



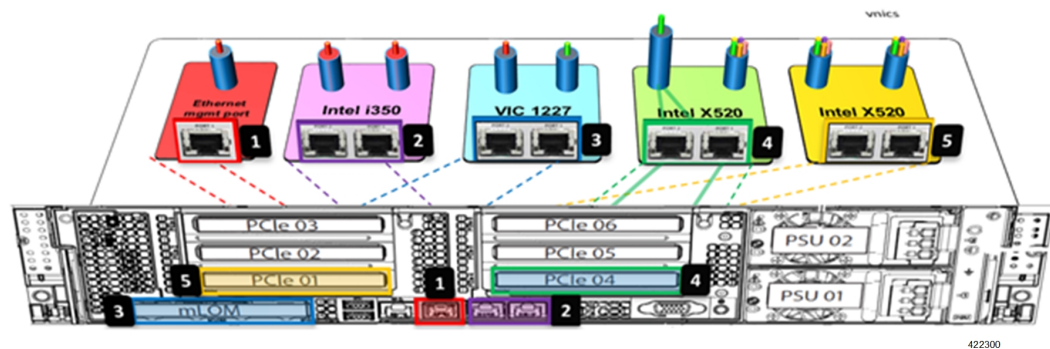
## Networking Overview

This section provides information on Ultra M networking requirements and considerations.

- [UCS-C240 Network Interfaces](#), page 1
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## UCS-C240 Network Interfaces

*Figure 1: UCS-C240 Back-Plane*



Number	Designation	Description	Applicable Node Types
1	CIMC/IPMI/M	The server's <i>Management</i> network interface used for accessing the UCS Cisco Integrated Management Controller (CIMC) application, performing Intelligent Platform Management Interface (IPMI) operations.	All
2	Intel Onboard	Port 1: VIM Orchestration (Undercloud) <i>Provisioning</i> network interface.	All
		Port 2: <i>External</i> network interface for Internet access. It must also be routable to External floating IP addresses on other nodes.	Ultra M Manager Node Staging Server

Number	Designation	Description	Applicable Node Types
3	Modular LAN on Motherboard (mLOM)	VIM networking interfaces used for:	
		<ul style="list-style-type: none"> <li>External floating IP network.</li> </ul>	Controller
		<ul style="list-style-type: none"> <li>Internal API network</li> </ul>	Controller
		<ul style="list-style-type: none"> <li>Storage network</li> </ul>	Controller Compute OSD Compute Ceph
		<ul style="list-style-type: none"> <li>Storage Management network</li> </ul>	Controller Compute OSD Compute Ceph
<ul style="list-style-type: none"> <li>Tenant network (virtio only – VIM provisioning, VNF Management, and VNF Orchestration)</li> </ul>	Controller Compute OSD Compute		
4	PCIe 4	Port 1: With NIC bonding enabled, this port provides the active Service network interfaces for VNF ingress and egress connections.	Compute
		Port 2: With NIC bonding enabled, this port provides the standby <i>Di-internal</i> network interface for inter-VNF component communication.	Compute OSD Compute

Number	Designation	Description	Applicable Node Types
5	PCIe 1	Port 1: With NIC bonding enabled, this port provides the active <i>Di-internal</i> network interface for inter-VNF component communication.	Compute OSD Compute
		Port 2: With NIC bonding enabled, this port provides the standby Service network interfaces for VNF ingress and egress connections.	Compute

## VIM Network Topology

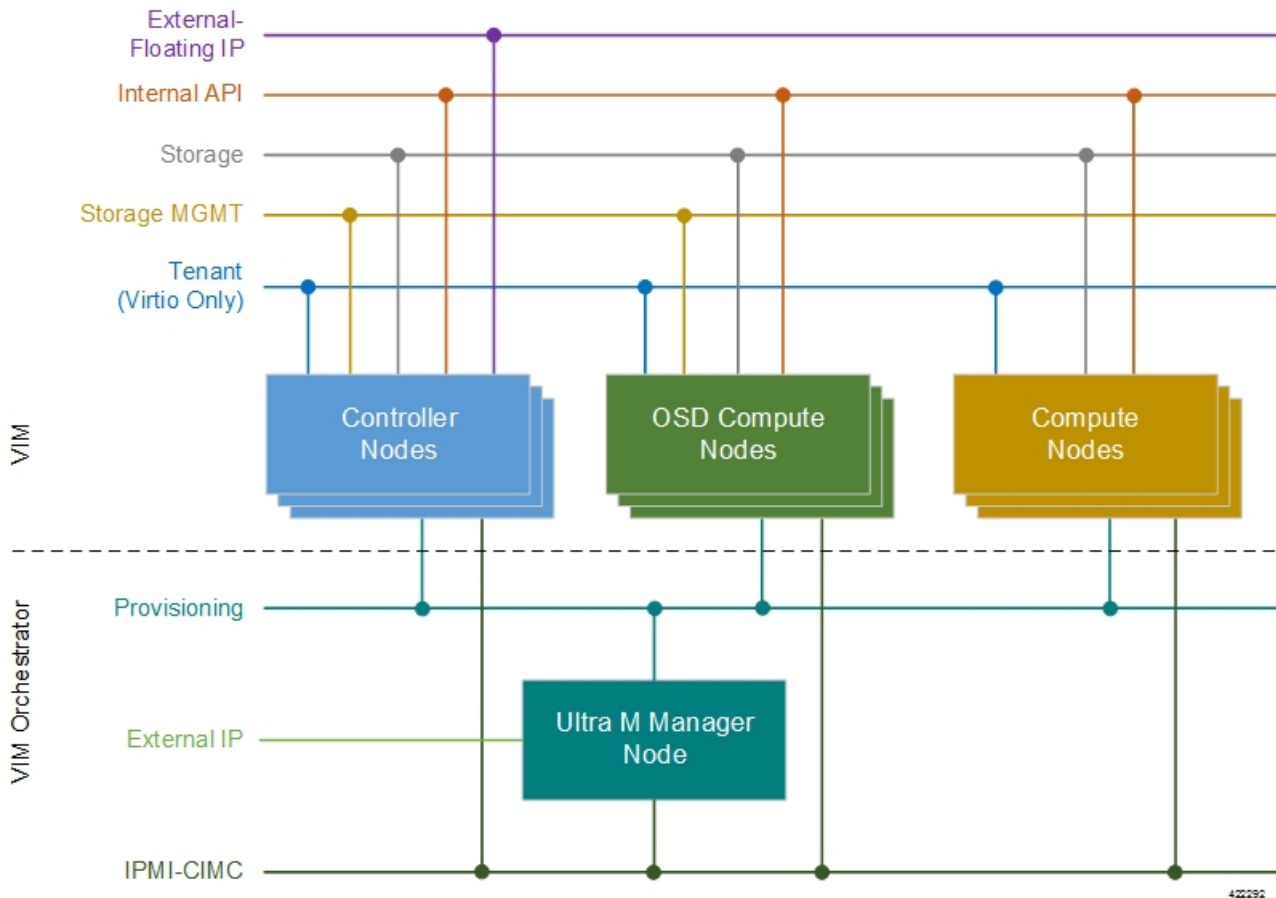
Ultra M's VIM is based on the OpenStack project TripleO ("OpenStack-On-OpenStack") which is the core of the OpenStack Platform Director (OSP-D). TripleO allows OpenStack components to install a fully operational OpenStack environment.

Two cloud concepts are introduced through TripleO:

- **VIM Orchestrator (Undercloud):** The VIM Orchestrator is used to bring up and manage the VIM. Though OSP-D and Undercloud are sometimes referred to synonymously, the OSP-D bootstraps the Undercloud deployment and provides the underlying components (e.g. Ironic, Nova, Glance, Neutron, etc.) leveraged by the Undercloud to deploy the VIM. Within the Ultra M Solution, OSP-D and the Undercloud are hosted on the same server.

- **VIM (Overcloud):** The VIM consists of the compute, controller, and storage nodes on which the VNFs are deployed.

**Figure 2: Hyper-converged Ultra M Single and Multi-VNF Model OpenStack VIM Network Topology**



Some considerations for VIM Orchestrator and VIM deployment are as follows:

- External network access (e.g. Internet access) can be configured in one of the following ways:
  - Across all node types: A single subnet is configured on the Controller HA, VIP address, floating IP addresses and OSP-D/Staging server's external interface provided that this network is data-center routable as well as it is able to reach the internet.
  - Limited to OSP-D: The *External IP* network is used by Controllers for HA and Horizon dashboard as well as later on for Tenant Floating IP address requirements. This network must be data-center routable. In addition, the *External IP* network is used only by OSP-D/Staging Server node's external interface that has a single IP address. The *External IP* network must be lab/data-center routable must also have internet access to Red Hat cloud. It is used by OSP-D/Staging Server for subscription purposes and also acts as an external gateway for all controllers, computes and Ceph-storage nodes.
- IPMI must be enabled on all nodes.
- Two networks are needed to deploy the VIM Orchestrator:

- IPMI/CIMC Network
- Provisioning Network
- The OSP-D/Staging Server must have reachability to both IPMI/CIMC and Provisioning Networks. (VIM Orchestrator networks need to be routable between each other or have to be in one subnet.)
- DHCP-based IP address assignment for Introspection PXE from Provisioning Network (Range A)
- DHCP based IP address assignment for VIM PXE from Provisioning Network (Range B) must be separate from Introspection.
- The Ultra M Manager Node/Staging Server acts as a gateway for Controller, Ceph and Computes. Therefore, the external interface of this node/server needs to be able to access the Internet. In addition, this interface needs to be routable with the Data-center network. This allows the External interface IP-address of the Ultra M Manager Node/Staging Server to reach Data-center routable Floating IP addresses as well as the VIP addresses of Controllers in HA Mode.
- Prior to assigning floating and virtual IP addresses, make sure that they are not already allocated through OpenStack. If the addresses are already allocated, then they must be freed up for use or you must assign a new IP address that is available in the VIM.
- Multiple VLANs are required in order to deploy OpenStack VIM:
  - 1 for the Management and Provisioning networks interconnecting all the nodes regardless of type
  - 1 for the Staging Server/OSP-D Node external network
  - 1 for Compute, Controller, and Ceph Storage or OSD Compute Nodes
  - 1 for Management network interconnecting the Leafs and Spines
- Login to individual Compute nodes will be from OSP-D/Staging Server using heat user login credentials. The OSP-D/Staging Server acts as a “jump server” where the br-ctlplane interface address is used to login to the Controller, Ceph or OSD Computes, and Computes post VIM deployment using heat-admin credentials.

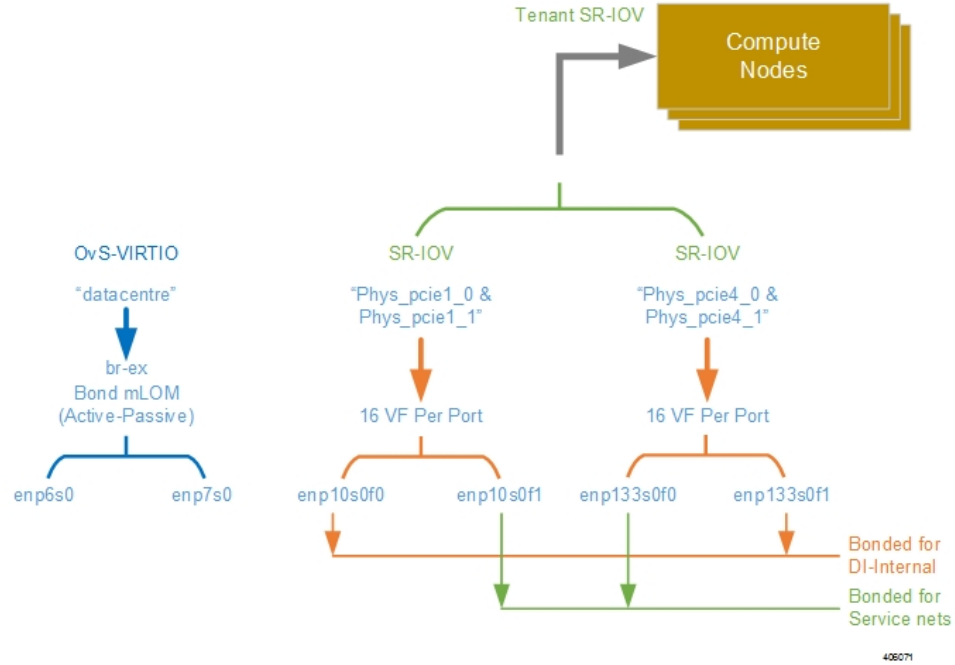
Layer 1 networking guidelines for the VIM network are provided in [Layer 1 Leaf and Spine Topology, on page 9](#). In addition, a template is provided in [Network Definitions \(Layer 2 and 3\)](#) to assist you with your Layer 2 and Layer 3 network planning.

## Openstack Tenant Networking

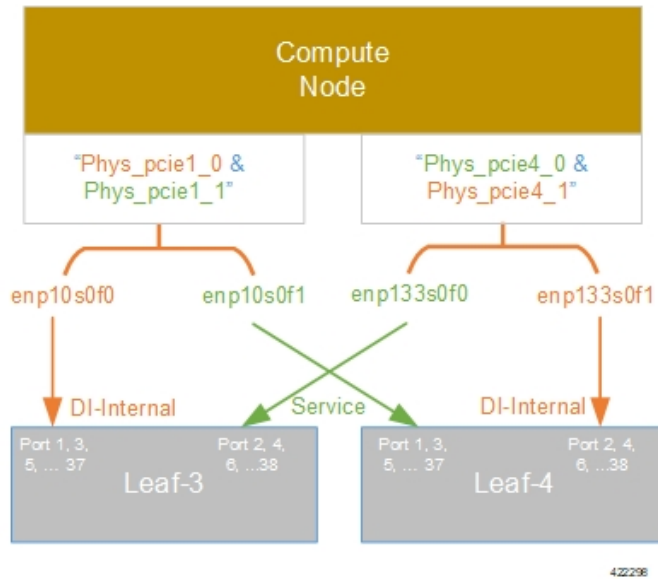
The interfaces used by the VNF are based on the PCIe architecture. Single root input/output virtualization (SR-IOV) is used on these interfaces to allow multiple VMs on a single server node to use the same network interface as shown in [Figure 3: Physical NIC to Bridge Mappings, on page 7](#). SR-IOV Networking is network

type *Flat* under OpenStack configuration. NIC Bonding is used to ensure port level redundancy for PCIe Cards involved in SR-IOV Tenant Networks as shown in [Figure 4: NIC Bonding](#), on page 7.

**Figure 3: Physical NIC to Bridge Mappings**



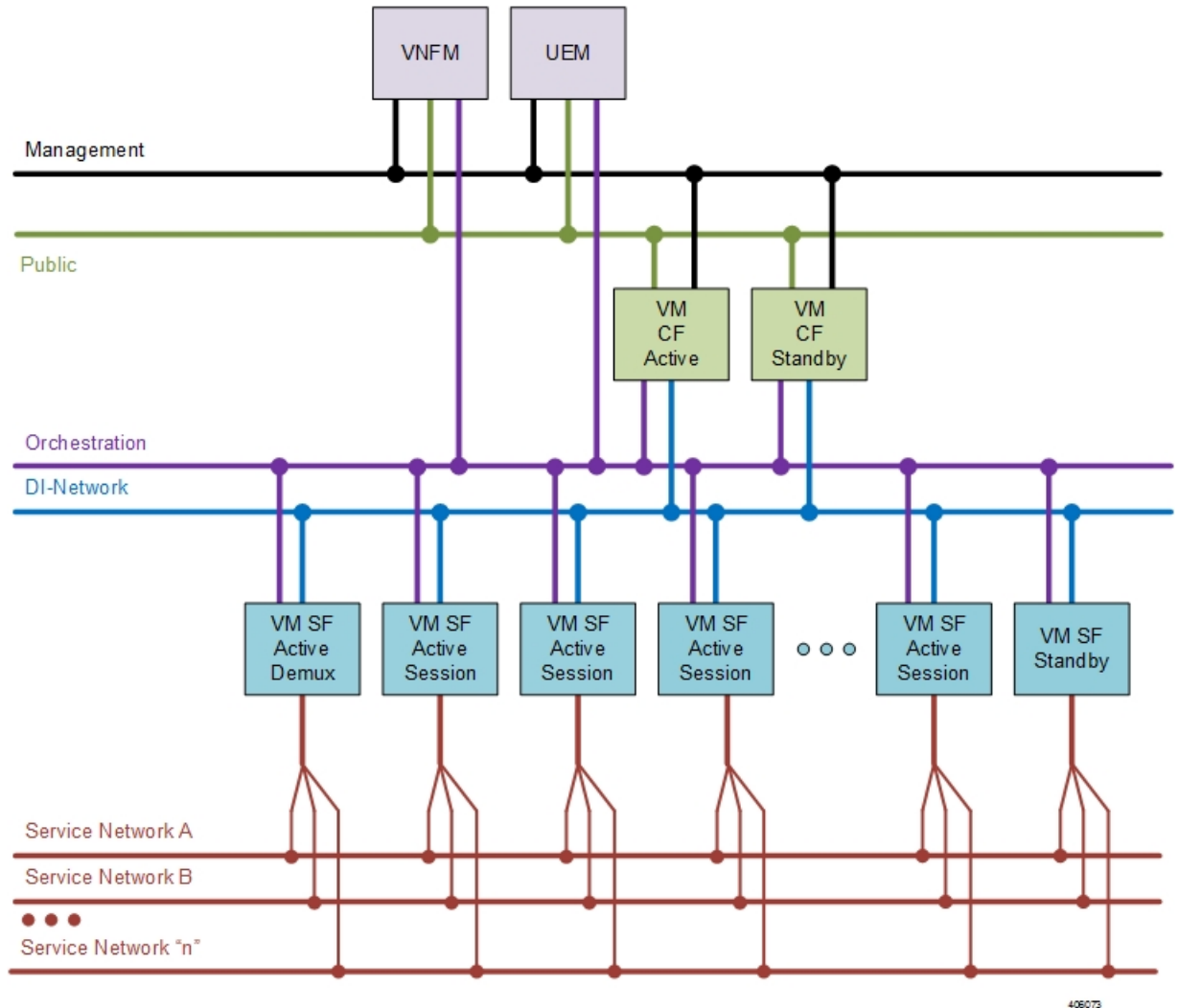
**Figure 4: NIC Bonding**



## VNF Tenant Networks

While specific VNF network requirements are described in the documentation corresponding to the VNF, [Figure 5: Typical USP-based VNF Networks, on page 8](#) displays the types of networks typically required by USP-based VNFs.

**Figure 5: Typical USP-based VNF Networks**



The USP-based VNF networking requirements and the specific roles are described here:

- **Public:** *External public network.* The router has an external gateway to the public network. All other networks (except DI-Internal and ServiceA-*n*) have an internal gateway pointing to the router. And the router performs secure network address translation (SNAT).
- **DI-Internal:** This is the DI-internal network which serves as a 'backplane' for CF-SF and CF-CF communications. Since this network is internal to the UGP, it does not have a gateway interface to the



router in the OpenStack network topology. A unique DI internal network must be created for each instance of the UGP. The interfaces attached to these networks use performance optimizations.

- **Management:** This is the local management network between the CFs and other management elements like the UEM and VNFM. This network is also used by OSP-D to deploy the VNFM and AutoVNF. To allow external access, an OpenStack floating IP address from the Public network must be associated with the UGP VIP (CF) address.

You can ensure that the same floating IP address can be assigned to the CF, UEM, and VNFM after a VM restart by configuring parameters in the AutoDeploy configuration file or the UWS service delivery configuration file.



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**Note** Prior to assigning floating and virtual IP addresses, make sure that they are not already allocated through OpenStack. If the addresses are already allocated, then they must be freed up for use or you must assign a new IP address that is available in the VIM.

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- **Orchestration:** This is the network used for VNF deployment and monitoring. It is used by the VNFM to onboard the USP-based VNF.
- **ServiceA-n:** These are the service interfaces to the SF. Up to 12 service interfaces can be provisioned for the SF with this release. The interfaces attached to these networks use performance optimizations.

Layer 1 networking guidelines for the VNF network are provided in [Layer 1 Leaf and Spine Topology, on page 9](#). In addition, a template is provided in [Network Definitions \(Layer 2 and 3\)](#) to assist you with your Layer 2 and Layer 3 network planning.

## Supporting Trunking on VNF Service ports

Service ports within USP-based VNFs are configured as trunk ports and traffic is tagged using the VLAN command. In This configuration is supported by trunking to the uplink switch via the *sriovnicswitch mechanism* driver.

This driver supports Flat network types in OpenStack, enabling the guest OS to tag the packets.

Flat networks are untagged networks in OpenStack. Typically, these networks are previously existing infrastructure, where OpenStack guests can be directly applied.

## Layer 1 Leaf and Spine Topology

Ultra M implements a Leaf and Spine network topology. Topology details differ between Ultra M models based on the scale and number of nodes.



**Note**

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When connecting component network ports, ensure that the destination ports are rated at the same speed as the source port (e.g. connect a 10G port to a 10G port). Additionally, the source and destination ports must support the same physical medium (e.g. Ethernet) for interconnectivity.

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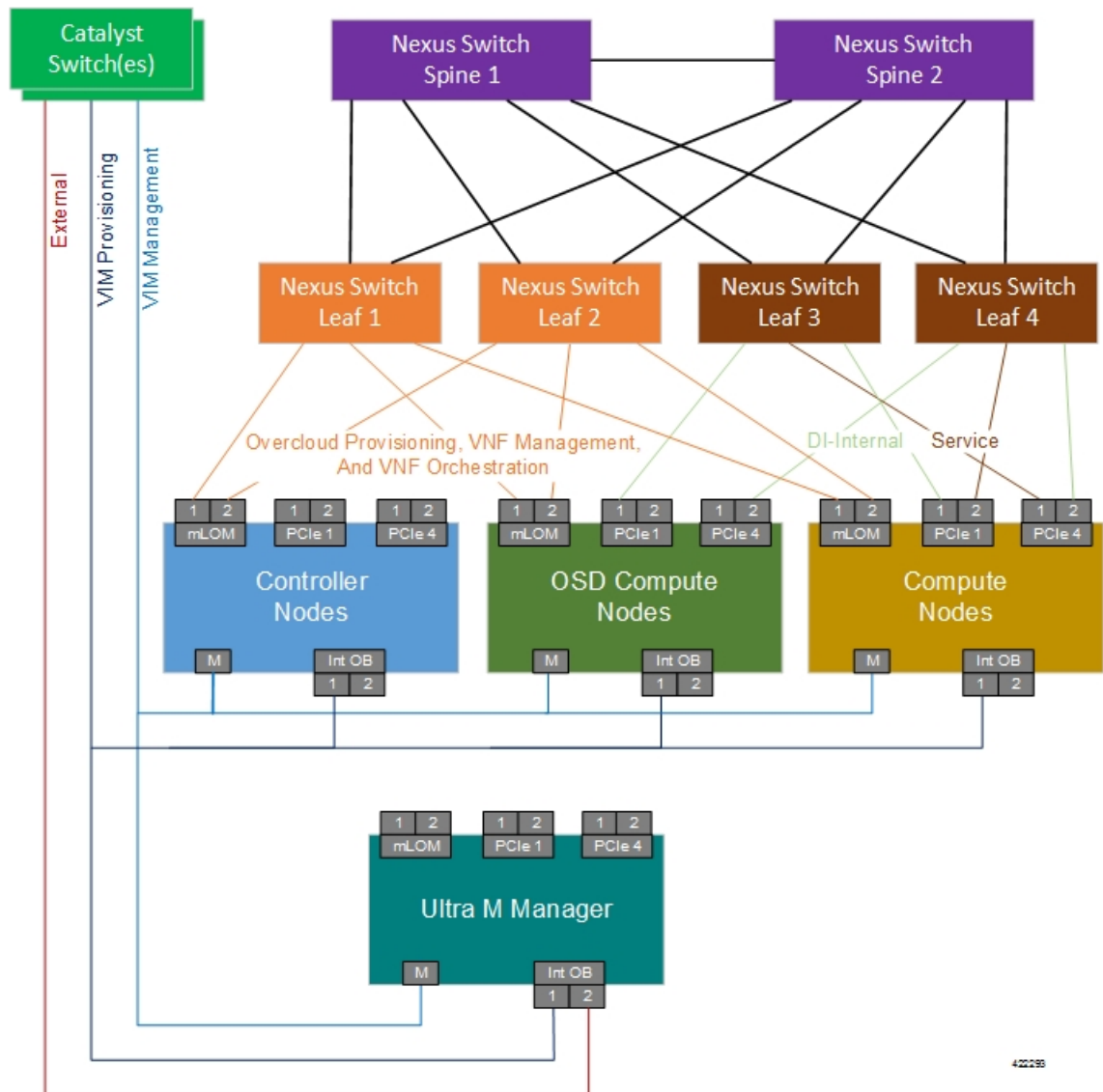
# Hyper-converged Ultra M Single and Multi-VNF Model Network Topology

Figure 6: Hyper-converged Ultra M Single and Multi-VNF Leaf and Spine Topology, on page 10 illustrates the logical leaf and spine topology for the various networks required for the Hyper-converged Ultra M models.

In this figure, two VNFs are supported. (Leaves 1 and 2 pertain to VNF1, Leaves 3 and 4 pertain to VNF 2). If additional VNFs are supported, additional Leaves are required (e.g. Leaves 5 and 6 are needed for VNF 3, Leaves 7 and 8 for VNF4). Each set of additional Leaves would have the same meshed network interconnects with the Spines and with the Controller, OSD Compute, and Compute Nodes.

For single VNF models, Leaf 1 and Leaf 2 facilitate all of the network interconnects from the server nodes and from the Spines.

Figure 6: Hyper-converged Ultra M Single and Multi-VNF Leaf and Spine Topology



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As identified in [Cisco Nexus Switches](#), the number of leaf and spine switches differ between the Ultra M models. Similarly, the specific leaf and spine ports used also depend on the Ultra M solution model being deployed. That said, general guidelines for interconnecting the leaf and spine switches in an Ultra M XS multi-VNF deployment are provided in [Table 1: Catalyst Management Switch 1 \(Rack 1\) Port Interconnects, on page 11](#) through [Table 10: Spine 2 Port Interconnect Guidelines, on page 21](#). Using the information in these tables, you can make appropriate adjustments to your network topology based on your deployment scenario (e.g. number of VNFs and number of Compute Nodes).

**Table 1: Catalyst Management Switch 1 (Rack 1) Port Interconnects**

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
1, 2, 11	OSD Compute Nodes	Management	CIMC	3 non-sequential ports - 1 per OSD Compute Node
3-10	Compute Nodes	Management	CIMC	6 sequential ports - 1 per Compute Node
12	Ultra M Manager Node	Management	CIMC	Management Switch 1 only
13	Controller 0	Management	CIMC	
21, 22, 31	OSD Compute Nodes	Provisioning	Mgmt	3 non-sequential ports - 1 per OSD Compute Node
23-30	Compute Nodes	Provisioning	Mgmt	6 sequential ports - 1 per Compute Node
32-33	Ultra M Manager Node	Provisioning	Mgmt	2 sequential ports
34	Controller 0	Management	CIMC	
47	Leaf 1	Management	48	Switch port 47 connects with Leaf 1 port 48
48	Leaf 2	Management	48	Switch port 48 connects with Leaf 2 port 48

**Table 2: Catalyst Management Switch 2 (Rack 2) Port Interconnects**

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
1-10	Compute Nodes	Management	CIMC	10 sequential ports - 1 per Compute Node

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
14	Controller 1	Management	CIMC	
15	Controller 2	Management	CIMC	
21-30	Compute Nodes	Provisioning	Mgmt	10 sequential ports - 1 per Compute Node
35	Controller 1	Provisioning	Mgmt	
36	Controller 2	Provisioning	Mgmt	
47	Leaf 3	Management	48	Switch port 47 connects with Leaf 3 port 48
48	Leaf 4	Management	48	Switch port 48 connects with Leaf 4 port 48

**Table 3: Catalyst Management Switch 3 (Rack 3) Port Interconnects**

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
1-10	Compute Nodes	Management	CIMC	10 sequential ports - 1 per Compute Node
21-30	Compute Nodes	Provisioning	Mgmt	10 sequential ports - 1 per Compute Node
47	Leaf 5	Management	48	Switch port 47 connects with Leaf 5 port 48
48	Leaf 6	Management	48	Switch port 48 connects with Leaf 6 port 48

**Table 4: Catalyst Management Switch 4 (Rack 4) Port Interconnects**

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
1-10	Compute Nodes	Management	CIMC	10 sequential ports - 1 per Compute Node

From Switch Port(s)	To			Notes
	Device	Network	Port(s)	
21-30	Compute Nodes	Provisioning	Mgmt	10 sequential ports - 1 per Compute Node
47	Leaf 7	Management	48	Switch port 47 connects with Leaf 7 port 48
48	Leaf 8	Management	48	Switch port 48 connects with Leaf 8 port 48

**Table 5: Leaf 1 and 2 (Rack 1) Port Interconnects\***

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
<b>Leaf 1</b>				
1, 2, 11	OSD Compute Nodes	Management & Orchestration (active)	MLOM P1	3 non-sequential ports - 1 per OSD Compute Node
12	Controller 0 Node	Management & Orchestration (active)	MLOM P1	
17, 18, 27	OSD Compute Nodes	Di-internal (active)	PCIe01 P1	3 non-sequential ports - 1 per OSD Compute Node
3 - 10 (inclusive)	Compute Nodes	Management & Orchestration (active)	MLOM P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
19-26 (inclusive)	Compute Nodes	Di-internal (active)	PCIe01 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
33-42 (inclusive)	Compute Nodes / OSD Compute Nodes	Service (active)	PCIe04 P1	Sequential ports based on the number of Compute Nodes and/or OSD Compute Nodes - 1 per OSD Compute Node and/or Compute Node  <b>Note</b> Though the OSD Compute Nodes do not use the Service Networks, they are provided to ensure compatibility within the OpenStack Overcloud (VIM) deployment.

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
48	Catalyst Management Switches	Management	47	Leaf 1 connects to Switch 1
49-50	Spine 1	Downlink	1-2	Leaf 1 port 49 connects to Spine 1 port 1 Leaf 1 port 50 connects to Spine 1 port 2
51-52	Spine 2	Downlink	3-4	Leaf 1 port 51 connects to Spine 2 port 3 Leaf 1 port 52 connects to Spine 2 port 4
<b>Leaf 2</b>				
1, 2, 11	OSD Compute Nodes	Management & Orchestration (redundant)	MLOM P2	3 non-sequential ports - 1 per OSD Compute Node
12	Controller 0 Node	Management & Orchestration (redundant)	MLOM P2	
17, 18, 27	OSD Compute Nodes	Di-internal (redundant)	PCIe04 P2	3 non-sequential ports - 1 per OSD Compute Node
3 - 10 (inclusive)	Compute Nodes	Management & Orchestration (redundant)	MLOM P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
19-26 (inclusive)	Compute Nodes	Di-internal (redundant)	PCIe04 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
33-42 (inclusive)	Compute Nodes / OSD Compute Nodes	Service (redundant)	PCIe01 P2	Sequential ports based on the number of Compute Nodes and/or OSD Compute Nodes - 1 per OSD Compute Node and/or Compute Node  <b>Note</b> Though the OSD Compute Nodes do not use the Service Networks, they are provided to ensure compatibility within the OpenStack Overcloud (VIM) deployment.
48	Catalyst Management Switches	Management	48	Leaf 2 connects to Switch 1

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
49-50	Spine 1	Downlink	1-2	Leaf 2 port 49 connects to Spine 1 port 1 Leaf 2 port 50 connects to Spine 1 port 2
51-52	Spine 2	Downlink	3-4, 7-8, 11-12, 15-16	Leaf 2 port 51 connects to Spine 2 port 3 Leaf 2 port 52 connects to Spine 2 port 4

**Table 6: Leaf 3 and 4 (Rack 2) Port Interconnects**

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
<b>Leaf 3</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (active)	MLOM P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1 (Rack 1). These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
13-14 (inclusive)	Controller Nodes	Management & Orchestration (active)	MLOM P1	Leaf 3 port 13 connects to Controller 1 MLOM P1 port Leaf 3 port 14 connects to Controller 1 MLOM P1 port
17-26 (inclusive)	Compute Nodes	Di-internal (active)	PCIe01 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (active)	PCIe04 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
48	Catalyst Management Switches	Management	47	Leaf 3 connects to Switch 2

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
49-50	Spine 1	Downlink	5-6	Leaf 3 port 49 connects to Spine 1 port 5 Leaf 3 port 50 connects to Spine 1 port 6
51-52	Spine 2	Downlink	7-8	Leaf 3 port 51 connects to Spine 2 port 7 Leaf 3 port 52 connects to Spine 2 port 8
<b>Leaf 4</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (redundant)	MLOM P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
13-14 (inclusive)	Controller Nodes	Management & Orchestration (redundant)	MLOM P2	Leaf 4 port 13 connects to Controller 1 MLOM P2 port Leaf 4 port 14 connects to Controller 1 MLOM P2 port
17-26 (inclusive)	Compute Nodes	Di-internal (redundant)	PCIe04 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (redundant)	PCIe01 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
48	Catalyst Management Switches	Management	48	Leaf 4 connects to Switch 2
49-50	Spine 1	Downlink	5-6	Leaf 4 port 49 connects to Spine 1 port 5 Leaf 4 port 50 connects to Spine 1 port 6
51-52	Spine 2	Downlink	7-8	Leaf 4 port 51 connects to Spine 2 port 7 Leaf 4 port 52 connects to Spine 2 port 8



Table 7: Leaf 5 and 6 (Rack 3) Port Interconnects

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
<b>Leaf 5</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (active)	MLOM P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
17-26 (inclusive)	Compute Nodes	Di-internal (active)	PCIe01 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (active)	PCIe04 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
48	Catalyst Management Switches	Management	47	Leaf 5 connects to Switch 3
49-50	Spine 1	Downlink	9-10	Leaf 5 port 49 connects to Spine 1 port 9 Leaf 5 port 50 connects to Spine 1 port 10
51-52	Spine 2	Downlink	3-4, 7-8, 11-12, 15-16	Leaf 5 port 51 connects to Spine 2 port 11 Leaf 5 port 52 connects to Spine 2 port 12
<b>Leaf 6</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (redundant)	MLOM P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
17-26 (inclusive)	Compute Nodes	Di-internal (redundant)	PCIe04 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (redundant)	PCIe01 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
48	Catalyst Management Switches	Management	48	Leaf 6 connects to Switch 3
49-50	Spine 1	Downlink	9-10	Leaf 6 port 49 connects to Spine 1 port 9 Leaf 6 port 50 connects to Spine 1 port 10
51-52	Spine 2	Downlink	11-12	Leaf 6 port 51 connects to Spine 2 port 11 Leaf 6 port 52 connects to Spine 2 port 12

Table 8: Leaf 7 and 8 (Rack 4) Port Interconnects

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
<b>Leaf 7</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (active)	MLOM P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node  <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
17-26 (inclusive)	Compute Nodes	Di-internal (active)	PCIe01 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (active)	PCIe04 P1	Sequential ports based on the number of Compute Nodes - 1 per Compute Node
48	Catalyst Management Switches	Management	47	Leaf 7 connects to Switch 4
49-50	Spine 1	Downlink	13-14	Leaf 7 port 49 connects to Spine 1 port 13 Leaf 7 port 50 connects to Spine 1 port 14
51-52	Spine 2	Downlink	15-16	Leaf 7 port 51 connects to Spine 2 port 15 Leaf 7 port 52 connects to Spine 2 port 16
<b>Leaf 8</b>				
1 - 10 (inclusive)	Compute Nodes	Management & Orchestration (redundant)	MLOM P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 1 and 2 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
17-26 (inclusive)	Compute Nodes	Di-internal (redundant)	PCIe04 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node <b>Note</b> Leaf Ports 17 and 18 are used for the first two Compute Nodes on VNFs other than VNF1. These are used to host management-related VMs as shown in <a href="#">Figure 2</a> .
33-42 (inclusive)	Compute Nodes	Service (redundant)	PCIe01 P2	Sequential ports based on the number of Compute Nodes - 1 per Compute Node

From Leaf Port(s)	To			Notes
	Device	Network	Port(s)	
48	Catalyst Management Switches	Management	48	Leaf 8 connects to Switch 4
49-50	Spine 1	Downlink	13-14	Leaf 8 port 49 connects to Spine 1 port 13 Leaf 8 port 50 connects to Spine 1 port 14
51-52	Spine 2	Downlink	15-16	Leaf 8 port 51 connects to Spine 2 port 15 Leaf 8 port 52 connects to Spine 2 port 16

Table 9: Spine 1 Port Interconnect Guidelines

From Spine Port(s)	To			Notes
	Device	Network	Port(s)	
1-2, 5-6, 9-10, 13-14	Leaf 1, 3, 5, 7	Downlink	49-50	Spine 1 ports 1 and 2 connect to Leaf 1 ports 49 and 50 Spine 1 ports 5 and 6 connect to Leaf 3 ports 49 and 50 Spine 1 ports 9 and 10 connect to Leaf 5 ports 49 and 50 Spine 1 ports 13 and 14 connect to Leaf 7 ports 49 and 50
3-4, 7-8, 11-12, 15-16	Leaf 2, 4, 6, 8	Downlink	49-50	Spine 1 ports 3 and 4 connect to Leaf 2 ports 49 and 50 Spine 1 ports 7 and 8 connect to Leaf 4 ports 49 and 50 Spine 1 ports 11 and 12 connect to Leaf 6 ports 49 and 50 Spine 1 ports 15 and 16 connect to Leaf 8 ports 49 and 50
29-30, 31, 32, 33-34	Spine 2	Interlink	29-30, 31, 32, 33-34	Spine 1 ports 29-30 connect to Spine 2 ports 29-30 Spine 1 port 31 connects to Spine 2 port 31 Spine 1 port 32 connects to Spine 2 port 32 Spine 1 ports 33-34 connect to Spine 2 ports 33-34

From Spine Port(s)	To			Notes
	Device	Network	Port(s)	
21-22, 23-24, 25-26	Router	Uplink	-	

**Table 10: Spine 2 Port Interconnect Guidelines**

From Spine Port(s)	To			Notes
	Device	Network	Port(s)	
1-2, 5-6, 9-10, 13-14	Leaf 1, 3, 5, 7	Downlink	51-52	Spine 1 ports 1 and 2 connect to Leaf 1 ports 51 and 52 Spine 1 ports 5 and 6 connect to Leaf 3 ports 51 and 52 Spine 1 ports 9 and 10 connect to Leaf 5 ports 51 and 52 Spine 1 ports 13 and 14 connect to Leaf 7 ports 51 and 52
3-4, 7-8, 11-12, 15-16	Leaf 2, 4, 6, 8	Downlink	51-52	Spine 1 ports 3 and 4 connect to Leaf 2 ports 51 and 52 Spine 1 ports 7 and 8 connect to Leaf 4 ports 51 and 52 Spine 1 ports 11 and 12 connect to Leaf 6 ports 51 and 52 Spine 1 ports 15 and 16 connect to Leaf 8 ports 51 and 52
29-30, 31, 32, 33-34	Spine 1	Interconnect	29-30, 31, 32, 33-34	Spine 2 ports 29-30 connect to Spine 1 ports 29-30 Spine 2 port 31 connects to Spine 1 port 31 Spine 2 port 32 connects to Spine 1 port 32 Spine 2 ports 33-34 connect to Spine 1 ports 33-34
21-22, 23-24, 25-26	Router	Uplink	-	

