Application Note

OcNOS as a Cell Site Gateway for a 4G-LTE Fixed Wireless Access

1. Introduction

Fixed LTE wireless services, where the UE is largely immobile allows for higher data bandwidth rates This allows service providers to offer multiple service offerings to end customers in both residential and enterprise categories at an attractive price point. 4G LTE with a fixed wireless last mile access. Using wireless customer premise equipment allows for a significant cost capex saving is achieved, equally allows for native & quick greenfield applications.

Derived from the 3GPPP design the field eNodeB's backhaul connection used to transport the user plane traffic should be able to meet the service needs for the different applications running on the customer premise. It should also be able to meet the transport level needs required for the control plane signalling required between the eNodeB and the EPC core.

Increased bandwidth demands from end users, require more aggregate transport backhaul. The network upgrades at the same time need to be backwardly compatible with incumbent equipment and core network equipment.

SKY Brasil as a part of their network upgrade chose disaggregation because it allowed them to upgrade to network nodes with both higher bandwidth and a choice of operating systems of their own. This gave them the flexibility to improve the network services they offer with newer technologies while maintain the CAPEX of hardware investment.

OcNOS in particular benefits them by bringing in multiple Layer2, Layer3 and MPLS technologies by which they could have interoperability with existing equipment at the core and yet upgrade the access bandwidth. An open standards compliant NOS like OcNOS, gives the future proofing to change to newer technologies like EVPN and Segment Routing again maintaining investments.

The below use case examines a deployment use case of using OcNOS as the NOS to provide the access transport segment for wireless access.

2. Network Topology Brief

The below deployment depicts the use case where OcNOS is used as a Cell site Gateway for a 4G LTE wireless access transport design. Further the case depicts a case where the transport services start from the ENodeB and ends in the EPC core, as such it is spans a single metro area and is called termed as Intra area. A second possible design and usage, but not covered in this document is when multiple metro area's can communicate with each other via the EPC core.

In this design the OcNOS is deployed with MPLS as the backhaul transport technology. In particular L2 Psuedowire using RSVP-TE and targeted LDP are used as the protocol choice. Using RSVP-TE allows for fast reroute benefits and using Psuedowire's in active and backup condition, the transport setup time and convergence time are reduced in case of link or node failures.

The given topology is representative of a single area metro deployment for FWA where only key transport service nodes are shown. Each metro deployment is expected to aggregate at a core level and provide users service like internet access.

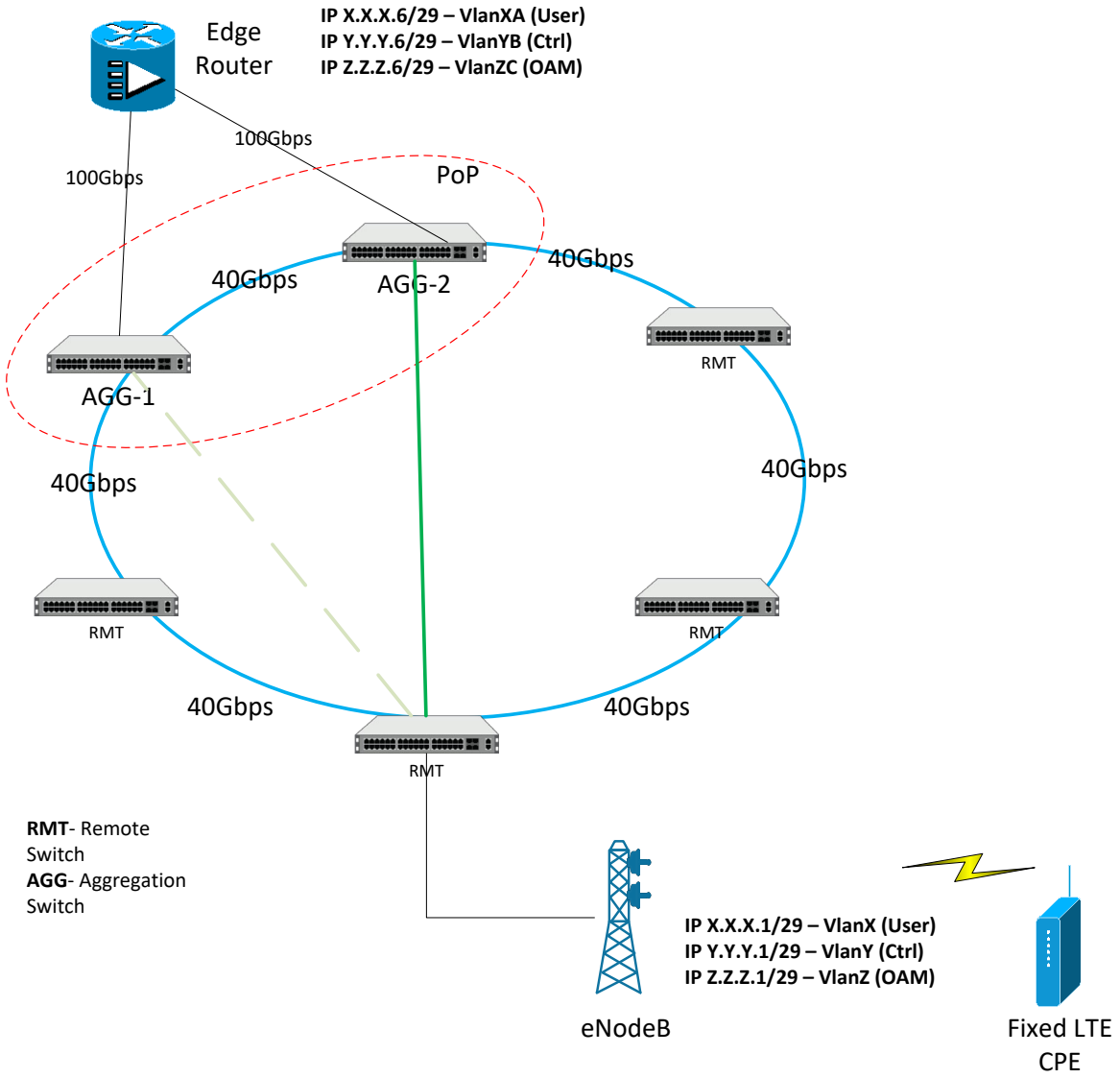

Figure 1. Representative topology of a Metro Network for FWA using 4G LTE

Type of Node	OcNOS Software SKU	Hardware Options
Cell Site Gateway	OcNOS-SP-MPLS	Edgecore AS5916-54XK Dell S4248FBL-ON

3. Logical Configurations:

RMT-Switches:

1. Configure loopback interface IP address of RMT-Switch.
2. Configure IGP(OSPF) between adjacent nodes in single area with BFD enabled.
3. Configure router rsvp with no-php option.
4. Configure primary RSVP LSP to loopback of AGG nodes with strict hop option.
5. Configure detour RSVP LSP to loopback of AGG nodes with rsvp-frr one-to-one node protection.
6. Configure targeted-LDP session between loopback of RMT and loopback of AGG-1 and AGG-2 nodes with no multicast-hellos & pw-status-tlv options.
7. Configure Service-template to match Single-Tag VLAN(outer-vlan) and rewrite with option as Push for S-VLAN.
8. Configure primary VPWS service to AGG-1 node with service-tpid as dot1.ad(0x88a8).
9. Configure secondary VPWS service to AGG-2 node with service-tpid as dot1.ad(0x88a8).
10. Configure switchport and attach primary and secondary VPWS services with service-template to AC interface connected to Base Station.

Detailed configurations are given below in Detailed Configuration section.

AGG-1/AGG-2:

1. Configure loopback interface IP address of AGG node.
2. Configure IGP(OSPF) between adjacent nodes in single area with BFD enabled.
3. Configure L2 Port-Channel between “Router Edge(Juniper)” to “AGG-Switches”.
4. Configure Mc-LAG using inter-domain link between AGG1 and AGG2.
5. Configure router rsvp with no-php option.
6. Configure primary RSVP LSP to loopback of RMT node with strict hop option.
7. Configure detour RSVP LSP to loopback of RMT node with rsvp-frr one-to-one node protection.
8. Configure targeted-LDP session with loopback of RMT node with no multicast-hellos & pw-status-tlv options.
9. Configure Service-template to match Double-Tag VLAN (outer-vlan & inner-vlan).

10. Configure VPWS service to RMT node with service-tpid as dot1.ad(0x88a8).
11. Configure switchport and attach VPWS services with service-template to AC interface (Port-channel in this case) connected to “Router Edge”.

Detailed configurations are given below in Detailed Configuration section.

Traffic flow:

From Base-Station, IP-VLAN-Packet comes to RMT-Switch.

RMT-Switch.

RMT-Switch receive this IP-VLAN-packet in AC interface and treats this packet as L2 packet.
And it push S-VLAN on top of this packet(now the packet is having 2 VLANs).
And then packet is encapsulated with VC-Label and RSVP-transport-Label and sends to AGG-Switch.

AGG-Switch.

Once the AGG-Switch receives this packet it POP all the labels and send the L2 packet(with 2 VLANS because no rewrite option configured in Service-template) out of AC-Interface to “Router Edge”.

Now in “Edge Router”.

If it treats receiving traffic as L2 packet then it will do PB switching and the packet will switched to another Ring with in the Metro-Domain.
If it treats receiving traffic as L3 packet then it will do IP routing and the packet will routed to another Ring with in the Metro-Domain.

4. Detailed Configuration

Given below are the sample configuration of one of RMT nodes. Similar configuration needs to be done on other RMT nodes:

4.1. RMT Configuration

#configure terminal	Enter the Configure mode.
(config)#interface lo	Enter interface mode
(config-if)# ip address 9.9.9.9/32 secondary	Configure the IP address of the interface loopback
(config-if)#exit	Exit interface mode
(config)#interface ce1	Enter interface mode
(config-if)# ip address 31.34.1.34/24	Configure the IP address of the interface ce1
(config-if)#label-switching	Enable label-switching on interface ce1
(config-if)#exit	Exit interface mode.
(config)#interface ce0	Enter interface mode
(config-if)# ip address 34.36.1.34/24	Configure the IP address of the interface ce0
(config-if)#label-switching	Enable label-switching on interface ce0
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process OSPF with process Id 100
(config-router)# network 31.34.1.0/24 area 0.0.0.0	Advertise connected interfaces to other RMTs under ospf 100 area 0.
(config-router)# network 34.36.1.0/24 area 0.0.0.0	Advertise connected interfaces to other RMTs under ospf 100 area 0.
(config-router)# network 9.9.9.9/32 area 0.0.0.0	Advertise lo interface under ospf 100 area 0.
(config-router)# bfd all-interfaces	Enable bfd over OSPF .
(config-router)#exit	Exit from router ospf mode
(config)#router rsvp	Enter Router rsvp config mode
(config-router)#no-php	Configure no-php under router rsvp config mode.
(config-router)#exit	Exit from router rsvp mode.
(config)#interface ce1	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface ce1
(config-if)#exit	Exit interface mode.

(config)#interface ce0	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface ce0
(config-if)#exit	Exit interface mode.
(config)#rsvp-path 9-to-2 mpls	Configure rsvp path to AGG-1 node.
(config-path)# 31.34.1.31 strict	Path specified as strict hop.
(config-path)# 31.35.1.35 strict	Path specified as strict hop.
(config-path)# 35.39.1.39 strict	Path specified as strict hop.
(config-if)#exit	Exit rsvp path config mode.
(config)#rsvp-path 9-to-3 mpls	Configure rsvp path to AGG-2 node.
(config-path)# 31.34.1.31 strict	Path specified as strict hop.
(config-path)# 31.35.1.35 strict	Path specified as strict hop.
(config-path)#exit	Exit rsvp path config mode.
(config)# rsvp-trunk 9-to-2 ipv4	Configure rsvp trunk to AGG-1 node.
(config-trunk)# primary fast-reroute protection one-to-one	Enable rsvp frr with protection as one-to-one.
(config-trunk)# primary fast-reroute node-protection	Enable rsvp frr with node protection.
(config-trunk)# primary path 9-to-2	Configure primary path to be used.
(config-trunk)# to 2.2.2.2	Configure loopback of AGG-1 node.
(config-trunk)#exit	Exit rsvp trunk config mode.
(config)# rsvp-trunk 9-to-3 ipv4	Configure rsvp trunk to AGG-2 node.
(config-trunk)# primary fast-reroute protection one-to-one	Enable rsvp frr with protection as one-to-one.
(config-trunk)# primary fast-reroute node-protection	Enable rsvp frr with node protection.
(config-trunk)# primary path 9-to-3	Configure primary path to be used.
(config-trunk)# to 3.3.3.3	Configure loopback of AGG-2 node.
(config-trunk)#exit	Exit rsvp trunk config mode.
(config)#router ldp	Enter Router ldp config mode

(config-router)# pw-status-tlv	Configure pw status tlv under router ldp config mode.
(config-router)# targeted-peer ipv4 2.2.2.2	Configure targeted ldp session to lo ip address of primary AGG node.
(config-router)# targeted-peer ipv4 3.3.3.3	Configure targeted ldp session to lo ip address of secondary AGG node.
(config-router)# no multicast-hellos	Disable multicast-hellos under router ldp.
(config-router)#exit	Exit from router ldp mode.
(config)#interface ce1	Enter interface mode
(config-if)# enable-ldp ipv4	Enable label-switching on interface ce1
(config-if)#exit	Exit interface mode.
(config)#interface ce0	Enter interface mode
(config-if)# enable-ldp ipv4	Enable label-switching on interface ce0
(config-if)#exit	Exit interface mode.
(config)# service-template vl1000	Configure service-template vl1000.
(config-svc)# match outer-vlan 1000	Match customer vlan 1000 .
(config-svc)# rewrite ingress push 100	Rewrite outer-vlan as : 100 and inner-vlan as :1000.
(config-svc)#exit	Exit from service-template config mode.
(config)# mpls l2-circuit vl1000 1000 2.2.2.2 service-tpid dot1.ad	Configure primary VPWS service to AGG-1 node with service-tpid as dot1.ad.
(config)# mpls l2-circuit vl1300 1300 3.3.3.3 service-tpid dot1.ad	Configure secondary VPWS service to AGG-2 node with service-tpid as dot1.ad.
(config)#interface xe8	Enter AC interface mode
(config-if)# switchport	Configure port as switchport.
(config-if)# mpls-l2-circuit vl1000 service-template vl1000	Attach primary VPWS services to AC interface.
(config-if)# mpls-l2-circuit vl1300 service-template vl1000 secondary	Attach secondary VPWS services to AC interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit global config mode.

4.2. AGG-1 Configuration

#configure terminal	Enter the Configure mode.
(config)#interface lo	Enter interface mode
(config-if)# ip address 2.2.2.2/32 secondary	Configure the IP address of the interface loopback
(config-if)#exit	Exit interface mode
(config)#interface xe16	Enter interface mode
(config-if)# ip address 39.40.1.40/24	Configure the IP address of the interface xe16
(config-if)#label-switching	Enable label-switching on interface xe16
(config-if)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode
(config-if)# ip address 63.40.1.40/24	Configure the IP address of the interface xe22
(config-if)#label-switching	Enable label-switching on interface xe22
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process OSPF with process Id 100
(config-router)# network 39.40.1.0/24 area 0.0.0.0	Advertise connected interfaces to secondary AGG node under ospf 100 area 0.
(config-router)# network 63.40.1.0/24 area 0.0.0.0	Advertise connected interfaces to other RMTs under ospf 100 area 0.
(config-router)# network 2.2.2.2/32 area 0.0.0.0	Advertise lo interface under ospf 100 area 0.
(config-router)# bfd all-interfaces	Enable bfd over OSPF .
(config-router)#exit	Exit from router ospf mode
(config)#interface Po1	Enter Port-channel config mode.
(config-if)#switchport	Configure Port-channel as L2 port-channel.
(config-if)#exit	Exit interface mode.
(config)#interface xe1	Enter Interface config mode.
(config-if)# channel-group 1 mode active	Configure Interface as member of Port-channel .

(config-if)#exit	Exit interface mode.
(config)#interface xe2	Enter Interface config mode.
(config-if)# channel-group 1 mode active	Configure Interface as member of Port-channel .
(config-if)#exit	Exit interface mode.
(config)# mcec domain configuration	Configure Mlag domain.
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mlag domain address
(config-mcec-domain)# domain-system-number 1	Configure mlag domain system number.
(config-mcec-domain)# intra-domain-link xe15	Configure mlag IDL link .
(config-mcec-domain)#exit	Exit from mlag domain configuration mode.
(config)#interface Po1	Enter Port-channel config mode.
(config-if)#mlag 1	Configure Port-channel as member of mlag 1.
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Router rsvp config mode
(config-router)#no-php	Configure no-php under router rsvp config mode.
(config-router)#exit	Exit from router rsvp mode.
(config)#interface xe22	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface xe22
(config-if)#exit	Exit interface mode.
(config)#interface xe16	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface xe16
(config-if)#exit	Exit interface mode.
(config)# rsvp-path 2-to-9 mpls	Configure rsvp path to RMT node.
(config-path)# 39.40.1.39 strict	Path specified as strict hop.
(config-path)# 35.39.1.35 strict	Path specified as strict hop.
(config-path)# 31.35.1.31 strict	Path specified as strict hop.
(config-path)#exit	Exit rsvp path config mode.

(config)# rsvp-trunk 2-to-9 ipv4	Configure rsvp trunk to RMT node.
(config-trunk)# primary fast-reroute protection one-to-one	Enable rsvp frr with protection as one-to-one.
(config-trunk)# primary fast-reroute node-protection	Enable rsvp frr with node protection.
(config-trunk)# primary path 2-to-9	Configure primary path to be used.
(config-trunk)# to 9.9.9.9	Configure loopback of RMT node.
(config-trunk)#exit	Exit rsvp trunk config mode.
(config)#router ldp	Enter Router ldp config mode
(config-router)# pw-status-tlv	Configure pw status tlv under router ldp config mode.
(config-router)# targeted-peer ipv4 9.9.9.9	Configure targeted ldp session to lo ip address of RMT node.
(config-router)# no multicast-hellos	Disable multicast-hellos under router ldp.
(config-router)#exit	Exit from router ldp mode.
(config)#interface xe16	Enter interface mode
(config-if)# enable-ldp ipv4	Enable ldp on interface xe16
(config-if)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode
(config-if)# enable-ldp ipv4	Enable ldp on interface xe22
(config-if)#exit	Exit interface mode.
(config)# service-template vl1000	Configure service-template vl1000.
(config-svc)# match double-tag outer-vlan 100 inner-vlan 1000	Match S-Vlan as : 100 and C-Vlan as :1000 .
(config-svc)#exit	Exit from service-template config mode.
(config)# mpls l2-circuit vl1000 1000 9.9.9.9 service-tpid dot1.ad	Configure primary VPWS service to RMT node with service-tpid as dot1.ad.
(config)#interface po1	Enter Port-channel interface mode
(config-if)# mpls-l2-circuit vl1000 service-template vl1000	Attach primary VPWS services to AC interface.
(config-if)#exit	Exit interface mode.

(config)#exit	Exit global config mode.

4.3. AGG-2 Configuration

#configure terminal	Enter the Configure mode.
(config)#interface lo	Enter interface mode
(config-if)# ip address 3.3.3.3/32 secondary	Configure the IP address of the interface loopback
(config-if)#exit	Exit interface mode
(config)#interface xe16	Enter interface mode
(config-if)# ip address 39.40.1.39/24	Configure the IP address of the interface xe16
(config-if)#label-switching	Enable label-switching on interface xe16
(config-if)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode
(config-if)# ip address 35.39.1.39/24	Configure the IP address of the interface xe22
(config-if)#label-switching	Enable label-switching on interface xe22
(config-if)#exit	Exit interface mode.
(config)#router ospf 100	Configure the routing process OSPF with process Id 100
(config-router)# network 35.39.1.0/24 area 0.0.0.0	Advertise connected interfaces to AGG node under ospf 100 area 0.
(config-router)# network 39.40.1.0/24 area 0.0.0.0	Advertise connected interfaces to other RMTs under ospf 100 area 0.
(config-router)# network 3.3.3.3/32 area 0.0.0.0	Advertise lo interface under ospf 100 area 0.
(config-router)# bfd all-interfaces	Enable bfd over OSPF .
(config-router)#exit	Exit from router ospf mode
(config)#interface Po1	Enter Port-channel config mode.
(config-if)#switchport	Configure Port-channel as L2 port-channel.
(config-if)#exit	Exit interface mode.

(config)#interface xe7	Enter Interface config mode.
(config-if)# channel-group 1 mode active	Configure Interface as member of Port-channel .
(config-if)#exit	Exit interface mode.
(config)#interface xe8	Enter Interface config mode.
(config-if)# channel-group 1 mode active	Configure Interface as member of Port-channel .
(config-if)#exit	Exit interface mode.
(config)# mcec domain configuration	Configure Mlag domain.
(config-mcec-domain)# domain-address 1111.2222.3333	Configure mlag domain address
(config-mcec-domain)# domain-system-number 2	Configure mlag domain system number.
(config-mcec-domain)# intra-domain-link xe15	Configure mlag IDL link .
(config-mcec-domain)#exit	Exit from mlag domain configuration mode.
(config)#interface Po1	Enter Port-channel config mode.
(config-if)#mlag 1	Configure Port-channel as member of mlag 1.
(config-if)#exit	Exit interface mode.
(config)#router rsvp	Enter Router rsvp config mode
(config-router)#no-php	Configure no-php under router rsvp config mode.
(config-router)#exit	Exit from router rsvp mode.
(config)#interface xe22	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface xe22
(config-if)#exit	Exit interface mode.
(config)#interface xe16	Enter interface mode
(config-if)#enable-rsvp	Enable rsvp on interface xe16
(config-if)#exit	Exit interface mode.
(config)# rsvp-path 3-to-9 mpls	Configure rsvp path to RMT node.
(config-path)# 35.39.1.35 strict	Path specified as strict hop.
(config-path)# 31.35.1.31 strict	Path specified as strict hop.

(config-path)#exit	Exit rsvp path config mode.
(config)# rsvp-trunk 3-to-9 ipv4	Configure rsvp trunk to RMT node.
(config-trunk)# primary fast-reroute protection one-to-one	Enable rsvp frr with protection as one-to-one.
(config-trunk)# primary fast-reroute node-protection	Enable rsvp frr with node protection.
(config-trunk)# primary path 3-to-9	Configure primary path to be used.
(config-trunk)# to 9.9.9.9	Configure loopback of RMT node.
(config-trunk)#exit	Exit rsvp trunk config mode.
(config)#router ldp	Enter Router ldp config mode
(config-router)# pw-status-tlv	Configure pw status tlv under router ldp config mode.
(config-router)# targeted-peer ipv4 9.9.9.9	Configure targeted ldp session to lo ip address of RMT node.
(config-router)# no multicast-hellos	Disable multicast-hellos under router ldp.
(config-router)#exit	Exit from router ldp mode.
(config)#interface xe16	Enter interface mode
(config-if)# enable-ldp ipv4	Enable ldp on interface xe16
(config-if)#exit	Exit interface mode.
(config)#interface xe22	Enter interface mode
(config-if)# enable-ldp ipv4	Enable ldp on interface xe22
(config-if)#exit	Exit interface mode.
(config)# service-template vl1300	Configure service-template vl1300.
(config-svc)# match double-tag outer-vlan 100 inner-vlan 1000	Match S-Vlan as : 100 and C-Vlan as :1000 .
(config-svc)#exit	Exit from service-template config mode.
(config)# mpls l2-circuit vl1300 1300 9.9.9.9 service-tpid dot1.ad	Configure primary VPWS service to RMT node with service-tpid as dot1.ad.
(config)#interface po1	Enter Port-channel interface mode

(config-if)# mpls-l2-circuit vl1300 service-template vl1300	Attach primary VPWS services to AC interface.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit global config mode.

4.4. Verification on RMT

RMT-34U#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Pri State Dead Time Address Interface Instance ID

7.7.7.7 1 Full/Backup 00:00:34 31.34.1.31 ce1 0

8.8.8.8 1 Full/Backup 00:00:33 34.36.1.36 ce0 0

RMT-34U#

RMT-34U#sh bfd session

BFD process for VRF: (DEFAULT VRF)

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Sess-Idx Remote-Disc Lower-Layer Sess-Type Sess-State UP-Time Interface Down-Reason Remote-Addr

1 1 IPv4 Single-Hop Up 1d03h14m ce0 NA 34.36.1.36/32

2 1 IPv4 Single-Hop Up 10:19:59 ce1 NA 31.34.1.31/32

Number of Sessions: 2

RMT-34U#show rsvp session

Ingress RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

2.2.2.2 9.9.9.9 Up Yes 1 1 SE - 24978 9-to-2-Primary 10:22:50 0s 17ms DEFAULT

2.2.2.2 34.36.1.34 Up No 1 1 SE - 24960 9-to-2-Detour 02:58:46 0s 12ms DEFAULT

3.3.3.3 9.9.9.9 Up Yes 1 1 SE - 24980 9-to-3-Primary 10:22:43 0s 8ms DEFAULT

3.3.3.3 34.36.1.34 Up No 1 1 SE - 24981 9-to-3-Detour 02:58:13 0s 12ms DEFAULT

Total 4 displayed, Up 4, Down 0.

Transit RSVP:

To	From	State	Pri	Rt	Style	Labelin	Labelout	LSPName	Uptime	Est.time	DSType
2.2.2.2	32.63.1.63	Up	Yes	1	1 SE	25615	24975	4-to-2-Detour	02:58:32	N/A	ELSP_CON
2.2.2.2	31.35.1.35	Up	Yes	1	1 SE	25622	24982	5-to-2-Detour	02:58:12	N/A	ELSP_CON
2.2.2.2	32.36.1.32	Up	Yes	1	1 SE	25620	24982	6-to-2-Detour	02:58:21	N/A	ELSP_CON
2.2.2.2	31.34.1.31	Up	Yes	1	1 SE	25602	24963	7-to-2-Detour	02:58:42	N/A	ELSP_CON
2.2.2.2	34.36.1.36	Up	Yes	1	1 SE	25609	24969	8-to-2-Detour	02:58:36	N/A	ELSP_CON
4.4.4.4	39.40.1.40	Up	Yes	1	1 SE	25613	24972	2-to-4-Detour	02:58:34	N/A	ELSP_CON
4.4.4.4	35.39.1.39	Up	Yes	1	1 SE	25604	24964	3-to-4-Detour	02:58:42	N/A	ELSP_CON
3.3.3.3	32.63.1.63	Up	Yes	1	1 SE	25605	24965	4-to-3-Detour	02:58:40	N/A	ELSP_CON
3.3.3.3	31.35.1.35	Up	Yes	1	1 SE	25617	24977	5-to-3-Detour	02:58:31	N/A	ELSP_CON
3.3.3.3	32.36.1.32	Up	Yes	1	1 SE	25616	24976	6-to-3-Detour	02:58:32	N/A	ELSP_CON
3.3.3.3	31.34.1.31	Up	Yes	1	1 SE	25623	24983	7-to-3-Detour	02:58:10	N/A	ELSP_CON

3.3.3.3 34.36.1.36 Up Yes 1 1 SE 25603 24964 8-to-3-Detour 02:58:41 N/A ELSP_CON

5.5.5.5 63.40.1.40 Up Yes 1 1 SE 25614 24973 2-to-5-Detour 02:58:33 N/A ELSP_CON

5.5.5.5 39.40.1.39 Up Yes 1 1 SE 25612 24971 3-to-5-Detour 02:58:34 N/A ELSP_CON

6.6.6.6 39.40.1.40 Up Yes 1 1 SE 25619 24979 2-to-6-Detour 02:58:22 N/A ELSP_CON

6.6.6.6 35.39.1.39 Up Yes 1 1 SE 25601 24962 3-to-6-Detour 02:58:43 N/A ELSP_CON

7.7.7.7 63.40.1.40 Up Yes 1 1 SE 25600 24960 2-to-7-Detour 02:58:45 N/A ELSP_CON

7.7.7.7 39.40.1.39 Up Yes 1 1 SE 25606 24966 3-to-7-Detour 02:58:37 N/A ELSP_CON

8.8.8.8 39.40.1.40 Up Yes 1 1 SE 25608 24968 2-to-8-Detour 02:58:37 N/A ELSP_CON

8.8.8.8 35.39.1.39 Up Yes 1 1 SE 25610 24970 3-to-8-Detour 02:58:36 N/A ELSP_CON

Total 20 displayed, Up 20, Down 0.

Egress RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

9.9.9.9 2.2.2.2 Up Yes 1 1 SE 25621 - 2-to-9-Primary 10:22:36 N/A ELSP_CON

9.9.9.9 63.40.1.40 Up Yes 1 1 SE 25618 - 2-to-9-Detour 02:58:26 N/A ELSP_CON

9.9.9.9 3.3.3.3 Up Yes 1 1 SE 25607 - 3-to-9-Primary 10:23:05 N/A ELSP_CON

9.9.9.9 39.40.1.39 Up Yes 1 1 SE 25611 - 3-to-9-Detour 02:58:35 N/A ELSP_CON

Total 4 displayed, Up 4, Down 0.

RMT-34U#

RMT-34U#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,

B - BGP FTN, K - CLI FTN, t - tunnel

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	Nexthop
R(t)>	2.2.2.2/32	5	5001	Yes	LSP_DEFAULT	24978	ce1	31.34.1.31
R(t)>	2.2.2.2/32	1	5001	No	LSP_DEFAULT	24960	ce0	34.36.1.36
R(t)>	3.3.3.3/32	2	5002	Yes	LSP_DEFAULT	24980	ce1	31.34.1.31
R(t)>	3.3.3.3/32	3	5002	No	LSP_DEFAULT	24981	ce0	34.36.1.36

RMT-34U#

RMT-34U#show ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
2.2.2.2	ce0	Active	OPERATIONAL	30	1d00h32m
3.3.3.3	ce0	Active	OPERATIONAL	30	1d03h12m

RMT-34U#

RMT-34U#sh mpls vc-table

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status
1000	N/A	N/A	xe8	ce1	25212	24978	2.2.2.2	Active
1300	N/A	N/A	xe8	ce1	24724	24980	3.3.3.3	Inactive

RMT-34U#

4.5. Verification on AGG-1

AGG1#show ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Pri State Dead Time Address Interface Instance ID

3.3.3.3 1 Full/DR 00:00:32 39.40.1.39 xe16 0

4.4.4.4 1 Full/DR 00:00:30 63.40.1.63 xe22 0

AGG1#sh bfd session

BFD process for VRF: (DEFAULT VRF)

==========

Sess-Idx Remote-Disc Lower-Layer Sess-Type Sess-State UP-Time Interface Down-Reason Remote-Addr

1 2 IPv4 Single-Hop Up 17:38:54 xe16 NA 39.40.1.39/32

2 1 IPv4 Single-Hop Up 03:02:13 xe22 NA 63.40.1.63/32

Number of Sessions: 2

AGG1#sh rsvp session

Ingress RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

4.4.4.4 2.2.2.2 Up Yes 1 1 SE - 24960 2-to-4-Primary 03:02:20 0s 3ms DEFAULT

4.4.4.4 39.40.1.40 Up No 1 1 SE - 24968 2-to-4-Detour 03:02:03 0s 17ms DEFAULT

5.5.5.5 2.2.2.2 Up Yes 1 1 SE - 24964 2-to-5-Primary 17:38:49 1s 132ms DEFAULT

5.5.5.5 63.40.1.40 Up No 1 1 SE - 24975 2-to-5-Detour 03:02:02 0s 58ms DEFAULT

6.6.6.6 2.2.2.2 Up Yes 1 1 SE - 24979 2-to-6-Primary 03:01:51 0s 14ms DEFAULT

6.6.6.6 39.40.1.40 Up No 1 1 SE - 24976 2-to-6-Detour 03:01:51 0s 53ms DEFAULT

7.7.7.7 2.2.2.2 Up Yes 1 1 SE - 24972 2-to-7-Primary 17:38:36 3s 208ms DEFAULT

7.7.7.7 63.40.1.40 Up No 1 1 SE - 24962 2-to-7-Detour 03:02:14 0s 12ms DEFAULT

8.8.8.8 2.2.2.2 Up Yes 1 1 SE - 24968 2-to-8-Primary 03:02:06 0s 18ms DEFAULT

8.8.8.8 39.40.1.40 Up No 1 1 SE - 24966 2-to-8-Detour 03:02:06 0s 16ms DEFAULT

9.9.9.9 2.2.2.2 Up Yes 1 1 SE - 24981 2-to-9-Primary 10:26:05 0s 12ms DEFAULT

9.9.9.9 63.40.1.40 Up No 1 1 SE - 24978 2-to-9-Detour 03:01:55 0s 42ms DEFAULT

Total 12 displayed, Up 12, Down 0.

Transit RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

4.4.4.4 3.3.3.3 Up Yes 1 1 SE 25602 24964 3-to-4-Primary 03:02:11 N/A ELSP_CON

3.3.3.3 4.4.4.4 Up Yes 1 1 SE 25605 24963 4-to-3-Primary 03:02:09 N/A ELSP_CON

3.3.3.3 31.35.1.35 Up Yes 1 1 SE 25616 24974 5-to-3-Detour 03:02:00 N/A ELSP_CON

3.3.3.3 6.6.6.6 Up Yes 1 1 SE 25613 24969 6-to-3-Primary 03:02:01 N/A ELSP_CON

3.3.3.3 31.34.1.31 Up Yes 1 1 SE 25623 24983 7-to-3-Detour 03:01:39 N/A ELSP_CON

3.3.3.3 8.8.8.8 Up Yes 1 1 SE 25604 24961 8-to-3-Primary 03:02:10 N/A ELSP_CON

3.3.3.3 34.36.1.34 Up Yes 1 1 SE 25620 24982 9-to-3-Detour 03:01:42 N/A ELSP_CON

5.5.5.5 39.40.1.39 Up Yes 1 1 SE 25611 24974 3-to-5-Detour 03:02:03 N/A ELSP_CON

6.6.6.6 3.3.3.3 Up Yes 1 1 SE 25601 24963 3-to-6-Primary 03:02:12 N/A ELSP_CON

7.7.7.7 39.40.1.39 Up Yes 1 1 SE 25606 24969 3-to-7-Detour 03:02:06 N/A ELSP_CON

8.8.8.8 3.3.3.3 Up Yes 1 1 SE 25609 24971 3-to-8-Primary 03:02:05 N/A ELSP_CON

9.9.9.9 39.40.1.39 Up Yes 1 1 SE 25610 24972 3-to-9-Detour 03:02:04 N/A ELSP_CON

Total 12 displayed, Up 12, Down 0.

Egress RSVP:

To	From	State	Pri	Rt	Style	Labelin	Labelout	LSPName	Uptime	Est.time	DSType
2.2.2.2	4.4.4.4	Up	Yes	1	1 SE	25612	-	4-to-2-Primary	03:02:01	N/A	ELSP_CON
2.2.2.2	32.63.1.63	Up	Yes	1	1 SE	25614	-	4-to-2-Detour	03:02:01	N/A	ELSP_CON
2.2.2.2	5.5.5.5	Up	Yes	1	1 SE	25618	-	5-to-2-Primary	17:38:33	N/A	ELSP_CON
2.2.2.2	31.35.1.35	Up	Yes	1	1 SE	25622	-	5-to-2-Detour	03:01:41	N/A	ELSP_CON
2.2.2.2	6.6.6.6	Up	Yes	1	1 SE	25617	-	6-to-2-Primary	03:01:50	N/A	ELSP_CON
2.2.2.2	32.36.1.32	Up	Yes	1	1 SE	25619	-	6-to-2-Detour	03:01:50	N/A	ELSP_CON
2.2.2.2	7.7.7.7	Up	Yes	1	1 SE	25615	-	7-to-2-Primary	17:38:34	N/A	ELSP_CON
2.2.2.2	31.34.1.31	Up	Yes	1	1 SE	25603	-	7-to-2-Detour	03:02:11	N/A	ELSP_CON
2.2.2.2	8.8.8.8	Up	Yes	1	1 SE	25607	-	8-to-2-Primary	03:02:05	N/A	ELSP_CON
2.2.2.2	34.36.1.36	Up	Yes	1	1 SE	25608	-	8-to-2-Detour	03:02:05	N/A	ELSP_CON
2.2.2.2	9.9.9.9	Up	Yes	1	1 SE	25621	-	9-to-2-Primary	10:26:19	N/A	ELSP_CON
2.2.2.2	34.36.1.34	Up	Yes	1	1 SE	25600	-	9-to-2-Detour	03:02:15	N/A	ELSP_CON

Total 12 displayed, Up 12, Down 0.

AGG1#sh mlag domain summary

Domain Configuration

Domain System Number : 1

Domain Address : 1111.2222.3333

Domain Priority : 32768

Intra Domain Interface : xe15

Domain Adjacency : UP

MLAG Configuration

MLAG-1

Mapped Aggregator : po1

Physical properties Digest : 33 e0 6d 8a 88 5e 89 59 23 54 4f a3 9e 55 1b 9f

Total Bandwidth : 20g

Mlag Sync : IN_SYNC

Mode : Active-Standby

Current Mlag state : Active

AGG1#

AGG1#

AGG1#sh ldp session

Peer IP Address	IF Name	My Role	State	KeepAlive	UpTime
4.4.4.4	xe22	Passive	OPERATIONAL	30	03:02:27
5.5.5.5	xe16	Passive	OPERATIONAL	30	1d00h37m
6.6.6.6	xe22	Passive	OPERATIONAL	30	03:34:27
7.7.7.7	xe16	Passive	OPERATIONAL	30	1d00h37m

8.8.8.8 xe22 Passive OPERATIONAL 30 1d00h37m

9.9.9.9 xe22 Passive OPERATIONAL 30 1d00h37m

AGG1#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,

B - BGP FTN, K - CLI FTN, t - tunnel

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	Nexthop
R(t)>	4.4.4.4/32	1	5001	Yes	LSP_DEFAULT	24960	xe22	63.40.1.63
R(t)>	4.4.4.4/32	5	5001	No	LSP_DEFAULT	24968	xe16	39.40.1.39
R(t)>	5.5.5.5/32	6	5002	Yes	LSP_DEFAULT	24964	xe16	39.40.1.39
R(t)>	5.5.5.5/32	7	5002	No	LSP_DEFAULT	24975	xe22	63.40.1.63
R(t)>	6.6.6.6/32	9	5003	Yes	LSP_DEFAULT	24979	xe22	63.40.1.63
R(t)>	6.6.6.6/32	11	5003	No	LSP_DEFAULT	24976	xe16	39.40.1.39
R(t)>	7.7.7.7/32	10	5004	Yes	LSP_DEFAULT	24972	xe16	39.40.1.39
R(t)>	7.7.7.7/32	2	5004	No	LSP_DEFAULT	24962	xe22	63.40.1.63
R(t)>	8.8.8.8/32	3	5005	Yes	LSP_DEFAULT	24968	xe22	63.40.1.63
R(t)>	8.8.8.8/32	4	5005	No	LSP_DEFAULT	24966	xe16	39.40.1.39
R(t)>	9.9.9.9/32	12	5006	Yes	LSP_DEFAULT	24981	xe16	39.40.1.39
R(t)>	9.9.9.9/32	8	5006	No	LSP_DEFAULT	24978	xe22	63.40.1.63

AGG1#sh mpls vc-table

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status
1000	N/A	N/A	po1	xe16	24960	24981	9.9.9.9	Active

4.6. Verification on AGG-2

AGG2#sh ip ospf neighbor

Total number of full neighbors: 2

OSPF process 100 VRF(default):

Neighbor ID Pri State Dead Time Address Interface Instance ID

5.5.5.5 1 Full/DR 00:00:39 35.39.1.35 xe22 0

2.2.2.2 1 Full/Backup 00:00:34 39.40.1.40 xe16 0

AGG2#sh bfd session

BFD process for VRF: (DEFAULT VRF)

==========

Sess-Idx Remote-Disc Lower-Layer Sess-Type Sess-State UP-Time Interface Down-Reason Remote-Addr

1 2 IPv4 Single-Hop Up 1d03h21m xe22 NA 35.39.1.35/32

2 1 IPv4 Single-Hop Up 17:42:01 xe16 NA 39.40.1.40/32

Number of Sessions: 2

AGG2#sh rsvp session

Ingress RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

4.4.4.4 3.3.3.3 Up Yes 1 1 SE - 25602 3-to-4-Primary 03:05:17 0s 6ms DEFAULT

4.4.4.4 35.39.1.39 Up No 1 1 SE - 24962 3-to-4-Detour 03:05:17 0s 21ms DEFAULT

5.5.5.5 3.3.3.3 Up Yes 1 1 SE - 24968 3-to-5-Primary 01d03h20m 0s 3ms DEFAULT

5.5.5.5 39.40.1.39 Up No 1 1 SE - 25611 3-to-5-Detour 03:05:09 0s 18ms DEFAULT

6.6.6.6 3.3.3.3 Up Yes 1 1 SE - 25601 3-to-6-Primary 03:05:18 0s 8ms DEFAULT

6.6.6.6 35.39.1.39 Up No 1 1 SE - 24960 3-to-6-Detour 03:05:18 0s 13ms DEFAULT

7.7.7.7 3.3.3.3 Up Yes 1 1 SE - 24961 3-to-7-Primary 01d03h20m 0s 5ms DEFAULT

7.7.7.7 39.40.1.39 Up No 1 1 SE - 25606 3-to-7-Detour 03:05:12 0s 19ms DEFAULT

8.8.8.8 3.3.3.3 Up Yes 1 1 SE - 25609 3-to-8-Primary 03:05:11 0s 20ms DEFAULT

8.8.8.8 35.39.1.39 Up No 1 1 SE - 24970 3-to-8-Detour 03:05:11 0s 9ms DEFAULT

9.9.9.9 3.3.3.3 Up Yes 1 1 SE - 24967 3-to-9-Primary 10:29:40 0s 9ms DEFAULT

9.9.9.9 39.40.1.39 Up No 1 1 SE - 25610 3-to-9-Detour 03:05:10 0s 12ms DEFAULT

Total 12 displayed, Up 12, Down 0.

Transit RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time DSType

2.2.2.2 32.63.1.63 Up Yes 1 1 SE 24970 25614 4-to-2-Detour 03:05:07 N/A ELSP_CON

2.2.2.2 5.5.5.5 Up Yes 1 1 SE 24977 25618 5-to-2-Primary 17:41:39 N/A ELSP_CON

2.2.2.2 32.36.1.32 Up Yes 1 1 SE 24979 25619 6-to-2-Detour 03:04:56 N/A ELSP_CON

2.2.2.2 7.7.7.7 Up Yes 1 1 SE 24975 25615 7-to-2-Primary 17:41:40 N/A ELSP_CON

2.2.2.2 34.36.1.36 Up Yes 1 1 SE 24967 25608 8-to-2-Detour 03:05:11 N/A ELSP_CON

2.2.2.2 9.9.9.9 Up Yes 1 1 SE 24978 25621 9-to-2-Primary 10:29:25 N/A ELSP_CON

4.4.4.4 39.40.1.40 Up Yes 1 1 SE 24968 24972 2-to-4-Detour 03:05:09 N/A ELSP_CON

5.5.5.5 2.2.2.2 Up Yes 1 1 SE 24964 24964 2-to-5-Primary 17:41:55 N/A ELSP_CON

6.6.6.6 39.40.1.40 Up Yes 1 1 SE 24976 24982 2-to-6-Detour 03:04:57 N/A ELSP_CON

7.7.7.7 2.2.2.2 Up Yes 1 1 SE 24972 24973 2-to-7-Primary 17:41:46 N/A
ELSP_CON

8.8.8.8 39.40.1.40 Up Yes 1 1 SE 24966 24966 2-to-8-Detour 03:05:12 N/A
ELSP_CON

9.9.9.9 2.2.2.2 Up Yes 1 1 SE 24981 24981 2-to-9-Primary 10:29:11 N/A
ELSP_CON

Total 12 displayed, Up 12, Down 0.

Egress RSVP:

To From State Pri Rt Style Labelin Labelout LSPName Uptime Est.time
DSType

3.3.3.3 4.4.4.4 Up Yes 1 1 SE 24963 - 4-to-3-Primary 03:05:15 N/A
ELSP_CON

3.3.3.3 32.63.1.63 Up Yes 1 1 SE 24965 - 4-to-3-Detour 03:05:15 N/A
ELSP_CON

3.3.3.3 5.5.5.5 Up Yes 1 1 SE 24960 - 5-to-3-Primary 01d03h20m N/A
ELSP_CON

3.3.3.3 31.35.1.35 Up Yes 1 1 SE 24974 - 5-to-3-Detour 03:05:06 N/A
ELSP_CON

3.3.3.3 6.6.6.6 Up Yes 1 1 SE 24969 - 6-to-3-Primary 03:05:07 N/A
ELSP_CON

3.3.3.3 32.36.1.32 Up Yes 1 1 SE 24973 - 6-to-3-Detour 03:05:07 N/A
ELSP_CON

3.3.3.3 7.7.7.7 Up Yes 1 1 SE 24971 - 7-to-3-Primary 01d03h20m N/A
ELSP_CON

3.3.3.3 31.34.1.31 Up Yes 1 1 SE 24983 - 7-to-3-Detour 03:04:45 N/A
ELSP_CON

3.3.3.3 8.8.8.8 Up Yes 1 1 SE 24961 - 8-to-3-Primary 03:05:16 N/A
ELSP_CON

3.3.3.3 34.36.1.36 Up Yes 1 1 SE 24962 - 8-to-3-Detour 03:05:16 N/A
ELSP_CON

3.3.3.3 9.9.9.9 Up Yes 1 1 SE 24980 - 9-to-3-Primary 10:29:18 N/A
ELSP_CON

3.3.3.3 34.36.1.34 Up Yes 1 1 SE 24982 - 9-to-3-Detour 03:04:48 N/A
ELSP_CON

Total 12 displayed, Up 12, Down 0.

AGG2#sh mlag domain summary

Domain Configuration

Domain System Number : 2

Domain Address : 1111.2222.3333

Domain Priority : 32768

Intra Domain Interface : xe15

Domain Adjacency : UP

MLAG Configuration

MLAG-1

Mapped Aggregator : po1

Physical properties Digest : 33 e0 6d 8a 88 5e 89 59 23 54 4f a3 9e 55 1b 9f

Total Bandwidth : 20g

Mlag Sync : IN_SYNC

Mode : Active-Standby

Current Mlag state : Standby

AGG2#sh ldp session

Peer IP Address IF Name My Role State KeepAlive UpTime

4.4.4.4 xe16 Passive OPERATIONAL 30 03:05:42

5.5.5.5 xe22 Passive OPERATIONAL 30 1d03h21m

6.6.6.6 xe16 Passive OPERATIONAL 30 03:37:42

7.7.7.7 xe22 Passive OPERATIONAL 30 1d03h21m

8.8.8.8 xe16 Passive OPERATIONAL 30 1d03h20m

9.9.9.9 xe22 Passive OPERATIONAL 30 1d03h20m

AGG2#sh mpls forwarding-table

Codes: > - installed FTN, * - selected FTN, p - stale FTN,

B - BGP FTN, K - CLI FTN, t - tunnel

L - LDP FTN, R - RSVP-TE FTN, S - SNMP FTN, I - IGP-Shortcut,

U - unknown FTN, O - SR-OSPF FTN, i - SR-ISIS FTN, k - SR-CLI FTN

Code	FEC	FTN-ID	Tunnel-id	Pri	LSP-Type	Out-Label	Out-Intf	Nexthop
R(t)>	4.4.4.4/32	5	5001	Yes	LSP_DEFAULT	25602	xe16	39.40.1.40
R(t)>	4.4.4.4/32	7	5001	No	LSP_DEFAULT	24962	xe22	35.39.1.35
R(t)>	5.5.5.5/32	6	5002	Yes	LSP_DEFAULT	24968	xe22	35.39.1.35
R(t)>	5.5.5.5/32	12	5002	No	LSP_DEFAULT	25611	xe16	39.40.1.40
R(t)>	6.6.6.6/32	1	5003	Yes	LSP_DEFAULT	25601	xe16	39.40.1.40
R(t)>	6.6.6.6/32	3	5003	No	LSP_DEFAULT	24960	xe22	35.39.1.35
R(t)>	7.7.7.7/32	2	5004	Yes	LSP_DEFAULT	24961	xe22	35.39.1.35
R(t)>	7.7.7.7/32	8	5004	No	LSP_DEFAULT	25606	xe16	39.40.1.40
R(t)>	8.8.8.8/32	11	5005	Yes	LSP_DEFAULT	25609	xe16	39.40.1.40
R(t)>	8.8.8.8/32	4	5005	No	LSP_DEFAULT	24970	xe22	35.39.1.35
R(t)>	9.9.9.9/32	9	5006	Yes	LSP_DEFAULT	24967	xe22	35.39.1.35
R(t)>	9.9.9.9/32	10	5006	No	LSP_DEFAULT	25610	xe16	39.40.1.40

AGG2#sh mpls vc-table

VC-ID	Vlan-ID	Inner-Vlan-ID	Access-Intf	Network-Intf	Out Label	Tunnel-Label	Nexthop	Status
1300	N/A	N/A	po1	xe22	24961	24967	9.9.9.9	Inactive

AGG2#

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5. Summary

OcNOS MPLS psuedowire services can be deployed to provide L2VPN transport backhaul required for fixed wireless LTE services.