CCIE Service Provider v3.0 Sample Lab
Part 7/7

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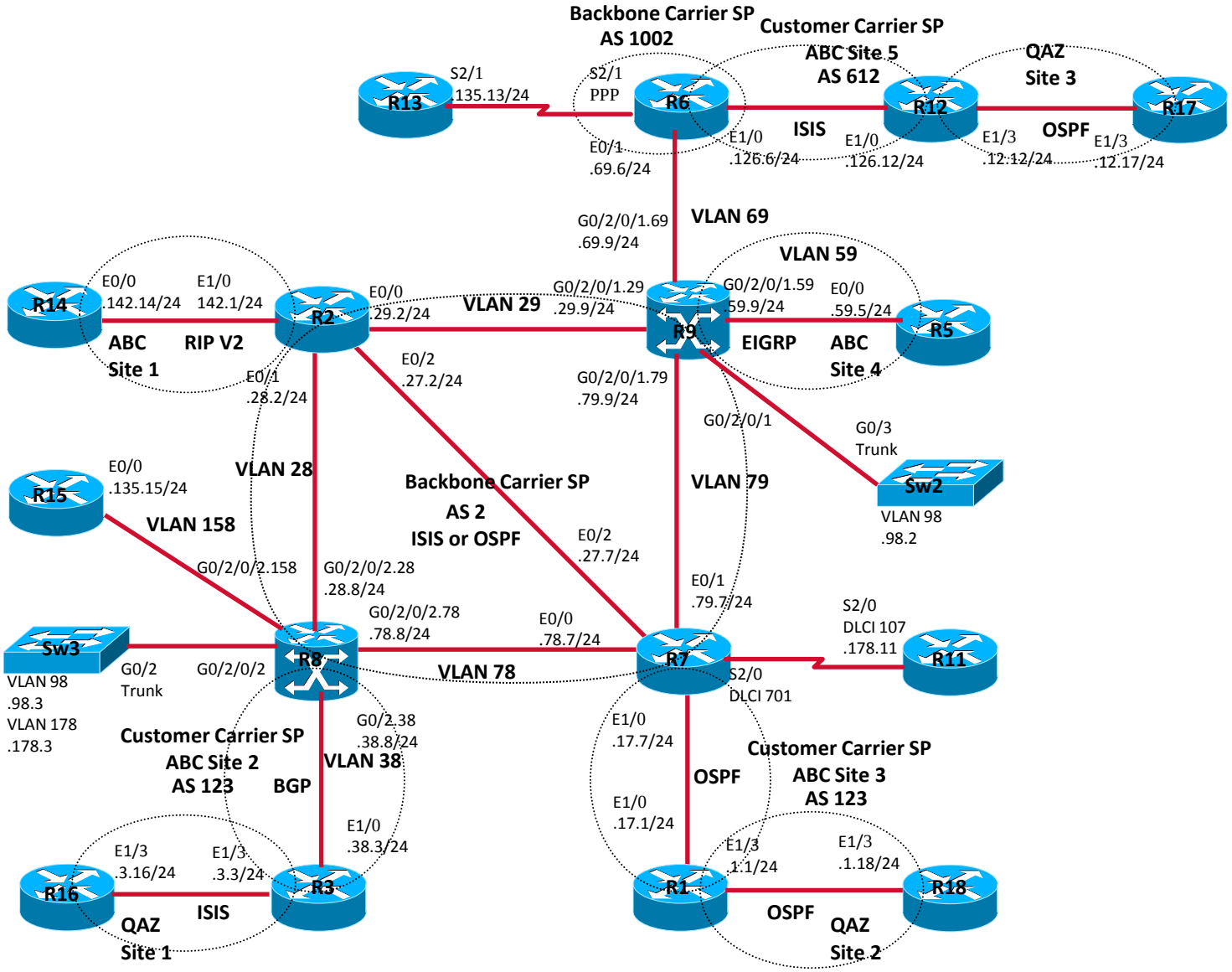
Cisco Systems

SP Sample Lab – Main Topology



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

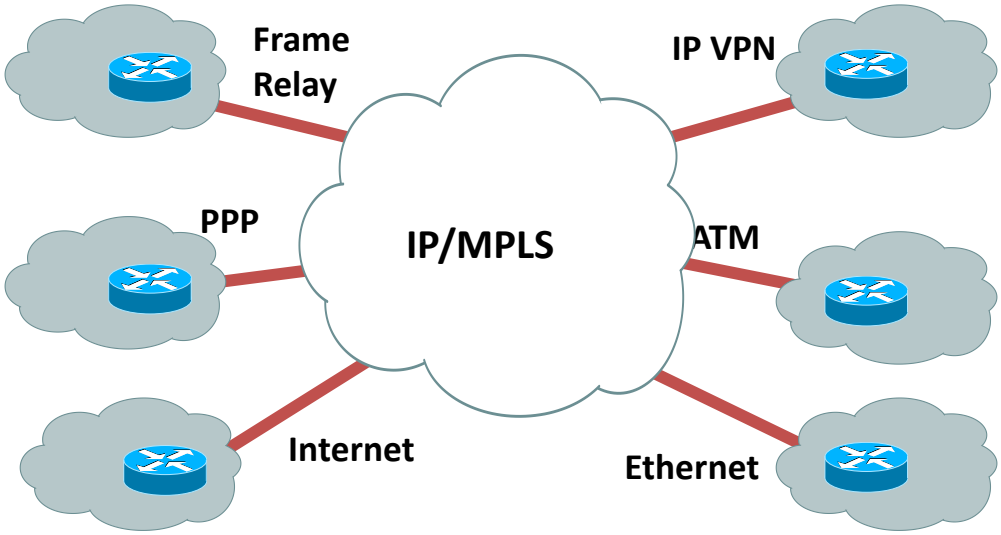
  c3560-advipservicesk9-mz.122-46.SE.bin

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

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

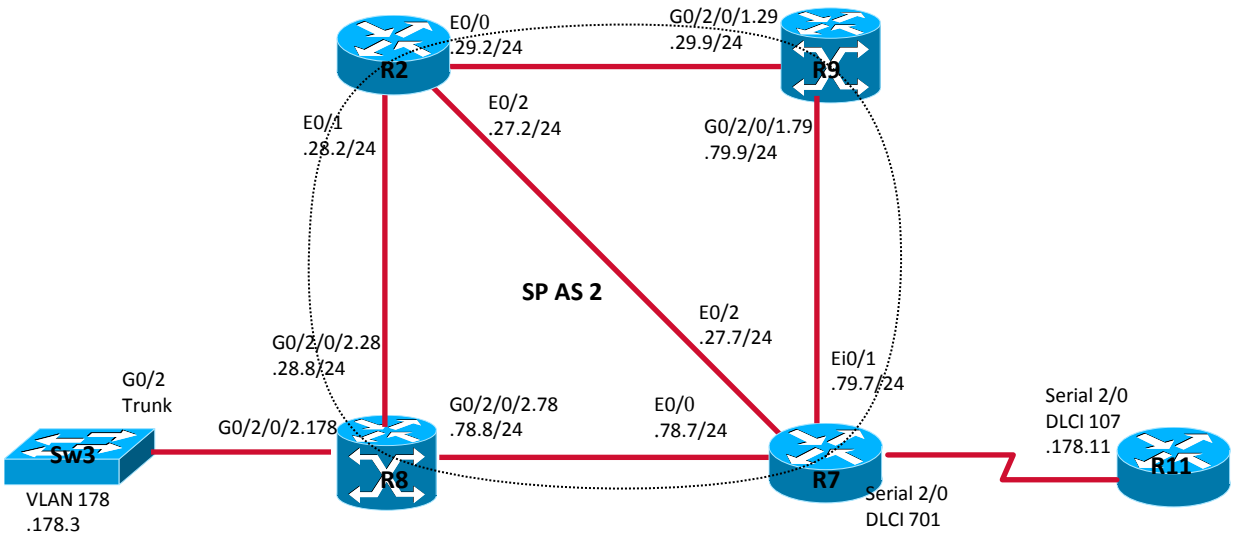
  4.0 – Implement, Optimize and Troubleshoot L2VPN Technologies

    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)
      ------------ ------------------------------ ------------------------------
```

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

```
R7#show mpls forwarding-table
Local  Outgoing     Prefix          Bytes Label     Outgoing     Next Hop
Label  Label or VC  or Tunnel Id     Switched       interface
28     No Label     l2ckt(101)       1500           Se2/0        point2point
```

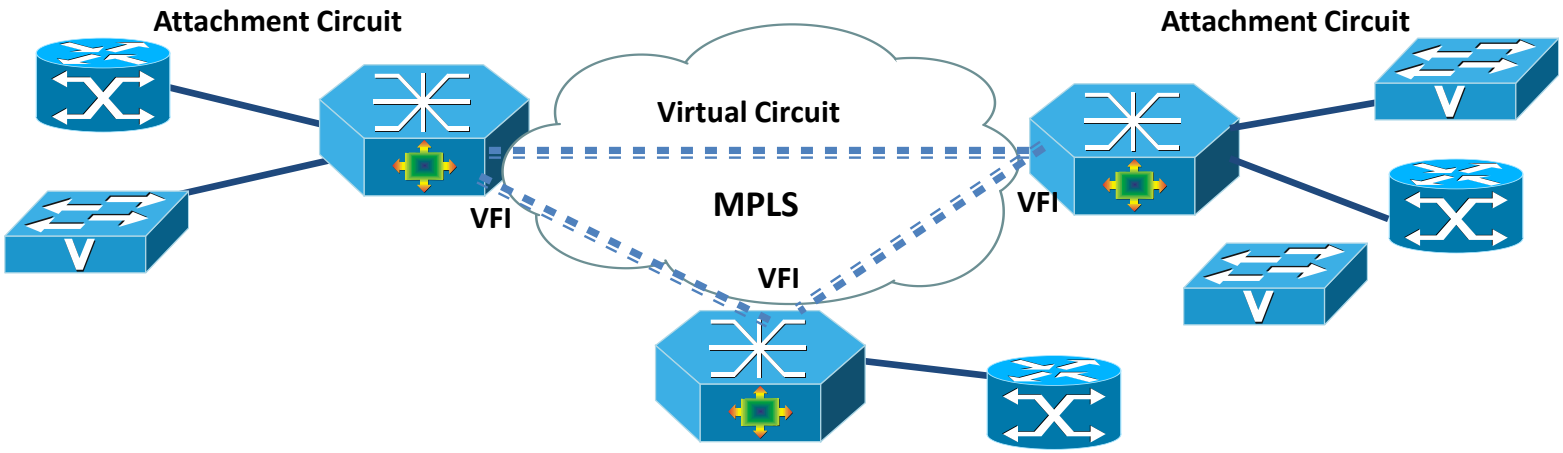
Pseudowire Ping Veification

```
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

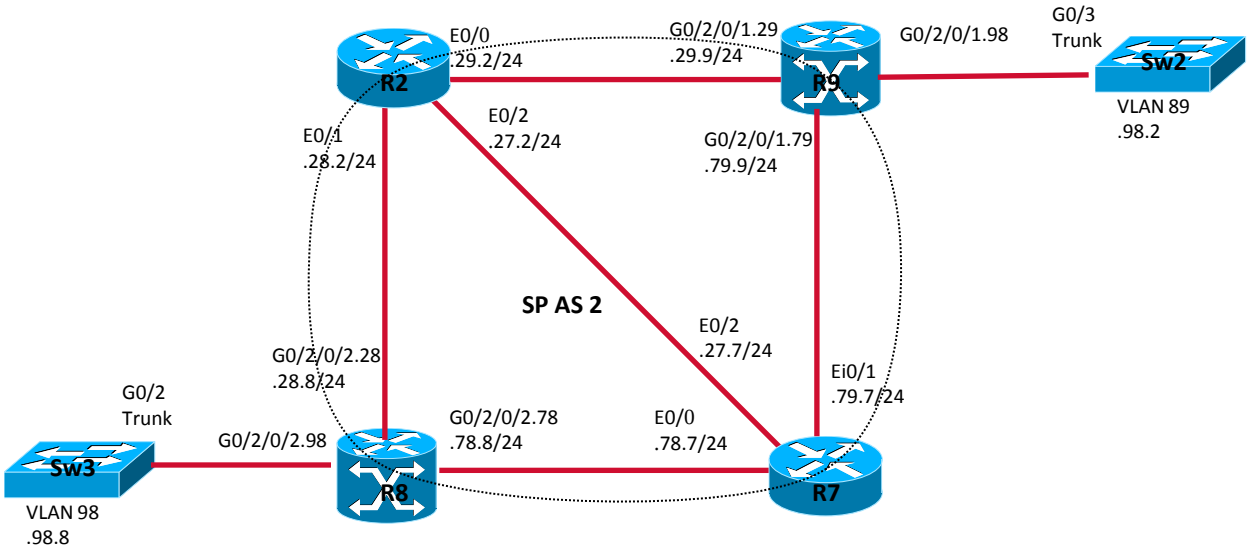
  4.0 – Implement, Optimize and Troubleshoot L2VPN Technologies

    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
```

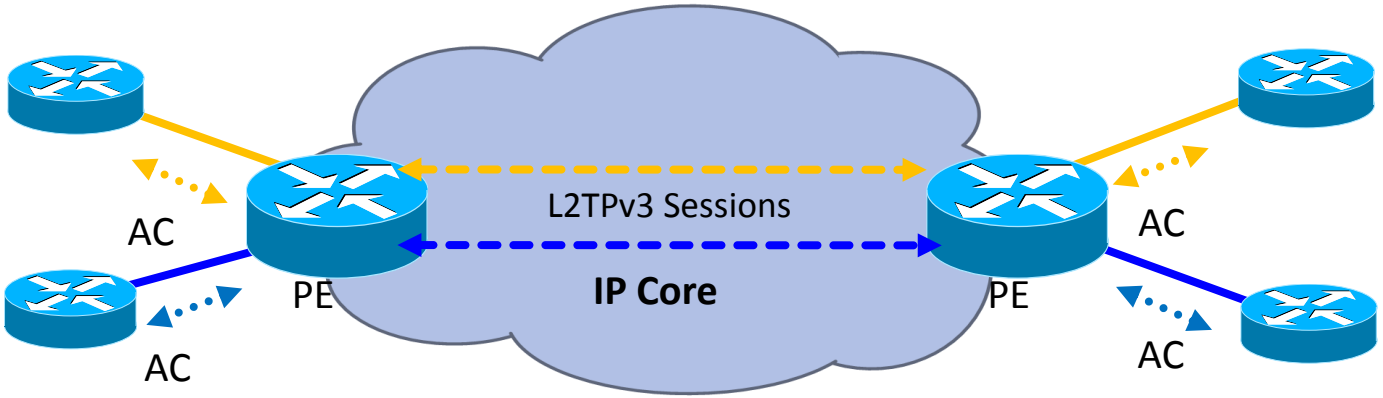
VPLS Connection verification

```
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

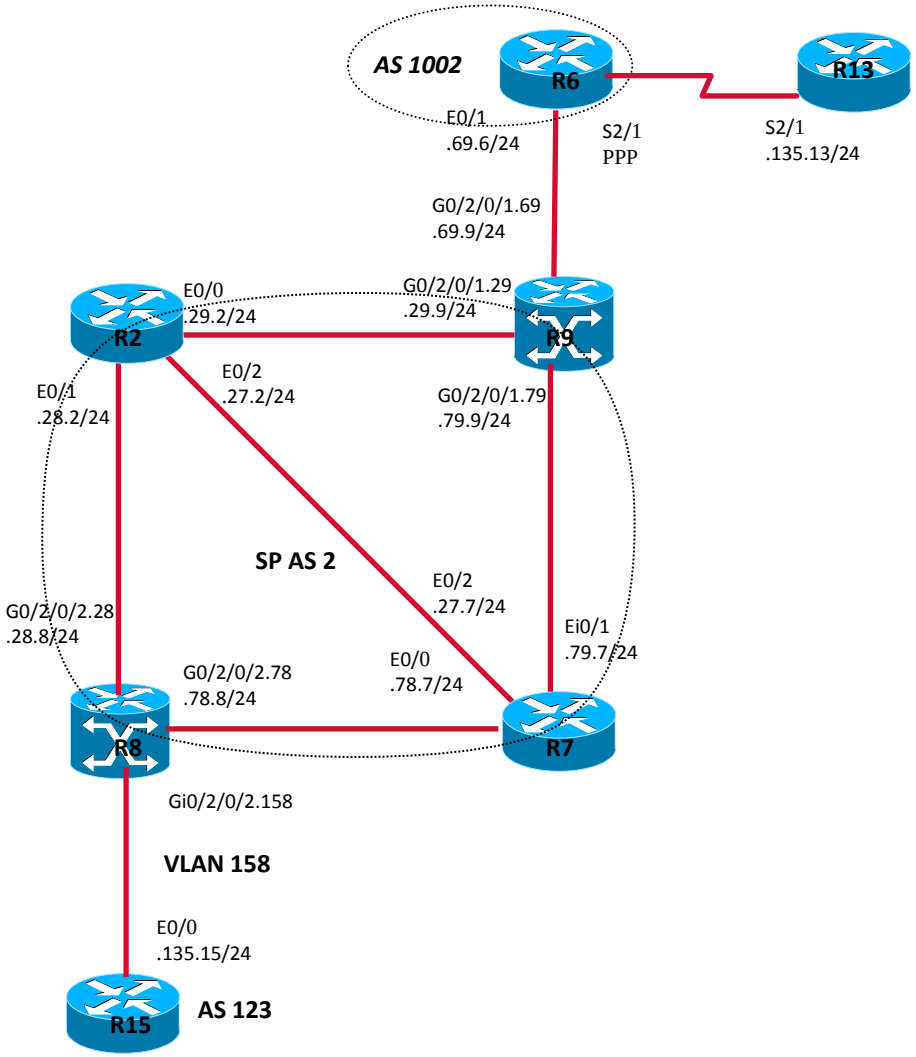
    4.3 – Implement, Optimize and Troubleshoot L2TPv3 for L2 VPN

- 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



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
```

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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