
- MPLS MPLS-VPN enabled Carrier's backbone

- CSC-PE: MPLS VPN PEs located in backbone Carrier's Core

- CSC-CE: Located at the Customer Carrier network edge and connects to a CSC-PE

- PE: located in Customer carrier networks & carries customer VPN routers

- CSC-RR: Route Reflectors located in MPLS Backbone provider network

- RR: Route Reflectors located in Customer Carrier Network

- MPLS Label exchange between backbone Carrier's PE and customer Carrier's CE

CSC Building Blocks (Cont.)

- Control Plane configuration is similar to single domain MPLS VPN

- CSC-CE to CSC-PE is a VPN link to exchange Customer Carrier's internal routes. These routes are redistributed into the BSP's CSC-PE using:

  1. Static Routes   OR   2. Dynamic IGP   OR   3. eBGP

- Customer Carriers don't exchange their Subscribers' (external) VPN routes with the Backbone Service Provider

- CSC-PE-to-CSC-CE links extend Label Switching Path using:

  IGP+LDP

  eBGPv4 + Labels

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

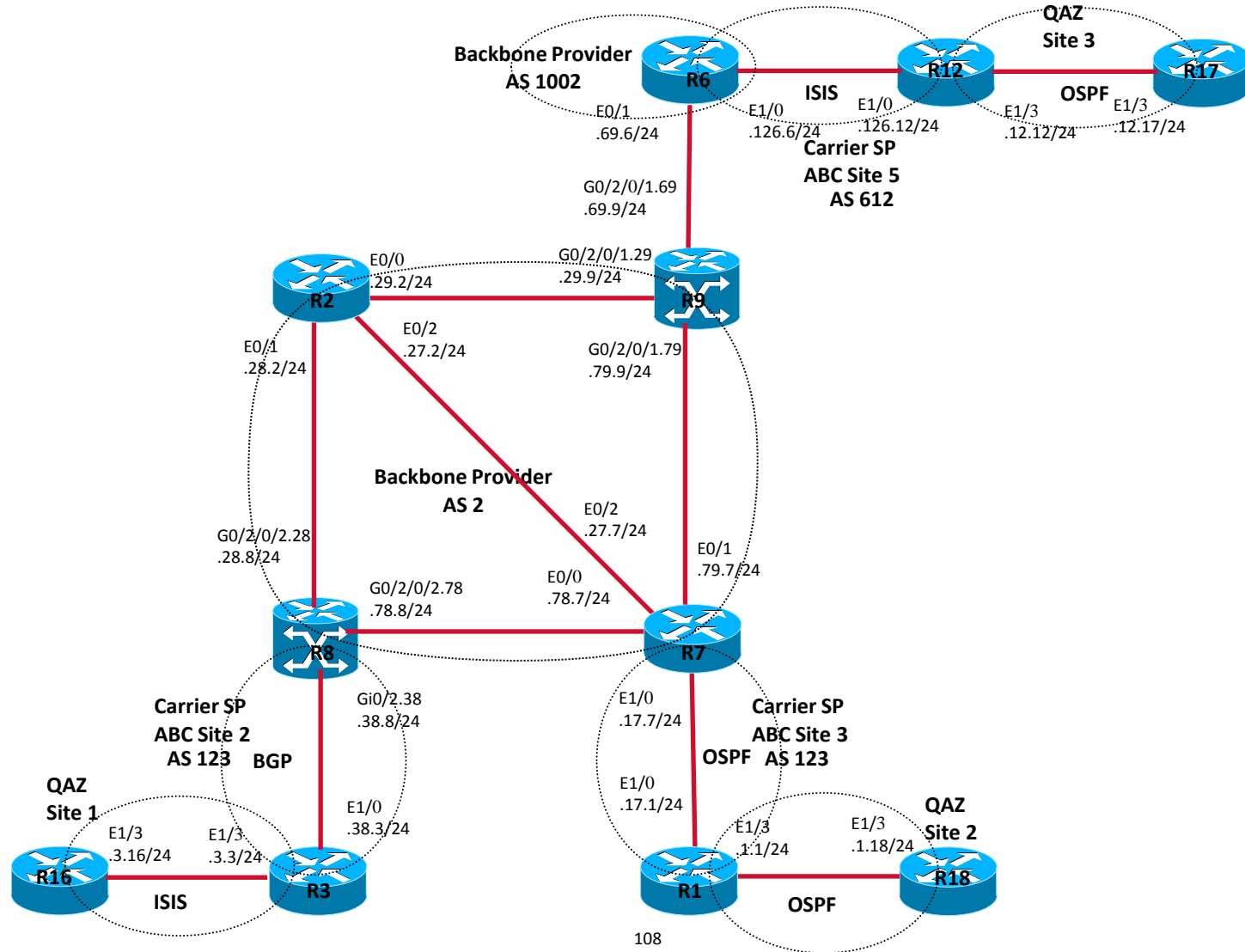 https://learningnetwork.cisco.com/docs/DOC-9991

  3.0 – Implement, Optimize and Troubleshoot L3VPN Technologies

  3.3 – Implement, Optimize and Troubleshoot Carrier Supporting Carrier (CSC)

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

CSC – Sub Topology

Backbone Provider
AS 1002

QAZ
Site 3

ISIS

OSPF

E0/1
.69.6/24

E1/0
.126.6/24

E1/0
.126.12/24

E1/3
.12.12/24

E1/3
.12.17/24

Carrier SP
ABC Site 5
AS 612

G0/2/0/1.69
.69.9/24

E0/0
.29.2/24

G0/2/0/1.29
.29.9/24

E0/1
.28.2/24

E0/2
.27.2/24

G0/2/0/1.79
.79.9/24

Backbone Provider
AS 2

E0/2
.27.7/24

E0/1
.79.7/24

G0/2/0/2.28
.28.8/24

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

Carrier SP
ABC Site 2
AS 123

Gi0/2.38
.38.8/24

Carrier SP
ABC Site 3
AS 123

BGP

E1/0
.17.7/24

OSPF

QAZ
Site 1

E1/0
.17.1/24

QAZ
Site 2

E1/3
.3.16/24

E1/3
.3.3/24

E1/0
.38.3/24

E1/3
.1.1/24

E1/3
.1.18/24

ISIS

OSPF

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CSC - Question

- R2, R7, R8 and R9 form Backbone Provider at AS 2. R6 is another Backbone Provider at AS 1002

- Configure EBGPv4+labels on R8 and R3 at ABC site 2

- Configure IGP+LDP on R7 and R1 at ABC site 3

- Configure R1 and R3 to establish IBGP VPNv4 to distribute VRF QAZ VPN information

- Ensure R16 and R18 can ping each other

- Configure IGP+LDP on R6 and R12 at ABC site 5

- Configure R3 and R12 to establish EBGP VPNv4 to distribute VRF QAZ VPN information, R1 and R12 are not be permitted to establish EBGP VPNv4 session

- Ensure R16, R17 and R18 can ping each other

CSC Configuration

R6 configuration

interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.126.6 255.255.255.0
 mpls ip
!

R7 configuration

interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.17.7 255.255.255.0
mpls ip
!

R8 configuration

router bgp 2
 vrf ABC
 rd 2:2
 address-family ipv4 unicast
 allocate-label all
 !
!
 neighbor 172.2.38.3
 remote-as 123
 address-family ipv4 labeled-unicast
 route-policy default_policy_pass_all in
 route-policy default_policy_pass_all out
 as-override
 send-extended-community-ebgp
 !
 !

CSC Configuration (Cont.)

R3 configuration

```
vrf definition QAZ
 rd 123:123
 !
 address-family ipv4
 route-target export 123:123
 route-target import 123:123
 exit-address-family
 !
interface Ethernet1/0
 ip address 172.2.38.3 255.255.255.0
 mpls bgp forwarding
!
interface Ethernet1/3
 vrf forwarding QAZ
 ip address 192.2.3.3 255.255.255.0
 ip router isis
!
router isis
 vrf QAZ
 net 47.0192.0000.0000.0003.00
 metric-style wide
 redistribute bgp 123
```

```
router bgp 123
 neighbor 172.2.0.1 remote-as 123
 neighbor 172.2.0.1 update-source Loopback0
 neighbor 172.2.0.12 remote-as 612
 neighbor 172.2.0.12 ebgp-multihop 255
 neighbor 172.2.0.12 update-source Loopback0
 neighbor 172.2.38.8 remote-as 2
 !
 address-family ipv4
  network 172.2.0.3 mask 255.255.255.255
  neighbor 172.2.38.8 activate
  neighbor 172.2.38.8 send-community both
  neighbor 172.2.38.8 send-label
 exit-address-family
 !
 address-family vpnv4
  neighbor 172.2.0.1 activate
  neighbor 172.2.0.1 send-community both
  neighbor 172.2.0.12 activate
  neighbor 172.2.0.12 send-community both
  neighbor 172.2.0.12 next-hop-unchanged
 exit-address-family
 !
 address-family ipv4 vrf QAZ
  redistribute isis level-1-2 metric 10
 exit-address-family
```

CSC Configuration (Cont.)

R1 configuration

```
vrf definition QAZ                          router bgp 123
 rd 123:123                                  neighbor 172.2.0.3 remote-as 123
 !                                           neighbor 172.2.0.3 update-source Loopback0
 address-family ipv4                         !
 route-target export 123:123                address-family vpnv4
 route-target import 123:123                 neighbor 172.2.0.3 activate
 exit-address-family                         neighbor 172.2.0.3 send-community extended
 !                                          exit-address-family
interface Ethernet1/0                        !
 ip address 172.2.17.1 255.255.255.0        address-family ipv4 vrf QAZ
 mpls ip                                     no synchronization
!                                            redistribute ospf 18 vrf QAZ
interface Ethernet1/3                       exit-address-family
 vrf forwarding QAZ                          !
 ip address 192.2.1.1 255.255.255.0
 !
router ospf 18 vrf QAZ
 redistribute bgp 123 subnets
 network 192.2.1.0 0.0.0.255 area 0
 !
```

CSC Configuration (Cont.)

R12 configuration

```
vrf definition QAZ
 rd 12:12
 !
 address-family ipv4
 route-target export 123:123
 route-target import 123:123
!
interface Ethernet1/0
 ip address 172.2.126.12 255.255.255.0
 mpls ip
!
interface Ethernet1/3
 vrf forwarding QAZ
 ip address 192.2.12.12 255.255.255.0
!
router ospf 100 vrf QAZ
 redistribute bgp 612 metric 10 subnets
 network 192.2.12.0 0.0.0.255 area 0
!
```

```
router bgp 612
 neighbor 172.2.0.3 remote-as 123
 neighbor 172.2.0.3 ebgp-multihop 255
 neighbor 172.2.0.3 update-source Loopback0
 !
 address-family vpnv4
  neighbor 172.2.0.3 activate
  neighbor 172.2.0.3 send-community both
 exit-address-family
 !
 address-family ipv4 vrf QAZ
  no synchronization
  redistribute ospf 100 vrf QAZ metric 20
 exit-address-family
 !
```

CSC Configuration (Cont.)

R16 configuration

interface Loopback0
 ip address 192.2.0.16 255.255.255.255
 ip router isis
!
interface Ethernet1/3
 ip address 192.2.3.16 255.255.255.0
 ip router isis
!
router isis
 net 47.0192.0000.0000.0016.00
 metric-style wide

R17 configuration

interface Loopback0
 ip address 192.2.0.18 255.255.255.255
!
interface Ethernet1/3
 ip address 192.2.1.18 255.255.255.0
!
router ospf 18
 network 192.2.0.18 0.0.0.0 area 0
 network 192.2.1.0 0.0.0.255 area 0

R18 configuration

interface Loopback0
 ip address 192.2.0.17 255.255.255.255
!
interface Ethernet1/3
 ip address 192.2.12.17 255.255.255.0
!
router ospf 100
 network 192.2.0.17 0.0.0.0 area 0
 network 192.2.12.0 0.0.0.255 area 0

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CSC VPNv4 Session

R3 VPNv4 neighbor

R3#show ip bgp vpnv4 all summary
BGP router identifier 172.2.0.3, local AS number 123

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
172.2.0.1	4	123	2950	2959	85	0	0	1d20h	2
172.2.0.12	4	612	2769	2771	85	0	0	1d17h	2

R1 VPNv4 neighbor

R1#show ip bgp vpnv4 all summary
BGP router identifier 172.2.0.1, local AS number 123

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
172.2.0.3	4	123	2960	2951	105	0	0	1d20h	5

R12 VPNv4 neighbor

R12#show ip bgp vpnv4 all summary
BGP router identifier 172.2.0.12, local AS number 612

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
172.2.0.3	4	123	2773	2770	159	0	0	1d17h	5

CSC VPNv4 table

R3 VPNv4 table

R3#show ip bgp vpnv4 vrf QAZ
```
   Network        Next Hop        Metric LocPrf Weight Path
Route Distinguisher: 123:123 (default for vrf QAZ)
*> 192.2.0.16/32    192.2.3.16           10      32768 ?
*> 192.2.0.17/32   172.2.0.12           20         0 612 ?
*>i192.2.0.18/32   172.2.0.1           11   100    0 ?
*>i192.2.1.0       172.2.0.1          0   100    0 ?
*> 192.2.3.0       0.0.0.0           0     32768 ?
*> 192.2.12.0      172.2.0.12           0         0 612 ?
```

R1 VPNv4 table

R1#show ip bgp vpnv4 vrf QAZ
```
   Network        Next Hop        Metric LocPrf Weight Path
Route Distinguisher: 123:123 (default for vrf QAZ)
*>i192.2.0.16/32   172.2.0.3           10   100    0 ?
*>i192.2.0.17/32   172.2.0.12           20   100     0 612 ?
*> 192.2.0.18/32   192.2.1.18           11      32768 ?
*> 192.2.1.0       0.0.0.0           0     32768 ?
*>i192.2.3.0       172.2.0.3          0   100    0 ?
*>i192.2.12.0      172.2.0.12           0   100     0 612 ?
```

CSC VPNv4 table (Cont.)

R12 VPNv4 table

R12#show ip bgp vpnv4 vrf QAZ
   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 12:12 (default for vrf QAZ)
*> 192.2.0.16/32   172.2.0.3   10   0 123 ?
*> 192.2.0.17/32   192.2.12.17   20   32768 ?
*> 192.2.0.18/32   172.2.0.1   0 123 ?
*> 192.2.1.0   172.2.0.1   0 123 ?
*> 192.2.3.0   172.2.0.3   0   0 123 ?
*> 192.2.12.0   0.0.0.0   0   32768 ?

CSC VPN customer routes

R16 , R18 and R17 route

R16#show ip route isis

i L2   192.2.0.17 [115/10] via 192.2.3.3, Ethernet1/3
i L2   192.2.0.18 [115/10] via 192.2.3.3, Ethernet1/3
i L2 192.2.1.0/24 [115/10] via 192.2.3.3, Ethernet1/3
i L2 192.2.12.0/24 [115/10] via 192.2.3.3, Ethernet1/3

R18#show ip route ospf

O E2   192.2.0.16 [110/10] via 192.2.1.1, 1d20h, Ethernet1/3
O E2   192.2.0.17 [110/20] via 192.2.1.1, 1d03h, Ethernet1/3
O E2 192.2.3.0/24 [110/1] via 192.2.1.1, 1d20h, Ethernet1/3
O E2 192.2.12.0/24 [110/1] via 192.2.1.1, 1d03h, Ethernet1/3

R17#show ip route ospf

O E2   192.2.0.16 [110/10] via 192.2.12.12, 1d03h, Ethernet1/3
O E2   192.2.0.18 [110/10] via 192.2.12.12, 1d03h, Ethernet1/3
O E2 192.2.1.0/24 [110/10] via 192.2.12.12, 1d03h, Ethernet1/3
O E2 192.2.3.0/24 [110/10] via 192.2.12.12, 1d03h, Ethernet1/3

CSC VPN customer routes (Cont.)

R3 and R1 VRF QAZ routes

R3#show ip route vrf QAZ

i L1   192.2.0.16 [115/20] via 192.2.3.16, Ethernet1/3
B   192.2.0.17 [20/20] via 172.2.0.12, 1d03h
B   192.2.0.18 [200/11] via 172.2.0.1, 1d20h
B   192.2.1.0/24 [200/0] via 172.2.0.1, 1d20h
      192.2.3.0/24 is variably subnetted, 2 subnets, 2 masks
C   192.2.3.0/24 is directly connected, Ethernet1/3
L   192.2.3.3/32 is directly connected, Ethernet1/3
B   192.2.12.0/24 [20/0] via 172.2.0.12, 1d03h

R1#show ip route vrf QAZ

B   192.2.0.16 [200/10] via 172.2.0.3, 1d20h
B   192.2.0.17 [200/20] via 172.2.0.12, 1d03h
O   192.2.0.18 [110/11] via 192.2.1.18, 5d22h, Ethernet1/3
C   192.2.1.0/24 is directly connected, Ethernet1/3
L   192.2.1.1/32 is directly connected, Ethernet1/3
B   192.2.3.0/24 [200/0] via 172.2.0.3, 1d20h
B   192.2.12.0/24 [200/0] via 172.2.0.12, 1d03h

CSC VPN customer routes (Cont.)

R12 VRF QAZ routes

R12#show ip route vrf QAZ

B   192.2.0.16 [20/10] via 172.2.0.3, 1d03h
O   192.2.0.17 [110/11] via 192.2.12.17, 5d22h, Ethernet1/3
B   192.2.0.18 [20/0] via 172.2.0.1, 1d03h
B   192.2.1.0/24 [20/0] via 172.2.0.1, 1d03h
B   192.2.3.0/24 [20/0] via 172.2.0.3, 1d03h
C   192.2.12.0/24 is directly connected, Ethernet1/3
L   192.2.12.12/32 is directly connected, Ethernet1/3

CSC MPLS table

R3 and R1 mpls table

R3#show mpls forwarding-table
Local Outgoing   Prefix   Bytes Label   Outgoing   Next Hop
Label Label or VC   or Tunnel Id   Switched   interface
17   Pop Label   172.2.38.8/32   0   Et1/0   172.2.38.8
20   No Label   192.2.0.16/32[V] 1266   Et1/3   192.2.3.16
21   No Label   192.2.3.0/24[V]   0   aggregate/QAZ

R1#show mpls forwarding-table
Local Outgoing   Prefix   Bytes Label   Outgoing   Next Hop
Label Label or VC   or Tunnel Id   Switched   interface
16   No Label   192.2.0.18/32[V] 570   Et1/3   192.2.1.18
17   No Label   192.2.1.0/24[V]   570   aggregate/QAZ
18   45   172.2.0.12/32   0   Et1/0   172.2.17.7
39   31   172.2.0.3/32   0   Et1/0   172.2.17.7
43   37   172.2.38.0/24   0   Et1/0   172.2.17.7
45   44   172.2.126.0/24   0   Et1/0   172.2.17.7

CSC MPLS table (Cont.)

R12 MPLS table

R12#show mpls forwarding-table

Local Label	Outgoing Label or VC	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
17	No Label	192.2.0.17/32[V]	4751	Et1/3	192.2.12.17
18	No Label	192.2.12.0/24[V]	0	aggregate/QAZ	
23	16038	172.2.0.3/32	0	Et1/0	172.2.126.6
24	16042	172.2.17.0/24	0	Et1/0	172.2.126.6
25	16043	172.2.38.0/24	0	Et1/0	172.2.126.6
51	16003	172.2.0.1/32	0	Et1/0	172.2.126.6

Connection and Path Verification

R16#ping 192.2.0.18 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.18, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.16
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 20/20/20 ms

R16#traceroute 192.2.0.18 source loopback 0
Type escape sequence to abort.
Tracing the route to 192.2.0.18

 1 192.2.3.3 4 msec 0 msec 0 msec
 2 172.2.38.8 [MPLS: Labels 16021/16 Exp 0] 24 msec 20 msec 16 msec
 3 2.2.78.7 [MPLS: Labels 62/16 Exp 0] 20 msec 20 msec 20 msec
 4 192.2.1.1 [MPLS: Label 16 Exp 0] 16 msec 24 msec 20 msec
 5 192.2.1.18 20 msec * 20 msec

Connection and Path Verification (Cont.)

R16#ping 192.2.0.17 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.17, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.16
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 40/42/52 ms

R16#trace 192.2.0.17 source loopback 0
Type escape sequence to abort.
Tracing the route to 192.2.0.17

 1 192.2.3.3 4 msec 0 msec 0 msec
 2 172.2.38.8 [MPLS: Labels 16028/17 Exp 0] 36 msec 36 msec 40 msec
 3 2.2.78.7 [MPLS: Labels 18/16048/17 Exp 0] 40 msec 40 msec 40 msec
 4 2.2.79.9 [MPLS: Labels 16048/17 Exp 0] 40 msec 40 msec 40 msec
 5 2.2.69.6 [MPLS: Labels 16021/17 Exp 0] 40 msec 40 msec 40 msec
 6 192.2.12.12 [MPLS: Label 17 Exp 0] 40 msec 40 msec 40 msec
 7 192.2.12.17 40 msec * 40 msec

Connection and Path Verification (Cont.)

R18#ping 192.2.0.16 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.16, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.18
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/4 ms

R18#traceroute 192.2.0.16 source loopback 0

Type escape sequence to abort.
Tracing the route to 192.2.0.16

 1 192.2.1.1 0 msec 4 msec 0 msec
 2 172.2.17.7 [MPLS: Labels 28/20 Exp 0] 4 msec 4 msec 0 msec
 3 2.2.78.8 [MPLS: Labels 16020/20 Exp 0] 8 msec 4 msec 4 msec
 4 192.2.3.3 [MPLS: Label 20 Exp 0] 0 msec 4 msec 0 msec
 5 192.2.3.16 4 msec * 4 msec

Connection and Path Verification (Cont.)

R18#ping 192.2.0.17 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.17, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.18
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/19/20 ms

R18#traceroute 192.2.0.17 source loopback 0
Type escape sequence to abort.
Tracing the route to 192.2.0.17

 1 192.2.1.1 4 msec 0 msec 0 msec
 2 172.2.17.7 [MPLS: Labels 45/17 Exp 0] 24 msec 20 msec 20 msec
 3 2.2.79.9 [MPLS: Labels 16048/17 Exp 0] 20 msec 20 msec 20 msec
 4 2.2.69.6 [MPLS: Labels 16021/17 Exp 0] 20 msec 20 msec 20 msec
 5 192.2.12.12 [MPLS: Label 17 Exp 0] 20 msec 20 msec 20 msec
 6 192.2.12.17 20 msec * 20 msec

Connection and Path Verification (Cont.)

R17#ping 192.2.0.16 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.16, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.17
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/4/8 ms

R17#traceroute 192.2.0.16 source loopback 0
Type escape sequence to abort.
Tracing the route to 192.2.0.16

1 192.2.12.12 [MPLS: Label 34 Exp 0] 8 msec 4 msec 4 msec
2 172.2.126.6 [MPLS: Labels 121/20 Exp 0] 4 msec 4 msec 4 msec
3 2.2.69.9 [MPLS: Labels 16019/20 Exp 0] 4 msec 8 msec 8 msec
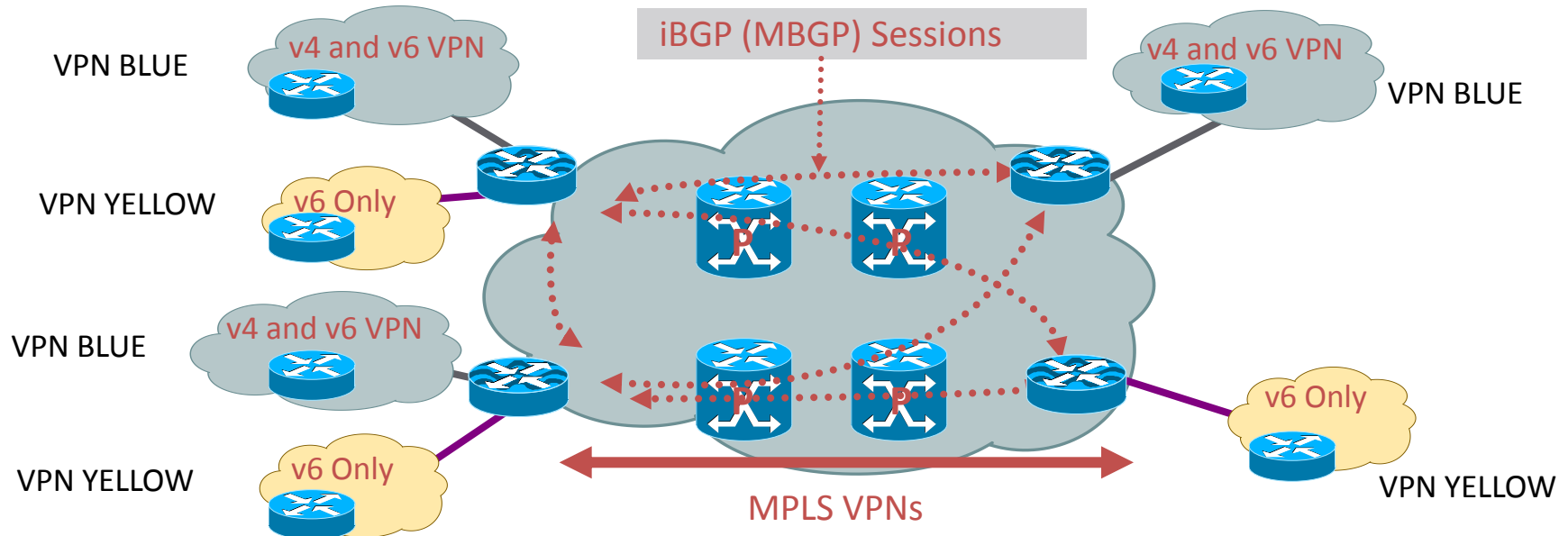4 2.2.79.7 [MPLS: Labels 20/16020/20 Exp 0] 4 msec 4 msec 4 msec
5 2.2.78.8 [MPLS: Labels 16020/20 Exp 0] 4 msec 8 msec 8 msec
6 192.2.3.3 [MPLS: Label 20 Exp 0] 4 msec 4 msec 0 msec
7 192.2.3.16 4 msec * 4 msec

Connection and Path Verification (Cont.)

R17#ping 192.2.0.18 source loopback 0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.2.0.18, timeout is 2 seconds:
Packet sent with a source address of 192.2.0.17
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/8 ms

R17#traceroute 192.2.0.18 source loopback 0
Type escape sequence to abort.
Tracing the route to 192.2.0.18

  1 192.2.12.12 [MPLS: Label 18 Exp 0] 8 msec 4 msec 4 msec
  2 172.2.126.6 [MPLS: Labels 120/23 Exp 0] 4 msec 4 msec 4 msec
  3 2.2.69.9 [MPLS: Labels 16018/23 Exp 0] 4 msec 8 msec 8 msec
  4 2.2.79.7 [MPLS: Labels 35/23 Exp 0] 4 msec 4 msec 4 msec
  5 192.2.1.1 [MPLS: Label 23 Exp 0] 0 msec 0 msec 4 msec
  6 192.2.1.18 4 msec * 4 msec

SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP intra-AS VPNv4
8	MP-BGP inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

MP-BGP VPNv6 - 6VPE Deployment

VPN BLUE

v4 and v6 VPN

iBGP (MBGP) Sessions

v4 and v6 VPN

VPN BLUE

VPN YELLOW

v6 Only

P P

P P

VPN BLUE

v4 and v6 VPN

VPN YELLOW

v6 Only

v6 Only

VPN YELLOW

MPLS VPNs

- 6VPE ~ IPv6 + BGP-MPLS IPv4   VPN + 6PE
- Cisco 6VPE is an implementation of RFC4659
- VPNv6 address:
  – Address including the 64 bits route distinguisher and the 128 bits IPv6 address

- MP-BGP VPNv6 address-family:
  – AFI "IPv6" (2), SAFI "VPN" (128)
- VPN IPv6 MP_REACH_NLRI
  – With VPNv6 next-hop (192bits) and NLRI in the form of <length, IPv6-prefix, label>
- Encoding of the BGP next-hop

MP-BGP Inter-AS VPNv6 Options
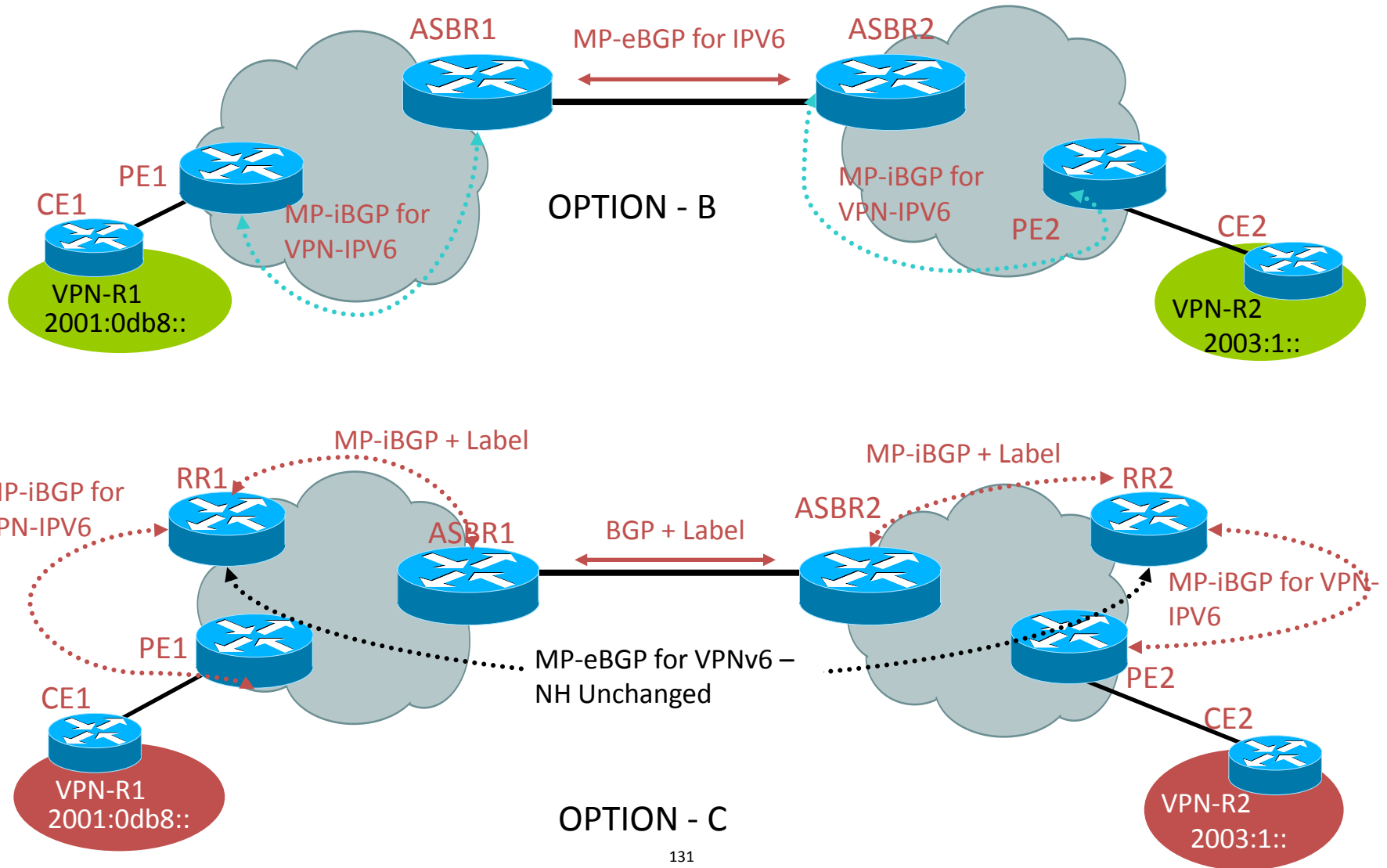
ASBR1

MP-eBGP for IPV6

ASBR2

PE1

CE1

MP-iBGP for
VPN-IPV6

OPTION - B

MP-iBGP for
VPN-IPV6

PE2

CE2

VPN-R1
2001:0db8::

VPN-R2
2003:1::

MP-iBGP + Label

MP-iBGP + Label

RR1

MP-iBGP for
VPN-IPV6

ASBR1

BGP + Label

ASBR2

RR2

MP-iBGP for VPN-
IPV6

PE1

MP-eBGP for VPNv6 –
NH Unchanged

PE2

CE1

CE2

VPN-R1
2001:0db8::

OPTION - C

VPN-R2
2003:1::

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

  3.0 – Implement, Optimize and Troubleshoot L3VPN Technologies

  3.1 – Implement, Optimize and Troubleshoot Intra-AS L3VPN

  3.2 – Implement, Optimize and Troubleshoot Inter-AS L3VPN

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

MP-BGP VPNv6 - 6VPE – Sub Topology
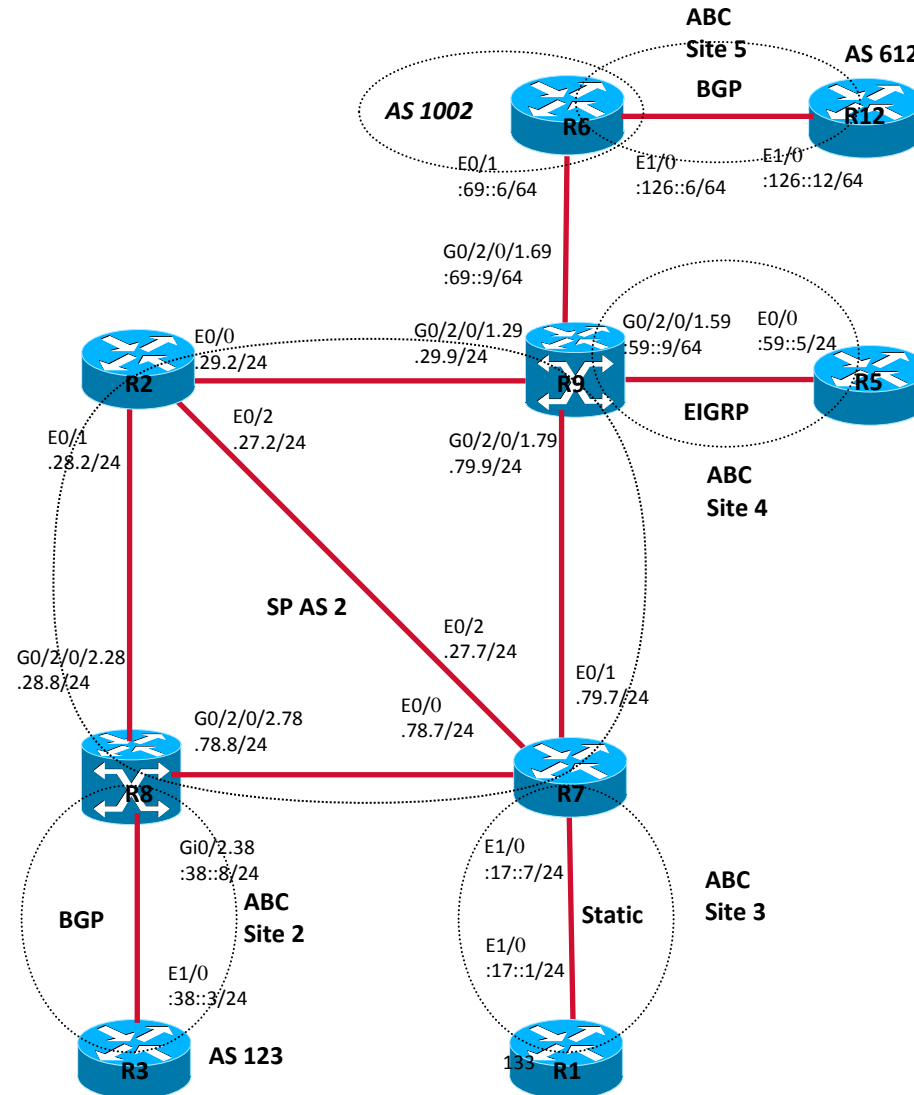
MP-BGP VPNv6 - 6VPE - Question

- Configure R2, R7, R8 and R9 to support MP-BGP intra AS VPNv6 (6VPE) information exchange. R9 is VPNv6 route-reflector to R2, R7 and R8.

- Ensure R1, R3 and R5 can ping each other via IPv6

- Configure MP-BGP Inter-AS VPNv6 (6VPE) on R6 and R9

- Ensure R1, R3, R5 and R12 can ping each other via IPv6.

6VPE Configuration

R7 (IOS) configuration

vrf definition ABC
 rd 2:2
 !
 address-family ipv6
 route-target export 2:2
 route-target import 2:2
 route-target import 1002:2
 exit-address-family
!
interface Ethernet1/0
 vrf forwarding ABC
 ipv6 address 2002:172:2:17::7/64
!
router bgp 2
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 !
 address-family vpnv6
  neighbor 2.2.0.9 activate
  neighbor 2.2.0.9 send-community both
 exit-address-family
 !

 address-family ipv6 vrf ABC
 redistribute static
  no synchronization
 exit-address-family
!
ipv6 route vrf ABC 2002:172:2::1/128 Ethernet1/0 FE80::C00:FF:FE00:A01

6VPE Configuration (Cont.)

R8 (IOS-XR) configuration

```
vrf ABC
 !
 address-family ipv6 unicast
  import route-target
   2:2
   1002:2
  !
  export route-target
   2:2
  !
 !
!
interface GigabitEthernet0/2/0/2.38
 vrf ABC
 ipv6 address 2002:172:2:38::8/64
 dot1q vlan 38
!
```

```
router bgp 2
 address-family vpnv6 unicast
 !
 neighbor 2.2.0.9
  remote-as 2
  update-source Loopback0
  address-family vpnv6 unicast
  !
 !
 vrf ABC
  rd 2:2
  !
  neighbor 2002:172:2:38::3
   remote-as 123
   address-family ipv6 unicast
    route-policy default_policy_pass_all in
    route-policy default_policy_pass_all out
!
```

6VPE Configuration (Cont.)

R9 (IOS-XR) configuration

vrf ABC
 address-family ipv6 unicast
  import route-target
   2:2
   1002:2
  !
  export route-target
   2:2
  !
 !
interface GigabitEthernet0/2/0/1.59
 vrf ABC
 ipv6 address 2002:172:2:59::9/64
 dot1q vlan 59
!
interface GigabitEthernet0/2/0/1.69
 ipv4 address 2.2.69.9 255.255.255.0
 ipv6 address 2002:2:2:69::9/64
 dot1q vlan 69
!

router bgp 2
 address-family vpnv6 unicast
 !
 neighbor 2.2.0.2
  remote-as 2
  update-source Loopback0
  address-family vpnv6 unicast
   route-reflector-client
   next-hop-self
  !
 neighbor 2.2.0.7
  remote-as 2
  update-source Loopback0
  address-family vpnv6 unicast
   route-reflector-client
   next-hop-self
  !
 neighbor 2.2.0.8
  remote-as 2
  update-source Loopback0
  address-family vpnv6 unicast
   route-reflector-client
   next-hop-self
  !

 neighbor 2.2.69.6
  remote-as 1002
  address-family vpnv6 unicast
   route-policy default_policy_pass_all in
   route-policy default_policy_pass_all out
  !
 vrf ABC
  rd 2:2
  address-family ipv6 unicast
   redistribute eigrp 100
  !
 !
router eigrp 100
 vrf ABC
  address-family ipv6
   default-metric 100000 10 250 1 1500
   autonomous-system 100
   redistribute bgp 2
   interface GigabitEthernet0/2/0/1.59
   !
  !

6VPE Configuration (Cont.)

R6 (IOS) configuration

vrf definition ABC
 rd 1002:2
 !
 address-family ipv6
 route-target export 1002:2
 route-target import 1002:2
 route-target import 2:2
 exit-address-family
!
interface Ethernet1/0
 vrf forwarding ABC
 ipv6 address 2002:172:2:126::6/64
!

router bgp 1002
 no bgp default route-target filter
 neighbor 2.2.69.9 remote-as 2
!
 address-family vpnv6
  neighbor 2.2.69.9 activate
  neighbor 2.2.69.9 send-community both
 exit-address-family
 !
 address-family ipv6 vrf ABC
  no synchronization
  neighbor 2002:172:2:126::12 remote-as 612
  neighbor 2002:172:2:126::12 activate
  neighbor 2002:172:2:126::12 send-community both
 exit-address-family
 !

6VPE Configuration (Cont.)

R1 configuration

interface Loopback0
 ipv6 address 2002:172:2::1/128
!
interface Ethernet1/0
 ipv6 address 2002:172:2:17::1/64
!
ipv6 route 2002:172:2::/48 Ethernet1/0
FE80::C00:FF:FE00:4601

R3 configuration

interface Loopback0
 ipv6 address 2002:172:2::3/128
!
interface Ethernet1/0
 ipv6 address 2002:172:2:38::3/64
!
router bgp 123
 neighbor 2002:172:2:38::8 remote-as 2
 !
 address-family ipv6
  no synchronization
  network 2002:172:2::3/128
  neighbor 2002:172:2:38::8 activate
  neighbor 2002:172:2:38::8 send-community both
 exit-address-family
 !

6VPE Configuration (Cont.)

R5 configuration

interface Loopback0
 ipv6 address 2002:172:2::5/128
 ipv6 eigrp 100
!
interface Ethernet0/0
 ipv6 address 2002:172:2:59::5/64
 ipv6 eigrp 100
!
ipv6 router eigrp 100
 no shutdown

R12 configuration

interface Loopback0
 ipv6 address 2002:172:2::12/128
!
interface Ethernet1/0
 ipv6 address 2002:172:2:126::12/64
!
router bgp 612
 neighbor 2002:172:2:126::6 remote-as 1002
!
 address-family ipv6
 no synchronization
 network 2002:172:2::12/128
 neighbor 2002:172:2:126::6 activate
 neighbor 2002:172:2:126::6 send-community both

6VPE Adjacency

R9 6VPE neighbor

RP/0/0/CPU0:R9#show bgp vpnv6 unicast summary
Process   RcvTblVer bRIB/RIB LabelVer ImportVer SendTblVer StandbyVer
Speaker   4025   4025   4025   4025   4025   4025

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.0.2	0	2	112319	109696	4025	0	0	4d22h	1
2.2.0.7	0	2	111068	105904	4025	0	0	4d21h	2
2.2.0.8	0	2	100455	109877	4025	0	0	4d22h	3
2.2.69.6	0	1002	113188	104835	4025	0	0	3d01h	2

R6 6VPE neighbor

R6#show ip bgp vpnv6 unicast all summary
BGP router identifier 2.2.0.6, local AS number 1002

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2002:172:2:126::12	4	612	264	268	32	0	0	03:47:37	1
2.2.69.9	4	2	4453	4883	32	0	0	3d01h	8

6VPE Adjacency (Cont.)

R7 6VPE neighbor

R7#show ip bgp vpnv6 unicast all summary
BGP router identifier 2.2.0.77, local AS number 2

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.0.9	4	2	1309	1421	25	0	0	21:21:52	8

R8 6VPE neighbor

RP/0/0/CPU0:R8#show bgp vpnv6 unicast summary
BGP router identifier 2.2.0.8, local AS number 2

Process	RcvTblVer	bRIB/RIB	LabelVer	ImportVer	SendTblVer	StandbyVer
Speaker	3687	3687	3687	3687	3687	3687

Neighbor	Spk	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	St/PfxRcd
2.2.0.9	0	2	117546	108682	3687	0	0	22:33:14	7

R2 6VPE neighbor

R2#show ip bgp vpnv6 unicast all summary
BGP router identifier 2.2.0.2, local AS number 2

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
2.2.0.9	4	2	1320	1431	24	0	0	21:24:08	9

VPNv6 table

R9 VPNv6 table

RP/0/0/CPU0:R9#show bgp vpnv6 unicast vrf ABC
BGP router identifier 2.2.0.9, local AS number 2
Status codes: s suppressed, d damped, h history, * valid, > best
      i - internal, S stale
Origin codes: i - IGP, e - EGP, ? - incomplete
  Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf ABC)
*>i2002:172:2::1/128 2.2.0.7   0   100   0 ?
*>i2002:172:2::3/128 2.2.0.8   0   100   0 123 i
*> 2002:172:2::5/128 fe80::c00:ff:fe00:3200
           130816   32768 ?
*> 2002:172:2::12/128 2.2.69.6   0 1002 612 i
*>i2002:172:2:17::/64 2.2.0.7   0   100   0 ?
*>i2002:172:2:38::/64 2.2.0.8   0   100   0 ?
*> 2002:172:2:59::/64 ::   0   32768 ?
*> 2002:172:2:126::/64
         2.2.69.6   0   0 1002 ?

VPNv6 table (Cont.)

R7 VPNv6 table

R7#show ip bgp vpnv6 unicast vrf ABC
BGP table version is 86, local router ID is 2.2.0.7
   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf ABC)
*> 2002:172:2::1/128
               ::   0   32768 ?
*>i2002:172:2::3/128
               ::FFFF:2.2.0.8   0   100   0 123 i
*>i2002:172:2::5/128
               ::FFFF:2.2.0.9   130816   100   0 ?
*>i2002:172:2::12/128
               ::FFFF:2.2.0.9   100   0 1002 612 i
*> 2002:172:2:17::/64
               ::   0   32768 ?
*>i2002:172:2:38::/64
               ::FFFF:2.2.0.8   0   100   0 ?
*>i2002:172:2:59::/64
               ::FFFF:2.2.0.9   0   100   0 ?
*>i2002:172:2:126::/64
               ::FFFF:2.2.0.9   0   100   0 1002 ?

VPNv6 table (Cont.)

R6 VPNv6 table

R6#show ip bgp vpnv6 unicast vrf ABC
BGP table version is 32, local router ID is 2.2.0.6
  Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 1002:2 (default for vrf ABC)
*> 2002:172:2::1/128
          ::FFFF:2.2.69.9   0 2 ?
*> 2002:172:2::3/128
          ::FFFF:2.2.69.9   0 2 123 i
*> 2002:172:2::5/128
          ::FFFF:2.2.69.9   130816   0 2 ?
*> 2002:172:2::12/128
          2002:172:2:126::12
                         0   0 612 i
*> 2002:172:2:17::/64
          ::FFFF:2.2.69.9   0 2 ?
*> 2002:172:2:38::/64
          ::FFFF:2.2.69.9   0 2 ?
*> 2002:172:2:59::/64
          ::FFFF:2.2.69.9   0   0 2 ?
*> 2002:172:2:126::/64
          ::   0   32768 ?

VPNv6 table (Cont.)

R8 VPNv6 table

RP/0/0/CPU0:R8#show bgp vpnv6 unicast vrf ABC
BGP router identifier 2.2.0.8, local AS number 2
   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf ABC)
*>i2002:172:2::1/128 2.2.0.7   0   100   0 ?
*> 2002:172:2::3/128 2002:172:2:38::3
                       0   0 123 i
*>i2002:172:2::5/128 2.2.0.9   130816   100   0 ?
*>i2002:172:2::12/128 2.2.0.9   100   0 1002 612 i
*>i2002:172:2:17::/64 2.2.0.7   0   100   0 ?
*> 2002:172:2:38::/64 ::   0   32768 ?
*>i2002:172:2:59::/64 2.2.0.9   0   100   0 ?
*>i2002:172:2:126::/64
                       2.2.0.9   0   100   0 1002 ?

IPv6 routes

R1 ipv6 routes

R1#show ipv6 route

S 2002:172:2::/48 [1/0]
    via FE80::C00:FF:FE00:4601, Ethernet1/0
LC 2002:172:2::1/128 [0/0]
    via Loopback0, receive
C   2002:172:2:17::/64 [0/0]
    via Ethernet1/0, directly connected
L 2002:172:2:17::1/128 [0/0]
    via Ethernet1/0, receive
L FF00::/8 [0/0]
    via Null0, receive

R3 ipv6 routes

R3#show ipv6 route bgp

B 2002:172:2::1/128 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0
B 2002:172:2::5/128 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0
B 2002:172:2::12/128 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0
B 2002:172:2:17::/64 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0
B 2002:172:2:59::/64 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0
B 2002:172:2:126::/64 [20/0]
    via FE80::215:C7FF:FE5C:3552, Ethernet1/0

IPv6 routes (Cont.)

R5 ipv6 routes

R5#show ipv6 route eigrp

EX 2002:172:2::1/128 [170/309760]
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0
EX 2002:172:2::3/128 [170/309760], tag 123
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0
EX 2002:172:2::12/128 [170/309760], tag 1002
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0
EX 2002:172:2:17::/64 [170/309760]
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0
D   2002:172:2:38::/64 [90/281856]
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0
EX 2002:172:2:126::/64 [170/309760], tag 1002
   via FE80::213:7FFF:FEE1:C551, Ethernet0/0

R12 ipv6 routes

R12#show ipv6 route bgp

B 2002:172:2::1/128 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0
B 2002:172:2::3/128 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0
B 2002:172:2::5/128 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0
B 2002:172:2:17::/64 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0
B 2002:172:2:38::/64 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0
B 2002:172:2:59::/64 [20/0]
   via FE80::A8BB:CCFF:FE00:3C01, Ethernet1/0

IPv6 routes (Cont.)

R8 VRF ABC ipv6 route

RP/0/0/CPU0:R8#show route vrf ABC ipv6

B   2002:172:2::1/128
     [200/0] via ::ffff:2.2.0.7 (nexthop in vrf default), 02:11:12
B   2002:172:2::3/128
     [20/0] via fe80::c00:ff:fe00:1e01, 4d22h, GigabitEthernet0/2/0/2.38
B   2002:172:2::5/128
     [200/130816] via ::ffff:2.2.0.9 (nexthop in vrf default), 4d21h
B   2002:172:2::12/128
     [200/0] via ::ffff:2.2.0.9 (nexthop in vrf default), 04:06:06
B   2002:172:2:17::/64
     [200/0] via ::ffff:2.2.0.7 (nexthop in vrf default), 4d21h
C   2002:172:2:38::/64 is directly connected,
     8w5d, GigabitEthernet0/2/0/2.38
L   2002:172:2:38::8/128 is directly connected,
     8w5d, GigabitEthernet0/2/0/2.38
B   2002:172:2:59::/64
     [200/0] via ::ffff:2.2.0.9 (nexthop in vrf default), 4d21h
B   2002:172:2:126::/64
     [200/0] via ::ffff:2.2.0.9 (nexthop in vrf default), 04:10:07

IPv6 routes (Cont.)

R9 VRF ABC ipv6 route

RP/0/0/CPU0:R9#show route vrf ABC ipv6

B   2002:172:2::1/128
    [200/0] via ::ffff:2.2.0.7 (nexthop in vrf default), 02:12:12
B   2002:172:2::3/128
    [200/0] via ::ffff:2.2.0.8 (nexthop in vrf default), 4d20h
D   2002:172:2::5/128
    [90/130816] via fe80::c00:ff:fe00:3200, 4d21h, GigabitEthernet0/2/0/1.59
B   2002:172:2::12/128
    [20/0] via ::ffff:2.2.69.6 (nexthop in vrf default), 04:07:02
B   2002:172:2:17::/64
    [200/0] via ::ffff:2.2.0.7 (nexthop in vrf default), 4d20h
B   2002:172:2:38::/64
    [200/0] via ::ffff:2.2.0.8 (nexthop in vrf default), 4d20h
C   2002:172:2:59::/64 is directly connected,
    10w1d, GigabitEthernet0/2/0/1.59
L   2002:172:2:59::9/128 is directly connected,
    10w1d, GigabitEthernet0/2/0/1.59
B   2002:172:2:126::/64
    [20/0] via ::ffff:2.2.69.6 (nexthop in vrf default), 04:11:02

IPv6 routes (Cont.)

R7 VRF ABC ipv6 route

R7#show ipv6 route vrf ABC

S   2002:172:2::1/128 [1/0]
     via FE80::C00:FF:FE00:A01, Ethernet1/0
B   2002:172:2::5/128 [200/130816]
     via 2.2.0.9%default, indirectly connected
B   2002:172:2::8/128 [200/0]
     via 2.2.0.8%default, indirectly connected
B   2002:172:2::12/128 [200/0]
     via 2.2.0.9%default, indirectly connected
C   2002:172:2:17::/64 [0/0]
     via Ethernet1/0, directly connected
L   2002:172:2:17::7/128 [0/0]
     via Ethernet1/0, receive
B   2002:172:2:38::/64 [200/0]
     via 2.2.0.8%default, indirectly connected
B   2002:172:2:59::/64 [200/0]
     via 2.2.0.9%default, indirectly connected
B   2002:172:2:126::/64 [200/0]
     via 2.2.0.9%default, indirectly connected
L   FF00::/8 [0/0]
     via Null0, receive

IPv6 routes (Cont.)

R6 VRF ABC ipv6 route

R6#show ipv6 route vrf ABC

B 2002:172:2::1/128 [20/0]
    via 2.2.69.9%default, indirectly connected
B 2002:172:2::3/128 [20/0]
    via 2.2.69.9%default, indirectly connected
B 2002:172:2::5/128 [20/130816]
    via 2.2.69.9%default, indirectly connected
B 2002:172:2::12/128 [20/0]
    via FE80::A8BB:CCFF:FE00:7801, Ethernet1/0
B 2002:172:2:17::/64 [20/0]
    via 2.2.69.9%default, indirectly connected
B 2002:172:2:38::/64 [20/0]
    via 2.2.69.9%default, indirectly connected
B 2002:172:2:59::/64 [20/0]
    via 2.2.69.9%default, indirectly connected
C 2002:172:2:126::/64 [0/0]
    via Ethernet1/0, directly connected
L 2002:172:2:126::6/128 [0/0]
    via Ethernet1/0, receive
L FF00::/8 [0/0]
    via Null0, receive

MPLS forwarding table

R9 mpls forwarding table

```
RP/0/0/CPU0:R9#show mpls forwarding
Local  Outgoing   Prefix            Outgoing      Next Hop        Bytes
Label  Label      or ID             Interface                     Switched
------ ----------- ----------------- ------------ --------------- ------------
16002  Unlabelled  2002:172:2::5/128[V]  \
                   Gi0/2/0/1.59 fe80::c00:ff:fe00:3200  \
16016  16010       2002:172:2::3/128[V]  \
                           point2point    0
16019  16000       2002:172:2:38::/64[V]  \
                           point2point    0
16028  16022       1002:2:172.2.126.0/24  \
                   Gi0/2/0/1.69 2.2.69.6      0
16046  16019       1002:2:2002:172:2::12/128  \
                   Gi0/2/0/1.69 2.2.69.6      825
16048  16021       1002:2:172.2.0.12/32  \
                   Gi0/2/0/1.69 2.2.69.6      0
16049  46          2002:172:2::1/128[V]  \
                           point2point    0
16051  29          2002:172:2:17::/64[V]  \
                           point2point    0
16053  16020       1002:2:2002:172:2:126::/64  \
                   Gi0/2/0/1.69 2.2.69.6      0     153
```

MPLS forwarding table (Cont.)

R6 mpls forwarding table

R6#show mpls forwarding-table
Local Outgoing   Prefix   Bytes Label   Outgoing   Next Hop
Label Label or VC   or Tunnel Id   Switched   interface
16011 16019   [2:2]2002:172:2:38::/64   \
                    0   Et0/1   2.2.69.9
16012 16021   [2:2]2002:172:2:59::/64   \
                    0   Et0/1   2.2.69.9
16013 16051   [2:2]2002:172:2:17::/64   \
                    0   Et0/1   2.2.69.9
16015 16049   [2:2]2002:172:2::1/128   \
                    0   Et0/1   2.2.69.9
16017 16016   [2:2]2002:172:2::3/128   \
                    0   Et0/1   2.2.69.9
16018 16002   [2:2]2002:172:2::5/128   \
                    0   Et0/1   2.2.69.9
16019 No Label   2002:172:2::12/128[V]   \
                    4830   Et1/0   FE80::A8BB:CCFF:FE00:7801
16020 Pop Label   2002:172:2:126::/64[V]   \
                    570   aggregate/ABC

MPLS forwarding table(Cont.)

R8 mpls forwarding table

RP/0/0/CPU0:R8#show mpls forwarding
Local Outgoing   Prefix   Outgoing   Next Hop   Bytes
Label Label   or ID   Interface   Switched
------ ---------- ----------------- ----------- --------------- ------------
16010 Unlabelled 2002:172:2::3/128[V]   \
                    Gi0/2/0/2.38 fe80::c00:ff:fe00:1e01   \
                              5280

R7 mpls forwarding table

R7#show mpls forwarding-table
Local Outgoing   Prefix   Bytes Label   Outgoing   Next Hop
Label Label or VC   or Tunnel Id   Switched   interface
46   No Label   2002:172:2::1/128[V]   \
                      1710   Et1/0   FE80::C00:FF:FE00:A01

Connectivity verification

R3#ping 2002:172:2::1 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::1, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/19/20 ms

R3#traceroute 2002:172:2::1

Type escape sequence to abort.
Tracing the route to 2002:172:2::1

 1 2002:172:2:38::8 [AS 2] 12 msec 8 msec 12 msec
 2 2002:172:2:17::7 [AS 2] [MPLS: Label 46 Exp 0] 20 msec 20 msec 20 msec
 3 2002:172:2:17::1 [AS 2] 20 msec 20 msec 20 msec

Connectivity verification (Cont.)

R3#ping 2002:172:2::12 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::12, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/41/56 ms

R3#traceroute 2002:172:2::12

Type escape sequence to abort.
Tracing the route to 2002:172:2::12

 1 2002:172:2:38::8 [AS 2] 12 msec 8 msec 8 msec
 2 2002:2:2:29::2 [MPLS: Labels 52/16046 Exp 0] 44 msec 40 msec 36 msec
 3 2002:2:2:29::9 [MPLS: Label 16046 Exp 0] 40 msec 40 msec 40 msec
 4 2002:172:2:126::6 [AS 1002] [MPLS: Label 16019 Exp 0] 40 msec 40 msec 40 msec
 5 2002:172:2:126::12 [AS 1002] 40 msec 40 msec 44 msec

Connectivity verification (Cont.)

R1#ping 2002:172:2::12 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::12, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/19/20 ms

R1#traceroute 2002:172:2::12

Type escape sequence to abort.
Tracing the route to 2002:172:2::12

 1 2002:172:2:17::7 4 msec 0 msec 0 msec
 2 2002:2:2:79::9 [MPLS: Label 16046 Exp 0] 24 msec 20 msec 20 msec
 3 2002:172:2:126::6 [MPLS: Label 16019 Exp 0] 20 msec 20 msec 20 msec
 4 2002:172:2:126::12 20 msec 20 msec 20 msec

Connectivity verification (Cont.)

R5#ping 2002:172:2::1 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::1, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/2/4 ms

R5#ping 2002:172:2::3 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::3, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/4/8 ms

R5#ping 2002:172:2::12 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::12, timeout is 2 seconds:
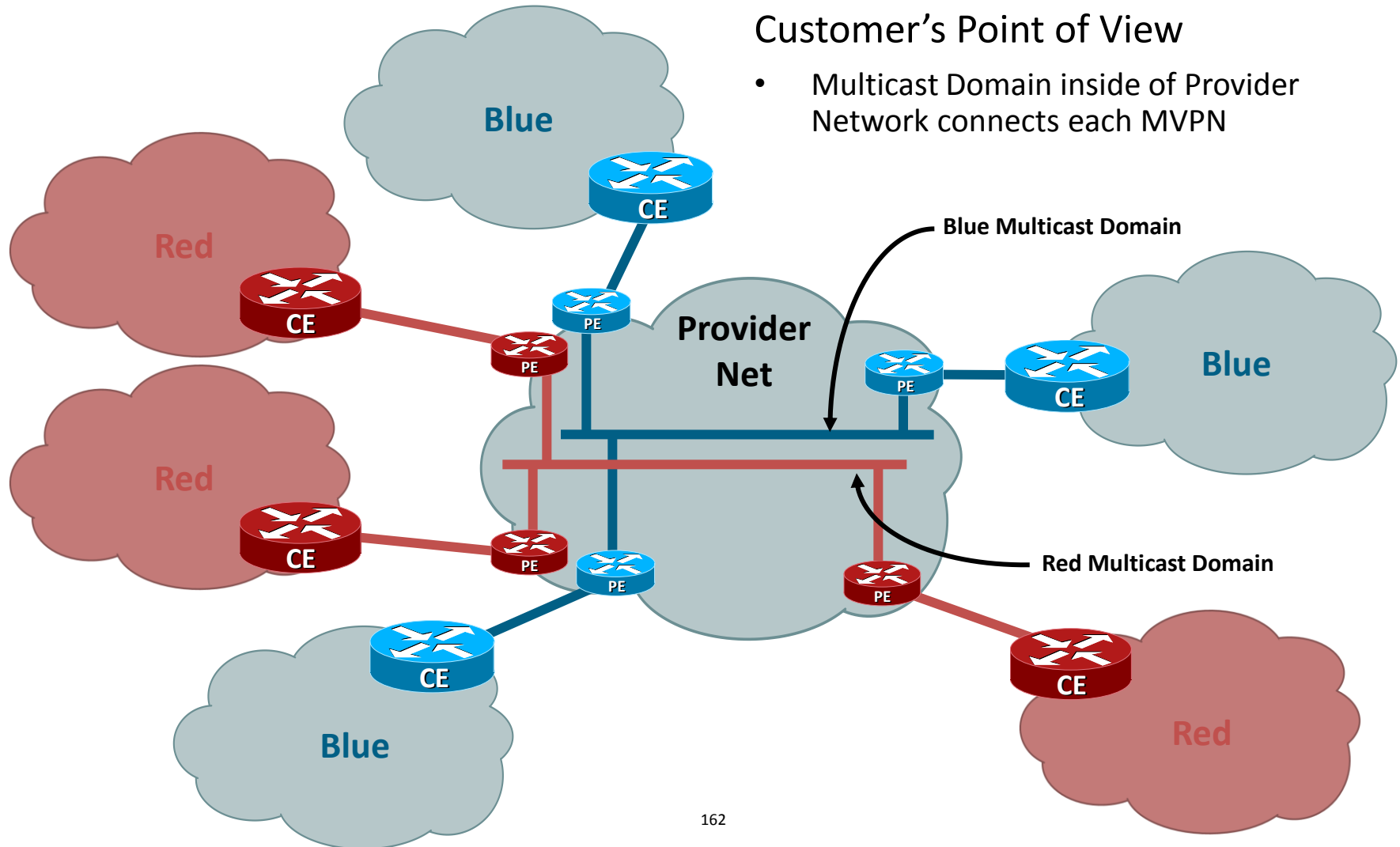Packet sent with a source address of 2002:172:2::5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/2/4 ms

Connectivity verification (Cont.)

R12#ping 2002:172:2::1 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::1, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::12
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/2/4 ms

R12#ping 2002:172:2::3 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::3, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::12
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/4/4 ms

R12#ping 2002:172:2::5 source loopback 0

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2002:172:2::5, timeout is 2 seconds:
Packet sent with a source address of 2002:172:2::12
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/2/4 ms
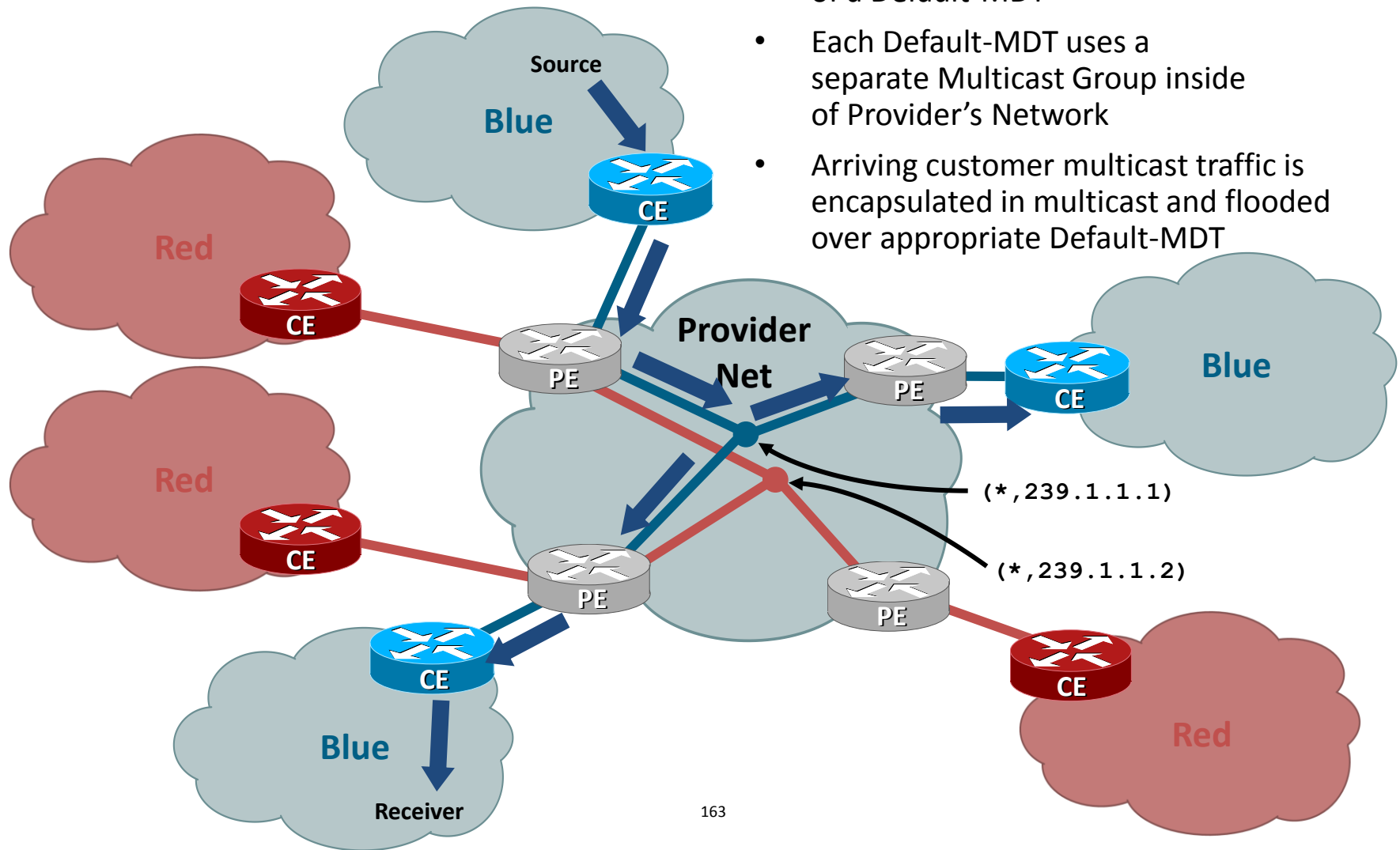
SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP intra-AS VPNv4
8	MP-BGP inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

Multicast VPN: Overview

Customer's Point of View

- Multicast Domain inside of Provider Network connects each MVPN

Blue Multicast Domain

Red Multicast Domain

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Multicast VPN: Overview (Cont.)

- Each Multicast Domain consists of a Default-MDT
- Each Default-MDT uses a separate Multicast Group inside of Provider's Network
- Arriving customer multicast traffic is encapsulated in multicast and flooded over appropriate Default-MDT

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

    https://learningnetwork.cisco.com/docs/DOC-9991

    1.0 – Implement, Optimize and Troubleshoot Core IP Technologies

    1.7 – Implement, Optimize and Troubleshoot Multicast

    3.0 – Implement, Optimize and Troubleshoot L3VPN Technologies

    3.6 – Implement, Optimize and Troubleshoot Multicast VPN

- For more details, please review the Lab Exam Checklist document below;

    https://learningnetwork.cisco.com/docs/DOC-10145

Multicast VPN – Sub Topology
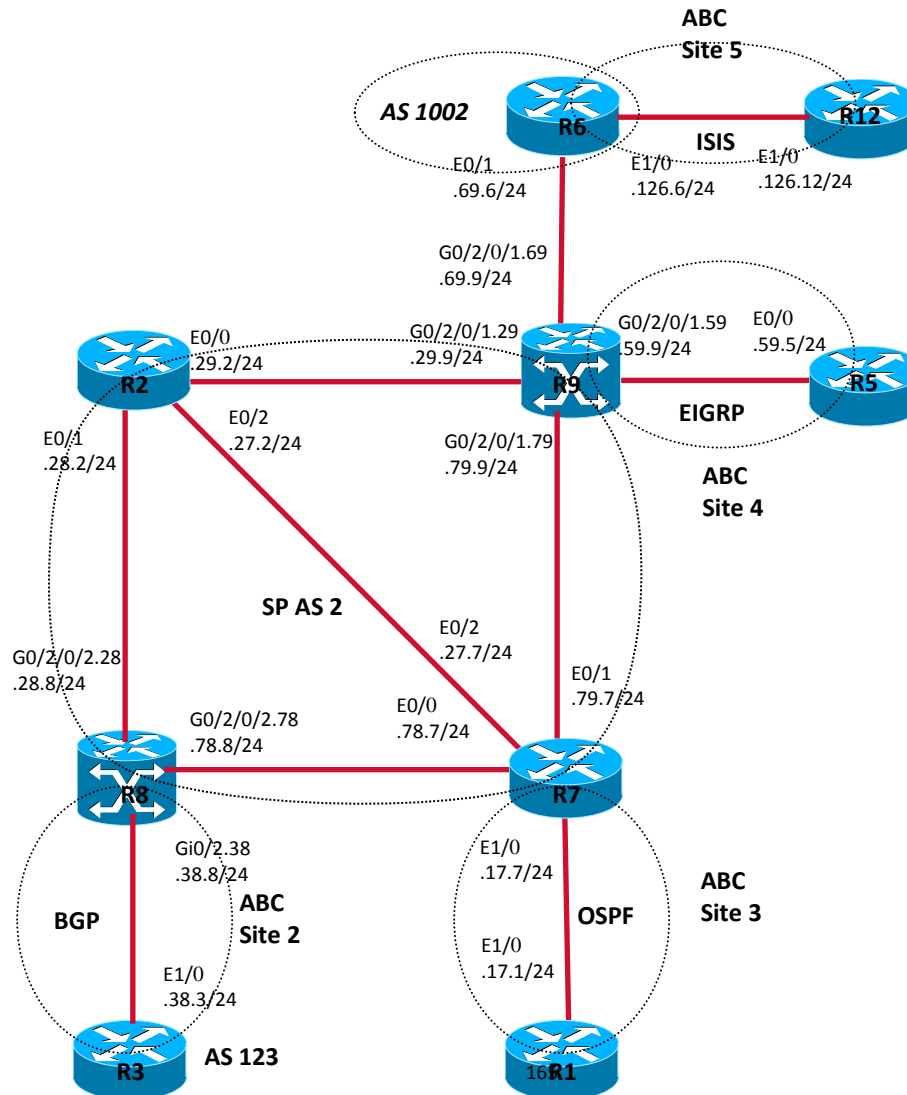
Multicast VPN - Question

- Configure default MDT address 239.255.13.27

- Configure R2 looback 0 as RP for AS 2 , use BSR method to distribute RP. Configure R6 loopback0 is RP for AS 1002

- Configure MSDP between R2 and R6, use loopback 0 IP address as source IP

- Configure R1 loopback0 as RP for ABC site 2, 3, 4 and 5. Use static method to define RP

- Configure R1, R3, R5 and R12 looback0 to join multicast group of 239.255.X.X (X is router number). Ensure R1, R3, R5 and R12 can ping these multicast group

- Configure MP-BGP IPv4 MDT between R2, R7, R8 and R9, R9 is route-reflector

- Configure MP-BGP IPv4 MDT between R6 and R9

- Ensure multicast VPN source and group information be distributed among R2, R7, R8, R9 and R6

Multicast VPN Configuration

R2 (IOS) configuration

vrf definition ABC
 rd 2:2
 !
 address-family ipv4
 route-target export 2:2
 route-target import 2:2
 route-target import 1002:2
 mdt default 239.255.13.27
!
ip multicast-routing
ip multicast-routing vrf ABC
!
interface Loopback0
 ip address 2.2.0.2 255.255.255.255
 ip pim sparse-mode
!
interface Ethernet0/0
 ip address 2.2.29.2 255.255.255.0
 ip pim sparse-mode
!

interface Ethernet0/1
 ip address 2.2.28.2 255.255.255.0
 ip pim sparse-mode
!
interface Ethernet0/2
 ip address 2.2.27.2 255.255.255.0
 ip pim sparse-mode
!
interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.142.2 255.255.255.0
 ip pim sparse-mode
!
router bgp 2
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 !
 address-family ipv4 mdt
  no bgp nexthop trigger enable
  neighbor 2.2.0.9 activate
  neighbor 2.2.0.9 send-community extended
 !
 ip pim bsr-candidate Loopback0 0 255
 ip pim rp-candidate Loopback0 priority 255
 ip pim vrf ABC rp-address 172.2.0.1
 ip msdp peer 2.2.0.6 connect-source Loopback0

Multicast VPN Configuration (Cont.)

R7 (IOS) configuration

```
vrf definition ABC
 rd 2:2
 !
 address-family ipv4
 route-target export 2:2
 route-target import 2:2
 route-target import 1002:2
 mdt default 239.255.13.27
!
ip multicast-routing
ip multicast-routing vrf ABC
!
interface Loopback0
 ip address 2.2.0.7 255.255.255.255
 ip pim sparse-mode
!
interface Ethernet0/0
 ip address 2.2.78.7 255.255.255.0
 ip pim sparse-mode
!
```

```
interface Ethernet0/1
 ip address 2.2.79.7 255.255.255.0
 ip pim sparse-mode
!
interface Ethernet0/2
 ip address 2.2.27.7 255.255.255.0
 ip pim sparse-mode
!
interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.17.7 255.255.255.0
 ip pim sparse-mode
!
router bgp 2
 neighbor 2.2.0.9 remote-as 2
 neighbor 2.2.0.9 update-source Loopback0
 !
 address-family ipv4 mdt
  no bgp nexthop trigger enable
  neighbor 2.2.0.9 activate
  neighbor 2.2.0.9 send-community extended
 exit-address-family
 !
ip pim vrf ABC rp-address 172.2.0.1
 !
```

Multicast VPN Configuration (Cont.)

R8 (IOS-XR) configuration

router bgp 2
 address-family ipv4 mdt
 !
 neighbor 2.2.0.9
 remote-as 2
 update-source Loopback0
 address-family ipv4 mdt
 !
 !
multicast-routing
 vrf ABC address-family ipv4
 interface GigabitEthernet0/2/0/2.38
 enable
 !
 mdt default ipv4 239.255.13.27
 rate-per-route
 !
 address-family ipv4
 interface Loopback0
 enable
 !

interface GigabitEthernet0/2/0/2.28
 enable
 !
 interface GigabitEthernet0/2/0/2.78
 enable
 !
 mdt source Loopback0
 rate-per-route
 !
router pim vrf ABC address-family ipv4
 rp-address 172.2.0.1
 interface GigabitEthernet0/2/0/2.38
 enable
!
router pim vrf default address-family ipv4
 interface Loopback0
 enable
 !
 interface GigabitEthernet0/2/0/2.28
 enable
 !
 interface GigabitEthernet0/2/0/2.78
 enable
 !

Multicast VPN Configuration (Cont.)

R9 (IOS-XR) configuration

```
router bgp 2
 address-family ipv4 mdt
 !
 neighbor 2.2.0.2
  remote-as 2
  update-source Loopback0
  address-family ipv4 mdt
   route-reflector-client
   next-hop-self
  !
 !
 neighbor 2.2.0.7
  remote-as 2
  update-source Loopback0
  address-family ipv4 mdt
   route-reflector-client
   next-hop-self
  !
 !
 neighbor 2.2.0.8
  remote-as 2
  update-source Loopback0
  address-family ipv4 mdt
   route-reflector-client
   next-hop-self
  !
 !
```

```
 neighbor 2.2.69.6
  remote-as 1002
  address-family ipv4 mdt
   route-policy default_policy_pass_all in
   route-policy default_policy_pass_all out
  !
multicast-routing
 vrf ABC address-family ipv4
  interface GigabitEthernet0/2/0/1.59
   enable
  !
  mdt default ipv4 239.255.13.27
 !
 address-family ipv4
  interface Loopback0
   enable
  !
  interface GigabitEthernet0/2/0/1.29
   enable
  !
  interface GigabitEthernet0/2/0/1.69
   enable
  !
  interface GigabitEthernet0/2/0/1.79
   enable
  !
  mdt source Loopback0
```

```
router pim vrf ABC address-family ipv4
 rp-address 172.2.0.1
 interface GigabitEthernet0/2/0/1.59
  enable
 !
!
router pim vrf default address-family ipv4
 interface Loopback0
  enable
 !
 interface GigabitEthernet0/2/0/1.29
  enable
 !
 interface GigabitEthernet0/2/0/1.69
  bsr-border
  enable
 !
 interface GigabitEthernet0/2/0/1.79
  enable
 !
!
```

Multicast VPN Configuration (Cont.)

R6 (IOS) configuration

vrf definition ABC
 rd 1002:2
 !
 address-family ipv4
 route-target export 1002:2
 route-target import 1002:2
 route-target import 2:2
 mdt default 239.255.13.27
!
ip multicast-routing
ip multicast-routing vrf ABC
!
interface Ethernet0/0
 ip address 2.2.46.6 255.255.255.0
 ip pim sparse-mode
!
interface Ethernet0/1
 ip address 2.2.69.6 255.255.255.0
 ip pim bsr-border
 ip pim sparse-mode
!

interface Ethernet1/0
 vrf forwarding ABC
 ip address 172.2.126.6 255.255.255.0
 ip pim sparse-mode
 !
router bgp 1002
 neighbor 2.2.69.9 remote-as 2
 !
 address-family ipv4 mdt
  neighbor 2.2.69.9 activate
  neighbor 2.2.69.9 send-community extended
 exit-address-family
 !
ip pim bsr-candidate Loopback0 0
ip pim rp-candidate Loopback0
ip pim vrf ABC rp-address 172.2.0.1
ip msdp peer 2.2.0.2 connect-source Loopback0

Multicast VPN Configuration (Cont.)

R3 configuration

ip multicast-routing
!
interface Loopback0
 ip address 172.2.0.3 255.255.255.255
 ip pim sparse-mode
 ip igmp join-group 239.255.3.3
!
interface Ethernet1/0
 ip address 172.2.38.3 255.255.255.0
 ip pim sparse-mode
!
ip pim rp-address 172.2.0.1

R1 configuration

ip multicast-routing
!
interface Loopback0
 ip address 172.2.0.1 255.255.255.255
 ip pim sparse-mode
 ip igmp join-group 239.255.1.1
!
interface Ethernet1/0
 ip address 172.2.17.1 255.255.255.0
 ip pim sparse-mode
!
ip pim rp-address 172.2.0.1

Multicast VPN Configuration (Cont.)

R5 configuration

ip multicast-routing
!
interface Loopback0
 ip address 172.2.0.5 255.255.255.255
 ip pim sparse-mode
 ip igmp join-group 239.255.5.5
!
interface Ethernet1/0
 ip address 172.2.59.5 255.255.255.0
 ip pim sparse-mode
!
ip pim rp-address 172.2.0.1

R12 configuration

ip multicast-routing
!
interface Loopback0
 ip address 172.2.0.12 255.255.255.255
 ip pim sparse-mode
 ip igmp join-group 239.255.5.5
!
interface Ethernet1/0
 ip address 172.2.126.12 255.255.255.0
 ip pim sparse-mode
!
ip pim rp-address 172.2.0.1

RP group map

R2 RP group map

R2#show ip pim rp mapping
PIM Group-to-RP Mappings
This system is a candidate RP (v2)
This system is the Bootstrap Router (v2)
Group(s) 224.0.0.0/4
 RP 2.2.0.2 (?), v2
  Info source: 2.2.0.2 (?), via bootstrap, priority 255, holdtime 150
    Uptime: 6d02h, expires: 00:01:35

R7 RP group map

R7#show ip pim rp mapping
PIM Group-to-RP Mappings
Group(s) 224.0.0.0/4
 RP 2.2.0.2 (?), v2
  Info source: 2.2.0.2 (?), via bootstrap, priority 255, holdtime 150
    Uptime: 6d01h, expires: 00:01:59

RP group map (Cont.)

R8 RP group map

RP/0/0/CPU0:R8#show pim group-map
Group Range   Proto Client   Groups RP address   Info
224.0.1.39/32*   DM   perm   0   0.0.0.0
224.0.1.40/32*   DM   perm   1   0.0.0.0
224.0.0.0/24*   NO   perm   0   0.0.0.0
232.0.0.0/8*   SSM   config 0   0.0.0.0
224.0.0.0/4*   SM   bsr+   2   2.2.0.2   RPF: Gi0/2/0/2.28,2.2.28.2
224.0.0.0/4   SM   static 0   0.0.0.0   RPF: Null,0.0.0.0

R9 RP group map

RP/0/0/CPU0:R9#show pim group-map
Group Range   Proto Client   Groups RP address   Info
224.0.1.39/32*   DM   perm   0   0.0.0.0
224.0.1.40/32*   DM   perm   1   0.0.0.0
224.0.0.0/24*   NO   perm   0   0.0.0.0
232.0.0.0/8*   SSM   config 0   0.0.0.0
224.0.0.0/4*   SM   bsr+   2   2.2.0.2   RPF: Gi0/2/0/1.29,2.2.29.2
224.0.0.0/4   SM   static 0   0.0.0.0   RPF: Null,0.0.0.0

MSDP connection

R2#show ip msdp summary
MSDP Peer Status Summary
Peer Address   AS   State   Uptime/ Reset SA   Peer Name
                        Downtime Count Count
2.2.0.6   1002   Up   5d01h 3   1   ?

R6#show ip msdp summary
MSDP Peer Status Summary
Peer Address   AS   State   Uptime/ Reset SA   Peer Name
                        Downtime Count Count
2.2.0.2   2   Up   5d01h 1   4   ?

MSDP Active Source

R2#show ip msdp sa-cache
MSDP Source-Active Cache - 1 entries
(2.2.0.6, 239.255.13.27), RP 2.2.0.6, BGP/AS 1002, 1d02h/00:05:53, Peer 2.2.0.6

R6#show ip msdp sa-cache
MSDP Source-Active Cache - 4 entries
(2.2.0.2, 239.255.13.27), RP 2.2.0.2, BGP/AS 2, 1d02h/00:05:50, Peer 2.2.0.2
(2.2.0.7, 239.255.13.27), RP 2.2.0.2, BGP/AS 2, 1d02h/00:05:50, Peer 2.2.0.2
(2.2.0.8, 239.255.13.27), RP 2.2.0.2, BGP/AS 2, 1d02h/00:05:50, Peer 2.2.0.2
(2.2.0.9, 239.255.13.27), RP 2.2.0.2, BGP/AS 2, 1d02h/00:05:50, Peer 2.2.0.2

VRF Site RP group map

R8 VRF ABC RP group map

RP/0/0/CPU0:R8#show pim vrf ABC group-map
Group Range   Proto Client   Groups RP address   Info

224.0.1.39/32*   DM   perm   0   0.0.0.0
224.0.1.40/32*   DM   perm   1   0.0.0.0
224.0.0.0/24*   NO   perm   0   0.0.0.0
232.0.0.0/8*   SSM   config 0   0.0.0.0
224.0.0.0/4*   SM   config 2   172.2.0.1   RPF: md,2.2.0.7
224.0.0.0/4   SM   static 0   0.0.0.0   RPF: Null,0.0.0.0

R7 VRF RP ABC RP group map

R2#show ip pim vrf ABC rp mapping
PIM Group-to-RP Mappings

Group(s): 224.0.0.0/4, Static
    RP: 172.2.0.1 (?)

VRF Site RP group map (Cont.)

R9 VRF ABC RP group map

RP/0/0/CPU0:R9#show pim vrf ABC group-map
Group Range   Proto Client   Groups RP address   Info

224.0.1.39/32*   DM   perm   0   0.0.0.0
224.0.1.40/32*   DM   perm   1   0.0.0.0
224.0.0.0/24*   NO   perm   0   0.0.0.0
232.0.0.0/8*   SSM   config 0   0.0.0.0
224.0.0.0/4*   SM   config 2   172.2.0.1   RPF: md,2.2.0.7
224.0.0.0/4   SM   static 0   0.0.0.0   RPF: Null,0.0.0.0

R6 VRF ABC RP group map

R6#show ip pim vrf ABC rp mapping
PIM Group-to-RP Mappings

Group(s): 224.0.0.0/4, Static
   RP: 172.2.0.1 (?)

Multicast VPN Tunnel Adjacency

R8 Tunnel neighbor

RP/0/0/CPU0:R8#show pim vrf ABC neighbor

Neighbor Address	Interface	Uptime	Expires	DR pri	Flags
2.2.0.2	mdtABC	6d02h	00:01:28	1	P
2.2.0.6	mdtABC	4d05h	00:01:16	1	P
2.2.0.7	mdtABC	6d01h	00:01:44	1	P
2.2.0.8*	mdtABC	10w2d	00:01:34	1	B
2.2.0.9	mdtABC	6d02h	00:01:17	1 (DR)	B
172.2.38.3	GigabitEthernet0/2/0/2.38	6d02h	00:01:17	1	P
172.2.38.8*	GigabitEthernet0/2/0/2.38	8w6d	00:01:36	1 (DR)	B P

R7 Tunnel neighbor

R7#show ip pim vrf ABC neighbor

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
172.2.17.1	Ethernet1/0	6d01h/00:01:17	v2	1 / S P
2.2.0.6	Tunnel1	4d05h/00:01:42	v2	1 / S P
2.2.0.9	Tunnel1	6d01h/00:01:44	v2	1 / DR
2.2.0.8	Tunnel1	6d01h/00:01:31	v2	1 /
2.2.0.2	Tunnel1	6d01h/00:01:24	v2	1 / S P

Multicast VPN Tunnel Adjacency (Cont.)

R9 Tunnel neighbor

RP/0/0/CPU0:R9#show pim vrf ABC neighbor

Neighbor Address	Interface	Uptime	Expires	DR pri	Flags
2.2.0.2	mdtABC	6d23h	00:01:29	1	P
2.2.0.6	mdtABC	5d02h	00:01:25	1	P
2.2.0.7	mdtABC	6d22h	00:01:27	1	P
2.2.0.8	mdtABC	6d23h	00:01:36	1	B
2.2.0.9*	mdtABC	10w3d	00:01:39	1 (DR)	B A
172.2.59.5	GigabitEthernet0/2/0/1.59	6d23h	00:01:41	1	P
172.2.59.9*	GigabitEthernet0/2/0/1.59	10w3d	00:01:21	1 (DR)	B P A

R6 Tunnel neighbor

R6#show ip pim vrf ABC neighbor

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
172.2.126.12	Ethernet1/0	2d05h/00:01:18	v2	1 / S P
2.2.0.9	Tunnel0	5d02h/00:01:21	v2	1 / DR
2.2.0.8	Tunnel0	5d02h/00:01:18	v2	1 /
2.2.0.2	Tunnel0	5d02h/00:01:41	v2	1 / S P
2.2.0.7	Tunnel0	5d02h/00:01:39	v2	1 / S P

Multicast VPN Multicast routes

R7 MVPN mroute

R7#show ip mroute 239.255.13.27

(*, 239.255.13.27), 01:11:12/stopped, RP 2.2.0.2, flags: SJCFZ
 Incoming interface: Ethernet0/2, RPF nbr 2.2.27.2
 Outgoing interface list:
   MVRF ABC, Forward/Sparse, 01:11:12/00:00:46

(2.2.0.2, 239.255.13.27), 01:10:44/00:02:39, flags: JTZ
 Incoming interface: Ethernet0/2, RPF nbr 2.2.27.2
 Outgoing interface list:
   MVRF ABC, Forward/Sparse, 01:10:44/00:01:15

(2.2.0.8, 239.255.13.27), 01:11:08/00:03:19, flags: TZ
 Incoming interface: Ethernet0/0, RPF nbr 2.2.78.8
 Outgoing interface list:
   Ethernet0/1, Forward/Sparse, 01:10:25/00:03:05
   MVRF ABC, Forward/Sparse, 01:11:08/00:00:51

(2.2.0.6, 239.255.13.27), 01:11:09/00:03:19, flags: TZ
 Incoming interface: Ethernet0/1, RPF nbr 2.2.79.9
 Outgoing interface list:
   Ethernet0/0, Forward/Sparse, 01:10:54/00:02:34
   MVRF ABC, Forward/Sparse, 01:11:12/00:00:47

(2.2.0.7, 239.255.13.27), 01:11:13/00:03:26, flags: FT
 Incoming interface: Loopback0, RPF nbr 0.0.0.0
 Outgoing interface list:
   Ethernet0/1, Forward/Sparse, 01:10:38/00:02:52
   Ethernet0/0, Forward/Sparse, 01:10:54/00:02:34
   Ethernet0/2, Forward/Sparse, 01:11:13/00:03:13

(2.2.0.9, 239.255.13.27), 01:11:14/00:03:26, flags: TZ
 Incoming interface: Ethernet0/1, RPF nbr 2.2.79.9
 Outgoing interface list:
   Ethernet0/0, Forward/Sparse, 01:10:54/00:02:34
   MVRF ABC, Forward/Sparse, 01:11:14/00:00:45

Multicast VPN Multicast routes(Cont.)

R8 MVPN mroute

RP/0/0/CPU0:R8#show mrib ipv4 route 239.255.13.27

(*,239.255.13.27) RPF nbr: 2.2.28.2 Flags: C MD MH CD
  Incoming Interface List
    GigabitEthernet0/2/0/2.28 Flags: A NS, Up: 6d22h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 10w3d

(2.2.0.2,239.255.13.27) RPF nbr: 2.2.28.2 Flags: MD MH CD
  MVPN TID: 0xe0000001
  Incoming Interface List
    GigabitEthernet0/2/0/2.28 Flags: A, Up: 6d22h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.6,239.255.13.27) RPF nbr: 2.2.78.7 Flags: MD MH CD
  Incoming Interface List
    GigabitEthernet0/2/0/2.78 Flags: A, Up: 2d17h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.7,239.255.13.27) RPF nbr: 2.2.78.7 Flags: MD MH CD
  Incoming Interface List
    GigabitEthernet0/2/0/2.78 Flags: A, Up: 2d17h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 4w5d

(2.2.0.8,239.255.13.27) RPF nbr: 2.2.0.8 Flags: ME MH
  Incoming Interface List
    Loopback0 Flags: F A, Up: 10w3d
  Outgoing Interface List
    GigabitEthernet0/2/0/2.28 Flags: F NS, Up: 5d03h
    GigabitEthernet0/2/0/2.78 Flags: F NS, Up: 5d03h
    Loopback0 Flags: F A, Up: 10w3d

(2.2.0.9,239.255.13.27) RPF nbr: 2.2.78.7 Flags: MD MH CD
  Incoming Interface List
    GigabitEthernet0/2/0/2.78 Flags: A, Up: 2d17h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 4w5d

Multicast VPN Multicast routes(Cont.)

R9 MVPN mroute

RP/0/0/CPU0:R9#show mrib ipv4 route 239.255.13.27

(*,239.255.13.27) RPF nbr: 2.2.29.2 Flags: C MD MH CD
  Incoming Interface List
    GigabitEthernet0/2/0/1.29 Flags: A NS, Up: 3d20h
  Outgoing Interface List
    Loopback0 Flags: F NS, Up: 10w3d

(2.2.0.2,239.255.13.27) RPF nbr: 2.2.29.2 Flags: MD MH
  Incoming Interface List
    GigabitEthernet0/2/0/1.29 Flags: A, Up: 3d20h
  Outgoing Interface List
    GigabitEthernet0/2/0/1.69 Flags: F NS, Up: 5d03h
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.6,239.255.13.27) RPF nbr: 2.2.69.6 Flags: MD MH
  Incoming Interface List
    GigabitEthernet0/2/0/1.69 Flags: A, Up: 5d03h
  Outgoing Interface List
    GigabitEthernet0/2/0/1.29 Flags: F NS, Up: 3d20h
    GigabitEthernet0/2/0/1.79 Flags: F NS, Up: 4d22h
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.7,239.255.13.27) RPF nbr: 2.2.79.7 Flags: MD MH
  Incoming Interface List
    GigabitEthernet0/2/0/1.79 Flags: A, Up: 6d22h
  Outgoing Interface List
    GigabitEthernet0/2/0/1.69 Flags: F NS, Up: 5d03h
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.8,239.255.13.27) RPF nbr: 2.2.79.7 Flags: MD MH
  Incoming Interface List
    GigabitEthernet0/2/0/1.79 Flags: A, Up: 2d18h
  Outgoing Interface List
    GigabitEthernet0/2/0/1.69 Flags: F NS, Up: 5d03h
    Loopback0 Flags: F NS, Up: 6d23h

(2.2.0.9,239.255.13.27) RPF nbr: 2.2.0.9 Flags: ME MH
  Incoming Interface List
    Loopback0 Flags: F A, Up: 10w3d
  Outgoing Interface List
    GigabitEthernet0/2/0/1.29 Flags: F NS, Up: 3d20h
    GigabitEthernet0/2/0/1.69 Flags: F NS, Up: 5d03h
    GigabitEthernet0/2/0/1.79 Flags: F NS, Up: 5d04h
    Loopback0 Flags: F A, Up: 10w3d

Multicast VPN Multicast routes(Cont.)

R6 MVPN mroute

R6#show ip mroute 239.255.13.27

(*, 239.255.13.27), 01:37:35/stopped, RP 2.2.0.6, flags: SJCZ
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    MVRF ABC, Forward/Sparse, 01:37:35/00:01:24

(2.2.0.2, 239.255.13.27), 01:37:28/00:02:31, flags: JTZ
  Incoming interface: Ethernet0/1, RPF nbr 2.2.69.9
  Outgoing interface list:
    MVRF ABC, Forward/Sparse, 01:37:28/00:01:31

(2.2.0.6, 239.255.13.27), 01:37:32/00:03:21, flags: T
  Incoming interface: Loopback0, RPF nbr 0.0.0.0
  Outgoing interface list:
    Ethernet0/1, Forward/Sparse, 01:37:29/00:03:02

(2.2.0.7, 239.255.13.27), 01:37:35/00:02:51, flags: JTZ
  Incoming interface: Ethernet0/1, RPF nbr 2.2.69.9
  Outgoing interface list:
    MVRF ABC, Forward/Sparse, 01:37:35/00:01:24

(2.2.0.8, 239.255.13.27), 01:37:36/00:02:59, flags: JTZ
  Incoming interface: Ethernet0/1, RPF nbr 2.2.69.9
  Outgoing interface list:
    MVRF ABC, Forward/Sparse, 01:37:36/00:01:22

(2.2.0.9, 239.255.13.27), 01:37:36/00:02:59, flags: JTZ
  Incoming interface: Ethernet0/1, RPF nbr 2.2.69.9
  Outgoing interface list:
    MVRF ABC, Forward/Sparse, 01:37:36/00:01:22

Multicast ping Verification

R3

R3#ping 239.255.5.5 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.5.5, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.3
Reply to request 0 from 172.2.59.5, 56 ms
Reply to request 1 from 172.2.59.5, 60 ms

R3#ping 239.255.1.1 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.1.1, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.3
Reply to request 0 from 172.2.17.1, 20 ms
Reply to request 1 from 172.2.17.1, 32 ms

R3#ping 239.255.12.12 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.12.12, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.3
Reply to request 0 from 172.2.126.12, 52 ms
Reply to request 1 from 172.2.126.12, 48 ms

Multicast ping Verification (Cont.)

R5

R1#ping 239.255.5.5 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.5.5, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.1
Reply to request 0 from 172.2.59.5, 24 ms
Reply to request 0 from 172.2.59.5, 24 ms
Reply to request 1 from 172.2.59.5, 20 ms
Reply to request 1 from 172.2.59.5, 28 ms

R1#ping 239.255.12.12 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.12.12, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.1
Reply to request 0 from 172.2.126.12, 24 ms
Reply to request 0 from 172.2.126.12, 24 ms
Reply to request 1 from 172.2.126.12, 20 ms
Reply to request 1 from 172.2.126.12, 32 ms

Multicast ping Verification (Cont.)

R12

R12#ping 239.255.1.1 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.1.1, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.12
Reply to request 0 from 172.2.17.1, 20 ms
Reply to request 0 from 172.2.17.1, 28 ms
Reply to request 1 from 172.2.17.1, 20 ms
Reply to request 1 from 172.2.17.1, 28 ms

R12#ping 239.255.3.3 source loopback 0 repeat 2
Type escape sequence to abort.
Sending 2, 100-byte ICMP Echos to 239.255.3.3, timeout is 2 seconds:
Packet sent with a source address of 172.2.0.12
Reply to request 0 from 172.2.38.3, 48 ms
Reply to request 0 from 172.2.38.3, 48 ms
Reply to request 1 from 172.2.38.3, 44 ms
Reply to request 1 from 172.2.38.3, 52 ms

Multicast VPN MDT table

R2 MVPN mdt table

R2#show ip bgp ipv4 mdt all
BGP table version is 31, local router ID is 2.2.0.2

Network	Next Hop	Metric	LocPrf	Weight	Path

Route Distinguisher: 2:2 (default for vrf ABC)

*> 2.2.0.2/32	0.0.0.0			0	?
*>i2.2.0.7/32	2.2.0.7	0	100	0	?
*>i2.2.0.8/32	2.2.0.8		100	0	i
*>i2.2.0.9/32	2.2.0.9		100	0	i

Route Distinguisher: 1002:2

*>i2.2.0.6/32	2.2.0.9	0	100	0	1002 ?

R8 MVPN mdt table

RP/0/0/CPU0:R8#show bgp ipv4 mdt
BGP router identifier 2.2.0.8, local AS number 2

Network	Next Hop	Metric	LocPrf	Weight	Path

Route Distinguisher: 2:2

*>i2.2.0.2/96	2.2.0.2	0	100	0	?
*>i2.2.0.7/96	2.2.0.7	0	100	0	?
*> 2.2.0.8/96	0.0.0.0			0	i
*>i2.2.0.9/96	2.2.0.9		100	0	i

Route Distinguisher: 1002:2

*>i2.2.0.6/96	2.2.0.9	0	100	0	1002 ?

Multicast VPN MDT table (Cont.)

R7 MVPN mdt table

R7#show ip bgp ipv4 mdt all
BGP table version is 21, local router ID is 2.2.0.77
   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 2:2 (default for vrf ABC)
*>i2.2.0.2/32   2.2.0.2   0   100   0 ?
*> 2.2.0.7/32   0.0.0.0   0 ?
*>i2.2.0.8/32   2.2.0.8   100   0 i
*>i2.2.0.9/32   2.2.0.9   100   0 i
Route Distinguisher: 1002:2
*>i2.2.0.6/32   2.2.0.9   0   100   0 100

R9 MVPN mdt table

RP/0/0/CPU0:R9#show bgp ipv4 mdt
BGP router identifier 2.2.0.9, local AS number 2
   Network   Next Hop   Metric LocPrf Weight Path
Route Distinguisher: 2:2
*>i2.2.0.2/96   2.2.0.2   0   100   0 ?
*>i2.2.0.7/96   2.2.0.7   0   100   0 ?
*>i2.2.0.8/96   2.2.0.8   100   0 i
*> 2.2.0.9/96   0.0.0.0   0 i
Route Distinguisher: 1002:2
*> 2.2.0.6/96   2.2.69.6   0   0 1002 ?

Multicast VPN MDT table (Cont.)

R6 MVPN mdt table

R6#show ip bgp ipv4 mdt all
BGP table version is 7, local router ID is 2.2.0.6

```
   Network        Next Hop        Metric LocPrf Weight Path
Route Distinguisher: 2:2
*> 2.2.0.2/32     2.2.69.9                      0 2 ?
*> 2.2.0.7/32     2.2.69.9                      0 2 ?
*> 2.2.0.8/32     2.2.69.9                      0 2 i
*> 2.2.0.9/32     2.2.69.9                      0 2 i
Route Distinguisher: 1002:2 (default for vrf ABC)
*> 2.2.0.6/32     0.0.0.0                       0 ?
```
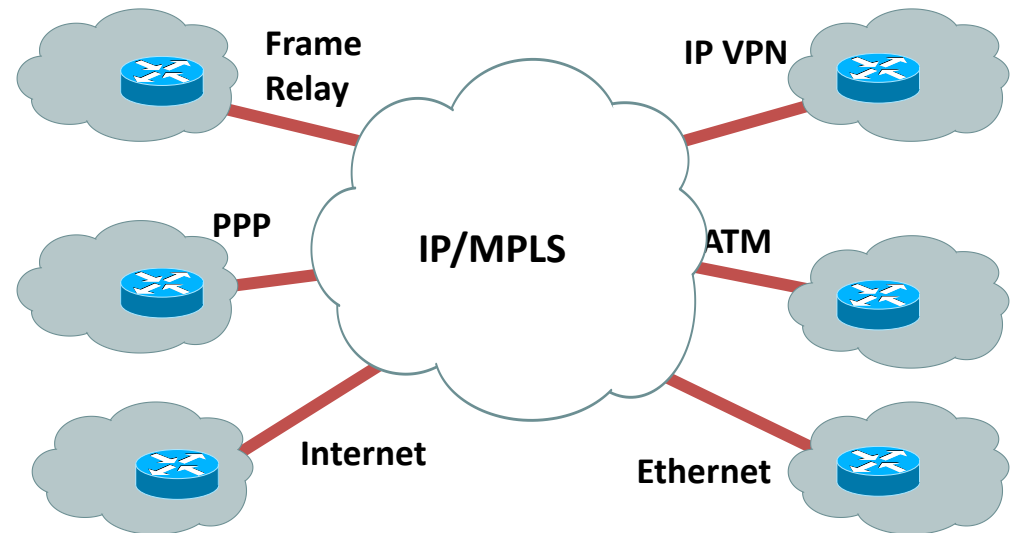
SP Sample Lab Questions

	Question, Configuration and Verification
1	IS-IS IPv4/IPv6
2	OSPF IPv4/IPv6
3	BGP unicast IPv4/IPv6
4	MPLS LDP
5	MPLS TE
6	MPLS TE FRR
7	MP-BGP intra-AS VPNv4
8	MP-BGP inter-AS VPNv4
9	CSC
10	MP-BGP VPNv6 - 6VPE
11	Multicast VPN
12	AToM
13	VPLS
14	L2TPv3

Any Transport over MPLS (AToM)

- AToM
  - Ethernet over MPLS
  - Frame Relay over MPLS
  - ATM AAL5 over MPLS
  - ATM Cell Relay over MPLS
  - PPP over MPLS
  - HDLC over MPLS
  - TDM over MPLS

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

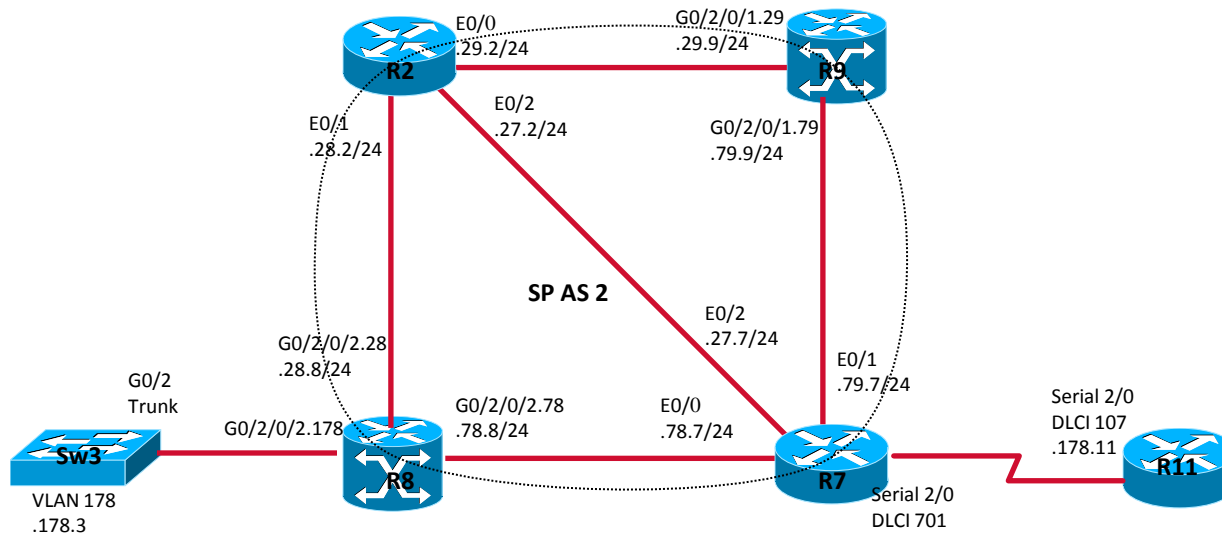   https://learningnetwork.cisco.com/docs/DOC-9991

    4.0 – Implement, Optimize and Troubleshoot L2VPN Technologies

    4.1 – Implement, Optimize and Troubleshoot AToM

- For more details, please review the Lab Exam Checklist document below;

    https://learningnetwork.cisco.com/docs/DOC-10145

AToM – Sub Topology and Question

- Configure R7 and R8 to support VLAN and Frame-Relay interworking of AToM

- Ensure R11 and VLAN 178 can ping each other

AToM Configuration

R8 (IOS-XR) configuration

interface GigabitEthernet0/2/0/2.178 l2transport
 dot1q vlan 178
!
l2vpn
 pw-class atom
  encapsulation mpls
  !
 !
 xconnect group R8-R7
  p2p abc
   interface GigabitEthernet0/2/0/2.178
   neighbor 2.2.0.7 pw-id 101
    pw-class atom
   !
   interworking ipv4
  !
 !

R7 (IOS) configuration

pseudowire-class atom
 encapsulation mpls
 interworking ip
!
interface Serial2/0
 no ip address
 encapsulation frame-relay
 no frame-relay inverse-arp
 frame-relay lmi-type ansi
!
connect abc Serial2/0 701 l2transport
 xconnect 2.2.0.8 101 pw-class atom
 !
!

AToM Configuration (Cont.)

Sw3 configuration

interface GigabitEthernet0/2
 switchport trunk encapsulation dot1q
 switchport mode trunk
!
interface Vlan178
 ip address 172.2.178.3 255.255.255.0
!

R11 configuration

interface Serial2/0
 ip address 172.2.178.11 255.255.255.0
 encapsulation frame-relay
 no fair-queue
 serial restart-delay 0
 frame-relay map ip 172.2.178.3 107 broadcast
 no frame-relay inverse-arp

AToM VC

R8

RP/0/0/CPU0:R8#show l2vpn xconnect detail
Group R8-R7, XC abc, state is up; Interworking IPv4
 AC: GigabitEthernet0/2/0/2.178, state is up
   Type VLAN; Num Ranges: 1
   VLAN ranges: [178, 178]
   MTU 1500; XC ID 0x3000004; interworking IPv4; MSTi 0
PW: neighbor 2.2.0.7, PW ID 101, state is up (established)
   PW class atom, XC ID 0x3000004
   Encapsulation MPLS, protocol LDP
   PW type IP, control word enabled, interworking IPv4
   PW backup disable delay 0 sec
   Sequencing not set
    MPLS   Local   Remote
    ------------ ----------------------------- ----------------------------
    Label   16011   28
    Group ID   0x3000700   0x0
    Interface   GigabitEthernet0/2/0/2.178   unknown
    MTU   1500   1500
    Control word enabled   enabled
    PW type   IP   IP
    VCCV CV type 0x2   0x2
          (LSP ping verification)   (LSP ping verification)
    VCCV CC type 0x3   0x3
           (control word)   (control word)
           (router alert label)   (router alert label)
    ------------ ----------------------------- ---------------------------- 198

AToM VC (Cont.)

R7

R7#show mpls l2transport vc detail
Local interface: Se2/0 up, line protocol up, FR DLCI 701 up
  MPLS VC type is FR DLCI, interworking type is IP
  Destination address: 2.2.0.8, VC ID: 101, VC status: up
    Output interface: Et0/0, imposed label stack {16011}
    Preferred path: not configured
    Default path: active
    Next hop: 2.2.78.8
  Create time: 1w0d, last status change time: 5d05h
  Signaling protocol: LDP, peer 2.2.0.8:0 up
    Targeted Hello: 2.2.0.7(LDP Id) -> 2.2.0.8
    Status TLV support (local/remote)   : enabled/not supported
      Label/status state machine   : established, LruRru
      Last local dataplane   status rcvd: no fault
      Last local SSS circuit status rcvd: no fault
      Last local SSS circuit status sent: no fault
      Last local LDP TLV   status sent: no fault
      Last remote LDP TLV   status rcvd: not sent
    MPLS VC labels: local 28, remote 16011
    Group ID: local 0, remote 50333440
    MTU: local 1500, remote 1500
    Remote interface description: GigabitEthernet0_2_0_2.178
  Sequencing: receive disabled, send disabled

AToM MPLS forwarding table

RP/0/0/CPU0:R8#show mpls forwarding

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16011	Pop	PW(2.2.0.7:101)	Gi0/2/0/2.178	point2point	6000

R7#show mpls forwarding-table

Local Label	Outgoing Label or VC	Prefix or Tunnel Id	Bytes Label Switched	Outgoing interface	Next Hop
28	No Label	l2ckt(101)	1500	Se2/0	point2point

Pseudowire Ping Verification

R7#ping mpls pseudowire 2.2.0.8 101
Sending 5, 100-byte MPLS Echos to 2.2.0.8,
   timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
 'L' - labeled output interface, 'B' - unlabeled output interface,
 'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
 'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label entry,
 'P' - no rx intf label prot, 'p' - premature termination of LSP,
 'R' - transit router, 'I' - unknown upstream index,
 'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 280/291/300 ms

Connection verification

R11#ping 172.2.178.3

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.178.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 48/50/52 ms
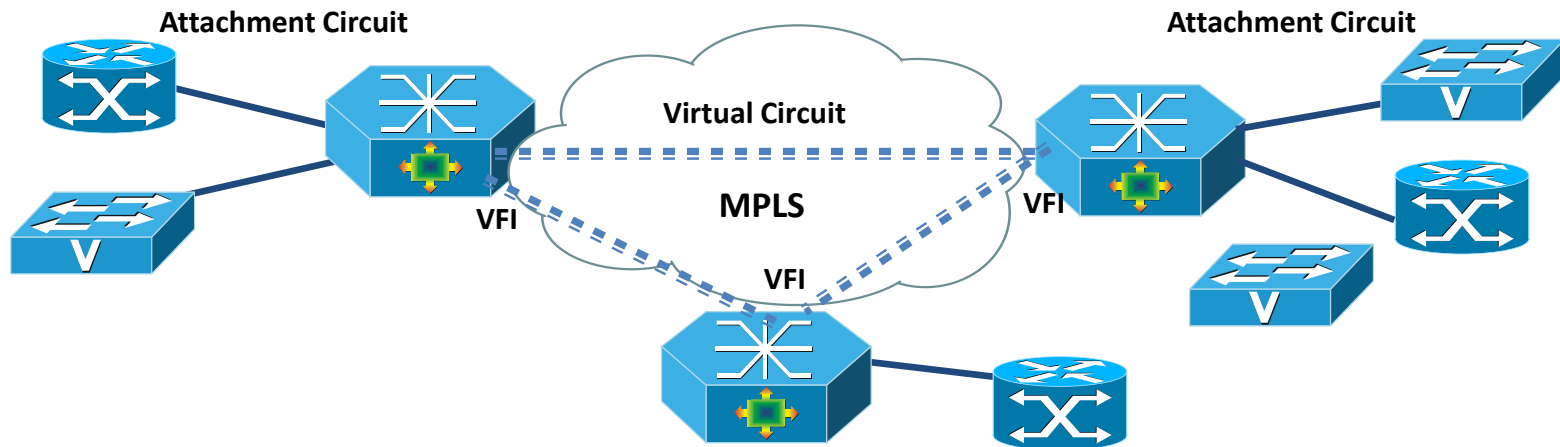
Sw3#ping 172.2.178.11

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.178.11, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 42/48/51 ms

VPLS Components

- ## AC (Attachment Circuit)
  - –Connect to CE device, it could be Ethernet physical or logical port, ATM bridging (RFC-1483), FR bridging (RFC-1490), even AToM pseudo wire; one or multiple ACs can belong to same VFI

- ## VC (Virtual Circuit)
  - –EoMPLS data encapsulation, tunnel label is used to reach remote PE, VC label is used to identify VFI; one or multiple VCs can belong to same VFI

- ## VFI (Virtual Forwarding Instance)
  - –Also called VSI (Virtual Switching Instance); VFI create L2 multipoint bridging among all ACs and VCs; it's L2 broadcast domain like VLAN
  - –Multiple VFI can exist on the same PE box to separate user traffic like VLAN

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

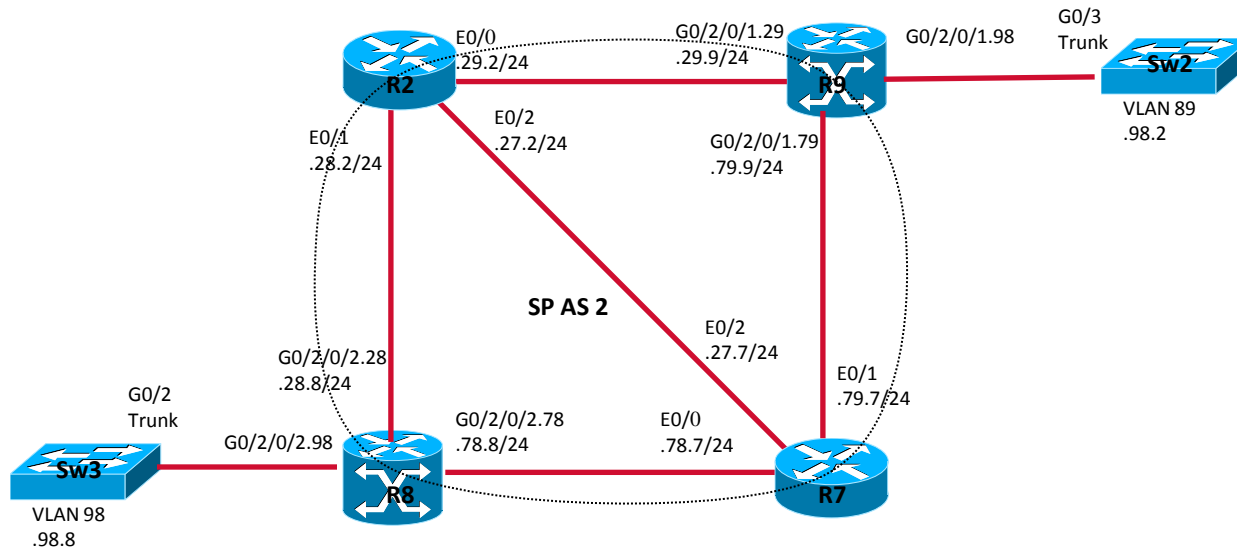 https://learningnetwork.cisco.com/docs/DOC-9991

  4.0 – Implement, Optimize and Troubleshoot L2VPN Technologies

  4.2 – Implement, Optimize and Troubleshoot VPLS and Carrier Ethernet

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

VPLS – Sub Topology and Question

- Configure R8 and R9 to provide VPLS service to connect VLAN 98

- Change VLAN spanning tree priority on Sw2 so that Sw2 is root for VLAN 98

Note: VPLS on IOS-XR support only Bridge group mode on current version

VPLS Configuration

R8 (IOS-XR) configuration

```
interface GigabitEthernet0/2/0/2.98 l2transport
 dot1q vlan 98
!
l2vpn
 pw-class atom
  encapsulation mpls
 !
!
 bridge group vpls
  bridge-domain v98
   interface GigabitEthernet0/2/0/2.98
   !
   vfi 98
    neighbor 2.2.0.9 pw-id 908
     pw-class atom
!
```

R9 (IOS-XR) configuration

```
interface GigabitEthernet0/2/0/1.98 l2transport
 dot1q vlan 98
!
l2vpn
 pw-class atom
  encapsulation mpls
 !
!
 bridge group vpls
  bridge-domain v98
   interface GigabitEthernet0/2/0/1.98
   !
   vfi 98
    neighbor 2.2.0.8 pw-id 908
     pw-class atom
!
```

VPLS Configuration (Cont.)

Sw3 configuration

spanning-tree mode pvst
spanning-tree extend system-id
!
vlan 98
!
interface GigabitEthernet0/2
 switchport trunk encapsulation dot1q
 switchport mode trunk
!
interface Vlan98
 ip address 172.2.98.3 255.255.255.0
!

Sw2 configuration

spanning-tree mode pvst
spanning-tree extend system-id
spanning-tree vlan 98 priority 20480
!
vlan 98
!
interface GigabitEthernet0/3
 switchport trunk encapsulation dot1q
 switchport mode trunk
!
interface Vlan98
 ip address 172.2.98.2 255.255.255.0
!

VPLS VC

R8 VPLS VC

RP/0/0/CPU0:R8#show l2vpn bridge-domain detail
Bridge group: vpls, bridge-domain: v98, id: 1, state: up
 MAC learning: enabled
 MAC withdraw: disabled
 Flooding:
  Broadcast & Multicast: enabled
  Unknown unicast: enabled
 Security: disabled
 DHCPv4 snooping: disabled
 Bridge MTU: 1500
 Filter MAC addresses:
 ACs: 1 (1 up), VFIs: 1, PWs: 1 (1 up)
 List of ACs:
  AC: GigabitEthernet0/2/0/2.98, state is up
   Type VLAN; Num Ranges: 1
   VLAN ranges: [98, 98]
   MTU 1500; XC ID 0x3000005; interworking none;
   MAC learning: enabled
   Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
   MAC aging time: 300 s, Type: inactivity
   MAC limit: 4000, Action: none, Notification: syslog
   MAC limit reached: no
   Security: disabled
   DHCPv4 snooping: disabled
   Static MAC addresses:

List of Access PWs:
 List of VFIs:
  VFI 98
   PW: neighbor 2.2.0.9, PW ID 908, state is up (established)
    PW class atom, XC ID 0xff000003
    Encapsulation MPLS, protocol LDP
    PW type Ethernet, control word disabled, interworking none
    PW backup disable delay 0 sec
    Sequencing not set

MPLS	Local	Remote
Label	16017	16014
Group ID	0x1	0x1
Interface	98	98
MTU	1500	1500
Control word disabled		disabled
PW type	Ethernet	Ethernet
VCCV CV type 0x2		0x2
	(LSP ping verification)	(LSP ping verification)
VCCV CC type 0x2		0x2
	(router alert label)	(router alert label)

VPLS VC (Cont.)

R9 VPLS VC

RP/0/0/CPU0:R8#show l2vpn bridge-domain detail
Bridge group: vpls, bridge-domain: v98, id: 1, state: up
 MAC learning: enabled
 MAC withdraw: disabled
 Flooding:
  Broadcast & Multicast: enabled
  Unknown unicast: enabled
 Security: disabled
 DHCPv4 snooping: disabled
 Bridge MTU: 1500
 Filter MAC addresses:
 ACs: 1 (1 up), VFIs: 1, PWs: 1 (1 up)
 List of ACs:
  AC: GigabitEthernet0/2/0/1.98, state is up
   Type VLAN; Num Ranges: 1
   VLAN ranges: [98, 98]
   MTU 1500; XC ID 0x3000004; interworking none;
   MAC learning: enabled
   Flooding:
    Broadcast & Multicast: enabled
    Unknown unicast: enabled
   MAC aging time: 300 s, Type: inactivity
   MAC limit: 4000, Action: none, Notification: syslog
   MAC limit reached: no
   Security: disabled
   DHCPv4 snooping: disabled
   Static MAC addresses:

 List of Access PWs:
 List of VFIs:
  VFI 98
   PW: neighbor 2.2.0.8, PW ID 908, state is up (established)
   PW class atom, XC ID 0xff000003
   Encapsulation MPLS, protocol LDP
   PW type Ethernet, control word disabled, interworking none
   PW backup disable delay 0 sec
   Sequencing not set

MPLS	Local	Remote
Label	16014	16017
Group ID	0x1	0x1
Interface	98	98
MTU	1500	1500
Control word disabled		disabled
PW type	Ethernet	Ethernet
VCCV CV type 0x2		0x2
	(LSP ping verification)	(LSP ping verification)
VCCV CC type 0x2		0x2
	(router alert label)	(router alert label)

MPLS forwarding table

```
RP/0/0/CPU0:R8#show mpls forwarding
Local  Outgoing   Prefix            Outgoing    Next Hop      Bytes
Label  Label      or ID             Interface            Switched
------ ----------- ------------------ ------------ --------------- ------------
16017  Pop        PW(2.2.0.9:908)   BD=1       point2point   0


RP/0/0/CPU0:R9#show mpls forwarding
Local  Outgoing   Prefix            Outgoing    Next Hop      Bytes
Label  Label      or ID             Interface            Switched
------ ----------- ------------------ ------------ --------------- ------------
16014  Pop        PW(2.2.0.8:908)   BD=1       point2point   0
```

Pseudowire Ping

RP/0/0/CPU0:R8#ping mpls pseudowire 2.2.0.9 908

Sending 5, 100-byte MPLS Echos to 2.2.0.9 VC: 908,
    timeout is 2 seconds, send interval is 0 msec:

Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
 'L' - labeled output interface, 'B' - unlabeled output interface,
 'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
 'M' - malformed request, 'm' - unsupported tlvs, 'N' - no rx label,
 'P' - no rx intf label prot, 'p' - premature termination of LSP,
 'R' - transit router, 'I' - unknown upstream index,
 'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 14/15/18 ms

VPLS Connection verification

Sw3#show spanning-tree vlan 98

VLAN0098
 Spanning tree enabled protocol ieee
 Root ID   Priority   20578
        Address   0019.e758.4d00
        Cost   4
        Port   2 (GigabitEthernet0/2)
        Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

  Bridge ID Priority   32866 (priority 32768 sys-id-ext 98)
        Address   0019.e758.4400
        Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
        Aging Time 300 sec

Interface   Role Sts Cost   Prio.Nbr Type
------------------- ---- --- --------- -------- -------------------------------
Gi0/2   Root FWD 4   128.2   P2p

Sw3#ping 172.2.98.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.98.2, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 16/20/26 ms

VPLS Connection verification (Cont.)

Sw2#show spanning-tree vlan 98

VLAN0098
 Spanning tree enabled protocol ieee
 Root ID   Priority   20578
       Address   0019.e758.4d00
       This bridge is the root
       Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec

 Bridge ID Priority   20578 (priority 20480 sys-id-ext 98)
       Address   0019.e758.4d00
       Hello Time   2 sec Max Age 20 sec Forward Delay 15 sec
       Aging Time 300 sec

Interface   Role Sts Cost   Prio.Nbr Type
------------------ ---- --- -------- -------- -------------------------------
Gi0/3   Desg FWD 4   128.3   P2p
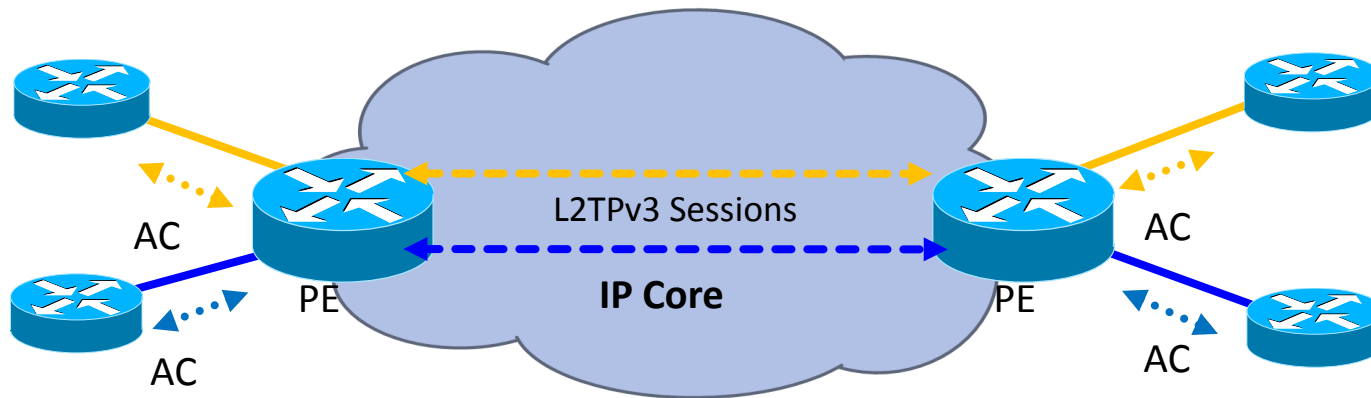

Sw2#ping 172.2.98.3
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.98.3, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 17/20/25 ms

L2TPv3 Architecture

- The L2TPv3 Control Connection exists between two peers and is used for advertising and negotiating capabilities

- For each emulated pseudowire, L2TPv3 negotiates individual sessions

Mapping to Lab Exam Blueprint

- This question of the sample lab maps to following sections/sub-sections in the Lab Exam Blueprint document below;

  https://learningnetwork.cisco.com/docs/DOC-9991

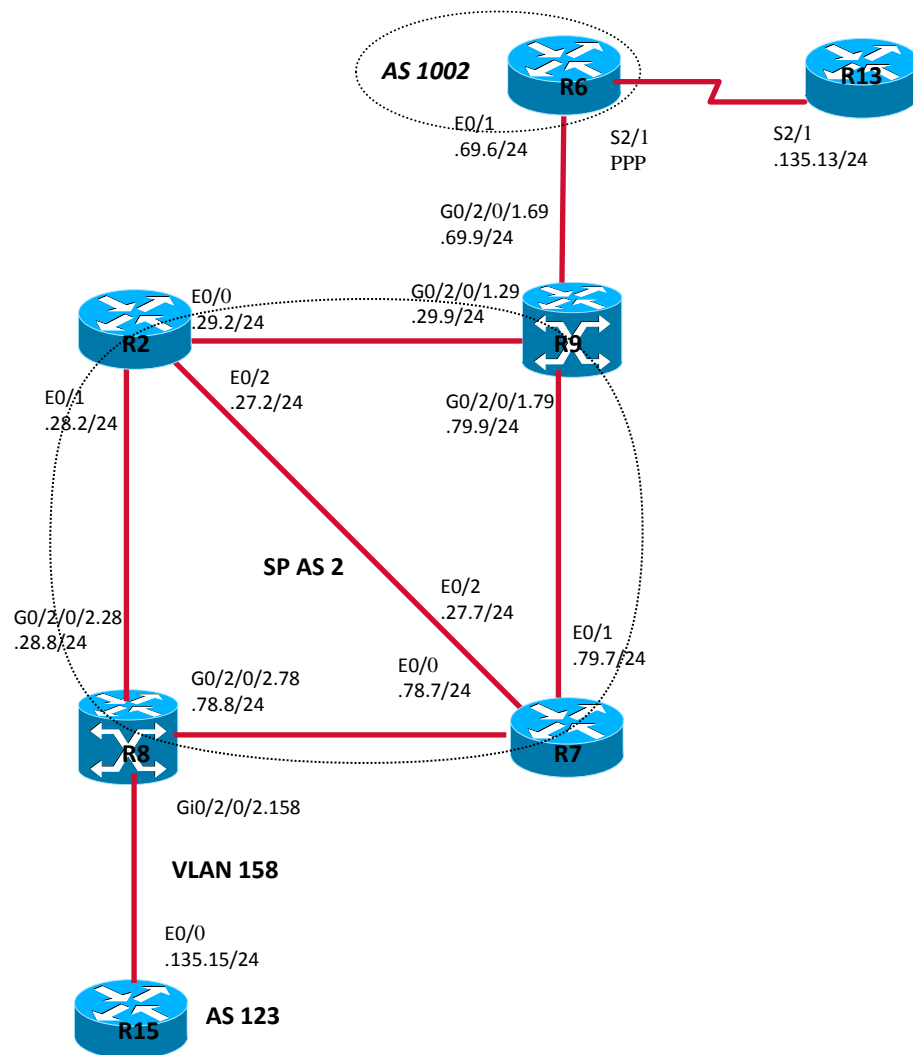   4.0 – Implement, Optimize and Troubleshoot L2VPN Technologies

      4.3 – Implement, Optimize and Troubleshoot L2TPv3 for L2 VPN

- For more details, please review the Lab Exam Checklist document below;

  https://learningnetwork.cisco.com/docs/DOC-10145

L2TPv3 – Sub Topology and Question

- Confgure R6 and R8 to establish L2TPv3 session

- Configure L2TPv3 to support ip interworking

- Ensure VLAN 158 on R15 connect with PPP on R13 and they can ping each other

AS 1002

R6

R13

E0/1
.69.6/24

S2/1
PPP

S2/1
.135.13/24

G0/2/0/1.69
.69.9/24

E0/0
.29.2/24

G0/2/0/1.29
.29.9/24

R2

R9

E0/1
.28.2/24

E0/2
.27.2/24

G0/2/0/1.79
.79.9/24

SP AS 2

E0/2
.27.7/24

E0/1
.79.7/24

G0/2/0/2.28
.28.8/24

G0/2/0/2.78
.78.8/24

E0/0
.78.7/24

R8

R7

Gi0/2/0/2.158

VLAN 158

E0/0
.135.15/24

R15   **AS 123**

L2TPv3 Configuration

R8 (IOS-XR) configuration

interface GigabitEthernet0/2/0/2.158 l2transport
 dot1q vlan 158
!
l2vpn
 pw-class l2tp
  encapsulation l2tpv3
   protocol l2tpv3
   ipv4 source 2.2.0.8
  !
 !
 xconnect group efg
  p2p efg
   interface GigabitEthernet0/2/0/2.158
   neighbor 2.2.0.6 pw-id 86
    pw-class l2tp
   !
   interworking ipv4
  !
 !

R6 (IOS) configuration

pseudowire-class l2tp
 encapsulation l2tpv3
 interworking ip
 ip local interface Loopback0
!
interface Serial2/1
 no ip address
 encapsulation ppp
 serial restart-delay 0
 xconnect 2.2.0.8 86 pw-class l2tp
!

L2TPv3 configuration (Cont.)

R15 configuration

interface Ethernet0/0
 ip address 172.2.135.15 255.255.255.0
!

R13 configuration

interface Serial2/1
 ip address 172.2.135.13 255.255.255.0
 encapsulation ppp
!

L2TPv3 session

R8 L2TPv3 session

RP/0/0/CPU0:R8#show l2tp session detail
Session id 32485 is up, tunnel id 3283985468, logical session id 32783
  Remote session id is 2258215147, remote tunnel id 1879924250
  Remotely initiated session
Call serial number is 30200001
Remote tunnel name is R6
  Internet address is 2.2.0.6
Local tunnel name is R8
  Internet address is 2.2.0.8
IP protocol 115
  Session is L2TP signaled
  Session state is established, time since change 1d06h
  UDP checksums are disabled
    1859145 Packets sent, 923702 received
    215663860 Bytes sent, 93358423 received
  Last clearing of counters 11w0d
  Counters, ignoring last clear:
    0 Packets sent, 0 received
    0 Bytes sent, 0 received

  Receive packets dropped:
    out-of-order: 0
    other: 0
    total: 0
  Send packets dropped:
    exceeded session MTU: 0
    other: 3261105
    total: 3261105
  Sequencing is off
  Conditional debugging is disabled
  Unique ID is 86
Session Layer 2 circuit
  Payload type is IP, Name is GigabitEthernet0_2_0_2.158
  Session vcid is 86
  Circuit state is UP
    Local circuit state is UP
    Remote circuit state is UP

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L2TPv3 session (Cont.)

R6 L2TPv3 session

R6#show l2tp session all
Session id 2258215147 is up, tunnel id 1879924250
  Remote session id is 32485, remote tunnel id
3283985468
  Locally initiated session
  Unique ID is 4
Session Layer 2 circuit, type is PPP, name is Serial2/1
  Session vcid is 86
  L2TP VC type is IP, interworking type is IP
  Circuit state is UP
    Local circuit state is UP
    Remote circuit state is UP
Call serial number is 30200001
Remote tunnel name is R8
  Internet address is 2.2.0.8
Local tunnel name is R6
  Internet address is 2.2.0.6

IP protocol 115
  Session is L2TP signaled
  Session state is established, time since change 1d06h
    27250 Packets sent, 0 received
    2335720 Bytes sent, 0 received
  Last clearing of counters never
  Counters, ignoring last clear:
    27250 Packets sent, 0 received
    2335720 Bytes sent, 0 received
DF bit off, ToS reflect disabled, ToS value 0, TTL value 255
  UDP checksums are disabled
  No session cookie information available
  FS cached header information:
    encap size = 24 bytes
    45000014 00000000 FF73B767 02020004
    02020008 00007EE5
  Sequencing is off
  Conditional debugging is disabled

Connection verification

R13#ping 172.2.158.15
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.158.15, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/40/44 ms

R15#ping 172.2.158.13

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.2.158.13, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 36/40/44 ms