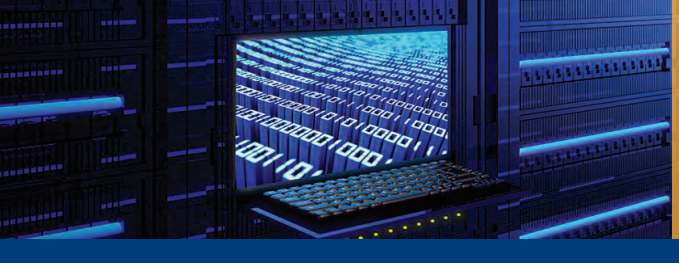


Solution Guide

Open Compute Network Operating System Version 1.2.0

OcNOS™ Validated Solution Guide
Data Center Interconnect using MPLS

ip infusion™

Contents

Glossary

MPLS	Multi protocol label switching
VPLS	Virtual Pseudowire LAN services
VPWS	VPWS – Virtual Pseudowire services
VxLAN	Virtual Extensible LAN
OTV	Overlay transport virtualization
LISP	Locator/Identifier Separation Protocol
DCI	Data center interconnect
MC-LAG	Multi-Chassis LAG

Chapter 1

Data Center Interconnect Overview

- Data center interconnect use-cases
- Data center interconnect technologies
- Multipoint interconnect using VPLS

Data Center Interconnect Use Cases

Data centers are usually not local to a particular geographical location. They span across regions and countries throughout the globe. Data centers often manage critical and voluminous data which poses a challenge to the networking technology.

The applications running inside the data center are agnostic to the interconnection technology and often treat data centers on different sites transparently. One requirement of having multiple data centers is to provide a High-Availability clusters in which if one data center site fails, traffic can switch to the other without disruption. Another use case is server mobility across data center which is often done for load balancing or better user experience. A general requirement therefore is to have layer-2 connectivity between the data centers to expose a unified network towards the applications or the servers running in different data centers. MPLS data center interconnection is a viable choice as the sections below describe.

Data Center Interconnect Technologies

The popular ways of data center interconnects are;

- Dark Fiber
- IP Based
  - VxLAN
  - OTV and LISP
- MPLS Based
  - Point to Point interconnect using VPWS
  - Multipoint interconnect using VPLS

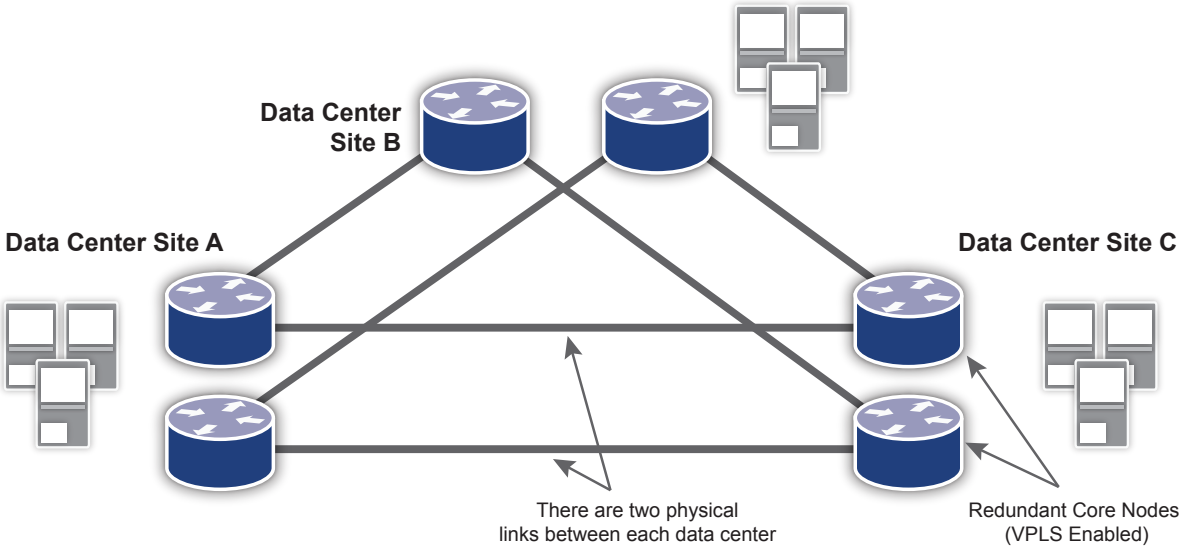
Dark Fiber can give end to end layer 2 connectivity but is not always a feasible solution when sites are separated geographically over very wide areas. Using VxLAN for data center connectivity is an emerging technology. OcNOS has support for this but it will not be elaborated in this current document. OTV is a proprietary solution.

The preferred choice of data center interconnect (DCI) is using MPLS. This is a proven technology and most modern data centers are interconnected using MPLS. Sometimes large data center enterprises prefer owning the MPLS core nodes themselves, to have better flexibility in designing their data center interconnect solution. OcNOS enables them with this by its MPLS interconnect solution.

Layer 2VPN connectivity can be achieved by either VPWS or VPLS. VPWS can be only used when interconnecting two sites, while VPLS allows for a multi-site connectivity and therefore is more flexible. VPLS works by essentially creating multiple point to point MPLS tunnels carrying the Layer2 frame encapsulated. It uses a combination of LDP and/or BGP for peer discovery and signaling. This validated solution guide will explain how OcNOS switches can be used to connect multisite data centers using VPLS.

Multipoint Interconnect using VPLS

The following diagram shows a typical case of data center interconnect where three data center sites are involved. Generally it is preferred to have an IP/MPLS loop connection such that there is a backup path available in case of failure. In each data center two DCI core nodes are deployed as redundant to each other and there are two links between each data center site, each terminating on one of the redundant nodes.



Note: Only the DCI core switches of each data center is shown.

The data center core nodes terminate the Layer-2 network of the data center and map the traffic over VPLS to the other data center sites. Thus, the layer 2 domains of the each data center is extended onto the other.

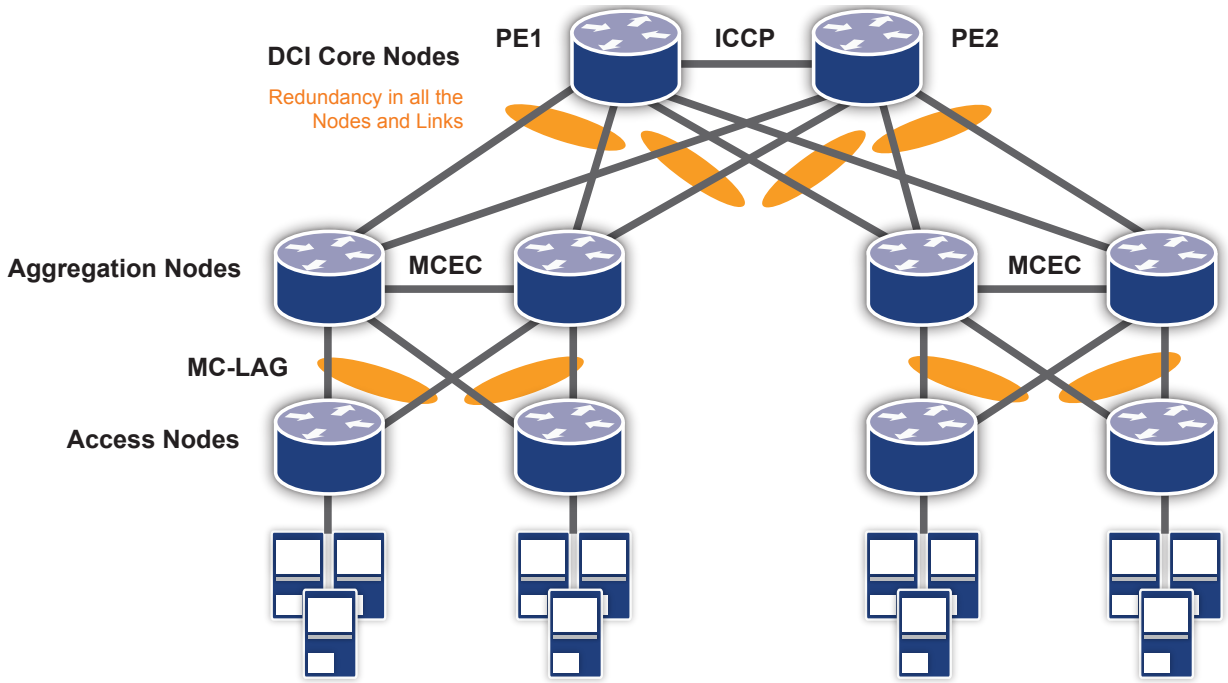
Chapter 2

OcNOS DCI MPLS Overview

- OcNOS DCI MPLS architecture
- Role determination using ICCP
- VPLS redundancy
- MC-LAG in the data center using MPLS DCI

OcNOS DCI VPLS Architecture

Figure 2. DCI VPLS Architecture



The above topology diagram demonstrates the network architecture on which this solution is developed.

The topology is a standard 3-tier architecture of access, aggregation and core nodes. OcNOS is running on all the nodes. The DCI core node is a layer 3 switch with MPLS enabled and is serving as the layer 2/layer 3 edge node. The aggregation and access nodes are layer 2 switches.

- The layer 3 switches (the DCI core nodes), terminate the layer 2 connections on one end and have VPLS deployed over the Data center interconnect. The layer 3 switches run Inter-Chassis Communication protocol (ICCP). The same VPLS instance is running on both the DCI core nodes. ICCP synchronizes which node will act as the active/standby for a particular VPLS instance.
- On the layer 2 switches (the aggregation and access nodes), an IPI proprietary OcNOS Multi-Chassis Lag (MC-LAG) is deployed, which provides node redundancy as well as link redundancy. MC-LAG is working in Active-Active mode.

The DCI Core nodes does load sharing based on VLANs which will be mapped to different VPLS instances. Some key features of this solution is

- Aggregation nodes are in MLAG domain. Core Nodes are not in MLAG Domain.
- All the nodes have redundancy, and all are active in steady state.
- All the links have redundancy and working in active/active mode.

Role determination using ICCP

ICCP protocol is defined in RFC 7275. The OcNOS implementation of ICCP is modelled on RFC 7275 with some proprietary implementations for better results. Two nodes form a 'Redundancy Group'. An ICCP connection is established between the two nodes over a LDP connection.

```
Configure interchassis peer
PE1(config)#redundancy interchassis group 1
PE1(config-red)#member ip 1.0.0.2
PE1(config-red)#exit
PE1(config)#
PE1#show iccp session
ICCP Session Status:
ICCP RG ID :1
ICCP Member IP :1.0.0.2
Session Current State = Operational(3)
Session Previous State = Connecting(2)
```

ICCP exchanges the VPLS information between the redundant groups, and decides which VPLS instance will be Active/Standby. The administrator can give a preference primary/secondary for a certain VPLS instance on a node and based on that ICCP will choose on which node the VPLS instance will be made Active. The other will be standby. If no preference is given, admin preference is taken as primary, and then ICCP will do a tie-breaker and chooses one on its own logic.

As shown in the diagram below, VPLS-A had the admin role of primary but the operational role determined by ICCP by communicating with its redundant pair is secondary. So this VPLS instance will be standby and will not be forwarding any traffic mapped to it.

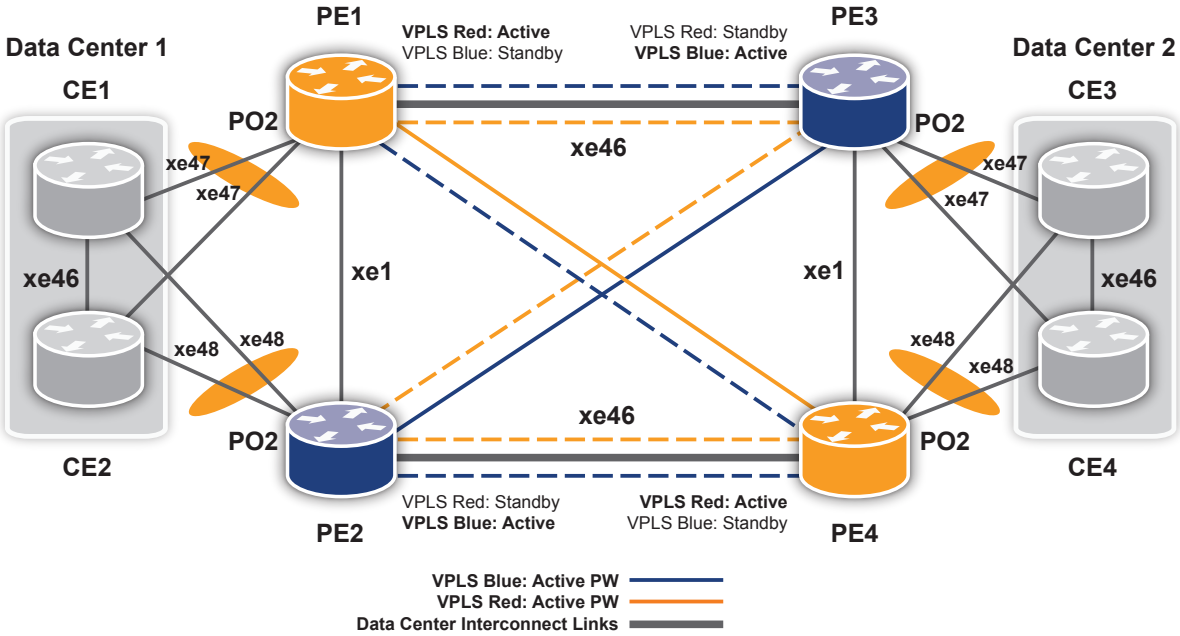
```
PE1#show mpls vpls detail
Virtual Private LAN Service Instance: VPLS-Red, ID: 1
SIG-Protocol: LDP
Learning: Enabled
Group ID: 0, VPLS Type: Ethernet VLAN, Configured MTU: 1500
Description: none
Operating mode: Tagged
Svlan Id: 0
Svlan Tpid: 0
Redundancy admin role: Primary
Redundancy oper role: Secondary
Configured interfaces:
Interface: xe17
Vlan Id: 500
```

VPLS Redundancy

As mentioned earlier (See Figure DCI VPLS Architecture), the DCI core nodes terminate the layer 2 connections of the data center and extend it over to the other data center using VPLS. The core node which is running VPLS are connected to each other on different data centers. If the core node fails the entire data center connectivity will be lost. Thus, it is very critical for the data center to have a redundancy on the core nodes. For the core node redundancy, VPLS redundancy is also required.

The following diagram shows how typically two data centers are interconnected. The PE nodes (DCI Core nodes) are dual homed to CEs nodes which are part of a MCLAG domain. MC-LAG expands the concept of link aggregation so that it provides node-level redundancy by allowing two or more nodes to share a common LAG endpoint. It emulates multiple nodes to represent as a single logical node to the remote node running Link aggregation. From the perspective of the PE nodes it can be considered that its 'dual homed' to a single CE node. The VPLS instances running in the PE node, have attachment circuits as LAG ports (not MCLAG). Pseudo wires(which are essentially MPLS tunnels encapsulating the Layer2 circuits) are set up between each PE node in one data center to both the PE nodes in other data center. ICCP decides which VPLS instance will be made Active/Standby and based on that the pseudo wires corresponding to the VPLS instances exchange pseudo wire status messages. After negotiations, one pseudo wire per VPLS will be active between the data centers. In the figure, the standby Pseudo wires are shown in dotted lines and the active in bold lines. For VPLS RED the pseudo wire between PE1 and PE4 is active. For VPLS Blue pseudo wire between PE2 and PE3 is active.

Figure 3. VPLS Redundancy



VPLS redundancy always operates in Active/Standby mode, that is both nodes cannot be active simultaneously. Thus if there is a single VPLS instance only one core node in a data center will have an active VPLS and the other node will be standby and unutilized. That is why in solution design for data center adopted an approach to split the layer 2 traffic based on VLAN ranges and map them to two VPLS instances. Each node will have one active VPLS instance, and one standby VPLS instance. This is applicable if the VPLS attachment circuits are in Port+VLAN mode.

```
PE1(config)#mpls vpls VPLS-Red 1
PE1(config-vpls)#redundancy-role primary
PE1(config-vpls)#exit
PE1(config)#mpls vpls VPLS-Blue 2
PE1(config-vpls)#redundancy-role secondary
PE1(config-vpls)#exit
PE1(config)#interface xe9
PE1(config-if)#mpls-vpls VPLS-Red vlan 2-100
PE1(config-if)#mpls-vpls VPLS-Blue vlan 101-200
```

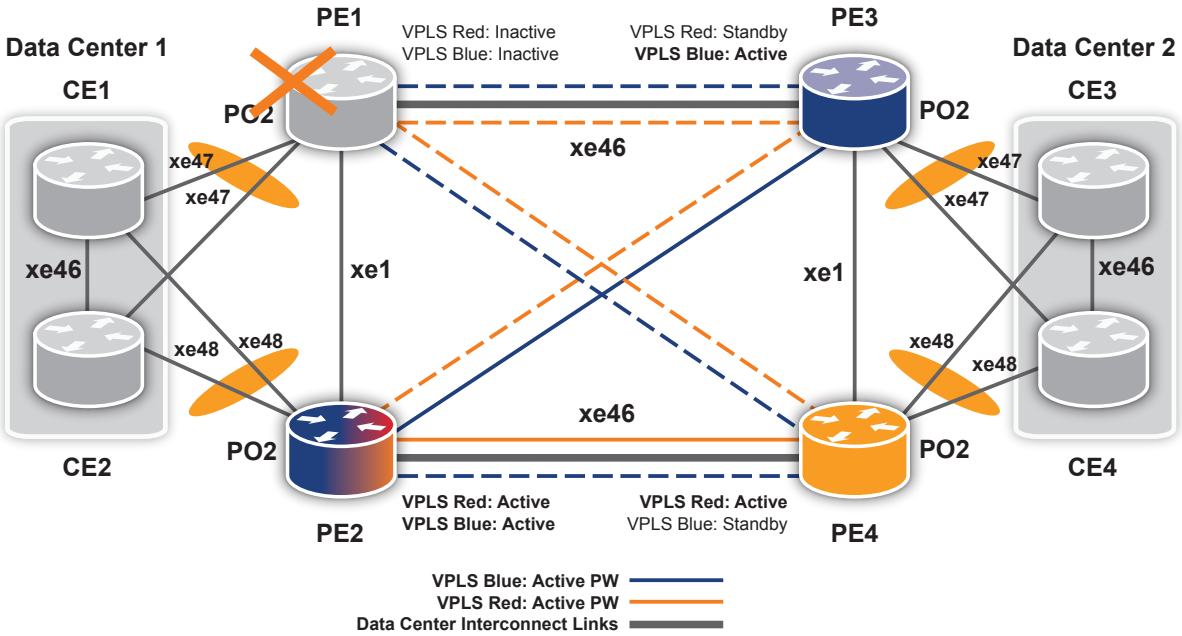
Admin preference for VPLS-Blue is secondary, so that it can become standby in this node.

VLAN 2-200 distributed between VPLS-Red and VPLS-Blue while binding VPLS to xe9 port.

With reference to the topology in figure 3, the VLANs 2-200 are distributed between VPLS-Red and VPLS-Blue. In data center 1, PE1 has VPLS-Red as 'Active', serving VLANs 2-100 and PE2 has VPLS-Blue as 'Active' serving VLANs 101-200. Thus the traffic is load balanced between the two redundant Nodes. The pseudo wires send status TLV corresponding to the active/standby status of the VPLS its part of and after negotiation one pseudo wire between the data centers will be up per VPLS.

Handling Failure Scenarios

Figure 4. Handling Failure Scenarios



In practice we can even have more than two VPLS instances dedicated to different ranges of VLANs, or even mapped to particular VLANs. If the preference given for a particular VPLS instance on both the redundant DCI core node is the same, ICCP will do a tie-breaker and select only one as active.

Note: The same VLAN should not be mapped to two different VPLS instances.

If the attachment circuit connected to a DCI core node is down, or the Node itself is down, the redundant node will take up all the operations.

The figure above(Figure: Handling Failure Scenarios) shows that PE1 is down. ICCP communication between the DCI core nodes detects this failure and thus PE2 will now host all the operations. Thus both the VPLS instances become active in PE2 node. The pseudo wire status is exchanged accordingly and again there will be one pseudo wire active per VPLS between the two data centers, in this case for VPLS Red between PE2 and PE4 and for VPLS Blue between PE2 and PE3.

MC-LAG in a Data Center using MPLS DCI

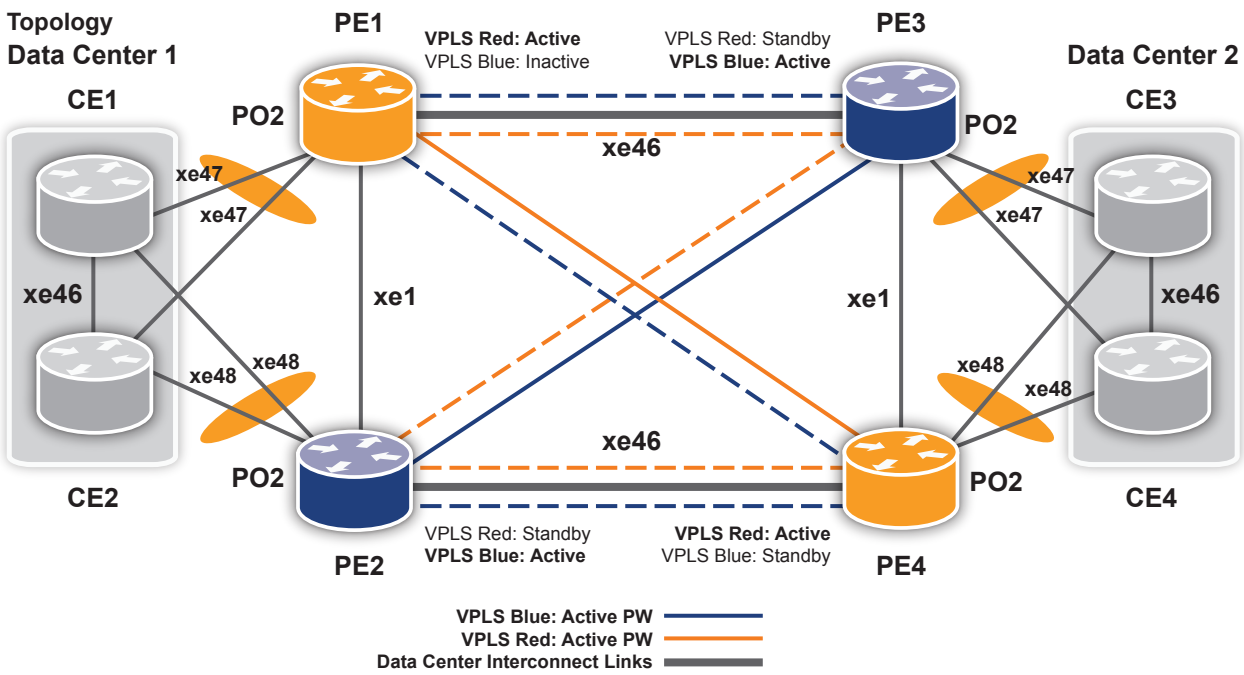
As explained earlier MC-LAG expands the concept of link aggregation so that it provides node-level redundancy by allowing two or more nodes to share a common LAG endpoint. It emulates multiple nodes to represent as a single logical node to the remote node running Link aggregation. As a result even if one of the nodes is down there exists a path to reach the destination via other nodes.

The topology in the figure “Handling Failure Scenarios” shows that DCI only deploys MC-LAG only at the Aggregation Nodes. The DCI Core nodes are not running it. However we still have link redundancy between Aggregation and DCI layer. This is because as shown in figure 4, there is a dual homing between each Aggregation node towards both the DCI core node. If the link CE1-PE1 fails, then CE2-PE1 link takes up by virtue of MC- LAG. If both the CE1-PE1, CE2-PE1 link fails, then ICCP will trigger switchover and the PE2 node will be active for all the VPLS instances.

Also there is no duplicate traffic going out of the DCI core nodes because they have VLAN-based load sharing, and a particular VLAN is taken up only by one of the two core nodes when both nodes are up. Thus, even though duplicate traffic reaches to the core nodes, it is dropped by the node which is not serving that particular VLAN. Guaranteeing a loop free topology.

Basic Example Configuration

Figure 5. Basic Example Configuration



PE1

	CLI command	Purpose
Create the interfaces		
Step 1	`(config)#interface xe1`	Enter interface mode.
Step 2	`(config-if)#ip address 20.0.0.1/24`	Configure ip address on ICCP interface
Step 3	`(config-if)#label-switching`	Enable label switching
Step 4	`(config-if)#exit`	Exit interface mode.
Step 5	`(config)#interface xe46`	Enter interface mode.
Step 5	`(config-if)#ip address 11.0.0.1/24`	Configure ip address on interface
Step 7	`(config-if)#label-switching`	Enable label switching
Step 8	`(config-if)#exit`	Exit interface mode.
Step 9	`(config)#interface lo`	Enter interface mode.
Step 10	`(config-if)#ip address 1.1.1.1/32`	Set the IP address of the loopback interface
Step 11	`(config-if)#exit`	Exit interface mode.
Configure OSPF		
Step 12	`(config)#router ospf`	Configure the OSPF routing process,
Step 13	`(config-router)#network 1.1.1.1/32 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
Step 14	`(config-router)#network 20.0.0.0/24 area 0`	
Step 15	`(config-router)#network 11.0.0.0/24 area 0`	
Step 16	`(config-router)#exit`	Exit Router mode.
Configure the LDP router instance and enable it on the interface		
Step 17	`(config)#router ldp`	Enter Router LDP mode.
Step 18	`(config-router)#pw-status-tlv`	
Step 19	`(config-router)#transport-address ipv4 1.1.1.1`	Configure the transport address for a label space by binding the address to a loopback address.
Step 20	`(config-router)#targeted-peer ipv4 2.2.2.2`	Specify the peers (PE2, PE3, and PE4) as targeted peers to enable targeted LDP session.
Step 21	`(config-router)#targeted-peer ipv4 3.3.3.3`	
Step 22	`(config-router)#targeted-peer ipv4 4.4.4.4`	
Step 23	`(config-router)#keepalive-interval 1`	
Step 24	`(config-router)#keepalive-timeout 3`	
Step 25	`(config-router)#hello-interval 1`	
Step 26	`(config-router)#exit`	Exit Router mode.
Step 27	`(config)#interface xe1`	Enter interface mode.
Step 28	`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface.
Step 29	`(config-if)#exit`	Exit interface mode.
Step 30	`(config)#interface xe46`	Enter interface mode.
Step 31	`(config-if)#enable-ldp ipv4`	Enable LDP on the specified interface.
Step 32	`(config-if)#exit`	Exit interface mode.
Configure VPLS instances and do the binding		
Step 33	`#configure terminal`	Enter Configure mode.
Step 34	`(config)#mpls vpls VPLS-Red 1`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Red) and VPLS ID (1).

PE1 Cont.

Step 35	`(config-vpls)# redundancy-role primary`	Configure the redundancy Admin role of the VPLS instance. (By default the Redundancy admin role: Primary)
Step 36	`(config-vpls)#vpls-type vlan`	Configure the VPLS as VLAN.
Step 37	`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
Step 38	`(config-vpls-sig)#vpls-peer 3.3.3.3`	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 39	`(config-vpls-sig)#vpls-peer 4.4.4.4`	
Step 40	`(config-vpls-sig)#exit`	Exit signaling LDP mode.
Configure VPLS instances and do the binding		
Step 41	`(config)#mpls vpls VPLS-Blue 2`	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Blue) and VPLS ID (2).
Step 42	`(config-vpls)#redundancy-role secondary`	Configure the redundancy Admin role of the VPLS instance. (By default the Redundancy admin role: Primary)
Step 43	`(config-vpls)#vpls-type vlan`	Configure the VPLS as VLAN.
Step 44	`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
Step 45	`(config-vpls-sig)#vpls-peer 3.3.3.3`	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 46	`(config-vpls-sig)#vpls-peer 4.4.4.4`	
Step 47	`(config-vpls-sig)#exit`	Exit signaling LDP mode.
Step 48	`(config)#bridge 1 protocol rstp vlan-bridge`	Configure bridge
Step 49	`(config) vlan 2-200 bridge 1 state enable`	Configure the VLANs
Step 50	`(config)#int xe25`	Enter interface mode
Step 51	`(config-if)#switchport`	Switch to layer-2 mode
Step 52	`(config-if)#bridge-group 1`	Configure bridge group
Step 53	`(config-if)#channel-group 2 mode active`	Add the interface to a layer 2 port channel
Step 54	`(config)#int xe26`	Enter interface mode
Step 55	`(config-if)#switchport`	Switch to layer-2 mode
Step 56	`(config-if)#bridge-group 1`	Configure bridge group
Step 57	`(config-if)#channel-group 2 mode active`	Add the interface to the same layer 2 port channel
Step 58	`(config)#interface po2`	Enter interface mode. (Port channel)
Step 59	`(config-if)#switchport`	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
Step 60	`(config-if)#bridge-group 1`	Configure bridge group
Step 61	`(config-if)#switchport mode trunk`	For VLAN based vpls this config applies.
Step 62	`(config-if)#switchport trunk allowed vlan add 2-200`	Configure the VLANs that should be allowed this interface.
Step 63	`config-if)#mpls-vpls VPLS-Red vlan 2-100`	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.

PE1 Cont.

Step 64	(config-if)#mpls-vpls VPLS-Blue vlan 101-200	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 65	(config)#redundancy interchassis group 1	Configure an ICCP group instance on router by specifying a valid group id. Note that the Group id should be same for both the ICCP peers.
Step 66	(config-red)#member ip 2.2.2.2	In redundancy mode, configure Member IP with the other ICCP peer.
Step 67	(config-red)#exit	

CE1

	CLI command	Purpose
Step 1	(config)#bridge 1 protocol rstp vlan-bridge	Configure Bridge
Step 2	(config)#interface xe47	Enter interface mode
Step 3	(config-if)#bridge-group 1	Associate bridge to interface
Step 4	(config-if)#switchport mode trunk	Configure as Trunk port
Step 5	(config-if)#switchport trunk allowed vlan add 2-200	Configure the VLANs to allow through the port
Step 6	(config-if)#channel-group 1 mode active	Associate the interface to portchannel -1
Step 7	(config-if)#exit	Exit interface mode.
Step 8	(config)#interface xe48	Enter interface mode.
Step 9	(config-if)#bridge-group 1	Associate the bridge to interface
Step 10	(config-if)#switchport mode trunk	Configure interface as trunk
Step 11	(config-if)#switchport trunk allowed vlan add 2-200	Configure the VLANs to allow through the port
Step 12	(config-if)#channel-group 2 mode active	Associate the interface to portchannel -1
Step 13	(config-if)#exit	Exit interface mode
Step 14	(config)#interface po1	Enter interface port channel mode
Step 15	(config-if)#mlag 1	Associate the port channel to mlag group -1
Step 16	(config-if)#exit	Exit interface mode
Step 17	(config)#interface po2	Enter interface port channel mode
Step 18	(config-if)#mlag 2	Associate the port channel to mlag group -2
Step 19	(config-if)#exit	Exit interface mode
Step 20	(config)#mcec domain configuration	Enter Multichasis Etherchannel domain configuration mode.
Step 21	(config-mcec-domain)#domain-address 1111.2222.3333	Configure the domain address.
Step 22	(config-mcec-domain)#domain-system-number 1	Configure the domain system number.
Step 23	(config-mcec-domain)#intra-domain-link xe46	Specify the intra domain link for MLAG communication.
Step 24	(config-mcec-domain)#exit	Exit MLAG mode

CE2

	CLI command	Purpose
Step 1	(config)#bridge 1 protocol rstp vlan-bridge	Configure Bridge
Step 2	(config)#interface xe47	Enter interface mode
Step 3	(config-if)#bridge-group 1	Associate bridge to interface
Step 4	(config-if)#switchport mode trunk	Configure as Trunk port

CE2 Cont.

Step 5	`(config-if)#switchport trunk allowed vlan add 2-200`	Configure the VLANs to allow through the port
Step 6	`(config-if)#channel-group 1 mode active`	Associate the interface to portchannel -1
Step 7	`(config-if)#exit`	Exit interface mode.
Step 8	`(config)#interface xe48`	Enter interface mode.
Step 9	`(config-if)#bridge-group 1`	Associate the bridge to interface
Step 10	`(config-if)#switchport mode trunk`	Configure interface as trunk
Step 11	`(config-if)#switchport trunk allowed vlan add 2-200`	Configure the VLANs to allow through the port
Step 12	`(config-if)#channel-group 2 mode active`	Associate the interface to portchannel -1
Step 13	`(config-if)#exit`	Exit interface mode
Step 14	`(config)#interface po1`	Enter interface port channel mode
Step 15	`(config-if)#mlag 1`	Associate the port channel to mlag group -1
Step 16	`(config-if)#exit`	Exit interface mode
Step 17	`(config)#interface po2`	Enter interface port channel mode
Step 18	`(config-if)#mlag 2`	Associate the port channel to mlag group -2
Step 19	`(config-if)#exit`	Exit interface mode
Step 20	`(config)#mcec domain configuration`	Enter Multichasis Etherchannel domain configuration mode.
Step 21	`(config-mcec-domain)#domain-address 1111.2222.3333`	Configure the domain address.
Step 22	`(config-mcec-domain)#domain-system-number 2`	Configure the domain system number.
Step 23	`(config-mcec-domain)#intra-domain-link xe46`	Specify the intra domain link for MLAG communication
Step 24	`(config-mcec-domain)#exit`	Exit MLAG mode

PE3

	CLI command	Purpose
Step 1	`(config)# interface xe1`	Enter interface mode.
Step 2	`(config-if)# ip address 21.0.0.1/24`	Configure ip address on ICCP interface
Step 3	`(config-if)#label-switching`	
Step 4	`(config-if)#exit`	Exit interface mode.
Step 5	`(config)#interface xe46`	Enter interface mode.
Step 6	`(config-if)# ip address 11.0.0.2/24`	Configure ip address on interface
Step 7	`(config-if)#label-switching`	Enable label switching
Step 8	`(config-if)#exit`	Exit interface mode.
Step 9	`(config)#interface lo`	Enter interface mode.
Step 10	`(config-if)# ip address 3.3.3.3/32`	Set the IP address of the loopback interface
Step 11	`(config-if)#exit`	Exit interface mode.
Configure OSPF on the router		
Step 12	`(config)#router ospf`	Configure the OSPF routing process,
Step 13	`(config-router)#network 3.3.3.3/32 area 0`	Define the interfaces on which OSPF runs, and specify the backbone area 0.
Step 14	`(config-router)#network 21.0.0.0/24 area 0`	

PE3 Cont.

Step 15	(config-router)#network 11.0.0.0/24 area 0	
Step 16	(config-router)#exit	Exit Router mode.
Configure LDP router instance and enable on the interface		
Step 17	(config)#router ldp	Enter Router LDP mode.
Step 18	(config-router)#pw-status-tlv	
Step 19	(config-router)# transport-address ipv4 3.3.3.3	Configure the transport address for a label space by binding the address to a loopback address.
Step 20	(config-router)#targeted-peer ipv4 1.1.1.1	Specify the peers (PE2, PE3 and PE4) as targeted peers to enable targeted LDP session.
Step 21	(config-router)#targeted-peer ipv4 2.2.2.2	
Step 22	(config-router)#targeted-peer ipv4 4.4.4.4	
Step 23	(config-router)#keepalive-interval 1	
Step 24	(config-router)#keepalive-timeout 3	
Step 25	(config-router)#hello-interval 1	
Step 26	(config-router)#exit	Exit Router mode.
Step 27	(config)#interface xe1	
Step 28	(config-if)#enable-ldp ipv4	
Step 29	(config-if)#exit	
Step 30	(config)#interface xe46	Enter interface mode.
Step 31	(config-if)#enable-ldp ipv4	Enable LDP on the specified interface
Step 32	(config-if)#exit	Exit interface mode.
Configure VPLS instances on the router and do the binding		
Step 33	#configure terminal	Enter Configure mode.
Step 34	(config)#mpls vpls VPLS-Red 1	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Red) and VPLS ID (1).
Step 35	(config-vpls)# redundancy-role secondary	Configure the redundancy Admin role of the VPLS instance.
Step 36	(config-vpls)#vpls-type vlan	(By default the Redundancy admin role: Primary)
Step 37	(config-vpls)#signaling ldp	Configure the VPLS as VLAN.
Step 38	(config-vpls-sig)#vpls-peer 1.1.1.1	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 39	(config-vpls-sig)#vpls-peer 2.2.2.2	
Step 40	(config-vpls-sig)#exit	Exit signaling LDP mode.
Step 41	(config)#mpls vpls VPLS-Blue 2	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Blue) and VPLS ID (2).
Step 42	(config-vpls)# redundancy-role primary	Configure the redundancy Admin role of the VPLS instance.
Step 43	(config-vpls)#vpls-type vlan	(By default the Redundancy admin role: Primary)
Step 44	(config-vpls)#signaling ldp	Configure the VPLS as VLAN.
Step 45	(config-vpls-sig)#vpls-peer 1.1.1.1	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 46	(config-vpls-sig)#vpls-peer 2.2.2.2	

PE3 Cont.

Step 47	(config-vpls-sig)#exit	Exit signaling LDP mode.
Step 48	(config)#bridge 1 protocol rstp vlan-bridge	Configure bridge
Step 49	(config) vlan 2-200 bridge 1 state enable	Configure the VLANs
Step 50	(config)#int xe25	Enter interface mode
Step 51	(config-if)#switchport	Switch to layer-2 mode
Step 52	(config-if)#bridge-group 1	Configure bridge group
Step 53	(config-if)# channel-group 2 mode active	Add the interface to a layer 2 port channel
Step 54	(config)#int xe26	Enter interface mode
Step 55	(config-if)#switchport	Switch to layer-2 mode
Step 56	(config-if)#bridge-group 1	Configure bridge group
Step 57	(config-if)# channel-group 2 mode active	Add the interface to the same layer 2 port channel
Step 58	(config)#interface po2	Enter interface mode. (Port channel)
Step 59	(config-if)#switchport	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
Step 60	(config-if)#bridge-group 1	
Step 61	(config-if)#switchport mode trunk	Configure bridge group
Step 62	(config-if)#switchport trunk allowed vlan add 2-200	For VLAN based vpls this config applies.
Step 63	config-if)#mpls-vpls VPLS-Red vlan 2-100	Configure the VLANs that should be allowed on this interface
Step 64	(config-if)#mpls-vpls VPLS-Blue vlan 101-200	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 65	(config-if)#exit	
Step 66	(config)# redundancy interchassis group 1	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 67	(config-red)#member ip 4.4.4.4	Configure an ICCP group instance on router by specifying a valid group id. (Pls note that the Group id should be same for both the ICCP peers)
Step 68	(config-red)#exit	Under the Redundancy mode, configure Member IP with the other ICCP peer.

PE4

	CLI command	Purpose
Step 1	(config)# interface xe1	Enter interface mode.
Step 2	(config-if)#ip address 21.0.0.2/24	Configure ip address on ICCP interface
Step 3	(config-if)#label-switching	
Step 4	(config-if)#exit	Exit interface mode.
Step 5	(config)#interface xe46	Enter interface mode.
Step 6	(config-if)# ip address 30.0.0.2/24	Configure ip address on interface
Step 7	(config-if)#label-switching	Enable label switching
Step 8	(config-if)#exit	Exit interface mode.

PE4 Cont.

Step 9	(config)#interface lo	Enter interface mode.
Step 10	(config-if)# ip address 4.4.4.4/32	Set the IP address of the loopback interface
Step 11	(config-if)#exit	Exit interface mode.
Configure OSPF on the router		
Step 12	(config)#router ospf	Configure the OSPF routing process,
Step 13	(config-router)#network 4.4.4.4/32 area 0	Define the interfaces on which OSPF runs, and specify the backbone area 0.
Step 14	(config-router)#network 30.0.0.0/24 area 0	
Step 15	(config-router)#network 21.0.0.0/24 area 0	
Step 16	(config-router)#exit	Exit Router mode.
Configure LDP router instance and enable on the interface		
Step 17	(config)#router ldp	Enter Router LDP mode.
Step 18	(config-router)# transport-address ipv4 4.4.4.4	Configure the transport address for a label space by binding the address to a loopback address.
Step 20	(config-router)#targeted-peer ipv4 1.1.1.1	Specify the peers (PE1, PE3 and PE4) as targeted peers to enable targeted LDP session.
Step 21	(config-router)#targeted-peer ipv4 2.2.2.2	
Step 22	(config-router)#targeted-peer ipv4 3.3.3.3	
Step 23	(config-router)#keepalive-interval 1	
Step 24	(config-router)#keepalive-timeout 3	
Step 25	(config-router)#hello-interval 1	
Step 26	(config-router)#exit	Exit Router mode.
Step 27	(config)#interface xe1	
Step 28	(config-router)#enable -ldp ipv4	
Step 29	(config-router)#exit	
Step 30	(config)#interface xe46	Enter interface mode.
Step 31	(config-if)#enable-ldp ipv4	Enable LDP on the specified interface
Step 32	(config-if)#exit	Exit interface mode.
Configure VPLS instances on the router and do the binding		
Step 33	#configure terminal	Enter Configure mode.
Step 34	(config)#mpls vpls VPLS-Red 1	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Red) and VPLS ID (1).
Step 35	(config-vpls)# redundancy-role primary	Configure the redundancy Admin role of the VPLS instance.
Step 36	(config-vpls)#vpls-type vlan	Configure the VPLS as VLAN.
Step 37	(config-vpls)#signaling ldp	Enter VPLS signaling LDP mode.
Step 38	(config-vpls-sig)#vpls-peer 1.1.1.1	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 39	(config-vpls-sig)#vpls-peer 2.2.2.2	
Step 40	(config-vpls-sig)#exit	Exit signaling LDP mode.
Step 41	(config)#mpls vpls VPLS-Blue 2	Create an instance of VPLS, and switch to the VPLS command mode, by specifying the VPLS name (VPLS-Blue) and VPLS ID (2).

PE4 Cont.

Step 42	(config-vpls)# redundancy-role secondary	Configure the redundancy Admin role of the VPLS instance.
Step 43	(config-vpls)#vpls-type vlan	(By default the Redundancy admin role: Primary)
Step 44	(config-vpls)#signaling ldp	Configure the VPLS as VLAN.
Step 45	(config-vpls-sig)#vpls-peer 1.1.1.1	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 46	(config-vpls-sig)#vpls-peer 2.2.2.2	
Step 47	(config-vpls-sig)#exit	Exit signaling LDP mode.
Step 48	(config)#bridge 1 protocol rstp vlan-bridge	Configure bridge
Step 49	(config) vlan 2-200 bridge 1 state enable	Configure the VLANs
Step 50	(config)#interface xe25	Enter interface mode
Step 51	(config-if)#switchport	Switch to layer-2 mode
Step 52	(config-if)#bridge-group 1	Configure bridge group
Step 53	(config-if)# channel-group 2 mode active	Add the interface to a layer 2 port channel
Step 54	(config-if)#exit	
Step 55	(config)#interface xe26	Enter interface mode
Step 56	(config-if)#switchport	Switch to layer-2 mode
Step 57	(config-if)#bridge-group 1	Configure bridge group
Step 58	(config-if)#channel-group 2 mode active	Add the interface to the same layer 2 port channel
Step 59	(config-if)#exit	
Step 60	(config)#interface po2	Enter interface mode. (Port channel)
Step 61	(config-if)#switchport	Switch to Layer-2 mode. (VPLS can be bound only on the Layer-2 port.)
Step 62	(config-if)#bridge-group 1	
Step 63	(config-if)#switchport mode trunk	Configure bridge group
Step 64	(config-if)#switchport trunk allowed vlan add 2-200	For VLAN based vpls this config applies.
Step 65	config-if)#mpls-vpls VPLS-Red vlan 2-100	Configure the VLANs that should be allowed this interface
Step 66	(config-if)#mpls-vpls VPLS-Blue vlan 101-200	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 67	(config)# redundancy interchassis group 1	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 68	(config-red)#member ip 3.3.3.3	Configure an ICCP group instance on router by specifying a valid group id. (Pls note that the Group id should be same for both the ICCP peers)
Step 69	(config-red)#exit	Under the Redundancy mode, configure Member IP with the other ICCP peer.

CE3

	CLI command	Purpose
Step 1	(config)#bridge 1 protocol rstp vlan-bridge	Configure Bridge
Step 2	(config)#interface xe47	Enter interface mode

CE3 Cont.

Step 3	(config-if)# bridge-group 1	Associate bridge to interface
Step 4	(config-if)#switchport mode trunk	Configure as Trunk port
Step 5	(config-if)#switchport trunk allowed vlan add 2-200	Configure the vlans to allow through the port
Step 6	(config-if)#channel-group 1 mode active	Associate the interface to portchannel -1
Step 7	(config-if)#exit	Exit interface mode.
Step 8	(config)#interface xe48	Enter interface mode.
Step 9	(config-if)# bridge-group 1	Associate the bridge to interface
Step 10	(config-if)#switchport mode trunk	Configure interface as trunk
Step 11	(config-if)#switchport trunk allowed vlan add 2-200	Configure the vlans to allow through the port.
Step 12	(config-if)#channel-group 2 mode active	Associate the interface to portchannel -1
Step 13	(config-if)#exit	Exit interface mode
Step 14	(config)#interface po1	Enter interface port channel mode
Step 15	(config-if)#mlag 1	Associate the port channel to mlag group -1
Step 16	(config-if)#exit	Exit interface mode
Step 17	(config)#interface po2	Enter interface port channel mode
Step 18	(config-if)#mlag 2	Associate the port channel to mlag group -2
Step 19	(config-if)#exit	Exit interface mode
Step 20	(config)#mcec domain configuration	Enter Multichasis Etherchannel domain configuration mode.
Step 21	(config-mcec-domain)#domain-address 1111.2222.3333	Configure the domain address.
Step 22	(config-mcec-domain)#domain-system-number 1	Configure the domain system number.
Step 23	(config-mcec-domain)#intra-domain-link xe46	Specify the intra domain link for MLAG communication
Step 24	(config-mcec-domain)#exit	Exit MLAG mode

CE4

	CLI command	Purpose
Step 1	(config)#bridge 1 protocol rstp vlan-bridge	Configure Bridge
Step 2	(config)#interface xe47	Enter interface mode
Step 3	(config-if)# bridge-group 1	Associate bridge to interface
Step 4	(config-if)#switchport mode trunk	Configure as Trunk port
Step 5	(config-if)#switchport trunk allowed vlan add 2-200	Configure the vlans to allow through the port
Step 6	(config-if)#channel-group 1 mode active	Associate the interface to portchannel -1
Step 7	(config-if)#exit	Exit interface mode.
Step 8	(config)#interface xe48	Enter interface mode.
Step 9	(config-if)# bridge-group 1	Associate the bridge to interface
Step 10	(config-if)#switchport mode trunk	Configure interface as trunk
Step 11	(config-if)#switchport trunk allowed vlan add 2-200	Configure the vlans to allow through the port
Step 12	(config-if)#channel-group 2 mode active	Associate the interface to portchannel -1
Step 13	(config-if)#exit	Exit interface mode
Step 14	(config)#interface po1	Enter interface port channel mode
Step 15	(config-if)#mlag 1	Associate the port channel to mlag group -1
Step 16	(config-if)#exit	Exit interface mode

CE4 Cont.

Step 17	(config)#interface po2	Enter interface port channel mode
Step 18	(config-if)#mlag 2	Associate the port channel to mlag group -2
Step 19	(config-if)#exit	Exit interface mode
Step 20	(config)#mcec domain configuration	Enter Multichasis Etherchannel domain configuration mode.
Step 21	(config-mcec-domain)#domain-address 1111.2222.3333	Configure the domain address.
Step 22	(config-mcec-domain)#domain-system-number 2	Configure the domain system number.

PE2

	CLI command	Purpose
Step 1	(config)# interface xe1	Enter interface mode.
Step 2	(config-if)#ip address 20.0.0.2/24	Configure address on ICCP interface.
Step 3	(config-if)#label-switching	Enable label switching.
Step 4	(config-if)#exit	Exit interface mode.
Step 5	(config)#interface xe46	Enter interface mode.
Step 6	(config-if)#ip address 30.0.0.1/24	Configure IP address on interface.
Step 7	(config-if)#label-switching	Enable label switching.
Step 8	(config-if)#exit	Exit interface mode.
Step 9	(config)#interface lo	Enter interface mode.
Step 10	(config-if)#ip address 2.2.2.2/32	Set the IP address for the loopback interface.
Step 11	(config-if)#exit	Exit interface mode.
Configure OSPF on the router		
Step 12	(config)#router ospf	Configure the OSPF routing process.
Step 13	(config-router)#network 2.2.2.2/32 area 0	Define the interfaces on which OSPF runs and specify the backbone area 0.
Step 14	(config-router)#network 30.0.0.0/24 area 0	
Step 15	(config-router)#network 20.0.0.0/24 area 0	
Step 16	(config-router)#exit	Exit router mode.
Configure LDP router instance and enable it on the interface		
Step 17	(config)#router ldp	Enter router LDP mode.
Step 18	(config-router)#pw-status-tlv	
Step 19	(config-router)#transport-address ipv4 2.2.2.2	Configure the transport address for a label space by binding the address to the loopback address.
Step 20	(config-router)#targeted-peer ipv4 1.1.1.1	
Step 21	(config-router)#targeted-peer ipv4 3.3.3.3	
Step 22	(config-router)#targeted-peer ipv4 4.4.4.4	
Step 23	(config-router)#hello-interval 1	
Step 24	(config-router)#keepalive-timeout 3	
Step 25	(config-router)#hello-interval 1	
Step 26	(config-router)#exit	Exit the router mode.
Step 27	(config)#interface xe1	Enter interface mode.
Step 28	(config-if)#enable-ldp ipv4	Enable LDP on the specified interface.
Step 29	(config-if)#exit	Exit interface mode.
Step 30	(config)#interface xe46	Enter interface mode.
Step 31	(config-if)#enable-ldp ipv4	Enable LDP on the specified interface.
Step 32	(config-if)#exit	

PE2 Cont.

Configure VPLS instances on the router and perrform the binding		
Step 33	`#configure terminal`	Enter Configure mode.
Step 34	`(config)#mpls vpls VPLS-Red 1`	Create an instance of VPLS and switch to the VPLS command mode by specifying the VPLS name (`VPLS-Red`) and VPLS ID (`1`).
Step 35	`config-vpls)#redundancy-role secondary`	Configure the redundancy ADMIN role of the VPLS instance. (By default, the redundancy admin role is primary).
Step 36	`(config-vpls)#vpls-type vlan`	Configure the VPLS as VLAN.
Step 37	`(config-vpls)#signaling ldp`	Enter VPLS signaling LDP mode.
Step 38	`(config-vpls-sig)#vpls-peer 3.3.3.3`	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 39	`(config-vpls-sig)#vpls-peer 4.4.4.4`	
Step 40	`(config-vpls-sig)#exit`	Exit signaling LDP mode.
Step 41	`(config)#mpls vpls VPLS-Blue 2`	Create an instance of VPLS and switch to the VPLS commsnd mode by specifying the VPLS name (`VPLS-Blue`) and VPLS ID (`2`).
Step 42	`(config-vpls)#redundancy-role primary`	Configure the redundancy Admin role of the VPLS instance.
Step 43	`(config-vpls)#vpls-type vlan`	Configure the VPLS as VLAN.
Step 44	`(config-vpls)#signaling ldp`	Enter VPLS signaling mode.
Step 45	`(config-vpls-sig)#vpls-peer 3.3.3.3`	Create a VPLS VC with peer core routers, PE3 and PE4 to which the mesh VC is to be associated by configuring the IP address of the peer nodes.
Step 46	`(config-vpls-sig)#vpls-peer 4.4.4.4`	
Step 47	`(config-vpls-sig)#exit`	Exit signaling LDP mode.
Step 48	`(config)#bridge 1 protocol rstp vlan-bridge`	Configure the bridge.
Step 49	`(config)#vlan 2-200 bridge 1 state enable`	Configure the VLANs.
Step 50	`(config)#interface xe25`	Enter interface mode.
Step 51	`(config-if)#switchport`	Switch to Layer-2 mode.
Step 52	`(config-if)#bridge-group 1`	Configure the bridge group.
Step 53	`(config-if)#channel-group 2 mode active`	Add the interface to the Layer-2 port channel.
Step 54	`(config-if)#exit`	Exit interfacce mode.
Step 55	`(config)#interface xe26`	Enter interface mode.
Step 56	`(config-if)#switchport`	Switch to Layer-2 mode.
Step 57	`(config-if)#bridge-group 1`	Configure the bridge group.
Step 58	`(config-if)#channel-group 2 mode active`	Add the interface to the same Layer-2 port channel.
Step 59	`(config-if)#exit`	Exit interface mode.
Step 60	`(config)#interface po2`	Enter interface mode (Port Channel).
Step 61	`(config-if)#switchport`	Switch to Layer-2 mode. The VPLS can be bound only on the Layer-2 port.
Step 62	`(config-if)#bridge-group 1`	Configure the bridge group.
Step 63	`(config-if)#switchport mode trunk`	For VLAN-based VPLS, the configuration applies.
Step 64	`(config-if)#switchport trunk allowed vlan add 2-200`	Configure the VLANs that should be allowed on the interface.

PE2 Cont.

Step 65	`(config-if)#mpls-vpls VPLS-Red vlan 2-100`	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 66	`(config-if)#mpls-vpls VPLS-Blue vlan 101-200`	Associate an interface with the VPLS instance for VLAN binding by specifying the VPLS name on the interface and the VLAN ID. Repeat this step for all interfaces connected to CE devices associated with this VPLS instance.
Step 67	`(config-if)#exit`	Exit interface mode.
Step 68	`(config)#redundancy interchassis group 1`	Configure an ICCP group instance on router by specifying a valid group id. Note that the Group id should be same for both the ICCP peers.
Step 69	`(config-red)#member ip 1.1.1.1`	Under the Redundancy mode, configure member IP with the other ICCP peer.
Step 70	`(config-red)#exit`	

Conclusion

The OcNOS data center interconnect solution provides connectivity between the data centers enabling them to extend their Layer 2 network.

The OcNOS data center interconnect solution handles redundancy at all levels, including the core nodes using ICCP and VPLS redundancy. The links between aggregation and core are dual homed and redundant. In the aggregation and access nodes, the OcNOS MC-LAG solution provides both node and link level redundancy. Also, all the nodes and links are active and there are no unused links.

About IP Infusion

IP Infusion, the leader in disaggregated networking solutions, delivers the best network OS for white box and network virtualization. IP Infusion offers network operating systems for both physical and virtual networks to carriers, service providers and enterprises to achieve the disaggregated networking model. With the OcNOS™ and VirNOS™ network operating systems, IP Infusion offers a single, unified physical and virtual software solution to deploy new services quickly at reduced cost and with greater flexibility. Over 300 customers worldwide, including major networking equipment manufacturers, use IP Infusion's respected ZebOS platform to build networks to address the evolving needs of cloud, carrier and mobile networking. IP Infusion is headquartered in Santa Clara, Calif., and is a wholly owned and independently operated subsidiary of ACCESS CO., LTD. Additional information can be found at http://www.ipinfusion.com.

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