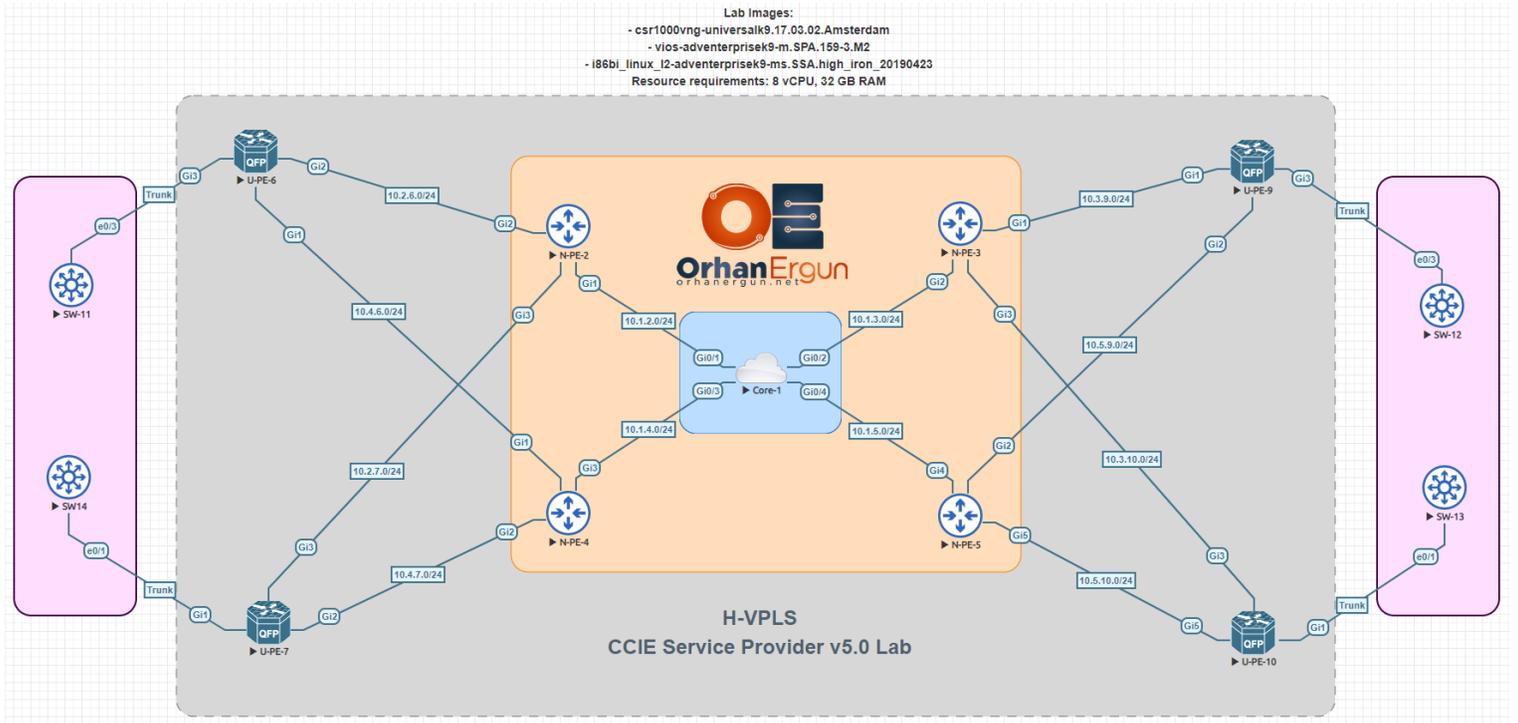# H-VPLS Lab

Hierarchical Virtual Private LAN Service

Topology:

📋 Task 01:

- Configure Full Mesh Pseudowires between N-PE devices (Use static peers not BGP AD)

💡 Solution:

H-VPLS is a framework or a way of configuring VPLS in a Hierarchical manner in order to solve the scalability problem. Imagin a service provider has 500 PE devices and 10,000 customers, what will happen if all those PE devices form a lot of Pseudowires in a Full Mesh way?!

In order to overcome this scalability issue, H-VPLS can be used.

PE devices are going to be devided into two parts: N-PE and U-PE.

- ➢ N-PE or the Network PE devices are going to form a Full mesh of Pseudowires with each other (Peers can be configured staticaly just link this task or Auto-Discovery using MP-BGP L2VPN VPLS could be used with eighter LDP or BGP as the signaling protocol).
- ➢ U-PE devices are the PE devices that are actually connected to the Customer side devices (CE devices) and they service the customer.
- ➢ U-PE devices are forming pseudowires with the N-PE device or devices.

Let's start configuring N-PE devices first:

```
N-PE-2:

l2vpn vfi context H-VPLS-01

 vpn id 1

 member 10.255.255.3 encapsulation mpls

 member 10.255.255.4 encapsulation mpls

 member 10.255.255.5 encapsulation mpls

 !


N-PE-3:

l2vpn vfi context H-VPLS-01

 vpn id 1

 member 10.255.255.2 encapsulation mpls

 member 10.255.255.4 encapsulation mpls

 member 10.255.255.5 encapsulation mpls

 !
```

```
N-PE-4:

l2vpn vfi context H-VPLS-01

 vpn id 1

 member 10.255.255.2 encapsulation mpls

 member 10.255.255.3 encapsulation mpls

 member 10.255.255.5 encapsulation mpls

 !


N-PE-5:

l2vpn vfi context H-VPLS-01

 vpn id 1

 member 10.255.255.2 encapsulation mpls

 member 10.255.255.3 encapsulation mpls

 member 10.255.255.4 encapsulation mpls

 !
```

What an easy task! The only thing you needed to do is just simply make Full mesh of pseudowires between all N-PE devices.

NOTE: There is no need to enable split-horizon for these members. By default in IOS-XE when you configure some member under the L2VPN VFI (Virtual Forwarding Instance), the Split Horizon is going to be turned on automatically.

Verification:

```
N-PE-2#show l2vpn vfi detail

Legend: RT=Route-target, S=Split-horizon, Y=Yes, N=No


VFI name: H-VPLS-01, state: up, type: multipoint, signaling: LDP

  VPN ID: 1

  Bridge-Domain 1 attachment circuits:

  Pseudo-port interface: pseudowire100001

  Interface          Peer Address      VC ID          S

  pseudowire100006   10.255.255.6      1              N

  pseudowire100005   10.255.255.7      1              N

  pseudowire100004   10.255.255.3      1              Y

  pseudowire100003   10.255.255.4      1              Y

  pseudowire100002   10.255.255.5      1              Y
```

Task 02-04:

- ➢ Configure Pseudowires between U-PE and N-PE devices according to the diagram (in Hub and Spoke manner)
- ➢ Provide Hub Redundancy for U-PE devices (each U-PE device should redundant pseudowires towards N-PE devices)
- ➢ Provide VPLS Service to the Multilayer Switches (SW11-14)
- ➢ U-PE to MLS links should be a Trunk and two VLANs in forwarding state (VLAN 1112-1113)

Solution:

We have configured Pseudowires between N-PE devices, and Split-Horizon was on.

This time we will configure the pseudowires between U-PE and N-PE devices.

In order to do this task each N-PE device should form two different pseudowires with their two U-PE members.

In the previous task, members has been configured under the L2VPN VFI instance, in this task, On the N-PE devices we will use Bridge-Domain instead in order to define the members.

NOTE: Split Horizon should be disabled with the N-PE to U-PE peering, otherwise, U-PE devices will not get any data (VPLS encapsulated data) received from another N-PE devices. By default in IOS-XE if you define a member under Bridge-Domain, Split-Horizon will be disabled for that peer automatically.

```
N-PE-2:

bridge-domain 1

 member vfi H-VPLS-01

 member 10.255.255.6 1 encapsulation mpls

 member 10.255.255.7 1 encapsulation mpls

 !


N-PE-3:

bridge-domain 1

 member vfi H-VPLS-01

 member 10.255.255.9 1 encapsulation mpls

 member 10.255.255.10 1 encapsulation mpls

 !

N-PE-4:

bridge-domain 1

 member vfi H-VPLS-01

 member 10.255.255.7 1 encapsulation mpls
```

```
  member 10.255.255.6 1 encapsulation mpls

 !



 N-PE-5:

 bridge-domain 1

  member vfi H-VPLS-01

  member 10.255.255.9 1 encapsulation mpls

  member 10.255.255.10 1 encapsulation mpls

  !
```

Now it's time to configure the Pseudowires on the U-PE devices. If you take a look at the topology, each U-PE device has two physical connection to two N-PE devices in order to provide the redundancy.

NOTE: We cannot have two Pseudowires on the U-PE devices in active forwarding mode, the only option is to configure them in a way to make one of them Active and the Other one in the standby mode. When we loose the Active one, The standby Pseudowire becomes active.

That is why there will be no bridge domain or VFI configuration on the U-PE devices when it comes to the redundancy.

The only choice is to configure an Cross Connect (Xconnect) context and define two members (2 N-PE devices) in a redundancy group and make one of them to be prefered as the active member:

```
 U-PE-6:

 interface GigabitEthernet3

  service instance 1112 ethernet

   encapsulation dot1q 1112-1113

   l2protocol forward stp

  !

 l2vpn xconnect context H-VPLS

  member 10.255.255.2 1 encapsulation mpls group N-PE-RD priority 2

  member 10.255.255.4 1 encapsulation mpls group N-PE-RD priority 4

  member GigabitEthernet3 service-instance 1112

  !
```

In all of the previous VPLS labs, a customer was sending the traffic Untagged or tagged with a single dot1q tag.

This time U-PE devices connected to the Service Provider Access switches (SW-11 for example) can handle multiple VLAN traffic thanks to the dot1q tags.

In this example SW-11 – SW-14 can providede VPLS service for multiple customers by making the access ports (towards) Cutomer Edge devices with a specific VLAN.

All U-PE to access layer switch links are trunk so they can handle multiple VLANs (in this example 1112 and 1113).

Let's configure the rest of the U-PE devices:

```
U-PE-7:

interface GigabitEthernet1

 service instance 1112 ethernet

  encapsulation dot1q 1112-1113

  l2protocol peer stp

 !

l2vpn xconnect context H-VPLS

 member 10.255.255.2 1 encapsulation mpls group N-PE-RD priority 2

 member 10.255.255.4 1 encapsulation mpls group N-PE-RD priority 4

 member GigabitEthernet1 service-instance 1112

!


U-PE-9:

interface GigabitEthernet3

 service instance 1112 ethernet

  encapsulation dot1q 1112-1113

  l2protocol peer stp

 !

l2vpn xconnect context H-VPLS

 member pseudowire3 group N-PE-RD priority 3

 member pseudowire5 group N-PE-RD priority 5

 member GigabitEthernet3 service-instance 1112

!


U-PE-10:

interface GigabitEthernet1

 service instance 1112 ethernet
```

```
   encapsulation dot1q 1112-1113

   l2protocol peer stp

  !

l2vpn xconnect context H-VPLS

 member GigabitEthernet1 service-instance 1112

 member pseudowire3 group N-PE-RD priority 3

 member pseudowire5 group N-PE-RD priority 5

 !
```

Everything is ready to test the conectivity.

Verification:

```
U-PE-10#show xconnect all

Legend:     XC ST=Xconnect State   S1=Segment1 State   S2=Segment2 State

  UP=Up          DN=Down           AD=Admin Down       IA=Inactive

  SB=Standby   HS=Hot Standby    RV=Recovering       NH=No Hardware


XC ST   Segment 1                        S1 Segment 2                          S2

------+--------------------------------+--+--------------------------------+--

UP pri    ac Gi1:1112(Ethernet)            UP mpls 10.255.255.3:1          UP

IA pri    ac Gi1:1112(Ethernet)            UP mpls 10.255.255.5:1          SB


N-PE-2#show l2vpn vfi

Legend: RT=Route-target, S=Split-horizon, Y=Yes, N=No


VFI name: H-VPLS-01, state: up, type: multipoint, signaling: LDP

  VPN ID: 1

  Bridge-Domain 1 attachment circuits:

  Pseudo-port interface: pseudowire100001

  Interface          Peer Address     VC ID        S

  pseudowire100006   10.255.255.6     1            N

  pseudowire100005   10.255.255.7     1            N

  pseudowire100004   10.255.255.3     1            Y

  pseudowire100003   10.255.255.4     1            Y

  pseudowire100002   10.255.255.5     1            Y
```

```
N-PE-2#show bridge-domain

Bridge-domain 1 (5 ports in all)

State: UP                    Mac learning: Enabled

Aging-Timer: 300 second(s)

Maximum address limit: 65536

    vfi H-VPLS-01 neighbor 10.255.255.5 1

    vfi H-VPLS-01 neighbor 10.255.255.4 1

    vfi H-VPLS-01 neighbor 10.255.255.3 1

    vfi H-VPLS-01 neighbor 10.255.255.7 1

    vfi H-VPLS-01 neighbor 10.255.255.6 1

  AED MAC address     Policy  Tag      Age  Pseudoport

  0    AABB.CC80.0D00 forward dynamic   300  H-VPLS-01.404012

  0    AABB.CC80.0800 forward dynamic   298  H-VPLS-01.404013

  0    AABB.CC80.0C00 forward dynamic   299  H-VPLS-01.404012

  0    AABB.CC80.0B00 forward dynamic   297  H-VPLS-01.404014



SW-11#show run interface vlan 1112

Building configuration...


Current configuration : 64 bytes

!

interface Vlan1112

 ip address 10.11.12.11 255.255.255.0

end


SW-11#show run interface vlan 1113

Building configuration...


Current configuration : 64 bytes

!

interface Vlan1113

 ip address 10.11.13.11 255.255.255.0

end
```

```
SW-11#show run int e0/3

Building configuration...


Current configuration : 155 bytes

!

interface Ethernet0/3

 switchport trunk allowed vlan 1112,1113

 switchport trunk encapsulation dot1q

 switchport mode trunk

 switchport nonegotiate


SW-11#show run | sec router

router eigrp 100

 network 10.0.0.0


SW-11#show ip eigrp ne

EIGRP-IPv4 Neighbors for AS(100)

H   Address               Interface          Hold Uptime   SRTT   RTO  Q  Seq
                                             (sec)         (ms)       Cnt Num
5   10.11.13.13           Vl1113              12 03:11:27     5   100  0  19
4   10.11.12.13           Vl1112              14 03:11:28     3   100  0  20
3   10.11.13.12           Vl1113              11 03:11:37     1   100  0  18
2   10.11.12.12           Vl1112              11 03:11:37     1   100  0  17
1   10.11.13.14           Vl1113              10 03:11:48     2   100  0  21
0   10.11.12.14           Vl1112              12 03:11:48     2   100  0  22


SW-11#ping 10.11.12.255 re 1

Type escape sequence to abort.

Sending 1, 100-byte ICMP Echos to 10.11.12.255, timeout is 2 seconds:


Reply to request 0 from 10.11.12.14, 6 ms

Reply to request 0 from 10.11.12.12, 9 ms

Reply to request 0 from 10.11.12.13, 7 ms

SW-11#ping 10.11.13.255 re 1
```

```
Type escape sequence to abort.

Sending 1, 100-byte ICMP Echos to 10.11.13.255, timeout is 2 seconds:


Reply to request 0 from 10.11.13.14, 2 ms

Reply to request 0 from 10.11.13.12, 2 ms

Reply to request 0 from 10.11.13.13, 2 ms


SW-11#show mac address-table

         Mac Address Table

-------------------------------------------


Vlan    Mac Address       Type        Ports

----    -----------       --------    -----

1112    aabb.cc80.0800    DYNAMIC     Et0/3

1112    aabb.cc80.0c00    DYNAMIC     Et0/3

1112    aabb.cc80.0d00    DYNAMIC     Et0/3

1113    aabb.cc80.0800    DYNAMIC     Et0/3

1113    aabb.cc80.0c00    DYNAMIC     Et0/3

1113    aabb.cc80.0d00    DYNAMIC     Et0/3
```

We can configrm that everything works fine and all Access Layer switches have L2 connectivity thanks to the H-VPLS!

In addition to the H-VPLS configuration let's take a look at the Access Layer switches configuration, in the real implementations, PE or U-PE devices are not directly connected to the Customer Equipement. Instead they are connected to the Service Provider Access Layer switches, and those switches provides connectivity to the Customer Edge devices:

```
SW-11:

interface Ethernet0/3

 switchport trunk allowed vlan 1112,1113

 switchport trunk encapsulation dot1q

 switchport mode trunk

 switchport nonegotiate

!

vlan 1112-1113

!
```

```
router eigrp 100
 network 10.0.0.0
!
interface Vlan1112
 ip address 10.11.12.11 255.255.255.0
!
interface Vlan1113
 ip address 10.11.13.11 255.255.255.0
!
```

SW-12:

```
interface Ethernet0/3
 switchport trunk allowed vlan 1112,1113
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport nonegotiate
!
vlan 1112-1113
!
router eigrp 100
 network 10.0.0.0
!
interface Vlan1112
 ip address 10.11.12.12 255.255.255.0
!
interface Vlan1113
 ip address 10.11.13.12 255.255.255.0
!
```

SW-14:

```
interface Ethernet0/1
 switchport trunk allowed vlan 1112,1113
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport nonegotiate
```

```
vlan 1112-1113
!
router eigrp 100
 network 10.0.0.0
!
interface Vlan1112
 ip address 10.11.12.14 255.255.255.0
!
interface Vlan1113
 ip address 10.11.13.14 255.255.255.0
!


SW-13:
interface Ethernet0/1
 switchport trunk allowed vlan 1112,1113
 switchport trunk encapsulation dot1q
 switchport mode trunk
 switchport nonegotiate
!
vlan 1112-1113
!
router eigrp 100
 network 10.0.0.0
!
interface Vlan1112
 ip address 10.11.12.13 255.255.255.0
!
interface Vlan1113
 ip address 10.11.13.13 255.255.255.0
!
```