Pluribus Networks

Netvisor ONE Configuration Guide

Version 6.1.1 HF1

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Preface

Audience

This publication is for experienced network administrators responsible for configuring and maintaining network switches with some expertise in the following areas:

- Network administration
- Storage administration
- Server administration
- Application delivery administration
- Network security administration

Conventions

This document uses the following conventions:

Convention	Indication
Bold font	Keywords, user interface elements, and user-entered text appear in **bold** font.
Italic font	Document titles, new or emphasized terms, and variables that you supply values are in *italic* font.
[]	Elements in square brackets are optional.
{x|y|z}	Required elements are grouped in curly braces and are separated by vertical bars.
[x|y|z]	Optional parameters are grouped in brackets and separated by vertical bars.
String	A non-quoted set of characters. Do not use quotation marks around the string or the string includes the quotation marks.
courier font	Command Line Interface (CLI) commands and samples appear in courier font.
< >	Non-printing characters such as passwords are indicated by angle brackets.
[]	Default responses to system prompts are in square brackets.
:	Indicates that you enter the following text at the command prompt.

Note:	Indicates information of special interest.
Caution!	Indicates a situation that could cause equipment failure or loss of data.

TIP!	Indicates information that can help you solve a problem.
Warning:	Indicates information that could impact you or your network.
Time Saver:	Indicates information that can help you save time.

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Glossary of Pluribus Networks' Netvisor ONE® and UNUM Terms

To review the Glossary, refer to the online document here.

About the Netvisor ONE CLI

This chapter provides information about Pluribus Networks Netvisor ONE command line interface (CLI) on a Netvisor ONE switch.

- Understanding Important Terms
- Entering Commands and Getting Help
- Finding Command Options
- About Alternate Command Format
- Specifying IP Address Netmasks
- Specifying Measurement Units
- Customizing Show Output Formats
- Specifying a Switch or Fabric for Command Scope
- Displaying NIC Information and Statistics
- Running Commands on a Local Switch
- Changing Switch Setup Parameters
- Configuring 802.1X Authentication During Switch Setup
- Creating Switch Groups
- About GREP Support with Netvisor ONE OS

Understanding Important Terms

The following list of important terms and concepts as well as definitions is important for understanding Netvisor One features and determine the best configuration to meet your needs.

Term	Meaning
ACL	An Access Control List is a list of rules that are used to filter network traffic and apply certain actions to it.
Adaptive Cloud Fabric	A number of Netvisor ONE-powered switches that operate and are managed as a single holistic entity is referred to as *Adaptive Cloud Fabric* (*Fabric* in short).
API	An Application Programming Interface is a method to interact with Netvisor ONE switches (typically in a programmatic way) that is functionally equivalent to and has a similar scope as the CLI.
ARP	The Address Resolution Protocol is an IETF standard protocol used to discover the link layer address, such as a MAC address, associated with a given IPv4 address.
AS	An Autonomous System is a collection of connected IP routing prefixes under the control of one or more network operators on behalf of a single administrative entity or domain.
BFD	Bidirectional Forwarding Detection is a UDP-based protocol that provides fast detection of Layer 3 peer failures. It is used in conjunction with routing protocols to accelerate convergence in IP networks.
BGP	The Border Gateway Protocol is a popular standard routing protocol used to exchange routing and reach-ability data among autonomous systems.
BPDU	A Bridge Protocol Data Unit is a frame that carries information about the Spanning Tree Protocol (STP).
CLI	The Command Line Interface is a method to interact with Netvisor ONE switches through user-entered commands, which can be executed on an individual switch, on a cluster, or on a fabric.
Cluster	A pair of adjacent Netvisor ONE-powered

	switches acting as one logical unit at Layer 2 for high availability.
CoS	Class of Service: a 3-bit Ethernet field defined by the IEEE 802.1p standard. It's used to define and apply eight possible levels of QoS to the traffic.
Cgroups	cgroups (abbreviated from control groups), is a Linux kernel feature that limits, accounts for, and isolates the resource usage (such as CPU, memory, disk I/O, network) of a collection of processes.
DCI	Data Center Interconnect is a category of technologies, including those leveraging the VXLAN packet encapsulation, meant to enable the remote interconnection of data centers for improved scalability, performance and reliability or fault tolerance.
DHCP	The Dynamic Host Configuration Protocol is a network management protocol used in IP networks to dynamically assign an IP address and other network configuration parameters to each DHCP client device (host or network node) from one or more DHCP servers.
DSCP	The Differentiated Services Code Point is a 6-bit value in the 8-bit Differentiated Services (DS) field in the IP header. It's used for packet classification purposes for QoS and other applications.
ECMP	Equal-Cost Multi-Path is a routing strategy in which next-hop packet forwarding to a single destination can occur over multiple *best paths*.
EULA	End User License Agreement (or software license agreement) is the contract between the licensors and purchaser, establishing the purchaser's right to use the software.
FIB	The Forwarding Information Base is the (software or hardware) IP forwarding table used by a switch or router to forward IP packets to their destinations.
Firewall	A firewall is a network security system that monitors and controls incoming and outgoing network traffic based on predetermined security policies.
FRR	An IP routing protocol suite for Linux and Unix platforms and include protocol daemons for BGP, IS-IS, LDP, OSPF, PIM, and RIP. FR Routing (FRR) is used for connecting hosts, virtual machines, and containers to the network for

	network switching and routing, advertising network services, and internet peering.
In-band Interface	An internal interface facing the Netvisor ONE kernel used as a fabric-control port when building a fabric over any IP network.
In-band IP Address	The IP address of the switch on a production or management network for administration and inter-switch communication.
ICMP	The Internet Control Message Protocol is a supporting protocol in the Internet Protocol (IP) suite. It is used by network devices, including routers, to send error messages and operational information. With IP version 6, ICMPv6 expanded its capabilities to support additional functions such as Neighbor Discovery Protocol (NDP) and Multicast Listener Discovery (MLD).
IDS	An Intrusion Detection System is a device or a software application that monitors the network infrastructure and/or the end devices for malicious activity or policy violations.
IGMP	The Internet Group Management Protocol is a communications protocol used by hosts and adjacent routers on IPv4 networks to establish multicast group memberships.
Insight Analytics	Insight Analytics is a Network Performance Management (NPM) add-on module to UNUM.
IPS	An Intrusion Prevention System, also known as intrusion detection and prevention system (IDPS), is a network security appliance that monitors the network and/or the end devices for malicious activity. The main functions of an IPS are: to identify malicious activity, to log information about this activity, to report it and also to attempt to block it.
Jumbo Frames	Jumbo frames, or jumbos in short, are Ethernet frames with more than 1500 bytes of payload.
LACP	Link Aggregation Control Protocol (LACP) is a protocol for the collective handling of multiple physical ports that can be seen as a single logical transmission channel (also called trunk, port channel, link aggregation group or link bundle) for network purposes such as traffic load balancing and link redundancy. It was defined in the IEEE 802.3ad standard, later incorporated into 802.3 and later moved to IEEE 802.1AX-2008.
LAG	Link aggregation is a technology used to combine multiple connections in order to

	increase the aggregate bandwidth beyond what a single connection can sustain, and to provide redundancy in case of link failure. A Link Aggregation Group (LAG) *bundles* a number of physical ports together to create a single high-bandwidth data path, so as to implement traffic load sharing and link redundancy. Other terms used to describe this technology include port trunking, port channel, link bundling, channel bonding "and–with" servers–NIC bonding and NIC teaming. The link aggregation process is supported by a dynamic protocol called Link Aggregation Control Protocol (LACP).
LLDP	The Link Layer Discovery Protocol is a standard link layer protocol (IEEE 802.1AB) used by network devices to advertise their identity, capabilities and neighbors on an IEEE 802 local area network.
MAC Address	The medium access control (MAC) is a sub-layer of the data link layer in IEEE 802 LAN/MAN standards.
MIB	A Management Information Base is a database used for managing the entities in a computer network. MIBs are typically used with Simple Network Management Protocol (SNMP).
MLD	Multicast Listener Discovery is a process used by IPv6 routers to discover multicast listeners on a directly attached link, much like the Internet Group Management Protocol (IGMP) is used in IPv4.
MSTP	The Multiple Spanning Tree Protocol is a protocol introduced by the IEEE 802.1s standard and later incorporated into IEEE 802.1Q-2005, to extend the Rapid Spanning Tree Protocol to support multiple STP instances for load balancing and to introduce various other protocol enhancements.
MTU	The Maximum Transmission Unit is the size of the largest protocol data unit (PDU) that can be transmitted in a single network layer or data link layer transaction.
NDP or ND	Neighbor Discovery (Protocol) is an IPv6 node discovery process that has similar (and improved) functionalities compared to IPv4's ARP. It is based on the ICMPv6 standard protocol.
Netflow	NetFlow is a feature of Cisco routers and switches that provides the ability to collect IP network traffic statistics and to export them to a

	collector device.
Netvisor ONE	Netvisor Open Networking Edition (ONE) is Pluribus' enterprise-class Network Operating System built for Open Networking hardware, which supports an extensive range of networking services: from the more basic ones such as Layer 2 and Layer 3 switching for both IPv4 and IPv6 protocols, to the more advanced ones such as data center interconnect (DCI) through VXLAN support and in-depth traffic analytics.
NFS	Network File System is a distributed file system protocol that enables a user on a client computer to access files over a computer network much like local storage is accessed.
OSPF	Open Shortest Path First is a standard routing protocol that falls into the category of interior gateway protocols (IGPs), operating within a single autonomous system.
OVSDB	The Open vSwitch Database Management Protocol is an SDN configuration protocol. It is used, for example, to interface with a SDN controller such as OpenDayLight or VMware NSX.
Out-of-band Interface	A dedicated out-of-band port on Netvisor ONE switches, used either as a management-only interface or as a fabric-control port to form the fabric and exchange fabric information over the out-of-band management network.
Overlay	In the VXLAN context, this term refers to all the elements built on top of the generic IP transport infrastructure in order to offer higher-level transport functionalities and services.
PIM	Protocol-Independent Multicast is a family of standard multicast routing protocols for IP networks that enable one-to-many and many-to-many forwarding of data over a LAN, WAN or the Internet.
Quagga	Quagga is a network routing software suite providing implementations of Open Shortest Path First (OSPF), Routing Information Protocol (RIP), Border Gateway Protocol (BGP) and IS-IS for Unix-like platforms.
QinQ	QinQ is a technique (also known as stacked VLANs, or Q-in-Q) that can apply an extra VLAN tag on top of the standard 802.1Q tag (hence the term of VLAN stacking).
QoS	Quality of Service refers to traffic prioritization

	and resource reservation control mechanisms that can provide different priorities to different applications, users, or data flows, and that can guarantee a certain level of performance to each data flow.
QSFP+	The Quad Small Form-factor Pluggable module is a compact, hot-pluggable transceiver used for data communications applications. QSFP+ is an evolution of QSFP to support four channels carrying 10 Gigabit Ethernet that can be combined to form a single 40 Gigabit Ethernet link.
RA	Router Advertisement is a type of ICMPv6 message used for the Neighbor Discovery (ND) process.
RESTful	Representational State Transfer (REST) is a software architectural style that defines a set of rules to be used for creating web services. Web services that conform to the REST architectural style are called RESTful.
RIB	The Routing Information Base is the IP routing table created by a switch or router by collecting routing information from multiple sources including configuration (static routes), dynamic routing protocols (RIP, OSPF, BGP), etc.
RIP	The Routing Information Protocol is an old distance-vector routing protocol that employs the hop count as a routing metric. It has two versions, RIPv1 and RIPv2, for IPv4 while RIPng is an extension of RIPv2 with support for IPv6.
RMA	A Return Merchandise Authorization is usually referred to the process of returning a product to receive a replacement or repair (and implicitly following the associated network administrator procedures).
RSTP	The Rapid Spanning Tree Protocol was introduced as standard IEEE 802.1w to provide significantly faster spanning tree convergence after a topology change compared to regular STP, while maintaining full backward compatibility with it.
SCP	The Secure Copy Protocol is a network protocol based on the BSD RCP protocol that supports secure file transfers between devices on a network. Security (authenticity and confidentiality of the data in transit) is based on the Secure Shell (SSH) protocol.
SDN	Software-Defined Networking is defined by the

	Open Networking Foundation as an emerging architecture that is dynamic, manageable, cost-effective and adaptable, making it ideal for the high-bandwidth, dynamic nature of today's applications.
SFP+	The enhanced Small Form-factor Pluggable module is a compact, hot-pluggable transceiver that supports data rates of up to 16 Gbit/s and is therefore used for 10 Gigabit Ethernet interfaces.
SFTP	The SSH File Transfer Protocol is an IETF network protocol that provides file access, file transfer and file management over any reliable data stream. It was designed as an extension of the Secure Shell protocol (SSH) version 2.0 to provide secure file transfer capabilities.
SLACC	IPv6 State-Less Address Auto-Configuration is the process by which IPv6 hosts can configure themselves automatically when connected to an IPv6 network using the Neighbor Discovery Protocol function via ICMPv6 router discovery messages.
SNMPv3	Simple Network Management Protocol is an IETF standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change a device’s behavior. SNMPv1 is the original version of the protocol, while SNMPv2c and SNMPv3 are more recent versions that feature improvements in performance, flexibility and security.
SSH	Secure Shell is a cryptographic network protocol that enables network services to operate securely over an insecure network. Typical applications include remote command-line login and remote command execution.
STP	In a bridged network the Spanning Tree Protocol (IEEE 802.1D and IEEE 802.1Q-2014 standards) is used to turn a redundant physical topology into a loop-free, tree-like logical forwarding topology by setting one or more ports to blocking state, so as to prevent bridging loops.
Syslog	Syslog is a standard technology for message logging which logically separates the software that generates the messages, the system that stores them, and the software that reports them.
TLS	Transport Layer Security is a cryptographic protocol designed to provide communication

	security over a computer network with the aim of guaranteeing privacy and data integrity between two or more communicating computer applications.
Traffic Flow	Also known as packet flow or network flow, is a sequence of packets from a source device to a destination (a unicast destination, a multicast group, or a broadcast address).
Underlay	In the VXLAN context, this term refers to the generic IP transport infrastructure used to ensure IP reach-ability among all Virtual Tunnel Endpoints (VTEP) in the network that create the overlay.
UNUM™	Pluribus Unified Management, Automation and Analytics Platform is a multi-functional web management portal that enhances the intrinsic automation of the Adaptive Cloud Fabric architecture.
vCenter Server	vCenter Server is the centralized management utility for VMware. It is used to centrally manage hypervisors (ESXi), storage, virtual machines, and all dependent components (such as network and security).
vFlow	Pluribus' mechanism used to filter fabric-wide data center switching traffic on a granular flow level, and to apply security/QoS (Quality of Service) actions or forwarding decisions on each defined flow.
VIP	A Virtual IP is an IP address that does not correspond to an actual physical device but to a virtual forwarding entity (for example for redundancy purposes). In this document's context it's the IP address used by VRRP instances and by VTEPs.
vLAG	Virtual Link Aggregation Group is a Netvisor ONE multi-chassis link aggregation technology to bundle two or more links together when the links belong to two different chassis (behaving as a single virtual chassis/cluster).
VLAN	A Virtual LAN is a logical broadcast domain that is identified by using a specific frame tag format (defined by the IEEE 802.1Q standard) and is isolated at the data link layer in a computer network.
vLE	Virtual Link Extension is a Netvisor ONE technology that enables the creation of Layer 1 pseudo-wires that can emulate a direct connection between devices on top of an IP

	transport network.
vNET	A Virtual NETwork is a partition of the fabric. A vNET is defined by a group of network objects that can operate independently and have dedicated resources. This is how Netvisor ONE provides multi-tenancy support and in-depth network segmentation (beyond VLANs and VRFs).
VNI	In VXLAN parlance, each segment is identified through a 24-bit segment ID called the “VXLAN Network Identifier” (VNI). This allows up to 16M VXLAN segments to coexist within the same administrative domain.
vPorts	“Virtual ports” are software Layer 2 entries associated to all ports a Pluribus switch performs MAC address learning on.
VRF	Virtual Routing and Forwarding is a technology that allows multiple routing spaces to coexist on the same switch. It complements the vRouter construct, offering a highly scalable solution for multi-tenant environments.
vRouter	An object used to provide routing between subnets, VLANs and/or vNETs. The vRouter runs in a dedicated operating system container.
VRRP	Virtual Router Redundancy Protocol is a networking protocol that provides redundancy of routing paths by creation of virtual routers, which are an abstract representation of multiple routers (i.e., master and backup routers) acting as a group.
VTEP	A VXLAN Tunnel Endpoint is the entity responsible for encapsulating / de-encapsulating VXLAN packets.
VTEP HA	VTEP High Availability refers to a mechanism designed to ensure redundancy of the VTEP entity.
VXLAN	Virtual Extensible LAN is a standard UDP-based packet encapsulation technology defined in RFC 7348. VXLAN’s Ethernet-in-UDP encapsulation is used to implement the overlaying of virtualized Layer 2 networks over Layer 3 networks.
Wireshark	Wireshark is a free open source packet analyzer. It is used for network troubleshooting and analysis, and for software and communications protocol development.
ZTP	Zero Touch Provisioning is a network device capability that enables it to be provisioned and

	configured automatically, reducing the overhead required for a complete network deployment.

Entering Commands and Getting Help

Commands, options, and arguments are entered at the CLI prompt. A command name must be typed, but included command-completion and help features contribute to the command entry process.

To display a list of commands you use within a command mode, enter a question mark (?), or use the tab key, or type help at the command prompt.

You also display keywords and arguments for each command with this context-sensitive help feature.

Use the complete commands and display keywords and arguments for each command using the tab key to assist with context-sensitive command help and completion.

Table 1, lists the command that you enter to get help specific to a command, keyword, or argument.

Table 1: Getting Help

`abbreviated- command-entry?`	Displays a list of commands that begin with a specific character string. Do not leave a space between the string and question mark.
`abbreviated- command-entry` `<tab>`	Completes a partial command name.
`?`	Lists all commands.
`command` `?`	Lists all keywords for the command. Leave a space between the command and the question mark.
`command keyword` `?`	Lists all arguments for the keyword. Leave a space between the command and the question mark.

Where a text string is used, such as *name-string*, the following characters are allowed as part of the text string:

- a-z, A-Z, 0-9, _ (underscore), . (period), , (comma), : (colon), and - (dash).

> **Note:** If you enter an invalid command, using the ? and tab key has no effect and does not return any changes to the CLI.

Note: The CLI has an editing ability similar to UNIX and Linux functionality using emacs keys. For example, ^**p** steps backward through previous commands, ^**n** moves to the next command in the history, ^**a** moves to the first character in the command and ^**e** moves to the end of the line, ^**u** erases the current line, and ^**w** erases the previous word. Also, you can use the up and down arrows on your keyboard to retrieve the last command entered at the CLI.

Finding Command Options

The syntax can consist of optional or required keywords.

To display keywords for a command, enter a question mark (?) at the command prompt or after entering part of a command followed by a space.

Netvisor One CLI displays a list of available keywords along with a brief description of the keywords.

For example, if you want to see all of the keywords for the command **user**, enter **user ?**.

Table 2, displays examples of using the question mark (?) to assist you with entering commands.

Table 2: Finding Command Options

CLI network-admin@switch > ? All commands: acl-ip-create acl-ip-delete ...	Displays a list of commands that begin with a specific character string. Do not leave a space between the string and question mark.
Switch> user auth User: <user> Password: <password>	Completes a partial command name.
?	Lists all commands.
command ?	Lists all keywords for the command. Leave a space between the command and the question mark.
command option ?	Lists all arguments for the option. Leave a space between the command and the question mark.

Note: Other useful options, especially for displaying statistics, include: `sort`, `interval`, `start-time`, `end-time`, `duration`, `count`, `show-interval`, and `show-diff-interval`. The commands that display the statistics have `show-diff-interval` as a command option, while other show commands have `show-interval` as a command option.

About Alternate Command Format

Netvisor ONE provides with an alternate command format, where the commands start with a verb instead of a noun. This format omits the hyphen in the command names.

For example, `connection-stats-show` can also be entered as `show connection-stats`.

The command formats have the same features and can be used interchangeably.

Specifying IP Address Netmasks

Some commands call for the specification of an IP address netmask. The Netvisor ONE supports both Classless Inter-Domain Routing (CIDR) and subnet notations.

For example, to specify the range of IP addresses from 192.168.0.0 to 192.168.0.255, you can express as:

- IP address: 192.168.0.0/24 or
- IP address: 192.168.0.0:: 255.255.255.0 (netmask)

Here is a sample of the CIDR to subnet notation mapping:

CIDR	Subnet Mask
/24	255.255.255.0
/25	255.255.255.128
/26	255.255.255.192

Specifying Measurement Units

Many commands include input and output of capacity and throughput. Network values are always in bits and storage values in bytes.

Scale factors are allowed on input and displayed in output as well as shown in the following table.

Table 3: Scale Numbers

Scale Indicator	Meaning (Networking)	Meaning (Storage)
K or k	Kilobits	Kilobytes
M or m	Megabits	Megabytes
G or g	Gigabits	Gigabytes
T or t	Terabits	Terabytes

Customizing Show Output Formats

The output generated by the show commands can be customized by using the optional arguments described in the following table.

Table 4: Show Output Formats

`format <column_name1>, <column_name2>, <column_nameX>`	Displays only the columns matching the list of column header names. **NOTE**: The list of column names is comma-separated without spaces.
`format all`	Displays all available column headers. This output is also called **verbose mode**. By default, show commands output a terse set of the most commonly useful column headers.
`layout horizontal|vertical`	Specify if you want to display show output in a horizontal or vertical format. Vertical may be more useful for verbose show outputs. For example: `CLI (network-admin@switch) > vlan-show format all layout vertical`
`parsable-delim <separator>`	Displays the output of show command by separating columns by the specified <separator> character(s). For example, parsable-delim , produces a comma-separated output (CSV). **NOTE**: If the parsable-delim option is specified, the column header names (titles) are suppressed from the output.
`pager on|off`	Displays the output as pages (pager `on`) or as a single scroll-able page (pager `off`).

Below are some examples of how the output for the show commands are displayed in Netvisor ONE CLI.

To display the select columns, enter the command followed by the option `format <column_name1>, <column_name2>, <column_nameX>` as below:

```
CLI (network-admin@pn-1) switch pn-1 lldp-show format switch,
local-port, chassis-id, port-id, port-desc

switch   local-port  chassis-id  port-id  port-desc
-------  ----------  ----------  -------  ----------------------------
pn-1      1           0e0000e8     1       spine-cluster cluster link
pn-1      2           1100013f     5       trunk from cluster-1 to spine cluster
pn-1      3           11000141     5       trunk from cluster-1 to spine cluster
pn-1      4           11000147     5       trunk from cluster-2 to spine cluster
pn-1      5           11000145     5       trunk from cluster-2 to spine cluster
```

To display the output on a local switch that you had logged in (the * indicates the local switch in the example below). You don't need to specify the switch-name for all the commands that you run on the local switch.

```
CLI (network-admin@switch-1) > switch-local

CLI (network-admin@pn-sw01*) > lldp-show

 local-port      chassis-id      port-id       port-desc                               sys-name
 ----------      ----------      --------      ----------                              ----------

 1               0e0000e8        1             spine-cluster cluster link              pn-sw02

 2               1100013f        5             trunk from cluster-1 to spine cluster   pn-swl01

 3               11000141        5             trunk from cluster-1 to spine cluster   pn-swl02

 13              0e000063        2             PN Switch Port(2                        pn-swl06
```

To display all the switches in a fabric, for example, use the `switch <tab>` command:

```
CLI (network-admin@pn-sw01) > switch

pn-sw01
pn-swl04
pn-swl02
pn-sw02
leaf_clust_1        pn-swl01,pn-swl02
leaf_clust_2        pn-swl03,pn-swl04
even-cluster-nodes pn-swl02,pn-swl04,pn-swl06,pn-sw02
odd-cluster-nodes  pn-swl01,pn-swl03,pn-swl05,pn-sw01
spine_clust         pn-sw01,pn-sw02
*                   all switches in the fabric
```

To display the output in vertical format, for example, use the command:

```
CLI (network-admin@pn-swl03) > cluster-show layout vertical

switch:                     pn-swl01
name:                       pn-swl0102
state:                      online
cluster-node-1:             pn-swl01
cluster-node-2:             pn-swl02
tid:                        4034
mode:                       master
ports:                      1,125,272
```

```
remote-ports:                1,125,272
cluster-sync-timeout(ms):    2000
cluster-sync-offline-count: 3
switch:                      pn-swl02
name:                        pn-swl0102
state:                       online
cluster-node-1:              pn-swl01
cluster-node-2:              pn-swl02
tid:                         4034
mode:                        slave
ports:                       1,125,272
remote-ports:                1,125,272
cluster-sync-timeout(ms):    2000
cluster-sync-offline-count: 3
```

Specifying a Switch or Fabric for Command Scope

In Netvisor ONE Adaptive Cloud Fabric, a switch is designed as the building block of a fabric and the goal of Netvisor ONE design is to manage the fabric of switches as a single switch. Due to this capability, you can run the CLI commands on a local switch, a cluster of switches, other switches in the fabric, or the entire fabric. You do not have to login to each switch to run the commands because all the switches are part of the same fabric. By default, you can run the commands on the switch that you had logged-in.

For example, to disable a port (`port 5`) on the switch that you had logged in (`switch-1`), use the command,

```
CLI(network-admin@Switch-1) >  port-config-modify port 5
disable
```

To specify a different switch for a single command, use the `switch` prefix. For example, use `switch pn-switch-2 port-config-modify port 5 enable` to enables port 5 on pn-switch-2, even if the CLI is connected to a different switch in the fabric:

```
CLI(network-admin@Switch-1) >  switch pn-switch-2 port-config-
modify port 5 enable
```

To specify a different switch for a series of commands, use the `switch` prefix with no command. For example,

```
CLI(network-admin@Switch-1) >  switch pn-switch-2 <return>

CLI(network-admin@pn-switch-2) >
```

The CLI prompt changes to indicate that `pn-switch-2` is the switch you are executing commands. You can run other commands on `pn-switch-2` even though the switch that you are physically connected to is switch-1.

For most CLI show commands, the command displays results from all switches in the fabric by default. For example, when the CLI command `port-show` is entered on the switch, it shows the ports of all switches in the fabric.

To specify that a CLI show command should apply to a specific switch, use the switch prefix to the CLI command. For example, to view the show output of the `port-show` command of the switch named pn-switch-1, type the command:

```
CLI(network-admin@Switch-1) > switch pn-switch-1 port-show

 switch         port      bezel-port      status
-----------     ----     ----------     --------------------
pn-switch-1      9          3            phy-up,host-disabled
pn-switch-1      10         3.2          phy-up,host-disabled
```

Displaying NIC Information and Statistics

Starting from Netvisor ONE version 6.0.0, you can view the NIC information and packet statistics for management and rear-facing interfaces.

To view the switch NIC information, use the command: `switch-nic-info-show`.

```
CLI (network-admin@Leaf1) > switch-nic-info-show
```

`switch-nic-info-show`	Display switch NIC information.
`name` *`switch-nic-stats-list-name`*	Specify the name of the interface.

For example, to display the NIC information for the interface eth0, use the command:

```
CLI (network-admin@Leaf1) > switch-nic-info-show name eth0

name driver version    firmware      speed rxqnum txqnum rxqsize txqsize autoneg rxpause
txpause
---- ------ ------- --------------- ----- ------ ------ ------- ------- ------- -------
-------
eth0 igb    5.4.0-k 3.25,0x800005cd 1000    4      4      4096    4096    on      on
 off
```

The output displays the interface name, driver, version, firmware, speed, reception queue size, and transmitter queue size, among other details.

The `switch-nic-stats-show` command displays NIC statistics including the number of input packets, input bytes, output packets, output bytes, errors, and drops.

```
CLI (network-admin@Leaf1) > switch-nic-stats-show
```

`switch-nic-stats-show`	Display switch NIC statistics.
`time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the time to start statistics collection.
`start-time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the start date and time for statistics collection.
`end-time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the end date and time for statistics collection.
`duration` *`duration: #d#h#m#s`*	Specify the duration for statistics collection.
`interval` *`duration: #d#h#m#s`*	Specify the interval for statistics collection.
`since-start`	Displays statistics from the start.
`older-than` *`duration: #d#h#m#s`*	Displays statistics older than the specified date and time.
`within-last` *`duration:`*	Displays statistics within the specified

#d#h#m#s	duration.
name *switch-nic-stats-list name*	Specify the name of the interface.

For example, to display the NIC statistics on eth0 interface within last 2 minutes, use the command:

```
CLI (network-admin@Leaf1) > switch-nic-stats-show name eth0
within-last 2m layout vertical
time:          00:22:35
name:          eth0
ipkts:         3.22M
ibytes:        1.92G
opkts:         1.10M
obytes:        277M
ierrs:         0
oerrs:         0
idrops:        0
odrops:        0
imcast:        2.08M
omcast:        119K
ibcast:        121K
obcast:        37.3K
mcast:         2.08M
bcast:         0
ioverruns:     0
rxnobuf:       0
icrcerrs:      0
iframeerrs:    0
ififoerrs:     0
ofifoerrs:     0
ilongerrs:     0
ishorterrs:    0
```

To display the statistics between a specified `start-time` and `end-time`, use the sample command:

```
CLI (network-admin@leaf1) > switch-nic-stats-show start-time
2020-07-21T05:00:00 end-time 2020-07-21T06:00:00 layout
vertical
time:          05:26:27
name:          eth0
ipkts:         25.2M
ibytes:        3.76G
opkts:         29.7M
obytes:        3.95G
ierrs:         0
oerrs:         0
idrops:        0
odrops:        0
imcast:        834K
```

```
omcast:       10.6K
ibcast:       291K
obcast:       352
mcast:        834K
bcast:        0
ioverruns:    0
rxnobuf:      0
icrcerrs:     0
iframeerrs:   0
ififoerrs:    0
ofifoerrs:    0
ilongerrs:    0
ishorterrs:   0
time:         05:26:27
```

To modify the settings for statistics collection, use the command:

```
CLI (network-admin@Leaf1) > switch-nic-stats-settings-modify
```

`switch-nic-stats-settings-modify`	Modify switch NIC statistics settings.
Specify one or more of the following options:	
`enable|disable`	Enable or disable statistics collection.
`interval` *`duration : #d#h#m#s`*	Specify the time interval to collect NIC statistics. The default value is 1 minute.
`disk-space` *`disk-space-number`*	Specify the disk-space allocated for statistics (including rotated log files). The default value is 50M.

For example, use the command below to modify the interval for statistics collection:

```
CLI (network-admin@Leaf1) > switch-nic-stats-settings-modify
interval 50s
```

To view the current settings, use the command:

```
CLI (network-admin@Leaf1) > switch-nic-stats-settings-show
switch:      Leaf1
enable:      yes
interval:    50s
disk-space:  50M
```

Running Commands on a Local Switch

You can specify to run commands locally on a switch by using the `switch-local` parameter.

For instance, using `switch-local  port-stats-show` displays output for the local switch ports only.

Changing Switch Setup Parameters

You can modify the following switch parameters by using the `switch-setup-modify` command:

- Switch name
- Management IPv4 and IPv6 addresses
- Management IPv4 and IPv6 netmasks
- Management IPv4 and IPv6 address assignments
- In-band IPv4 and IPv6 addresses
- In-band IPv4 and IPv6 netmasks
- Gateway IPv4 and IPv6 addresses
- Loopback IPv4 and IPv6 addresses
- Primary and secondary IPv4 addresses for DNS services
- Domain name
- NTP server and NTP secondary server
- Timezone
- End User License Agreement (EULA) acceptance and timestamp
- Password
- Date
- Enable or disable host ports
- Message of the Day (MOTD)
- Banner
- Management interface LAG: enable or disable
- LACP mode of the management interface
- NTP enable or disable
- IEEE 802.1X authentication of the management interface (when not part of a LAG)

For example if you want to change the date and time on the switch, use the command:

```
CLI (network-admin@switch-1) > switch-setup-modify date 2020-
01-28 T22:14:27
```

To view the changed date (see **bold** in output), use the show command:

```
CLI (network-admin@sw-leaf1) > switch-setup-show
switch-name:                  sw-leaf1
mgmt-ip:                      10.0.0.01/23
mgmt-ip-assignment:           static
mgmt-ip6:                      aa80::aab4:bbff:fffc:aa65/64
mgmt-ip6-assignment:          autoconf
mgmt-link-state:              up
mgmt-link-speed:              1g
in-band-ip:                    10.168.0.02/24
in-band-ip6:                   aa80::640a:94ff:ff52:aa9d/64
in-band-ip6-assign:           autoconf
gateway-ip:                   10.0.0.1
dns-ip:                       10.10.0.13
dns-secondary-ip:              172.10.0.4
domain-name:                   pluribusnetworks.com
ntp-server:                    0.ubuntu.pool.ntp.org
ntp-secondary-server:          1.ubuntu.pool.ntp.org
timezone:                      America/Los_Angeles
date:                         2020-01-28,22:14:27
hostid:                       184556370
location-id:                  6
enable-host-ports:            yes
banner:                        * Welcome to Pluribus Networks Inc.
Netvisor(R). This is a monitored system.     device-id: 6K1K0Z1
banner: * ACCESS RESTRICTED TO AUTHORIZED USERS ONLY
banner:                       * By using the Netvisor(R) CLI,you
agree to the terms of the Pluribus Networks  banner: * End
User License Agreement (EULA). The EULA can be accessed via
banner:                       *
http://www.pluribusnetworks.com/eula or by using the command
"eula-show"      *
```

Changing NTP Secondary Server During Switch Setup

From Netvisor ONE version 6.0.0 and later release, you can undo or unset a configured NTP secondary server by using the `switch-setup-modify` command along with an empty string ("") as parameter. You can use either single-quotes ('') or double-quotes ("") to indicate the empty string.

First, view the switch setup details using the command:

```
CLI (network-admin@sw-leaf1) > switch-setup-show
switch-name:                 sw-leaf1
mgmt-ip:                     10.0.0.01/23
mgmt-ip-assignment:          static
mgmt-ip6:                     aa80::aab4:bbff:fffc:aa65/64
mgmt-ip6-assignment:         autoconf
mgmt-link-state:             up
mgmt-link-speed:             1g
in-band-ip:                  10.168.0.02/24
in-band-ip6:                  aa80::640a:94ff:ff52:aa9d/64
in-band-ip6-assign:          autoconf
gateway-ip:                  10.0.0.1
dns-ip:                      10.10.0.13
dns-secondary-ip:            172.10.0.4
domain-name:                 pluribusnetworks.com
ntp-server:                  0.ubuntu.pool.ntp.org
ntp-secondary-server:        1.ubuntu.pool.ntp.org
timezone:                    America/Los_Angeles
date:                        2020-01-28,22:14:27
hostid:                      184556370
location-id:                 6
enable-host-ports:           yes
```

To remove or unset the secondary NTP server, use the command with an empty string in single quotes or double quotes as below:

```
CLI (network-admin@sw-leaf1) > switch-setup-modify ntp-
secondary-server
Server ip or host-name / empty string to unset

CLI (network-admin@sw-leaf1) > switch-setup-modify ntp-
secondary-server ""
```

or

```
CLI (network-admin@sw-leaf1) > switch-setup-modify ntp-
secondary-server ''
```

Check the show output to view the changes by using the command:

```
CLI (network-admin@sw-leaf1) > switch-setup-show
switch-name:                  sw-leaf1
mgmt-ip:                      10.0.0.01/23
mgmt-ip-assignment:           static
mgmt-ip6:                      aa80::aab4:bbff:fffc:aa65/64
mgmt-ip6-assignment:          autoconf
mgmt-link-state:              up
mgmt-link-speed:              1g
in-band-ip:                   10.168.0.02/24
in-band-ip6:                   aa80::640a:94ff:ff52:aa9d/64
in-band-ip6-assign:           autoconf
gateway-ip:                   10.0.0.1
dns-ip:                       10.10.0.13
dns-secondary-ip:             172.10.0.4
domain-name:                   pluribusnetworks.com
ntp-server:                    0.ubuntu.pool.ntp.org
timezone:                      America/Los_Angeles
date:                         2020-01-28,22:14:27
hostid:                       184556370
location-id:                  6
enable-host-ports:            yes
```

Configuring 802.1X Authentication During Switch Setup

A Pluribus switch can be connected to an out-of-band network for management purposes using the dedicated management interface.

Starting from Netvisor ONE release 6.1.0, it is possible to use the `switch-setup-modify` command to configure the standard IEEE 802.1X authentication (as a supplicant) on the switch management interface. The interface needs to be connected to an authenticator device and cannot be part of a LAG for this feature to work.

An external network device used for out-of-band connectivity may be capable of running the IEEE 802.1X standard as an authenticator. In such cases, for security purposes the network administrator may want to enable the IEEE 802.1X authentication exchange between the switch management interface (as a supplicant) and the external authenticator.

Once the management interface is configured as supplicant and comes up, it sends out a special 802.1X message (*EAPoL Start*) to start the authentication process. If the authentication of the configured credentials is successful, then the interface is *authorized*. Before the interface is authenticated, only 802.1X packets are allowed and all other traffic is dropped on the authenticator device.

> **Note**: In Netvisor ONE release 6.1.0 support was added for the *EAP-MD5 authentication* method only. In addition, Netvisor ONE supports the 802.1X-2001 version of the standard for interoperability with older authenticators as well as the 802.1X-2004 version.

802.1X can be configured during a fresh switch install or later using the `switch-setup-modify` and `switch-setup-show` commands.

However, the 802.1X configuration requires the creation of a host profile before the feature can be enabled. That cannot be achieved within the `switch-setup-modify` command, so a two-step process is required.

First, a host profile needs to be created like so:

```
CLI (network-admin@switch) > eap-host-profile-create name
profile1 mode md5 identity user1 password
password for user identity:
confirm password for user identity:
```

The profile can be created with local (or cluster) scope and then verified with the command:

```
CLI (network-admin@switch) > eap-host-profile-show
switch  name          mode identity    scope
------- ------------- ---- ----------- -----
switch  profile1      md5  user1       local
```

Then 802.1X can be enabled with the `switch-setup-modify` command by specifying the newly created profile plus an additional parameter such as the standard version to use:

```
CLI (network-admin@switch) > switch-setup-modify mgmt-dot1x-
enable mgmt-dot1x-profiles profile1 mgmt-dot1x-version 802.1X-
2004

CLI (network-admin@switch) > switch-setup-show
switch-name:                switch
mgmt-dot1x-enable:          true
mgmt-dot1x-version:         802.1X-2004
mgmt-dot1x-profiles:        profile1
mgmt-dot1x-status:          CONNECTING
mgmt-ip:                    10.14.8.90/23
mgmt-ip-assignment:         static
mgmt-ip6:                   fe80::660e:94ff:fe4c:de/64
mgmt-ip6-assignment:        autoconf
mgmt-link-state:            up
mgmt-link-speed:            1g
in-band-ip:                 192.168.3.55/24
in-band-ip6:                fe80::640e:94ff:fe03:faf8/64
in-band-ip6-assign:         autoconf
gateway-ip:                 10.14.8.1
dns-ip:                     10.135.2.13
dns-secondary-ip:           10.20.4.1
domain-name:                pluribusnetworks.com
ntp-server:                 10.135.2.13
ntp-secondary-server:       10.20.4.1
ntp-tertiary-server:        2.ubuntu.pool.ntp.org
timezone:                   America/Los_Angeles
date:                       2021-04-09,03:37:57
hostid:                     436207619
location-id:                1
enable-host-ports:          yes
banner:                     * Welcome to Pluribus Networks Inc.
Netvisor(R). This is a monitored system.    *
device-id:                  1648AC5800042
ntp:                        on
banner:                     *                 ACCESS RESTRICTED
TO AUTHORIZED USERS ONLY                      *
banner:                     * By using the Netvisor(R) CLI,you
agree to the terms of the Pluribus Networks *
banner:                     * End User License Agreement
(EULA). The EULA can be accessed via              *
banner:                     *
http://www.pluribusnetworks.com/eula or by using the command
"eula-show"      *
```

The `mgmt-dot1x-status` line in the output can have one of these values:

- AUTHENTICATED (authentication successful and port authorized)
- CONNECTING (connecting to the authenticator, check periodically for updates)
- UNKNOWN (unknown condition that can occur in corner cases)

- HELD (authentication failed on the authentication backend server)

After connecting, if the credentials are correctly configured both in the backend's database and in the supplicant's profile, the port gets authenticated as shown below:

```
CLI (network-admin@switch) > switch-setup-show
switch-name:               switch
mgmt-dot1x-enable:         true
mgmt-dot1x-version:        802.1X-2004
mgmt-dot1x-profiles:       profile1
mgmt-dot1x-status:         AUTHENTICATED
mgmt-ip:                   10.14.8.90/23
mgmt-ip-assignment:        static
mgmt-ip6:                  fe80::660e:94ff:fe4c:de/64
mgmt-ip6-assignment:       autoconf
mgmt-link-state:           up
mgmt-link-speed:           1g
in-band-ip:                192.168.3.55/24
in-band-ip6:               fe80::640e:94ff:fe03:faf8/64
in-band-ip6-assign:        autoconf
gateway-ip:                10.14.8.1
dns-ip:                    10.135.2.13
dns-secondary-ip:          10.20.4.1
domain-name:               pluribusnetworks.com
<snip>
```

The same two-step process can be used during a fresh switch install like so:

```
Netvisor OS Command Line Interface 6.1
        By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT
YOU HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER
LICENSE AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?
: YES or NO?
        By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT
YOU HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER
LICENSE AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?
: YES or NO?
        By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT
YOU HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER
LICENSE AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?
: YES or NO?
        By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT
YOU HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER
LICENSE AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?
:
YES or NO?
        By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT
YOU HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER
LICENSE AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?
: YES
Switch setup required:
        Switch Name (switch):
        network-admin Password:
```

```
        Re-enter Password:
        Mgmt IP/Netmask (10.14.8.90/23):
        Mgmt IPv6/Netmask:
        In-band IP/Netmask (192.168.3.55/24):
        In-band IPv6/Netmask:
        Gateway IP (10.14.8.1):
        Gateway IPv6:
        Primary DNS IP (10.135.2.13):
        Secondary DNS IP (10.20.4.1):
        Domain name (pluribusnetworks.com):
        Automatically Upload Diagnostics (yes):
        Enable host ports by default (yes):

Switch Setup:
        Switch Name            : switch
        Mgmt 802.1x cfg        : no
        Mgmt 802.1x profiles   :
        Mgmt 802.1x status     :
        Switch Mgmt IP         : 10.14.8.90/23
        Switch Mgmt IPv6       : fe80::660e:94ff:fe4c:de/64
        Switch In-band IP      : 192.168.3.55/24
        Switch In-band IPv6    : fe80::640e:94ff:fe03:faf8/64
        Switch Gateway         : 10.14.8.1
        Switch IPv6 Gateway    : ::
        Switch DNS Server      : 10.135.2.13
        Switch DNS2 Server     : 10.20.4.1
        Switch Domain Name     : pluribusnetworks.com
        Switch NTP Server      : 10.135.2.13
        Switch Timezone        : America/Los_Angeles
        Switch Date            : 2021-04-09,04:00:14
        Enable host ports      : yes
        Analytics Store        : optimized
Fabric required. Please use fabric-create/join/show
Connected to Switch switch; nvOS Identifier:0x1a000003; Ver:
6.1.0-6010018092

CLI (network-admin@switch) > eap-host-profile-create name
profile1 mode md5 identity user1 password
password for user identity:
confirm password for user identity:

CLI (network-admin@switch) > switch-setup-modify mgmt-dot1x-
enable mgmt-dot1x-profiles profile1 mgmt-dot1x-version 802.1X-
2004
```

Note: If you try to delete a profile that is in use, you will get an error message:

```
CLI (network-admin@switch) > eap-host-profile-delete name
profile1
eap-host-profile-delete: EAP Host profile profile1 is
currently used
```

If you need to delete it, you can create and assign another profile first, then you can delete the old one:

```
CLI (network-admin@switch) > switch-setup-modify mgmt-dot1x-
profiles profile2

CLI (network-admin@switch) > eap-host-profile-delete name
profile1

CLI (network-admin@switch) > eap-host-profile-show
switch   name          mode identity    scope
------- ------------- ---- ----------- -----
switch   profile2      md5  user1       local
```

802.1X can be disabled with the following command:

```
CLI (network-admin@switch) > switch-setup-modify mgmt-dot1x-
disable
```

Creating Switch Groups

This feature allows you to create a switch group, and you can create as many switch groups as needed. You provide a name to a group of switches, and a switch can be a member of more than one group.
If a switch is offline when you add it to a group, the configuration fails for that switch. Online switches are added normally.

Switch groups are static and you must manually remove a switch from a group. You cannot use a switch name for the switch group name and a warning message is displayed because the configuration is invalid.

Use the following commands:

```
CLI (network-admin@Spine1) > switch-group-create
```

`name` *`name-string`*	Specify a name for the switch group.
`description` *`description-string`*	Specify a description for the switch group.

To create a switch-group with the name, **`rack-1-row-1`**, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-create name rack-1-row-1 description "datacenter rack 1"
```

```
CLI (network-admin@Spine1) > switch-group-delete
```

`name` *`name-string`*	Specify a name for the switch group.
`description` *`description-string`*	Specify a description for the switch group.

To delete a switch-group with the name, **`rack-1-row-1`**, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-delete name rack-1-row-1
```

```
CLI (network-admin@Spine1) > switch-group-modify
```

`name` *`name-string`*	Specify a name for the switch group.

To modify a switch-group with the name, **`rack-1-row-1`**, and change the description, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-modify name rack-1-row-1 description datacenter
```

```
CLI (network-admin@Spine1) > switch-group-show
```

name *name-string*	Displays the name of the switch group.
description *description-string*	Displays a description of the switch group.

To display a switch-group with the name, **`rack-1-row-1`**, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-show name rack-1-row-
1

name                    description
------------  -----------
rack-1-row-1  datacenter
```

Adding Switches to Switch-Groups

```
(CLI (network-admin@Spine1) > switch-group-member-add
```

name *name-string*	Specify the name of the switch group to add the member.
member *fabric-node name*	Specify the name of the switch to add as a member.

To add switch, Leaf-1, to switch-group, **`rack-1-row-1`**, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-member-add name rack-
1-row-1 member Leaf-1

CLI (network-admin@Spine1) > switch-group-member-remove
```

name *name-string*	Specify the name of the switch group to remove the member.
member *fabric-node name*	Specify the name of the switch to remove as a member.

To remove switch, Leaf-1, from switch-group, **`rack-1-row-1`**, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-member-remove name
rack-1-row-1 member Leaf-1

CLI (network-admin@Spine1) > switch-group-member-show
```

`name` *`name-string`*	Displays the name of the switch group.
`member` *`fabric-node name`*	Displays the name of the switches in a group.

To display switch-group, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-group-member-show

switch   name         member
-------  ------------ ------
Spine-1  rack-1-row-1 Leaf-1
```

Support for Enabling or Disabling LLDP

This feature provides for a generic LLDP ON/OFF toggle function set at the system level.

Currently, to disable LLDP on a switch you must disable the LLDP configuration on all ports. This resets all related configurations of LLDP protocol setting and LLDP vFlows.

Use the following CLI command to enable and disable the protocol:

```
CLI (network-admin@Leaf1) > system-settings-modify [lldp|no-
lldp]
```

LLDP packets are executed on the CPU with the help of LLDP vFlows.

To clear all LLDP protocol system flows use the parameter `no-lldp`.

To add all LLDP protocol system flows use the parameter `lldp`.

This approach ensures port LLDP configurations are not disturbed.

```
CLI (network-admin@Leaf1) > system-settings-show

switch:         Spine1
optimize-arps:  on
lldp:           on
```

Configuring System Settings

You can use the `system-settings-modify` command to configure a host of system settings. These settings correspond to different features and are discussed in detail in the related sections.

```
CLI (network-admin@leaf1) > system-settings-modify
```

`system-settings-modify`	Use this command to modify system settings.
Specify one or more of the following options:	
`optimize-arps|no-optimize-arps`	Enable or disable ARP optimization. This feature is ON by default. When ON, the Netvisor sends all ARP requests and Gratuitous ARP requests to the local CPU of the corresponding switch, and responds to ARP requests on behalf of the intended ARP targets. This feature corresponds to an ARP-proxy function on the corresponding switch. It is assumed that ARP requests and Gratuitous ARP requests are used by Netvisor to learn the MAC address to IPv4 address mapping, as well as Unknown Unicast and Broadcast traffic when the parameters, `manage-unknown-unicast` or `manage-broadcast` are ON. When OFF, the Netvisor learns and bridges ARP requests on the switch ASIC instead of relying on the local CPU.
`lldp|no-lldp`	Enable or disable LLDP at the system level. The Link Layer Discovery Protocol (LLDP) is an open, vendor-independent protocol that advertises a device's identity, abilities, and neighboring devices connected within the Local Area Network.
`policy-based-routing|no-policy-based-routing`	Enable or disable policy-based routing. Policy-Based Routing (PBR) enables flexible packet forwarding and routing through user defined policies.
`optimize-nd|no-optimize-nd`	Enable or disable Neighbor Discovery optimization. This feature is ON by default. When ON, Netvisor sends all Neighbor Solicitations and Unsolicited Neighbor Advertisements to the local CPU of the corresponding switch, responds to Neighbor Solicitation requests on behalf of the intended ND targets themselves.

	This feature corresponds to an ND-proxy function on the corresponding switch. Neighbor Solicitations and Unsolicited Neighbor Advertisements are used by Netvisor to learn the MAC address to IPv6 address mapping, as well as Unknown Unicast and Broadcast traffic when tthe parameters, `manage-unknown-unicast` or `manage-broadcast` are ON. When OFF, Netvisor ONE learns and bridges Neighbor Solicitations on the switch ASIC instead of relying on Netvisor.
`reactivate-mac|no-reactivate-mac`	Enable or disable reactivation of aged out MAC entries. This feature is ON by default. When ON, if a vPort entry is looked up and found as inactive, the corresponding l2-table entry is re-activated on the switch. When OFF, the traffic is flooded on the corresponding broadcast domain by Netvisor ONE. Please note that l2-table entries are refreshed on the Ethernet switch ASIC every time it is used, otherwise it is removed after a time of inactivity corresponding to configured aging period. Requires unknown-unicast to be enabled.
`reactivate-vxlan-tunnel-mac|no-reactivate-vxlan-tunnel-mac`	Enable or disable reactivation of MAC entries over VXLAN tunnels.
`manage-unknown-unicast|no-manage-unknown-unicast`	Enable or disable unknown unicast management. This feature is ON by default. Netvisor sends all unknown-unicast traffic to the local CPU of the corresponding switch. Netvisor learns the source of unknown-unicast packets and floods the packets on the corresponding unknown-unicast domain. When OFF, all unknown-unicast traffic is flooded on the corresponding unknown-unicast domain by the switch instead of relying on Netvisor.
`manage-broadcast|no-manage-broadcast`	Enable or disable broadcast management. This feature is ON by default. Netvisor sends all broadcast traffic to the local CPU of the corresponding switch. Netvisor learns the source of broadcast packets and floods the packets on the corresponding broadcast domain. When OFF, all unicast traffic is flooded on the corresponding broadcast domain by the switch instead of

	relying on Netvisor.
`block-loops|no-block-loops`	Enable or disable loop detection. Netvisor Loop Detection exposes loops to customers using system log messages, `port-show` output, and `vport-show` output. **Note:** This parameter is available only on NSU, NRU-02, NRU-03, and NRU-S0301 platforms.
`auto-trunk|no-auto-trunk`	Enable or disable auto trunking.
`auto-host-bundle|no-auto-host-bundle`	Enable or disable auto host bundling. This feature enables auto trunking of ports between PN switches and ESXi hosts.
`cluster-active-active-routing|no-cluster-active-active-routing`	Enable or disable active-active routing on a cluster. Here, two cluster switches run vRouters with active-active VRRP in order to provide redundant Layer 3 next hops (using virtual IPs) to both upstream and downstream devices.
`fast-route-download|no-fast-route-download`	Enable or disable fast route download from routesnoop.
`fast-interface-lookup|no-fast-interface-lookup`	Enable or disable fast router interface lookup.
`routing-over-vlags|no-routing-over-vlags`	Enable or disable routing over vLAGs. This feature allows packets crossing the cluster link to be routed without being dropped when egressing vLAGs.
`source-mac-miss to-cpu|copy-to-cpu`	Specify either of the options as the unknown source MAC learn behavior.
`optimize-datapath disable|cluster-only|all`	Specify the datapath optimization for cluster, fabric and vRouter communication: · `disable`: disables datapath optimization. · `cluster-only`: enables datapath optimization for cluster-only, where cluster traffic is redirected to cluster 4094 vNIC. · `all`: enables datapath optimization for fabric and data traffic. The default value is `all`.
`cpu-class-enable|no-cpu-`	Enable or disable CPU class. This feature

`class-enable`	enables advanced CPTP which operates over 43 independent queues (from 0 to 42) in order to be able to provide separation and granular control over different types of control plane traffic classes.
`usb-port|no-usb-port`	Enable or disable the USB port on the front of the switch. This is only applicable to switches with ONVL.
`use-igmp-snoop-l2|use-igmp-snoop-l3`	Specify whether L2 or L3 tables are to be used for IGMP snooping.
`vle-tracking-timeout <3..30>`	Set a VLE tracking timeout as a value between 3 and 30s. The default timeout is 3s.
`pfc-buffer-limit` *`pfc-buffer-limit-string`*	Specify the percent of global system buffer space allowed for PFC.
`cosq-weight-auto|no-cosq-weight-auto`	Specify either of the options to enable or disable automatic weight assignment for CoS (Class of Service) queues based on min-guarantee configuration.
`lossless-mode|no-lossless-mode`	Enable or disable lossless mode.
`stagger-queries|no-stagger-queries`	Stagger igmp/mld snooping queries.
`host-refresh|no-host-refresh`	Enable or disable refreshing host ARP entries to keep L2 entries active.
`proxy-conn-retry|no-proxy-conn-retry`	Enable or disable proxy connection retry.
`proxy-conn-max-retry 0..10`	Set the maximum number of proxy connection retry attempts as a value between 0 and 10.
`proxy-conn-retry-interval 100..2000`	Set the number of milliseconds to wait between proxy connection retry attempts. This is a value between 100 and 2000.
`nvos-debug-logging|no-nvos-debug-logging`	Logging mode selection (Direct OR viz. nvlog demon)
`manage-l2-uuc-drop|no-manage-l2-uuc-drop`	Enable or disable L2 UUC (Unknown Unicast Drop) towards data port.
`xcvr-link-debug|no-xcvr-link-debug`	Enable or disable system debug to capture link information.
`fastpath-bfd|no-fastpath-bfd`	Enable or disable BFD fastpath. This feature is disabled by default.

`linkscan-interval 10000..1000000`	Specify the linkscan interval as a value between 10000µ s and 1000000µ s. The default value is 150000µ s.
`linkscan-mode software|hardware`	Specify the linkscan mode as hardware or software. Software linkscan mode is enabled by default.
`single-pass-flood|no-single-pass-flood`	Enable or disable single-pass flood.

For example, enable Policy-based routing by using the command:

```
CLI (network-switch) > system-settings-modify policy-based-routing
```

Use the system-settings-show command to display the configuration:

```
CLI (network-switch) > system-settings-show
switch:                              eri-spine1
optimize-arps:                       off
lldp:                                on
policy-based-routing:                on
optimize-nd:                         off
reactivate-mac:                      on
reactivate-vxlan-tunnel-mac:         on
manage-unknown-unicast:              off
manage-broadcast:                    off
auto-trunk:                          on
auto-host-bundle:                    off
cluster-active-active-routing:       on
routing-over-vlags:                  off
source-mac-miss:                     copy-to-cpu
optimize-datapath:                   all
cpu-class-enable:                    on
usb-port:                            on
igmp-snoop:                          use-l3
vle-tracking-timeout:                3
pfc-buffer-limit:                    40%
cosq-weight-auto:                    off
lossless-mode:                       off
snoop-query-stagger:                  no-stagger-queries
host-refresh:                        off
proxy-conn-retry:                    on
proxy-conn-max-retry:                3
proxy-conn-retry-interval:           500
optimize-rxlos:                      off
xcvr-link-debug:                     disable
fastpath-bfd:                        off
linkscan-interval:                   150000
linkscan-mode:                       software
single-pass-l2-known-multicast:      off
single-pass-flood:                   off
```

```
batch-move-mac-hw-group-for-vlan-only:   off
memory-tracker:                          on
symmetric-hash:                          off
hash-suppress-unidir-fields:             off
prioritize-rx-reasons:                   off
```

About GREP Support with Netvisor ONE OS

Netvisor ONE supports filtering output and allows switch administrators to filter output "`grep|`" from the CLI. This functionality is limited to the following commands:

- `running-config-show`
- `tech-support-show`
- `help`

Installing Netvisor ONE and Initial Configuration

This chapter contains information about initial configuration of your switch as well as commands to manage, upgrade, and restore configurations on a Netvisor ONE switch.

Changes to the End User License Agreement (EULA)

Currently, the Netvisor One EULA is displayed when the switch is setup.

```
Netvisor OS Command Line Interface 6.0.0
By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT YOU
HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER LICENSE
AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?: yes
```

If you enter the EULA option, the output displays the complete EULA text. After this action, it is not possible to confirm EULA acceptance again. In some cases, an integrator may have accepted the EULA on behalf of the actual end user.

A new command is now available to display the EULA acceptance with a timestamp of the event:

```
CLI (network-admin@pn-sw-01) > eula-show
End User License Agreement
Pluribus Networks, Inc.'s ("Pluribus", "we", or "us") software
products are designed to provide fabric networking and
analytics solutions that simplify operations, reduce operating
expenses, and introduce applications online more rapidly.
Before you download and/or use any
 of our software, whether alone or as loaded on a piece of
equipment, you will need to agree to the terms of this End
User License Agreement (this "Agreement").
...
PN EULA v. 2.1

eula-show: No fabric
eula-show: Fabric required. Please use fabric-create/join/show
CLI (network-admin@pn-sw-01) >
```

Adding License Keys to Netvisor ONE

Note: You can use this feature only on switches that are completely provisioned and where the EULA setup is also completed.

Caution: Do not attempt to use this feature on a newly added switch where provisioning of the switch is not done and when the switch is in fresh-install mode or new-install mode.

This feature is applicable when you want to renew an expired license or add additional licenses to an existing license on a switch that was provisioned previously.

Netvisor ONE binds the license key to the serial number of the switch and when downloading or upgrading the Netvisor ONE software, the Pluribus Networks Cloud locates the serial number.

To install the license key, use the following syntax:

```
CLI (network-admin@switch) > software-license-install key
<key-string>
```

The license key has the format of four words separated by commas. For example,

```
    License Key: rental,deer,sonic,solace
```

Once the license key is installed, you can display information about the key using the following command:

```
CLI (network-admin@switch) > software-license-show

switch: T6001-ON
license-id: NVOS-CLD-LIC-60D
description: Pluribus Open Netvisor OS Linux Cloud Edition
License
expires-on: never
status: VALID
```

Using the Serial Console Port for Initial Configuration

This procedure assumes that you have installed the switch in the desired location and it is powered on.

Warning: Do not connect any ports to the network until the switch is configured. You can accidentally create loops or cause IP address conflicts on the network.

If you are going to cable host computers to the switch, there is an option to enable or disable host ports by default.

1. Connect the console port on the rear or front (depending on the model) of the switch to your laptop or terminal concentrator using a serial cable.
2. From the terminal emulator application on your computer, log into the switch with the username **network-admin** and the default password **admin**.

Note: Netvisor ONE supports both IPv4 and IPv6 addresses for the in-band interface.

Warning: Be sure to type in a static IP address for the management interface during the initial configuration. Netvisor One initially uses DHCP to obtain an IP address, but DHCP is not supported after the initial configuration.

3. Begin the initial configuration using the initialization procedure displayed.
4. Enter the following details when prompted, an example is provided in the output below:

   - Accept the EULA agreement
   - Type-in the switch name. An example is provided in the output below.
   - Enter and re-enter the password
   - Enter the Management IP and netmask. An example is provided in the output below.
   - Enter the In-band IP and netmask. An example is provided in the output below.
   - Enter the IP address of the Gateway.
   - Enter the IP address for the primary and secondary DNS.
   - Enter the domain name.

```
switch console login: network-admin
Password: admin

root@switch-new:~# cli

Netvisor OS Command Line Interface 6.0
By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT YOU
HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER LICENSE
AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?: yes
```

```
Switch setup required:
Switch Name (switch-new):pn-switch-01
network-admin Password:password <return>
Re-enter Password:password <return>
Mgmt IP/Netmask (10.13.27.218/23):
Mgmt IPv6/Netmask:
In-band IP/Netmask (192.168.10.8/24):
In-band IPv6/Netmask:
Gateway IP (10.13.26.1):
Gateway IPv6:
Primary DNS IP (10.135.2.13):
Secondary DNS IP (10.20.4.1):
Domain name (pluribusnetworks.com):
Automatically Upload Diagnostics (yes):
Enable host ports by default (yes):

Switch Setup:
Switch Name            : pn-switch-01
Switch Mgmt IP         : 10.13.27.218/23
Switch Mgmt IPv6       : fe80::aa2b:b5ff:febc:c78e/64
Switch In-band IP      : 192.168.10.8/24
Switch In-band IPv6    : fe80::640e:94ff:feba:f719/64
Switch Gateway         : 10.13.26.1
Switch IPv6 Gateway    : ::
Switch DNS Server      : 10.135.2.13
Switch DNS2 Server     : 10.20.4.1
Switch Domain Name     : pluribusnetworks.com
Switch NTP Server      : 0.ubuntu.pool.ntp.org
Switch Timezone        : America/Los_Angeles
Switch Date            : 2020-07-20,19:48:20
Enable host ports      : yes
Analytics Store        : optimized
Fabric required. Please use fabric-create/join/show
Connected to Switch ghspine01-new; nvOS Identifier:0xb001dba;
Ver: 6.0.0-6000016292
CLI (network-admin@switch-new) >
```

When you setup a switch for initial configuration, the host facing ports are enabled by default. However, you can disable the host ports until you are ready to plug-in host cables to the switch. If Netvisor ONE does not detect adjacency on a port during the `quickstart` procedure, the ports remain in the disabled state.

To enable the ports after plugging in cables, use the `port-config-modify port port-list host-enable` command. Netvisor ONE enables host ports by default unless you specify NO during the `quickstart` procedure as displayed below.

```
Netvisor OS Command Line Interface 6.0.0
By ANSWERING "YES" TO THIS PROMPT YOU ACKNOWLEDGE THAT YOU
HAVE READ THE TERMS OF THE PLURIBUS NETWORKS END USER LICENSE
AGREEMENT (EULA) AND AGREE TO THEM. [YES | NO | EULA]?: yes
Switch setup required:
Switch Name (netvisor): pn-switch-01
network-admin Password: password <return>
```

```
Re-enter Password: ******** <return>
Mgmt IP/Netmask (dhcp): 10.14.2.42/23
Mgmt IPv6/Netmask:
In-band IP/Netmask: 12.1.165.21/24
In-band IPv6/Netmask:
Loopback IP:
Loopback IPv6:
Gateway IP (10.14.2.1):
Gateway IPv6:
Primary DNS IP: 10.135.2.13
Secondary DNS IP: 10.20.4.1
Domain name: pluribusnetworks.com
Automatically Upload Diagnostics (yes):
Enable host ports by default (yes): no
```

To verify, use the command:

```
CLI (network-admin@pn-switch-01) > port-show port 9,10

switch        port  bezel-port   status               config
------------  ----  ---------- --------------------   ------
pn-switch-01   9      3        phy-up,host-disabled    10g
pn-switch-01   10     3.2      phy-up,host-disabled    10g
```

To enable the port (s), use the command:

```
CLI (network-admin@pn-switch-01) > port-config-modify port
9,10 enable host-enable

CLI (network-admin@pn-switch-01) > port-show port 9,10

switch        port  bezel-port  status     config
------------  ---- ----------  ---------- ------
pn-switch-01   9     3          up,vlan-up  fd,10g
pn-switch-01   10    3.2        up,vlan-up  fd,10g
```

You cannot change (enable or disable) the host-ports by using the switch setup process after the initial configuration is done. If you try to modify the host-ports, Netvisor ONE displays an error as displayed in the example here:

```
CLI (network-admin@pn-switch-01) > switch-setup-modify
disable-host-ports

switch-setup-modify: disable/enable host ports can be set only
at initial switch-setup time
```

During the initial configuration of the switch, if the host ports are disabled, then all ports having the same port configuration will be disabled. This can be viewed using the following command:

```
<CLI (network-admin@pn-switch-01) > port-config-show port
port-list host-enable
```

In this mode, when any port comes up physically, Netvisor ONE automatically sends and receives LLDP packets to look for peer switches. If Netvisor ONE does not detect an adjacency within 5 seconds, the port is flagged as `host-disabled`. With this flag set, Netvisor ONE only accepts LLDP packets and does not initiate packet transmission.

```
CLI (network-admin@pn-switch-01) > port-config-show port 9,10

switch         port  bezel-port       status                 config
------------   ----  ----------  -----------------------  ------
pn-switch-01    9      3          up,vlan-up,PN-other,LLDP  fd,10g
pn-switch-01    10     3.2        up,vlan-up                fd,10g
```

After completing switch discovery and fabric creation, use the `host-enable` option to enable host, server, or router traffic switching, and ports:

```
CLI (network-admin@pn-switch-01) > port-config-modify port 9
host-enable
```

Managing Netvisor ONE Certificates

Pluribus Networks includes the Netvisor ONE certificates along with the switches during shipment and you can access the certificates from /var/nvos/certs directory. These certificates are necessary for communication between switches in a fabric and hinders the transactions between fabric members if the certificate expires. You can view the validity (dates valid from and dates valid until) for Netvisor ONE certificate using the `switch-info-show` command.

When you configure the alarm, the certificate is checked every 24 hours and an alarm is issued if the number of days of expiry is equal to or less than 30 days . The certificate expiry alert is enabled by default for 30 days, but can configured between 7 days through 180 days on Netvisor ONE. You can disable this feature using the `cert-expiration-alert-modify no-netvisor` command.

You can view the certificate expiration alert or alarm configuration by using the `cert-expiration-alert-show` command and can schedule an alert notification before the certificate expires. You can view the alarm or alert notification in the `event.log` file and also by running the `log-alert-show command.` You can also configure a new SNMP `trap` for certificate expiry on the SNMP services.

Alarm is an event in the *event log*, an alert in `log-alert-show` command and a new SNMP trap if the trap server is configured. Frequency of alarm will be every 24 hours until the certificate has expired.

To configure the certificate expiry alert, use the command:

```
CLI (network-admin@switch01) > cert-expiration-alert-modify
```

Specify one or more of the following options:	
`netvisor|no-netvisor`	Specify whether to enable or disable Netvisor ONE certificate expiration alerts.
`days-before-expiration 7..180`	Modify the number of days before expiration to send alerts (Default 30 days). The value ranges from 7 through 180 days.

To view the alert configuration for the certificate expiry, use the command:

```
CLI (network-admin@switch01) > cert-expiration-alert-show

switch:                          switch01
days-before-expiration(d):       30
```

To enable or disable the SNMP trap for certificate expiry alert, use the command:

```
CLI (network-admin@switch01) > snmp-trap-enable-modify cert-
```

expiry|no-cert-expiry
where,

cert-expiry|no-cert-expiry	Specify whether to monitor certificate expiry or not.

To view the alert configuration details older than an hour, use the command:

```
CLI (network-admin@switch01) > log-alert-show older-than 1h

time      switch      code   name                count   last-message
-------- ---------- ----- ------------------ -----  ------------------------------
00:17:05  switch01   31008  smf_nvOSd_stop        1     SMF Service stopping nvOSd
00:17:08  switch01   11008  nvOSd_start           1     version 5.1.5010014665
00:35:49  switch01   31016  certificate_expiry    1     switch cert expiring in 19 days
```

The switch-info-show command displays the validity (dates valid from and dates valid until) for Netvisor ONE certificate. For example,

```
CLI (network-admin@nru03-sw-1*) > switch-info-show

model:                      NRU03
chassis-serial:             1937ST9100075
cpu1-type:                  Intel(R) Xeon(R) CPU D-1557 @ 1.50GHz
cpu2-type:                  Intel(R) Xeon(R) CPU D-1557 @ 1.50GHz
cpu3-type:                  Intel(R) Xeon(R) CPU D-1557 @ 1.50GHz
cpu4-type:                  Intel(R) Xeon(R) CPU D-1557 @ 1.50GHz
system-mem:                 30.6G
switch-device:              OK
fan1-status:                OK
fan2-status:                OK
fan3-status:                OK
fan4-status:                OK
fan5-status:                OK
fan6-status:                OK
fan7-status:                OK
fan8-status:                OK
fan9-status:                OK
fan10-status:               OK
fan11-status:               OK
fan12-status:               OK
ps1-status:                 OK
ps2-status:                 OK
disk-model:                 Micron_1300_MTFDDAV256TDL
disk-firmware:              M5MU000
disk-size:                  238G
disk-type:                  Solid State Disk, TRIM Supported
bios-vendor:                American Megatrends Inc.
bios-version:               1.00.00
netvisor-cert-valid-from:   Sep 13 07:00:00 2019 GMT
netvisor-cert-valid-till:   Sep 14 06:59:59 2039 GMT
```

Viewing the Validity of Netvisor ONE Certificates

Starting with Netvisor ONE version 6.1.1, you can view the validity of Netvisor ONE certificates on your switch. That is, after you upgrade to version 6.1.1, you can check the validity of certificates available on Netvisor ONE using the `cert-switch-show` command. You can also REST API command to verify the validity of certificates.

The command output also gets logged into `tech-support-show` command output and can be helpful during a customer support (TAC) call.

To check the validity of certificates on a switch, use the command:

```
CLI (network-admin@switch) > cert-switch-show

name:                   /usr/nvos/cert/core.pem
cert-type:             server
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Core
Encryption/CN=Core  Encryption
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         291
valid-from:            Mar  9 10:19:06 2021 GMT
valid-to:              Mar  4 10:19:06 2041 GMT
status:                 Certificate valid for 7174 days
----------------------------------------
name:                   /usr/nvos/cert/cacert.pem
cert-type:             ca
subject:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          17400531076958470354
valid-from:            Apr  9 11:00:34 2021 GMT
valid-to:              Apr  4 11:00:34 2041 GMT
status:                 Certificate valid for 7205 days
----------------------------------------
name:                   /usr/nvos/cert/pkg.pem
cert-type:             server
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Package/CN=Package
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         31
valid-from:            Oct 15 19:24:41 2012 GMT
valid-to:              Oct 13 19:24:41 2022 GMT
status:                 Certificate valid for 458 days
----------------------------------------
name:                   /usr/nvos/cert/newswitch.pem
cert-type:             server
subject:                /C=US/ST=California/O=Pluribus
```

```
Networks/OU=New
Switch/CN=New  Pluribus  Switch
issuer:                  /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         290
valid-from:            Mar  9 10:18:37 2021 GMT
valid-to:              Mar  4 10:18:37 2041 GMT
status:                 Certificate valid for 7174 days
-----------------------------------------
name:                   /var/nvos/cert/switch.pem
cert-type:             server
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Switch/CN=hostid:184560120   serial:2126PN8500255
issuer:                 /C=US/ST=California/O=Pluribus
Networks/CN=Pluribus  Update
Server  CA
serial-number:         12343
valid-from:            Jun 21 07:00:00 2021 GMT
valid-to:              Jun 22 06:59:59 2041 GMT
status:                 Certificate valid for 7284 days
-----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          17400531076958470354
valid-from:            Apr  9 11:00:34 2021 GMT
valid-to:              Apr  4 11:00:34 2041 GMT
status:                 Certificate valid for 7205 days
-----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=Pluribus  Update  DNI  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         295
valid-from:            Mar  9 14:34:32 2021 GMT
valid-to:              Mar  4 14:34:32 2041 GMT
status:                 Certificate valid for 7174 days
-----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=Pluribus  Update  Celestica  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         296
valid-from:            Mar  9 14:40:07 2021 GMT
```

```
valid-to:              Mar  4 14:40:07 2041 GMT
status:                Certificate valid for 7174 days
-----------------------------------------
name:                  /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:               /C=US/ST=California/O=Pluribus
Networks/CN=Pluribus  Update
Leadman  CA
issuer:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         298
valid-from:            Mar  9 14:45:58 2021 GMT
valid-to:              Mar  4 14:45:58 2041 GMT
status:                Certificate valid for 7174 days
-----------------------------------------
name:                  /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:               /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=cb-update.pluribusnetworks.com
issuer:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         297
valid-from:            Mar  9 14:43:55 2021 GMT
valid-to:              Mar  4 14:43:55 2041 GMT
status:                Certificate valid for 7174 days
-----------------------------------------
name:                  /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:               /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=celestica-update2.pluribusnetworks.com
issuer:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         299
valid-from:            Mar  9 14:47:48 2021 GMT
valid-to:              Mar  4 14:47:48 2041 GMT
status:                Certificate valid for 7174 days
-----------------------------------------
name:                  /var/nvos/cert/cacerts.pem
cert-type:             ca
subject:               /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=celestica-update.pluribusnetworks.com
issuer:                /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:         300
valid-from:            Mar  9 14:48:29 2021 GMT
valid-to:              Mar  4 14:48:29 2041 GMT
status:                Certificate valid for 7174 days
-----------------------------------------
name:                  /var/nvos/cert/cacerts.pem
cert-type:             ca
```

```
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=ct-update2.pluribusnetworks.com
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          301
valid-from:             Mar  9 14:49:17 2021 GMT
valid-to:               Mar  4 14:49:17 2041 GMT
status:                 Certificate valid for 7174 days
----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:              ca
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=ct-update.pluribusnetworks.com
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          302
valid-from:             Mar  9 14:49:56 2021 GMT
valid-to:               Mar  4 14:49:56 2041 GMT
status:                 Certificate valid for 7174 days
----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:              ca
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=staging-update.pluribusnetworks.com
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          303
valid-from:             Mar  9 14:50:26 2021 GMT
valid-to:               Mar  4 14:50:26 2041 GMT
status:                 Certificate valid for 7174 days
----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:              ca
subject:                /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=Pluribus  Update  Manufacturing  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
serial-number:          110
valid-from:             Nov  4 01:08:14 2014 GMT
valid-to:               Nov  1 01:08:14 2024 GMT
status:                 Certificate valid for 1207 days
----------------------------------------
name:                   /var/nvos/cert/cacerts.pem
cert-type:              ca
subject:                /C=US/ST=California/O=Pluribus
Networks/CN=Pluribus  Update
Server  CA
issuer:                 /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus  Update  Root  CA
```

```
serial-number:        304
valid-from:           Mar  9 14:51:10 2021 GMT
valid-to:             Mar  4 14:51:10 2041 GMT
status:               Certificate valid for 7174 days
------------------------------------------
name:                 /var/nvos/cert/cacerts.pem
cert-type:            ca
subject:              /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=Pluribus Update Advantech CA
issuer:               /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus Update Root CA
serial-number:        344
valid-from:           Apr 21 12:02:10 2021 GMT
valid-to:             Apr 16 12:02:10 2041 GMT
status:               Certificate valid for 7217 days
------------------------------------------
name:                 /var/nvos/cert/cacerts.pem
cert-type:            ca
subject:              /C=US/ST=California/O=Pluribus
Networks/OU=Update
Servers/CN=Pluribus Update staging CA
issuer:               /O=Pluribus Networks/L=Palo
Alto/ST=California/C=US/CN=Pluribus Update Root CA
serial-number:        101
valid-from:           Jun  2 22:30:14 2014 GMT
valid-to:             May 30 22:30:14 2024 GMT
status:               Certificate valid for 1053 days
```

To view the certificate expiration alert, use the command:

```
CLI (network-admin@switch) > cert-expiration-alert-show
switch:                     sff-pvt-ptf
netvisor:                   yes
days-before-expiration(d):  180
```

Enabling Administrative Services

There are many features of the Pluribus Networks fabric that require or can be enhanced using remote access. For example, when packets are written to a log file, you may want to transfer that file from a switch to a different system for analysis. Also, if you are creating a NetVM environment, an IOS image of the guest OS must be loaded on the switch.

You can enhance or modify several services such as SSH, NFS, Web, SNMP, SFTP.

To check the status of various services, use the following command:

```
CLI (network-admin@Leaf-1) > admin-service-show

switch:             Leaf-1
if:                 mgmt
ssh:                on
```

```
nfs:                on
web:                on
web-ssl:            off
web-ssl-port:       443
web-port:           80
web-log:            off
snmp:               on
net-api:            on
icmp:               on
switch:             Leaf-1
if:                 data
ssh:                on
nfs:                on
web:                on
web-ssl:            off
web-ssl-port:       443
web-port:           80
web-log:            off
snmp:               on
net-api:            on
icmp:               on
```

To modify administrative services, use the command:

```
CLI (network-admin@Leaf-1) > admin-service-modify
```

`admin-service-modify`	Modifies services on the switch.
`if` *`if-string`*	Specify the administrative service interface. The options are `mgmt` or `data`.
`ssh|no-ssh`	Specify if you want to enable or disable SSH.
`web|no-web`	Specify if you want to enable web management. Use this option to enable REST API access over HTTP.
`web-ssl|no-web-ssl`	Specify if you want to use SSL and certificates for web services. Use this option to enable REST API access over HTTPS.
`web-ssl-port` *`web-ssl-port-number`*	Specify the web SSL port.
`web-port` *`web-port-number`*	Specify the port for web management.
`web-log|no-web-log`	Specify if you want to turn web logging on or off. **Note:** This option is for use in debugging with Pluribus support's guidance.
`vrrp|no-vrrp`	Specify if you want to enable or disable

	VRRP.
`snmp|no-snmp`	Specify if you want to enable or disable SNMP.
`net-api|no-net-api`	Specify if you want to enable or disable Netvisor API.
`icmp|no-icmp`	Specify if you want to enable or disable Internet Message Control Protocol (ICMP).

Netvisor ONE supports the file transfer method, SFTP and SFTP is enabled by default on Netvisor ONE. Because SFTP relies on Secure Shell (SSH), you must enable SSH before enabling SFTP.

To enable SSH, use the following command

```
CLI (network-admin@Leaf1) > admin-service-modify nic mgmt ssh
```

To enable SFTP, use the following command:

```
CLI (network-admin@Leaf1) > admin-sftp-modify enable

sftp password: <password>
confirm sftp password: <password>
```

The default SFTP username is sftp and the password can be changed using the `admin-sftp-modify` command:

```
CLI (network-admin@Leaf1) > admin-sftp-modify

sftp password: <password>
confirm sftp password: <password>
```

To display the details, use the following commands:

```
CLI (network-admin@Leaf-1) > admin-service-show

switch if   ssh nfs web web-ssl web-ssl-port web-port snmp net-api icmp
------ ---- --- --- --- ------- ------------ -------- ---- ------- ----
Leaf-1 mgmt on  off off off     443          80       on   off     on
Leaf-1 data on  off off off     443          80       on   off     on

admin-service-show: Fabric required. Please use fabric-
create/join/show

CLI (network-admin@Leaf1) > admin-sftp-show

switch:    Leaf1
sftp-user: sftp
enable:    yes
```

Use SFTP from a host to the switch, and login with the username **sftp** and the password configured for SFTP. Then you can download the available files or upload files to the switch.

```
CLI (network-admin@Leaf1) > admin-service-show

switch nic  ssh nfs web web-port snmp net-api icmp
------ ---- --- --- --- -------- ---- ------- ----
Leaf1  mgmt on  off on  80       off  on      on
```

Configuring Administrative Session Timeout

Netvisor ONE sets the administrator sessions to timeout after 60 minutes (by default) of idle time or no activity, but allows you to change the timeout value to a user desirable time. During the session timeout, you are logged out of the CLI and the Shell prompt and your privileges changes to *root user*. To access the switch, you must login again using the CLI or Shell prompt.

To verify the default or user configured session timeout value, use the command:

```
CLI (network-admin@Spine1) > admin-session-timeout-show
```

```
switch:  Spine1
timeout:  1h
```

To modify the timeout value, use the command:

```
CLI (network-admin@Spine1) > admin-session-timeout-modify
```

`timeout duration: #d#h#m#s`	Specify the maximum time to wait for user inactivity before terminating login session.

Confirming Connectivity on the Network

After connecting your switch, take the time to ensure connectivity by pinging an external IP address (supports both IPv4 and IPv6), and pinging a domain to ensure domain name resolution.

To ping the external network from the switch, use the `ping` command:

```
CLI (network-admin@switch) > ping 2010::2
```

```
PING 2010::2(2010::2) 56 data bytes
64 bytes from 2010::2: icmp_seq=1 ttl=64 time=1.69 ms
64 bytes from 2010::2: icmp_seq=2 ttl=64 time=0.412 ms
64 bytes from 2010::2: icmp_seq=3 ttl=64 time=0.434 ms
64 bytes from 2010::2: icmp_seq=4 ttl=64 time=0.418 ms
```

To ping an IP address from the switch, use the ping command:

```
CLI (network-admin@switch) > ping 98.138.253.109 : 56 data
bytes
```

```
PING 98.138.253.109 (98.138.253.109) 56(84) bytes of data.
64 bytes from 98.138.253.109: icmp_seq=1 ttl=47 time=51.8 ms
64 bytes from 98.138.253.109: icmp_seq=2 ttl=47 time=51.9 ms
64 bytes from 98.138.253.109: icmp_seq=3 ttl=47 time=53.6 ms
```

To ping a domain, use the ping command again:

```
CLI (network-admin@Leaf1) > ping yahoo.com
```

```
PING yahoo.com (98.138.253.109) 56(84) bytes of data.
64 bytes from ir1.fp.vip.ne1.yahoo.com (98.138.253.109): icmp_seq=1 ttl=47 time=52.2 ms
64 bytes from ir1.fp.vip.ne1.yahoo.com (98.138.253.109): icmp_seq=2 ttl=47 time=52.5 ms
64 bytes from ir1.fp.vip.ne1.yahoo.com (98.138.253.109): icmp_seq=3 ttl=47 time=51.9 ms
64 bytes from ir1.fp.vip.ne1.yahoo.com (98.138.253.109): icmp_seq=4 ttl=47 time=51.8 ms
```

Setting the Date and Time

You can set the date and time on a switch by modifying the switch configuration using the `switch-setup-modify` command. For example, to change the date and time to September 24, 2019, 09:30:00, use the following command syntax:

```
CLI (network-admin@Leaf1) > switch-setup-modify date 2019-09-
24T09:30:00
```

To display the configured setting, use the `switch-setup-show` command:

```
CLI (network-admin@Leaf2) > switch-setup-show
switch-name:                Leaf2
mgmt-ip:                    10.14.30.18/23
mgmt-ip-assignment:         static
mgmt-ip6:                    2721::3617:ebff:fef7:94c4/64
mgmt-ip6-assignment:        autoconf
mgmt-link-state:            up
mgmt-link-speed:            1g
in-band-ip:                  192.168.101.7/24
in-band-ip6:                 fe80::640e:94ff:fe83:cefa/64
in-band-ip6-assign:         autoconf
gateway-ip:                 10.14.30.1
dns-ip:                     10.20.4.1
dns-secondary-ip:            172.16.1.4
domain-name:                 pluribusnetworks.com
ntp-server:                  0.us.pool.ntp.org
ntp-secondary-server:        0.ubuntu.pool.ntp.org
timezone:                    America/Los_Angeles
date:                       2019-09-24,09:30:00
hostid:                     184555395
location-id:                7
enable-host-ports:          yes
banner:                      * Welcome to Pluribus Networks Inc.
Netvisor(R). This is a monitored system.    *
device-id:                  1WDQX42
banner:                     *                ACCESS RESTRICTED
TO AUTHORIZED USERS ONLY                     *
banner:                     * By using the Netvisor(R) CLI,you
agree to the terms of the Pluribus Networks *
banner:                     * End User License Agreement
(EULA). The EULA can be accessed via              *
banner:                     *
http://www.pluribusnetworks.com/eula or by using the command
"eula-show"     *
```

Changing the Default Timezone

By default, Netvisor sets the default timezone to US/Pacific Standard Time (PST).

To change the timezone, use the switch-setup-modify command:

```
CLI (network-admin@Leaf1) > switch-setup-modify timezone time-
zone name
```

Viewing User Sessions on a Switch

Netvisor ONE enables you to view the user sessions on a specified switch and displays all currently logged-in users along with the IP address of the user and login time when you run the command, `mgmt-session-show`. This information is useful for troubleshooting purposes or while dealing on issues with Pluribus Customer Support teams.

```
CLI (network-admin@Leaf1) > mgmt-session-show
```

Specify any of the following:	
`user` *user-string*	Displays the user name.
`cli-user` *cli-user-string*	Displays the name used to log into the switch.
`pid` *pid-number*	Displays the process ID.
`terminal` *terminal-string*	Displays the terminal ID
`from-ip` *ip-address*	Displays the IP address of the user.
`login-time date/time:` *yyyy-mm-ddTHH:mm:ss*	Displays the time and date that the user logged into the switch.
`remote-node` *remote-node-string*	Displays the name of the remote node.
`vnet` *vnet-string*	Displays the vNET assigned to the user.
`type cli|api|shell`	Displays the type of login session.

For example,

```
CLI (network-admin@Leaf1) > mgmt-session-show

user   cli-user       pid    terminal  from-ip      login-time     type
----   -------        ---    -------   --------     ---------      ----
admin  network-admin  13805  pts/3     10.60.1.216  11:20:52         cli
root   network-admin  8589   pts/2     10.14.20.109 11-15,17:16:17 cli
       network-admin                                08:24:10       cli
root                  19139   pts/1     10.14.22.54  11-15,11:01:08 shell
```

In this example, the `root` user represents the user who has all access by default, while the admin user has only customized access privileges.

Archiving Netvisor ONE Log Files Outside the Switch

Netvisor ONE enables you to archive the nvOSd log files to an external file server periodically and these log files may be helpful for troubleshooting purposes. As a network administrator, you can configure the following parameters to enable archiving of the log files:

- Server IP address and hostname
- Username and password
- Log archival interval (minimum interval is 30 minutes and the default value is 24 hours)

On configuring this feature, the log archival configuration parameters are saved in the *log_archival_config.xml* file with an encrypted password string. A binary file deciphers the configuration parameters and also the files that are to be archived. Netvisor ONE sends an empty *time-stamped directory* to the configured remote server path and subsequently, all the log files
are archived to the newly created remote directory. The new directory in the remote server is created in the *nvOS_archive.yyyymmdd_hh.mm.ss* format.

Netvisor ONE uses the Secure Copy Protocol (SCP) to archive the log files from the switch to the remote external server at specific intervals. Using the `enable` or `disable` parameter in the CLI command, you can start or stop archiving of the log files. You can archive regular log files, a set pattern of log files, or a whole directory from one of the following paths only. If you add files from other paths than the directories specified here, Netvisor ONE displays an error.

- /var/nvOS/log/*
- /nvOS/log/*
- /var/log/*

Use the below CLI commands to configure the log archival parameters and schedule the archival interval.

To modify the archival schedule parameters for the log files, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-modify
```

enable|disable	Specify to enable or disable the log archival schedule.
Specify one or many of the following options:	
archive-server-username <*string*>	Specify the SCP username of log archival server.
archive-server <*string*>	Specify the IP address or hostname of the log archival server.

`archive-server-path <string>`	Specify the SCP server path to archive the log files in.
`archive-interval <30..4294967295>`	Specify the log archival interval in minutes. The range varies from 30 minutes to 4294967295 minutes with a default value of 1440 minutes (one day).
`archive-server-password <string>`	Enter the SCP server password.

For example, if you had modified the log-archival-schedule by specifying the archive-server-username as `pn-user`, archive-server as `pn-server`, and `archive-server-path` as `/home/pn-server/workspace/log_archival_tests`, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-modify
archive-server-username pn-user archive-server pn-server
archive-server-path /home/pn-
server/workspace/log_archival_tests
```

To display the modified configuration, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-show

switch:                    switch-1
archive-server-username:   pn-user
archive-server:            pn-server
archive-server-path:       /home/pn-
server/workspace/log_archival_tests
enable:                    no
archive-interval(m):       1440
```

To add the log files to the archival list, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file log-file-string
```

`log-file log-file-string`	Specify a comma-separated list of log file names to add to the archive list.

For example, to add the `nvOSd.log` or `audit.log` or all *log* files or a whole directory, use the following commands:

```
CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file /var/nvOS/log/nvOSd.log

CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file /var/nvOS/log/*.log

CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file /var/log
```

```
CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file /nvOS/log/audit.log
```

To view the list of log files that you had scheduled to be archived, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-files-
show

/var/nvOS/log/nvOSd.log
/var/nvOS/log/*.log
/var/log
/nvOS/log/audit.log
```

If you try to add an unsupported file or directory, an error message is displayed. For example,

```
CLI (network-admin@switch-1) > log-archival-schedule-files-add
log-file /var/nvOS

/var/nvOS, not from valid logs supported
```

To remove the log files or a list of log files from the archival list, use the command,

```
CLI (network-admin@switch-1) > log-archival-schedule-files-
remove log-file log-file-string
```

Guidelines and Tips

- When the `log-archival-schedule` is enabled and if all files are removed from the archival list, the log-archival-schedule gets disabled.
- If the systemd timer expires before the previous log-archival process is finished, then the systemd waits for the process to complete before starting the new process.

Displaying and Managing Boot Environment (BE) Information

Netvisor ONE provides two boot environments (BEs): the current boot environment, and the previous boot environment. The presence of two BEs enable you to rollback or rollforward the software versions or configurations.

During software upgrade, a new boot environment is automatically created to install the new software and after the software upgrade, the switch boots into the newly created BE that is running the new software. Also, during software upgrade the older BE (which was not active) is deleted, and the current BE from where software upgrade started is preserved, and then the switch boots into newer BE with new software. This process ensures that there are only two boot environments (BEs) after upgrade.

To display boot environment information, use the following command:

```
CLI (network-admin@switch) > bootenv-show

name       version     current reboot space created        apply-current-config
--------- ----------- ------- ------ ----- -------------- --------------------
netvisor-1 5.2.1-15718  no      no     0    02-23,04:22:46      false
netvisor-2 6.1.0-17888  yes     yes    0    03-06,20:47:13      false
```

To reboot the switch into one of the boot environments other than current boot environment, use the following command:

```
CLI (network-admin@switch) > bootenv-activate-and-reboot name
netvisor-1
```

To delete a boot environment, use the following syntax:

```
CLI (network-admin@switch) > bootenv-delete name netvisor-2
```

You can display information about different boot environments on the switch.

Exporting Configurations Using Secure Copy Protocol (SCP)

Netvisor ONE supports export of switch configuration to a configuration bundle. This functionality allows the network administrator to create configuration backups that can be used in cases when the administrator needs to restore the switch configuration to a previous revision of the configuration.

The switch config export functionality in Netvisor ONE can export the configuration bundle to a local disk on the switch or can upload the configuration bundle to an external server using Secure Copy Protocol(SCP). To upload the configuration bundle to an external server using SCP, the upload server should support SCP protocol.

To export a switch configuration, use the command:

```
CLI (network-admin@Leaf1) > switch-config-export
```

Specify any of the following options:	
`export-file switch-config` *`export-file`*	File name for exported configuration bundle.
`upload-server` *`upload-server-string`*	DNS Name or IP address of upload server and path to store configuration bundle on the upload server.Uploads the config file to server via SCP

For example,

```
CLI (network-admin@switch-crater) > switch-config-export
export-file crater-backup-04142011 upload-server root@server-
test-67:/var/tmp/
server password:
Uploaded configuration to server at /var/tmp/
CLI (network-admin@switch-crater) >
server password:
Uploaded configuration to server at /root
CLI (network-admin@switch-crater) >
```

During the software upgrade process, Netvisor ONE exports the switch configuration and makes it available at a /export directory that is accessible when the admin connects to the switch using SFTP client. Netvisor ONE stores a maximum of three configuration archives on the switch. All older configurations are deleted.

Similar to Netvisor configuration export functionality, during software upgrade Netvisor can optionally upload the configuration bundle to an external upload server using SCP protocol to create a configuration back up. Similar to switch-config-export command, admin can use `upload-server` parameter of software-upgrade command to specify details of upload server to upload configurations to the external server.

```
CLI (network-admin@switch-crater) > software-upgrade package
nvOS-6.1.0-6010018109-onvl.pkg upload-server root@server-test-
```

```
67:/var/tmp/
server password:
Scheduled background update.
* software-upgrade-status-show to check the progress
* software-upgrade-instant-status-show to check the instant
upgrade status
Switch will reboot itself.DO NOT reboot manually.
CLI (network-admin@switch-crater) >
```

On upload server, configuration bundle is saved as below(`upgrade-<hostname>-<bename>-<sw version>-<timestamp>.tar.gz`):

```
root@server-test-67:/var/tmp# ls -l | grep crater
-rw-r--r--  1 root      root           16219 Apr 14 14:19
upgrade-switch-crater-crater-rfc-6.1.0-6010018118.2021-04-
14T14.19.59.tar.gz
root@server-test-67:/var/tmp#
```

Upgrading the Netvisor ONE Software

Software upgrades are a routine maintenance procedure that must be completed every so often. However, there are some guidelines to consider before you start the upgrade procedures.

Before you start the upgrade process, obtain the required upgrade software. You can download the software manually and copy it to a switch before beginning the upgrade procedures.

Note: If you are upgrading from Netvisor ONE version 3.0.4 or earlier to Netvisor ONE version 5.x.x or 6.x.x, then, you must first upgrade to Netvisor ONE version 3.1.1 before upgrading to a later release. The direct upgrade from version 3.0.4 or earlier to version 5.x.x/6.x.x is not supported.

Caution: We recommend disabling the *split brain* script before performing any software upgrades on the switches in the cluster if you had installed split brain detection script as a service on both nodes of the cluster pair.

Software and fabric upgrade process comprises of two distinct phases: (i) the installation (upgrade) of the new software and (ii) a switch reboot to activate the new software.

Read this section completely before starting the software upgrade procedure.

To upgrade the software on a switch, use the software-upgrade command.

```
CLI (network-admin@switch) > software-upgrade
```

`software-upgrade`
 	
`package upgrade-package-name.pkg`
	Starts software upgrade on local switch using software bundle from /sftp/import directory.

`software-upgrade`
 	
`package upgrade-package-name.pkg`
`auto-reboot|no-auto-reboot`
	Starts software upgrade on local switch using software bundle from /sftp/import directory. Use the `auto-reboot` or `no-auto-reboot` parameter to specify whether the switch needs to be automatically rebooted after software upgrade or whether admin will manually reboot the switch at a later time to start with new upgraded software. The default value is auto-reboot.

	This parameter is added in Netvisor ONE 6.1.0.
software-upgrade *package upgrade-package-name.pkg* *upload-server upload-server-name/ip:/path/to/upload/to*	Starts software upgrade on local switch using software bundle from /sftp/import directory and uploads switch configuration backup file to the specified path on server using SCP.
software-upgrade *package upgrade-package-name.pkg* *auto-reboot|no-auto-reboot* *upload-server upload-server-string*	Starts software upgrade on local switch using software bundle from /sftp/import directory. Use the `auto-reboot` or `no-auto-reboot` parameter to specify whether switch needs to be automatically rebooted after software upgrade or not. The default value is `auto-reboot`. The presence of `upload-server` parameter in software-upgrade command uploads switch configuration bundle to the specified path on server using SCP.
software-upgrade-abort	Aborts an *in progress* software upgrade. Note that software upgrade will be aborted when upgrade process completes its current step and reaches logical next step. This command is added in Netvisor ONE 6.1.0.
software-upgrade-reboot	Indicates the software upgrade process to reboot the switch after software upgrade is complete. This command is used when `no-auto-reboot` parameter is specified when software upgrade is started. This command is added in Netvisor ONE 6.1.0.
software-upgrade-instant-status-show	Displays the current (most recent status of software upgrade during a fabric-wide upgrade process. This command accepts various format options of Netvisor CLI. This command is introduced in Netvisor ONE 6.1.0
software-upgrade-status-show	Displays the current status of software upgrade that is in progress or completed.

Starting with Netvisor ONE 6.1.0 release, additional options such as `auto-reboot|no-`

`auto-reboot`, `abort`, and `manual reboot` are supported on the `software-upgrade` command. By using these options, you can control the automatic reboot of switch after software upgrade completes or you can abort an upgrade that is in progress.

If you start software upgrade by specifying `auto-reboot` parameter for `software-upgrade` command, switch automatically reboots after software upgrade completes and switch boots up with new software version.

However, if you start the software upgrade by specifying the `no-auto-reboot` parameter for `software-upgrade` command, switch completes the software upgrade and waits for administrator to manually reboot the switch to boot into upgraded software. After determining that upgrade is complete, you must issue a `software-upgrade-reboot` command to reboot the switch to boot with upgraded software.

While software upgrade is in progress or software upgrade is complete and switch is waiting for administrator to issue `software-upgrade-reboot` command, if you want to abort the upgrade and keep switch in current software version, you can use `software-upgrade-abort` command to abort the upgrade process. This scenario is explained further in the examples below.

> **Note**: The software-upgrade-abort and software-upgrade-reboot commands are supported only if upgrade is started using software-upgrade command. Do not run these commands if you started fabric wide upgrade using fabric-upgrade command. An error message is displayed if you do so.

To start a software upgrade follow the steps below:

1. View the current version of Netvisor ONE on the switch by using command:

   For example,

   CLI network-admin@switch > software-show

   version: 6.0.1-6000116966
2. Identify the software package. Depending on the version of Netvisor ONE running on your switch, you should use appropriate software upgrade package. Select the appropriate upgrade bundle from the following upgrade matrix table based on the current version on your switch:

Current Software	Target Release for Upgrade	Upgrade Type	Upgrade Software Package
3.x GA	6.1.0 GA	Software Upgrade using release upgrade bundle	nvOS-relupg-6.1.0-6010018118-onvl.pkg
5.x.x OR 6.x.x	6.1.0 GA	Software Upgrade using regular offline upgrade bundle	nvOS-relupg-6.1.0-6010018118-onvl.pkg

3. Copy the upgrade package to the switch, to do:

a) Enable Secure File Transfer Protocol (SFTP) on the switch:

```
CLI (network-admin@switch)> admin-sftp-modify enable
sftp password:
confirm sftp password:
CLI (network-admin@switch)>
```

b) Upload the Software package to the switch:

```
root@server-os-9:~/# sftp sftp@switch
The authenticity of host 'switch (10.0.0.02)' can't be
established.
RSA key fingerprint is
SHA256:SI8VQZgJCppbrF4sRcby36Fx7rz3Hh5EJllPPyScLZU.
Are you sure you want to continue connecting (yes/no)?
yes
Warning: Permanently added 'switch1, 10.0.0.02 (RSA) to
the list of known hosts.
* Welcome to Pluribus Networks Inc. Netvisor(R). This
is a monitored system. *
* ACCESS RESTRICTED TO AUTHORIZED USERS ONLY *
* By using the Netvisor(R) CLI,you agree to the terms
of the Pluribus Networks *
* End User License Agreement (EULA). The EULA can be
accessed via *
* http://www.pluribusnetworks.com/eula or by using the
command "eula-show" *
Password:
Connected to switch
sftp> cd import
sftp> put nvOS- nvOS-6.1.0-6010018118-onvl.pkg
Uploading nvOS- nvOS-6.1.0-6010018118-onvl.pkg
nvOS-  nvOS-6.1.0-6010018118-onvl.pkg
nvOS- nvOS-6.1.0-6010018118-onvl.pkg 100% 332MB 7.5MB/s
04:00
```

4. Start the upgrade process by using the software-upgrade command with package parameter, which allows you to specify the name of the upgrade file. The switch gets automatically rebooted after software upgrade is complete.

```
CLI (network-admin@switch) > software-upgrade package nvOS-
6.1.0-6010018118-onvl.pkg
Scheduled background update. Use software-upgrade-status-
show to check. Switch will reboot itself. DO NOT reboot
manually.
```

Caution: Do not reboot or power off the switch during the upgrade procedure. When software upgrade is complete, switch reboots automatically.

5. Monitor the upgrade process using the software-upgrade-status-show command:

```
CLI  (network-admin@switch)>software-upgrade-status-show
show-interval5
```

```
[Apr11.21:30:41] Starting software upgrade ...
[Apr11.21:30:42] Cleaning old package bundles
[Apr11.21:30:42] Checking available disk space...
[Apr11.21:30:42] Avbl free space: 12.69G, Required: 0.62G
[Apr11.21:30:42] Unpacking local package bundle...
[Apr11.21:30:42] Extracting initial bundle.
.
.
log
------------------------------------------------------------
-----
[Apr11.21:30:41] Starting software upgrade ...
[Apr11.21:30:42] Cleaning old package bundles
[Apr11.21:30:42] Checking available disk space...
[Apr11.21:30:42] Avbl free space: 12.69G, Required: 0.62G
[Apr11.21:30:42] Unpacking local package bundle...
[Apr11.21:30:42] Extracting initial bundle.
[Apr11.21:30:50] Decrypting signed bundle.
[Apr11.21:30:52] Extracting signed bundle.
[Apr11.21:31:00] Extracting packages.
[Apr11.21:31:09] Fetching repository metadata.
[Apr11.21:31:09] Skipping dpkg update in current boot image
[Apr11.21:31:11] Computing package update requirements.
[Apr11.21:31:12] Upgrade agent version: 6.0.1-6000116966
[Apr11.21:31:12] Upgrading software upgrade framework
[Apr11.21:31:16] Fetching repository metadata.
[Apr11.21:31:17] Skipping dpkg update in current boot image
[Apr11.21:31:17] Computing package update requirements.
[Apr11.21:31:17] Upgrade agent version: 6.1.0-6010018118
[Apr11.21:31:17] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010018118
[Apr11.21:32:28] Cleaning up old BEs.
[Apr11.21:32:30] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010018118
[Apr11.21:32:30] Software upgrade completed. Rebooting.
```

After the switch reboots and you see following message in serial console of the switch, you can SSH to switch as the *network-admin*:

```
nvOS system info:
serial number: 1XXXXXXX00059
hostid: 090XXX9d
device id:
[ OK ] Started NetVisor Operating System.
Starting nvOSd Monitor...
[ OK ] Started nvOSd Monitor.
[ OK ] Reached target Multi-User System.
[ OK ] Reached target Graphical Interface.
[ OK ] Started Stop ureadahead data collection 45s after
completed startup.
Starting Update UTMP about System Runlevel Changes...
```

```
[ OK ] Started Update UTMP about System Runlevel Changes.
* Welcome to Pluribus Networks Inc. Netvisor(R). This is a
monitored system. *
* ACCESS RESTRICTED TO AUTHORIZED USERS ONLY *
* By using the Netvisor(R) CLI,you agree to the terms of the
Pluribus Networks *
* End User License Agreement (EULA). The EULA can be
accessed via *
* http://www.pluribusnetworks.com/eula or by using the
command "eula-show" *
switch1 login: network-admin
Password:
Netvisor OS Command Line Interface 6.1
Connected to Switch switch; nvOS Identifier:0x90XXXX9; Ver:
6.1.0-6010018118
CLI (network-admin@switch) > software-show
version:  6.1.0-6010018118
```

To verify that a standalone (non-cluster) switch is fully operational after the software upgrade, you can use the `log-event-show` command. The 'System is up for service' log message indicates that the switch is ready for forwarding. For example:

```
CLI (network-admin@Leaf1)> log-event-show

category time                       name           code  level event-type message
-------- -------------------------- -------------- ----- ----- ----------
------------------------
event    2021-03-10,23:37:40.572119 systemup_alert 11513 note  system     System is up
for service
```

> **Note**: You can also use the 'System is up for service' log message to verify that a switch is functional after a reboot or restart triggered by the following operations: `fabric-upgrade`, `switch-reboot`, `nvos-restart`, `fabric-join`, `cluster repeer`, and `config import` commands.

Apart from upgrading Netvisor ONE on individual switches, starting from Netvisor ONE version 6.1.0, you can perform software upgrade on all switches in a fabric using `software-upgrade` from one switch and reboot the switches to perform fabric-wide software upgrade (software upgrade on all the nodes in a fabric).

You can choose one of the below options to perform software upgrade on all switches from one switch:

- Start software upgrade on entire fabric and reboot the switches sequentially

OR

- Start software upgrade on entire fabric and reboot all switches, but not sequentially

Start software upgrade on entire fabric and reboot the switches sequentially

Follow the steps to perform software upgrade on entire fabric and reboot the switches sequentially:

1. Enable SFTP on all switches and provide the credentials for each switch using the CLI command:

```
CLI (network-admin@switch)> switch * admin-sftp-modify
enable
```

2. Enable shell access for *network-admin* role on all switches in the fabric:

```
CLI (network-admin@switch)> switch * role-modify name
network-admin shell
```

3. Download the software upgrade bundle to each switch by entering the below command only on one switch:

```
CLI (network-admin@switch)> switch * shell
cd /sftp/import;wget
http://sandy.pluribusnetworks.com//offline-pkgs/onvl/nvOS-
6.1.0/nvOS-6.1.0-6010018118-onvl.pkg
```

4. Start the software upgrade process on all the switches using the command:

```
CLI (network-admin@switch)> switch * software-upgrade
package nvOS-6.1.0-6010018118-onvl.pkg no-auto-reboot
```

5. Verify that all nodes display the "*Waiting for software-upgrade-abort/software-upgrade-reboot*" message by using the command individually on each switch:

```
CLI (network-admin@switch)> software-upgrade-status-show
```

6. Issue the *software-upgrade-reboot* command on each switch in the fabric one by one based on the reboot sequence that best works for your deployment.

Start software upgrade on entire fabric and reboot all switches non-sequentially

Follow the steps to perform fabric-wide software upgrade without reboot sequence:

1. Enable SFTP on all switches and provide the credentials for each switch using the CLI command:

```
CLI (network-admin@switch)> switch * admin-sftp-modify
enable
```

2. Enable shell access for *network-admin* role on all switches in the fabric:

```
CLI (network-admin@switch)> switch * role-modify name
network-admin shell
```

3. Download the software upgrade bundle to each switch by entering the below command only on one switch:

```
CLI (network-admin@switch)> switch * shell
cd /sftp/import;wget
```

```
http://sandy.pluribusnetworks.com//offline-pkgs/onvl/nvOS-6.1.0/nvOS-6.1.0-6010018118-onvl.pkg
```

4. Start the software upgrade process on all the switches with no-auto-reboot command parameter:

```
CLI (network-admin@switch)> switch * software-upgrade package nvOS-6.1.0-6010018118-onvl.pkg no-auto-reboot
```

5. Verify that all nodes display the "*Waiting for software-upgrade-abort/software-upgrade-reboot*" message by using the command individually on each switch

```
CLI (network-admin@switch)> software-upgrade-status-show
```

6. Reboot all the switches except the node where you are running the commands. This step ensures that the `software-upgrade-reboot` command is executed by all the switches before the node where you originally started the upgrade process goes down.

```
CLI (network-admin@switch)> switch <comma separated non controller switches> software-upgrade-reboot
```

7. Reboot the node where you started the upgrade and complete the upgrade process of the fabric:

```
CLI (network-admin@switch)> switch <controller node> software-upgrade-reboot
```

Below are some examples of the software upgrade that can be used when you want the switch to not reboot automatically after upgrade is complete, but wants to reboot manually or if you want to abort the software upgrade that is in progress.

- Usage of the `software-upgrade` command with `no-auto-reboot` option and later issuing an `abort` command to abort the upgrade process:

```
CLI (network-admin@switch) > software-upgrade package nvOS-6.1.0-6010017911-onvl.pkg  no-auto-reboot

CLI (network-admin@ switch) > software-upgrade-status-show log
--------------------------------------------------------------------
[Mar11.07:47:21] Starting software upgrade ...
[Mar11.07:47:22] Checking available disk space...
[Mar11.07:47:22] Avbl free space: 82.67G, Required: 1.28G
[Mar11.07:47:22] Unpacking local package bundle...
[Mar11.07:47:22] Extracting initial bundle.
[Mar11.07:47:38] Decrypting signed bundle.
[Mar11.07:47:39] Extracting signed bundle.
[Mar11.07:47:56] Extracting packages.
[Mar11.07:48:13] Fetching repository metadata.
[Mar11.07:48:13] Skipping dpkg update in current boot image
[Mar11.07:48:13] Computing package update requirements.
[Mar11.07:48:13] Upgrade agent version: 6.1.0-6010017911
[Mar11.07:48:13] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-6010017911
[Mar11.07:49:01] Waiting for software-upgrade-abort/software-
```

```
upgrade-reboot

CLI (network-admin@switch) > software-upgrade-abort
Upgrade running, scheduled abort

CLI (network-admin@switch) > software-upgrade-status-show
log
----------------------------------------------------------------------
-------
[Mar11.07:47:21] Starting software upgrade ...
[Mar11.07:47:22] Checking available disk space...
[Mar11.07:47:22] Avbl free space: 82.67G, Required: 1.28G
[Mar11.07:47:22] Unpacking local package bundle...
[Mar11.07:47:22] Extracting initial bundle.
[Mar11.07:47:38] Decrypting signed bundle.
[Mar11.07:47:39] Extracting signed bundle.
[Mar11.07:47:56] Extracting packages.
[Mar11.07:48:13] Fetching repository metadata.
[Mar11.07:48:13] Skipping dpkg update in current boot image
[Mar11.07:48:13] Computing package update requirements.
[Mar11.07:48:13] Upgrade agent version: 6.1.0-6010017911
[Mar11.07:48:13] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.07:49:01] Waiting for software-upgrade-abort/software-
upgrade-reboot
[Mar11.07:50:39] User indicated software-upgrade-abort
[Mar11.07:50:40] User aborted the upgrade.
[Mar11.07:50:42] Software upgrade aborted
[Mar11.07:50:42] ERR: Upgrade failed: User aborted the
upgrade.
```

- Usage of the `software-upgrade` command with `no-auto-reboot` option and later issuing a `software-upgrade-reboot` command to complete the upgrade process:

```
CLI (network-admin@switch) > software-upgrade package nvOS-
6.1.0-6010017911-onvl.pkg  no-auto-reboot

CLI (network-admin@switch) > software-upgrade-status-show
log
----------------------------------------------------------------------
[Mar11.07:52:59] Starting software upgrade ...
[Mar11.07:52:59] Checking available disk space...
[Mar11.07:52:59] Avbl free space: 82.67G, Required: 1.28G
[Mar11.07:52:59] Unpacking local package bundle...
[Mar11.07:52:59] Extracting initial bundle.
[Mar11.07:53:16] Decrypting signed bundle.
[Mar11.07:53:17] Extracting signed bundle.
[Mar11.07:53:33] Extracting packages.
[Mar11.07:53:50] Fetching repository metadata.
[Mar11.07:53:50] Skipping dpkg update in current boot image
[Mar11.07:53:50] Computing package update requirements.
[Mar11.07:53:51] Upgrade agent version: 6.1.0-6010017911
```

```
[Mar11.07:53:51] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.07:54:38] Waiting for software-upgrade-abort/software-
upgrade-reboot

CLI (network-admin@switch) > software-upgrade-reboot
Upgrade running, scheduled reboot

CLI (network-admin@switch) > Shared connection to switch
closed.
```

Check the status on the new BE:

```
CLI (network-admin@switch) > software-upgrade-status-show
log
----------------------------------------------------------------
[Mar11.07:52:59] Starting software upgrade ...
[Mar11.07:52:59] Checking available disk space...
[Mar11.07:52:59] Avbl free space: 82.67G, Required: 1.28G
[Mar11.07:52:59] Unpacking local package bundle...
[Mar11.07:52:59] Extracting initial bundle.
[Mar11.07:53:16] Decrypting signed bundle.
[Mar11.07:53:17] Extracting signed bundle.
[Mar11.07:53:33] Extracting packages.
[Mar11.07:53:50] Fetching repository metadata.
[Mar11.07:53:50] Skipping dpkg update in current boot image
[Mar11.07:53:50] Computing package update requirements.
[Mar11.07:53:51] Upgrade agent version: 6.1.0-6010017911
[Mar11.07:53:51] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.07:54:38] Waiting for software-upgrade-abort/software-
upgrade-reboot
[Mar11.07:57:07] User indicated software-upgrade-reboot
[Mar11.07:57:08] User issued software-upgrade-reboot,
rebooting the switch.
[Mar11.07:57:08] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.07:57:08] Software upgrade completed. Rebooting.
[Mar11.07:59:35] Upgrade agent is listening.
```

- Usage of the `software-upgrade` command in default mode:

```
CLI (network-admin@switch) > software-upgrade package nvOS-
6.1.0-6010017911-onvl.pkg

log
-----------------------------------------------------------------
[Mar11.09:32:10] Starting software upgrade ...
[Mar11.09:32:10] Checking available disk space...
[Mar11.09:32:10] Avbl free space: 81.89G, Required: 1.28G
[Mar11.09:32:10] Unpacking local package bundle...
[Mar11.09:32:10] Extracting initial bundle.
[Mar11.09:32:27] Decrypting signed bundle.
```

```
[Mar11.09:32:28] Extracting signed bundle.
[Mar11.09:32:44] Extracting packages.
[Mar11.09:33:01] Fetching repository metadata.
[Mar11.09:33:01] Skipping dpkg update in current boot image
[Mar11.09:33:02] Computing package update requirements.
[Mar11.09:33:02] Upgrade agent version: 6.1.0-6010017911
[Mar11.09:33:02] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.09:33:51] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-
6010017911
[Mar11.09:33:51] Software upgrade completed. Rebooting.
Shared connection to switch closed.
```

- Usage of the `software-upgrade` command in default mode and later issuing an abort command to abort the upgrade process. The `software-upgrade-abort` command is also supported in the default mode (same as `auto-reboot` mode):

```
CLI (network-admin@switch) > software-upgrade package nvOS-
6.1.0-6010017911-onvl.pkg

CLI (network-admin@switch) > software-upgrade-abort

CLI (network-admin@switch) > software-upgrade-status-show
log
-----------------------------------------------------------------
[Mar11.09:43:04] Starting software upgrade ...
[Mar11.09:43:04] Checking available disk space...
[Mar11.09:43:04] Avbl free space: 81.15G, Required: 1.28G
[Mar11.09:43:04] Unpacking local package bundle...
[Mar11.09:43:04] Extracting initial bundle.
[Mar11.09:43:13] User indicated software-upgrade-reboot
<============ time at which user initiated the command
[Mar11.09:43:21] Decrypting signed bundle.
[Mar11.09:43:22] Extracting signed bundle.
[Mar11.09:43:38] Extracting packages.
[Mar11.09:43:55] Fetching repository metadata.
[Mar11.09:43:56] Skipping dpkg update in current boot image
[Mar11.09:43:56] Computing package update requirements.
[Mar11.09:43:56] Upgrade agent version: 6.1.0-6010017911
[Mar11.09:43:56] User aborted the upgrade.  <================
place at which actual abort is performed (consistent state)
[Mar11.09:43:56] Software upgrade aborted
[Mar11.09:43:56] ERR: Upgrade failed: User aborted the
upgrade.
```

Another new command added in Netvisor ONE version 6.1.0 is the `software-upgrade-instant-status-show` command, which displays the most current status of the upgrade process of all the switches in the fabric. This command is different from the `software-upgrade-status-show` command, where all details of the upgrade process is displayed.

Use this command to view the most recent status on each switch in the fabric when you perform the upgrade process on all switches of the fabric (fabric-wide upgrade):

```
CLI (network-admin@switch) >  switch * software-upgrade-instant-status-show show-interval 1

switch       log
-------   ----------------------------------------------------------------
Switch1 [Mar11.07:48:13] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-6010017911
Switch2 [Mar11.07:48:13] Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-6010017911
```

The `switch *` in the above command indicates all the switches in that fabric which is undergoing the software upgrade process.

Implementing a Fabric Upgrade

A switch that is part of a fabric can be upgraded locally using software-upgrade process or you can start a fabric-wide upgrade of all nodes in the fabric.

While performing a fabric wide upgrade, the switch on which fabric-upgrade command is issued acts as the controller node. It is mandatory to copy the package to /sftp/import/ directory of the controller node.

Netvisor ONE copies the upgrade package to other nodes in the fabric as part of fabric-wide upgrade. The controller node monitors the progress of the upgrade on each node and you can view the status of the upgrade using the fabric-upgrade-status-show command. The controller node is identified by an "*" after the switch name in the status output.

Netvisor ONE enables you to implement a fabric-wide upgrade and reboot the switches at the same time or in a sequential order.

Upgrading the Fabric

Follow the tasks explained here to upgrade all switches in the fabric:

Upgrade Commands

Following are the commands that control the fabric upgrade process:

- **`fabric-upgrade-start`** – begin the upgrade process on entire fabric by specifying the package name
- **`fabric-upgrade-status-show`** – monitor the progress of the upgrade for each node in the fabric
- **`fabric-upgrade-finish`** – finalize when upgrade is complete
- **`fabric-upgrade-abort`** – abort the entire upgrade process and return switches to their prior state

The `fabric-upgrade-start` command defines all the future behavior of the upgrade process, that is, any optional settings need to be defined with the *`start`* command. In addition, the `fabric-upgrade-start` command acquires a configuration lock from all the members of the fabric. No configuration changes are permitted during the upgrade process.

The `fabric-upgrade-start` command includes the following options:

```
CLI (network-admin@switch) > fabric-upgrade-start
```

`fabric-upgrade-start`	Starts the software upgrade or prepare process on entire fabric.
`packages sftp-files name`	Comma separate list of software bundles.
Specify between 0 and 7 of the following	

options:	
`auto-finish|no-auto-finish`	Automatically starts the software upgrade on the entire fabric. The default option is `no-auto-finish`.
`abort-on-failure|no-abort-on-failure`	Whether to abort fabric upgrade if a node fails or not. The default option is `no-abort-on-failure`.
`manual-reboot|no-manual-reboot`	Whether to defer to user for reboot after upgrade.
`download-count 1..5`	Number of concurrent downloads. The default value is 5 (maximum). This option is introduced in version 6.1.0.
`prepare|no-prepare`	Perform setup steps for the actual upgrade.
`upload-server` *`upload-server-string`*	Upload config file to server via SCP.
`server-password`	SCP host password.

During a fabric upgrade, all members of fabric downloads the upgrade bundle from controller node. By default, fabric upgrade allows a maximum of 5 switches in the fabric to download the upgrade bundle from controller at a given time.

However, this can cause issues if there is bandwidth constraint or can overwhelm the controller node if the controller is of a lower hardware specification switch. To address this issue, starting with Netvisor ONE version 6.1.0, you can use the `download-count` parameter of `fabric-upgrade` command to reduce the number of concurrent downloads depending upon your network conditions and hardware capabilities of the controller node. By default, the `download-count` is five.

For example, to set the download count to 2, use the command:

```
CLI (network-admin@switch) > fabric-upgrade-start packages
nvOS-6.0.1-6010017911-onvl.pkg download-count 2
```

Before you start the fabric-wide upgrade

1. Copy image to */sftp/import/* directory of controller node.
2. Ensure there is a reliable in-band and/or out-off-band connectivity between fabric members, which helps to distribute the software for the upgrade and monitor the progress of the upgrade process. The distribution of software to the nodes of the fabric is done in parallel, that is, each node receives the software approximately at the same time. An independent communications link is established over the fabric communications path to distribute the software to each node in the fabric.
3. Console access to switches are recommended.
4. Switches do not accept any configuration commands once upgrade starts, so plan accordingly.

Copying Image to the Switch

To copy the image:

- First, enable Secure File Transfare Protocol (SFTP) service on all switches by using the following command and create an /sftp/import directory:

```
CLI (network-admin@switch)>switch* admin-sftp-modify
enable
sftp password:
confirm sftp password:
CLI (network-admin@switch)>
```

  OR

  Enable shell access on all the switches to copy the file to the folder by using the command:

```
 CLI(admin@netvisor) > switch* role-modify name network-
admin shell
```

  And access the shell:

```
 CLI(admin@netvisor) > shell
 network-admin@netvisor:~$ cd /sftp/import
  network-admin@netvisor:/sftp/import$
```

- Copy the image to */sftp/import* directory

```
root@server-os-9:~/# sftp sftp@switch
The authenticity of host 'switch (10.0.0.02)' can't be
established.
RSA key fingerprint is
SHA256:SI8VQZgJCppbrF4sRcby36Fx7rz3Hh5EJllPPyScLZU.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'switch, 10.0.0.02 (RSA) to the
list of known hosts.
* Welcome to Pluribus Networks Inc. Netvisor(R). This is a
monitored system. *
* ACCESS RESTRICTED TO AUTHORIZED USERS ONLY *
* By using the Netvisor(R) CLI,you agree to the terms of the
Pluribus Networks *
* End User License Agreement (EULA). The EULA can be
accessed via *
* http://www.pluribusnetworks.com/eula or by using the
command "eula-show" *
Password:
Connected to switch
sftp> cd import
sftp> put nvOS-6.1.0-6010018118-onvl.pkg
Uploading nvOS-6.1.0-6010018118-onvl.pkg
nvOS-6.1.0-6010018118-onvl.pkg
```

```
nvOS-6.1.0-6010018118-onvl.pkg  100%  332MB  7.5MB/s  04:00
```

Fabric upgrade with *manual-reboot* option

This option completes in three phases:

- Copy upgrade package to switches in fabric and start upgrade with `fabric-upgrade-start` command.
- Finish or abort fabric upgrade with `fabric-upgrade-finish` or `fabric-upgrade-abort` commands.
- Manually reboot switches with the `switch-reboot` command.

Starting the Fabric Upgrade

> Before starting the upgrade process, ensure that all the nodes of the fabric are online, you can use the command `fabric-node-show` and check that the `state` is online for all the nodes.

Use the following command to copy the upgrade package from controller switch to all other switches in the fabric and start the upgrade process.

Run the `fabric-upgrade-finish` command to reboot the fabric and complete the upgrade process:

```
CLI network-admin@switch >fabric-upgrade-start packages
<image> manual-reboot
```

The `fabric-upgrade-start` command defines all behavior of the upgrade process during the upgrade, that is, any optional settings need to be defined with the "start" command (see optional settings below). In addition, the `fabric-upgrade-start` command acquires a configuration lock from all the members of the fabric. No configuration changes are permitted during the upgrade process.

The optional setting parameters for the `fabric-upgrade-start` command includes:

- `auto-finish` — specify to start software upgrade on the entire fabric. The default is `no-auto-finish.`
- `abort-on-failure` — specify if you want the upgrade to stop if there is a failure during the process.
- `manual-reboot` — specify if you want to manually reboot individual switches after the upgrade process. If you specify no-manual-reboot, all switches reboot automatically after the upgrade is complete.
- `prepare` — specify if you want to perform setup steps prior to performing the upgrade. This step copies the offline software package and then extracts and prepares for the final upgrade process. Once you begin the prepare process, you cannot add new switches to the fabric.

A sample upgrade process is explained below. Start the upgrade process by using the command:

```
CLI (network-admin@switch) > fabric-upgrade-start packages
nvOS-6.1.0-6010018118-onvl.pkg auto-finish manual-reboot
Warning: This will start software upgrade on your entire
fabric.
Please confirm y/n (Default: n):y
Scheduled background update.
Use:
* fabric-upgrade-status-show to check progress
* fabric-upgrade-finish to finalize when complete
* fabric-upgrade-abort to cancel cleanly
* switch-reboot on each switch in fabric to reboot manually
when complete
```

Monitoring the Upgrade Process

The controller node monitors the progress of the upgrade on each node and reports the status of the upgrade by using the `fabric-upgrade-status-show` command.

There are many interim steps to the upgrade process and to continually monitor the upgrade process use the *show-interval (in seconds)* option with the `fabric-upgrade-status-show` command:

Use the following commands to:

- To monitor the progress of the upgrade for each node in the fabric:

```
CLI (network-admin@switch) > fabric-upgrade-status-show
```

For example,

```
CLI (network-admin@switch) > fabric-upgrade-status-show show-
interval 5

log                                 switch          state              cluster
----------------------------------  --------------- ------------------
----------------------
(0:00:36)Agent needs restart        eq-colo-7       Agent restart wait aqr07-
08(sec)
(0:00:34)Agent needs restart        tucana-colo-7   Agent restart wait spine-
cl(sec)
(0:03:57)Extracting signed bundle. aquarius-test-1 Running
aquarius-test-1-2(sec)
(0:00:45)Agent needs restart        dorado-test-3   Agent restart wait dorado-
test-2-3(sec)
(0:03:57)Extracting signed bundle. aqr08           Running            aqr07-
08(pri)
(0:00:28)Agent needs restart        switch*         Agent restart wait spine-
cl(pri)
(0:03:57)Extracting signed bundle. aquarius-test-2 Running
```

```
aquarius-test-1-2(pri)
(0:00:38)Agent needs restart       dorado-test-2   Agent restart wait dorado-
test-2-3(pri)
(0:01:00)Agent needs restart       scorpius10      Agent restart wait none
(0:00:47)Agent needs restart       vnv-mini-1      Agent restart wait none
log                                switch          state              cluster
---------------------------------  --------------- ------------------
----------------------
(0:00:36)Agent needs restart       eq-colo-7       Agent restart wait aqr07-
08(sec)
(0:00:34)Agent needs restart       tucana-colo-7   Agent restart wait spine-
cl(sec)
(0:04:02)Extracting packages.      aquarius-test-1 Running
aquarius-test-1-2(sec)
(0:00:45)Agent needs restart       dorado-test-3   Agent restart wait dorado-
test-2-3(sec)
(0:04:02)Extracting signed bundle. aqr08           Running            aqr07-
08(pri)
(0:00:28)Agent needs restart       switch*         Agent restart wait spine-
cl(pri)
(0:04:02)Extracting packages.      aquarius-test-2 Running
aquarius-test-1-2(pri)
(0:00:38)Agent needs restart   dorado-test-2   Agent restart wait dorado-test-
2-3(pri)
(0:01:00)Agent needs restart   scorpius10      Agent restart wait none
(0:00:47)Agent needs restart   vnv-mini-1      Agent restart wait none
.
.
log                                                           switch
state            cluster
-----------------------------------------------------------   ---------------
---------------  ----------------------
(0:01:53)Waiting for completion processing                    eq-colo-7
Upgrade complete aqr07-08(sec)
(0:01:25)Waiting for completion processing                    tucana-colo-7
Upgrade complete spine-cl(sec)
(0:06:24)Waiting for completion processing                    aquarius-test-1
Upgrade complete aquarius-test-1-2(sec)
(0:02:29)Waiting for completion processing                    dorado-test-3
Upgrade complete dorado-test-2-3(sec)
(0:06:43)Waiting for completion processing                    aqr08
Upgrade complete aqr07-08(pri)
(0:01:23)Waiting to reboot                                    tucana-colo-6*
Upgrade complete spine-cl(pri)
(0:06:16)Waiting for completion processing                    aquarius-test-2
Upgrade complete aquarius-test-1-2(pri)
(0:02:19)Waiting for completion processing                    dorado-test-2
Upgrade complete dorado-test-2-3(pri)
(0:06:09)Waiting for completion processing                    scorpius10
Upgrade complete none
(0:08:09)Upgrading nvOS 6.0.1-6000116966 -> 6.1.0-6010017911 vnv-mini-1
Running          none
.
.
log                                               switch          state
      cluster
---------------------------------------  ---------------  ----------------
----------------------
(0:01:53)Current/Reboot BE: netvisor-16           eq-colo-7       Upgrade
complete aqr07-08(sec)
```

```
(0:01:25)Waiting for completion processing          tucana-colo-7    Upgrade
complete  spine-cl(sec)
(0:06:24)Waiting for completion processing          aquarius-test-1  Upgrade
complete  aquarius-test-1-2(sec)
(0:02:29)Destroy BE: netvisor-45                    dorado-test-3    Upgrade
complete  dorado-test-2-3(sec)
(0:06:43)Waiting for completion processing          aqr08            Upgrade
complete  aqr07-08(pri)
(0:01:23)Waiting to reboot                          switch*   Upgrade complete
spine-cl(pri)
(0:06:16)Current/Reboot BE: netvisor-10             aquarius-test-2  Upgrade
complete  aquarius-test-1-2(pri)
(0:02:19)Software upgrade done. Waiting for reboot  dorado-test-2    Upgrade
complete  dorado-test-2-3(pri)
(0:06:09)Waiting for completion processing          scorpius10       Upgrade
complete  none
(0:13:17)Waiting for completion processing          vnv-mini-1       Upgrade
complete  none
-----------------------------------------  ----------------
---------------------  --------------
(0:01:53)Upgrade complete                        eq-colo-7       Reboot wait
   aqr07-08(sec)
(0:01:25)Upgrade complete                        tucana-colo-7   Reboot wait
   spine-cl(sec)
(0:06:24)Upgrade complete                        aquarius-test-1 Reboot wait
   aquarius-test-1-2(sec)
(0:02:29)Upgrade complete                        dorado-test-3   Reboot wait
   dorado-test-2-3(sec)
(0:06:43)Upgrade complete                        aqr08           Reboot wait
   aqr07-08(pri)
(0:01:23)Sending Reboot wait message to handler switch*   Reboot wait
spine-cl(pri)
(0:06:16)Upgrade complete                        aquarius-test-2 Reboot wait
   aquarius-test-1-2(pri)
(0:02:19)Upgrade complete                        dorado-test-2   Reboot wait
   dorado-test-2-3(pri)
(0:06:09)Upgrade complete                        scorpius10      Reboot wait
   none
(0:13:17)Waiting for completion processing       vnv-mini-1      Upgrade
complete  none
Connection to switch closed by remote host.
Connection to switch closed.
```

The first entry in the log is the elapsed time of the upgrade process. It does not include waiting time. The switch with the asterisk (*) is the upgrade controller node where the `fabric-upgrade-start` command was issued.

During a fabric-wide upgrade, the messages displayed by the `fabric-upgrade-status-show` command, based on the current progress status is described in table below:

Message	Description
`Downloading package bundle`	The upgrade package is downloaded from the initial node to all the other nodes.
`Extracting initial bundle`	Once successfully downloaded, the offline

	bundle is extracted.
`Extracting signed bundle`	The signature of the package is verified.
`Extracting packages`	The packages are extracted and readied to install.
`Agent needs restart`	The nodes wait for the package to be extracted on all nodes of the fabric.
`Upgrading nvOS *`	The switch upgrades Netvisor from the older version to the newer one
`Waiting for fabric-upgrade-finish/abort`	The switches wait for the user to complete the upgrade once it completes using either of the commands mentioned above.

- Once the upgrade package is copied to all switches by fabric upgrade process and the upgrade process is completed, run the `fabric-upgrade-finish` or `fabric-upgrade-abort` command to either finish the upgrade or abort it.

```
CLI (network-admin@switch) > fabric-upgrade-finish
```

Once the upgrade phase is complete, all switches display the *Upgrade complete* message in the log field. You can then reboot the fabric. Following is an example:

```
CLI (network-admin@switch) > fabric-upgrade-finish

      log                                              switch   state
   cluster
------------------------------------------------- ------   ---------------
 ------------
(0:13:00)Waiting for fabric-upgrade-finish/abort   sw2     Upgrade complete
 spine(sec)
(0:12:04)Waiting for fabric-upgrade-finish/abort   sw1*    Upgrade complete
 spine(pri)
(0:16:49)Waiting for fabric-upgrade-finish/abort   sw1     Upgrade complete
 none
(0:15:27)Waiting for fabric-upgrade-finish/abort   sw2     Upgrade complete
 none

Finalizing upgrade. Manual reboot of nodes required.
```

- Manual reboot: each switch in the fabric need to be manually rebooted after the upgrade is completed. The `fabric-upgrade-status-show` command displays the status as *switch waiting to reboot*. For example,

```
CLI (network-admin@switch) > fabric-upgrade-status-show
fabric-upgrade-status-show: Switch waiting to reboot
```

At this point, upgrade is completed on all switches, reboot switches one at a time by the following command:

`CLI (network-admin@switch) >` switch-reboot

> **Note**: You should **reboot** the *controller switch* at the end only.

> **Note**: All the nodes of the fabric should be running the same software version for the Netvisor ONE features to work correctly.

- During the installation, if there is any issue, the upgrade process can be rolled back using the command `fabric-upgrade-abort`. To abort the upgrade process and return the switches to their prior state (no reboot needed):

```
CLI (network-admin@switch) > fabric-upgrade-abort
```

Aborts the fabric upgrade process. All changes to the switches are cleaned up and the server-switches do not reboot. The configuration lock on the fabric is also released. If you issue the `fabric-upgrade-abort` command during the upgrade process, it may take some time before the process stops because the upgrade has to reach a logical completion point before the changes are rolled back on the fabric. This allows the proper cleanup of the changes.

> **Warning**: DO NOT use the switch-reboot command to reboot the switch while upgrade is in progress.

> **Note**: During the fabric-upgrade process, the fabric configuration is locked throughout the entire process and you cannot change any configurations during the process.

Related Command:

Other related commands for fabric-upgrade includes:

- `fabric-upgrade-prepare-cancel` — cancels a fabric upgrade that was prepared earlier.
- `fabric-upgrade-prepare-resume` — resume a fabric upgrade that was prepared earlier.
- `fabric-upgrade-prepare-show` — displays the status of prepared upgrades on the fabric nodes.

Review bootenv

A new boot environment is built during the upgrade process. Upon reboot this new boot environment becomes active and the new software is up-and-running on the switch. Generally, it is not required to interact with the boot environments during the upgrade process. It may be necessary to review the boot environments using the command `bootenv-show` if there is some failure during the upgrade process.

Modifying the Fabric Password

Netvisor ONE version 6.0.0 offers support for changing and resetting the fabric password. Use the `fabric-local-modify` command to change the current fabric password or reset the password forcefully.

```
CLI (network-admin@switch) > fabric-local-modify
```

`fabric-local-modify`	Modify fabric local information.
Specify one or more of the following options:	
`vlan` *`0..4095`*	Specify the VLAN assigned to the fabric.
`change-password` *`change-password-string`*	Use this option to change the fabric password after confirming the current password.
`reset-password` *`reset-password-string`*	Use this option to reset the fabric password forcefully. **Note:** Resetting the password requires assistance from Pluribus support.
`fabric-network in-band|mgmt|vmgmt`	Specify the type of interface over which the fabric administration network communicates.
`control-network in-band|mgmt|vmgmt`	Specify the type of interface over which the control plane network communicates.
`fabric-advertisement-network inband-mgmt|inband-vmgmt|inband-only|mgmt-only`	Specify the interface to send fabric advertisement packets on.

For example, to change the current fabric password, use the command:

```
CLI (network-admin@switch) > fabric-local-modify change-password
Please note this will disrupt fabric communications affecting user traffic till the password is changed on ALL nodes.
Please confirm y/n (Default: n):<y>
current password: <current-password>
fabric password: <fabric-password>
confirm fabric password: <fabric-password>
Password changed. Please ensure that the password is changed on all nodes of the fabric.
```

You can leave the `<current-password>` field empty, if the fabric does not have a pre-existing password. Enter the new password in the `<fabric-password>` field.

If you forget the fabric password, you can reset the same with assistance from Pluribus support. For example:

```
CLI (network-admin@switch) > fabric-local-modify reset-
password
Please note this will disrupt fabric communications affecting
user traffic till the password is changed on ALL nodes.
Please confirm y/n (Default: n):<y>
fabric password: <fabric-password>
confirm fabric password: <fabric-password>
fabric-local-modify: Contact Pluribus Networks to reset
password
```

> **Note:** Changing or resetting the fabric password on one of the nodes disrupts fabric communication and can affect the user traffic as well. You must change or reset the password individually on all fabric nodes to re-establish the communication.

If you modify the password on one of the nodes in a fabric, the `fabric-node-show` output displays the state of other nodes in the fabric as 'offline'.

For example, if you change the password on switch1, while switch2 and switch3 are other nodes in the fabric, the `fabric-node-show` output is:

```
CLI (network-admin@switch1) > fabric-node-show layout vertical
name:                  switch1
fab-name:              fabric10
mgmt-ip:                10.10.10.29/23
in-band-ip:             192.168.0.33/24
in-band-vlan-type:     public
version:                6.0.0-6000016140
state:                 online
firmware-upgrade:       not-required
device-state:          ok
name:                  switch2
fab-name:              fabric10
mgmt-ip:                10.10.10.14/23
in-band-ip:             192.168.0.227/24
in-band-vlan-type:     public
version:                6.0.0-6000016140
state:                 offline
firmware-upgrade:       not-required
device-state:          ok
name:                  switch3
fab-name:              fabric10
mgmt-ip:                10.10.10.16/23
in-band-ip:             192.168.0.223/24
in-band-vlan-type:     public
version:                6.0.0-6000016140
state:                 offline
firmware-upgrade:       not-required
device-state:          ok
```

To add a switch to a fabric, you must authenticate the `fabric-join` operation by using the fabric password. For example:

```
CLI (network-admin@switch1) > fabric-join name fabric1
password
fabric password: <fabric-password>
confirm fabric password: <fabric-password>
Joined fabric fabric1. Restarting nvOS...
```

If a cluster node exits a fabric, and the fabric password changes thereafter, you must authenticate the cluster re-peer process by using the new password. For example, to re-peer node1 with node2, use the command:

```
CLI (network-admin@node1) > fabric-join repeer-to-cluster-node
node2 password
fabric password: <fabric-password>
confirm fabric password: <fabric-password>
Joined fabric fabric1. Restarting nvOS...
```

Copying and Importing Configuration Files

You can create a configuration file to import to another switch by using the `switch-config-copy-to-import` command. To create a configuration file with the name config-092613 to import on another switch, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-config-copy-to-import
export-file config-092613
```

After you create the configuration file, you can export it to `/nvOS/export/` directory, and SFTP to it from the target switch.

To review the available files for import and export, use the following syntax:

```
CLI (network-admin@Leaf1) > switch-config-show

switch        export-file
pbg-nvos      config-092613.tar.gz
```

Depending on the available remote access services, you can now copy the configuration file to a different switch. For example, you can SFTP to another switch using the IP address of the switch, login as SFTP with the password that you previously set, `cd /nvOS/import` and `get` the configuration file.

To upload the configuration file to the target switch and set the configuration from the configuration file, transfer the configuration file to the target switch with the IP address, 192.168.3.35.

To export a configuration to a server, use the `switch-config-export` command:

```
CLI (network-admin@Leaf1) > switch-config-export
```

Auto-configuration of IPv6 Addresses on the Management Interface Support

IPv6 Stateless Address Auto-Configuration (SLAAC)

Like IPv4 addresses, you can configure hosts in a number of different ways for IPv6 addresses. Dynamic Host Configuration Protocol (DHCP) assigns IPv4 addresses dynamically and static addresses assign fixed IP addresses. DHCP provides a method of dynamically assigning addresses, and provides a way to assign the host devices other service information like DNS servers, domain names, and a number of different custom information.

SLAAC allows you to address a host based on a network prefix advertised from a local network router using Router Advertisements (RA). RA messages are sent by default by IPv6 router.

These messages are sent out periodically by the router and include following details:

- One or more IPv6 prefixes (Link-local scope)
- Prefix lifetime information
- Flag information
- Default device information (Default router to use and its lifetime)

Netvisor ONE enables SLAAC by default on the switch.

When you configure IPv6 address on the management interface during setup, the parameter, **assignment**, has two options:

- **none** — Disables IPv6 addresses.
- **autoconf** — Configure the interface with SLAAC.

Support for Local Loopback IP Addresses

Netvisor ONE uses the loopback interface as an always up and available virtual interface, and you can assign it a unique IPv4 or IPv6 address. Netvisor ONE uses a loopback interface as a termination address for some routing protocols, because of the availability of the interface. Netvisor ONE allows you to configure a loopback address for a global zone.

- Send a dedicated ping to loopback interface
- Create a BGP neighbor using the loopback Interface with OSPF so reach-ability is there for BGP and BGP next hop self
- Make sure log messages do not show any issues

Netvisor ONE deploys the loopback IP address as persistent in the configuration and not affected by a reboot or reset of Netvisor ONE.

To add a loopback IPv4 or IPv6 address or both to an existing configuration, use the following syntax:

```
CLI (network-admin@switch1) > switch-setup-modify loopback-ip
ip-address loopback-ipv6 ipv6-address
```

For example, to add the IPv4 address, 12.1.1.1, and the IPv6 address, 1212::1, use the following syntax:

```
CLI (network-admin@switch1) > switch-setup-modify loopback-ip
12.1.1.1 loopback-ip6 1212::1

CLI (network-admin@switch1) > switch-setup-show format in-
band-ip,in-band-ip6,loopback-ip,loopback-ip6,   layout
horizontal

in-band-ip     in-band-ip6  loopback-ip  loopback-ip6
------------  -----------  -----------  ------------
150.1.1.1/24  2001::1/96   12.1.1.1      1212::1
150.1.1.2/24  2001::2/96   12.1.1.2      1212::2
```

After configuring the loopback address, you can SSH to the switch over the management, in-band, or loopback interface using the following syntax:

```
CLI (network-admin@switch1) > ssh network-
admin@<mgmt/inband/loopback  ip-address>
```

Then from CLI, execute the `shell` command to access the switch shell:

```
CLI (network-admin@switch1) > network-admin@switch:~$
```

Configuring REST API Access

Netvisor ONE enables you to use REST API over HTTP and HTTPS to manage the switches in a fabric, in addition to using the CLI. Though REST API access over HTTP is simpler to configure, Pluribus recommends using HTTPS for security reasons. The vREST web application that runs on the switch enables the REST API client to access the resources on the switch.

Follow the steps below to configure REST API access over HTTP:

- Enable the web service using the command `admin-service-modify`.

```
CLI (network-admin@switch1) admin-service-modify if mgmt web
```

`admin-service-modify`	Modifies services on the switch.
`if` *`if-string`*	Specify the administrative service interface. The options are `mgmt` or `data`.
`web|no-web`	Specify if you want to enable web management. **Use this option to enable REST API access over HTTP.**
`web-ssl|no-web-ssl`	Specify if you want to use SSL and certificates for web services. **Use this option to enable REST API access over HTTPS.**
`web-ssl-port` *`web-ssl-port-number`*	Specify the web SSL port.
`web-port` *`web-port-number`*	Specify the port for web management.
`web-log|no-web-log`	Specify if you want to turn on or off web logging.

- Verify configuration using the command `admin-service-show:`

```
CLI (network-admin@switch1) admin-service-show

switch      if   ssh nfs web web-ssl web-ssl-port web-port snmp net-api icmp
----------- ---- --- --- --- ------- ------------ -------- ---- ------- ----
switch1     mgmt on  off on  on      443          80       on   off     on
switch1     data on  off on  off     443          80       on   off     on
```

- Download Swagger tool onto the desktop and open index.html file.
- Paste the URL http://<ip-address>/vRest/api-docs into the URL field.

  <ip-address> should be the hostname or management IP address of your switch.

- Click 'Explore'. Commands are populated as below:

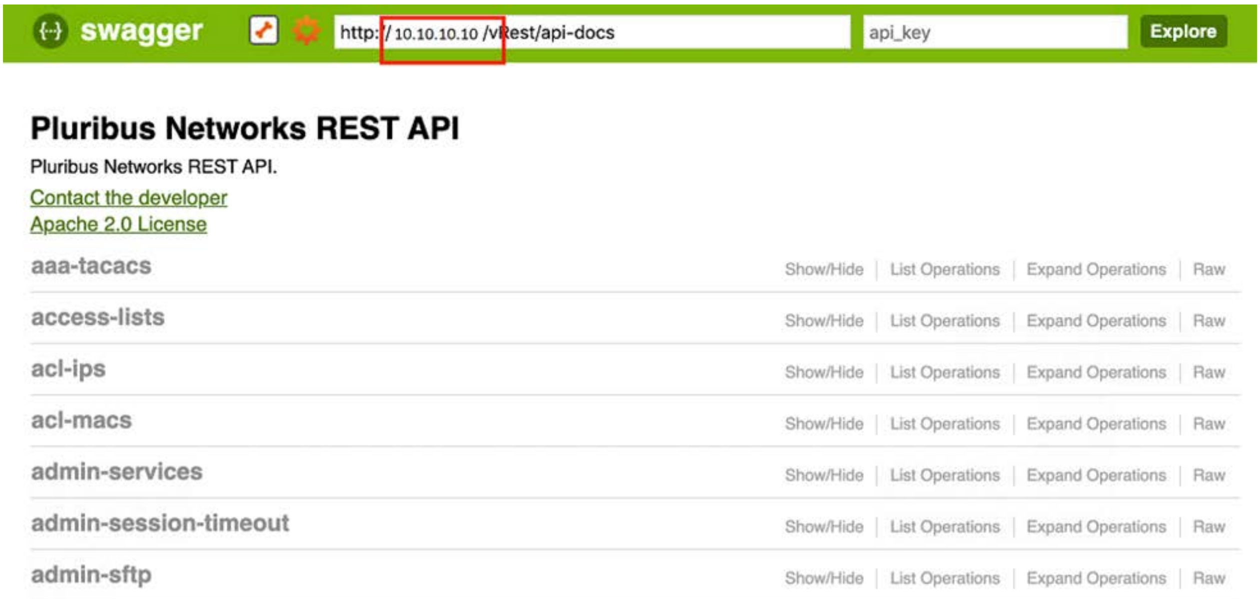


Figure 2- 1: Swagger UI for Pluribus REST API

- Right click to enable Chrome Inspect, and view the network tab to ensure that all the commands are loaded.
- Expand one of the CLI commands to see the corresponding GET/POST/DELETE/PUT options.
- Click on the model schema to view the list of configurable options supported under that model (vRest API) which are populated as key-value pairs. Make the required modifications to the values and click 'Try it out!'.

Using cURL with REST API

To create a VLAN, use the vREST API:

```
$ curl -u network-admin:pluribus!23 -H "Content-
Type:application/json" -X POST http://switch1/vRest/vlans -d
   '{
    "scope": "local",
    "id": 1111,
    "description": "hello world"
    }'
```

By default, all the vRest APIs provide fabric level information. To specifically access the resources of the switch (scope : local), the switch ID needs to be specified in the URL.

For switch ID specific information, use the command:

```
$ curl -u network-admin:pluribus!23 http://switch1/vRest/vlans?
api.switch={hostid} | python -m json.tool
```

as in the following example:

```
$ curl -u network-admin:pluribus!23 http://10.10.10.10/vRest/vlans?
api.switch=201327131 | python -m json.tool
```

For switch information listing a local scope:

```
$ curl -u network-admin:pluribus!23 http://switch1/vRest/vlans?
api.switch=fabric | python -m json.tool
```

or

```
$ curl -u network-admin:pluribus!23 http://switch1/vRest/vlans |
python -m json.tool
```

as in the following example:

```
$ curl -u network-admin:pluribus!23 http://10.110.0.48/vRest/vlans | python -m
json.tool
```

Configuring REST API Access over HTTPS

To enable HTTPS communication between a REST API client and Netvisor vREST web service, you have two options:

1. You can generate a self-signed certificate using Netvisor CLI and use this certificate for REST web service.

2. After creating a self-signed certificate using Netvisor CLI, create a certificate request, get the certificate request signed by a trusted Certificate Authority (CA), import the

signed certificate and CA certificate into Netvisor ONE and use the certificates for REST web service.

Follow the steps below to create the certificates and deploy them:

- Generate self-signed certificate (the private key and the certificate file, in PEM format) using the `web-cert-self-signed-create` command.

```
CLI (network-admin@switch1) > web-cert-self-signed-create
```

`web-cert-self-signed-create`	This command creates a self-signed certificate and deletes any existing certificates.
`country country-string`	Specify the contact address of the organization, starting with the country code.
`state state-string`	Specify the state or province.
`city` *`city-string`*	Specify the city.
`organization` *`organization-string`*	Specify the name of the organization.
`organizational-unit` *`organizational-unit-string`*	Specify the organizational unit.
`common-name` *`common-name-string`*	Specify the common name. The common name must precisely match the hostname where the certificate is installed.

For example:

```
CLI (network-admin@switch1) > web-cert-self-signed-create
country US state California city "Santa Clara" organization
"Pluribus Networks Inc" organizational-unit Engineering
common-name  switch1.pluribusnetworks.com
Successfully generated self-signed certificate.
```

- ·If you want to get the certificate signed by a trusted Certificate Authority(CA), generate a CSR from the self-signed certificate by using the command `web-cert-request-create.`

```
CLI (network-admin@switch1) > web-cert-request-create
Certificate signing request successfully generated
at  /sftp/export/switch1.pluribusnetworks.com.csr.
```

- To view the CSR, use the command `web-cert-request-show.`

```
CLI (network-admin@switch1) > web-cert-request-show
```

`web-cert-request-show`	Displays the certificate signing request.

`cert-request`	*`cert-request-string`*	Specify the name of the CSR.

For example:

```
CLI (network-switch1) > web-cert-request-show

cert-request
-----------------------------------------------------------------
-----BEGIN CERTIFICATE REQUEST-----
MIICnDCCAYQCAQEwVzELMAkGA1UEBhMCVVMxCzAJBgNVBAgMAkNBMQswCQYDVQQH
DAJTSjELMAkGA1UECgwCUE4xDTALBgNVBAsMBEVuZ2cxEjAQBgNVBAMMCWVxLWNv
bG8tMTCCASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBALMmrZ8hvZ5J+FRs
Lo1sfVtwmmLEaxyhaxD/HNVdXSRhzbQDT20+qySfOudxtWGKyCsuCFFbgMUz7rgu
H1Xle8uwPSoxgTjLGq20sgBQIfNBT5UwDLDuzUUPzMEEjFb3/9Cg1VWju2t1KPim
Gqg3rcA3PCsMeCr/q+9Gz6gfLe6Rfx91yxTA44ZWsOWnvgDdXAPfHOLZ5zBWG8a3
ohgOwMLjy21ytDTA6aR1M9I12MkJwev3t0y6n/CLp6Zigp5wXiArPPnR9sZ+E7so
MqpEzz0rjFDfrNwNAGMzT3WPcmlYRjYrUJ0QsOEQ+O1uHJaNbw1pJEmK2jm97kbk
/HvEFmMCAwEAAaAAMA0GCSqGSIb3DQEBBQUAA4IBAQCnlgEwzoesbuiCYG7HZJN/
Rxm/NcznpvJXxdlTAdzSbTWWLswrZMyX6bQqUTWEb3qvVccD4tIZShyIGiR0CpCD
22m8LD4+e6/FA6NijjanHkKsRW9Z7ka97TFpsUaH27sUTtfFDDkDImwRIGfns+nu
kTRNMuNiyC/+uHovsvCxS8is3OasQtS1lkG28sZgxisvP17qmfjlb9fQC3pcvR4t
K8GciPMUfgcIA5qLDmCZAg1A6JBMb/UHtUuEnztLrLz4qjWqJJK3pWvdLWZcKDEz
C0t5Dre9ByJ2RT75GdUq2c16xYBGAwZNCzjdhParyBnvn00Mwb6PpPmLGcBQiRNn
-----END CERTIFICATE REQUEST-----
```

- Send the CSR to your trusted CA. You can copy the `web-cert-request-show` output and send it to the CA for signing the certificate.

You can also connect to the switch by using SFTP and copy the certificate file from /sftp/export location and send it to the CA.

If disabled, use the command `admin-sftp-modify enable` to enable SFTP.

- Upload the signed certificate, the CA root certificate, and the intermediate CA certificate (if the certificate is signed by an intermediate CA) to /sftp/import directory on the switch using SFTP.

For example, to upload the file server-cert.pem to the /sftp/import directory, follow the steps below:

```
$ sftp sftp@switch1

Password:

sftp> cd /sftp/import

sftp> put server-cert.pem
```

- Import the signed server certificate, CA root certificate, and the intermediate certificate (if available) onto the switch using the `web-cert-import` command:

```
CLI (network-admin@switch1) > web-cert-import
```

`web-cert-import`	This command imports certificates from /sftp/import directory.
`file-ca` *`file-ca-string`*	Specify the name of the CA certificate file.
`file-server` *`file-server-string`*	Specify the name of server certificate file (signed by CA).
`file-inter` *`file-inter-string`*	Specify the name of intermediate CA certificate file.

```
CLI (network-admin@switch1) > web-cert-import file-ca ca.pem
file-server server-cert.pem file-inter intermediate.pem
Successfully imported certificates.
```

- After the import is successful, enable `web-ssl` using the `admin-service-modify` command.

```
CLI (network-admin@switch) > admin-service-modify if mgmt web-
ssl
```

- Download the Swagger tool and follow the general steps above to complete the configuration of REST API access.

Related Commands

- `web-cert-clear`

Use this command to delete previously generated certificates.

For example:

```
CLI (network-admin@switch1) > web-cert-clear
Successfully deleted all certificate files.
```

- `web-cert-info-show`

Use this command to display web certificate information.

```
CLI (network-admin@switch1) web-cert-info-show
```

`web-cert-info-show`	Displays the web certificate information.
Specify any of the following options:	
`cert-type ca|intermediate|server`	Specify the one among the options as the certificate type.
`subject` *`subject-string`*	Specify the the subject of the certificate.
`issuer` *`issuer-string`*	Specify the issuer of the certificate.
`serial-number` *`serial-number`*	Specify the serial number of the certificate.
`valid-from` *`valid-from-string`*	Specify the time from which the

	certificate is valid.
`valid-to` *`valid-to-string`*	Specify the time at which the certificate expires and is no longer valid.

For example:

```
CLI (network-admin@switch1) web-cert-info-show

switch:         switch1
cert-type:      ca
subject:         /C=US/ST=CA/L=SJ/O=PN/OU=Engg/CN=switch1
issuer:          /C=US/ST=CA/L=SJ/O=PN/OU=Engg/CN=switch1
serial-number:  1
valid-from:     May  7 18:16:10 2019 GMT
valid-to:       May  6 18:16:10 2020 GMT
------------------------------------------
switch:         switch1
cert-type:      server
subject:         /C=US/ST=CA/L=SJ/O=PN/OU=Engg/CN=switch1
issuer:          /C=US/ST=CA/L=SJ/O=PN/OU=Engg/CN=switch1
```

Using cURL to Implement SSL Certificates

Use cURL to automate the upload of the CA root, CA intermediate, and signed switch certificates.

Run the following command for each of the PEM formatted certificates:

```
awk 'NF {sub(/\r/, ""); printf "%s\\n",$0;}'  <file-name>.pem
```

For example:

```
$ awk 'NF {sub(/\r/, ""); printf "%s\\n",$0;}'  /tmp/server-
cert.pem.bkp
```


```
-----BEGIN CERTIFICATE-----
\nMIIDHDCCAgQCAQEwDQYJKoZIhvcNAQELBQAwVDELMAkGA1UEBhMCSU4xCzAJBgNV\nB
AgMAktBMQwwCgYDVQQHDANCTFIxCzAJBgNVBAoMAlBOMQwwCgYDVQQLDANFTkcx\nDzAN
BgNVBAMMBlNQSU5FMTAeFw0yMDA1MDQxODM4NTZaFw0yMTA1MDQxODM4NTZa\nMFQxCzA
JBgNVBAYTAklOMQswCQYDVQQIDAJLQTEMMAoGA1UEBwwDQkxSMQswCQYD\nVQQKDAJQTj
EMMAoGA1UECwwDRU5HMQ8wDQYDVQQDDAZTUElORTEwggEiMA0GCSqG\nSIb3DQEBAQUAA
4IBDwAwggEKAoIBAQCot16ddH0LNHOrWZt63FHYiArVXYIYbCDh\nWCY6MX3suoXYvKst
vRgJkUe/6G5As+vYtwRi2bDqdDsgTC5+Qo4SnjrdTcTM98F+
\n0Qzqv02c+dbzk5GclUkljqq0PHGXRPGOMhou8B/6LI9Hg5XkG+FSfaDGQTM39uj2\nz
zvrMOFn96gzpTBoh40sMoIpnKQLrWeGjlNxaBxhM342c1jn1CVmXss/uHMQeang\nsVhP
TynikyxIrDwl9gh/2X1EwzVzpAnUBTUZvJ9rgrceC9GcuGmiPZgxxSruNb0w\nK8xsyH8
/hLwhK4Axgu3a+lfmmKFmSWjywmcxlmQl+jwiMPA/Ty55AgMBAAEwDQYJ\nKoZIhvcNAQ
ELBQADggEBAEG0D/2FcNU6Z6w/6eKbyH855kHSrJyqeU8eoCW9rnOb\nqdnAsFX3aYwiU
CjzSFXpWA3bRr3L7X0Y01x7VSvwITuDvwO43llK29rQfrSvoPiw\nf7fhU7bszlUc2GAu
mU9OEdYBnSI1DzfBawUcPmbDmm+ci27k0po53KDWTbxkBIZR\n2Oh25LXkmq8ZBzE4vgS
+mAw436nToazB1/vDTMWoBuLVzOUlU8cdcjJUnJBevTbX\nThP691sHVMED8B8Fhl08Bz
IJmQQ9qp1tjplFq1Ea9oEFnT5U5gKvJYy48qEPlW+r\nhRIHysvZXF/dghtrLXDMSBWLl
LofUsDQsh+qLxpo1+k=\n-----END CERTIFICATE-----\n
```


Copy the output into the JSON payload.

> **Note:** The escape character syntax of \n" must be used as highlighted in red in the example below. Otherwise, the script will fail, and the certificates will not install.

```
$ curl -u network-admin:test123 http://10.100.64.5/vRest/web-certs/upload -H "content-type:application/json" -v -X POST -d
'{"cert-ca":"-----BEGIN CERTIFICATE-----
\nMIIDHDCCAgQCAQEwDQYJKoZIhvcNAQELBQAwVDELMAkGA1UEBhMCSU4xCzAJBgNV\nB
AgMAktBMQwwCgYDVQQHDANCTFIxCzAJBgNVBAoMAlBOMQwwCgYDVQQLDANFTkcx\nDzAN
BgNVBAMMBlNQSU5FMTAeFw0yMDA1MDQxODM4NTZaFw0yMTA1MDQxODM4NTZa\nMFQxCzA
JBgNVBAYTAklOMQswCQYDVQQIDAJLQTEMMAoGA1UEBwwDQkxSMQswCQYD\nVQQKDAJQTj
EMMAoGA1UECwwDRU5HMQ8wDQYDVQQDDAZTUElORTEwggEiMA0GCSqG\nSIb3DQEBAQUAA
4IBDwAwggEKAoIBAQCot16ddH0LNHOrWZt63FHYiArVXYIYbCDh\nWCY6MX3suoXYvKst
vRgJkUe/6G5As+vYtwRi2bDqdDsgTC5+Qo4SnjrdTcTM98F+
\n0Qzqv02c+dbzk5GclUkljqq0PHGXRPGOMhou8B/6LI9Hg5XkG+FSfaDGQTM39uj2\nz
zvrMOFn96gzpTBoh40sMoIpnKQLrWeGjlNxaBxhM342c1jn1CVmXss/uHMQeang\nsVhP
TynikyxIrDwl9gh/2X1EwzVzpAnUBTUZvJ9rgrceC9GcuGmiPZgxxSruNb0w\nK8xsyH8
/hLwhK4Axgu3a+lfmmKFmSWjywmcxlmQl+jwiMPA/Ty55AgMBAAEwDQYJ\nKoZIhvcNAQ
ELBQADggEBAEG0D/2FcNU6Z6w/6eKbyH855kHSrJyqeU8eoCW9rnOb\nqdnAsFX3aYwiU
CjzSFXpWA3bRr3L7X0Y01x7VSvwITuDvwO43llK29rQfrSvoPiw\nf7fhU7bszlUc2GAu
mU9OEdYBnSI1DzfBawUcPmbDmm+ci27k0po53KDWTbxkBIZR\n2Oh25LXkmq8ZBzE4vgS
+mAw436nToazB1/vDTMWoBuLVzOUlU8cdcjJUnJBevTbX\nThP691sHVMED8B8Fhl08Bz
IJmQQ9qp1tjplFq1Ea9oEFnT5U5gKvJYy48qEPlW+r\nhRIHysvZXF/dghtrLXDMSBWLl
LofUsDQsh+qLxpo1+k=\n-----END CERTIFICATE-----\n", "cert-
server":"-----BEGIN CERTIFICATE-----
\nMIIDHDCCAgQCAQEwDQYJKoZIhvcNAQELBQAwVDELMAkGA1UEBhMCSU4xCzAJBgNV\nB
AgMAktBMQwwCgYDVQQHDANCTFIxCzAJBgNVBAoMAlBOMQwwCgYDVQQLDANFTkcx\nDzAN
BgNVBAMMBlNQSU5FMTAeFw0yMDA1MDQxODM4NTZaFw0yMTA1MDQxODM4NTZa\nMFQxCzA
JBgNVBAYTAklOMQswCQYDVQQIDAJLQTEMMAoGA1UEBwwDQkxSMQswCQYD\nVQQKDAJQTj
EMMAoGA1UECwwDRU5HMQ8wDQYDVQQDDAZTUElORTEwggEiMA0GCSqG\nSIb3DQEBAQUAA
4IBDwAwggEKAoIBAQCot16ddH0LNHOrWZt63FHYiArVXYIYbCDh\nWCY6MX3suoXYvKst
vRgJkUe/6G5As+vYtwRi2bDqdDsgTC5+Qo4SnjrdTcTM98F+
\n0Qzqv02c+dbzk5GclUkljqq0PHGXRPGOMhou8B/6LI9Hg5XkG+FSfaDGQTM39uj2\nz
zvrMOFn96gzpTBoh40sMoIpnKQLrWeGjlNxaBxhM342c1jn1CVmXss/uHMQeang\nsVhP
TynikyxIrDwl9gh/2X1EwzVzpAnUBTUZvJ9rgrceC9GcuGmiPZgxxSruNb0w\nK8xsyH8
/hLwhK4Axgu3a+lfmmKFmSWjywmcxlmQl+jwiMPA/Ty55AgMBAAEwDQYJ\nKoZIhvcNAQ
ELBQADggEBAEG0D/2FcNU6Z6w/6eKbyH855kHSrJyqeU8eoCW9rnOb\nqdnAsFX3aYwiU
CjzSFXpWA3bRr3L7X0Y01x7VSvwITuDvwO43llK29rQfrSvoPiw\nf7fhU7bszlUc2GAu
mU9OEdYBnSI1DzfBawUcPmbDmm+ci27k0po53KDWTbxkBIZR\n2Oh25LXkmq8ZBzE4vgS
+mAw436nToazB1/vDTMWoBuLVzOUlU8cdcjJUnJBevTbX\nThP691sHVMED8B8Fhl08Bz
IJmQQ9qp1tjplFq1Ea9oEFnT5U5gKvJYy48qEPlW+r\nhRIHysvZXF/dghtrLXDMSBWLl
LofUsDQsh+qLxpo1+k=\n-----END CERTIFICATE-----\n"}'

Note: Unnecessary use of -X or --request, POST is already inferred.
* Trying 10.100.64.5...
* TCP_NODELAY set
* Connected to 10.100.64.5 (10.100.64.5) port 80 (#0)
* Server auth using Basic with user 'network-admin'
> POST /vRest/web-certs/upload HTTP/1.1
> Host: 10.100.64.5
> Authorization: Basic bmV0d29yay1hZG1pbjp0ZXN0MTIz
> User-Agent: curl/7.54.0
> Accept: */*
> content-type:application/json
> Content-Length: 2348
> Expect: 100-continue
>
< HTTP/1.1 100 Continue
* We are completely uploaded and fine
```

```
< HTTP/1.1 200 OK
< Server: Apache-Coyote/1.1
< Access-Control-Allow-Origin: *
< Access-Control-Allow-Methods: GET, POST, DELETE, PUT
< Set-Cookie: JSESSIONID=C52C3170DEEAC8E4996FF428D152BF25;
Path=/vRest/; HttpOnly
< Date: Tue, 05 May 2020 19:34:05 GMT
< Content-Type: application/json
< Content-Length: 162
<
* Connection #0 to host 10.100.64.5 left intact

{"result":{"status":"Success","result":[{"api.switch-
name":"local","scope":"local","status":"Success","code":0,"message":"
Successfully uploaded certificates."}]}}
```

Running Shell Commands or Scripts Using REST API

Netvisor ONE version 5.1.0 provides the ability to run shell commands or scripts using REST API or through CLI commands. As a network administrator or as an admin user, you can run the scripts from the directories */opt/nvOS/bin/pn-scripts* (directory and all files are delivered as part of pn-upgrade-agent package) and */usr/bin/pn-scripts* (backup directory for running custom scripts).

The commands introduced to enable this feature are: `pn-script-show` (to view all the available scripts) and `pn-script-run name <script-name>` (to run a specified script).

Usage Guidelines:

To run a custom script,

- You should have permission to run the script.
- You should not have any duplicate scripts in the directories, */opt/nvOS/bin/pn-scripts* and */usr/bin/pn-scripts*. In case of duplicate scripts, the script from the directory, */opt/nvOS/bin/pn-scripts* takes precedence.
- It is not recommended to execute any scripts that are manually copied to the directory.

You can use the CLI commands or the vREST API to run the scripts. To run the scripts using the CLI commands, for example:

To display the available scripts using the CLI command:

```
CLI (network-admin@switch) > pn-script-show

name
-----------------
storm.c
testscript.sh
block_learning.pl
cint.sh
```

To display the scripts using vREST API:

```
$ curl  -s -u network-admin:test123 http://leo-ext-leaf1/vRest/pn-scripts
```


```
{"data":[{"name":"storm.c"},{"name":"testscript.sh"},
{"name":"block_learning.pl"},{"name":"cint.sh"}],"result":
{"status":"Success","result":[{"api.switch-
name":"local","scope":"local","status":"Success","code":0,"mes
sage":""}]}}%
```


To run the script using the CLI command:

```
CLI (network-admin@switch) > pn-script-run name testscript.sh
```

```
Executing   /opt/nvOS/bin/pn-scripts/testscript.sh:
Executing Test PN script!
```

To run the scripts using vREST API, use the following API call:

```
$ curl  -s -u network-admin:test123 -X POST http://leo-ext-leaf1/vRest/pn-scripts/run -d '{ "name" : "testscript.sh" }' -H "Content-Type: application/json"
{"result":{"status":"Success","result":[{"api.switch-name":"local","scope":"local","status":"Success","code":0,"message":"Executing   /opt/nvOS/bin/pn-scripts/testscript.sh:\nExecuting Test PN script!\n"}]}}%
```

To display the API docs of pn-scripts-*, use the following API call:

```
$ curl  -s -u network-admin:test123 http://leo-ext-leaf1/vRest/api-docs/pn-scripts
{"apiVersion":"1.0.0","swaggerVersion":"1.2","basePath":"/vRest","resourcePath":"/pn-scripts","produces":["application/json","application/x-ndjson"],"consumes":["application/json"],"apis":[{"path":"/pn-scripts","operations":[{"method":"GET","summary":"","notes":"","type":"pn-script-show-response","nickname":"showPnScripts","consumes":["application/x-www-form-urlencoded"],"parameters":[]}]},{"path":"/pn-scripts/run","operations":[{"method":"POST","summary":"","notes":"","type":"result-list","nickname":"runPnScript","consumes":["application/json"],"parameters":[{"name":"body","required":false,"type":"pn-script-run","paramType":"body","allowMultiple":false}]}]},{"path":"/pn-scripts/{name}","operations":[{"method":"GET","summary":"","notes":"","type":"pn-script-show-response","nickname":"showPnScriptByName","consumes":["application/x-www-form-urlencoded"],"parameters":[{"name":"name","required":true,"type":"string","paramType":"path","allowMultiple":false}]}]}],"models":{"result-list":{"id":"result-list","required":["status","result"],"properties":{"status":{"type":"string","enum":["Success","Failure"]},"result":{"type":"array","items":{"$ref":"result"}}}},"result":{"id":"result","required":["api.switch-name","scope","status","code"],"properties":{"api.switch-name":{"type":"string"},"scope":{"type":"string","enum":["local","fabric"]},"status":{"type":"string","enum":["Success","Failure"]},"code":{"type":"integer","format":"int32"},"message":{"type":"string"}}},"pn-script-show-response":{"id":"pn-script-show-response","required":["data","result"],"properties":{"data":{"type":"array","items":{"$ref":"pn-script-show"}},"result":{"$ref":"result-list"}}},"pn-script-run":{"id":"pn-script-
```

run","description":"Run PN script","required":
["name"],"properties":{"name":
{"type":"string","description":"desc=Script   to
execute:pattern=^[a-zA-Z0-9_.:-]+$:pattern-help=letters,
numbers, _, ., :, and -"}}},"pn-script-show":{"id":"pn-script-
show","description":"Show PN scripts","required":
["name"],"properties":{"api.switch-name":
{"type":"string"},"name":
{"type":"string","description":"desc=Script   to   execute"}}}}}%

Managing RMAs for Switches

In the event of a switch failure, you must raise an RMA request with the respective hardware vendor.

After the RMA is received, do the following to reconnect the switch back in the fabric:

1. Power on the switch
2. Connect to the Console window
3. Configure the initial switch settings
4. Enable SFTP
5. Install or upgrade the software to the same version that was available on the failed switch
6. Upload or import the previously backed up Configuration file

In Pluribus Adaptive Cloud Fabric, the configurations can be on per scope basis: `Local`, `Cluster`, or `Fabric` scoped configurations. The scope defines the set of nodes participating in a transaction:

- Local — only the local node (switch) participates in the transaction
- Cluster — only two cluster peer nodes participate in the transaction
- Fabric — all nodes in the same fabric instance participate in the transaction

Based on the switch configurations, use the below processes to restore the configurations on an RMAed switch.

Cluster Re-Peer Process

When the failed switch is part of a cluster, Pluribus recommends the use the cluster re-peer process to restore configuration on the failed switch . Use the `fabric-join repeer-to-cluster-node` command if one of the member-nodes of the cluster is active and none of the nodes in fabric is offline, except the node that is faulty, for which the configuration needs to be restored. In this case, using the `fabric-join repeer-to-cluster-node` command is helpful because each cluster node automatically backs-up the other node's configuration. If one node in cluster fails, the above command restores the configuration from the other node. For details, see the *Performing the Cluster Re-peer Process* in the *Configuring High Availability* chapter.

However, if both member-nodes of a cluster fail or is being RMAed, or in the cases where multiple fabric member-nodes are offline, then use the `switch-config-import` command to restore the configuration on the cluster member-node.

Switch Config Export and Import process

In the case of a standalone switch or a non-cluster node (switch) failure, to restore back the configuration, Pluribus recommends the Switch Config Export-Import process. For details, see the Configuring the Export and Import of the Switch Configurations for RMA in the *Installing Netvisor ONE and Initial Configuration* chapter.

> **Note**: As a best practice, Pluribus recommends to periodically backup the configurations of all fabric nodes (including cluster nodes) and save the configurations on to a external server.

Configuring the Export and Import of the Switch Configurations for RMA

A switch contains fabric configuration information and local configuration information such as port settings. When a switch is replaced, removed, or otherwise disrupted, you can restore the local configuration information if the configuration was saved earlier.

The information that is saved and restored on the local switch includes the following:

- VNETs with vNET manager running on the switch
- Port VLAN associations
- Network services running on the switch

To display a full list of the current configuration details on a switch, use the `running-config-show` command.

To save and restore the switch configuration, the following process is involved:

- Exporting (saving) the configuration
- Importing the saved configuration on the replaced (new) switch.

> **Note**: Pluribus recommends you to take periodic backup of the switch by exporting the configurations. In the event of a hardware failure, the exported configuration can be imported onto a new replaced switch.

Exporting the Configuration

To save or export the switch configuration to a file, use the following command:

```
CLI (network-admin@Leaf1) > switch-config-export
```

`switch-config-export`	Use this command to export the switch configuration
`Specify any of the following:`	
`export-file switch-config` *`export-file`*	Specify a file name for the exported configuration file. See *Note* below for more details.
`upload-server` *`upload-server-string`*	Specify this parameter to upload or save the configuration file to an SCP server (that is, on a server outside the switch). The syntax for the `upload-server` parameter is: *`<username>@<servername>:/<path to directory on server>/`*. See the example below.

The file created from the above command is a *tar* file, which includes a number of configuration files for the switch. The file is created under */nvOS/export* directory.

Configuration File Naming

If you run the `switch-config-export` command without including any additional parameters, the file created is in the format: *<switch-name-fabric-name.timestamp.tar.gz>*. However, if you mention the filename for the configuration file, for example, `switch-config-export export-file switch-config export-file` command, then the configuration file format is: filename followed by timestamp format.

For example, to export the configuration on a switch (*Leaf1*), which is part of a fabric (*multi-VRF*), use the command:

```
CLI (network-admin@Leaf1) > switch-config-export
Exported configuration to /nvOS/export/Leaf1-multi-vrf.2020-
10-11T23.46.38.tar.gz
```

where, *`Leaf1`* is the switch name and *`multi-vrf`* is the already configured fabric name.

To export the configuration specifying the filename, use the command:

```
CLI (network-admin@Leaf1) > switch-config-export export-file
Leaf1
Exported configuration to /nvOS/export/Leaf1.2020-10-
11T23.48.49.tar.gz
```

Exporting the Configuration to an External Server using Direct Command:

Use the `switch-config-export` command with the `upload-server` parameter to upload (save) the configuration file to an external SCP server by using the command syntax:

```
CLI (network-admin@Leaf1) > switch-config-export export-file
<file-name> upload-server <username>@<servername>:/<path to
directory on server>/
```

For example, to save the configuration file with a name (here, *`leaf1-config`*), to the *root* directory of an external server (here *server-test1),* use the command and enter the password:

```
CLI (network-admin@Leaf1) > switch-config-export export-file
leaf1-config upload-server root@server-test1:/root/
server password:
Uploaded configuration to server at /root/
```

> **Note**: If you specify the `upload-server` parameter while exporting the configuration file, you do not have to follow the secure FTP (SFTP) process described below to upload the file to an external server.

Pluribus recommends to use the `switch-config-export` command with the `upload-server` parameter as this process is faster, easier, and also safer during a switch failure.

To export the configurations from all the nodes (switches) in the fabric, use the `switch * switch-config-export upload-server` command. For example, if you have six switches in a fabric, use this command to export the configurations from all six nodes to */build/diags/<name>/tmp* directory :

```
CLI (network-admin@switch) > switch * switch-config-export
upload-server   root@server:/build/diags/<name>/tmp
server password:
switch-config-export [switch-leaf1]: switch-leaf1: Uploaded
configuration to server at /build/diags/<name>/tmp
server password:
switch-config-export [switch-leaf2]: switch-leaf2: Uploaded
configuration to server at /build/diags/<name>/tmp
server password:
switch-config-export [switch-leaf3]: switch-leaf3: Uploaded
configuration to server at /build/diags/<name>/tmp
server password:
switch-config-export [switch-leaf4]: switch-leaf4: Uploaded
configuration to server at /build/diags/<name>/tmp
server password:
switch-config-export [switch-leaf4]: switch-leaf4: Uploaded
configuration to server at /build/diags/<name>/tmp
```

To view the details of the saved configuration file, use the following command:

```
CLI (network-admin@Leaf1) > switch-config-show

switch   export-file
------    -------------------------------
Leaf1     leaf1.2020-10-11T23.48.49.tar.gz
```

To view the software version installed on the switch, use the command:

```
CLI (network-admin@Leaf1) > software-show
version:             6.0.1-6000116966
```

Copying the Configuration to an External Server using SFTP

For any reason if you had missed using the `switch-config-export` command with the `upload-server` parameter to upload the file to an external server, you can still copy the configuration file to a different server using SFTP (secure FTP). You must enable the transfer protocol client first before copying the files:

Note: Pluribus recommends to use the direct command as described in the *Exporting* *the Configuration to an External Server using Direct Command* section.

To enable SFTP, use the following command:

```
CLI (network-admin@Leaf1) > admin-sftp-modify enable
password: *******
password: *******
CLI (network-admin@Leaf1)
sftp-user: sftp
enable:    yes
CLI (network-admin@Leaf1)
```

Then copy the configuration file to a backup server by using the following command:

```
backup-user@backupserver:~$ sftp network-admin@Leaf1
Connecting to Leaf1
Password:

sftp> cd /nvOS/export
sftp> ls
leaf1.2020-10-11T23.48.49.tar.gz

sftp> get  leaf1.2020-10-11T23.48.49.tar.gz
sftp> bye
backup-user@backupserver:~$
```

Note: Whenever you reset a switch by using the `switch-config-reset` command, Netvisor takes a back-up the configuration file and the file is stored in the same location (*/nvOS/export*).

Importing the Saved Configuration on the Replaced (new) Switch

After the switch configuration is exported (see above section) , you can import or retrieve the configuration by using the `switch-config-import` command. Before importing the saved configuration, you must copy (upload) the file back from the backup location.

Note: Please ensure to install the same software version (that was available on the replaced switch) onto the new switch.

To copy the configuration file from the backup location, use the following command:

```
backup-user@backupserver:~$ sftp network-admin@Leaf1
Connecting to Leaf1
Password:

sftp> cd /nvOS/import
sftp> put leaf1.2020-10-11T23.48.49.tar.gz

sftp> ls
leaf1.2020-10-11T23.48.49.tar.gz
sftp> bye
```

This command copies the configuration *tar* file from the backup location to the */nvOS/import* directory. Once in the */nvOS/import* directory, by using the `switch-config-import` command, you can import the previously saved switch configuration.

Import the previously saved configuration on the new switch by using the `switch-config-import` command:

```
CLI (network-admin@Leaf1) > switch-config-import import-file
<file-name>
```

`switch-config-import`	Use this command to import the previously saved (exported) switch configuration
`import-file` *`switch-config import-file`*	Specify the filename of the configuration file that you want to import.
`Specify Optional parameters:`	
`apply-system-config|ignore-system-config`	This is an optional parameter. Choose: • `apply-system-config`: if you want to import (along with the configuration file) the additional switch settings such as the management IP address, in-band IP address, IPv4 and IPv6 addresses, gateway, etc to the new switch. • `ignore-system-config`: if you do not want to import any additional setting, import only the configuration file. The default option is `ignore-system-config.`

For example, if you want to import the previously saved configuration file (*leaf1.2020-10-11T23.48.49.tar.gz*) on the switch *Leaf1*, use the command:

```
CLI (network-admin@Leaf1) > switch-config-import import-file
leaf1.2020-10-11T23.48.49.tar.gz

New configuration imported. Restarting nvOS...
```

```
Connected to Switch Leaf1; nvOS Identifier:0xb000011; Ver:
6.0.1-6000116966
```

Usage Guidelines for Switch Export-Import Process

- Pluribus recommends you to backup the configurations on all switches to an external server using the `switch-config-export upload-server` command to retrieve the configurations in case of a hardware failure.
- The configuration file must use the *`*.tar.gz`* extension to be recognized by nvOS.
- Importing the configuration file causes nvOS to restart which results in a brief interruption in traffic. Hence a scheduled maintenance window is advised.
- The `switch-config-import` command imports the last backed-up configuration and if the configuration has changed after the last backup, you must manually make those configuration changes after restoring the previously saved configuration.
- There are two options that allow you to control how the `switch-config-import` command modifies the switch:

  - `apply-system-config` — While replacing a faulty switch, apply this parameter to the `switch-config-import` command if you want all the switch settings (displayed in the `switch-setup-show` command output) including hostname, mgmt IP address, in-band IP address, etc., from the old switch to be restored onto the new switch.

  - `ignore-system-config` — Use this parameter if you do not want to restore the additional switch settings from the old switch on to the new switch. This is the default setting.
- The `switch-config-reset`, `software-upgrade`, and `fabric-upgrade-start` commands automatically back-up the configuration before executing these commands.
- To restore the configuration on a non-cluster node, use the `switch-config-import` process described in this section.
- To restore the configuration on a cluster member-node, Pluribus recommends to use the cluster re-peer process. Use the `fabric-join repeer-to-cluster-node` command if one of the member-nodes of the cluster is active and none of the nodes in fabric is offline except the node that is faulty, for which the configuration needs to be restored. This is because each cluster node automatically backs-up the other node's configuration. If one node in cluster fails, the above command restores the configuration from the other node. For details, see the *Performing the Cluster Re-peer Process* in the *Configuring High Availability* chapter.

  However, if both member-nodes of a cluster fail or is being RMAed, or in the cases where multiple fabric member-nodes are offline, then use the `switch-config-import` command to restore the configuration on the cluster member-node.

> **Note**: As a best practice, Pluribus recommends to periodically backup the configurations on all fabric nodes, including cluster nodes and save them to an external server.

Contacting Technical Assistance for Troubleshooting Purposes

While configuring and using the Netvisor ONE fabric, you can contact the Technical Assistance Team for support. Before you contact the TAC team, gather all relevant details regarding the issue.

Use the `tech-support-show` command to view all details of the running configuration that can help with TAC troubleshooting assistance. You can save and export the log file using SFTP with TAC team.

```
CLI (network-admin@switch) > tech-support-show

Netvisor OS Command Line Interface 3.1
Connected to Switch leafsw01.xyz; nvOS Identifier:0xb000d95;
Ver: 3.1.3010113816
==================== admin-service-show ======================
if   ssh nfs web web-ssl web-ssl-port web-port snmp net-api
icmp
---- --- --- --- ------- ------------ -------- ---- -------
----
mgmt on  on  off off     443          80       on   on      on

data on  on  off off     443          80       on   on      on

==================== admin-session-timeout-show ==============
timeout: 10m
==================== admin-sftp-show =========================
sftp-user:     sftp
enable:        yes
==================== cluster-bringdown-show ==================
vlag-port-staggered-interval: 0s
==================== cluster-bringup-show ====================
state:                                    ports-enabled
l3-port-bringup-mode:                      staggered
l3-port-staggered-interval:               3s
vlag-port-bringup-mode:                    staggered
vlag-port-staggered-interval:             3s
maximum-sync-delay:                       1m
l3-to-vlag-delay:                         15s
l3-to-vlan-interface-delay:               0s
port-defer-bringup-delay:                 30s
port-defer-bringup-mode:                   staggered
port-defer-bringup-staggered-interval:    0s
.
<snip>
.
=================== vxlan-stats-settings-show ===============
enable:     yes
interval:   30m
disk-space: 50M
diags@jerry:/build/diags/name$
```

Configuring Switch Ports

This section contains information about the configuration and management of switch ports.

Introduction

Switch ports are physical interfaces (typically on the front-panel of the device) that are associated with the switch forwarding engine(s) (that is, the forwarding ASICs). They can carry Layer 2 and Layer 3 traffic for data plane and control plane/management purposes.

Netvisor ONE offers numerous techniques to manage and monitor the traffic that traverses switch ports. These features include port statistics, port storm control, port buffering, Class of Service (CoS), Forward Error Correction (FEC), jumbo frame support, port link status detection, and others. Below are the major features discussed in this chapter:

Port Statistics: Provide useful information such as the number of incoming and outgoing packets (unicast, multicast, or broadcast), discarded or dropped packets, and errors.

Port Speed Configuration: Enables you to configure switch ports with different speed values up to 100 Gbps (depending on the transceiver type).

Port Storm Control: This feature limits the percentage of the total available port bandwidth that can be used by broadcast, multicast, or flooded unicast traffic. It can be enabled to prevent excessive flooded traffic from degrading network performance.

Configuring Port Link Status Detection: Enables you to configure port link status detection checks on Pluribus switches.

Port Buffering: Allocates storage space for packets that cannot be immediately forwarded on a port.

Class of Service-based Queuing: Lets you segregate traffic into different queues based on Class of Service priority.

Forward Error Correction: A technique to detect and correct a limited number of errors in the transmitted data without the need for re-transmission.

Static Pre-emphasis: Static pre-emphasis settings help shape the outputs of ports into a well-defined, clean signal.

Link Scan Mode: The Link Scan feature detects physical link state changes. You can configure interrupt-based detection as an alternative to the software-based link scan process.

Jumbo Frame Support: Enables ports to accept and forward jumbo frames (frames with an MTU size greater than 1500 bytes)

Displaying Port Information

The Netvisor ONE CLI features multiple commands that display relevant switch port information including transceiver information, physical-to-logical port mappings, Layer 2 configuration of physical ports.

Use the `port-show` command to display a host of parameters for all the ports with active links. Information displayed for each port includes the IP addresses and MAC addresses of hosts connected to that port. There can be more than one host per port if a network device such as an external switch is connected to it.

The `port-show` command also displays port status, VLAN ID, VXLAN ID, and configuration details.

```
CLI (network-admin@Leaf1) > port-show
```

`port-show`	Displays port information.
`port` *`port-list`*	Specify the switch network data port number, list of ports, or range of ports. The range of valid port numbers depends on the platform's hardware configuration.
`bezel-port` *`bezel-port-string`*	The port number printed on the device bezel above the physical port's receptacle.
`ip` *`ip-address`*	IP address of a host connected to a switch data port.
`mac` *`mac-address`*	MAC address of a host connected to a switch data port.
`vnet` *`vnet-name`*	Name of the vNET.
`bd` *`bridge-domain-name`*	Name of the bridge domain.
`vlan` *`vlan-id`*	VLAN identifier as a value between 0 and 4095.
`vxlan` *`vxlan-id`*	VXLAN identifier as a value between 0 and 16777215.
`hostname` *`hostname`*	Name of a host connected to a switch data port.
`status phy-up|up|disabled|hw-nat-loop|mirror-loop|mirror-to|inuse|PN-switch|PN-fabric|PN-other|PN-cluster|PN-internal|PN-hypervisor|PN-guest|snmp-host|host|uplink|drop-pkts|no-pktin|no-fwd|no-flood|STP-BPDUs|LLDP|trunk|l3-port|remote-l3-port|vdp|`	Status of a switch data port.

dhcp|dhcpsvrblocked|no-BPDU|LACP-PDUs|vlag-active|vlag-blocked|stp-edge-port|LACP-wait|adjacency-wait|adjacency-check|vlag-wait|multicast-router|host-disabled|loop|vxlan-loopback|vlan-up|vle|vle-wait|phy-down|down|enabled|err-disabled|err-bpdu-guard|mac-violation|stp-bpdu-guard|stp-root-guard|defer-bringup-wait	
loop-vlans vlan-list	VLANs looping on the ports.
rem-ip *ip-address*	IP address of the remote switch.
lport *lport-number*	Logical port number on the switch.
rport *rport-number*	Port number on the remote switch.
config fd|hd|10m|100m|1g|2.5g|10g|25g|40g|50g|100g|loopback|mirror-only|autoneg|fiber|copper|qos|jumbo|pause|asymetric-pause|vxlan-termination|no-local-switching|fec	Configured port features.
description *description-string*	Description of the port.
trunk *trunk-name*	ID of the trunk that a switch data port is a member of.
recover-time duration: #d#h#m#s	Time left for recovery from err-disable state.
err-bpduguard *err-bpduguard-number*	Total count of err-disables by BPDU guard.
err-maclimit *err-maclimit-number*	Total count of err-disables by MAC address limit.
hide-connections	Specifies whether the connections on switch data ports should be displayed.
link-detail	Details of the link such as PHY, link, status etc.

For example:

```
CLI (network-admin@switch*) > port-show port 2 layout vertical
switch:            switch
port:              2
bezel-port:        2
ip:                200.1.23.2
mac:               66:0e:94:b7:90:6f
vlan:              4091
hostname:          taurus-dev-spine2
status:            up,PN-switch,PN-other,STP-BPDUs,LLDP,l3-port,remote-l3-port,vlan-up
config:            fd,10g
```

Displaying Port Numbering

Bezel interface numbers are the labels for ports on the face plate of a switch. As Netvisor ONE supports flexing of ports (breaking a high speed port to lower speed ports) the logical port numbers in the software may not match the bezel interface numbers. The bezel interface numbers may deviate from the logical port numbers in order to represent each logical port uniquely. To display the mapping of logical ports to bezel interface numbers on Netvisor ONE platforms, use the command:

```
CLI (network-admin@switch) > bezel-portmap-show
```

`bezel-portmap-show`	Display the mapping of logical ports to bezel interface numbers.
`port` *`port-number`*	Logical port number.
`bezel-intf` *`bezel-intf-string`*	Bezel interface number.

```
CLI (network-admin@switch) > bezel-portmap-show
switch port bezel-intf
------ ---- ----------
switch 1    1
switch 2    1.2
switch 3    1.3
switch 4    1.4
switch 5    2
switch 6    3
switch 7    3.2
switch 8    3.3
switch 9    3.4
switch 10   4
switch 11   4.2
switch 12   4.3
switch 13   4.4
```

As seen from the above output, the bezel interface numbers 1, 1.2, 1.3, and 1.4 represent a physical port's receptacle connected to a breakout cable with four transceivers. Such transceivers are mapped to logical ports 1, 2, 3 and 4 respectively. For example it could be a 40 GbE QSFP+ receptacle that is divided into four 10 GbE SFP+ ports or a 100 GbE QSFP28 receptacle that is divided into four 25 GbE SFP28 ports. Also, you can infer from the output that bezel interface 2 is not connected to a breakout cable as there is only a single corresponding logical interface

Displaying Physical Port Information

You can display physical port information by using the `port-phy-show` command.

The command displays: port state and mode, speed and auto-negotiation settings, Ethernet mode, default VLAN, maximum frame size, and status information.

```
CLI (network-admin@switch) > port-phy-show
```

`port-phy-show`	Displays physical port information.
`port` *`port-list`*	Specify the switch data port number, list of ports, or range of ports. Port numbers must be in the range of 1-64.
`state off|admin-down|adminpwrdown|bist|dfe-tuning|down|local-fault|partially-up|remote-fault|up|failed`	State of physical ports.
`autoneg` *`autoneg-string`*	Auto-negotiation setting of physical ports
`speed` *`speed-number`*	Speed of physical ports.
`eth-mode unconfigured|disabled|1000base-x|sgmii|1000base-kx|2500base-x|6Gbase-kr|6Gbase-cr|10Gbase-kr|10Gbase-cr|10Gbase-sr|AN-73|Xaui|10Gbase-kx4|10Gbase-cx4|24Gbase-kr4|24Gbase-cr4|40Gbase-kr4|xlaui|40Gbase-cr4|40Gbase-sr4|no-phy-present|MII|gmii|TBI|10G-XGMII|1G-RGMII|sfi|xfi|cx|kr4|sr4|lr4|er4|cr4|cx4|kx4|caui4|kr2|er2|cr2|sr2|lr2|xlaui2|cx2|sr|lr|er|cr|kx|kr|zr|base-x|sys-default|caui|aoc|xlppi|psm4|base_t|base_cx|base_lx|base_sx`	Ethernet mode.
`max-frame` *`max-frame-number`*	The Maximum Transmission Unit (MTU) for the port.
`def-vlan` *`def-vlan-number`*	Default VLAN identifier of the physical port.

```
CLI (network-admin@switch) > port-phy-show format all
port state autoneg speed  eth-mode max-frame def-vlan
---- ----- ------- ------ -------- --------- --------
1    up    none    100000 caui4    9412      1
5    down  none    100000 caui4    1540      1
9    down  none    100000 caui4    1540      1
```

```
13    down   none     100000 caui4    1540      1
17    up     none     100000 caui4    1540      4091
21    down   none     100000 caui4    1540      1
25    down   none     100000 caui4    1540      1
```

Displaying Transceiver Information

To display information on the transceivers connected to a switch, use the `port-xcvr-show` command. The displayed information includes vendor name, part number, and the serial number of the transceiver.

```
CLI (network-admin@switch) > port-xcvr-show format all
```

`port-xcvr-show`	Display port transceiver information.
`port` *`port-list`*	List of ports.
`vendor-name` *`vendor-name-string`*	Vendor name of the transceiver.
`part-number` *`part-number-string`*	Part number of the transceiver.
`serial-number` *`serial-number-string`*	Serial number of the transceiver.
`type unknown|sfp|qsfp`	Type of the transceiver.
`eth-mode unconfigured|disabled|1000base-x|sgmii|1000base-kx| 2500base-x|6Gbase-kr|6Gbase-cr|10Gbase-kr|10Gbase-cr|10Gbase-sr|AN-73|Xaui|10Gbase-kx4|10Gbase-cx4|24Gbase-kr4|24Gbase-cr4|40Gbase-kr4|xlaui|40Gbase-cr4|40Gbase-sr4|no-phy-present|MII|gmii|TBI|10G-XGMII|1G-RGMII|sfi|xfi|cx|kr4|sr4|lr4|er4|cr4|cx4|kx4|caui4|kr2|er2|cr2|sr2|lr2|xlaui2|cx2|sr|lr|er|cr|kx|kr|zr|base-x|sys-default|caui|aoc|xlppi|psm4|base_t|base_cx|base_lx|base_sx`	Transceiver Ethernet mode.
`cbl-len cbl-len-number`	Active Optical Cable (AOC) or Direct Attach Cable (DAC) length.
`temp[C] temp[C]-string`	Transceiver temperature in degrees Centigrade.
`vcc33[V] vcc33[V]-string`	3.3V supply voltage.
`tx-bias1[mA] tx-bias1[mA]-string`	Transmit bias current (mA).

tx-pwr[dBm]	tx-pwr[dBm]-*string*	Transmit power (dBm).
rx-pwr[dBm]	rx-pwr[dBm]-*string*	Receive power (dBm).

```
CLI (network-admin@switch) > port-xcvr-show
switch port vendor-name      part-number   serial-number
------ ---- ---------------- ------------- --------------
switch 25   Amphenol         123456789     ABC00000000DEF
switch 27   Amphenol         123456789     ABC00000000DEF
switch 28   Amphenol         123456789     ABC00000000DEF
switch 45   PluribusNetworks 123456780     HIJ00001
switch 46   PluribusNetworks 123456780     HIJ00001
switch 47   PluribusNetworks 123456780     HIJ00001
switch 48   PluribusNetworks 123456780     HIJ00001
switch 49   Amphenol         123456789     ABC00000000DEF
switch 50   Amphenol         123456789     ABC00000000DEF
switch 51   Amphenol         123456789     ABC00000000DEF
switch 52   Amphenol         123456789     ABC00000000DEF
switch 53   PluribusNetworks 123456780     HIJ00001
switch 54   PluribusNetworks 123456780     HIJ00001
switch 55   PluribusNetworks 123456780     HIJ00001
switch 56   PluribusNetworks 123456780     HIJ00001
switch 65   PluribusNetworks 123456780     HIJ00001
switch 66   PluribusNetworks 123456780     HIJ00001
switch 67   PluribusNetworks 123456780     HIJ00001
switch 68   PluribusNetworks 123456780     HIJ00001
```

Displaying Port Statistics

The port statistics information is useful for understanding the data traffic on switch ports. Port statistics information includes the number of incoming and outgoing packets (classified as unicast, multicast, and broadcast), bytes dropped, bytes discarded, Head-End-Replicated (HER) packets, and errors. Use the `port-stats-show` command to display the port statistics for all active ports on a switch:

```
CLI (network-admin@switch) > port-stats-show
```

`port-stats-show`	Displays port statistics.
`time date/time: yyyy-mm-ddThh:mm:ss`	Specify a time for the packet count statistics using the timestamp format yyyy-mm-ddThh:mm:ss.
`start-time` *`start-time`*	Specify a start time for the packet count statistics using the timestamp format yyyy-mm-ddThh:mm:ss.
`end-time` *`end-time`*	Specify an end time for the packet count statistics using the timestamp format YYYY-MM-DDTHH:MM:SS
`duration` *`duration`*	Specify the duration in seconds.
`interval duration: #d#h#m#s`	Specify the interval between statistics collection.
`since-start|no-since-start`	Specify if the statistics are collected from the start of collecting statistics.
`older-than duration: #d#h#m#s`	Specify if the statistics are older than the duration in days, hours, minutes, and seconds.
`within-last duration: #d#h#m#s`	Specify if the statistics are within the duration in days, hours, minutes, and seconds.
`port` *`port-list`*	Specify one or more switch network data port numbers. Multiple ports can be specified as a comma-separated list of numbers or a range (-).
`description` *`description`*	Displays the port description.
`counter` *`counter-number`*	Displays the counter number.
`ibytes ibytes-number`	Displays the incoming number of bytes.
`ibits` *`ibits-number`*	Displays the number of incoming bits.
`iUpkts` *`iUpkts-number`*	Displays the number of incoming unicast packets.
`iBpkts` *`iBpkts-number`*	Displays the number of incoming broadcast packets.

`iMpkts` *`iMpkts-number`*	Displays the number of incoming multicast packets.
`iPauseFs` *`iPauseFs-number`*	Displays the number of incoming pause frames.
`iCongDrops` *`iCongDrops-number`*	Displays the number of incoming packets dropped due to congestion.
`idiscards` *`idiscards-number`*	Displays the number of incoming packets discarded.
`ierrs` *`ierrs-number`*	Displays the number of incoming packets with errors.
`obytes` *`obytes-number`*	Displays the number of outgoing bytes.
`oUpkts` *`oUpkts-number`*	Displays the number of outgoing unicast packets.
`oBpkts` *`oBpkts-number`*	Displays the number of outgoing broadcast packets.
`oMpkts` *`oMpkts-number`*	Displays the number of outgoing multicast packets.
`oPauseFs` *`oPauseFs-number`*	Displays the number of outgoing pause frames.
`oCongDrops` *`oCongDrops`*`-number`	Displays the number of outgoing packets dropped due to congestion.
`odiscards` *`odiscards-number`*	Displays the number of outgoing discarded packets.
`oerrs` *`oerrs-number`*	Displays the number of outgoing packets with errors.
`mtu-errs` *`mtu-errs-number`*	Displays the number of MTU errors.
`HER-packets` *`HER-pts-number`*	Displays the number of Head End Replicated (HER) packets.
`HER-bytes` *`HER-bytes-number`*	Displays the number of Head End Replicated (HER) bytes.
`HER-bits` `HER-bits-number`	Displays the number of Head End Replicated (HER) bits.

```
CLI (network-admin@switch) > port-stats-show port 1 format all
layout vertical
time:          22:45:12
port:          1
description:
counter:       0
ibytes:        170K
ibits:         1.39M
iUpkts:        165
iBpkts:        22
```

```
iMpkts:       402
iPauseFs:     0
iCongDrops:   0
idiscards:    2
ierrs:        46
obytes:       144K
obits:        1.18M
oUpkts:       158
oBpkts:       4
oMpkts:       249
oPauseFs:     0
oCongDrops:   0
odiscards:    48
oerrs:        0
mtu-errs:     0
HER-pkts:     0
HER-bytes:    0
HER-bits:     0
```

Configuring Port Speed

Netvisor ONE enables you to configure switch ports with different speed values up to 100 Gbps depending on the specific transceiver. For example, you must use SFP transceivers for ports configured with speeds of 1 Gbps, and SFP+ or QSFP transceivers for ports configured with speeds of 10 Gbps or higher.

With a transceiver that is capable of breakout configuration, you can divide a 40 Gigabit Ethernet (GbE) port into four logical 10 GbE ports or a 100 Gigabit Ethernet (GbE) port into four logical 25 GbE ports. You must first disable a port before creating this configuration.

Use the `port-config-modify` command to configure the desired throughput on a port.

```
CLI (network-admin@switch) > port-config-modify
```

`port-config-modify`	Modify port configuration.
`port port-list`	Specify a single port or a list of ports. **Note:** If more than one port is specified, the list must be comma-separated without spaces.
Specify any of the following options:	
`speed disable|10m|100m|1g|2.5g|10g|25g|40g|50g|100g`	Specify the port speed. Ports configured for speeds of 1G must be equipped with SFP transceivers. Ports configured for 10G or higher must be equipped with SFP+ or QSFP+ transceivers.
`egress-rate-limit unlimited`	Specify an egress rate limit for the port.
`eth-mode 1000base-x|sgmii|xlaui|gmii|sfi|xfi|cx|kr4|sr4|lr4|er4|cr4|cx4|kx4|caui4|kr2|er2|cr2|sr2|lr2|xlaui2|cx2|sr|lr|er|cr|kx|kr|zr|base-x|sys-default|caui|aoc|xlppi|psm4|base_t|base_cx|base_lx|base_sx`	Select one of the ethernet modes from the available options.
`autoneg|no-autoneg`	Specify if the port auto-negotiates the port speed with a peer.
`jumbo|no-jumbo`	Specify if the port forwards jumbo frames. Jumbo frames are Ethernet frames with more than 1500 bytes of payload.
`enable|disable`	Specify if the port is enabled and forwards or drops frames.
`lacp-priority` *`integer`*	Specify the LACP priority for the port. If

	you specify a low value for the priority, the port has a higher priority. This is a value between 1 and 65535.
`reflect|no-reflect`	Specify if the port reflects frames received for loopback testing.
`edge-switch|no-edge-switch`	Specify if the port connects to another Pluribus Networks device or is an uplink to a third-party switch or host.
`pause|no-pause`	Specify if you want to pause traffic on the port.
`description` *`description-string`*	Specify a description for the port.
`loopback|no-loopback`	Specify to use loopback or no loopback.
`vxlan-termination|no-vxlan-termination`	Specify if a VXLAN terminates on a port.
`mirror-only|no-mirror-receive-only`	Specify if the port receives mirrored traffic only.
`port-mac-address mac-address`	Specify the MAC address for the physical port.
`send-port` *`send-port-number`*	Specify the port to send traffic.
`loop-vlans vlan-list`	Specifies VLANs that are looping on the network.
`routing|no-routing`	Specify if the port is participating in routing on the switch.
`defer-bringup|no-defer-bringup`	Specify if you want to delay port activation.
`host-enable|host-disable`	Specify if you want host-facing ports enabled or disabled.
`crc-check-enable|crc-check-disable`	Specify if you want CRC checking performed by the port. This is applicable to a switch in Virtual Wire mode. The default value is `crc-check-disable`.
`dscp-map dscp-map name|none`	Specify a DSCP map name to enable on port.
`local-switching|no-local-switching`	Specify if local switching is allowed on the port.
`allowed-tpid vlan|q-in-q|q-in-q-old`	Specify the allowed TPID in addition to 0x8100 on VLAN header
`fabric-guard|no-fabric-guard`	Specify if you want loop detection enabled on the port.
`fec|no-fec|fec-auto`	Specify to enable port forward

	correction error (FEC) mode.

For example, to configure a 40 GbE port as four 10 GbE ports, use the following command:

```
CLI (network-admin@Leaf1) > port-config-modify port 49-52
speed 10g
```

To unify the four logical ports and to set the port configuration back to 40 GbE, use the following command:

```
CLI (network-admin@Leaf1) > port-config-modify port 49 speed
40g
```

Configuring Port Storm Control

A traffic storm occurs when packets flood the LAN, creating excessive load and degrading network performance. When enabled, port storm control discards the excess unicast, multicast, or broadcast traffic that is detected on a port.

Use the `port-storm-control-modify` command to modify the percentage of total available bandwidth that can be used by broadcast, multicast, or unicast traffic.

```
CLI (network-admin@switch) > port-storm-control-modify
```

`port-storm-control-modify`	Modify port storm control configuration.
`port` *`port-list`*	Specify a single port or a list of ports.
`unknown-ucast-level` *`unknown-ucast-level-string`*	Specify the bandwidth to be allotted for unknown unicast as a percentage of the port link speed. The default is 30%.
`unknown-mcast-level` *`unknown-mcast-level-string`*	Specify the bandwidth to be allotted for unknown multicast as a percentage of the port link speed. The default is 30%.
`broadcast-level` *`broadcast-level-string`*	Specify the bandwidth to be allotted for broadcast as a percentage of the port link speed. The default is 30%.

To set the available bandwidth for broadcast traffic to 10% of port link speed on port 5, use the command:

```
CLI (network-admin@switch) > port-storm-control-modify port 5
broadcast-level 10
```

Use the `port-storm-control-show` command to display the configuration:

```
CLI (network-admin@switch) > port-storm-control-show
switch port speed unknown-ucast-level unknown-mcast-level broadcast-level
------ ---- ----- ------------------- ------------------- ---------------
Leaf1  1    100g  30%                 30%                 30%
Leaf2  2    25g   30%                 30%                 30%
Leaf3  3    25g   30%                 30%                 30%
Leaf4  4    25g   30%                 30%                 30%
Leaf5  5    100g  30%                 30%                 10%
Leaf6  6    25g   30%                 30%                 30%
```

This setting discards broadcast traffic if it exceeds 10% of the link speed on port 5.

Configuring 10/100M Override Using Bel-Fuse SFP-1GBT-05 on F9372-X Platforms

> **Note**: This feature is applicable for F9372-X or AS5812-54X platforms.

Auto-negotiation function between two connected devices stipulates a set of shared parameters - link speed, duplex mode, and flow control. The F9372-X or AS5812-54X platform, with the Bel-Fuse SFP-1GBT-05 copper transceiver plugged into one of its ports, can support legacy 10M/100M devices that do not have auto-negotiation capability. As the SFP-1GBT-05 transceiver performs auto-negotiation by default, this function should be disabled on the F9372-X switch through nvOS. An operating link speed of either 10M or 100M can be configured. With the exception of F9372-X, the 10/100M override capability is not available on other switch platforms and is supported only on the SFP-1GBT-05 transceiver.

Use the command below for disabling auto-negotiation and overriding the link speed on F9372-X platform. Enter the *port number* on which the transceiver is connected in the command:

```
CLI (network-admin@Leaf1) > port-config-modify port <port
number> speed <10m|100m> no-autoneg
```

`port-config-modify`	Use this command to update port configuration.
`port <port-list>`	Specify the ports that need to be configured as a list separated by commas. **Note**: For 10/100M override, specify the port number on which the transceiver is connected.
`Specify one or more of the following options:`	
`speed <disable|10m|100m|1g>`	Specify one among the options as the speed at which the port should operate. **Note**: specify the speed as either 10m or 100m for legacy device support.
`autoneg|no-autoneg`	Specify either of the options to enable auto-negotiation or to disable it. **Note**: auto-negotiation has to be disabled to achieve 10/100M override.

For example, to disable auto-negotiation on port 38 and set a speed of 10M, use the command below:

```
CLI (network-admin@Leaf1) port-config-modify port 38 speed 10m
no-autoneg
```

However, the device do not get reprogrammed upon reinsertion. To recover from this, remove and re-add the 10M/100M override port configuration. [PR30110]

Configuring Fabric and vRouter Communication through KNET-vNICs

> **Note:** This feature is available only on Dell and whitebox platforms that do not have rear-facing NICs.

From Netvisor ONE 6.0.1 release onwards, Pluribus provides support for using KNET-vNIC as the OVS uplink from the CPU to OVS. The KNET exposes a standard network interface that is connected as an uplink port to OVS for forwarding fabric, cluster, or vRouter packets. This implementation avoids copying of traffic between OVS and nvOSd and ensures direct transmission of fabric, cluster, and vRouter NIC packets between OVS and the CPU. Therefore, communication through KNET-vNICs results in improved CPU datapath performance.

To support cluster, fabric, and vRouter traffic using KNET-vNIC, you must enable KNET on Whitebox platforms that do not have rear-facing NICs by using the `system-settings-modify` command.

To enable or disable KNET, use the command:

```
CLI (network-admin@switch1) > system-settings-modify optimize-datapath  disable|cluster-only|all
```

`optimize-datapath disable|cluster-only|all`	Specify the datapath optimization for cluster, fabric, and vRouter communication: • `disable`: disables datapath optimization. • `cluster-only`: enables datapath optimization for cluster-only, where cluster traffic is redirected to cluster 4094 vNIC. • `all`: enables datapath optimization for fabric and data traffic. The default value is `all`.

To view the existing configuration on a local switch, use the `system-settings-show` command:

```
CLI (network-admin@switch1) > system-settings-show format
optimize-datapath
optimize-datapath:  all
```

To view the settings on all the switches in the fabric, use the `system-settings-show` command prefixed with `switch *` as below:

```
CLI (network-admin@switch1) > switch * system-settings-show
format  optimize-datapath
optimize-datapath:  all
optimize-datapath:  all
optimize-datapath: all
optimize-datapath:  all
optimize-datapath:  all
optimize-datapath:  all
optimize-datapath:  all
```

Note: Pluribus recommends rebooting the switch by using the `switch-reboot` command after running the `system-settings-modify optimize-datapath` command.

Using Port Buffering

Port buffering allocates storage for packets that cannot be immediately forwarded or processed on a port. To display port buffer information, use the `port-buffer-show` command. This command displays ingress and egress buffer utilization for each port.

`CLI (network-admin@switch) > port-buffer-show`

`port-buffer-show`	Display port buffer information.
`time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Time to start statistics collection.
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Start time of statistics collection
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	End time of statistics collection
`duration duration:` *`#d#h#m#s`*	Duration of statistics collection
`interval duration:` *`#d#h#m#s`*	Interval between statistics collection.
`since-start`	Specify to display port buffering since start.
`older-than duration:` *`#d#h#m#s`*	Specify an older-than time to display port buffering.
`within-last duration:` *`#d#h#m#s`*	Specify a within-last time to display port buffering.
`port` *`port-list`*	The list of ports.

```
CLI (network-admin@switch) > port-buffer-show
switch port ingress-used-buf ingress-used-buf-val egress-used-buf egress-used-buf-val
------ ---- ---------------- -------------------- --------------- -------------------
Leaf1  25   0%               0                    0%              0
Leaf1  27   0%               0                    0%              0
Leaf1  28   0%               0                    0%              0
Leaf1  45   0%               0                    0%              0
Leaf1  49   0%               0                    0%              0
Leaf1  53   0%               0                    0%              0
Leaf1  65   0%               0                    0%              0
Leaf1  69   0%               0                    0%              0
Leaf1  70   0%               0                    0%              0
Leaf1  71   0%               0                    0%              0
Leaf1  72   0%               0                    0%              0
```

Use the `port-buffer-settings-modify` command to enable the collection of port buffer information and to modify the logging interval and buffer size for the command output above.

`CLI (network-admin@switch) > port-buffer-settings-modify`

`port-buffer-settings-modify`	Modify port buffer settings.

`enable|disable`	Specify if you want to enable or disable the collection of port buffer information.
`interval duration:` *`#d#h#m#s`*	Specify the interval for the logging of port buffer information.
`disk-space` *`disk-space-number`*	Specify the amount of memory to be allotted for the collection of port buffering information. The default value is 50MB.

For example, to set an interval of 2 minutes for logging port buffer information, use the command:

```
CLI (network-admin@switch) > port-buffer-settings-modify
interval 2m
```

To display the port buffering settings, use the `port-buffer-settings-show` command:

```
CLI (network-admin@switch) > port-buffer-settings-show
switch: switch
enable: yes
interval: 2m
disk-space: 50M
```

Configuring Queues 8 and 9 for Control Traffic

During network traffic congestion, if all traffic is dispatched with the same priority, mission critical traffic may get dropped with the same probability as lower priority traffic. To mitigate this issue, Netvisor ONE allows you to configure traffic prioritization on a per port basis through Quality of Service (QoS) queues. QoS queues allow the switch to differentiate and prioritize various traffic types and avoid random loss of data. The hardware supports Strict Priority (SP) and Deficit Weighted Round Robin (DWRR) scheduling for the QoS queues.

Netvisor ONE assigns default weights to each queue. However, you can view and modify these weights to suit your requirements. You can also configure data rate limits, minimum guaranteed bandwidth, and maximum bandwidth on a queue basis.

> **Note:** This feature is available only on NRU01, NRU02, NRU03, and NRU-S0301 platforms.

Netvisor ONE version 6.0.1 introduces queues 8 and 9 to isolate user traffic from internal control traffic. In previous versions of Netvisor ONE, fabric and control traffic used queues 6 and 7 which were also used by user traffic. This release eliminates the contention between user traffic and control traffic, as fabric and control messages are now moved from queues 6 and 7 to queues 8 and 9. The queues 8 and 9 are mapped to system vFlow classes `control2` and `control3` respectively. This feature provides improved stability and resiliency to the network especially in cases where the network is overloaded.

To enable queues 8 and 9, use the command:

```
CLI (network-admin@switch) > system-settings-modify cos8-and-
9-queue
!!!! Please reboot the system for cos 8 and 9 queue setting to
take effect correctly !!!!
```

> **Note:** You must reboot the system for the queues 8 and 9 to become operational.

To view all flow classes, use the command:

```
CLI (network-admin@switch) > vflow-class-show
name             scope  type   priority cos
-------------   ------ ------ -------- ---
meter            fabric system 0        0
class0           fabric system 0        0
class1           fabric system 1        1
class2           fabric system 2        2
class3           fabric system 3        3
class4           fabric system 4        3
class5           fabric system 5        4
class6           fabric system 6        4
class7           fabric system 7        5
```

```
guaranteed_bw fabric system 9         6
class8        fabric system 10        6
lossless      fabric system 10        6
control       fabric system 11        7
control2      fabric system 12        8
control3      fabric system 13        9
```

Configuring Port Rate Limit

By using the command `port-cos-rate-setting-modify`, you can stipulate a port speed in packets per second (pps) to regulate the traffic corresponding to each QoS queue. This command is used for rate limiting the traffic of the port queues.

`CLI (network-admin@switch) > port-cos-rate-setting-modify`

`port-cos-rate-setting-modify`	Modify port queue rate limit.
`port control-port|data-port|span-ports`	Specify the port type to set QoS rate limit.
`cos0-rate unlimited|0..10000000`	
`cos1-rate unlimited|0..10000000`	
`cos2-rate unlimited|0..10000000`	
`cos3-rate unlimited|0..10000000`	
`cos4-rate unlimited|0..10000000`	
`cos5-rate unlimited|0..10000000`	Specify the rate limit (pps) for the queue.
`cos6-rate unlimited|0..10000000`	
`cos7-rate unlimited|0..10000000`	
`cos8-rate unlimited|0..10000000`	
`cos9-rate unlimited|0..10000000`	

For example:

```
CLI (network-admin@switch) > port-cos-rate-setting-modify port
data-port cos0-rate 50000
```

To display the port rate limit configuration, use the command:

```
CLI  (network-admin@switch)  >  port-cos-rate-setting-show
port            ports cos0-rate(pps) cos1-rate(pps) cos2-rate(pps) cos3-rate(pps) cos4-
rate(pps)  cos5-rate(pps)  cos6-rate(pps)  cos7-rate(pps)  cos8-rate(pps)  cos9-rate(pps)
------------  -----  -------------  -------------  -------------  -------------
-------------  -------------  -------------  -------------  -------------  -------------
control-port 0      100000         100000         100000         100000         100000
     100000         100000         100000         100000         100000
data-port     129    50000          100000         100000         100000         100000
     100000         100000         100000         100000         100000
span-ports    130    100000         100000         100000         100000         100000
     100000         100000         100000         100000         100000
```

The output displays the port rate limit configuration for control ports, data ports, and span ports. The `data` ports and `span` ports are platform specific. The default rate for each queue is 100000 packets per second. The queues 8 and 9 must be enabled for the columns `cos8-rate(pps)` and `cos9-rate(pps)` to be displayed.

Note:

- The `port-cos-rate-setting-modify` and `port-cos-rate-setting-show` commands are available only when CPTP is disabled
- Queues 8 and 9 are available only on NRU01, NRU02, NRU03, and NRU-S0301 platforms.

Configuring Minimum and Maximum Bandwidth on Ports

In older releases, Netvisor ONE allowed rate limiting only for CPU facing (PCIe, data and span) ports. The current version of Netvisor ONE support bandwidth guarantees on switch ports. You can configure bandwidth guarantees at egress queue level and manage prioritized traffic. Use this feature for setting Service Level Agreements (SLAs). In addition to the support for configuring maximum bandwidth policing at the vFlow level, you can also set a guaranteed minimum bandwidth.

Netvisor ONE supports the configuration of minimum and maximum bandwidth at a per port level. You can configure bandwidth guarantees as a percentage of port speed, and Netvisor ONE determines the data rate internally upon command execution. Additionally, when you update a port speed, the port configuration internally re-adjusts the minimum or maximum bandwidths on the applicable ports. However, when you logically divide a breakout cable into multiple ports of lower bandwidth, you need to adjust the port queue bandwidths manually.

Use the `port-cos-bw-modify` command to configure minimum and maximum bandwidth:

```
CLI (network-admin@switch) > port-cos-bw-modify
```

`port-cos-bw-modify`	Modify port CoS bandwidth settings.
`cos` *`integer`*	Specify the CoS priority between 0 and 9.
`port` *`port-list`*	Specify the physical port(s).
`min-bw-guarantee` *`min-bw-guarantee-string`*	Specify the minimum bandwidth as a percentage.
`max-bw-limit` *`max-bw-limit-string`*	Specify the maximum bandwidth as a percentage.
`weight priority|no-priority`	Specify to enable or disable weight scheduling after the bandwidth guarantee is met.

For example, to configure a minimum bandwidth guarantee of 10 percent on ports 2-5 with a QoS queue of 5, use the command:

```
CLI (network-admin@switch) > port-cos-bw-modify port 2-5 cos 5
min-bw-guarantee 10
```

Use the `port-cos-bw-show` command to view the configuration.

```
CLI (network-admin@Spine1) > port-cos-bw-show
```

cos *integer*	Specify the CoS priority.
port *port-list*	Specify the physical port(s).

```
CLI (network-admin@switch) > port-cos-bw-show
switch   cos port   min-bw-guarantee max-bw-limit weight
-------- --- ------ ---------------- ------------ ------
switch   0   1-72   0%               100%         16
switch   1   1-72   0%               100%         32
switch   2   1-72   0%               100%         32
switch   3   1-72   0%               100%         32
switch   4   1-72   0%               100%         32
switch   5   1,6-72 0%               100%         32
switch   5   2-5    10%              100%         32
switch   6   1-72   0%               100%         64
switch   7   1-72   0%               100%         127
```

> **Note:** The `port-cos-bw-show` command displays only modified port configurations. Ports not displayed in the show command output default to the settings of 100% link capacity, and no minimum guarantee for each QoS queue.

Configuring a maximum bandwidth limit helps in rate limiting or shaping the traffic on the egress queue. For example, to configure a minimum bandwidth of 20% and a maximum bandwidth of 80% on ports 11-13 for queue 4, use the command:

```
CLI (network-admin@switch) > port-cos-bw-modify port 11-13 cos
4 min-bw-guarantee 20 max-bw-limit 80
```

```
CLI (network-admin@switch) > port-cos-bw-show
switch   cos port   min-bw-guarantee max-bw-limit weight
-------- --- ------ ---------------- ------------ ------
switch   0   1-72   0%               100%         16
switch   1   1-72   0%               100%         32
switch   2   1-72   0%               100%         32
switch   3   1-72   0%               100%         32
switch   4   1-72   0%               100%         32
switch   4   11-13  20%              80%          32
switch   5   1,6-72 0%               100%         32
switch   5   2-5    10%              100%         32
switch   6   1-72   0%               100%         64
switch   7   1-72   0%               100%         127
```

Changing the port settings to new values overrides the previous settings.

Configuring QoS Queue Weights

Netvisor ONE automatically weights QoS queues in accordance with the minimum bandwidth guarantees. When you configure minimum bandwidth for a queue, the remaining bandwidth is assigned to the rest of the queues in the same ratio as the minimum bandwidth. For information on configuring minimum bandwidth, see *Configuring Minimum and Maximum Bandwidth on Ports* section.

When you configure a minimum bandwidth without specifying a weight value, the weight for the port and queue is automatically set on a scale of 1 to 100. For example, if you configure queue 1 with a minimum bandwidth of 10% and queue 2 with 30%, the weights are set to 10 and 30, respectively.

If auto-configuration of weights is disabled, you can also assign desired weight values to the queues. When you configure queue weights manually, the bandwidth that remains after meeting the minimum bandwidth guarantee is proportioned among the queues in accordance with the assigned weights.

To enable or disable automatic weight assignment for QoS queues, use the command:

```
CLI (network-admin@switch) > system-settings-modify cosq-
weight-auto|no-cosq-weight-auto
```

Note:

- If you enable auto configuration of queue weights, you cannot change the weights using the `port-cos-bw-modify` command thereafter. You can still use the command to enable strict priority queue.
- When you enable this feature, weights for all the queues that do not have minimum bandwidth configured are set to the default value of 1.

Use the `port-cos-weight-modify` command to change the queue weight of ports on the control panel (PCIe and CPU ports). This command assigns weights on a queue basis only and does not allow a per port configuration of weights.

```
CLI (network-admin@switch) > port-cos-weight-modify
```

port-cos-weight-modify		Modify port queue weight.
cos0-weight	priority|no-priority	
cos1-weight	priority|no-priority	
cos2-weight	priority|no-priority	
cos3-weight	priority|no-priority	
cos4-weight	priority|no-priority	Specify if you want to enable or disable strict priority. Or, specify the weight for the queue as an integer between 0 and 127.
cos5-weight	priority|no-priority	
cos6-weight	priority|no-priority	
cos7-weight	priority|no-priority	
cos8-weight	priority|no-priority	
cos9-weight	priority|no-priority	

For example:

```
CLI (network-admin@switch) > port-cos-weight-modify cos5-
weight 64
```

To display the port queue weight configuration, use the command:

```
CLI (network-admin@switch) > port-cos-weight-show
cos0-weight: 16
cos1-weight: 32
cos2-weight: 32
cos3-weight: 32
cos4-weight: 32
cos5-weight: 64
cos6-weight: 64
cos7-weight: 127
```

You can use the command `port-cos-bw-modify` to change the queue weight of ports on the front panel. This command provides granular control over bandwidth and weight settings for port queues.

```
CLI (network-admin@switch) > port-cos-bw-modify
```

port-cos-bw-modify	Modify port CoS bandwidth settings.
cos *integer*	Specify the CoS priority between 0 and 9. **Note:** queues 8 and 9 are platform specific.
port *port-list*	Specify the physical port(s).
min-bw-guarantee *min-bw-guarantee-string*	Specify the minimum bandwidth as a percentage.

`max-bw-limit` *`max-bw-limit-string`*	Specify the maximum bandwidth as a percentage.
`weight priority|no-priority`	Specify to enable or disable weight scheduling in proportion to the minimum bandwidth guarantee. Or, specify a scheduling weight

For example:

```
CLI (network-admin@switch) > port-cos-bw-modify cos 5 port 10
weight 64
```

Additionally, you can configure strict priority scheduling for any of the queues. If strict priority is configured on a queue, Netvisor ONE gives this queue a higher priority over the other queues.

To configure strict priority for queue 6, use the command:

```
CLI (network-admin@switch) > port-cos-bw-modify cos 6 weight
priority
```

Displaying and Configuring Port Queue Statistics

You can view the port queue statistics by using the command `port-cos-stats-show`. This command displays the number of bits of transmitted and dropped packets on a per queue basis.

```
CLI (network-admin@switch) > port-cos-stats-show
```

`port-cos-stats-show`	Display per port CoS queue statistics.
`time date/time: yyyy-mm-ddThh:mm:ss`	Time to start statistics collection.
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Start time for statistics collection.
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	End time for statistics collection.
`duration:` *`#d#h#m#s`*	Duration of statistics collection.
`interval duration:` *`#d#h#m#s`*	Interval between statistics collection.
`since-start`	Displays statistics from the start of collection.
`older-than duration: #d#h#m#s`	Displays statistics older than a specified duration.
`within-last duration: #d#h#m#s`	Displays statistics within the last specified duration.

For example:

```
CLI (network-admin@switch) > port-cos-stats-show layout
vertical
switch:          switch
time:            21:36:59
port:            21
cos0-obits:      0
cos0-dropbits:   0
cos1-obits:      0
cos1-dropbits:   0
cos2-obits:      0
cos2-dropbits:   0
cos3-obits:      0
cos3-dropbits:   0
cos4-obits:      0
cos4-dropbits:   0
cos5-obits:      0
cos5-dropbits:   0
cos6-obits:      0
cos6-dropbits:   0
cos7-obits:      0
cos7-dropbits:   0
```

To modify the port queue statistics collection settings, use the command:

```
CLI (network-admin@switch) > port-cos-stats-settings-modify
```

`port-cos-stats-settings-modify`	Modify port CoS statistics collection settings.
`enable|disable`	Specify if you want to enable or disable statistics collection.
`interval` *`duration: #d#h#m#s`*	Specify the interval to collect statistics.
`disk-space` *`disk-space-number`*	Specify the amount of memory allocated for statistics (including rotated log files). The default value is 50MB.

For example:

```
CLI (network-admin@switch) > port-cos-stats-settings-modify
enable
```

To view the port CoS statistics collection settings, use the command:

```
CLI (network-admin@switch) > port-cos-stats-settings-show
switch:      Spine-1
enable:      yes
interval:    30m
disk-space:  50M
```

You can clear port queue statistics by using the command `port-cos-stats-clear`.

Configuring Forward Error Correction

Note: This feature is supported only on the following platforms. The support is for 25 GbE and 100 GbE unless stated otherwise.

Ericsson: NRU02 (100 GbE only), NRU03, NRU-S0301

Dell: S5232F-ON, S5248F-ON, S5224F-ON, Z9264

Edgecore: AS7726-32X, AS7326-56X, AS5835-54X, AS7816-64X

Freedom: F9432-C, F9476-V, F9460-X, F9664-C

Forward Error Correction (FEC) or channel coding is an error correction technique that helps to detect and correct a limited number of errors in transmitted data without the need for re-transmission. In this method, the sender sends a redundant Error Correcting Code (ECC) along with the data frames using a fixed, higher forward channel bandwidth.

The IEEE 802.3-2018 standard for Ethernet introduced the support for FEC on 25 GbE or 25 Gbps port link. For details, refer to the clauses 74, 91 and 108 in the IEEE 802.3-2018 standard.

From Netvisor ONE version 5.1.4 onward, you can enable or disable FEC by using the Netvisor ONE CLI or REST API commands on individual 25 GbE ports or 100 GbE ports on NRU03 and NRU-S0301 platforms and 100 GbE ports on NRU02 platform.

From Netvisor ONE version 6.1.0 onward, the FEC support is extended to the AS7816-64X (F9664-C), AS7726-32X (F9432-C), AS7326-56X (F9476-V), AS5835-54X (F9460-X) and Z9264 platforms on 25 GbE and 100 GbE connections.

To implement FEC on 25 GbE and 100 GbE ports, Netvisor ONE follows the IEEE 802.3-2018 standard rules. (Refer to Table 105-2 and Table 80-3 of the IEEE 802.3-2018 standard).

You can enable the FEC feature by using the `port-config-modify` command while ensuring that `eth-mode` and `auto-neg` configurations are consistent with the FEC configuration.

The FEC feature can be enabled on:

- DAC cables with auto-negotiation enabled
- Optical cables without auto-negotiation (`no-autoneg`)

1. To configure FEC on the above platforms, use the command:

```
CLI (network-admin@switch) > port-config-modify
```

`port-config-modify`	Use this command to modify the port configuration to enable FEC.

`port <port-list>`	Specify a physical port or the list of ports you want to configure for FEC support.
Specify one or more of the following options based on cable and transceivers in use:	
`eth-mode [sr4|lr4|cr4|caui4|sr|lr|cr|sys-default]`	Select one of the ethernet modes from the available options.
`autoneg|no-autoneg`	Specify one of the options to enable or disable auto-negotiation on the physical port .
`fec|no-fec`	Specify one of the options to enable or disable the port forward error correction (FEC) mode.

> **Note**: For NRU03 and NRU-S0301 platforms, `eth-mode` should be set to `sys-default`.

2. On NRU03 and NRU03-S0301 platforms, in addition to the above configuration, use the `port-cable-type-modify` command to configure the port type as `sys-default` to ensure that the correct FEC setting is applied.

```
CLI (network-admin@switch) > port-cable-type-modify port
<port-list> type sys-default
```

`port-cable-type-modify`	Use this command to associate a cable type with port (s).
Specify between 2 and 3 of the following options:	
`port <port-list>`	Specify the list of ports you want to associate with the cable type.
`type optical|dac|sys-default`	Specify the cable type: optical or dac associated with the specified ports.
`cable-sub-type default|ca-n|ca-l|ca-s`	Specify the port cable assembly type from one of the options. Note that this optional parameter is applicable only for DAC cable types. **Note**: The cable sub type (N, L, or S) is a hardware-specific parameter based on the material used by the cable manufacturer. Hence, you must consult the vendor specification to identify the cable assembly type before configuring this parameter.

You can verify the configurations by using the `port-fec-status-show` command.

Note: All lengths of Ericsson RPM 777 053/xx and 777 054/xx cables are of assembly type CA-L.

Note: All four lanes of QSFP port share the same type or sub-type.

When configuring the cable type, please follow the guidelines below for both 25 GbE and 100 GbE ports:

- The `cable-sub-type` option is not valid for optical cables.
- The `cable-sub-type` option is not required for DAC cables operating at 100Gbps (non-flexed) as assembly type does not factor into the FEC variant per IEEE 802.3 2018.
- The `type` keyword is also used by Netvisor ONE to determine the pre-emphasis setting used for this port. This capability was introduced in Netvisor ONE release 5.1.3.

Note: The `type` and `cable-sub-type` parameters are not required to be configured for NRU02.

Usage Guidelines

- For NRU03 and NRU-S0301 platforms, the port cable type must be configured as `sys-default`.
- For DAC cables, physical port auto-negotiation should be configured for the peer links to come up.
- For optical cables, you can enable or disable FEC explicitly on both peers. Auto-negotiation should not be enabled.
- For DAC cables, the cable sub-type can be CA-S, CA-L, CA-N which is independent of the cable length. For example, you can have a 3 meter type S, 3 meter type N, or 3 meter type L cable.
- For optical cables, the `cable-sub-type` configuration is not allowed.
- For DAC cables, the `eth-mode` should be set to CR (25G) or CR4 (100G).
- The `eth-mode` should be configured by using the `port-config-modify` command to ensure the proper setting of the physical layer and also to address any link failure issues.

4. To clarify the FEC configuration further, an example configuration is provided below:

- Configure FEC on a 25 GbE port on a DAC cable connected on port 21 by using the commands:

```
CLI (network-admin@switch) > port-cable-type-modify port 21
type dac cable-sub-type ca-l

CLI (network-admin@switch) > port-config-modify port 21 eth-
mode cr autoneg fec enable
```

- Configure FEC on a 25 GbE port (port 17) using a multi-mode optical cable by using the command:

```
CLI (network-admin@switch) > port-cable-type-modify port 17
type optical

CLI (network-admin@switch) > port-config-modify port 17 eth-
mode sr no-autoneg fec enable
```

- Verify port status after FEC configuration:

```
CLI (network-admin@switch) > port-show port 1 layout vertical
switch:             switch
port:               1
bezel-port:         1
status:              up,host,LLDP,trunk,vlan-up
config:             fd,25g,fec
```

> **Note**: It is not mandatory to configure the `no-autoneg` parameter for optical cables, but is specified here to ensure that the port is operating without *auto-negotiation*.

- View the configured cable type and assembly type configuration by using the `port-cable-type-show` command on NRU03 or NRU-S0301:

```
CLI (network-admin@switch) > port-cable-type-show
switch port  type        cable-sub-type
------ ----  ----------- -------------
switch none  dac         ca-s
switch none  dac         ca-l
switch none  dac         ca-n
switch none  dac         default
switch none  optical     default
switch 1-125 sys-default default
```

- Configure FEC on a 100G port on NRU02 by using the command:

```
CLI (network-admin@switch) > port-config-modify port 25 fec
enable
```

Note: For NRU02 platforms, the `port-cable-type` and `eth-mode` configuration is not required.

```
CLI (network-admin@switch) > port-show port 25 layout vertical
switch:             switch
port:               25
bezel-port:         7
ip:                 192.170.20.110
mac:                 66:0e:94:f6:37:f2
hostname:            nru02-alpha2
status:               up,PN-switch,PN-other,STP-BPDUs,LLDP,vlan-up
config:              fd,100g,fec
```

To view the details of the configuration use the `port-fec-stats-show` command. For example,

```
CLI  (network-admin@switch)  >  port-fec-stats-show

switch   time     port BaseR-Fec-Corr BaseR-Fec-UnCorr Rs-Fec-Corr Rs-Fec-UnCorr
-------- -------- ---- -------------- ---------------- ----------- -------------
switch   12:34:00 5    0              0                0           0
switch   12:34:00 7    0              0                0           0
switch   12:34:00 8    0              0                0           0
switch   12:34:00 9    0              0                0           0
switch   12:34:00 10   0              0                0           0
switch   12:34:00 17   0              0                0           0
```

Caution: If you enable FEC between Cisco Nexus switches and the Pluribus switches AS7816-64X, F9664-C, or Z9264, the link may not come up. This is not an issue of Netvisor ONE or Pluribus switches.

Configuring Static Pre-Emphasis (Signal Integrity) Port Settings

The SerDes (serializer/deserializer) component in switch ports has several associated Signal Integrity (SI) parameters that help in shaping the output into a clean and well-defined signal based on the transmission line characteristics of the signal traces. This output shaping is used to cancel-out factors such as reflection and signal attenuation and enables the receiver to get a clean and well-defined signal. Collectively, these signal integrity parameters are also known as pre-emphasis settings.

If the pre-emphasis settings are incorrect, you may encounter unacceptable bit error rate (BER), especially when the port speed scales to higher values. The pre-emphasis settings vary per port based on the circuit board layout, the operational speed of the port, and the transmission medium (cable type and length).

> **Note**: Refer to the cable manufacturer documentation where the required pre-emphasis values are defined.

This feature is not available on the following platforms:

• F9372-X (AS5812-54X)	• F9372-T (AS5812-54T)	• F9532L-C (AS7712-32X)
• F9572L-V (AS7312-54XS)		

In earlier releases, Netvisor ONE had limitations to dynamically change the pre-emphasis settings based on the configured port number and port speed. However, from Netvisor ONE version 6.0.0 onward, you can override the default settings for a specified set of ports by using the `port-cable-type-modify port <port-list> type [optical|dac]` command. For the `cable-type` parameter, select either ***`dac`*** cable setting (for copper DAC cable, which is the default setting) or *`optical`* cable setting (for optical transceivers).

The port cable type database saves the details of the cable type you had configured by using the above CLI. However, if the cable type is not specified, then a default DAC cable length value of 3m is assumed for the port. These settings are then saved to the hardware database (registers).

When you modify the port speed or the cable type, the signal integrity or pre-emphasis settings are written to the hardware. If the port is already enabled, then the port gets disabled and then re-enabled while the settings are being written to the hardware. You are prompted to proceed with the changes prior to the port being disabled and re-enabled. Additionally note that, when a port that you want to modify is part of a port group, then all the ports in that port group are modified with the new signal integrity settings.

The *DAC* settings in Netvisor ONE is mapped to the 3m DAC settings, which is the current default on all Pluribus supported switches, except Z9100-ON.

Note - Guidelines for Z9100-ON platforms:

- During a fresh installation of Netvisor ONE 6.0.0, by default, all the ports are automatically set to *optical* cable type.
- While modifying the cable type, out of all the SFP ports, you cannot modify ports 129 and 130 (bezel ports 33 and 34) to `dac` cable type due to a hardware limitation on the Z9100-ON platform.

To change the cable type, and consequently, the pre-emphasis (Signal Integrity) settings for a specified port on any platform, use the command:

```
CLI (network-admin@switch) > port-cable-type-modify port
<port-list> type optical|dac
```

`port-cable-type-modify`	Use this command to associate a cable type with port (s)
`port <port-list>`	Specify the list of ports you want to associate with the cable type.
`type optical|dac|sys-default`	Select the cable type: `optical` or `dac` be to associated with the specified ports.
`cable-sub-type default|ca-n|ca-l|ca-s`	Specify the port cable sub-type. The `cable-sub-type` parameter is applicable only for NRU03 and NRU-S03 platforms with 25G FEC support. Ignore the `cable-sub-type` parameter for all other platforms.

To view the currently applied cable type settings for all ports, use the command:

```
CLI (network-admin@switch) > port-cable-type-show
```

Example: Pre-Emphasis Settings Configuration

Let us consider an example to further explain the changes implemented by this feature.

First verify the current port and cable type settings on a switch by using the `port-cable-type-show` command. From Netvisor ONE version 6.0.0, only *optical* and *dac* cable types are supported.

```
CLI (network-admin@switch*) > port-cable-type-show
port type        cable-sub-type
---- ----------- --------------
none dac         ca-s
none dac         ca-l
none dac         ca-n
```

```
none dac          default
none optical      default
1-24 sys-default  default
```

The `default` string in the `cable-sub-type` column is used to display which settings have not been changed by the user.

Now, modify the settings for port 1 by using the below command below (See the warning message regarding the application of the settings to all member ports in the port group) and confirm to proceed:

```
CLI (network-admin@switch*) > port-cable-type-modify port 1-4
type optical
Warning: updating SI settings will apply to all ports in a
port group and will flap enabled ports
Please confirm y/n (Default: n):y
Updated SI settings for port(s) 1-4 to optical
```

The system log file and nvOSd log file are automatically updated to reflect the Signal Integrity (SI) setting changes.

View the updated settings by using the command:

```
CLI (network-admin@switch*) > port-cable-type-show
port type         cable-sub-type
---- ----------- --------------
none dac          ca-s
none dac          ca-l
none dac          ca-n
none dac          default
1-4  optical      default
5-24 sys-default default
```

To reset all the ports to `dac` cable type, use this command with the `port all` parameter:

```
CLI (network-admin@switch*) > port-cable-type-modify port all
type dac

Warning: updating SI settings will apply to all ports in a
port group and will flap enabled ports
Please confirm y/n (Default: n):y
Updated SI settings for port(s) 1-24 to dac
```

View the changed settings again by using the command:

```
CLI (network-admin@switch*) > port-cable-type-show
port type         cable-sub-type
---- ----------- --------------
none dac          ca-s
none dac          ca-l
none dac          ca-n
1-24 dac          default
```

```
none optical     default
none sys-default default
```

Note: For platforms with copper RJ-45 ports such as S4148T-ON, an *invalid* message is displayed while modifying the port cable type to `optical` cable type for the copper ports. For example,

```
CLI (network-admin@S4148T) > port-cable-type-modify port all
type optical

Warning: updating SI settings will apply to all ports in a
port group and will flap enabled ports
Please confirm y/n (Default: n):y
SI settings invalid for port(s) 1-48 for optical
Updated SI settings for port(s) 49-56,65-72 to optical
```

View the details using the show command:

```
CLI (network-admin@S4148T) > port-cable-type-show port all

switch port   type          cable-sub-type
------ ------ -------       --------------
S4148T none   dac          ca-s
S4148T none   dac          ca-l
S4148T none   dac          ca-n
S4148T 1-48   dac           default
S4148T 49-72  optical       default
S4148T none    sys-default default
```

Note: This feature's settings are applied when you modify either the port speed or the cable type for a specified port. That is, the pre-emphasis (SI) settings in Netvisor ONE are applied during the initial port configuration when the port speed is modified by using the `port-config-modify` command, and also when the cable type is modified using the `port-cable-type-modify` command.

Caution: This feature enables you to modify the pre-emphasis settings by modifying the *cable-type* and *port speed*. However, the link quality could be impacted if incorrect settings are chosen and caution must be taken to ensure correct settings are configured.

Guidelines and Limitations

The following guidelines and limitations should be considered while configuring the pre-emphasis settings on a switch port:

- The pre-emphasis settings are written to hardware whenever you change the cable type using the `port-cable-type-modify` command.
- The pre-emphasis settings are written to hardware whenever you change the port

speed using the `port-config-modify` command.

- For Z9100-ON platforms with copper SFP ports, the cable type, `dac` is not accepted by Netvisor ONE. If you try to change the cable type for a single SFP copper port by using the `port-cable-type-modify` command, then an error is displayed as follows:

```
CLI (network-admin@switch) > port-cable-type-modify port 129
type dac
Warning: updating SI settings will apply to all ports in a
port group and will flap enabled ports
Please confirm y/n (Default: n):y
port-cable-type-modify: Invalid cable type setting
```

- However, if both `port all` and `type optical` parameters are used on a switch with copper ports, then the settings are selectively applied only to the optical ports, and no error is displayed.
- For those platforms that have hidden ports, such as S4148T-ON with 48 x 10GBaseT and 4 x 100 GbE ports, the cable type changes are skipped when `port all` parameter is specified in the `port-cable-type-modify` command.
- For platforms on which no pre-emphasis settings are configured on the ports, a minimum port speed of 10 Gbps is assumed.
- While this feature allows you to select the pre-emphasis settings, the link quality may get impacted if incorrect settings are applied. Ensure to apply the correct pre-emphasis settings during initial configuration.
- Currently the 3m DAC setting is implemented for all DAC cable lengths.

Related Commands

```
CLI (network-admin@nru03-switch) > port-config-modify
```

`port-config-modify`	Use this command to modify a port configuration.
`port` *`port-list`*	Specify the port or list of ports that you want to modify.
`speed disable|10g|25g|40g|100g`	Specify the physical port speed.

Configuring Link Scan Mode

The link scan feature in Netvisor ONE detects physical link state changes. Netvisor ONE version 6.0.0 (and later) supports interrupt-based link state change detection, in addition to the software-based link scan mode available in the previous versions. The software-based link scan mode performs state polling to detect changes at regular configurable intervals. When the link scan mode is set to `hardware`, on the other hand, the software uses the interrupt infrastructure to provide an improved detection mechanism for link state changes.

You can configure the link scan mode and interval by using the `system-settings-modify` command:

`system-settings-modify`	Use this command to modify system settings.
`linkscan-interval` *`10000..1000000`*	Specify the linkscan interval as a value between 10000 µs and 1000000 µs. The default value is 150000 µs. **Note:** This parameter is not applicable when the link scan mode is hardware.
`linkscan-mode software|hardware`	Specify the linkscan mode as hardware or software. Software linkscan mode is enabled by default. **Note:** Pluribus recommends software linkscan mode.

For example, to enable interrupt-based link state change detection, use the command:

```
CLI (network-admin@switch) > system-settings-modify linkscan-mode hardware
```

To view the current configuration, use the command:

```
CLI (network-admin@switch) > system-settings-show format linkscan-mode
linkscan-mode:  hardware
```

To modify the link scan interval used in software-based mode to 100,000 µs, enter the command:

```
CLI (network-admin@switch) > system-settings-modify linkscan-interval 100000
```

To view the details, enter the command:

```
CLI (network-admin@switch) > system-settings-show
switch:                         Leaf1
optimize-arps:                  off
```

```
lldp:                              on
policy-based-routing:              off
optimize-nd:                       off
reactivate-mac:                    on
reactivate-vxlan-tunnel-mac:       on
manage-unknown-unicast:            off
manage-broadcast:                  off
auto-trunk:                        on
auto-host-bundle:                  off
cluster-active-active-routing:     on
fast-route-download:               off
fast-interface-lookup:             on
routing-over-vlags:                off
source-mac-miss:                   copy-to-cpu
igmp-snoop:                        use-l3
vle-tracking-timeout:              3
pfc-buffer-limit:                  40%
cosq-weight-auto:                  off
port-cos-drop-stats-interval(s):   disable
lossless-mode:                     off
snoop-query-stagger:               no-stagger-queries
host-refresh:                      off
proxy-conn-retry:                  on
proxy-conn-max-retry:              3
proxy-conn-retry-interval:         500
manage-l2-uuc-drop:                on
xcvr-link-debug:                   disable
fastpath-bfd:                      off
linkscan-interval:                 100000
linkscan-mode:                     hardware
single-pass-flood:                 off
```

Note: To avoid flaps, the link scan mode must match on both the switch ports connected by a link.

Configuring Maintenance Mode

Netvisor ONE version 6.1.0 introduces the Maintenance Mode feature in which the software prevents user traffic from entering or leaving a switch and gracefully steers the traffic to network peers. This mode is useful during hardware or software maintenance of the switch including Return Merchandise Authorization (RMA), correction of out of sync fabric transactions, cluster re-peer, switch power down or reboot, and software upgrade. This functionality is supported on cluster nodes, non-cluster spine nodes, and standalone switches. In a use case where you need to enable maintenance mode on a standalone switch, you must ensure that an alternate path exists if the switch goes down.

> **Note:** You can enable maintenance mode only when `control-network` and `fabric-network` are configured as `mgmt`. You cannot change the fabric and control networks or the fabric VLAN while in maintenance mode.

A switch does not leave the fabric while entering maintenance mode. When you issue the command to enable maintenance mode, Netvisor ONE follows the normal port bring down sequence and disables all the user ports. Any cluster bring down configuration is also applicable. The sequence of actions performed by the software while entering maintenance mode (for a cluster switch) is as follows:

- Bring down orphan ports
- Bring down vLAG ports
- Disable VRRP service and BGP graceful shutdown
- Bring down Layer 3 ports
- Bring down ports with `defer-bringdown` configured
- Bring down cluster ports

While in maintenance mode, you can execute all CLI or REST API commands except port enable commands. The software defers all port enable actions and enables the ports only after exiting maintenance mode. If you reboot or power cycle the switch while in maintenance mode, the switch comes back up and stays in maintenance mode and does not enable any user ports.

A switch (cluster member) follows the below sequence of actions while leaving maintenance mode:

- Bring up cluster ports
- Enable VRRP and BGP services
- Bring up Layer 3 ports
- Bring up vLAG ports
- Bring up orphan ports or ports with `defer-bringup` configured

The switch assumes data forwarding responsibilities upon leaving maintenance mode. All pre-configured settings for cluster bring up are applicable during the exit and therefore, Netvisor ONE enforces staggered or delayed port bring based on the existing configuration. For more information, see the '*Restoring Ports for Cluster Configurations*' section of the '*Configuring High Availability*' chapter.

Use the command `system-state-modify` to enable or disable maintenance mode. For example, to enter maintenance mode, use the command:

```
CLI (network-admin@Leaf1) > system-state-modify maintenance-
enable
Warning: This configuration can have traffic impact. If
required, collect system snapshot via save-diags prior to this
command
Please confirm y/n (Default: n):y
CLI (network-admin@Leaf1) >
```

> **Note:** Pluribus recommends collecting the output of the `save-diags` command before entering maintenance mode. This helps in recording the state of the switch.

To view the status of maintenance mode, use the command:

```
CLI (network-admin@Leaf1) > system-state-show
system-state:      Maintenance mode, Ports disabled
```

To leave maintenance mode, use the command:

```
CLI (network-admin@Leaf1) > system-state-modify maintenance-
disable
```

> **Note:** You must ensure that transactions (fabric and cluster TIDs) are in sync with the rest of the fabric before executing the command to disable maintenance mode.

Use the `system-state-show` command to view the status:

```
CLI (network-admin@Leaf1) > system-state-show
system-state:      Operational, Ports enabled
```

The `system-state-show` command also displays the current state of port bring up or port bring down:

```
CLI (network-admin@Leaf1) > system-state-show
system-state:     coming up, l3 to vlag wait
system-state:     coming up, vlag ports being enabled
system-state:     coming up, defer bringup ports wait
```

When a switch enters or leaves maintenance mode, an event log messages is logged, as seen from the `log-event-show` output:

```
CLI (network-admin@Leaf1) > log-event-show
event maintenance_enabled(11529) : level=note event-type=system :  : System is in
Maintenance mode
event maintenance_disabled(11530) : level=note event-type=system :  : System is in
Operational mode
```

You can enforce maintenance mode on a switch as soon as the cluster re-peer process is complete by using the sample command:

```
CLI (network-admin@Leaf1) > fabric-join repeer-to-cluster-node
Leaf1 maintenance-enable
```

This operation is useful when replacing a cluster node and if you want to be in maintenance mode after the re-peer process.

Infrastructure Support for Transceiver Online Insertion and Removal (OIR)

> **Note**: The transceiver OIR infrastructure support is available only on NRU03 and NRU-S0301 platforms and is introduced in Netvisor ONE 6.0.1 release.

The transceiver OIR infrastructure supports the following three operations:

- Detecting the insertion or removal of optical devices and cables into or from the front-panel ports, thereby allowing subsequent actions to take place.
- Initializing the optical devices and cables at system start-up, and also as they are inserted into the chassis during run-time.
- Configuring key parameters into the Broadcom hardware based on the required settings for the optical devices and cables as they are detected.

The support for transceiver OIR infrastructure enhances Netvisor ONE to process the transceiver OIR events and apply appropriate configuration and startup sequencing based on the type of module inserted or removed. This infrastructure implementation improves the hardware monitor service to detect OIR events and notify Netvisor ONE.

Prior to version 6.0.1, Netvisor supported initialization of optical devices on NRU03 and NRU-S0301 switches only at power-on. Starting with Netvisor ONE version 6.0.1, with the Transceiver OIR infrastructure support, you can also facilitate run-time initialization of optical devices (hot-swappable) while the switch is powered-on. This provides scalable infrastructure for device-specific initialization requirements upon OIR of the transceiver on NRU03 and NRU-S0301 platforms.

That is, you can remove, insert, swap, or replace the transceivers when the system is functioning. Each transceiver has unique characteristics, parameters, timing requirement, initialization sequence, and configuration impact to the switch port and Netvisor ONE adheres to these characteristics for the transceiver to operate correctly.

With transceiver OIR infrastructure implemented in NRU03 and NRU-S0301 platforms, Netvisor ONE automatically detects the type of device installed in the physical port and the OIR determines the port settings if the `eth-mode` or pre-emphasis (`port-cable-type`) settings are not configured already.

An important distinction between 6.0.1 and later releases as compared to earlier releases for platforms which support Transceiver OIR is the use of the sys-default configuration option, as explained in the table:

Behavior in Release Version	Eth-mode set to sys-default	Cable-type set to sys-default
6.0.0 behavior	Eth-mode setting is determined by port speed; all ports of that speed will have same eth-mode setting.	Cable-type set to platform default (3m DAC) for all ports, regardless of which cable is plugged in.
6.0.1 behavior (for OIR platforms)	Eth-mode setting is applied per physical port based on the device type that is plugged in.	Cable-type setting is applied per physical port based on the device type that is plugged in.

For example, in Netvisor 6.0.0, a 100G DAC cable and 100G SR4 optic have the same eth-mode configuration if both ports are configured for `sys-default`. However in Netvisor 6.0.1 (for OIR platforms), these ports have `eth-mode` configured as CR4 and SR4, respectively.

If you are upgrading Netvisor ONE from a previous release to version 6.0.1, then the original settings are retained unless you revert to the system default settings by using the `port-config-modify port <port-num> eth-mode sys-default` command or the `port-cable-type-modify port <port-list> type sys-default` command upon upgrade. The `sys-default` parameter ensures that the transceiver OIR settings are reverted to the pre-upgrade settings after an upgrade to Netvsior ONE version 6.0.1.

For example, after upgrading to Netvisor ONE version 6.0.1, use the command:

```
CLI (network-admin@nru03-switch) > port-cable-type-modify port
all type sys-default
Warning: updating SI settings will apply to all ports in a
port group and will flap enabled ports
Please confirm y/n (Default: n):y
Updated SI settings for port(s) 1-125 to sys-default

CLI (network-admin@nru03-switch) > port-cable-type-show

switch        port   type          cable-sub-type
----------- -----  -----------  --------------
nru03-switch none   dac           ca-s
nru03-switch none   dac           ca-l
nru03-switch none   dac           ca-n
nru03-switch none   dac           default
nru03-switch none   optical       default
nru03-switch 1-125 sys-default default
```

The auto negotiation and the FEC are user configurable features, that is, you can enable or disable these features; Tranceiver OIR will not override those settings.

Note: When you upgrade from an earlier release to Netvisor ONE version 6.0.1, all existing user configuration is preserved.

Usage Guidelines

- At system startup with a fully-populated switch, an initial insertion event is generated for each transceiver, but this has a minimal impact on Netvisor startup time.
- The `eth-mode`, *ER4* is not supported by Broadcom SDK. Per Broadcom recommendation, the OIR infrastructure programs the hardware as *SR4* when *ER4* device is detected.
- For RDH 72/16 (PSM4) the recommended system default eth-mode is *CAUI4* at 100G speed and *LR4* for 4x25G speed as determined by the OIR.
- With transceiver OIR infrastructure, it is no longer required to run the recover port-lpmode-lr4-recover ports <port-list> command after the OIR of a *Sumitomo LR4* transceiver.
- The transceiver OIR implementation in Netvisor ONE version 6.0.1 has minimal error handling capabilities. Failures in the execution of OIR state machine events may cause port to enter into error state. If you encounter an error, you must remove and re-insert the transceiver to recover.

  Note: If for any reason you are unable to recover the transceiver, you must contact Pluribus TAC for support.

- The transceiver OIR infrastructure introduces a new SNMP event when entering and exiting the error state. You can enable the SNMP event by using the `snmp-trap-enable-modify port-oir-error-state|no-port-oir-error-state` command. Below is a sample SNMP event generated during an enter/exit error state as a reference:

```
2020-09-23 21:40:39 localhost [UDP: [127.0.0.1]:37190-
>[127.0.0.1]:162]:
DISMAN-EVENT-MIB::sysUpTimeInstance = Timeticks: (17946935) 2
days, 1:51:09.35
SNMPv2-MIB::snmpTrapOID.0 = OID: PN-LOG-
MIB::pnLogMatchNotification
PN-LOG-MIB::pnLogMatchName.0 = STRING: PortOIRErr PN-LOG-
MIB::pnLogFileName.0 = STRING: /nvOS/log/event.log PN-LOG-
MIB::pnLogMatchCount.0 = Gauge32: 3
PN-LOG-MIB::pnLogMatchData.0 = STRING: 2020-09-
23,21:40:01.352234-07:00
nru02-alpha2 nvOSd(3830) event port_oir_error_enter(11527) :
level=warn
event-type=port : port=1 : Port=1 enter xcvr oir error state

2020-09-23 21:41:39 localhost [UDP: [127.0.0.1]:37190-
>[127.0.0.1]:162]:
DISMAN-EVENT-MIB::sysUpTimeInstance = Timeticks: (17952935) 2
days, 1:52:09.35
SNMPv2-MIB::snmpTrapOID.0 = OID: PN-LOG-
MIB::pnLogMatchNotification
PN-LOG-MIB::pnLogMatchName.0 = STRING: PortOIRErr PN-LOG-
MIB::pnLogFileName.0 = STRING: /nvOS/log/event.log PN-LOG-
MIB::pnLogMatchCount.0 = Gauge32: 4
```

```
PN-LOG-MIB::pnLogMatchData.0 = STRING: 2020-09-
23,21:40:46.408637-07:00
nru02-alpha2 nvOSd(3830) event port_oir_error_exit(11528) :
level=warn
event-type=port : port=1 : Port=1 exit xcvr oir error state
```

- Because OIR is detected using a polling loop, there is a short delay of 1-2 seconds between when a transceiver is inserted or removed and when the OIR event is generated. Due to this polling loop delay, it is possible to miss an event if a transceiver is inserted and removed rapidly.

  Note: However, you must restrain from removing and inserting a transceiver rapidly because that could cause the port to enter error state in the OIR state machine, especially if a different type of transceiver is inserted.
- Transceiver OIR leverages the device characteristic information maintained in the device EEPROM. The infrastructure has been tested with all devices on the approved device list for NRU03 and NRU-S0301.

  Note: The vendors that do not comply with MSA standard may not operate properly when used with OIR. Use only the devices approved by Ericsson for use with NRU03 and NRU-S0301.

- With OIR infrastructure:
  - The pre-emphasis and the `eth-mode` settings are set in accordance with the device type
  - The DAC pre-emphasis setting is set in accordance with the DAC cable length

  Note: The vendor-provided pre-emphasis settings or all lengths of DAC cables are identical for NRU03 and NRU-S0301 switches.

CLI Settings

Use the `system-settings-show` command to view the details to confirm if OIR is supported on the platform in use:

```
CLI (network-admin@nru03-switch) > system-settings-show
switch:                                 nru03-switch
optimize-arps:                          off
lldp:                                   on
policy-based-routing:                   off
optimize-nd:                            off
reactivate-mac:                         on
reactivate-vxlan-tunnel-mac:            on
block-loops:                            on
auto-trunk:                             on
auto-host-bundle:                       off
cluster-active-active-routing:          on
fast-route-download:                    off
fast-interface-lookup:                  on
routing-over-vlags:                     off
source-mac-miss:                        copy-to-cpu
igmp-snoop:                             use-l3
vle-tracking-timeout:                   3
pfc-buffer-limit:                       40%
cosq-weight-auto:                       off
port-cos-drop-stats-interval(s):        disable
lossless-mode:                          off
snoop-query-stagger:                    no-stagger-queries
proxy-conn-retry:                       on
proxy-conn-max-retry:                   3
proxy-conn-retry-interval:              500
manage-l2-uuc-drop:                     on
xcvr-link-debug:                        disable
fastpath-bfd:                           off
linkscan-interval:                      150000
linkscan-mode:                          software
single-pass-l2-known-multicast:         off
single-pass-flood:                      off
single-pass-riot:                       off
xcvr-oir-debug-port:                    17,25
cos-8-and-9-queue:                      off
batch-move-mac-hw-group-for-vlan-only:  off
```

Note: You should never modify the OIR settings.

Enabling Jumbo Frame Support

Jumbo frames are (oversized) Ethernet frames with a size greater than 1518 bytes (including the Ethernet header and FCS) or 1522 bytes (when a VLAN tag is present).

Different vendors may support different maximum frame sizes for jumbos, as the IEEE standard does not cover jumbo frames (except for baby giants). Typically jumbo frames are described with the maximum payload length they support, namely, the Maximum Transmission Unit (MTU). It is common for platforms (including servers) to support jumbo frames with (at least) an MTU of 9K bytes. 1 K usually corresponds to 1000 (but may also equate to 1024 on some platforms), so that means that the MTU is 9000 (or 9216) bytes.

When you enable the jumbo frame feature on a port on Pluribus switches, the port can accept and forward jumbo frames. This feature is meant to optimize server-to-server performance (by minimizing the CPU processing overhead for large block transfers).

By default, jumbo frames are disabled on Netvisor ONE and so the default Ethernet MTU for all switch ports is 1500 bytes. When you enable the jumbo frame feature on a port, the MTU size is increased to accept 9K byte frames on that port.

The larger MTU supported on Pluribus switches helps on transport links to be able to deal with the transport overhead (for example, with the VXLAN and vLE functionalities described in the *Configuring VXLAN* and *Configuring Advanced Layer 2 Transport Services* sections).

To enable jumbo frame support, add the `jumbo` parameter to the `port-config-modify` command:

```
CLI (network-admin@switch) > port-config-modify port 1 jumbo
```

To enable jumbo frame support on trunk ports, add the jumbo parameter to the `trunk-modify` or `trunk-create` commands:

```
CLI (network-admin@switch) > trunk-modify name trunk1 jumbo
```

Configuring Layer 2 Features

This chapter provides information about the protocols and configurations supported on Layer 2 network by using the Netvisor ONE command line interface (CLI) on a Netvisor ONE switch.

Understanding the Supported Layer 2 Protocols in Netvisor ONE

Layer 2 (the Data Link layer) enables the transfer of data between adjacent nodes in a network segment, such as local or wide area networks. Layer 2 frames do not cross the boundaries of the local network. Services provided by Layer 2 include, but are not limited to: frame encapsulation, device addressing, error detection, packet forwarding, loop prevention, flow control, frame queuing, Quality of Service (QoS), and traffic segmentation through Virtual LANs (VLANs).

Netvisor ONE supports the following Layer 2 protocols and functionalities:

- Spanning Tree Protocol (STP)
- Rapid Spanning Tree Protocol (RSTP)
- Multiple Spanning Tree Protocol (MSTP)
- Link Aggregation (LAG)
- virtual Link Aggregation (vLAG)
- Link Aggregation Control Protocol (LACP)
- Link Layer Discovery Protocol (LLDP)
- Root Guard
- Fabric Guard

Configuring LLDP

The Link Layer Discovery Protocol (LLDP) is an open, vendor-independent protocol that advertises a device's identity, abilities, and neighboring devices connected within the Local Area Network. This protocol is based on IEEE 802.1ab standard. An LLDP device sends information as Ethernet frames at regular intervals and each frame contains one LLDP Data Unit (LLDPDU) which is a sequence of different Type-Length-Value (TLV) structures. These frames start with the mandatory TLVs that include the Chassis ID, Port ID, and Time-To-Live (TTL) followed by a number of optional TLVs.

Netvisor One provides a generic LLDP ON/OFF toggle function set at the system level. LLDP is enabled on a switch by default and without the generic function, you must disable LLDP configuration on all ports to disable LLDP on a switch. This resets all related configurations of LLDP protocol settings at the port level and LLDP vFlows. Use the following CLI command to enable or disable the protocol at the system level:

```
CLI (network-admin@leaf1) > system-settings-modify [lldp|no-
lldp]
```

LLDP packets are processed on the CPU after being directed there by specific vFlow policies. To clear all LLDP protocol system redirects, use the parameter `no-lldp`. To add all LLDP protocol system redirects, use the parameter `lldp`. This approach ensures that port LLDP configurations are not disturbed.

To verify the LLDP status, use the command:

```
CLI (network-admin@leaf1) > system-settings-show
switch:                         leaf1
optimize-arps:                  off
lldp:                           off
policy-based-routing:           off
optimize-nd:                    off
reactivate-mac:                 on
```

To enable/disable LLDP on one or more ports, use the command `port-lldp-modify.`

```
CLI (network-admin@Leaf1) > port-lldp-modify
```

`port-lldp-modify`	Modify the LLDP setting on ports.
Specify the following options:	
`port` *`port-list`*	Specify the ports on which LLDP has to be enabled or disabled as a list separated by commas.
`lldp|no-lldp`	Specify the option to enable or disable LLDP.

```
CLI (network-admin@switch) > port-lldp-modify port <port-list>
[lldp|no-lldp]
```

`lldp-show` command displays the LLDP information of the neighbors in the network.

```
CLI (network-admin@Leaf1) > lldp-show
```

`lldp-show`	This command displays LLDP information.
Specify any of the following options to view the LLDP information specific to that parameter.	
`local-port` *`local-port-number`*	Specify a local port number.
`chassis-id` *`chassis-id-string`*	Specify the chassis ID of the neighboring device.
`port-id` *`port-id-string`*	Specify the port ID of the neighboring device.
`sys-name` *`sys-name-string`*	Specify the system name of the neighboring device.

For example:

```
CLI (network-admin@SW1) > lldp-show
switch        local-port chassis-id port-id port-desc           sys-name
------------- ---------- ---------- ------- ------------------- -------------
SW1           17         090009ef   17      PN Switch Port(17)  proto-1
SW1           121        090009ee   121     PN Switch Port(121) proto-2
SW2           13         090009ef   13      PN Switch Port(13)  proto-1
SW2           117        090009ee   117     PN Switch Port(117) proto-2
```

`port-lldp-show` command displays the LLDP status on a port basis.

```
CLI (network-admin@Leaf1) > port-lldp-show
```

`port-lldp-show`	Display LLDP configuration on the ports. This command when executed without any parameters displays the LLDP status (on/off) of all the ports on the switch.
Specify any of the following parameters to view the LLDP information specific to that parameter.	
`port <port-list>`	Specify the list of ports separated by commas.
`lldp|no-lldp`	Use the option `lldp` to view all the ports on which LLDP is enabled. Use the option `no-lldp` to view all the ports on which LLDP is disabled.

For example:

```
CLI (network-admin@Leaf1) > port-lldp-show port 12,13,14,15
switch        port lldp
------------- ---- ----
Leaf1         12   on
Leaf1         13   on
```

```
Leaf1          14   on
Leaf1          15   on
```

Understanding and Configuring VLANs

A Virtual Local Area Network (VLAN) enables devices to be segmented into logically separate broadcast domains within the same LAN. VLANs improve network performance by directing network traffic only to the parts of the network that need to receive it. Network segments so created keep traffic isolated based on the respective VLAN IDs associated to the transmitted frames. Applying targeted security features to specific network areas is also made simpler through the use of VLANs.

As per the standards, Netvisor ONE uses the 12-bit field in the header of each packet as a VLAN identifier or VLAN tag. The maximum number of VLANs that can be defined is 4092. VLANs 4093, 4094, and 4095 are reserved for internal use while VLAN 1 is the default fabric VLAN for untagged traffic. Untagged packets can be mapped to any VLAN, but Netvisor ONE maps this traffic to VLAN 1 by default.

Configuring an untagged VLAN is necessary while connecting a switch to devices that do not support IEEE802.1Q VLAN tags. The ports on a switch can be configured to automatically map untagged packets to a specific VLAN. Netvisor ONE also allows you to block untagged traffic on a port basis, that is, the untagged VLAN on a port can be removed or deleted.

About VLAN 1

- VLAN 1 is enabled on all ports by default. However, VLAN 1 can be removed from any port on which it is the untagged VLAN. Now, the port has no untagged VLANs and all untagged traffic is dropped on that port.
- To generalize the point above, if VLAN x is the untagged VLAN for a port and if VLAN x is removed from that port, then the port has no untagged VLAN and all untagged traffic is dropped on that port.
- VLAN 1 can also function as a tagged VLAN for a port. This happens automatically in cases where VLAN 1 is the default untagged VLAN, and then another VLAN is configured as an untagged VLAN on the port.
- VLAN 1 cannot be created or deleted. VLAN 1 configuration is stored in persistent storage.

The default fabric VLAN can be changed from VLAN 1 to another VLAN ID using the command `fabric-local-modify`. For example, to set VLAN 20 as the default fabric VLAN, use the command:

```
CLI (network-admin@Leaf1) > fabric-local-modify vlan 20
```

Warning: If you create a VLAN with scope fabric and configure it as the untagged VLAN on all ports, it can disrupt the fabric communication.

Note: The untagged VLAN feature is not the same as the default VLAN using the IEEE 802.1Q tag 1.

The `vlan-create` command creates VLANs on the current switch.

```
CLI(network-admin@Leaf1) > vlan-create
```

`vlan-create`	Creates a VLAN. You can create a VLAN either by specifying a VLAN ID or by specifying a range of VLAN IDs.
`id 2...`*`4092`*	Specify the VLAN ID between 2 and 4092. Note: VLAN 0 and 1 represents all untagged or non-VLAN traffic, VLANs 4093, 4094, and 4095 are reserved for internal use.
`range` *`vlan-list`*	Specify the range of VLAN IDs. Use this parameter if you want to specify a VLAN range instead of a VLAN ID.
`scope [local|cluster|fabric]`	Specify the VLAN scope as local, cluster, or fabric.
Specify any of the following options:	
`vnet` *`vnet-name`*	Specify the vNET name for this VLAN. Note: A vNET segregates a physical fabric into many logical networks, each with separate resources, network services, and Quality of Service (QoS) guarantees.
`vxlan 1..`*`16777215`*	Specify the VXLAN identifier for the tunnel.
`auto-vxlan|no-auto-vxlan`	Specify if you want to enable or disable `auto-vxlan`. Enabling this option automatically assigns a user-defined VLAN/VNI mapping to all VTEP connections in the fabric. If the vxlan option is not specified, the software assigns a VNI automatically.
`vxlan-mode [standard|transparent|qinq-access]`	Specify the VXLAN encapsulation mode as standard, transparent, or Q-in-Q.
`replicators [vtep-group name|none]`	Specify the replicator group. Provide a VTEP group name to add a replicator. Specify `none` to not add a replicator or remove a configured replicator.
`public-vlan 2..`*`4092`*	Specify the Public VLAN for vNET VLAN.
`description` *`description-string`*	Provide a VLAN description.
`stats|no-stats`	Use the options to enable or disable statistics collection for the VLANs being created.

`ports` *`port-list`*	Specify the ports assigned to the VLAN as list separated by commas.
`untagged-ports` *`port-list`*	Specify the untagged ports assigned to the VLAN as a list separated by commas.

Note: Netvisor ONE allows you to create a large number of VLANs by using the `vlan-create` command and the `range` keyword. However, in large network topologies with several nodes with heavy CPU traffic, the CLI may timeout if you create large number of VLANs. In such scenarios, try creating smaller number of VLANs.

By default, all ports are tagged on a newly created VLAN. However, if you want to specify select ports that should be trunked, then use the optional parameter `ports` with a comma separated list of ports, or specify a range of ports.

In some cases, you may not want a VLAN to be created on all ports. You can specify the port parameter as `none` to apply the VLAN only to the internal ports. For example:

```
CLI (network-admin@Leaf1) > vlan-create id 35 scope fabric
ports none
```

To delete an existing VLAN, use the command:

```
CLI (network-admin@Leaf1) > vlan-delete
```

`vlan-delete`	Deletes a VLAN either by ID or by a range of IDs.
`id 2...`*`4092`*	Specify the VLAN ID that you want to delete.
`range` *`vlan-list`*	Specify the range of VLAN IDs that you want to delete. Use this parameter instead of `id`, if you want to specify a VLAN range.
Specify the following option:	
`vnet` *`vnet-name`*	Specify the name of the vNET from which the VLANs are to be deleted.

Configuration of an existing VLAN can be modified using the `vlan-modify` command.

```
CLI (network-admin@Leaf1) >vlan-modify
```

`vlan-modify`	Modify a VLAN by specifying the VLAN ID.
`id 2...`*`4092`*	Specify the VLAN ID that you intend to modify.

between 1 and 4 of the following options:	
`description` *`description-string`*	Provide a VLAN description.
`vxlan 1..`*`16777215`*	Specify the VXLAN identifier for the tunnel.
`replicators [vtep-group name | none]`	Specify the replicator group. Provide a VTEP group name to add a replicator. Specify `none` to not add a replicator or remove a configured replicator.
`vnet` *`vnet name`*	Specify the vNET name for this VLAN.
`public-vlan 2..`*`4092`*	Specify the public VLAN ID for vNET VLAN. Note: Public VLAN ID can only be specified for private VLANs.

For example, to modify VLAN25 description from blue to red:

```
CLI (network-admin@Leaf1) > vlan-modify id 25 description red
```

This description can be removed from VLAN25 using the command:

```
CLI (network-admin@Leaf1) > vlan-modify id 25 description ""
```

Netvisor ONE allows the addition of ports to a VLAN through the `vlan-port-add` command.

```
CLI (network-admin@Leaf1) > vlan-port-add
```

`vlan-port-add`	Add ports to VLANs.
Specify one of the following VLAN parameters:	
`vlan-id 2..`*`4092`*	Specify the VLAN ID to which ports are to be added.
`vlan-range` *`vlan-list`*	Specify the range of VLAN IDs to which ports are to be added.
`vlan-vnet` *`vnet-name`*	Specify the vNET for the VLANs to which the ports are to be added.
Provide one of the following port arguments:	
`switch` *`switch-name`*	Specify the name of the switch on which the ports are located.
`ports` *`port-list`*	Specify the ports that need to be added to the VLANs as a list separated by

	commas.
[untagged | tagged]	Specify either of the options to configure the ports as untagged or tagged ports.

For example, to configure ports 17 and 18 to accept untagged packets and map them to VLAN 595, use the following command:

```
CLI (network-admin@Leaf1) > vlan-port-add vlan-id 595 ports
17,18 untagged
```

To map ports on different switches into the `scope fabric` VLAN, use the following command:

```
CLI (network-admin@Leaf1) > vlan-port-add vlan-id 1-4095
switch switch-name ports port-list
```

Ports can be removed from a VLAN through the `vlan-port-remove` command.

```
CLI (network-admin@Leaf1) > vlan-port-remove
```

`vlan-port-remove`	Remove ports from VLANs.
Specify one of the following VLAN sectors:	
`vlan-id 2..4092`	Specify the VLAN ID from which ports are to be removed.
`vlan-range vlan-list`	Specify the range of VLAN IDs from which ports are to be removed
`vlan-vnet vnet name`	Specify the vNET for the VLANs from which ports are to be removed.
Provide one of the following port arguments:	
`switch switch name`	Specify the name of the switch on which the ports are located.
`port port list`	Specify the ports that need to be removed from the VLANs as a list separated by commas.

The `vlan-show command` displays the VLAN information.

```
CLI (network-admin@Leaf1) > vlan-show
```

`vlan-show`	Display VLAN information.
`Specify one of the following VLAN sectors:`	

id 2..*4092*	Specify the VLAN ID for which the information has to be displayed.
range *vlan-list*	Specify the range of VLAN IDs for which the information has to be displayed.
vnet *vnet name*	Specify the vNET for which VLAN information has to be displayed.
type [public | private]	Specify either of the type options to display information for public VLANs or private VLANs.
vxlan 1..*16777215*	Specify the VXLAN identifier for the tunnel.
vxlan-mode [standard | transparent | qinq-access]	Specify any of the VXLAN modes to display information for standard, transparent, or q-in-q modes.
hw-vpn *hw-vpn-number*	Specify the hardware VPN number to display the related information.
hw-mcast-group *hw-mcast-group-number*	Specify the hardware multi-cast group number to display the related information.
replicators [vtep-group name | none]	Provide a VTEP group name to view the VLAN information for that replicator group. Specify none to view the information on VLANs that do not involve replicator groups.
repl-vtep *ip-address*	Specify the IP address of the replicator VTEP to view the related information.
public-vlan 2..*4092*	Specify the public VLAN ID for vNET VLAN to view the related information.
scope [local | cluster | fabric]	Provide any of the scope options to view the information on VLANs with that specified scope.
description *description-string*	Specify a description to view the information on VLANs with that specific description.
active [yes | no]	Specify yes to view information on active VLANs. Specify no to view information on inactive VLANs.

For example: `CLI (network-admin@Leaf1) > vlan-show layout vertical`

```
switch:              leaf1
id:                  1
```

```
type:               public
auto-vxlan:         no
replicators:        none
scope:              local
description:        default-1
active:             yes
stats:              yes
ports:              2-72
untagged-ports:     2-69
active-edge-ports:  69-70

CLI (network-admin@Leaf1) > vlan-show format all layout
vertical

switch:             leaf1
id:                 1
type:               public
auto-vxlan:         no
hw-vpn:             0
hw-mcast-group:     0
replicators:        none
repl-vtep:          ::
scope:              local
description:        default-1
active:             yes
stats:              yes
vrg:                0:0
ports:              2-72
untagged-ports:     2-69
active-edge-ports:  69
```

Network traffic statistics per VLAN can be displayed using the `vlan-stats-show` command. This command may be useful when troubleshooting network issues.

```
CLI (network-admin@Leaf1) > vlan-stats-show format all layout
vertical
switch:  Leaf2
time:  10:51:02
vlan:  1
vnet:
ibytes:  36.2T
ipkts:  89.0G
idrops-bytes:  119M
idrops-pkts:  313K
obytes:  0
opkts:  0
odrops-bytes:  0
odrops-pkts:  0
switch:  Leaf2
time:  10:51:02
vlan:  35
vnet:
ibytes:  10.8K
```

```
ipkts:  154
idrops-bytes:  0
idrops-pkts:  0
obytes:  0
opkts:  0
odrops-bytes:  0
odrops-pkts:  0
switch:  Leaf1
time:  10:51:02
vlan:               1
vnet:
ibytes:  34.9T
ipkts:  84.6G
idrops-bytes:  3.03M
idrops-pkts:  5.69K
obytes:  0
opkts:  0
odrops-bytes:  0
odrops-pkts:  0
```

The output displays the following information:

- `switch` — switch name
- `time` — when the output was generated
- `VLAN ID` — ID assigned to the VLAN
- `vnet` — the vNET assigned to the VLAN
- `incoming and outgoing bytes` — in K (Kilobytes), M (Megabytes), or G (Gigabytes)
- `incoming and outgoing packets` — number of packets incoming and outgoing
- `incoming and outgoing dropped bytes` — in K (Kilobytes), M (Megabytes), or G (Gigabytes)
- `incoming and outgoing dropped packets` — number of dropped packets incoming and outgoing

Configuring Rapid Spanning Tree Protocol (RSTP)

Rapid Spanning Tree Protocol (RSTP), a standard inter-switch protocol, ensures a loop-free forwarding network topology at Layer 2. This protocol was defined by the IEEE 802.1w standard and is an extension of the 802.1D Spanning Tree Protocol (STP). RSTP is an improvement over STP as it provides faster convergence after a network topology change or failure. RSTP introduces new port roles, and the original five port states of STP are reduced to three.

To build a loop-free topology, switches (bridges) determine the root bridge and compute the port roles. To do this, the bridges use special data frames called Bridge Protocol Data Units (BPDUs) that exchange bridge IDs and root path cost information. BPDUs are exchanged regularly, typically at two second intervals, and enable switches to keep track of network topology changes and to start and stop forwarding on ports as required. Hosts should not send BPDUs to the switch ports and to avoid malfunctioning/malicious hosts from doing so, the switch can filter or block BPDUs. If you enable BPDU filtering on a port, BPDUs received on that port are dropped but other network traffic is forwarded as usual. If you enable BPDU blocking on a port, BPDUs received on that port are dropped and the port is shut down.

Port Roles in RSTP

Root Port (one per bridge): The forwarding port on each bridge which is on the best path to reach the root bridge.
Designated Port: The forwarding port for each LAN segment that leads away from the root bridge.
Alternate Port: An alternative path to the root bridge on a particular LAN segment, which is part of a bridge other than the one that has a designed port for the LAN segment. Alternate port is the second best root port.
Backup port: A backup/redundant port for the segment that already has one designated port. This port leads away from the root port.
Disabled: A port which is manually disabled and is not a part of STP.

Port States in RSTP

Discarding: No data is exchanged over the port.
Learning: Frames are not forwarded, but the MAC address table is populated.
Forwarding: Fully functional.

Switches in RSTP expect a BPDU every 2 seconds (hello time) and if they do not receive a BPDU for 6 seconds (3 hello time intervals), it is considered to be a link failure. This is significantly faster than the STP link failure detection time of 20 seconds, dictated by the max age timer. RSTP can actively confirm if a port can safely be transitioned to the forwarding state without having to rely on the timer mechanism. Ports can be configured as edge ports if they are attached to a LAN that has no other bridges connected to it. Such a port can transition directly to the forwarding state, but it loses the edge port status as soon as it receives a BPDU. RSTP achieves rapid transition to the forwarding state on edge ports and point-to-point links (operating in full-duplex mode) but not on shared links (i.e., ports connected to a shared medium, hence operating in. half-duplex mode)

If network connections form loops and STP is disabled, packets are forwarded indefinitely across the switches, causing degradation of network performance. STP supports limited Layer 2 multipathing and can result in sub-optimal utilization of available network links. Therefore, a fabric of switches does not rely only on RSTP within the boundaries of the network. Pluribus Networks recommends the use of RSTP for ad hoc networks that inter-operate in a heterogeneous, multi-vendor switch environment.

> **Note:** RSTP is enabled on the switch by default.

Before you begin configuring RSTP, view the status of the protocol on the switch by using the command `stp-show`

```
CLI (network-admin@Leaf1) > stp-show
switch: Leaf1
enable: yes
stp-mode: rstp
bpdus-bridge-ports: yes
bridge-id: 3a:7f:b1:43:8a:0f
bridge-priority: 32768
hello-time: 2
forwarding-delay: 15
max-age: 20
cluster-mode: master
```

The `cluster-mode` of a switch in an STP cluster could be `master` or `slave`. The master in an STP cluster is elected on the basis of which node has been up longer. The other node is the slave.

To display the STP state, use the following command:

```
CLI (network-admin@Leaf1) > stp-state-show
```

`stp-state-show`	Displays the STP state information.
Specify one or more of the following options to view the information specific to those options. Specifying no parameter will display all the information.	
`vlan` *`vlan-list`*	Specify the VLANs as a list separated by commas.
`port` *`port-list`*	Specify the ports as a list separated by commas.
`instance-id` *`instance-id-number`*	Specify the STP instance ID.
`name` *`name-string`*	Specify the name of the STP instance.
`bridge-id` *`mac-address`*	Specify the bridge ID for which the information has to be displayed.
`bridge-priority` *`bridge-priority-number`*	Specify the bridge priority number.

`root-id` *`mac-address`*	Specify the root ID.
`root-priority` *`root-priority-number`*	Specify the STP root priority.
`root-port` *`root-port-number`*	Specify the STP root port.
`root-port(peer)` *`root-port(peer)-number`*	Specify the root port of the peer.
`hello-time` *`hello-time-number`*	Specify the STP hello time between 1s and 10s. The hello time is the time between each bridge protocol data unit (BPDU) that is sent on a port. The default hello time is 2s.
`forwarding-delay` *`forwarding-delay-number`*	Specify the STP forwarding delay between 4s and 30s. This is the time interval that is spent in the listening and learning states. Default forwarding delay timer is 15s.
`max-age` *`max-age-number`*	Specify the maximum age between 6s and 40s. This is the maximum length of time interval that an STP switch port saves its configuration BPDU information. The default max-age timer is 20s.
`internal|no-internal`	Specify if the STP state is internal or not.
`peer|no-peer`	Specify if the STP state is peer state or not.

```
For example: CLI (network-admin@Leaf1) > stp-state-show layout
vertical

switch:                       Leaf1
vlan:                          1
ports:                         none
instance-id:            1
name:                                   stg-default
bridge-id:                      66:0e:94:65:e1:ef
bridge-priority:     8193
root-id:                           64:0e:94:c0:06:4b
root-priority:         4097
root-port:                128
hello-time:              2
forwarding-delay:  15
max-age:                    20
disabled:                   none
learning:                   none
forwarding:                 25-28,128-129
discarding:               none
edge:                            25-28
```

```
designated:                 25-28,129
alternate:                 none
backup:                       none
```

The STP information pertaining to the ports can be displayed by using the command `stp-port-show.`

```
CLI (network-admin@Leaf1) > stp-port-show
```

`stp-port-show`	Displays the STP port information.
Specify one or more of the following options to view the information specific to those options. Specifying no parameter will display all the information.	
`port` *`port-list`*	Specify the ports as a list separated by commas.
`block|no-block`	Specify if BPDU blocking is enabled on the ports or not.
`filter|no-filter`	Specify if BPDU filtering is enabled on the port or not.
`edge|no-edge`	Specify if the ports are edge ports or non-edge ports.
`bpdu-guard|no-bpdu-guard`	Specify if BPDU guard is configured on the ports or not.
`root-guard|no-root-guard`	Specify if root guard is configured on the ports or not.
`priority` *`0..240`*	Specify the priority as a value between 0 and 240.
`cost` *`1..200000000`*	Specify the port cost as a value between 1 and 200000000.

The STP state at the port level can be viewed using the command:

```
CLI (network-admin@Leaf1) > stp-port-state-show
```

`stp-port-state-show`	Display STP information at the port level.
Specify one or more of the following options to view the information specific to those options. Specifying none will display the information for all the parameters below.	
`vlan` *`vlan-list`*	Specify the VLANs as a list separated by commas.

port *port-list*	Specify the ports as a list separated by commas.
stp-state *Disabled|Discarding|Learning|Forwarding*	Specify one among the options as the STP state.
role *Disabled|Root|Designated|Alternate|Backup*	Specify one among the options as the port role.
selected-role *Disabled|Root|Designated|Alternate|Backup*	Specify one among the options as the selected role.
state *new-info|proposing|proposed|agreed|agreed|learn|learning|forward|forwarding|reselect|selected|reroot|rcvd-bpdu|rcvd-msg|rcvd-tc|rcvd-tc-ack|send-rstp|tc-prop|tc-ack|update-info|sync|synced|disputed|fdb-flush|online|looping|manual-online|edge|vlag-local-up|vlag-remote-up|requested-online|first-sync|p-is-d|p-is-m|root-guard-active*	Specify one among the options as the port state machine state.
designated-priority *designated-priority-string*	Specify the designated priority vector.
port-priority *port-priority-string*	Specify the port priority vector.
message-priority *message-priority-string*	Specify the message priority vector.
info-is *disabled|received|mine|aged*	Specify the origin of port information.
designated-times *designated-times-string*	Specify the designated times: age, max age, hello, and forward delay
port-times *port-times-string*	Specify the port times: age, max age, hello, and forward delay
message-times *message-times-string*	Specify the message times: age, max age, hello, and forward delay
hello-timer *hello-timer-number*	Specify the STP hello time between 1s and 10s. The hello time is the time between each Bridge Protocol Data Unit (BPDU) that is sent on a port. The default hello time is 2s.
topology-timer *topology-*	Specify the topology change timer value.

timer-number	
`forward-timer` *forward-timer-number*	Specify the STP forwarding delay between 4s and 30s. This is the time interval that is spent in the listening and learning states. The default forwarding delay time is 15s.
`rcvd-info-timer` *rcvd-info-timer-number*	Specify the received info timer value.
`recent-root-timer` *recent-root-timer-number*	Specify the recent root timer value.
`recent-backup-timer` *recent-backup-timer-number*	Specify the recent backup timer value.
`edge-delay-timer` *edge-delay-timer-number*	Specify the edge delay timer value.
`migration-timer` *migration-timer-number*	Specify the migration delay timer value.
`root-guard-timer` *root-guard-timer-number*	Specify the root guard BPDU delay timer value.
`sm-table-bits` *sm-table-bits-number*	Specify the state machine table state.
`sm-table` *sm-table-string*	Specify the state machine table description.
`vlag-peer-port` *vlag-peer-port-number*	Specify the VLAG peer port if active-active.
`peer|no-peer`	Specify the STP peer state.

RSTP can be configured using the command `stp-modify.`

```
CLI (network-admin@switch1) > stp-modify
```

`stp-modify`	Modify the Spanning Tree Protocol parameters.
Specify one or more of the following options:	
`enable|disable`	Specify to enable or disable STP
`stp-mode rstp|mstp`	**Specify the STP mode as RSTP or MSTP.**
`bpdus-bridge-ports|bpdus-all-ports`	Specify to send BPDUs only on switch ports or on all ports.
`bridge-id` *mac-address*	Specify the STP bridge ID. The first part of the bridge ID is a 2-byte bridge priority field (which can be configured) while the second part is the 6-byte MAC address of the switch.

`bridge-priority` *`0..61440`*	Specify the STP bridge priority in multiples of 4096. The default value is 32768.
`hello-time` *`1..10`*	Specify the STP hello time between 1s and 10s. The hello time is the time between each BPDU that is sent on a port. The default value is 2s.
`forwarding-delay` *`4..30`*	Specify the STP forwarding delay between 4s and 30s. The forwarding delay is the time that is spent in the listening and learning states. The default forwarding delay is 15s.
`max-age` *`6..40`*	Specify the max age time between 6s and 40s. The max age timer defines the maximum time for which a switchport stores config BPDU information. The default value is 20s. If a config BPDU does not arrive at a port for 20s (default), the switch detects a link failure and takes action to restore connectivity through the backup links.
`mst-max-hops` *`1..32`*	Specify the maximum hop count for MSTP BPDU. The default value is 20.
`mst-config-name` *`mst-config-name-string`*	Specify the name for MST configuration instance.
`mst-config-revision` *`mst-config-revision-number`*	Specify the MST configuration revision number. Enter a value between 0 and 65535.
`root-guard-wait-time` *`0..300`*	Specify the root guard wait time between 0s and 300s. The default value is 20. Specify the value as 0 to disable wait.

Note: Hello time, forwarding delay, and max age timers are not used by RSTP but are relevant to STP.

Netvisor ONE optimizes RSTP by not sending BPDUs on any ports except on inter-switch link-ports by default. However, if you do not configure Link Layer Discovery Protocol (LLDP), Netvisor does not detect host ports (i.e., ports directly connected to end devices) or send BPDU packets. As a result, both ports are in Forwarding state.

When you add the parameter `bpdus-all-ports` to the `stp-modify` command, it allows sending BPDUs on all ports even if hosts are not detected, unless the port is configured as an edge port. On a switch with a port connected to itself with this configuration, one of the ports goes into discarding state.

For example, to send BPDUs only on switch ports, use the command:

```
CLI (network-admin@switch1) > stp-modify bpdus-bridge-ports
```

To send BPDUs on all ports, use the command:

```
CLI (network-admin@switch1) > stp-modify bpdus-all-ports
```

STP ports can be configured using the command:

```
CLI (network-admin@Leaf1) > stp-port-modify
```

`stp-port-modify`	Displays the STP port information.
`port` *`port-list`*	Specify the ports as a list separated by commas.
Specify one or more of the following options:	
`block|no-block`	Specify if BPDU blocking is to be enabled on the ports or not.
`filter|no-filter`	Specify if BPDU filtering is to be enabled on the port or not.
`edge|no-edge`	Specify if the ports are to be configured as edge ports or non-edge ports.
`bpdu-guard|no-bpdu-guard`	Specify if BPDU guard is to be configured on the ports or not.
`root-guard|no-root-guard`	Specify if root guard is to be configured on the ports or not.
`priority` *`0..240`*	Specify the priority as a value between 0 and 240.
`cost` *`1..200000000`*	Specify the port cost as a value between 1 and 200000000.

For example: To filter BPDUs on port 17, use the following command:

```
CLI (network-admin@Leaf1) > stp-port-modify port 17 filter
```

To block BPDUs on port 17 and shut down the port if BPDUs are received on the port, use the following command:

```
CLI (network-admin@Leaf1) > stp-port-modify port 17 block
```

To stop blocking BPDUs on port 17, use the following command:

```
CLI (network-admin@Leaf1) > stp-port-modify port 17 no-block
```

Edge ports are the ports on a switch that connect to workstations or computers. An edge port does not take part in spanning tree calculations and therefore, port flapping on edge ports does cause topology changes. BPDUs are not sent on edge ports and they can quickly transition from disabled mode to forwarding mode.

To configure a port as an edge port, use the command:

```
CLI (network-admin@Leaf1) > stp-port-modify port 17 edge
```

Note: You can disable STP on a port or a group of ports. If the devices connected to the switch ports are hosts and not downstream switches, or you know that a loop is not possible, disable STP to enable the port much faster when the switch restarts.

To view STP events on a switch, the command `stp-port-event-show` command is used. This command displays the port states as specified by the timing parameters.

```
CLI (network-admin@Leaf1) > stp-port-event-show
```

`stp-port-event-show`	Displays information about STP port events.
`port` *`port-list`*	Specify the ports as a list separated by commas.
Specify one or more of the following options:	
`time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the time to start statistics collections.
`start-time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the start time of statistics collection.
`end-time` *`date/time: yyyy-mm-ddTHH:mm:ss`*	Specify the end time of statistics collection.
`duration` *`duration: #d#h#m#s`*	Specify the duration of statistics collection.
`interval` *`duration: #d#h#m#s`*	Specify the interval between statistics collection.
`older-than` *`duration: #d#h#m#s`*	Specify the time older than which the statistics has to be displayed.
`within-last` *`duration: #d#h#m#s`*	Display statistics within last specified duration.
`port` *`port-number`*	Specify the port number.
`vlan` *`vlan-list`*	Specify the list of VLANs.
`instance` *`instance-number`*	Specify the STP instance number.
`count` *`count-number`*	Specify the number of STP port events.
`initial-state Disabled|Discarding|Learning|Forwarding`	Specify the initial state as one among the options.
`other-state Disabled|Discarding|Learning|Forwarding`	Specify the other state as one among the options.
`final-state Disabled|`	Specify the final state as one among the

`Discarding|Learning|Forwarding`	options.

For example:

```
CLI (network-admin@Leaf1) > stp-port-event-show

switch        time     port vlan instance count initial-state other-state
final-state
------------- -------- ---- ---- -------- ----- ------------- -----------
-----------
Leaf1         20:36:39 121  1    0        1     Forwarding    Disabled
Disabled
Leaf1         20:38:05 17   1    0        4     Disabled      Disabled
Forwarding
Leaf1         20:40:04 17   1    0        1     Forwarding    Disabled
Disabled
```

Configuring Multiple Spanning Tree Protocol (MSTP)

Multiple Spanning Tree Protocol as defined in IEEE802.1s or IEEE802.1Q-2005 provides the ability to manage multiple VLANs using Multiple Spanning Tree Instances (MSTIs). MSTP allows the formation of MST regions that can run multiple MSTIs. MSTP regions and other STP bridges are interconnected using the Common and Internal Spanning Tree (CIST).

MSTP regions are defined to be a collection of switches that have the same VLANs configured on all of them. All switches in a region must have the same configuration name, revision level, VLANs, and VLAN to MSTI associations. Each MST region may have multiple MSTIs operating within it but an MSTI cannot span multiple regions. Each MSTI must have a regional root which it may or may not share with another MSTI.

The CIST is the default spanning tree instance in MSTP. CIST forms a larger spanning tree for the entire bridged network by combining MSTP regions and single-instance spanning trees. The CIST instance has an MSTI ID of 0 which cannot be deleted or changed. When a new port-based or tagged VLAN is created, it is associated with the CIST by default and is automatically given an MSTI ID of 0. The default VLAN on a switch is also associated with the CIST. When a VLAN is assigned to an MSTI, it partially remains a member of the CIST. This is because CIST is used by MSTP to enable communication with MSTP regions and RSTP/STP single-instances in the network. CIST also has regional roots.

The switch with the lowest CIST priority value functions as the root bridge for all the MSTP regions and STP/ RSTP single-instance spanning trees in the network.

The following commands support the configuration of MST instances on a local switch:

```
CLI (network-admin@Leaf1) > mst-config-create
```

`instance-id` *`0..64`*	Specify the ID as a number between 1 and 64 for MST configuration. MST ID 0 corresponds to the CIST instance.
`vlans` *`vlan-list`*	Specify the list of VLANs associated with the MST configuration
`bridge-priority` *`0..61440`*	Specify the bridge priority as a number between 0 and 61440 which is a multiple of 4096. For example, the values can be 0, 4096, 8192, up to 61440. The default value is 32768.

Prior to Netvisor ONE version 6.0.1, VLAN 1 could not be configured on any MST instance ID except 0. Netvisor ONE 6.0.1 release eliminates this constraint. For example:

```
CLI (network-admin@Leaf1) > mst-config-create instance-id 10
vlans 1-20
```

Use the `mst-config-show` command to view the current configuration:

```
CLI (network-admin@Leaf1) > mst-config-show

switch instance-id vlans          bridge-priority
Leaf1  0            21-4093,4095 32768
Leaf1  10           1-20         32768
Leaf1  64           4094         32768
```

In the above example, VLAN 1 is configured on instance ID 10.

You can modify the MST instance by using the command:

```
CLI (network-admin@Leaf1) > mst-config-modify
```

`instance-id` *0..64*	Specify the ID as a number between 1 and 64 for MST configuration. MST ID 0 corresponds to the CIST instance.
Specify one or more of the following options:	
`vlans` *vlan-list*	Specify the list of VLANs associated with the MST configuration.
`bridge-priority` *0..61440*	Specify the bridge priority as a number between 0 and 61440 which is a multiple of 4096. For example, the values can be 0, 4096, 8192, up to 61440. The default value is 32768.

Use the `mst-config-delete` command to delete the configuration.

```
CLI (network-admin@Leaf1) > mst-config-delete
```

`instance-id` *0..64*	Specify the MST instance ID that needs to be deleted.

Achieving a Loop-Free Layer 2 Topology

Note: This feature can be configured only in a full mesh topology.

Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP) ensure a loop-free topology in the Layer 2 as far as the networking equipment is concerned. Though RSTP prevents loops in the network caused by mis-cabled networking equipment, the protocol does not address mis-configured hosts. Netvisor ONE Loop Detection operates in conjunction with RSTP and MSTP to detect, log, and mitigate misbehaving and misconfigured hosts to prevent looping layer 2 traffic.

Netvisor ONE Control Plane — The Netvisor ONE control plane includes information about every MAC address in the Layer 2 network in a vPort database. This database is distributed throughout the fabric so that each Netvisor ONE switch has a copy of it for the entire fabric.

A MAC address is stored in a vPort, which includes the following information:

- MAC address, VLAN ID, and VXLAN ID
- Owner-port and local-port
- Migration history including owner, time, and port
- vPort state as active, static, moving, or loop-probe

Based on control plane data structures including the vPort database, Netvisor ONE decides if endpoints are to be allowed to access the network.

Detecting Loops

Netvisor ONE Loop Detection is implemented as part of Netvisor ONE source MAC address miss handling. Netvisor ONE disables hardware learning of MAC addresses, so when a packet arrives with an unknown source MAC address, the switch sends the packet to Netvisor One rather than switching the packet normally. Netvisor ONE examines the vPort table to determine if a packet with an unknown source MAC indicates a loop.

Netvisor ONE uses two criteria to detect a loop in the network:

- A MAC address associated with an in-band NIC of a node in the fabric appears as the source MAC on a packet that ingresses on a host port. Netvisor ONE detects this situation by noting the `PN-internal` status of a vPort that would otherwise migrate to a host port. Netvisor does not allow the migration to take place and starts loop mitigation.

For the purposes of Netvisor ONE Loop Detection, a host port is defined as a port not connected to another Pluribus switch, not an internal port, and does not participate in STP with Netvisor ONE which means that Netvisor One is not configured for STP or the device connected on the port is not configured for STP.

- Packets with the same source MAC address arrive on multiple host ports in the fabric at approximately the same time. In order to support VM and host migration, some rapid movement of MAC addresses through the fabric is tolerated. When the same MAC address moves rapidly back and forth between two ports, a loop is assumed and loop mitigation starts.

VRRP MAC addresses are not subject to loop detection and mitigation, and can migrate freely.

Loops are detected on a port by port basis. A single loop typically involves two ports, either on the same switch or on two different switches. When multiple loops occur with more than two ports then Netvisor ONE responds to each port separately.

Loop Mitigation

When Netvisor ONE detects a loop, a message appears in the system log indicating the host port and VLAN involved in the loop. In addition the host port involved in the loop has the "*loop*" status added and Netvisor ONE adds the VLAN to the host port loop-vlans VLAN map. Looping ports and VLANs are displayed in the `port-show` output.

At the start of loop mitigation, Netvisor ONE creates vPorts to send loop probe packets. The vPorts use the port MAC address for the in-band NIC port, status of PN-internal, and a state of loop-probe. Netvisor ONE propagates Loop-probe vPorts throughout the fabric. Netvisor ONE creates a loop-probe vPort for each looping VLAN.

Netvisor ONE deletes all vPorts from the looping host port and VLAN at the start of loop mitigation. This prevents the hardware from sending unicast packets to the looping port, and causes every packet arriving on the looping port to appear in the software as a source MAC miss. During loop mitigation, Netvisor ONE drops all packets arriving on the looping port.

During loop mitigation, Netvisor ONE sends loop probe packets on the looping VLANs every 3 seconds. As long as the loop persists, Netvisor ONE receives the probe packets as source MAC miss notification on the looping ports, so Netvisor ONE can determine if the loop is still present. If 9 seconds elapse with no received probe packets, Netvisor ONE detects the loop is resolved and ends loop mitigation.

At the end of loop mitigation, log messages are added to the system log, loop-probe vPorts are removed, and loop stats and loop VLANS are removed from the looping port.

To view affected ports, use the `port-show` command and add the parameter, `status loop`:

```
CLI (network-admin@switch-31) > port-show status loop

switch       port hostname status                    config
---------- ---- -------- --------------------   ------
switch-31   9                 up,stp-edge-port,loop   fd,10g
switch-32   9                 up,stp-edge-port,loop   fd,10g
```

> **Note:** the new status, `loop`, in the `status` column. When the loops are removed

> from the port, the *loop* flag is removed from the `port-show status` command output and log message is added regarding the removal of *loop*.

During loop mitigation, the MAC addresses for loop probes are displayed in the vPort table:

```
CLI (network-admin@switch-31) > vport-show state loop-probe

owner         mac                vlan  ports state       hostname   status
---------- ----------------- ---- ----- ---------- ---------- -----------
switch-32 06:c0:00:16:f0:45   42    69     loop-probe leo-ext-32 PN-internal
switch-31 06:c0:00:19:c0:45   42    69     loop-probe leo-ext-31 PN-internal
```

Note the `loop-probe` state as well as the PN-internal state. The loop probes use the port MAC address format, and use the internal port for the in-band NIC.

> **Note**: The `state` and the `status` columns are different in the above `vport-show stats loop-probe` command output. The `status` column refers to the vPort peer owner state in the fabric (the *PN-internal* parameter indicates that the MAC belongs to the PN fabric). The `state` column displays the vPort state.

If you notice a disruption in the network, use the `port-show` command to find the looping ports, and fix the loop. Fixing the loop typically involves correcting cabling issues, configuring virtual switches, or as a stop-gap measure, using the `port-config-modify` command to change port properties for the looping host ports. Once the loop is resolved, Netvisor ONE no longer detects probes and leaves the loop mitigation state, while logging a message:

```
2016-01-12,12:18:41.911799-07:00 leo-ext-31 nvOSd(25695)
system
host_port_loop_resolved(11381) : level=note : port=9 :
Traffic has stopped looping on host-port=9
```

At this point the `loop` status is removed from the `port-show` output for port 9 and the loop-probe vPorts are removed.

Netvisor ONE Loop Detection exposes loops using system log messages, `port-show` output, and `vport-show` output.

When Netvisor ONE detects an internal port MAC address on a host port, Netvisor ONE prints a log message as below:

```
system  2016-01-19,15:36:40.570184-07:00  mac_move_denied
          11379 note   MOVE DENIED mac=64:0e:94:c0:03:b3 vlan=1
vxlan=0
           from switch=leo-ext-31 port=69 to deny-switch=leo-ext-
```

```
31  deny-port=9
         reason=internal MAC of local switch not allowed to
change ports
```

Netvisor ONE starts Loop Mitigation by logging a message:

```
system   2016-01-19,15:36:40.570334-07:00
host_port_loop_detected
          11380 warn   Looping traffic detected on host-port=9
         vlan=1. Traffic on this port/VLAN will be ignored until
loop resolved
```

During Loop Mitigation, Netvisor ONE sends loop probes. When these probes, as well as any other packets, are received on a looping host port, Netvisor ONE logs a message:

```
system  2016-01-19,15:59:54.734277-07:00  mac_move_denied
           11379 note   MOVE DENIED mac=06:c0:00:19:c0:45 vlan=1
vxlan=0
            from switch=leo-ext-31 port=69 to deny-switch=leo-ext-
31
           deny-port=9 reason=port is looping
```

Netvisor ONE limits `mac_move_denied` messages are limited to one every 5 seconds for each vPort. This prevents the system log from filling up with `mac_move_denied` messages during loop mitigation.

During loop mitigation, you can use the `port-show` command to see which ports are involved in the loop:

```
CLI (network-admin@Leaf1) > port-show status loop

switch     port  hostname  status                          loop-vlans  conf
------   ---- --------  --------------------   ----------  ------
leaf1    9                up,stp-edge-port,loop    1
         fd,10g
leaf1    9                up,stp-edge-port,loop    1
         fd,10g
```

Note the `loop` status in the status column and the `loop-vlans` column.

During loop mitigation the MAC addresses for loop probes are displayed in the vPort table:

```
CLI (network-admin@Leaf1) > vport-show state loop-probe

owner        mac                  vlan    ports   state        hostname      status
------   -----------------    ----    ----- ----------   --------     ---------
leaf1     06:c0:00:16:f0:45    42      69      loop-probe  leo-ext-32  PN-internal
leaf1     06:c0:00:19:c0:45    42      69      loop-probe  leo-ext-31  PN-internal
```

Fast Failover for STP and Cluster

Previously, cluster STP operation did not support fast failover because Netvisor ONE did not share STP state between the two nodes. As a result, when the master failed and when it came back online, the slave had to recompute the STP state from scratch. This resulted in topology changes twice, causing traffic loss until STP converged.

Currently, Netvisor ONE supports fast failover by default. In the cluster-STP mode, the node that has been up longer is elected as the master. Cluster syncs (keep-alives) are used to detect the peer node being online, and negotiate the initial cluster state. Cluster syncs determine which node has been up longer based on exchanged uptime values.

The master runs the state machine for both nodes and sends the STP and port states to the slave. The slave in turn maintains the state as informed by the master. The slave generates its own BPDUs based on the synchronized state and forwards the BPDUs that it receives to the master. When the cluster goes offline, the slave/master uses the same bridge ID and priority, uses consistent port IDs in BPDUs, and continues from the existing synchronized state. The STP state machine state is thus never lost.

Internal state synchronization using consistent bridge ID/priority and port IDs regardless of whether the cluster is online or offline, and active-active vLAG handling ensure that an end node detects no topology change when the cluster nodes go offline/online.

When a cluster is created, the STP configuration between the two cluster nodes is checked and is synchronized. The following guidelines are true regardless of whether the cluster is online or offline, and whether the peer node is online or offline:

- Both nodes use the same bridge ID or priority.
- When node1 sends a BPDU, the port ID inside the packet is 1-256, except for active-active vLAGs.
- When node2 sends a BPDU, the port ID inside the packet is 257-512, except for active-active vLAGs.
- When either node sends a BPDU on an active-active vLAG, the port ID inside the packet is node1's port number.
- Configuration changes (STP mode, MST instances, bridge ID, etc.) are mirrored on both nodes through cluster transactions.

Due to the above guidelines, a BPDU sent on an active-active vLAG appears exactly the same to a third party receiver regardless of whether that packet came from cluster node1 or node2.

Netvisor ONE provides two show commands to view the details of this functionality: `stp-state-show` and `stp-port-state-show.`

For example:

```
CLI (network-admin@Leaf1) > stp-state-show
switch:                  Leaf-1
vlan:                    1
ports:                   none
instance-id:         1
name:                        stg-default
```

```
bridge-id:               66:0e:94:d5:b0:cc
bridge-priority:    32769
root-id:                 66:0e:94:35:c2:ce
root-priority:      32769
root-port:           128
hello-time:          2
forwarding-delay:  15
max-age:              20
disabled:            none
learning:            none
forwarding:         none
discarding:         none
edge:                  none
designated:         none
alternate:          none
backup:               none

CLI (network-admin@Switch2) > stp-port-state-show port 17
switch:               Switch2
vlan:                 1
port:                 17
stp-state:            Forwarding
role:                 Designated
selected-role:        Designated
state:                agreed,learn,learning,forward,forwarding,selected,send-
rstp,synced,online,requested-online
designated-priority: 32769-66:0e:94:38:39:80,100,32769-66:0e:94:b7:65:91,32785
port-priority:       32769-66:0e:94:38:39:80,100,32769-66:0e:94:b7:65:91,32785
message-priority:    0-00:00:00:00:00:00,0,0-00:00:00:00:00:00,0
info-is:              mine
hello-timer:          2
root-guard-timer:     0
sm-table-bits:        0xfaedee
sm-table:              prx=discard*,bdm=not-edge*,ptx=idle*,pim=current*,prt-
disabled=disable*,prt-root=root*,prt-desg=designated*,prt-alt-
bk=block*,pst=forwarding*,tcm=active*
```

Configuring Auto-Recovery of a Disabled Port

Netvisor ONE automatically disables physical ports due to certain violations. For example, if a port receives BPDU messages on an edge port, Netvisor ONE disables the port because receiving BPDUs on a edge port becomes a security violation. This happens because the edge port is configured for BPDU guard for the violation to take effect.

The port may be disabled due to the following errors:

- BPDU Guard Messages: The port is set to `err-disabled` when a BPDU is received on an edge port with BPDU guard enabled.
- Link Flaps: There are too many link flaps for a configured interval of time.
- MAC address Security Violation: The number of MAC addresses on an interface is greater than the configured limit.

To clear the counters for err-disable caused by BPDU guard and MAC security, use the following command:

```
CLI (network-admin@Leaf1) > err-disable-clear-counters
```

`err-disable-clear-counters`	Resets err-disable counters for all the ports on the switch.
Specify any of the following options:	
`bpduguard|no-bpduguard`	Specify if BPDU guard counters are to be cleared.
`macsecurity|no-macsecurity`	Specify if MAC security counters are to be cleared.
`recovery-timer` *`duration: #d#h#m#s`*	Specify the recovery timer value. The default timer value is 5 minutes. Example: 20s or 1d or 10d20m3h15s

To configure BPDU guard or MAC security on a switch, use the command:

```
CLI (network-admin@Leaf1) > err-disable-modify
```

`err-disable-modify`	Modifies the `err-disable` settings for the switch.
Specify any of the following options:	
`bpduguard|no-bpduguard`	Specify either of the options to enable or disable BPDU guard.
`macsecurity|no-macsecurity`	Specify either of the options to enable or disable MAC security.
`recovery-timer` *`duration:`*	Specify the recovery time value. The

#d#h#m#s	default timer value is 5 minutes. Example: 20s or 1d or 10d20m3h15s

To view the error recovery settings on a switch, use the `err-disable-show` command. For example:

```
CLI (network-admin@Leaf1) > err-disable-show
switch: Leaf1
bpduguard: off
macsecurity: off
recovery-timer: 5m
```

Configuring STP Root Guard

The Root Guard feature is used to enforce the positioning/placement of root bridge in a network. In STP, there is no provision to have full control on the selection of the root bridge or switch. Any switch can be selected as the root bridge. If the bridge priority is set to 0, that switch is likely to become the root bridge. However, even with this configuration, there is no guarantee since there can be another switch with priority 0 and a lower MAC address that gets selected as root bridge.

The Root Guard feature forces a port to be a designated port (and does not allow it to become root port). This prevents any one of the neighboring switches from becoming the root switch. Thus, the Root Guard feature provides a way to enforce the placement or positioning of the root bridge in the network.

If a port on which the Root Guard feature is enabled receives a superior BPDU, it moves the port into a root-inconsistent state (similar to a listening state). In this state, no traffic is forwarded across this port. Root Guard must be enabled on all ports where the root bridge should not appear.

To configure root guard, use the command:

```
CLI (network-admin@Leaf1) > stp-port-modify port port-list
root-guard
```

`stp-port-modify`	Modify the Spanning Tree Protocol Parameters.
`port` *`port-list`*	Specify the port or port list.
`Specify one or more of the following options:`	
`block|no-block`	Specify if a STP port blocks BPDUs.
`bpdu-guard|no-bpdu-guard`	Enable or disable STP port BPDU guard.
`root-guard|no-root-guard`	Enable or disable STP port Root guard.

To view the root guard configuration details, use the command:

```
CLI (network-admin@Leaf1) > stp-port-show
```

Configuring Fabric Guard

Currently, Netvisor ONE detects a Layer 2 loop using STP, LLDP, or loop detect code. However if a third party device connected to a Pluribus Networks switch consumes LLDP such as a hypervisor vSwitch, and you configure the port as an edge port, Netvisor ONE cannot detect loops in the network.

If you configure a port as fabric-guard port, Netvisor ONE triggers sending global discovery multicast packets on this port after the port is physically up and in an adjacency wait state. If a port with fabric-guard configuration receives a global discovery packet, Netvisor ONE disables the port in the same way LLDP disables the port when receiving messages from the same switch.

To enable fabric guard, use the following syntax:

```
CLI (network-admin@Leaf1) > port-config-modify port port-
number  fabric-guard
```

To disable fabric guard, use the following syntax:

```
CLI (network-admin@Leaf1) > port-config-modify port port-
number  no-fabric-guard
```

In order to re-enable the port once you fix the loop, you must manually enable the port using the command, `port-config-modify port port-number enable`.

Configuring Layer 2 Static Multicast Groups

The traffic addressed to a multicast group is confined to the ports in the group, which prevents flooding of traffic on all the ports. Hosts join multicast groups either by sending an unsolicited IGMP join message or by sending an IGMP join message in response to a general query from a multicast router (the switch forwards general queries from multicast routers to all ports in a VLAN). When you specify group membership for a multicast group address statically, the static setting supersedes any IGMP snooping learning. Hence, static multicast groups can prevent L2 multicast flooding, if the hosts do not implement the desired IGMP mechanism to restrict the traffic to certain ports, or if IGMP snooping is disabled.

To create an L2 static multicast group, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-create
```

`l2-static-multicast-group-create`	Create a Layer 2 static multicast group.
`group-mac` *`mac-address`*	Specify a MAC address for the multicast group.
`vlan` *`vlan-id`*	Specify a VLAN ID for the multicast group.
`ports` *`port-list`*	Specify a list of ports for the multicast group.

For example, to create an L2 static multicast group for the MAC address 01:00:5e:7f:00:12, VLAN 25, and ports 30-35, use the following syntax:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-create
group-mac 01:00:5e:7f:00:12 vlan 25 ports 30-35
```

To add ports to a preconfigured multicast group, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-port-add
```

`l2-static-multicast-group-port-add`	Add ports to a L2 static multicast group.
`group-mac` *`mac-address`*	Specify a MAC address for the multicast group.
`vnet vnet-name`	Specify a vNET for the multicast group.
`bd` *`bridge-domain-name`*	Specify a bridge domain for the multicast group.
`vlan` *`vlan-id`*	Specify a VLAN ID for the multicast group.

`switch` *`switch-name`*	Specify the name of the switch.
`ports` *`port-list`*	Specify a list of ports.

For example, to add port 36 to the multicast group created above, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-port-add
group-mac 01:00:5e:7f:00:12 vlan 25 ports 36
```

To view the configuration, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-show
switch group-mac         vnet bd vlan ports
------ ----------------- ---- -- ---- --------
leaf1  01:00:5e:7f:00:12         25   30-36
```

To remove port 36 from the multicast group, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-port-
remove group-mac 01:00:5e:7f:00:12 vlan 25 ports 36
```

To view the updated configuration, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-show
switch group-mac         vnet bd vlan ports
------ ----------------- ---- -- ---- --------
leaf1  01:00:5e:7f:00:12         25   30-35
```

To delete the L2 static multicast group, use the command:

```
CLI (network-admin@leaf1) > l2-static-multicast-group-delete
group-mac 01:00:5e:7f:00:12 vlan 25
```

Configuring Hardware Batch Move in Layer 2 Table

Note: This feature is useful in deployments with scaled-up regular VLANs, where the configuration has a lot of VLANs or MACs on a given vLAG. This feature is disabled by default on Netvsior ONE.

The Netvsior ONE version 6.0.1 release provides support for hardware batch move mechanism to accelerate the MAC programming in Layer 2 table in a switch.

You can enable the hardware batch move feature by using the `batch-move-mac-hw-group-for-vlan-only` option in the `system-settings-modify` command. If enabled, this feature uses an internal switch specific construct called *portgroups* to identify and move the MACs between a vLAG and Cluster communication ports when the vLAG comes up or goes down in a VLAN network.

Caution: You must enable this feature only for scaled-up VLAN or MAC environments.

When disabled (this feature is disabled by default), the MAC move mechanism uses the conventional software batch move process, which has an acceptable level of traffic loss during the MAC move process in a VLAN or VLAN-VXLAN network. The software batch move feature supports hybrid mechanism (that is, software batch move in VLAN network, VXLAN network, and VLAN-VXLAN network) that can accelerate the MAC programming in Layer 2 table of an underlying switch.

To elaborate, when the hardware batch move feature is enabled or disabled:

- For VLAN only networks - uses the Hardware batch move feature if enabled.
- For regular VXLAN only configurations - uses the Software batch feature.
- For a combination of regular VLAN and VXLAN- VLAN network - uses hybrid method. That is, regular VLAN network uses hardware batch move if the feature is enabled. The VXLAN-VLAN network uses software batch move.
- When the hardware batch move feature is disabled, both regular VLAN and VXLAN-VLAN network uses the software batch move as the default option.

To configure the hardware batch move, use the `system-settings-modify` command with the `batch-move-mac-hw-group-for-vlan-only` command option.

Note: When you enable the feature , you must reboot the switch for the changes to take effect.

To enable the hardware batch move feature:

```
CLI (network-admin@switch1) > system-settings-modify  batch-
move-mac-hw-group-for-vlan-only|no-batch-move-mac-hw-group-
for-vlan-only
```

`system-settings-modify`	Use this command to modify the system settings on a switch.
`batch-move-mac-hw-group-for-vlan-only|no-batch-move-mac-hw-group-for-vlan-only`	Specify to enable or disable the HW batch move for MAC by group for VLAN network only.

To verify if the hardware batch move is enabled or not on a switch, use the command:

```
CLI (network-admin@switch1) > system-settings-show
```

An example to enable the hardware batch move feature and view the details is provided below:

```
CLI (network-admin@switch1*) > system-settings-show format
batch-move-mac-hw-group-for-vlan-only,
batch-move-mac-hw-group-for-vlan-only:   off

CLI (network-admin@switch1*) > system-settings-modify batch-
move-mac-hw-group-for-vlan-only
Modified settings require a REBOOT to take effect.

CLI (network-admin@cham-colo-1*) > switch-reboot

CLI (network-admin@cham-colo-1*) > system-settings-show format
batch-move-mac-hw-group-for-vlan-only,

batch-move-mac-hw-group-for-vlan-only:   on
```

Note: This feature is available on all platforms except AS7816-64X (F9664-C) and Z9264 platforms.

Configuring Excessive MAC or IP Move Protection

Excessive MAC or IP moves necessitate numerous updates to vPort and Layer 3 tables over a short interval, which result in high CPU and disk utilization among other network problems. A MAC move is detected when two devices send the same MAC address on different interfaces on the same switch, or on different switches in a fabric with the same VLAN. An IP move is observed when an IP address oscillates between two MAC addresses.

Netvisor ONE version 6.0.1 offers protection against excessive MAC or IP moves by quarantining vPort and L3 entries, that is, by not updating the entries until MAC or IP move condition is resolved. When you enable the protection feature, if more than five IP moves or MAC moves are detected within an interval of 5s, Netvisor ONE performs the following:

- Updates the `excess-mac-move-detected` or `excess-ip-move-detected` flags
- Logs `excess_mac_move` or `excess_ip_move` message.

While sending the vPort or Layer 3 updates to other fabric nodes, the software skips the entries that have an excess move flag set, and thereby avoids sending a large number of updates.

The software then monitors the quarantined entries and if no MAC or IP moves are detected for a duration of 15s, Netvisor ONE performs the following:

- Clears the `excess-mac-move-detected` or `excess-ip-move-detected` flags.
- Logs `clear_excess_mac_move` or `clear_excess_ip_move` message.

Netvisor ONE can also protect the CPU from excessive traffic related to MAC or IP moves by regulating the punt rate of associated CoS (Class of Service) queues. MAC moves and IP moves are punted to the CPU from the *smac-miss* queue and the *arp* queue respectively. When excessive MAC or IP moves are detected, and if CPU utilization is above 70 percent, the software can limit the punt rate from *smac-miss* or *arp* queues by 50 percent.

To configure CoS queue protection, you must first enable extended queue setting by using the command:

```
CLI (network-admin@switch1) > system-settings-modify cpu-
    class-enable
```

Use the `vport-settings-modify` command to configure MAC and IP move protection. These protection schemes are disabled by default.

```
CLI (network-admin@switch1) > vport-settings-modify
```

`vport-settings-modify`	Modify vPort settings.
Specify one or more of the following options:	
`vport-disk-space` *`vport-disk-space-number`*	Specify the amount of disk space for vPorts. The default is 500M.

`stats-max-memory` *`stats-max-memory-number`*	Specify the maximum memory for collecting vPort information. The default memory is 50M.
`stats-log-enable|stats-log-disable`	Specify if you want to enable or disable logs for vPort statistics. Enabled by default.
`stats-log-interval duration:` *`#d#h#m#s`*	Specify the interval between logging events. The default is one minute.
`stats-log-disk-space` *`disk-space-number`*	Specify the amount of disk space for vPort logs. The default is 50M.
`system-stats-log-enable|system-stats-log-disable`	Specify if you want to enable or disable logging for the system. Enabled by default.
`system-stats-log-interval duration:` *`#d#h#m#s`*	Specify the interval between logging events. The default is one minute.
`system-stats-log-disk-space` *`disk-space-number`*	Specify the disk space for system statistics. The default is 50M.
`excess-mac-move-protection-enable|no-excess-mac-move-protection-enable`	Enable or disable excess MAC move protection.
`excess-mac-move-queue-protect|no-excess-mac-move-queue-protect`	Enable or disable excess MAC move queue protection.
`excess-ip-move-protection-enable|no-excess-ip-move-protection-enable`	Enable or disable excess IP move protection.
`excess-ip-move-queue-protect|no-excess-ip-move-queue-protect`	Enable or disable excess IP move queue protection.

For example, to configure excess MAC move protection, use the command:

```
CLI (network-admin@switch1) > vport-settings-modify excess-
     mac-move-protection-enable
```

To enable excess MAC move CoS queue protection in order to limit the punt rate from the *smac-miss* queue to the CPU by 50 percent, use the command:

```
CLI (network-admin@switch1) > vport-settings-modify excess-
     mac-move-queue-protect
```

To configure excess IP move protection, use the command:

```
CLI (network-admin@switch1) > vport-settings-modify excess-ip-
     move-protection-enable
```

To enable excess IP move CoS queue protection in order to limit the punt rate from the *arp* queue to the CPU by 50 percent, use the command:

```
CLI (network-admin@switch1) > vport-settings-modify excess-ip-
     move-queue-protect
```

Use the `vport-settings-show` command to view the current status of various protection schemes:

```
CLI (network-admin@switch1) > vport-settings-show format all
switch:                          switch1
vport-disk-space:                500M
stats-max-memory:                50M
stats-log-enable:                yes
stats-log-interval:              1m
stats-log-disk-space:            50M
system-stats-max-memory:         50M
system-stats-log-enable:         yes
system-stats-log-interval:       1m
system-stats-log-disk-space:     50M
loop-prevent:                    enabled
excess-mac-move-protect-enable:  yes
excess-mac-move-queue-protect:   yes
excess-mac-move-queue-state:     active
excess-ip-move-protect-enable:   yes
excess-ip-move-queue-protect:    yes
excess-ip-move-queue-state:      active
```

If queue protection is enabled, the fields `excess-mac-move-queue-state` and `excess-ip-move-queue-state` are set to `active` when MAC or IP moves are detected and CPU utilization is above 70 percent.

If excess MAC move is detected, the `vport-show` and `l2-table-show` outputs display the state of the corresponding entries with an `excess-mac-move-detected` flag. For example:

```
CLI (network-admin@switch) > vport-show vlan 100

owner   mac         vlan ip        num-ips ports state                         hostname migrate
------- ----------- ---- --------- ------- ----- ----------------------------- -------- -------
switch 00:x:x:x:x:x 100  100.0.0.1  2       126   active,excess-mac-move-detected  host     52840

CLI (network-admin@serpens-vle-1*) > l2-table-show vlan 100
mac               vlan ports state                            migrate
----------------- ---- ----- -------------------------------- -------
00:11:22:33:44:55 100   33    active,excess-mac-move-detected 56
```

If an excess IP move situation is detected, the `l3-table-show` output displays the state of the corresponding entry with an `excess-ip-move-detected` flag. For example:

```
CLI (network-admin@switch) > l3-table-show vlan 200

switch  mac          ip        vlan state
------ ------------ --------- ---- ------------------------------
```

```
switch 00:x:x:x:x:x 200.0.0.1 200  active,excess-ip-move-detected
```

You can view the log messages for excess MAC and IP move detection and resolution by using the command, `log-system-show.` For example:

```
CLI (network-admin@switch1) > log-system-show name excess_mac_move,excess_ip_move,clear_excess_mac_move,clear_excess_ip_move
```

```
category:           system
time:                2020-08-12,00:55:16.738453-07:00
name:               clear_excess_mac_move
code:               11525
level:              note
message:             Excess MAC move condition cleared for mac=00:01:02:03:04:05, vnet=
vlan=100  vxlan=0
category:           system
time:                2020-08-12,00:55:26.463901-07:00
name:               clear_excess_ip_move
code:               11526
level:              note
message:             Excess IP move condition cleared for ip=200.0.0.1 vnet= vlan=200
vxlan=0
category:           system
time:                2020-08-12,00:57:33.577668-07:00
name:               excess_mac_move
code:               11523
level:              note
message:             Excess MAC moves detected for mac=00:01:02:03:04:05, vnet= vlan=100
category:           system
time:                2020-08-12,00:57:33.717490-07:00
name:               excess_ip_move
code:               11524
level:              note
message:             Excess IP moves detected for ip=200.0.0.1 vnet= vlan=200 vxlan=0
```

About Layer 2 Hardware Hashing

A hardware hashing operation comprises two parts that can be performed at extremely high speed: first, packet field selection and extraction, then a mathematical bitwise computation.

The first step therefore is for the hardware parsing logic to select a number of packet fields 'to be hashed' depending on the traffic type.

The ***Table 4-1*** describes the traffic types and related packet fields that Netvisor ONE currently supports by default to perform hashing on:

Table Caption 4-1: Hardware Hashing Field Selection

Application	Traffic Type[2]	Hashed Fields[3]
Non-IP packets[1]	Ethernet (a.k.a. 'Layer 2')	Source MAC address, Destination MAC address, Ethertype, VLAN number, source physical port
Plain unicast and multicast IPv4 packets	IP	Source IPv4 address, Destination IPv4 address, VLAN number, Destination Layer 4 port, Source Layer 4 port, IP protocol number, source physical port
Plain unicast and multicast IPv6 packets	IP	Source IPv6 address, Destination IPv6 address, VLAN number, Destination Layer 4 port, Source Layer 4 port, IP protocol number, source physical port
VXLAN packets (UDP encapsulated)	IP	Source IP address, Destination IP address, VLAN number, Destination Layer 4 port, *Source Layer 4 port*, IP protocol number, source physical port
L2GRE	IP	Source IP address, Destination IP address, VLAN number, GRE Key, IP protocol number, source physical port
IPSEC	IP	Source IP address, Destination IP address, VLAN number, SPI

		field, IP protocol number, source physical port

Note:

- [1] Certain traffic types such as *Mac-in-Mac*, *FCoE* and *SCTP* are currently not supported for field selection; hence they are not load balanced as opposed to the supported traffic types (see also the next section).

- [2] Traffic types are based on IANA's Ethertype definitions (e.g., 0x0800 for IPv4 and 0x86DD for IPv6). Packet fields are based on standard protocol definitions (IEEE 802.3 for Ethernet, RFC 791 and RFC 8200 for IPv4 and IPv6 respectively).
- [3] (v)LAG hashing applies to bridged as well as routed traffic without distinction.

Once the proper field values are extracted based on the traffic type (as per the table above), the second step performed by the hardware is the *hash function calculation*. Netvisor ONE uses the standard *CRC16 CCITT* cyclic redundancy check algorithm for the hash function calculation.

However, before calculating the CRC, 128-bit IPv6 source and destination addresses get 'folded' into 32-bit shortened versions with the *FoldAndXOR* method:

address_bits(127:96) ^ address_bits(95:64) ^ address_bits(63:32) ^ address_bits(31:0)

where ^ means 32-bit XOR.

This preserves the variability over the entire 128-bit address length when fed in 32-bit chunks to the CRC16 CCITT calculation.

Starting from Netvisor ONE release 6.1.0, the default hashing mode is called enhanced hashing. It reflects the hashing field selection described in ***Table 4-1*** above.

As an alternate configuration for special cases, it is possible to select only a subset of the fields in Table 4-1 by explicitly configuring the hash mode to one of the following hashing options:

- *source MAC address based*
- *destination MAC address based*
- *source and destination MAC address based*
- *source IP address based*
- *destination IP address based*
- *source and destination IP address based*

These modes are less granular than the default enhanced mode, therefore they should be used only when the purpose is to have a less granular load balancing behavior (which in most cases means a less optimal traffic distribution).

About Resilient Hashing

Starting from Netvisor ONE release 6.1.0, a new resilient hashing mode is introduced. It is called `resilient` because it helps prevent unnecessary traffic disruption when the number of trunk member ports changes. It takes advantage of regular hashing field selection as shown in ***Table 4-1*** and employs an advanced table-based mechanism to provide better port selection resiliency. This feature is applicable to unicast flows only.

Resilient hashing can be configured when a trunk is created. Its configuration is not modifiable on the fly.

In case of auto trunks, they will come up using the default hashing mode, that is, enhanced. In order to apply resilient mode to these trunks, they need to be converted into regular (manual) trunks. In other words, for each of them you need to disable all the required auto-trunk ports, delete the trunk and re-create it as a regular trunk with resilient hashing configured. However, in such case you lose the convenience of the automatic trunk creation.

About Symmetric Hashing

In addition to regular (asymmetric) hashing, Netvisor ONE supports symmetric hashing for IPv4 and IPv6 traffic. When this mode is enabled, IP traffic is *normalized* before the fields are hashed. That means that the source and destination IP addresses and Layer 4 ports are swapped so that both directions of a bidirectional IP connection are hashed to the same output port in a LAG.

Symmetric hashing's normalization algorithm has to ignore certain fields that can vary on a per direction basis, such as the VLAN number, protocol value, and the ingress physical interface.

Moreover, as shown in ***Table 4-1,*** for the Hardware Hashing Field Selection, certain fields such as the GRE key or the IPSec SPI are intrinsically unidirectional. If any GRE or IPSec traffic is expected in the network, then Netvisor ONE provides an additional option for symmetric hashing to ignore these unidirectional GRE and IPSec fields so that the normalization only uses source and destination IP addresses and L4 ports for the hash computation.

Symmetric hashing is useful when traffic in both directions needs to be hashed to the same member port in a LAG. This is required, for instance, for analysis and correlation purposes, when a monitoring device connected to a member port of a trunk needs to receive a copy of all the packets of a connection in both directions (that is, both requests and replies).

Configuring Layer 3 Features

This chapter provides information about the protocols and configurations supported on Layer 3 network (aka Network layer protocols) by using the Netvisor ONE command line interface (CLI) on a Netvisor ONE switch.

Understanding the Layer 3 Protocols in Netvisor ONE

Layer 3 is the Network layer protocol that behaves as a transmission medium from the source to the destination by performing the routing and addressing aspects of a packet and ensuring data integrity without having any packet loss.

Netvisor ONE supports the following Layer 3 or Network protocols and functionalities:

- Open Shortest Path First (OSPF)
- OSPFv3
- Border Gateway Protocol (BGP)
- MP-BGP
- RIP
- VRRP for IPv4 and IPv6
- Dual-stack support (IPv4/IPv6)
- Equal-cost multi-path routing (ECMP)
- Policy Based Routing (PBR)
- Bidirectional Forwarding Detection (BFD) (IPv4 and IPv6), OSPF, BGP and static routes
- Static routes
- Loopback interface
- DHCP relay
- Multicast Listener Discovery (MLD)

Configuring Packet Relay for DHCP Servers

In general, routers do not forward broadcast packets from one subnet to another. However, there are cases in which the broadcast packets need to be passed onto other subnets. One typical example is DHCP (Dynamic Host Configuration Protocol) in which a new computer needs to acquire an available IP address by broadcasting the requests to DHCP server. DHCP protocols work seamlessly if both DHCP client and DHCP server are located in the same broadcast domain. However, that does not work across broadcast domains without supporting features such as DHCP relay. That is, when the DHCP server is not in the same subnet as the clients, use DHCP relay for broadcasting traffic.

Packet Relay is the router functionality that helps forward broadcast packets between broadcast domains. In Netvisor ONE architect, the packet relay functionality is implemented as a service running within a particular vRouter.

You can configure a vRouter to relay DHCP requests from local clients to a centralized DHCP server. Since the initial DHCP request arrives from a client that typically does not have an IP address, the client must find the DHCP server using a Layer 2 broadcast.

The DHCP server needs information before the server can allocate an IP address to the client. It must know the subnet and the MAC address of the client. The DHCP server needs the subnet information to ensure that the IP address that the client receives can work on the client's subnet. The MAC address is necessary so that the DHCP server can find any information that is unique to the client.

When you configure DHCP relay on a vRouter, the vRouter converts the local broadcast packet from the client to a unicast packet and forwards it to the server.

Since the DHCP client does not have an IP address when it sends the DHCP request packet, the client uses the IP address, 0.0.0.0, as the source IP address and the general broadcast address 255.255.255.255 for the destination.

The vRouter replaces the source address with the IP address assigned to the interface where the request is received, and replaces the destination IP address with the address you specify in the vRouter packet-relay command.

To configure packet-relay for a DHCP server with the IP address `172.16.21.34` and vRouter interface (on the network where the client is connected to) - `eth11.100`, use the following syntax:

```
CLI (network-admin@switch) > vrouter-packet-relay add vrouter-name vrouter-dhcp forward-proto dhcp forward-ip 172.16.21.34 nic eth11.100
```

Once you add the configuration, you cannot modify it. If you make a mistake or want to add a new configuration, you must use the `vrouter-packet-relay-remove` command.

Configuring DHCP Packet Relay over VXLAN

Netvisor ONE version 6.1.0 supports DHCP packet relay configuration over VXLAN. To demonstrate this functionality, consider the topology below:

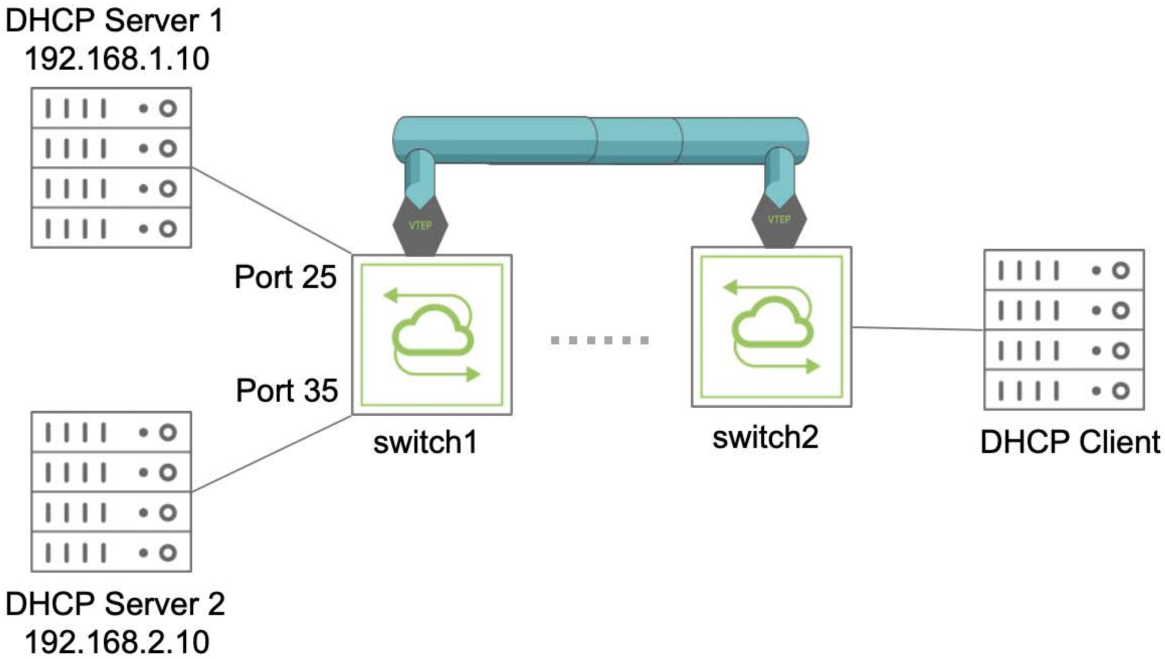


Figure 5-1 - DHCP Relay Configuration over VXLAN

The nodes switch1 and switch2 belong to two separate subnets and have VXLAN connectivity between them. For more information, see the *Configuring VXLAN* chapter. The DHCP servers 1 and 2 are connected to switch1 while the DHCP client is connected to switch2. The DHCP servers and the DHCP client belong to the VRF `vrf1`.

From Netvisor ONE version 6.1.1, DHCP relays are VRF-aware. To create a VRF, use the command:

```
CLI (network-admin@switch1) > vrf-create name vrf1 scope
fabric
```

Follow the steps below to configure DHCP relay between the DHCP servers and the client.

Create a VLAN for the DHCP client and associate a VXLAN with the VLAN:

```
CLI (network-admin@switch2) > vlan-create id 101 scope fabric
vxlan 100101
```

Create VLANs for the DHCP servers and associate the VLANs with VXLANs:

```
CLI (network-admin@switch1) > vlan-create id 103 scope fabric
ports 25 vxlan 100102
```

```
CLI (network-admin@switch1) > vlan-create id 104 scope fabric
ports 35 vxlan 100103
```

Create a vRouter and vRouter interface for VLAN 101:

```
CLI (network-admin@switch2) > vrouter-create name vr1 vnet
```

```
vnet1 router-type hardware

CLI (network-admin@switch2) > vrouter-interface-add vrouter-name vr1 ip 192.168.102.1/24 vlan 101 vlan-type public if data if-nat-realm internal vrf vrf1
```

> **Note:** You also need to configure VRRP interfaces if the DHCP client is attached to a cluster.

View the configuration using the `vrouter-interface-show` command:

```
CLI (network-admin@switch1) > vrouter-interface-show vlan 101 format vrouter-name,nic,ip,mac,vlan,vlan-type,nic-state

vrouter-name nic      ip               mac               vlan vlan-type nic-state
------------ -------- ---------------- ----------------- ---- --------- ---------
vr1          eth2.102 192.168.102.1/24 66:0e:94:79:34:fe 101  public    up
```

Associate the vRouter to the VRF by using the command:

```
CLI (network-admin@switch1) > vrouter-vrf-add vrouter-name vr1 vrf vrf1 bgp-as 65100 router-id 110.0.1.1 bgp-redistribute connected
```

Use the `vrouter-vrf-show` command to view the vRouter VRF configuration:

```
CLI (network-admin@switch1) > vrouter-vrf-show format switch,vrouter-name,vrf,hw-vrid,bgp-as,router-id,bgp-redistribute
switch  vrouter-name vrf      hw-vrid bgp-as router-id bgp-redistribute
------- ------------ -------- ------- ------ --------- ----------------
switch1 vr1          vrf1     1       65100  110.0.1.1 connected
```

Configure DHCP packet relay for both DHCP servers:

```
CLI (network-admin@switch2) > vrouter-packet-relay-add vrouter-name vr1 forward-ip 192.168.1.10 forward-proto dhcp nic eth2.102

CLI (network-admin@switch2) > vrouter-packet-relay-add vrouter-name vr1 forward-ip 192.168.2.10 forward-proto dhcp nic eth2.102
```

Here, `forward-ip` is the IP address of the DHCP server, `forward-proto` is the protocol supported by packet relay which is DHCP, and `nic` is the ingress interface of the vRouter on which DHCP broadcast packets are expected. The VRF ID is derived from the NIC value provided to the `vrouter-packet-relay-add` command.

View the packet relay configuration by using the command:

```
CLI (network-admin@switch2) > vrouter-packet-relay-show

vrouter-name forward-proto forward-ip   nic      vrf
------------ ------------- ------------ -------- ----
```

```
vr1           dhcp           192.168.1.10 eth2.102 vrf1
vr1           dhcp           192.168.2.10 eth2.102 vrf1
```

Note:

- If the DHCP client is connected through a vLAG to a cluster pair, you must configure vRouters, vRouter interfaces, and DHCP packet relay for both the cluster switches.
- If you configure the DHCP relay and filter on different nodes, the uplink port (from the DHCP filter node to the relay) and the downlink port (from the DHCP filter node to the server interface) must be configured as trusted ports. For more information, see *Support for DHCP Snooping* section of the *Configuring Network Security* chapter.
- You cannot specify VRRP VIP NICs in the `vrouter-packet-relay` command. You can specify VRRP primary NICs instead.

Configuring vRouter Services

A Virtual Router (vRouter) is an important part of fabric functionality. For example, for a VLAN to communicate with other VLANs, or networks external to the fabric, it may need a vRouter that spans the internal and the external network.

Fabric-wide vRouter commands can only be executed at the fabric level by the fabric administrator.

> **Note:** For switches with ONVL, the only available vNET is a global vNET created when a fabric is created for the first time. Use tab complete in the CLI to display the vNET and continue the configuration. However, some switches support multiple vNETs based on the platforms. Please refer to the Release Notes for the supported platforms.

Routing protocols essentially work the same way on virtual routers as physical routers.

Configuring vRouter Interfaces

You can now add IPv4 and IPv6 addresses to a vRouter interface. If you enable or disable the interface, both IPv4 and IPv6 are affected. Routing protocols can be enabled or configured independently using the IP address.

When you add a vRouter interface, you can configure it with two IP addresses, IPv4 and IPv6 and can have multiple IP addresses (primary and secondary).

```
CLI (network-admin@switch) > vrouter-interface-add  vrouter-name name-string vlan vlan-id ip ip-address netmask netmask assignment none|dhcp ip2 ip-address netmask2 netmask
```

You can display the IP addresses:

```
CLI (network-admin@switch) > vrouter-interface-show  vrouter-name name-string vlan vlan-id ip ip-address netmask netmask assignment none|dhcp|dchpv6 ip2 ip-address netmask2 netmask
```

To migrate the interface from a IPv4 address to a IPv6 address, the following commands are used:

```
CLI (network-admin@switch) > vrouter-interface-ip-add
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter.
`nic` *`nic-string`*	Specify the virtual NIC assigned to the interface.
`ip` *`ip-address`*	Specify the IP address assigned to the interface.
`netmask` *`netmask`*	Specify the netmask of the IP address.
Specify any of the following options:	
`vnet` *`vnet-name`*	Specify the vNET assigned to the vRouter.

```
CLI (network-admin@switch) > vrouter-interface-ip-remove
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter.
`nic` *`nic-string`*	Specify the virtual NIC assigned to the interface.
`ip` *`ip-address`*	Specify the IP address assigned to the interface.

```
CLI (network-admin@switch) > vrouter-interface-ip-show
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter.
`nic` *`nic-string`*	Specify the virtual NIC assigned to the interface.
`ip` *`ip-address`*	Specify the IP address assigned to the interface.
`netmask` *`netmask`*	Specify the netmask of the IP address.
Specify any of the following options	
`vnet` *`vnet-name`*	Specify the vNET assigned to the vRouter.

Configuring MTU Parameters for vRouter Interfaces

Support for IPv4 and IPv6 addresses requires configuring the MTU parameter differently for each type of IP address. By default MTU is set at 1500 for the vNICs. For IPv4 addresses, the Maximum Transmission Unit (MTU) the range is to 68 to 9216, but the range for IPv6 addresses is 1280-9216. However, Netvisor ONE displays the MTU range as 68-9216 which is supported by IPv4 addresses. But if you configure an IPv6 interface with an MTU value outside of the 1280-9216 for IPv6 addresses, Netvisor ONE returns an error.

In the case of interfaces configured with IPv4 and IPv6 addresses (dual-stack), Netvisor ONE limits the MTU range to 1280-9216. The following special rules apply to dual-stack interfaces:

- If you configure the MTU option for a vRouter interface with an IPv6 address using the command, `vrouter-interface-create`, Netvisor ONE performs a range check to ensure the MTU value is within 1280-9348.
- If you configure the MTU option for a vRouter interface using the `vrouter-interface-modify` command, Netvisor ONE performs a check for IPv6 addresses, and then performs a range check for 1280-9348.
- If you add an IPv6 address with the command, `vrouter-interface-ip-add`, Netvisor ONE performs a range check to ensure the MTU of the VNIC interface is within 1280-9348.
- If you configure a hardware vRouter, Netvisor ONE propagates the MTU value to the switch interface, so the MTU values are in the switch ASIC.

Informational Note: Starting from Netvisor ONE release 5.1.1 the maximum MTU size has been increased to 9348.

Configuring 802.1p-based Prioritization and Marking on Egress Interfaces

In Layer 3 networks, traffic priority is typically indicated in the Type of Service (ToS) or Diff Serv Code Point (DSCP) fields in the IPv4 or IPv6 headers of the packets.

Switches can be programmed to map these Quality of Service (QoS) or Class of Service (CoS) values to one of 8 traffic classes and then to use such class assignment to place packets into one of 8 egress queues of a port. This important capability (also known as class-based traffic queuing) helps to deal with traffic congestion in the network's choke-points.

However, in certain network designs such as, multi-tenant DC designs, it may not be always possible to use the ToS or DSCP fields for class-based prioritization.

An alternative solution is offered by the IEEE 802.1p standard classification, which allows any VLAN-tagged Ethernet traffic to be explicitly classified based on a Class of Service (CoS) 3-bit field, (also known as Priority Code Point (PCP).

Therefore, since packets forwarded on a Layer 3 interface do not usually carry an IEEE VLAN tag (and associated CoS field) by default, this enhancement introduces the capability of explicitly adding a CoS field in the traffic egressing a vRouter interface.

Netvisor ONE now supports a new parameter for the configuration of an IEEE 802.1p priority tag (i.e., CoS) on an interface:

```
CLI (network-admin@switch) > vrouter-interface-add priority-
tag|no-priority-tag
```

```
CLI (network-admin@switch) > vrouter-interface-modify
priority-tag|no-priority-tag
```

When priority-tag is selected, Netvisor ONE adds a CoS value based on the following ingress scenarios and configuration:

- Case A: On a vRouter interface when the ingress traffic contains an IEEE 802.1p priority tag (CoS), the default behavior is to trust such classification. Hence Netvisor ONE uses the same CoS value received in ingress for the egress traffic.

- Case B: When the ingress traffic is untagged, Netvisor ONE uses the default CoS value (0) for the egress traffic on the vRouter interface.

- Case C: When the ingress traffic contains a DSCP value and if the network admin adds a DSCP map to the port, then Netvisor ONE will set the egress CoS value according to the configured DSCP map. In other words, when this specific configuration is chosen by the network admin, the cases A and B is overridden and the egress traffic's CoS value will instead be decided by the ingress DSCP map (while the ingress CoS value is ignored).

Configuring IPv6 for vRouter Loopback Addresses

Netvisor ONE now supports IPv4 and IPv6 addresses on the same loopback interface.

When you configure a loopback interface, you can optionally associate a vRouter interface to the configuration. If you do not associate a vRouter interface, Netvisor ONE selects the first non-VRRP vRouter interface. Netvisor ONE uses the loopback interface for a vRouter as a host route in the Forwarding Information Database (FIB) for packets received from any port and routes them to the correct vRouter.

If there is no vRouter interface configured, the loopback interface is unreachable on the network. When you add the first vRouter interface, the loopback interface is reachable.

If you remove the associated vRouter interface, Netvisor ONE selects the next available vRouter interface.

Netvisor ONE does not support multiple vRouter loopback interfaces for IPv6 addresses.

To add an IPv4 address to a loopback interface for vRouter, vr1, use the following syntax:

```
CLI (network-admin@switch) > vrouter-loopback-interface-add
vrouter-name vr1 ip 99.1.1.1
```

To add an IPv6 vRouter loopback interface to vRouter, vr1, use the following syntax:

```
CLI (network-admin@switch) > vrouter-loopback-interface-add
vrouter-name vr1 ip 2999:1000::1
```

To display the vRouter loopback interface, use the `vrouter-loopback-interface-show` command:

```
CLI (network-admin@switch) > vrouter-loopback-interface-show

vrouter-name       index  ip                router-if
174 ------------ ----- ------------ ---------
175  vr1             1      99.1.1.1       eth0.100
176  vr1             2      2999:1000::1  eth0.100
```

```
CLI (network-admin@switch) > vrouter-routes-show

 vrouter-name   network           type         interface    next-hop                   distance   me
 ------------   ---------         ---------    ----------   --------------             --------   --
 vr1            10.1.1.0/24       connected    eth0.100
 vr1            10.1.1.0/24       connected    eth0.100
 vr1            20.1.1.0/24       ospf         eth0.121     12.1.1.2                   110        20
 vr1            88.1.1.1/32       ospf         eth0.121     12.1.1.2                   110        20
 vr1            99.1.1.1/32       connected    lo
 vr1            2100:100::/64     connected    eth0.100
 vr1            2121:100::/64     connected    eth0.121
 vr1            2200:100::/64     ospf6        eth0.121     fe80::640e:94ff:fe4d:d0c8  110        10
```

```
vr1           2888:1000::1/128   ospf6         eth0.121     fe80::640e:94ff:fe4d:d0c8   110       10
vr1           2999:1000::1/128   connected     lo
vr1           fe80::/64          connected     eth0.121
```

Displaying FRR Routing and Debug Information for vRouters

This feature provides a new vRouter command to display the output of an IP Stack FRR (Free Range Routing) and debug information from the Netvisor ONE command line interface(CLI).

```
CLI (network-admin@Spine1) > vrouter-vtysh-cmd
```

`vrouter-vtysh-cmd`	Specify the vRouter FRR command.
`name` *`name-string`*	name of service config.
`cmd` *`cmd-string`*	any FRR show/debug/undebug/no debug/clear ip/clear ipv6 command.

Show Output Examples

```
CLI (network-admin@Spine1) > vrouter-vtysh-cmd name vr1 cmd
"show ip route"

Codes: K - kernel route, C - connected, S - static, R - RIP,
       O - OSPF, I - IS-IS, B - BGP, P - PIM, A - Babel,
        > - selected route, * - FIB route

C>* 100.1.1.0/24 is directly connected, eth1.100

C>* 127.0.0.0/8 is directly connected, lo0

CLI (network-admin@Spine1) > vrouter-vtysh-cmd name vr1 cmd
"show  running-config"

Building  configuration...

Current  configuration:
!
frr  version  7.2-pluribus
frr  defaults  traditional
hostname  switch
log file zebra.log
log timestamp precision 6
log file bgpd.log
!
enable  password  zebra
password  zebra
!
router-id  1.1.1.7
!
router  bgp  650033
 bgp  router-id  1.1.1.7
 coalesce-time  1000
 bgp  bestpath  as-path  multipath-relax
```

```
 bgp prefer nh-global
 neighbor 18.18.18.2 remote-as 650033
 neighbor 10.10.50.129 remote-as 65001
 neighbor 10.10.60.129 remote-as 65002
 !
 address-family ipv4 unicast
  redistribute connected
  neighbor 18.18.18.2 next-hop-self
  neighbor 10.10.50.129 allowas-in
  neighbor 10.10.50.129 weight 200
  neighbor 10.10.60.129 allowas-in
  neighbor 10.10.60.129 weight 200
  maximum-paths 16
 exit-address-family
 !
 address-family ipv6 unicast
  redistribute connected
  maximum-paths 16
 exit-address-family
!
line vty
!
end
```

For this feature, only `show` commands are allowed as legal values in the CLI. For example,

```
CLI (network-admin@switch) > vrouter-vtysh-cmd name vr1 cmd
"config t"

vrouter-vtysh-cmd: Illegal value for "cmd"
vrouter-vtysh-cmd: Legal values: commands starting with show,
in quotes
```

Viewing FRR (Free Range Routing) Logs

FRR logs files, such as Zebra, OSPF, OSPF6, BGP, BFD and RIP can be viewed directly from the console using the Netvisor ONE CLI.

Since FRR log files accumulate on the switch, you may want to clear a particular log file so they do not create space issues.

Use this command to view FRR logs files directly from your console:

```
CLI (network-admin@switch) > vrouter-log-show  vrouter-name
vrouter-name protocol
```

`vrouter-log-show`	Displays vrouter protocol logs
`vrouter-name` *`vrouter-name`*	Specify name of the vRouter.
Specify any of the following options:	
`protocol zebra|ospf|ospf6|bgp|bfd|rip`	Specify the name of the protocol files to view.

Use this command to clear FRR files from a specific protocol log file:

```
CLI (network-admin@switch) > vrouter-log-clear
```

`vrouter-log-clear`	Clears vrouter protocol logs from a protocol log file
`vrouter-name` *`vrouter name`*	Specify the name of the vRouter service.
Specify any of the following options:	
`protocol zebra|ospf|ospf6|bgp|bfd|rip`	Specify the name of the log file to clear.

Configuring Hardware-based Routing

Configuring Hardware Routing for a vRouter

Create interfaces on hardware routers and map them to virtual NICs in the vRouter zone. The number of hardware vRouters you can create depends on the platform. You can create only one vRouter on low-end platforms and can range up to 32 vRouters on high-end platforms.

The supported protocols are as follows:

- **OSPF** — OSPF does not use a TCP/IP transport protocol such as UDP or TCP, but is encapsulated in the IP datagram with protocol number 89. OSPF uses multicast addressing for route flooding on a broadcast domain. For non-broadcast network, special provisions in the configuration facilitate neighbor discovery. OSPF reserves the multicast addresses 224.0.0.5/6 for IPv4 or FF02::5/6 for IPv6.
- **BGP** — BGP uses TCP and port number 179.
- **RIP** — uses the following parameters:
  - RIPv1 — IPv4 uses UDP and port 520, and advertise address - broadcasting
  - RIPv2 — IPv4 uses UDP and port 520, and advertise address - 224.0.0.9
  - RIPng — IPv6 uses UDP and port 521, and advertise address - FF02::9
- **PIM** — IPv4 uses protocol 103 with multicast address 224.0.0.13

To create a hardware-based vRouter called `hwtest`, use the following command:

```
CLI (network-admin@switch) > vrouter-create hwtest router-type
hardware
```

Use the same commands as software routing to add protocols and interfaces.

IPv6 Hardware Routing

Netvisor ONE supports both IPv4 and IPv6 natively, and both can be configured on the same interface.

In addition to static routing, Netvisor ONE supports the OSPFv3 and Multi-protocol BGP protocols for IPv6 unicast routing. vRouter interfaces can be configured with globally scoped IPv6 addresses.

```
CLI (network-admin@Spine-1) vrouter-interface-add vrouter-name vrouter-1 ip 2200:1111:2222:3333::1/64 vlan 100

CLI (network-admin@Spine-1) vrouter-interface-add vrouter-name vr0 ip 2200::1/64 vlan 200

CLI (network-admin@Spine-1) vrouter-interface-add vrouter-name vr0 ip 2211::1/64 vlan 211

CLI (network-admin@Spine-1) vrouter-ospf6-add vrouter-name vr0 nic eth0.200 ospf6-area 0.0.0.0

CLI (network-admin@Spine-1) vrouter-ospf6-add vrouter-name vr0 nic eth0.211 ospf6-area 0.0.0.0
```

BGP with IPv6 Unicast Peers Distributing IPv6 Prefixes

```
CLI (network-admin@Spine1) > vlan-create id 200 scope fabric ports 9

CLI (network-admin@Spine1) > vlan-create id 211 scope fabric

CLI (network-admin@Spine1) > vnet-create name vnet0 scope fabric vlans 200

CLI (network-admin@Spine1) > vrouter-create name vr0 vnet vnet0 router-type hardware router-id 1.1.1.1 hw-vrrp-id 1

CLI (network-admin@Spine1) > vrouter-interface-add vrouter-name vr0 ip 2200::1/16 vlan 200

CLI (network-admin@Spine1) > vrouter-interface-add vrouter-name vr0 ip 2211::1/24 vlan 211

CLI (network-admin@Spine1) > vrouter-modify name vr0 bgp-as 200 no-bgp-ipv4-unicast

CLI (network-admin@Spine1) > vrouter-modify name vr0 bgp-redistribute static,connected

CLI (network-admin@Spine1) > vrouter-bgp-add vrouter-name vr0 neighbor 2211::2 remote-as 222 multi-protocol ipv6-unicast
```

```
CLI (network-admin@Spine1) >  vrouter-bgp-add vrouter-name vr0 neighbor 2211::3 remote-as 233 multi-protocol ipv6-unicast
```

```
CLI (network-admin@Spine1) >  vrouter-bgp-network-add vrouter-name vr0 network 2200::/64
```

```
CLI (network-admin@Spine1) >  vrouter-bgp-network-add vrouter-name vr0 network 2211::/64
```

IPv6 and Prefix Lists

```
CLI (network-admin@Spine1) >  vrouter-prefix-list-add vrouter-name vr0 name block200 action deny prefix 2200::/16 seq 95
```

```
CLI (network-admin@Spine1) >  vrouter-bgp-add vrouter-name vr0 neighbor 2211::2 remote-as 222 multi-protocol ipv6-unicast prefix-list-out  block200
```

Static Route

```
CLI (network-admin@Spine1) >  vrouter-static-route-add vrouter-name vr0 network 7777::/64 gateway-ip 2200::9 distance 20
```

Layer 3 Table Validation

Layer 3 entries can become unsynchronized between the software table and the hardware table when you modify routes while the routes update in the network.

Use the `l3-setting-modify` command to automatically check Layer 3 entries:

```
CLI (network-admin@spine1) > l3-setting-modify
```

One or more of the following options:	
`aging-time` *`seconds`*	Specify the aging-time for Layer 3 entries, use 0 to disable aging.
`convergence-time` *`seconds`*	Specify the unicast convergence time on bootup (seconds)
`l3-checker|no-l3-checker`	Specify if you want to check Layer 3 consistency
`l3-checker-interval duration: #d#h#m#`	Specify the interval for Layer 3 consistency checker
`l3-checker-fix|no-l3-checker-fix`	Enable fixing of inconsistent entries

Netvisor ONE uses two commands to manually check and fix Layer 3 inconsistencies:

```
CLI (network-admin@spine1) > l3-check-show

CLI (network-admin@spine1) > l3-check-fix
```

Displaying Hardware Routes History

You can display the history of hardware routes in the RIB table. This is useful when troubleshooting hardware routing in the network.

```
CLI (network-admin@spine1) >  vrouter-rib-history-show time
15:30
```

```
time       caller      reason      ip            prelen   nexthop       flags                    vlan
intf_ip          intf_id
-------- --------- ------ ----------- ------ ----------- ------------------   ----
-----------    ---
15:29:41  router-if    add       10.16.111.0    24        10.16.111.1  in-hw,local-subnet  111
  10.16.111.1
15:29:43  router-if    add      10.16.100.0    24        10.16.100.1  in-hw,local-subnet  100
 10.16.100.1    1
```

You can also modify the settings for collecting the history:

```
CLI (network-admin@spine1) >  vrouter-rib-history-settings-
modify
```

Understanding ECMP Path Selection and Load Balancing

Pluribus Networks supports a number of technologies for traffic load balancing and path redundancy, such as LAG and vLAG.

For Layer 3 designs, Netvisor ONE supports standard routing protocols such as OSPF and BGP. When multiple next hops exist, Netvisor ONE employs ECMP (Equal-Cost Multi-Path) routing to choose amongst the available paths for traffic load balancing and redundancy.

In order to perform path selection in hardware, ECMP uses a high-performance technology called *packet field hashing*.

What that means is that the hardware extracts a number of packet fields and with them performs a special calculation to generate a *hardware index*. Such index is then used to select a next hop for an ECMP routing decision. Up to 16 next hops are supported for load balancing by the hardware-based hashing function.

About Layer 3 Hardware Hashing

A hardware hashing operation comprises two parts that can be performed at extremely high speed: first, packet field selection and extraction, then a mathematical bitwise computation.

The first step therefore is for the hardware parsing logic to select a number of packet fields 'to be hashed' depending on the traffic type. These are the traffic types and related packet fields that Netvisor ONE currently supports *by default* to perform hashing on:

Table Caption 5-1: Hardware Hashing Field Selection

Application	Traffic Type[1]	Hashed Fields
Plain unicast and multicast IPv4 packets	IP	Source IPv4 address, Destination IPv4 address, VLAN number, Destination Layer 4 port, Source Layer 4 port, IP protocol number, source physical port
Plain unicast and multicast IPv6 packets	IP	Source IPv6 address, Destination IPv6 address, VLAN number, Destination Layer 4 port, Source Layer 4 port, IP protocol number, source physical port
VXLAN packets (UDP encapsulated)	IP	Source IP address, Destination IP address, VLAN number, Destination Layer 4 port, *Source Layer 4 port*, IP protocol number, source physical port

Note: [1] Traffic types are based on IANA's Ethertype definitions (e.g., 0x0800 for IPv4 and 0x86DD for IPv6). Packet fields are based on standard protocol definitions (RFC 791 and RFC 8200 for IPv4 and IPv6 respectively).

Once the proper field values are extracted based on the traffic type (as per the table above), the second step performed by the hardware is the *hash function calculation*. Netvisor ONE uses the standard *CRC16 CCITT* cyclic redundancy check algorithm for the hash function calculation.

However, before calculating the CRC, 128-bit IPv6 source and destination addresses get 'folded' into 32-bit shortened versions with the *FoldAndXOR* method:

address_bits(127:96) ^ *address_bits(95:64)* ^ *address_bits(63:32)* ^ *address_bits(31:0)* where ^ means 32-bit XOR.

This preserves the variability over the entire 128-bit address length when fed in 32-bit chunks to the CRC16 CCITT calculation.

Configuring Static Routes

vRouters forward packets using either routing information from manually configured route tables or routing information calculated using dynamic routing algorithms.

Static routes define explicit paths between two vRouters and are not automatically updated. When network changes occur, you have to reconfigure static routes. Static routes use less bandwidth than dynamic routes.

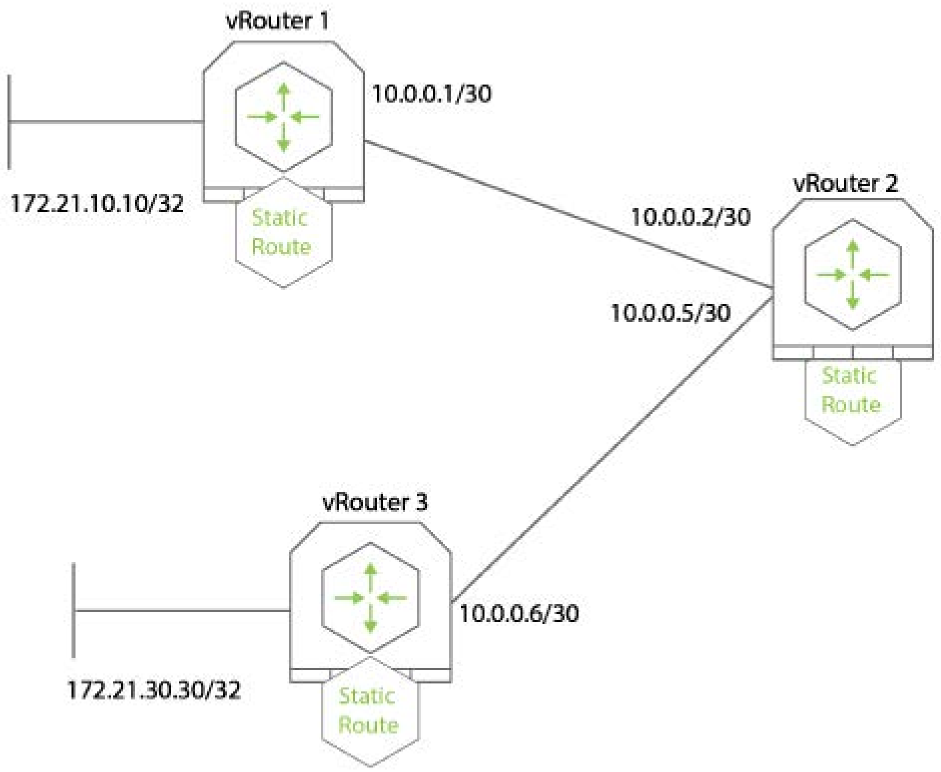


Figure 5-2 Configuring a Static Route

In this example, you configure a static route on vRouter1 by using the command `vrouter-static-route-add`.

```
CLI (network-admin@switch) > vrouter-static-route-add
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter service.
`network` *`ip-address`*	Specify the IP subnet of the network that you want to add a static route.
`netmask` *`netmask`*	Specify the netmask of the IP subnet.
`gateway-ip` *`ip-address`*	Specify the IP address of the gateway that you want to route packets destined for the network IP address to.

`drop`	Specify to drop traffic matching this route. **Note:** This option is mutually exclusive with `gateway-ip` parameter.
`bfd-dst-ip` *`ip-address`*	Specify the destination IP address for BFD monitoring.
`distance` *`number`*	Specify the administrative distance as a number between 0 and 255. • 0 – Connected interface • 1 – Static route • 110 – OSPF • 120 – RIP • 200 – Internal BGP
`interface` *`vrouter-interface-nic`*	Specify the vRouter interface for the static route, if the `gateway-ip` is a link-local IPv6 address.
`vrf` *`vrf`*	Specify the name of the VRF.

To create a static route on vRouter1 for the network 172.16.10.10/24 with a gateway IP address of 172.16.20.1, use the command:

```
CLI (network-admin@switch) > vrouter-static-route-add vrouter-name vRouter1 network 172.16.10.10/24 gateway-ip 172.16.20.1
```

To modify the configuration, use the command `vrouter-static-route-modify`.

```
CLI (network-admin@switch) > vrouter-static-route-modify vrouter-name vRouter1 network 172.16.10.10/24 gateway-ip 172.16.20.1 distance 20
```

Note: The administrative distance is the only parameter that can be modified using the `vrouter-static-route-modify` command. You must supply other parameters including `network` and `gateway-ip` correctly to make the modification.

To view the details of the configuration, use the command:

```
CLI (network-admin@switch) > vrouter-static-route-show

switch    vrouter-name network        gateway-ip  bfd-dst-ip distance interface vrf
--------- ------------ -------------- ----------- ---------- -------- --------- ---
switch1   vRouter1     172.16.10.0/24 172.16.20.1 ::         20
```

To remove the static route, use the command `vrouter-static-route-remove`. For example:

```
CLI (network-admin@switch) > vrouter-static-route-remove
vrouter-name vRouter1 network 172.16.10.10/24
```

Adding IPv6 Link-Local Addresses for Static Routing

IPv6 link-local addresses have a specific prefix `fe80::/10` and are relevant only on the local link. This makes it possible to have the same link-local address on multiple IPv6 interfaces. If you add a static route reachable through a link-local address, you must specify the outgoing interface.

For example, use the command below to specify the interface for a static route with an IPv6 link-local address as `gateway-ip`:

```
CLI (network-admin@switch) > vrouter-static-route-add vrouter-
name vr1 network 6666::/64 gateway-ip
fe80::640e:94ff:fe6f:8521 interface eth0.4092
```

To view the details, use the command:

```
CLI (network-admin@switch) > vrouter-static-route-show
```

```
switch vrouter-name network   gateway-ip                bfd-dst-ip distance interface
------ ------------ --------- ------------------------- ---------- -------- ---------
Leaf1   vr1         6666::/64 fe80::640e:94ff:fe6f:8521   ::         1       eth0.4092
```

Configuring Static Null Routing

You add a static route to a Null 0 interface when an access server with many clients is in your network. This causes Netvisor ONE to install host routes in the access server routing table. To ensure reach-ability to these clients, while not flooding the entire network with host routes, other routers in the network typically have a summary route pointing to the access server. In this type of configuration, the access server has the same summary route pointing to the access server Null 0 interface. If not, routing loops may occur when outside hosts attempt to reach IP addresses not currently assigned to a client but are part of the summary route. The access server bounces the packets back over the access server default route into the core network, and because the access server lacks a specific host route for the destination.

This feature introduces a new parameter for the command, `vrouter-static-route-add`:

```
CLI (network-admin@switch) > vrouter-static-route-add vrouter-name vr1 network 192.168.2.0/24 gateway-ip ip-address
drop         Drop packets matching this route
```

Netvisor ONE designates the drop keyword as mutually exclusive with keywords such as gateway or interface. Either drop or gateway must be used for valid syntax. Static routes with gateways cannot co-exist with drop routes for the same prefix.

```
CLI (network-admin@switch) > vrouter-static-route-show

vrouter-name network         gateway-ip    bfd-dst-ip distance  drop
------------ --------------- ------------- ---------- --------  ----
vr1          192.168.20.0/24 ::             ::         1        yes
vr1          192.168.30.0/24 192.168.100.2  ::         1        no
vr1          192.168.22.0/23 ::             ::         1        yes
```

```
CLI (network-admin@switch) > vrouter-routes-show format network, type, interface, next-hop, distance

vrouter-name network               type      interface next-hop      distance
------------ --------------------- --------- --------- ------------- --------
vr1          192.168.20.0/24       static     Null0                    1
vr1          192.168.22.0/23       static     Null0                    1
vr1          192.168.30.0/24       static     eth2.4092 192.168.100.2  1
vr1          192.168.100.0/24      connected  eth2.4092
vr1          2018:192:168:100::/96 connected  eth2.4092
vr1          fe80::/64             connected  eth2.4092
```

Configuring Static ARP for Unicast Traffic

A static Address Resolution Protocol (ARP) entry is a permanent entry in your ARP cache. You can create mappings between IP addresses and MAC addresses (called static ARP entry), which can remain active without aging out for the specified time. Netvisor ONE enables you to create static ARP entries for security and troubleshooting purposes.

One of the use cases in configuring static ARP table entries is to keep the Layer 2 and Layer 3 entries active for select hosts (IP addresses) even if those hosts do not send traffic very often. Another reason to add a static ARP entry is if you want two hosts to communicate regularly and can have a binding of the MAC address and the IP address of the hosts in general.

> **Note**: You must create a vRouter interface on the switch to send ARP requests and enable ARP binding.

The static ARP binding is established only after the first ARP packet is communicated (received and replied) between the vRouter and the host. Thereafter, the binding remains permanent by sending and receiving the ARP requests and replies as in the case of *host refresh* requests.

> Note: You can enable a static ARP on a Layer 3 entry only if the Layer 3 entry is active (see `l3-table-show` output below).

To create a static ARP entry using MAC address, use the command:

```
CLI (network-admin@switch) > static-arp-create scope [local|
cluster|fabric] mac mac-address ip ip-address
```

`static-arp-create`	Creates a unique static ARP entry
`scope [local|cluster|fabric]`	Specify the scope. A static entry with scope, `cluster` or `fabric` creates a static ARP entry configuration on one switch and enables the static flag for Layer 3 entry in the L3 table for all the other switches in the fabric or cluster.
`mac` *`mac-address`*	Unicast MAC address to bind with the IP address of the host
`ip` *`ip-address`*	IP address of the host to bind with the MAC address.
`vlan/vxlan (optional keywords)`	Specify the VLAN ID or VXLAN name for the static ARP entry configuration. You cannot specify both VLAN and VXLAN on the same configuration at the same time. You can specify either VLAN

	or VXLAN (both are optional parameters in establishing a static ARP entry.

To have the static ARP entries functional, you must have an active Layer 2 entry and a corresponding Layer 3 entry in the system.

After configuring the static ARP entry using the above CLI command, follow the tasks to ensure a working configuration:

- Check the matching Layer 3 entry (i.e, the host interface IP address and MAC address) on the switch
  - o If there is no information available, no action is required. You can view the details using the `static-arp-show` command.
  - o If a matching Layer 3 entry is found, that entry is marked with a *static* flag and you can verify this using the `l3-table-show ip <ip-address> mac <mac-address>` command.
- **When the Layer 3 entry age-out timer expires**, The static Layer 3 entries are kept alive by forced *arp-refresh*. That is, the vRouter sends an ARP request to the host and when a ARP reply is received. the L3 entry gets refreshed and remains active. This ARP reply ensures that the Layer 2 entry is refreshed, thereby, keeping the Layer 3 entry active and hence keeping the static ARP binding intact.
- If no ARP reply is received (when the port is down), then the Layer 2 entry ages out and the corresponding Layer 3 entry also ages out, keeping the *static* flag on the Layer 3 entry.
- If the ARP replies are received on a different port for the same IP address or MAC address, that triggers a modification of the previous Layer 2 entry with the new port details, which reactivates the previous Layer 3 entry and send out the ARP refresh messages. (MAC move happens)
- When the Layer 2 entry age-out timer expires, it deactivates the Layer 2 entry and the corresponding Layer 3 entry.

Note: While configuring static ARP, ensure that:

- the IP address is not 0.0.0.0 or :: for IPv6 addresses.
- the IP address is not multicast or broadcast
- the MAC is unicast only.

To delete a static ARP entry, use the command:

```
CLI (network-admin@switch) > static-arp-delete ip ip-address
```

When you delete the static ARP configuration, the corresponding Layer 3 entry is cleared off the *static* flag. In cases where there are multiple static ARP entries within the same VLAN, you must use specific parameters to delete the static ARP entry. For example, in such cases, include the required parameters in the command:

```
CLI (network-admin@switch) > static-arp-delete ip ip-address
mac mac-address vlan/vxlan
```

To view the details, use the command:

```
CLI (network-admin@switch) > static-arp-show scope [local|
cluster|fabric] mac mac-address ip ip-address
```

Below is a sample configuration for creating static ARP using the commands described earlier in this section. To create a static ARP binding between the host IP address 172.179.1.120 with the host MAC address 00:12:c0:88:0c:1d, use the command:

```
CLI (network-admin@switch) >  static-arp-create ip 172.148.0.0
mac  00:12:00:88:0c:00

CLI (network-admin@switch) >  static-arp-show scope local ip
172.148.0.0

switch  scope    ip              mac
------- ------ ------------  --------------------
switch  local  172.148.0.0  00:12:00:88:0c:00
```

When the host is actively sending ARP replies, the show command displays:

```
CLI (network-admin@switch) > l3-table-show ip 172.148.0.0
format all show-interval 1 layout vertical

mac:                    00:12:00:88:0c:00
ip:                     172.148.0.0
vlan:                   4092
intf:                   29
hw-intf:                29
rt-if:                  eth1.4092
state:                  active,static
egress-id:              100008
hit:                    1
```

When the static ARP entry is removed, the show output displays:

```
CLI (network-admin@switch) > l3-table-show ip 172.148.0.0
format all show-interval 1 layout vertical

mac:                    00:12:00:88:0c:00
ip:                     172.148.0.0
vlan:                   4092
intf:                   29
hw-intf:                29
rt-if:                  eth1.4092
state:                  active
egress-id:              100008
hit:                    23
```

Configuring VRF Aware Static ARP

Netvisor ONE offers static ARP support for VRF subnets configured with VXLAN. To have the static ARP entries functional, you must have an active VRF with subnets and a corresponding Layer 3 entry in the system. You must also create a subnet anycast gateway IP on the switch to send ARP requests. As in the case of static ARP on vRouters where ARP-reply is sent to the vRouter interface alone, the ARP-reply in this case is sent only to the subnet anycast gateway IP. For VRF configuration details, refer to the VRF section in the VXLAN chapter.

To create a static ARP entry on VXLAN enabled VRF, use the command `static-arp-create.` For example:

```
CLI (network-admin@switch) > static-arp-create scope cluster
mac 00:2d:01:00:00:02 ip 30.1.2.200 vxlan 3012
```

To view the configuration details for static ARP and VRF, use the following commands:

```
CLI (network-admin@switch) > static-arp-show

scope   ip         vxlan vlan mac
------- ---------- ----- ---- -----------------
cluster 30.1.2.200 3012  0    00:2d:01:00:00:02

CLI (network-admin@switch) > vrf-show layout vertical

name:                      vrf1
vnet:                      0:0
scope:                     local
anycast-mac:               64:0e:94:40:00:02
vrf-gw:                    ::
vrf-gw2:                   ::
vrf-gw-ipv6:               ::
vrf-gw2-ipv6:              ::
active:                    yes
hw-router-mac              hw-vrid
enable                     yes
description:

CLI (network-admin@switch) > subnet-show layout vertical

name:                      sub2
scope:                     local
vlan:                      3012
vxlan:                     3012
vrf:                       vrf1
network:                   30.1.2.0/24
anycast-gw-ip              30.1.2.1
packet-realy:              disable
forward-proto:             dhcp
state:                     ok
enable:                    yes
description:
```

To view the L3 table when the host is actively sending ARP replies, use the command `l3-table-show.`

```
CLI (network-admin@switch) > l3-table-show vxlan 3012 state 
active layout vertical

switch:                   switch
mac:                      00:2d:01:00:00:02
ip:                       30.1.2.200
vlan:                     3012
vxlan:                    3012
rt-if:
state:                    active, static
egress-id:
tunnel:
switch:                   switch2
mac:                      00:2d:01:00:00:02
ip:                       30.1.2.200
vlan:                     3012
vxlan:                    3012
rt-if:                    sub2
state:                    active, static, vxlan-loopback
egress-id:                100064
tunnel:                   auto-tunnel-10.30.0.1_10.30.1.1
```

After the static entry is removed, the L3 table output does not show the `'static'` state. This can be seen from the example below:

```
CLI (network-admin@switch) > l3-table-show vxlan 3012 state 
active layout vertical

switch:                   switch
mac:                      00:2d:01:00:00:02
ip:                       30.1.2.200
vlan:                     3012
vxlan:                    3012
rt-if:
state:                    active
egress-id:
tunnel:
switch:                   switch2
mac:                      00:2d:01:00:00:02
ip:                       30.1.2.200
vlan:                     3012
vxlan:                    3012
rt-if:                    sub2
state:                    active, vxlan-loopback
egress-id:                100064
tunnel:                   auto-tunnel-10.30.0.1_10.30.1.1
```

Guidelines and Limitations While Configuring Static ARP

- The host refresh time is twice the Layer 3 aging time (2*L3 age).
- You must create a vRouter interface on the switch to send ARP request. For VRF aware static ARP, a VRF subnet should be created.
- Host sends the ARP reply to the vRouter interface only. In the case of VRF aware static ARP, the ARP reply is sent to subnet anycast gateway IP.
- In cases where there are multiple static ARP entries within the same VLAN, use the `static-arp-delete ip` *`ip-address`* `mac` *`mac-address`* `vlan/vxlan` command to delete the specific entry.
- In the beginning, the Layer 3 entry should be activated with ping for the static ARP entry to be functional.
- Static ARP entry can be created with VLAN or VXLAN options. You cannot have both VLAN and VXLAN at the same time while creating the static ARP entry. For VRF-aware static ARP, the static ARP entry should be created only with the VXLAN option.
- When you create a static ARP entry with scope, `cluster` or `fabric,` Netvisor creates a static ARP entry configuration on one switch and enables the static flag for Layer 3 entry in the L3 table for all the other switches in the fabric or cluster.
- The modify static ARP command is not supported.

Configuring IPv4 and IPv6 Neighbor Discovery Process and Optimization

The IPv6 Neighbor Discovery Process (NDP) uses ICMPv6 messages and solicited-node multicast addresses to determine the link-layer address of a neighbor on the same network (local link), verify the reach-ability of a neighbor, and keep track of neighboring routers. NDP provides the same functionality as ARP in an IPv4 network. NDP has additional features such as auto-configuration of IPv6 addresses and duplicate address detection (DAD).

In an IPv6 Layer 3 network, a Netvisor ONE vRouter can be configured as a First Hop Router and send Router Advertisements to announce the presence, host configuration parameters, routes, and on-link prefixes. In a Layer 2 network, Netvisor ONE can enable NDP optimization to prevent flooding of neighbor solicitation messages.

Supported NDP Messages

- Router Solicitation (ICMPv6 type 133)
- Router Advertisement (ICMPv6 type 134)
- Neighbor Solicitation (ICMPv6 type 135)
- Neighbor Advertisement (ICMPv6 type 136)
- Redirect (ICMPv6 type 137)

Netvisor ONE sends Neighbor Solicitation messages (ICMPv6 Type 135) on the local link by nodes attempting to discover the link-layer addresses of other nodes on the local link. Netvisor ONE sends the Neighbor Solicitation message to the solicited-node multicast address. The source address in the neighbor solicitation message is the IPv6 address of the node sending the Neighbor Solicitation message. The Neighbor Solicitation message also includes the link-layer address of the source node.

After receiving a Neighbor Solicitation message, the destination node replies by sending a Neighbor Advertisement message (ICPMv6 Type 136) on the local link. The source address in the Neighbor Advertisement message reflects the IPv6 address of the node sending the Neighbor Advertisement message. The destination address reflects the IPv6 address of the node sending the Neighbor Solicitation message. The data portion of the Neighbor Advertisement message includes the link-layer address of the node sending the Neighbor Advertisement message.

After the source node receives the Neighbor Advertisement, the source node and destination node communicate.

Netvisor ONE uses Neighbor Solicitation messages to verify the reach-ability of a neighbor after identifying the link-layer address of a neighbor. When a node requires verification of the reachability of a neighbor, the destination address in a Neighbor Solicitation message includes the unicast address of the neighbor.

Netvisor ONE sends Neighbor Advertisement messages when a change occurs in the link-layer address of a node on a local link. When there is such a change, the destination address for the Neighbor Advertisement includes the all-nodes multicast address.

Netvisor ONE periodically sendsRouter Advertisement messages (ICMPv6 Type 134) to each IPv6 configured interface of security appliance. Netvisor ONE also sends the Router Advertisement messages to the all-nodes multicast address.

Router Advertisement messages typically include the following information:

- One or more IPv6 prefix the nodes use on the local link to automatically configure the IPv6 addresses.
- Lifetime information for each prefix included in the advertisement.
- Sets of flags that indicate the type of auto-configuration (stateless or stateful) that can be completed.
- Default router information (whether the router sending the advertisement should be used as a default router and, if so, the amount of time (in seconds) the router should be used as a default router).
- Additional information for hosts, such as the hop limit and MTU a host should use in origination packets.
- The amount of time between neighbor solicitation message re-transmissions on a given link.
- The amount of time a node considers a neighbor reachable.

Netvisor ONE sends Router Advertisements t in response to Router Solicitation messages (ICMPv6 Type 133). Hosts sends Router Solicitation messages at system startup so that the host can immediately auto-configure without waiting for the next scheduled router advertisement message. Router Solicitation messages usually sent by hosts at system startup, and the host does not have a configured unicast address, the source address in Router Solicitation messages includes the unspecified IPv6 address (0:0:0:0:0:0:0:0). If the host has a configured unicast address, the source address in the message uses the unicast address of the interface sending the Router Solicitation message. The destination address in Router Solicitation messages uses the all-routers multicast address with a scope of the link. When sending a Router Advertisement in response to a Router Solicitation message, the destination address in the Router Advertisement message uses the unicast address of the source of the Router Solicitation message.

Configure the following settings for router advertisement messages:

- The time interval between periodic Router Advertisement messages. Netvisor ONE uses the default time interval of 200 seconds with a range of 3 to 1800 seconds or 500 to 1800000 milliseconds if you specify milliseconds.

- The router lifetime value, which indicates the amount of time IPv6 nodes should consider the switch to be the default router. Valid values range from 0 to 9000 seconds. Netvisor ONE has a default value of 1800 seconds. Entering 0 indicates that the switch is not considered a default router on the selected interface.

- The IPv6 network prefixes in use on the link. In order for stateless auto-configuration to work properly, the advertised prefix length in Router Advertisement messages must always be 64 bits.

- Whether or not an interface transmits Router Advertisement messages. By default, Netvisor ONE automatically sends Router Advertisement messages in response to Router Solicitation messages. If you suppress the Router Advertisement messages, the switch appear as a regular IPv6 neighbor on the link and not as an IPv6 router.

Unless otherwise noted, the interface has specific the Router Advertisement message settings.

To configure NDP, use the vrouter-interface-config-add command:

```
CLI (network-admin@switch) > vrouter-interface-config-add
```

`vrouter-name name-string`	Specify the name of the service configuration.
Specify one of the options below:	Options:
`nic vrouter if-list nic`	Specify the vnic name.
`ospf-hello-interval <1..65535>`	Specify the OSPF hello interval from 1 to 65535. The default value is 10 (IPv4 or IPv6).
`ospf-dead-interval <2..65535>`	Specify the OSPF dead interval from 2 to 65535. The default value is 40 (IPv4 or IPv6).
`ospf-retransmit-interval <3..65535>`	Specify the OSPF retransmit interval from 3 to 65535. The default value is 5 (IPv4 or IPv6).
`ospf-priority <0..255>`	Specify the OSPF priority from 0 to 255. The default value is 1 (IPv4 or IPv6).
`ospf-auth-key ospf-auth-key-string`	Specify the OSPF authentication key (IPv4 only).
`ospf-cost <0..65535>`	Specify the OSPF Cost (IPv4 or IPv6).
`ospf-msg-digest-id <0..255>`	Specify the OSPF digest ID from 0 to 255 (IPv4 only).
`ospf-msg-digest-key ospf-msg-digest-key-string`	Specify the OSPF message digest key (IPv4 only).
`ospf-passive-if|no-ospf-passive-if`	Specify the OSPF passive interface (IPv4 or IPv6).
`ospf-network-type default|point-to-point`	Specify the OSPF network type (IPv4 or IPv6).
`ospf-bfd default|enable|disable`	Specify the BFD protocol support for OSPF fault detection.

`bfd-interval <200..3000>`	Specify the BFD desired transmit interval from 200 ms to 3000 ms. The default value is 750 ms.
`bfd-min-rx <200..3000>`	Specify the BFD required minimum receive interval from 200 ms to 3000 ms. The default value is 500 ms.
`bfd-multiplier <1..20>`	Specify the BFD detection multiplier from 1 to 20. The default value is 3.
`nd-suppress-ra|no-nd-suppress-ra`	Control the transmission of IPv6 Router Advertisements.
`ra-interval <1..1800>`	Specify the time interval between ipv6 router advertisements.
`ra-lifetime <0..9000>`	Specify the time for which router is considered as default router.

Configuring Routing Information Protocol (RIP)

Routing Information Protocol (RIP) remains the oldest routing protocol and provides networking information to routers. Routers need to know the available networks and the distance required to reach it.

RIP consists of a distance vector protocol, and uses hop counts to determine distance and destination. Every 30 seconds, RIP sends routing information to UDP port 520. If you designate the router as default gateway, the router advertises by sending 0.0.0.0 with a metric of 1.

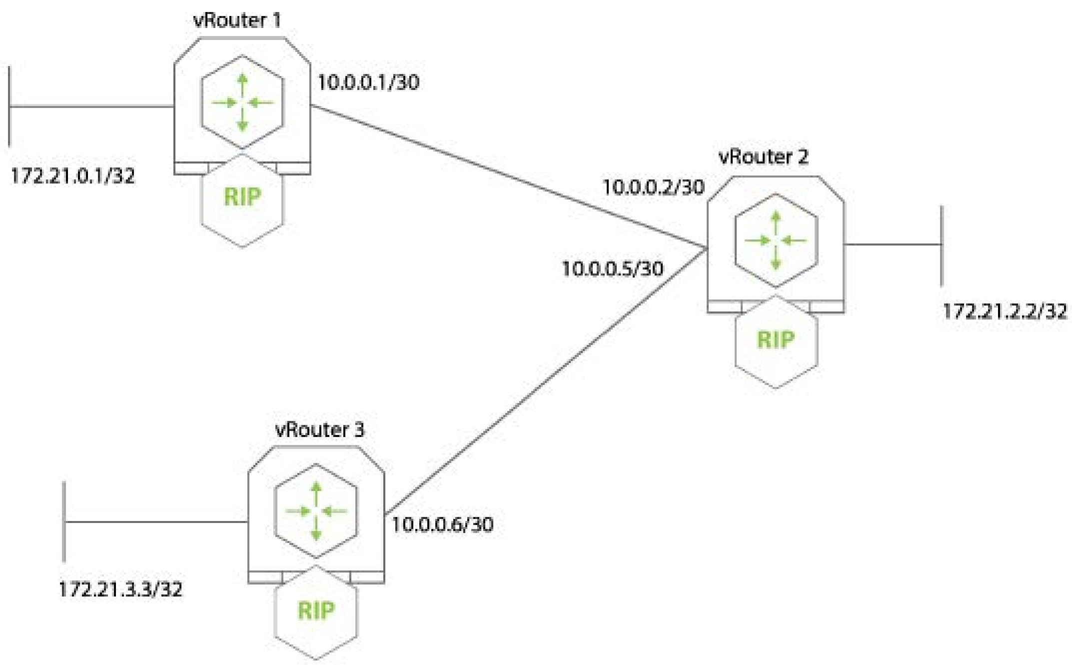


Figure 5-3: RIP Topology

1) Create vRouter1 on VLAN33:

```
CLI (network-admin@switch) > vrouter-create name vrouter1
fabricname-global router-type hardware
```

You can also specify how Netvisor ONE distributes RIP routes using the parameter, `rip-redistribute static|connected|ospf|bgp`.

2) Add network `10.16.33.0/24` to vrouter1:

```
CLI (network-admin@switch) > vrouter-rip-add vrouter-name
vrouter1 network 10.16.33.0/24 metric 2
```

3) Add network `10.16.35.0/24` to vrouter1:

```
CLI (network-admin@switch) > vrouter-rip-add vrouter-name
vrouter1 network 10.16.55.0/24 metric 2
```

4) To view the configuration, use the `vrouter-rip-show` command. This displays all RIP routes configured using the `vrouter-rip-add` command.

To view RIP routes not configured using the `vrouter-rip-add` command, use the `vrouter-rip-routes-show` command.

Configuring Open Shortest Path First (OSPF)

Open Shortest Path First (OSPF) is a robust link-state interior gateway protocol (IGP). It uses the concept of Areas which allows further segmentation on the network.

OSPF uses link-state information to make routing decisions, and make route calculations using the shortest path first (OSPF) algorithm. Each vRouter configured for OSPF floods link-state advertisements throughout the area that contains information about the interfaces attached to the router and routing metrics.

You can add more configuration options, such as hello intervals, for OSPF using the `vrouter-interface-config` commands. In addition, you can add stub or not-so-stubby areas to the OSPF configuration.

You can manually change the OSPF cost for the configuration. Cost is the metric used by OSPF to judge the feasibility of a path. If you specify 0 as the cost, the vRouter automatically calculates the cost based on the bandwidth of the interface. In Netvisor ONE, the OSPF value does not change.

> **Note:** For switches with ONVL, the only available vNET is a global vNET created when a fabric is created for the first time. Use tab complete in the CLI to display the vNET and continue the configuration.

In this example, you configure OSPF for two vRouters with an area, zero. The network has the following configuration:

- VLAN 35 with IP addresses 10.0.3.0/24
- VLAN 55 with IP addresses 172.37.0.0/24

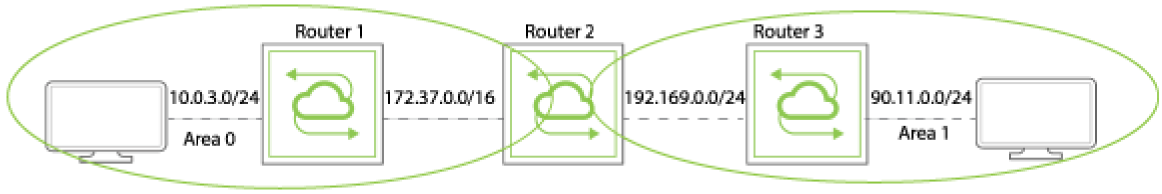


Figure 5-4 - OSPF

1) First, create the vRouter for Router1.

```
CLI (network-admin@switch) > vrouter-create name vrouter1 vnet
vnet-name fabricname-global  router-type  hardware
```

2) Add vRouter interfaces to the vRouter:

```
CLI (network-admin@switch) > vrouter-interface-add vnet  vnet-
name vrouter-name vrouter1 ip 10.0.3.0 netmask 24 vlan 35 if
data  nic-enable
```

```
CLI (network-admin@switch) > vrouter-interface-add  vrouter-name vrouter1 ip 172.37.0.0 netmask 16 vlan 55 if data nic-enable
```

3) Add the subnets, 10.0.3.0/24 and 172.37.0.0/16, to VLAN35 with the area 0:

```
CLI (network-admin@switch) > vrouter-ospf-add  vrouter-name vrouter1 network 10.0.3.0/24 ospf-area 0
```

4) Add the second IP address with the area 0.

```
CLI (network-admin@switch) > vrouter-ospf-add  vrouter-name vrouter1 network 172.37.0.0/16 ospf-area 0
```

5) Add interfaces for OSPF hello intervals of 30 seconds:

```
CLI (network-admin@switch) > vrouter-interface-config-add  name router1 nic eth0.35 ospf-hello-interval 30 ospf-cost 0

CLI (network-admin@switch) > vrouter-interface-config-add  name router1 nic eth0.55 ospf-hello-interval 30 ospf-cost 0
```

If you specify 0 as the cost value, the vRouter calculates the OSPF cost automatically based on the bandwidth of the interface. When you modify the OSPF hello interval, the `ospf-dead-interval` is automatically reset to 4 times the hello interval.

6) Display the configuration by using the vrouter-ospf-show command:

```
CLI (network-admin@switch) > vrouter-ospf-show layout vertical

vrouter-name:  vrouter1
network:  10.0.3.0
netmask:  24
ospf-area:  0
vrouter-name:  vrouter1
network:  172.37.0.0
netmask:  16
ospf-area:  0
stub-area:  11
stub-type:  stub
ospf-hello-interval:  30
metric:  34
```

The metric value can reflect the cost of routes advertised as OSPF routes. It may also reflect the cost of routes advertised with other protocols.

Displaying Default Timers for OSPF Configurations

Netvisor ONE now allows you to display default timers for OSPF configurations. To add a timer or modify an existing timer, use the following commands:

```
CLI (network-admin@switch) > vrouter-interface-config-add
```

`ospf-retransmit-interval` *`seconds`*	Specify the OSPF retransmit interval from 3 to 65535 seconds. The default is 5 seconds. (IPv4 orIPv6)

```
CLI (network-admin@switch) > vrouter-interface-config-modify
```

`ospf-retransmit-interval` *`seconds`*	Specify the OSPF retransmit interval from 3 to 65535 seconds. The default is 5 seconds. (IPv4 orIPv6)

A new command displays the OSPF configuration for an interface:

```
CLI (network-admin@switch) > vrouter-ospf-interface-show
```

`vrouter-name` *`name-string`*	Displays the name of the vRouter.
Specify any of the following optional OSPF parameters:	
`nic vrouter interface` *`nic`*	Displays the name of the vNIC.
`nic-state down|up`	Displays the NIC state.
`l3-port` *`l3-port-number`*	Displays the Layer 3 port numbers.
`ip` *`ip-address`*	Displays the IPv4 address of the interface.
`netmask` *`netmask`*	Displays the netmask of the IPv6 address.
`broadcast` *`ip-address`*	Displays the broadcast IP address.
`area ip-address`	Displays the area ID for the interface in IPv4 format.
`mtu` *`mtu-number`*	Displays MTU for the interface.
`mtu-mismatch-detection| no-mtu-mismatch-detection`	Displays if MTU mismatch detection is configured.
`router-id` *`ip-address`*	Displays the router ID as an IP address.
`network-type point-to-point| broadcast|loopback`	Displays the OSPF network type.
`state down|loopback|waiting| point-to-point|dr-other|`	Displays OSPF interface state.

`backup|dr`	
`dr-id` *`ip-address`*	Displays the designated router ID.
`dr-ip` *`ip-address`*	Displays the designated router IP address.
`bdr-id` *`ip-address`*	Displays the backup designated router ID.
`bdr-ip ip-address`	Displays the designated router IP address.
`priority` *`priority-number`*	Displays the priority.
`cost` *`cost-number`*	Displays the cost.
`hello` *`hello-number(s)`*	Displays the hello-interval in seconds.
`dead` *`dead-number(s)`*	Displays the dead time in seconds.
`retransmit` *`retransmit-number(s)`*	Displays the retransmit interval time in seconds.
`hello-due` *`hello-due-string`*	Displays the hello due in.
`neighbor` *`neighbor-number`*	Displays the neighbor count.
`adjacent` *`adjacent-number`*	Displays the adjacent number count.

```
CLI (network-admin@switch) > vrouter-ospf6-interface-show
```

`vrouter-name` *`name-string`*	Displays the name of the vRouter.
Specify any of the following optional OSPF parameters:	
`nic vrouter interface` *`nic`*	Displays the name of the vNIC.
`nic-state down|up`	Displays the vNIC state.
`l3-port` *`l3-port-number`*	Displays the Layer 3 port numbers.
`link-local` *`ip-address`*	Displays the IPv6 link-local IP address.
`ip6` *`ip-address`*	Displays the IPv6 address of the interface.
`netmask-ip6` *`netmask`*	Displays the netmask of the IP address.
`area ip-address`	Displays the area ID for the interface in IPv4 format.
`mtu` *`mtu-number`*	Displays MTU for the interface.
`mtu-mismatch-detection| no-mtu-mismatch-detection`	Displays if MTU mismatch detection is configured.
`state down|loopback|waiting| point-to-point|dr-other| backup|dr`	Displays OSPF interface state.

`dr-id` *`ip-address`*	Displays the designated router ID.
`bdr-id` *`ip-address`*	Displays the backup designated router ID.
`priority` *`priority-number`*	Displays the priority.
`cost` *`cost-number`*	Displays the cost.
`hello` *`hello-number(s)`*	Displays the hello-interval in seconds.
`dead` *`dead-number(s)`*	Displays the dead time in seconds.
`retransmit` *`retransmit-number(s)`*	Displays the retransmit interval time in seconds.
`if-scoped-lsa` *`if-scoped-lsa-number`*	Displays the number of interface LSAs scoped for the area.
`ls-update` *`ls-update-number`*	Displays the number of pending LSAs for LSUpdate.
`ls-ack` *`ls-ack-number`*	Displays the number of pending LSAs for LSAck.

Configuring Route Maps for OSPF Routes

Configure route maps to associate a redistributed metric or metric-type for OSPFv3. You can define a route map to prevent OSPF routes from getting added to the routing table. This filtering happens at the time when OSPF installs the route in the routing table.

Before you configure route maps, configure a list of prefixes using the following command:

```
CLI (network-admin@switch) > vrouter-prefix-list-add
```

Use the following set of commands to configure route maps for OSPF:

```
CLI (network-admin@switch) > vrouter-route-map-add
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter service.
`name` *`name-string`*	Specify the name for the route map.
`seq` *`integer`*	Specify the sequence number as an integer between 1 and 4294967295.
`action permit|deny`	Specify the route map action as permit or deny.
`match-prefix vrouter prefix-list` *`name-string`*	Specify the name of the prefix list used for the route map.
`community-attribute unset|none|no-export|no-advertise|internet|local-AS`	Specify the community attribute for the route map.
`local-pref` *`integer`*	Specify the local preference as an integer between -1 and 4294967295.
`metric none`	Specify the metric as none.
`metric-type 1|2`	Specify the metric type as 1 or 2.

```
CLI (network-admin@switch) > vrouter-route-map-remove
```

`vrouter-name` *`name-string`*	Specify the name of the vRouter service.
`name` *`name-string`*	Specify the name for the route map.
`seq` *`integer`*	Specify the sequence number as an integer between 1 and 4294967295.

```
CLI (network-admin@switch) > vrouter-route-map-show
```

`vrouter-name` *`name-string`*	`Displays the name of the vRouter service.`

name *name-string*	Displays the name for the route map.
seq *integer*	Displays the sequence number as an integer between 1 and 4294967295.
action permit|deny	Displays the route map action as permit or deny.
match-prefix vrouter prefix-list *name-string*	Displays the name of the prefix list used for the route map.
community-attribute unset|none|no-export|no-advertise|internet|local-AS	Displays the community attribute for the route map.
local-pref *integer*	Displays the local preference as an integer between -1 and 4294967295.
metric none	Displays the metric as none.
metric-type 1|2	Displays the metric type as 1 or 2.

Enabling or Disabling OSPF SNMP MIBs

You now enable or disable SNMP MIBs for OSPF configurations by using the command, `vrouter-create`, or `vrouter-modify`:

```
CLI (network-admin@switch) > vrouter-create name-string ospf-
snmp|no-ospf-snmp   ospf-snmp-notification|no-ospf-snmp-
notification
```

Configuring Default Route Information Settings for OSPF Routing

An OSPF vRouter, by default, does not generate a default route into the OSPF domain. In order for OSPF to generate a default route, you must explicitly configure the vRouter with this information.

There are two ways to inject a default route into a normal area.

1) If the ASBR already has the default route in the routing table, you can advertise the existing 0.0.0.0/0 into the OSPF domain with the `ospf-default-information` parameter.

2) If the ASBR doesn't have a default route, you can add the keyword `always` to the `ospf-default-information` command. However, we recommend not to add the `always` keyword.

The OSPF vRouter advertises a default route into the OSPF domain, even if a route to 0.0.0.0 is configured.

When you configure the metric type, you can use the parameters described for the `vrouter-*` commands for configuring a route map. These parameters control default route generation for IPv4 and IPv6 default routes.

```
CLI (network-admin@switch) > vrouter-create
```

`ospf-default-information none|originate|always`	Specify if you want to use the default route information for OSPF: • `none` — no default route is generated. • `originate` — the default route is generated only if a default route is present in the routing table. • `always` — the default route is generated even if no default route is present in the routing table.
`ospf-default-info-originate-metric none`	Specify the metric for the default route.
`ospf-default-info-originate-metric-type 1|2`	Specify the metric type as 1 or 2.

```
CLI (network-admin@switch) > vrouter-modify
```

`ospf-default-information none|originate|always`	Specify if you want to use the default route information for OSPF: • `none` — no default route is generated. • `originate` — the default route is generated only if a default route is present in the routing table. • `always` — the default route is generated even if no default route is present in the routing table.
`ospf-default-info-originate-metric none`	Specify the metric for the default route.
`ospf-default-info-originate-metric-type 1|2`	Specify the metric type as 1 or 2.
`ospf-default-info-originate-route-map vrouter route-map` *name*	Specify the OSPF default information route map.

```
CLI (network-admin@switch) > vrouter-show
```

`ospf-default-information none|originate|always`	Displays the default route information for OSPF: • `none` — no default route is generated. • `originate` — the default route is generated only if a default route is present in the routing table. • `always` — the default route is generated even if no default route is present in the routing table.
`ospf-default-info-originate-metric none`	Displays the metric for the default route.
`ospf-default-info-originate-metric-type 1|2`	Displays the metric type as 1 or 2.

`ospf-default-info-originate-route-map route-map` *name*	`vrouter`	Displays the OSPF default information route map.

Configuring Metric and Metric Type for Route Maps

Configure route maps to associate a redistribute metric and metric-type for OSPF and OSPFv3 and you cannot configure metrics using the current OSPF commands. Use route maps method to configure metric and metric-type on routers. Configuration of metrics and metric-type for OSPFv3 requires route maps.

```
CLI (network-admin@switch) > vrouter-route-map-add
```

`metric none`	Specify a metric for the route map.
`metric-type none|1|2`	Specify the metric type.

The new parameters also apply to the `vrouter-route-map-modify` and `vrouter-route-map-show` commands.

You can also specify metrics and route maps for vRouters configured as OSPF and BGP vRouters.

```
CLI (network-admin@switch) > vrouter-modify
```

`bgp-redist-static-route-map vrouter route-map` *name*	Specify the route map for BGP redistribution of static routes.
`bgp-redist-connected-route-map vrouter route-map name`	Specify the route map for BGP redistribution of connected routes.
`bgp-redist-ospf-route-map vrouter route-map` *name*	Specify the route map for BGP redistribution of OSPF routes.
`ospf-redist-static-route-map vrouter route-map` *name*	Specify the route map for OSPF redistribution of static routes.
`ospf-redist-connected-route-map vrouter route-map` *name*	Specify the route map for OSPF redistribution of connected routes.
`ospf-redist-bgp-route-map vrouter route-map` *name*	Specify the route map for OSPF redistribution of BGP routes.

Configuring BGP on a vRouter

Border Gateway Protocol (BGP) is a path-vector protocol and is the most commonly used routing protocol on the Internet. It advertises the paths required to reach a certain destination. BGP is also a protocol that sits on top of TCP, and is simpler than Open Shortest Path First (OSPF).

For example, in Figure 5-2, the network administrator wants to configure network traffic from the source host to reach the destination host. But when different VLANs are configured, the source host traffic is not aware of the route between the source host and the destination host. However, there is a VLAN that spans VLAN 33 and VLAN 55. You can solve this problem by configuring BGP in the same Autonomous System (AS) 100 that sends traffic over VLAN 35. This allows the source host to learn the route to the destination host.

Using a loopback address for peering is useful when there are multiple paths between the BGP peers which would otherwise tear down the BGP session if the physical interface used for establishing the session goes down. It also allows the vRouters running BGP with multiple links between vRouters to load balance over the available paths.

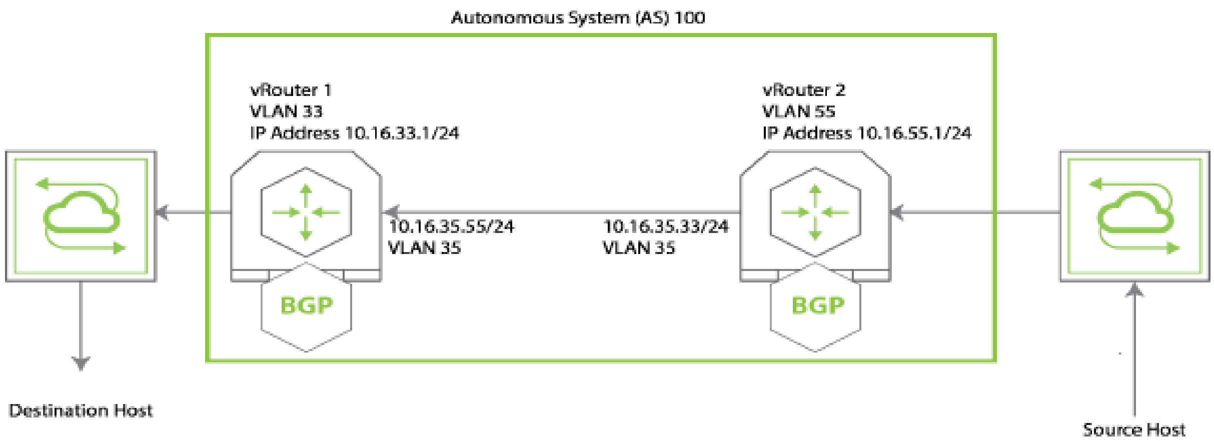


Figure 5-5: Configuring BGP for Two VLANs

This example assumes that you have two VLANs, VLAN33 and VLAN55. Also, that you have added ports to the configuration.

Begin by configuring vRouter1, a software vRouter, on VLAN 33 with the BGP information:

```
CLI (network-admin@switch) > vrouter-create name vrouter1
 fabricname-global router-type hardware bgp-as 100 bgp-redist-
connected-metric  none
```

Additional BGP parameters include the following:

- `bgp-redist-static-metric` — redistribute static BGP route metric number
- `bgp-redist-connected-metric` — redistribute connected BGP route metric
- `bgp-redist-rip-metric` — redistribute BGP into RIP process metric
- `bgp-redist-ospf-metric` — redistribute BGP into OSPF process metric
- `bgp-max-paths` — maximum number of BGP paths
- `bgp-ibgp-multipath` — allow the BGP vRouter to select multiple paths for load sharing.
- `bgp-bestpath-as-path` — allow BGP to use the best path for traffic forwarding.
- `bgp-dampening|no-bgp-dampening` — suppress flapping routes so they are not advertised.
- `bgp-stalepath-time` — how long a router waits before deleting stale routes after an end of record (EOR) message is received from the restarting router.
- `bgp-graceful-shutdown|no-bgp-graceful-shutdown`— how to configure BGP graceful shutdown (RFC8326)

Add the IP addresses and VLANs:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vrouter1 ip 10.16.35.33/24 vlan 35

CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vrouter1 ip 10.16.33.1/24 vlan 33
```

Add the BGP information:

```
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
vrouter1 neighbor 10.16.35.55 remote-as 100

CLI (network-admin@switch) > vrouter-bgp-network-add vrouter-
name vrouter1 network 10.16.33.0/24
```

Display the interface information for vrouter1:

```
CLI (network-admin@switch) > vrouter-interface-show format all
layout vertical

vrouter-name: vrouter1
nic: eth1.33
ip: 10.9.100.100/16
assignment: static
mac: 66:0e:94:30:c6:92
vlan: 33
vxlan: 0
if: data
alias-on:
```

```
exclusive:  no
nic-config:  enable
nic-state:  up
secondary-macs:
vrouter-name:  vrouter1
nic: eth2.33
ip:  192.168.42.11/24
assignment:  static
mac:  66:0e:94:30:25:5e
vlan:  33
vxlan: 0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
secondary-macs:
```

If you want to filter IP hosts, you can add prefix lists to the BGP configuration. See Configuring Prefix Lists for BGP and OSPF.

Then, configure vRouter2 on VLAN 55:

CLI (network-admin@switch) > vrouter-create name vrouter2 *fabricname-global* router-type hardware bgp-as 100 bgp-redist-connected-metric none

Add the IP addresses and VLANs:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-name vrouter2 ip 10.16.35.55/24 vlan 35

CLI (network-admin@switch) > vrouter-interface-add vrouter-name vrouter2 ip 10.16.55.1/24 vlan 55
```

Then add the BGP information:

```
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name vrouter2 neighbor 10.16.35.33 remote-as 100

CLI (network-admin@switch) > vrouter-bgp-network-add vrouter-name vrouter2 network 10.16.55.0/24
```

And finally, add the loopback address:

```
CLI (network-admin@switch) > vrouter-loopback-interface-add vrouter-name vrouter1 index 5 ip 1.1.1.1
```

Display the vRouter BGP configuration:

```
CLI (network-admin@switch) > vrouter-bgp-show format all
```

```
layout  vertical

vrouter-name:  vrouter33
ip:  10.16.35.55
neighbor:  10.16.35.55
remote-as:  100
next-hop-self: no
route-reflector-client:  no
override-capability:  no
soft-reconfig-inbound:  no
max-prefix-warn-only:  no
vrouter-name:  vrouter33
ip:  10.16.33.0
network:  10.16.33.0/24
description:  none
vrouter-name:  vrouter55
ip:  10.16.35.33
neighbor:  10.16.35.33
remote-as:  100
next-hop-self:  no
route-reflector-client:  no
override-capability:  no
soft-reconfig-inbound:  no
max-prefix-warn-only:  no
vrouter-name:  vrouter55
ip:  10.16.55.0
network:  10.16.55.0/24
description:  none
```

To reset BGP neighbors, use the `vrouter-bgp-neighbor-reset` command.

To display BGP neighbors, use the `vrouter-bgp-neighbor-show` command.

```
CLI  (network-admin@switch)  >  vrouter-bgp-neighbor-show

vrouter-name:  vrouter1
neighbor:          10.9.100.201
ver:                 4
remote-as:        100
msg_rcvd:         11
msg_sent:         19
tblver:             0
inQ:                 0
outQ:               0
up/down:            00:54:04
state/pfxrcd:  Connect
remote-router:  vrouter2
description:     none
vrouter-name:  vrouter2
neighbor:          10.9.100.101
ver:                 4
remote-as:        100
msg_rcvd:         12
```

```
msg_sent:        18
tblver:           0
inQ:                0
outQ:              0
up/down:           00:53:37
state/pfxrcd:  Connect
remote-router:  vrouter2
description:    none
```

Additional BGP Parameters

There are additional BGP parameters that you can use to optimize your BGP network. Add any of the following parameters:

- `ebgp-multihop` — a value for external BGP to accept or attempt BGP connections to external peers, not directly connected, on the network. This is a value between 1 and 255.
- `update-source  vrouter` — the source IP address of BGP packets sent by the router. This parameter is required if you want BGP to perform peering over a loopback interface.
- `prefix-list-in` — specify a list of incoming prefixes for route redistribution.
- `prefix-list-out` — specify a list of outgoing prefixes for route redistribution.
- `override-capability` — override the result of capability negotiation with the local configuration. This parameter allows you to ignore a remote peer's capability value.
- `soft-reconfig-inbound` — defines the route refresh capability by allowing the local device to reset inbound routing tables dynamically by exchanging route refresh requests to supporting peers.
- `max-prefix` — allows you to specify the maximum number of IP prefixes to filter.
- `max-prefix-warn` — add a parameter to warn when the maximum number of prefixes is reached.

Enabling or Disabling BGP SNMP MIBs

You can enable or disable SNMP MIBs for BGP configurations by using the `vrouter-create` or `vrouter-modify` commands:

```
CLI (network-admin@switch) > vrouter-create name-string bgp-
snmp|no-bgp-snmp   bgp-snmp-notification|no-bgp-snmp-
notification
```

Configuring AS and AS Prepending on BGP

You can prepend one or more autonomous system (AS) numbers at the beginning of an AS path. The AS numbers are added at the beginning of the path after the actual AS number from which the route originates has been added to the path. Prepending an AS path makes a shorter AS path look longer and therefore less preferable to BGP.

The BGP best path algorithm determines how the best path to an autonomous system (AS) is selected. The AS path length determines the best path when all of the following conditions are met:

There are multiple potential routes to an AS.

- BGP has the lowest preference value, sometimes referred to as the administrative distance, of the available routes.
- The local preferences of the available routes are equal.

When these conditions are met, the AS path length is used as the tie breaker in the best path algorithm. When two or more routes exist to reach a particular prefix, BGP prefers the route with the shortest AS Path length.

If you have multi-homing to one or more service providers, you may prefer for incoming traffic take a particular path to reach your network. Perhaps you have two connections, but one costs less than the other. Or you might have one fast connection and another, much slower connection that you only want to use as a backup if your primary connection is down. AS path prepending is an easy method that you can use to influence inbound routing to your AS.

Netvisor One has new parameters for the `vrouter-route-map-*` commands:

`CLI (network-admin@switch) > vrouter-route-map-add`

`as-path-prepend` *`integer`*	Specify a value between 1 and 4,294,967,295.
`as-path-prepend-last-as` *`integer`*	Specify a value between 1 and 10.
`as-path-exclude` *`integer`*	Specify a value between 1 and 4,294,967,295.

`CLI (network-admin@switch) > vrouter-route-map-show`

`as-path-prepend` *`integer`*	Displays a value between 1 and 4,294,967,295.
`as-path-prepend-last-as` *`integer`*	Displays a value between 1 and 10.

`as-path-exclude`	*`integer`*	Displays a value between 1 and 4,294,967,295.

Configuring Border Gateway Protocol (BGP) Communities

A BGP community is a group of prefixes that share some common property and can be configured with the BGP community attribute. The BGP Community attribute is an optional transitive attribute of variable length. The attribute consists of a set of four octet values that specify a community. The community attribute values are encoded with an Autonomous System (AS) number in the first two octets, with the remaining two octets defined by the AS. A prefix can have more than one community attribute. A BGP speaker that sees multiple community attributes in a prefix can act based on one, some or all the attributes. A router has the option to add or modify a community attribute before the router passes the attribute on to other peers.

The local preference attribute is an indication to the AS which path is preferred in order to reach a certain network. When there are multiple paths to the same destination, the path with the higher preference is preferred (the default value of the local preference attribute is 100).

Common Community Attributes

- **Standard** (well known) — These community attributes are 4 octets long, with well known values
    - Internet (0) — advertise these routes to all neighbors.
    - no-export (0xFFFFFF01) — do not advertise to outside a BGP confederation boundary.
    - no-advertise (0xFFFFFF02) — do not advertise to other BGP peers .
    - local-AS (0xFFFFFF03) — do not advertise to external BGP peers.
- **Standard** - generic (AS:value) — These community attributes are also 4 octet long, but values can be really generic. The first 16-bit number is normally the AS number of the network that sets the community or looks for it, and the second number is one that conveys the intended information, for example: 65001:100.

For example to set the community attribute, **no-export**, to all route prefixes matching prefix **subnet100**, use the following syntax:

```
CLI (network-admin@switch) > vrouter-route-map-add vrouter-
name vr1 name rmap1 seq 10 action permit match-prefix
subnet100 community-attribute no-export
```

To set the community attribute, **65002:200** to all route prefixes matching prefix subnet100, use the following syntax:

```
CLI (network-admin@switch) > vrouter-route-map-add vrouter-
name vr1 name peer vr2 action permit seq 20 match-prefix
subnet99 community-attribute-generic 65002:200
```

Community Lists

BGP community list is a user defined BGP communities attribute list. The BGP community list can be used for matching or manipulating BGP communities attribute in updates. This is used on the receive side of the BGP updates to match what is set in the received updates. Community lists can be used in route-map with match-community keyword to apply any policy on the receive side.

- **Standard** — Standard community list defines attribute which matches standard communities as defined above (well known or generic).

To set the community list permitting the community value **300** for AS **65002**, use the following syntax:

```
CLI (network-admin@switch) > vrouter-community-list-add
vrouter-name vr2 style standard name clist300 action permit
community-attribute  65002:300
```

The Netvisor One commands for `vrouter-route-maps-*` support additional parameters for BGP communities:

```
CLI (network-admin@switch) > vrouter-route-map-add
```

`match-community` *`match-community-string`*	Specify the community string to match. (BGP only)
`exact-match|no-exact-match`	Specify if the community string is an exact match or not. (BGP only)
`community-attribute-generic` *`community-attribute-generic-string`*	Specify a generic community attribute such as AA:NN. (BGP only)
`additive|no-additive`	Specify if a given community is appended to existing communities value.
`comm-list-del vrouter` *`community-list name`*	Specify if you want to remove community values from BGP community attributes.

New commands support creating BGP Communities:

```
CLI (network-admin@switch) > vrouter-community-list-add
```

`vrouter-name` *`name-string`*	Specify a vRouter to add the community list.
Add the following community list parameters:	
`style standard`	Specify the style of the community list.
`name` *`name-string`*	Specify a name for the community list.
`action permit|deny`	Specify the action for the community list.

community-attribute *community-attribute-string*	Specify the community attribute.

CLI (network-admin@switch) > vrouter-community-list-remove

vrouter-name *name-string*	Specify a vRouter to remove the community list.
Add the following community list parameters:	
style standard	Specify the style of the community list.
name *name-string*	Specify a name for the community list.
action permit|deny	Specify the action for the community list.
community-attribute *community-attribute-string*	Specify the community attribute.

CLI (network-admin@switch) > vrouter-community-list-show

vrouter-name *name-string*	Displays the vRouter name.
Add the following community list parameters:	
style standard	Displays the style of the community list.
name *name-string*	Displays a name for the community list.
action permit|deny	Displays the action for the community list.
community-attribute *community-attribute-string*	Displays the community attribute.

Configuring BGP Route Maps for Origin

Use the `vrouter-route-map` commands to define the conditions for redistributing routes from one routing protocol to another. The `route-map` command contains a list of match and set commands associated with it.

The `match` commands specify the match criteria: the conditions under which Netvisor ONE redistributes the current route-map command.

The set commands specify the set actions: the particular redistribution actions to perform if the criteria enforced by the match commands are met.

```
CLI (network-admin@switch) > vrouter-route-map-modify vrouter-name vr2 name TEST6 seq 10 origin <tab>
```

`none`	Resets the origin to none.
`egp`	Specifies the route as a remote EGP route.
`igp`	Specifies the route as a local IGP route.
`incomplete`	Route is of unknown heritage.

Configuring BGP Graceful Shutdown

The BGP Graceful Shutdown functionality enables the network administrators to gracefully shutdown all BGP sessions per vrouter between BGP peer(s). This feature does not shutdown the sessions, but notifies the neighbor peers that a maintenance event is occurring and that the traffic should be re-routed to another peer to avoid traffic black-holing. The *graceful, no traffic impact* behaviour of the feature depends on the topology and BGP setup in a network.

When a BGP speaker is rebooted, upgraded, or shut down during a maintenance window, the admin re-sends all the BGP routes (route refresh) to the neighbor peers by attaching a BGP GRACEFUL_SHUTDOWN community to each prefix. Upon receiving the prefixes, the BGP neighbors should dynamically change the local preference associated to these subnets to a very low value, typically, LP=0. By changing the local preference to 0, the BGP neighbors select another path (i.e. next-hop) to reach the prefixes carrying the GRACEFUL_SHUTDOWN community attribute. When the traffic is completely re-routed to alternate path, the BGP speaker can administratively shutdown all BGP sessions without experiencing traffic black-holing issue.

You must configure the vrouter and BGP neighbors prior to enabling the bgp-graceful-shutdown knob on the vrouter.

> **Note**: This feature do not support a per-session graceful shutdown, but supports a per-vRouter graceful shutdown (all BGP sessions of a particular vRouter are affected).

To configure BGP graceful shutdown, use the following commands (this command enables you to modify several parameters of BGP and other protocols.):

```
CLI (network-admin@switch) >  vrouter-modify name name-string
bgp-graceful-shutdown
```

`vrouter-create`	Allows you to create a hardware vRouter and specify the parameters for the vRouter.
`name` *`name-string`*	Specify a name for the service configuration.
`bgp-graceful-shutdown|no-bgp-graceful-shutdown`	Specify to enable or disable BGP graceful shutdown (RFC8326).

Below is an example of a vRouter configuration enabling BGP graceful shutdown on vr2:

```
CLI (network-admin@switch) >  vrouter-modify name vr2 router-
type hardware bgp-as 65200 router-id 22.22.22.22 bgp-graceful-
shutdown
```

To display the details, use the `vrouter-show` command (similar to other BGP parameters the new field is displayed only if the field is listed in the format statement or `format all` keyword is used) :

```
CLI (network-admin@switch) >  vrouter-show format
name,scope,router-type,bgp-as,router-id,bgp-graceful-shutdown
```

```
name scope  router-type bgp-as router-id   bgp-graceful-shutdown
---- ------ ----------- ------ ----------- ---------------------
vr1  fabric  hardware   65100  11.11.11.11    off
vr2  fabric  hardware   65200  22.22.22.22    on
vr3  local   hardware   65300  33.33.33.33    off
```

To disable BGP graceful shutdown knob, the configuration, use the command:

```
CLI (network-admin@switch) >  vrouter-modify name name-string
no-bgp-graceful-shutdown
```

Configuring BGP Unnumbered

The Border Gateway Protocol (BGP) is a path vector protocol used to exchange routing and reachability information. Traditionally, to exchange IPv4 prefixes, you must configure explicit BGP sessions with the neighbor IP address and remote-AS information for each BGP peer, which can become cumbersome in large networks. This also occupies significant address space as each BGP peer must have an IPv4 address.

By using RFC5549 (Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop), Netvisor ONE enables you to create BGP unnumbered sessions which are simpler to configure. Practically, you need not have an IPv4 address for every BGP-enabled interface and therefore it is called an unnumbered configuration. Instead of specifying an IPv4 neighbor address and the remote-AS number, you can provide the L3 port number and declare an eBGP session. BGP unnumbered uses the link-local IPv6 address as the next-hop IP address for both IPv4 and IPv6 prefixes.

In effect, the need for configuring IPv4 addresses on all BGP-enabled interfaces and the need for declaring an explicit ASN for the remote side is eliminated through BGP unnumbered.

> **Note:** Netvisor ONE does not support iBGP for unnumbered BGP sessions.

> **Note**: Prior to Netvisor ONE version 6.1.1 HF1 on Whitebox platforms, in cases where the next hop BGP neighbors on unnumbered interfaces having Netvisor ONE releases with different FRR versions (for example, Netvisor ONE version 5.2.x with FRR4 and version 6.1.1 with FRR 7.2), the route updates from FRR 7.2 gets dropped by FRR 4 based releases. See the configuration section below for additional details.

To configure a BGP unnumbered session, use the two following commands:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-name <name-string> l3-port <l3-port-usable-port-number> ipv6-unnumbered
```

`vrouter-interface-add`	Use this command to add an interface to a vRouter.
`vrouter-name` *`name-string`*	Specify the name of the vRouter to which the interface is to be added.
`vlan` *`<0..4095>`*	Specify the VLAN ID to which the interface has to be added (optional). **Note:** This option is not supported while configuring BGP unnumbered.
`Specify any of the following options:`	

`ip ip-address`	Specify the IP address to be assigned to the interface.
`Netmask` *`netmask`*	Specify the network mask for the IP address.
`Assignment [none | dhcp | dhcpv6]`	Specify one among the options as the type of IP address assignment.
`ip2` *`ip-address`*	Specify the second IP address of the interface.
`netmask2` *`netmask`*	Specify the network mask for the second IP address.
`assignment2 [none | dhcp | dhcpv6]`	Specify the type of assignment for the second IP address.
`linklocal` *`ip-address`*	Specify the IPv6 link local address.
`ipv6-unnumbered|no-ipv6-unnumbered`	Specify either of the options to enable or disable IPv6 unnumbered on the interface.
`vnet` *`vnet name`*	Specify the VNET name assigned to the vRouter.
`bd` *`bridge-domain name`*	Specify the Interface bridge domain name.
`vlan-type [public | private]`	Specify the interface VLAN type.
`if [mgmt | data | span | span2 | span3]`	Specify one among the options as the interface type.
`alias-on` *`alias-on-string`*	Specify an alias for the interface.
`exclusive | no-exclusive`	Specify if the interface is exclusive to the configuration. Exclusive means that other configurations cannot use the interface. Exclusive is specified when you configure the interface as a span interface and allows higher throughput through the interface.
`nic-enable | nic-disable`	Specify one of the options to enable or disable the NIC.
`pim | no-pim`	Specify either of the options to state if the VNIC is a Protocol Independent Multicast (PIM) interface or not.
`pim-dr-priority <1..4294967295>`	Specify the designated router priority for the PIM interface. Netvisor selects the vRouter interface with higher DR priority as the designated router.
`pim-cluster | no-pim-cluster`	Specify if the VNIC is on exclusive transit VLAN.

`fabric-nic | no-fabric-nic`	Specify if the VNIC is on a VLAN used for fabric setup or not.
`vrrp-id <0..255>`	Specify the VRRP ID.
`vrrp-primary` *`vrrp-primary-string`*	Specify the primary interface for VRRP failover.
`vrrp-priority <0..254>`	Specify the VRRP priority for the interface. This is a value between 0 (lowest) and 254 (highest).
`vrrp-adv-int <300..40950>`	Specify the VRRP advertisement interval in ms. The range is from 30 to 40950 with a default value of 1000.
`l3-port` *`l3port-usable-port name`*	Specify the name of the Layer 3 port to be added to the vrouter.
`secondary-macs` *`secondary-macs-string`*	Specify a secondary MAC address.
`mtu <68..9398>`	Specify a MTU value in bytes between 68 and 9216.
`if-nat-realm [internal | external]`	Specify the NAT interface realm as internal or external.
`priority-tag | no-priority-tag`	Specify either of the options to add a VLAN 0 priority tag on forwarded traffic or remove it.

Now, issue the second command to add a BGP neighbor to the vrouter and finish the BGP unnumbered configuration.

```
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
<name-string> l3-port <l3port-usable-port name> [remote-as
external]
```

`vrouter-bgp-add`	Use this command to add a BGP neighbor to a vrouter.
`vrouter-name` *`name-string`*	Specify the name of the vrouter to which the neighbor is being added.
Specify one of the two options:	
`neighbor` *`ip-address`*	Specify the IP address for BGP neighbor.
`l3-port` *`l3port-usable-port name`*	Specify the L3 port name for the BGP session.
Specify any of the following options:	
`remote-as <external|internal|-2..429496729>`	Supply this parameter to specify if the BGP session is external/internal or to

	provide an AS number **Note:** Specify `external` to configure a BGP unnumbered session. This parameter is redundant as an eBGP session is assumed for unnumbered BGP sessions.
`next-hop-self | no-next-hop-self`	Specify either of the options to set the next hop as self or to remove that configuration.
`password` *`password-string`*	Provide a password for MD5 BGP.
`ebgp-multihop <1..255>`	Specify the value for external BGP between 1 and 255.
`update-source` *`vrouter loopback-interface ip`*	Specify the source IP address of BGP packets sent by the router. This parameter is required if you want BGP to perform peering over a loopback interface.
`update-source-interface` *`update-source-interface-string`*	Specify the interface of BGP packets sent by the router. This parameter is required if you want BGP to perform peering over any interface.
`prefix-list-in` *`vrouter prefix-list name`*	Specify the prefix list to filter inbound packets.
`prefix-list-out` *`vrouter prefix-list name`*	Specify the prefix list to filter outbound packets.
`route-reflector-client|no-route-reflector-client`	Specify if a route reflector client is used.
`override-capability|no-override-capability`	Specify either of the options to enable or disable override capability.
`soft-reconfig-inbound|no-soft-reconfig-inbound`	Specify either of the options to enable or disable soft reset to reconfigure inbound traffic.
`max-prefix` *`max-prefix-number`*	Specify the maximum number of prefixes.
`max-prefix-warn-only|no-max-prefix-warn-only`	Specify either of the options to enable or disable the warning if the maximum number of prefixes is exceeded.
`bfd|no-bfd`	Specify either of the options to enable or disable BFD protocol support for fault detection.
`bfd-multihop|no-bfd-multihop`	Specify either of the options to enable or

	disable the use of BFD multi-hop port for fault detection.
`multi-protocol [ipv4-unicast|ipv6-unicast]`	Specify either of the options as a multi-protocol feature.
`weight [none	-1..65535]`	Specify the default weight value for the neighbor's routes either as `none` or as a value between 0 and 65535.
`default-originate|no-default-originate`	Specify either of the options to enable or disable the announcing of default routes to the neighbor.
`neighbor-keepalive-interval <0..65535>`	Specify the BGP keepalive interval in seconds. The keepalive interval stipulates how often the the keepalive messages are sent.
`neighbor-holdtime <0..65535>`	Specify the BGP holdtime in seconds. The hold time specifies how long a router will wait for incoming BGP messages before it assumes the neighbor is dead.
`connect-retry-interval <0..65535>`	Specify the BGP connect retry interval in seconds.
`send-community|no-send-community`	Specify either of the options to enable or disable the sending of any community attribute to the neighbor.
`route-map-in vrouter route-map name`	Specify the name of the route map for incoming routes.
`route-map-out vrouter route-map name`	Specify the name of the route map for outgoing routes.
`allowas-in|no-allowas-in`	Specify either of the options to allow/reject routes with local AS in AS_PATH.
`interface vrouter interface nic`	Specify the Interface to reach the neighbor.
`advertisement-interval <0..600>`	Specify the minimum interval between sending BGP routing updates.
`description` *`description-string`*	Add a vRouter BGP neighbor description.

These commands create an interface with a link-local IPv6 address and configures an eBGP session for the interface.

To view the configuration on the vrouter, use the command, `vrouter-interface-showcommand.` For example:

```
CLI (network-admin@switch) > vrouter-interface-show format nic,l3-
port,vlan,ip,ipv6-unnumbered

vrouter-name nic       l3-port vlan ip                            ipv6-unnumbered
------------ --------- ------- ---- ---------------------------- ---------------
vr1          eth0.4092 17      4092 fe80::640e:94ff:feff:7bdc/64 yes
```

View the BGP configuration by using the command:

```
CLI (network-admin@switch) > vrouter-bgp-show format l3-
port,nic,neighbor,remote-as

vrouter-name l3-port nic       remote-as
------------ ------- --------- ---------
vr1          17      eth0.4092 external
```

Use the following command to view the relevant neighbor information:

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-show vrouter-name vr2 format
neighbor,l3-port,nic,remote-as,up/down

vrouter-name  neighbor       l3-port nic        remote-as  up/down
------------  -------------  ------- ---------  ---------  --------
vr2                          17      eth2.4092 65100      00:06:20
vr2          192.168.101.1                     65100      00:02:48
```

The output shows that the neighbor field for the unnumbered interface does not have an IP address, while the l3-port and nic fields have information. Note that a BGP unnumbered session can co-exist with a numbered BGP session, but not on the same interface.

The Routing Information Database (RIB) and Forwarding Information Database (FIB) confirms that both IPv4 and IPv6 prefixes learned by BGP use IPv6 next-hop addresses:

```
CLI (network-admin@switch) > vrouter-rib-routes-show format
ip,prelen,nexthop,flags,vlan

ip            prelen nexthop                  flags vlan
------------- ------ ------------------------ ----- ----
192.168.111.0 24     fe80::640e:94ff:feff:7bdc in-hw 4092
5001:11:1::   48     fe80::640e:94ff:feff:7bdc in-hw 4092
```

```
CLI (network-admin@switch) > vrouter-fib-routes-show format
ip,prelen,vlan,port,nexthop-mac,egress-id

ip            prelen vlan port nexthop-mac       egress-id
------------- ------ ---- ---- ----------------- ---------
192.168.111.0 24     4092 17   66:0e:94:ff:7b:dc 100010
5001:11:1::   48     4092 17   66:0e:94:ff:7b:dc 100010
```

You can modify unnumbered BGP neighbor parameters by using the command `vrouter-bgp-modify`. For example:

```
CLI (network-admin@switch) >  vrouter-bgp-modify vrouter-name
vr3 l3-port 19 multi-protocol ipv6-unicast
```

You can remove an L3 port from a BGP configuration by using the command vrouter-bgp-remove. For example:

```
CLI (network-admin@switch) > vrouter-bgp-remove vrouter-name
vr3 l3-port 17
```

To remove an L3 interface from a vrouter, use the command `vrouter-interface-remove`. For example:

```
CLI (network-admin@switch) > vrouter-interface-remove vrouter-
name vr3 l3-port 20
```

To reset the Information regarding BGP neighbors, use the command vrouter-bgp-neighbor-reset. For example:

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-reset
vrouter-name vr3 l3-port port 11
```

You can shut down a BGP neighbor by using the command vrouter-bgp-neighbor-shutdown. For example:

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-shutdown
vrouter-name vr3 l3-port port 26
```

To bring a BGP neighbor back up after the shut down, use the command vrouter-bgp-neighbor-no-shutdown. For example:

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-no-shutdown
vrouter-name vr3 l3-port 10
```

As mentioned in the beginning of this topic, prior to Netvisor ONE version 6.1.1 HF1, in cases where the next hop BGP neighbors on unnumbered interfaces having Netvisor ONE releases with different FRR versions (for example, Netvisor ONE version 5.2.x with FRR4 and version 6.1.1 with FRR 7.2), the route updates from FRR 7.2 gets dropped by FRR 4 based releases.

For releases between versions 6.0.x and 6.1.1, the unnumbered neighbor interoperability with 5.2.x is not feasible. This issue is addressed in version 6.1.1 HF1 and beyond with the introduction of a new BGP config option, `unnumbered-interop` on a per unnumbered neighbor basis. For example, use the `unnumbered-interop` parameter in the `vrouter-bgp-add` or `vrouter-bgp-modify` commands as:

```
CLI(network-admin@switch)> vrouter-bgp-modify vrouter-name
<name-string> l3-port <l3port-usable-port name> unnumbered-
interop
OR
CLI(network-admin@switch)> vrouter-bgp-add vrouter-name <name-
string> l3-port <l3port-usable-port name> unnumbered-interop
```

The `no-unnumbered-interop` option restores the configuration to default values. In the newer releases when configured with the new knob, `unnumbered-interop`, Netvsior sends both *link-local* and *global next-hop* in the BGP Update. This option is specific to interop with unnumbered neighbors.

Below is an output of a sample configuration:

```
CLI(network-admin@switch)> vrouter-bgp-show format l3-
port,neighbor,unnum-interop,

vrouter-name        l3-port             unnum-interop
------------------- ------------------- -------------
antlia-dc-1-vrouter antlia-dc-1-eq-dc-1 no
antlia-dc-1-vrouter 53                  yes
```

Configuring BGP ASN Migration Mechanisms

Netvisor ONE release 6.1.0 supports BGP mechanisms for Autonomous System Number (ASN) migration as specified in RFC7705. These mechanisms are leveraged in the scenario of an Internet Service Provider (ISP) merger, acquisition, or divestiture to ensure that internal and external BGP speakers are migrated seamlessly from one ASN to another.

Consider the use case where there are two ISPs, ISP M (AS 65300) and ISP N (AS 65400) directly attached to customer X (AS 65200) and customer Y (AS 65100) respectively. In a scenario where ISP M merges the ASNs of both ISP M and ISP N, AS 65300 becomes the permanently retained ASN used across the consolidated set of both ISPs' network equipment, while AS 65400 is retired. After the ASN migration, there will be only ISP M and all internal BGP speakers are configured to use AS 65300. This is illustrated by figures 1 and 2 below.

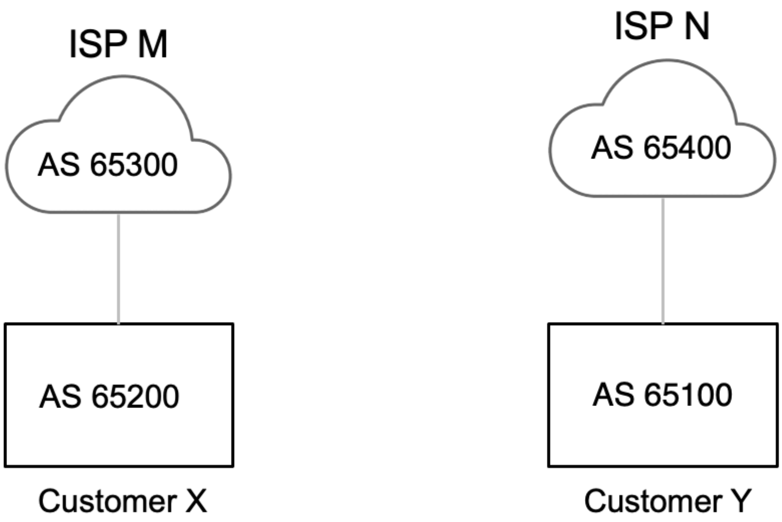


Figure 5-6: Before Migration

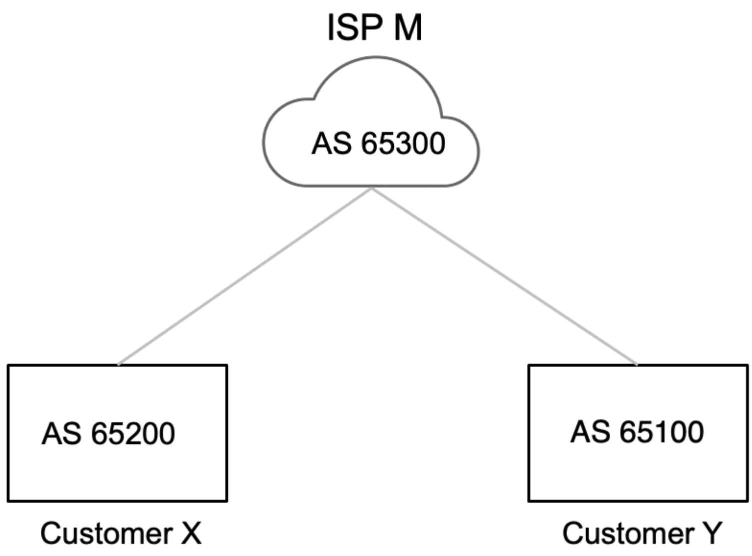


Figure 5-7: After Migration

During the migration, ISP N changes the global BGP ASN used by a Provider Edge (PE) router, from ASN 65400 to 65300. Immediately after this change, the router is no longer able to establish External BGP (eBGP) sessions toward the existing Customer Edge (CE) routers that are connected to it and still using AS 65400. Here, we make use of the migration mechanisms to enable the router to establish BGP neighbors using the legacy ASN and to modify the AS_PATH advertisement when transmitted toward CE devices to achieve the desired effect of not increasing the length of the AS_PATH.

Configuring "Local AS" Mechanism

The "Local AS" mechanism allows the PE router undergoing the ASN migration to establish eBGP sessions with existing CE devices that are using old ASN. This result is achieved by superceding the globally configured ASN with a locally defined ASN for a BGP neighbor or a group of neighbors. When this feature is used, the local router prepends the old or local ASN to the AS_PATH while installing or advertising routes received from a CE to iBGP neighbors inside the Autonomous System.

In the example illustrated below, when Local AS is configured on PE-Y, CE-X sees an AS_PATH of 65300 65400 65100, with an increased (and hence not desirable) AS_PATH length. The "No Prepend Inbound" mechanism described below solves this issue.

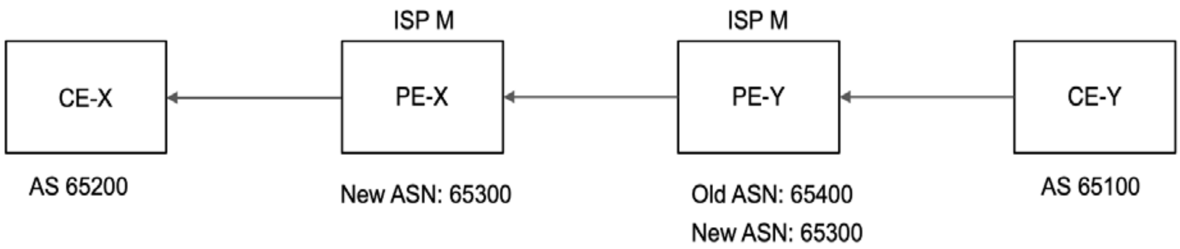


Figure 5-8: Local AS and No Prepend BGP UPDATE Diagram

To configure Local AS mechanism on the PE router which migrates to the new ASN, use the command:

```
CLI (network-admin@switch) > vrouter-bgp-modify vrouter-name
vr1 neighbor-ip 192.168.10.1 local-as 65400
```

Configuring the "No Prepend Inbound (of Local AS)" Mechanism

The "No Prepend Inbound " mechanism is used in conjunction with the Local AS mechanism. When `no-prepend` option is configured, the local BGP routers do not prepend the old or local ASN value to the AS_PATH while installing or advertising routes received from the CE. As a result, for the illustrated case above, CE-X sees an AS_PATH of 65100 65300, with a reduced AS_PATH length.

In this case, the `no-prepend` option has to be configured in the inbound direction on PE-Y, that is, in the direction of reception of routes. Use the command below to enable this option.

```
CLI (network-admin@switch) > vrouter-bgp-modify vrouter-name
vr1 neighbor-ip 192.168.10.1 local-as 65400 no-prepend
```

If you do not configure the `no-prepend` option , PE-X may drop the route it receives from PE-Y as the presence of the old ASN in the AS_PATH is perceived as a routing loop.

Table 1 - No Prepend Inbound Configuration

Configuration	AS_PATH as seen by CE-X
Without `no-prepend`	65100 65400 65300
With `no-prepend`	65100 65300

Configuring the "Replace Old AS" Mechanism

The "Local AS" and "No Prepend Inbound" configurations do not modify the AS_PATH attribute for BGP UPDATEs that are transmitted by the ISP's PEs to CE devices in the outbound direction. The "Replace Old AS" capability allows ISP M to prevent routers from appending the global or new ASN in outbound BGP UPDATEs toward customer networks that are using the "Local AS" mechanism. Instead, only the old or local AS is prepended in outbound BGP UPDATEs.

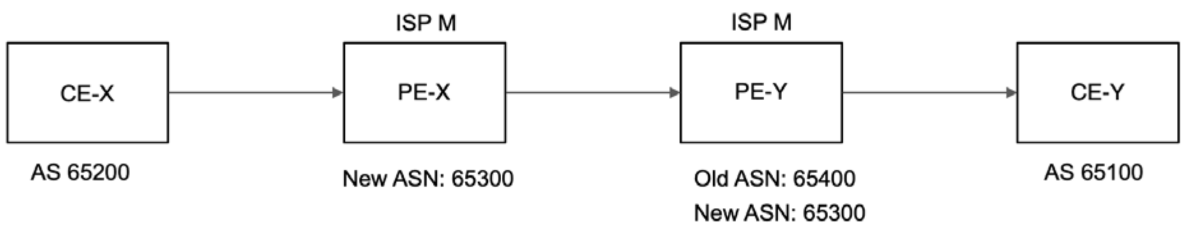


Figure 5-9: Replace AS BGP UPDATE Diagram

For example, without the use of "Replace Old AS", CE-Y would see an AS_PATH of 65400 65300 65200, with an unacceptable increase in AS_PATH length. After you configure

PE-Y to use "Replace Old AS", CE-Y receives an AS_PATH of 65400 65200, which is the same AS_PATH length prior to AS migration. Therefore, the Replace AS configuration helps retain the same AS_PATH length before and after ISP migration.

To configure this mechanism, use the `replace-as` option as in this example:

```
CLI (network-admin@switch) > vrouter-bgp-modify vrouter-name
vr1 neighbor-ip 192.168.10.1 local-as 65400 no-prepend
replace-as
```

Table 2 - Replace Old AS Configuration

Configuration	AS_PATH as seen by CE-Y
Without `replace-as`	65400 65300 65200
With `replace-as`	65400 65200

Configuring Prefix Lists for BGP and OSPF

Prefix lists allow you to permit or deny host IP addresses from route distribution in BGP and OSPF configurations. To configure prefix lists for BGP, this example assumes that you have a vRouter configured for BGP, vrouter-bgp, and you want to deny the IP address, 172.26.0.0 with the netmask 255.255.0.0, sequence number 5, and minimum prefix length 17 bits:

```
CLI (network-admin@switch) > vrouter-prefix-list-add vrouter-name vrouter-bgp name deny-bits action deny prefix 172.26.0.0 netmask 255.255.0.0 seq 5 min-prefix-len 17
```

This prefix list rejects any subnets of 172.26.0.0/16 with prefixes 17 bits or longer. For example, the subnets 172.26.16.9/30 and 172.26.101.0/24 are rejected from route distribution.

The sequence number allows you to insert or remove new lines in a prefix list as well as at the beginning or end. It is recommended that you increment the sequence numbers by 10 so you can easily add or subtract lists from the configuration. See also:

- Configuring Open Shortest Path First (OSPF)
- Configuring BGP on a vRouter

Configuring Bidirectional Forwarding Detection for IPv4 and IPv6

This feature adds bidirectional forwarding detection for IPv4 and IPv6 BGP neighbor and provides support for IPv6 BGP NBR reach-ability detection by using BFD protocol. When a BFD session goes from UP to DOWN, BFD informs BGP to bring the neighbor (NBR) down, until BFD returns to an UP state.

You create the BFD session by adding the bfd parameter to the vRouter configuration using the bfd parameter for the command, vrouter-bgp-modify. IPv6 BFD sessions for BGP NBRs are hosted in Netvisor ONE. The BFD session is started when you add the bfd parameter the BGP vRouter configuration.

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-show layout
vertical

 vrouter-name:                vr10
 neighbor:                    2002:100::2
 ver:                         4
 remote-as:                   51000
 msg_rcvd:                    189
 msg_sent:                    193
 up/down:
 state/pfxrcd:                00:00:49 0
 multi-protocol:              ipv6-unicast
 description:                 none
```

Netvisor ONE supports IPv6 static route reach-ability detection using BFD protocol. Add IPv6 BFD session by specifying two end point IPv6 addresses, a source IPv6 address and a destination IPv6 address. The source IPv6 address must be a known local IPv 6 address. When a BFD session is up, Netvisor ONE assesses all the IPv6 static routes configured with a gateway or a BFD destination IPv6 address matching the destination IPv6 address of the BFD session. When a match is found, this static route is installed in Routing Information Database (RIB) and Forwarding Information Database (FIB).

```
CLI (network-admin@switch) > vrouter-static-bfd-show layout
vertical

 vrouter-name:                vr10
 src-ip:                      2006:100::2
 dst-ip:                      2002:100::2
```

```
type:                               multi-hop
```

Configuring BFD for OSPF Fault Detection

Bidirectional Forwarding Detection (BFD) can be used for OSPF fault detection. This feature provides fast failure detection when there is an intermediate device between two non-adjacent OSPF neighbors. That is, BFD provides fast failure detection between two nodes and notifies any protocol (OSPF) of this event to make it converge much faster than with default timers in protocols. Since OSPF hello timers may not be fast enough for detecting neighbor loss, you can use BFD to establish a BFD connection with the OSPF neighbor and bring an OSPF neighbor down as soon as BFD detects an issue.

Note that BFD is used for down detection only. This means that regular OSPF neighbor discovery and state machine transitions are not affected by enabling BFD.

You can enable BFD on all OSPF interfaces at the global level or on a specific interface. By default, BFD is disabled globally and on all interfaces. Individual interface configuration takes precedence over the global configuration.

> **Note:** BFD is not supported for OSPFv6.

Setting the vrouter global OSPF level:

To enable OSPF BFD per vRouter on global OSPF level:

`CLI (network-admin@switch) > vrouter-modify name` *`vrouter-name`*

`vrouter-modify`	Modify a vrouter
One or more of the following options	
`ospf-bfd-all-if|no-ospf-bfd-all-if`	Enables or disables BFD protocol for fault detection on all OSPF interface. Default is disabled

Setting the Interface (nic) OSPF level:

To enable OSPF BFD per interface :

`CLI (network-admin@switch) > vrouter-interface-config-add vrouter-name` *`nic`*

`vrouter-interface-config-add`	Add an interface configuration to a vRouter VNIC name.
One or more of the following options	
`nic vrouter interface nic`	Specify the name of the vNIC.
`[ospf-bfd] default|enable|disable`	Enable BFD protocol support for OSPF fault detection

To modify OSPF BFD per interface:

```
CLI (network-admin@switch) > vrouter-interface-config-modify
vrouter-name name nic nic ospf-bfd  enable|disable|default
```

`vrouter-interface`	Modify an interface configuration to a vRouter
One or more of the following options:	Specify the name of the VNIC.
`ospf-bfd enable|disable|default`	Enables or disables the BFD protocol for fault detection on all OSPF interface. Default is disabled.

Displaying the OSPF BFD Configuration State

To display the configuration state of OSPF BFD, use these `show` commands:

```
CLI (network-admin@switch) > vrouter-show
```

```
CLI (network-admin@switch) > vrouter-interface-show
```

> **Note:** There are no changes to the commands: `vrouter-ospf-neighbor-show` and `vrouter-bfd-neighbor-show`

Configuring Optimized BFD Path

To address BFD flaps, Netvisor ONE offers an optimized path for BFD control packets to reach a destination vRouter. BFD packets are relayed by the Netvisor ONE OS from the switch to the destination vRouter using a PCIe link which connects one of the switch ports to the host CPU. The BFD fastpath functionality alleviates BFD timeout/delay issues when other high bandwidth traffic is coming to the host CPU.

The optimized path option can be enabled or disabled using the command:

```
CLI (network-admin@switch) > system-settings-modify
```

`system-settings-modify`	Use this command to modify system settings.
Specify one or more of the following options:	
`optimize-arps|no-optimize-arps`	Enable or disable ARP optimization.
`lldp|no-lldp`	Enable or disable LLDP.
`policy-based-routing|no-policy-based-routing`	Enable or disable Policy-Based Routing (PBR). This enables flexible packet forwarding and routing through user-defined policies.
`optimize-nd|no-optimize-nd`	Enable or disable ND optimization.
`reactivate-mac|no-reactivate-mac`	Enable or disable reactivation of aged out MAC entries.
`reactivate-vxlan-tunnel-mac|no-reactivate-vxlan-tunnel-mac`	Enable or disable reactivation of MAC entries over VXLAN tunnels.
`manage-unknown-unicast|no-manage-unknown-unicast`	Enable or disable unknown unicast management.
`manage-broadcast|no-manage-broadcast`	Enable or disable broadcast management
`block-loops|no-block-loops`	Enable or disable loop blocking. **Note**: This parameter is available only on NSU, NRU-02, NRU-03, and NRU-S0301 platforms.
`auto-trunk|no-auto-trunk`	Enable or disable auto trunking.
`auto-host-bundle|no-auto-host-bundle`	Enable or disable auto host bundling.

`cluster-active-active-routing|no-cluster-active-active-routing`	Enable or disable active-active routing on a cluster.
`fast-route-download|no-fast-route-download`	Enable or disable fast route download from routesnoop.
`fast-interface-lookup|no-fast-interface-lookup`	Enable or disable fast router interface lookup.
`routing-over-vlags|no-routing-over-vlags`	Enable or disable routing to vLAGs from cluster links.
`source-mac-miss to-cpu|copy-to-cpu`	Specify either of the options as the unknown source MAC learn behavior.
`use-igmp-snoop-l2|use-igmp-snoop-l3`	Specify whether L2 or L3 tables are to be used for IGMP snooping.
`vle-tracking-timeout <3..30>`	Set a VLE tracking timeout as a value between 3 and 30s. The default timeout is 3s.
`pfc-buffer-limit` *`pfc-buffer-limit-string`*	Specify the percent of global system buffer space allowed for PFC.
`cosq-weight-auto|no-cosq-weight-auto`	Specify either of the options to enable or disable automatic weight assignment for CoS (Class of Service) queues based on min-guarantee configuration.
`lossless-mode|no-lossless-mode`	Enable or disable lossless mode.
`stagger-queries|no-stagger-queries`	Stagger igmp/mld snooping queries.
`host-refresh|no-host-refresh`	Enable or disable refreshing host ARP entries to keep L2 entries active.
`proxy-conn-retry|no-proxy-conn-retry`	Enable or disable proxy connection retry.
`proxy-conn-max-retry 0..10`	Set the maximum number of proxy connection retry attempts as a value between 0 and 10.
`proxy-conn-retry-interval 100..2000`	Set the number of milliseconds to wait between proxy connection retry attempts. This is a value between 100 and 2000.
`nvos-debug-logging|no-nvos-debug-logging`	Logging mode selection (Direct OR viz. nvlog demon)
`manage-l2-uuc-drop|no-manage-l2-uuc-drop`	Enable or disable L2 UUC (Unknown Unicast Drop) towards data port.
`xcvr-link-debug|no-xcvr-`	Enable or disable system debug to capture

link-debug	link information.
fastpath-bfd|no-fastpath-bfd	Enable or disable BFD fastpath. This feature is disabled by default.
linkscan-interval 10000..1000000	Specify the linkscan interval as a value between 10000µ s and 1000000µ s. The default value is 150000µ s.
linkscan-mode software| hardware	Specify the linkscan mode as hardware or software. Software linkscan mode is enabled by default.
single-pass-flood|no-single-pass-flood	Enable or disable single-pass flood.

For example, use the command below to enable BFD fastpath:

```
CLI (network-admin@switch) > system-settings-modify fastpath-bfd
```

This command creates a new vFlow which redirects all BFD packets to CPU through the PCIe link.

To see the status of BFD fastpath on a switch, use the command `system-settings-show`. For example, to view the BFD fastpath status exclusively, use the command:

```
CLI (network-admin@switch) > system-settings-show format fastpath-bfd

fastpath-bfd: off
```

Netvisor ONE has the transmission queue `tx-class-inband-bfd` for sending out BFD packets. For reception, the `rx-bfd` queue is used.

To view the details of the transmission queue, use the command:

```
CLI (network-admin@switch) > nv-queue-stats-show name tx-class-inband-bfd
```

To view the receiver queue details, use the command:

```
CLI (network-admin@switch) > nv-queue-stats-show name rx-bfd
```

Configuring Policy-Based Routing

Policy-Based Routing (PBR) enables flexible packet forwarding and routing through user defined policies. Unlike traditional routing based on destination IP address only, PBR allows you to define flexible routing policies based on other parameters such as source and destination IP addresses, IP protocol type, or source and destination L4 port numbers.

PBR policies are implemented with vFlow entries, which Netvisor ONE allocates in a dedicated (hardware) vFlow table, called *System-L3-L4-PBR*.

In addition, the PBR policy configuration process leverages the vFlow command syntax as explained later in this section (refer also to the *Configuring and Using vFlows* section for further details on the feature).

PBR routing policies are higher priority than static and dynamic routes. They can match packets based on all Layer 4 and Layer 3 packet fields, as supported by the vFlow configuration syntax.

> **Note:** If a PBR policy clause is matched but the next-hop is not resolved, then the matching traffic is dropped until the next-hop gets resolved.

To enable PBR, use the following command:

```
CLI (network-admin@switch) > system-settings-modify policy-based-routing

Note: nvOSd must be restarted for this setting to take effect
```

To disable PBR, use the following command:

```
CLI (network-admin@switch) > system-settings-modify no-policy-based-routing
```

> **Note:** Restart the switch for this setting to take effect.

Use the following vflow command to configure a PBR policy. For details on configuring vFlows, see the *Configuring and Using vFlows* chapter.

```
CLI (network-admin@switch) > vflow-create name <policy-name> vrouter-name <vr-name> scope local [<match qualifiers>] action to-next-hop-ip action-to-next-hop-ip-value <ip-address> table-name System-L3-L4-PBR-1-0
```

> **Note:** You can only specify the scope as `local`.

Use the following command to modify the PBR policy:

```
CLI (network-admin@switch) > vflow-modify name <policy-name>
vrouter-name <vr-name> [<match qualifiers>] action to-next-
hop-ip  action-to-next-hop-ip-value  <ip-address>
```

Use the following command to delete the policy:

```
CLI (network-admin@switch) > vflow-delete name <policy-name>
```

Below is an example of PBR policy creation:

```
CLI (network-admin@switch) > vflow-create name test_pbr scope
local in-port 10 src-ip 192.168.1.1 src-ip-mask 255.255.255.0
vrouter-name vr1 action to-next-hop-ip action-to-next-hop-ip-
value  192.168.10.10
```

To view the configure policy, use the following command:

```
CLI  (network-admin@switch)>  vflow-show

switch:   spine1
name:     test_pbr
scope:    local
type:     pbr
in-port:  10
src-ip:   192.168.1.1/255.255.255.0
burst-size:    auto
vrouter-name:  vr1
precedence:    default
action:   to-next-hop-ip
action-to-next-hop-ip-value: 192.168.10.10
enable:   enable
table-name:    System-L3-L4-PBR-1-0
```

To modify this policy, the *vrouter name* and *action to-next-hop-ip* parameters are required in `vflow-modify` command to identify it is a *PBR vFlow entry* that is getting modified. For example, this command modifies the in-port value:

```
CLI (network-admin@switch) > vflow-modify name test_pbr in-
port 20 vrouter-name vr1 action to-next-hop-ip action-to-next-
hop-ip-value  192.168.10.10
```

To display the vFlow table's usage and a specific PBR policy, use the following command sequence:

```
CLI (network-admin@switch) > vflow-table-show layout vertical

name:     Egress-Table-1-0
flow-max-per-group:512
flow-used:     0
flow-tbl-slices:    2
capability:    match-metadata
flow-profile:  system
name:     System-L1-L4-Tun-1-0
```

```
flow-max-per-group:2048
flow-used:     54
flow-tbl-slices:   2
capability:    set-metadata
flow-profile:  system
name:     System-VCAP-table-1-0
flow-max-per-group:512
flow-used:     0
flow-tbl-slices:   1
capability:    none
flow-profile:  system
name:     System-L3-L4-PBR-1-0
flow-max-per-group:
flow-used:
flow-tbl-slices:
capability:    set-metadata
flow-profile:  system


CLI (network-admin@switch) > vflow-show name pbr_test layout
vertical

name:     pbr_test
scope:    local
type:     pbr
src-ip:   10.10.10.1/255.255.255.0
burst-size:    auto
vrouter-name:  vr1
precedence:    default
action:   to-next-hop-ip
action-to-next-hop-ip-value: 30.30.30.1
enable:   enable
table-name:    System-L3-L4-PBR-1-0
```

Sending Network Traffic to an ECMP Group with PBR

When it is required to specify multiple next hops for redundancy purposes in Policy-Based Routing policies, it is possible to use *static ECMP groups*. They can be created with the `static-ecmp-group-create` command and then used in a vFlow PBR configuration to identify all the next hops.

You can add up to 16 next hops (NH) to an ECMP group.

Static ECMP groups can be defined with any of the three scopes: `local`, `cluster` or `fabric`. They can become active only if they are associated with a vRouter in the configuration. In other words, only if a static ECMP group is associated with a vRouter or a VRF (with an active sub-net), does Netvisor ONE create an ECMP group entry in the hardware.

A static ECMP group can be associated with a vFlow PBR policy by using the `action to-ecmp-group` and the group's name as the action value for `action-to-ecmp-group-value`. For example:

```
CLI (network-admin@switch) > vflow-create name PBR_ECMP scope
local src-ip 3.3.3.0/24 vlan 300 action to-ecmp-group action-
to-ecmp-group-value group_name vrouter-name vr-s2 table-name
System-L3-L4-PBR-1-0
vflow-create: ecmp group group_name not created in hw
```

In the above case the vRouter did not exist hence the group was not programmed in hardware.

In addition, only if a Layer 3 entry is resolved and therefore is active as a given next hop, the associated egress ID is added to the ECMP group. Then, if a vFlow policy using the ECMP group is matched by some traffic, the hardware hashes (i.e., distributes) the traffic over the corresponding active next hops based on the Layer 3 and Layer 4 fields in the packets.

You can use the following command to create a static ECMP group associated to a vRouter:

```
CLI (network-admin@switch) > static-ecmp-group-create
```

`group-name` *`group-name-string`*	Specify an ECMP group name.
`scope local|cluster|fabric`	Specify the scope of the group.
`vrouter-name` *`vrouter-name`*	Specify the vRouter name.
`vrf` *`vrf-name`*	Specify the name of the VRF.
`vnet` *`vnet-name`*	Specify the vNET for the static ECMP group. **Note:** `vnet` is an optional parameter that you can specify along with `vrf`.

`hash-type static-fixed|resilient`	Specify the ECMP hash type.

For example:

```
CLI (network-admin@switch) > static-ecmp-group-create group-name gr1 scope local vrf vrf1 vnet vnet1 hash-type static-fixed
```

To display a static ECMP group's information you can use the command:

```
CLI (network-admin@switch) > static-ecmp-group-show
```

`group-name group-name-string`	Displays an ECMP group name.
`scope local|cluster|fabric`	Displays the scope of the group.
`vrouter-name vrouter-name`	Displays the vRouter name.
`vrf` *`vrf-name`*	Displays the name of the VRF.
`vnet` *`vnet-name`*	Displays the vNET for the static ECMP group.
`vrid vrid-number`	Displays the vRouter ID.
`hw-ecmp-id hw-ecmp-id-number`	Displays the hardware ID.
`hash-type static-fixed|resilient`	Displays the ECMP hash type.

For example, to view the information for the static ECMP group `gr1` configured above, use the command:

```
CLI (network-admin@switch) > static-ecmp-group-show group-name gr1

switch    group-name scope vrf  vnet   vrid hw-ecmp-id hash-type
------- ----------   ----- ---- ----   ---- ---------- ------------
switch1   gr1        local vrf1 vnet1  1    200256     static-fixed
```

You can use the following command to delete a static ECMP group:

```
CLI (network-admin@switch) > static-ecmp-group-delete group-name group-name-string
```

> **Informational note**: You cannot delete a static ECMP group while it is in use by any vFlow configuration.

You can use the following command to modify a static ECMP group:

```
CLI (network-admin@switch) > static-ecmp-group-modify group-name <group-name-string> vrouter-name <vrouter name> hash-type static-fixed|resilient
```

To add or remove a next hop to an ECMP group you can use:

```
CLI (network-admin@switch) > static-ecmp-group-nh-add
```

`group-name group-name-string`	Specify the name of the ECMP group.
`ip ip-address`	Specify the IP address for the next hop.

```
CLI (network-admin@switch) > static-ecmp-group-nh-remove
```

`group-name group-name-string`	Specify the name of the ECMP group.
`ip ip-address`	Specify the IP address for the next hop.

To show the next hop information you can use:

```
CLI (network-admin@switch) > static-ecmp-group-nh-show
```

`group-name group-name-string`	Displays the name of the ECMP group.
`ip ip-address`	Displays the IP address for the next hop.
`vlan vlan-id`	Displays the VLAN of the next hop.
`egress-id egress-id-number`	Displays the hardware egress ID.

By default ECMP groups use a fixed hashing algorithm to distribute the traffic across multiple next hops. The advantage of this choice is that such algorithm is simple to implement in hardware and hence is widely available on all switch models.

However, when a link associated with a next hop goes down, the traffic is automatically re-distributed to adapt to the change in the number of paths: this action requires a complete remapping of the hash values thus resulting in unnecessary traffic disruption for certain flows.

Therefore, starting from Netvisor ONE release 5.1.1, on certain models only, a new more flexible hashing algorithm is supported. It is called *resilient hashing*, because it helps prevent unnecessary traffic disruption when the number of next hops changes.

The hash type can be specified as a parameter when a static ECMP group is created like so:

```
CLI (network-admin@switch) > static-ecmp-group-create group-
name <name> [hash-type static-fixed|resilient]
```

The default hash type is static-fixed. For example, two groups with two different hash types can be created with the following commands:

```
CLI (network-admin@switch) > static-ecmp-group-create group-
name gr1 scope fabric
```

```
CLI (network-admin@switch) > static-ecmp-group-nh-add group-name gr1 ip 2.2.2.2

CLI (network-admin@switch) > static-ecmp-group-create group-name gr2 scope fabric hash-type resilient

CLI (network-admin@switch) > static-ecmp-group-nh-add group-name gr2 ip 3.3.3.3

CLI (network-admin@switch) > static-ecmp-group-show

group-name scope  vrouter-name vrid hw-ecmp-id hash-type
---------- ------ ------------ ---- ---------- -------------
gr1        fabric   vr1          1    200001    static-fixed
gr2        fabric   vr1          1    200000    resilient
```

Informational note: Resilient hashing is not supported in the following switch models:

- Dell Z9100, Freedom F9532-C
- Dell S5048, Freedom F9572L-V

Configuring vRouter-based VRF (Virtual Routing and Forwarding)

Virtual Routing and Forwarding (VRF) is a technology that is used to partition the routing table into virtual instances (called VRF instances, or simply VRFs) that segregate routing entries in the control plane as well as in the data plane. Because the routing instances are independent, the same or overlapping IP addresses can be used without conflicting with each other.

Before Netvisor ONE release 6.1.1, in order to support multiple VRF instances you needed to configure multiple vRouters to create isolated Layer 3 routing contexts in software. By using this strategy, you could create a 'dumb' 1:1 association between a vRouter and a VRF instance used to isolate Layer 3 domains in the data plane. *Unicast and Multicast Fabric VRFs* (see the *Configuring VXLAN* section for more details) were introduced as hardware entities for high-performance distributed routing and traffic segmentation. There was no corresponding VRF-aware vRouter entity associated to them and therefore no routing protocols could be run to exchange routing information (only static routing was supported).

Netvisor ONE release 6.1.1 introduces '*native*' multi-VRF support to vRouters by making use of new advanced control plane capabilities.

The new implementation is more scalable compared to previous releases as it is much less demanding in terms of memory usage and CPU load (note that the previous vRouter-per-VRF approach is basically limited by the maximum number of supported vRouters, which is switch model-dependent). In addition, since a vRouter can now run routing protocols that are VRF-aware, per VRF peering is supported with BGP.

The new implementation also allows the same interface IP address to be used across different VRF instances. (However, note that reusing the same VLAN number for two interfaces of the same vRouter is not supported.) From a multi-tenant management perspective, VRF instances can be allocated to different vNETs so that each vNET administrator can independently add or remove the VRFs from the vRouters.

The configuration of vRouter-based VRF instances leverages the existing vRouter CLI, which is augmented to include the `vrf` parameter in many of the existing commands (see the list below).

In addition, a key new command, `vrouter-vrf-add`, is added to associate VRF instances to vRouters. Corresponding `vrouter-vrf-modify`, `vrouter-vrf-remove` and `vrouter-vrf-show` commands are introduced too. (Note that `vrouter-vrf-remove` removes a VRF instance as well as all vRouter interfaces belonging to it.)

For example, you can create a vRouter and associate two VRFs to it by using the following commands:

```
CLI (network-admin@switch) > vrf-create name VRF1 scope fabric
CLI (network-admin@switch) > vrf-create name VRF2 scope fabric
```

> **Note:** The maximum VRF name length is 15 characters n Netvisor ONE.

```
CLI (network-admin@switch) > vrouter-create name vRouter1 vnet
vNET1 router-type hardware bgp-as 100

CLI (network-admin@switch) > vrouter-vrf-add vrouter-name
vRouter1 vrf VRF1
CLI (network-admin@switch) > vrouter-vrf-add vrouter-name
vRouter1 vrf VRF2
```

> **Note** : The same VRF cannot be added to more than one vRouter on the same node.

The next step is to configure Layer 3 interfaces and add them to the specific VRFs, for example:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vRouter1 vrf VRF1 ip 100.1.1.1/24 vlan 100
CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vRouter1 vrf VRF2 ip 100.1.1.1/24 vlan 101
```

Then you can specify the BGP neighbors on a per VRF basis with these commands:

```
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
vRouter1 vrf VRF1 neighbor 100.1.1.2 remote-as 100
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
vRouter1 vrf VRF2 neighbor 100.1.1.2 remote-as 101
```

Per-VRF BGP Parameters

Starting from Netvisor ONE release 6.1.1 the addition of the `vrf` keyword makes the routing parameters VRF-aware. Some BGP parameters (such as `bgp-as`, `bgp-redistribute`, etc.) can now be specified during the `vrouter-vrf-add` configuration like so:

```
CLI (network-admin@switch) > vrouter-vrf-add vrouter-name
<name> vrf <vrf-name> [bgp-as|bgp-redistribute|...]
```

(If a parameter is not specified, its value is inherited from the vRouter configuration.) Subsequently, a parameter can be modified by using the `vrouter-vrf-modify` command:

```
CLI (network-admin@switch) > vrouter-vrf-modify vrouter-name
<name> vrf <vrf-name> [bgp-as|bgp-redistribute|...]
```

For example, it is possible to configure and modify a router ID on a per-VRF basis with the `vrouter-vrf-add` and `vrouter-vrf-modify` commands like so:

```
CLI (network-admin@switch) > vrouter-vrf-add vrouter-name
vRouter1 vrf VRF1 router-id 11.1.1.1
```

```
CLI (network-admin@switch) > vrouter-vrf-show format vrf,hw-vrid,bgp-as,router-id,

vrouter-name vrf  hw-vrid bgp-as router-id
------------ ---- ------- ------ ---------
vRouter1     VRF1 3       100    11.1.1.1

CLI (network-admin@switch) > vrouter-vrf-modify vrouter-name vRouter1 vrf VRF1 router-id 11.1.1.10

CLI (network-admin@switch) > vrouter-vrf-show format vrf,hw-vrid,bgp-as,router-id,

vrouter-name vrf  hw-vrid bgp-as router-id
------------ ---- ------- ------ ---------
vRouter1     VRF1 3       100    11.1.1.10
```

BGP uses the per-VRF `router-id` parameter value when it is configured. If it's not, the operational per-VRF router ID value is inherited from the corresponding vRouter's (global) router ID.

This is the full list of supported per-VRF parameters:

`bgp-as`	BGP Autonomous System number from 1 to 4294967295
`router-id`	BGP router id
`bgp-redistribute`	BGP route redistribution
`bgp-redist-static-metric`	BGP route redistribution static metric
`bgp-redist-static-route-map`	Route map for BGP redistribution of static routes
`bgp-redist-connected-metric`	Metric for redistributing BGP connected routes
`bgp-redist-connected-route-map`	Route map for BGP redistribution of connected routes
`bgp-redist-rip-metric`	Metric for redistributing RIP connected routes
`bgp-redist-ospf-metric`	Metric for BGP to redistribute OSPF connected routes
`bgp-redist-ospf-route-map`	Route map for BGP redistribution of OSPF routes
`bgp-cluster-id`	IP address for BGP cluster ID
`no-bgp-dampening`	No dampening for BGP routes
`bgp-dampening`	dampening is active for BGP routes
`bgp-keepalive-interval`	BGP Keepalive interval (seconds) -

	default 60
`bgp-holdtime`	BGP Holdtime (seconds) - default 180
`bgp-distance-external`	BGP distance for routes external to AS
`bgp-distance-internal`	BGP distance for routes internal to AS
`bgp-distance-local`	BGP distance for local routes
`no-bgp-default-shutdown`	Disabled
`bgp-default-shutdown`	Enabled
`no-bgp-redist-static-route-map`	Remove BGP static redist route-map
`no-bgp-redist-connected-route-map`	Remove BGP connect redist route-map
`no-bgp-redist-ospf-route-map`	Remove BGP OSPF redist route-map
`no-bgp-graceful-shutdown`	BGP graceful shutdown RFC 8326
`bgp-graceful-shutdown`	BGP graceful shutdown RFC 8326

The BGP parameters below, instead, are inherited from the vRouter (in other words, for them per VRF configuration is not supported):

```
bgp-delayed-startup
bgp-update-delayed-strict
bgp-max-paths
bgp-ibgp-multipath
bgp-bestpat-as-path
bgp-global-nh-preference
```

VRF-aware BFD Support

VRF support was added to BFD for both static routing and dynamic routing with BGP. The following vRouter commands are VRF aware. For static routing:

```
CLI (network-admin@switch) > vrouter-static-bfd-show
vrouter-name src-ip    dst-ip    type       vrf
------------ --------- --------- ---------- ----
vRouter1     100.1.1.1 100.1.1.2 single-hop VRF1
vRouter2     100.1.1.2 100.1.1.1 single-hop VRF2

CLI (network-admin@switch) > vrouter-bfd-neighbor-show format out-
addr,neighbor,holdown,multiplier,state,interface,vrf,flap-count,remote-router

vrouter-name  out-addr   neighbor   holdown(ms)  multiplier  state  interface  vrf   flap-count
remote-router
------------  ---------  ---------  -----------  ----------  -----  ---------  ----  ----------
-------------
vRouter1     100.1.1.1 100.1.1.2 2191        3          up    eth0.100  VRF1 0
vr1
vRouter2     100.1.1.2 100.1.1.1 2230        3          up    eth1.100  VRF2 0
vr2
```

For BGP

```
CLI (network-admin@switch) > vrouter-bgp-neighbor-show format neighbor,l3-
port,nic,ver,remote-as,up/down,state/pfxrcd,remote-router,description,vrf

vrouter-name neighbor  l3-port nic ver remote-as up/down  state/pfxrcd remote-
router description vrf
------------ --------- ------- --- --- --------- -------- ------------
------------- ----------- ----
vRouter1     100.1.1.2 0           4   200       00:00:18 Established  vr1
             VRF1
vRouter2     100.1.1.1 0           4   100       00:00:19 Established  vr2
             VRF2

CLI (network-admin@switch) > vrouter-bfd-neighbor-show format out-
addr,neighbor,holdown,multiplier,state,interface,vrf,flap-count,remote-router

vrouter-name out-addr  neighbor  holdown(ms) multiplier state interface vrf
 flap-count remote-router
------------ --------- --------- ----------- ---------- ----- --------- ----
---------- -------------
vRouter1     100.1.1.1 100.1.1.2 2118        3          up    eth0.100  VRF1 0
         vr1
vRouter2     100.1.1.2 100.1.1.1 2024        3          up    eth1.100  VRF2 0
         vr2
```

VRF-aware Commands

The full list of vRouter commands with the new vrf keyword is:

```
vrouter-bfd-neighbor-show
vrouter-bgp-add
vrouter-bgp-modify
vrouter-bgp-neighbor-detail-show
vrouter-bgp-neighbor-no-shutdown
vrouter-bgp-neighbor-reset
vrouter-bgp-neighbor-show
vrouter-bgp-neighbor-shutdown
vrouter-bgp-network-add
vrouter-bgp-network-remove
vrouter-bgp-network-show
vrouter-bgp-remove
vrouter-bgp-show
vrouter-cached-routes-show
vrouter-ecmp-cached-routes-show
vrouter-ecmp-group-show
vrouter-fib-arps-show
vrouter-fib-routes-show
vrouter-interface-add
vrouter-interface-modify
vrouter-interface-show
vrouter-ping
vrouter-routes-show
vrouter-routes-stats-show
vrouter-static-bfd-add
vrouter-static-bfd-remove
vrouter-static-bfd-show
```

```
vrouter-static-route-add
vrouter-static-route-remove
vrouter-static-route-show
vrouter-traceroute
```

Below are a few examples of VRF-aware commands:

```
CLI (network-admin@switch) > vrf-show format switch,name,scope,anycast-mac,active,hw-vrid,flags,enable

switch name  scope   anycast-mac       active hw-vrid flags   enable
------ ----- ------- ----------------- ------ ------- ------- ------
switch vrf1  cluster 64:0e:94:40:00:02 no     1       vrouter yes
switch vrf10 cluster 64:0e:94:40:00:02 no     10      vrouter yes
switch vrf11 cluster 64:0e:94:40:00:02 no     11      vrouter yes
switch vrf12 cluster 64:0e:94:40:00:02 no     12      vrouter yes
switch vrf13 cluster 64:0e:94:40:00:02 no     13      vrouter yes
switch vrf14 cluster 64:0e:94:40:00:02 no     14      vrouter yes
switch vrf15 cluster 64:0e:94:40:00:02 no     15      vrouter yes
switch vrf2  cluster 64:0e:94:40:00:02 no     2       vrouter yes
switch vrf3  cluster 64:0e:94:40:00:02 no     3       vrouter yes
switch vrf4  cluster 64:0e:94:40:00:02 no     4       vrouter yes
switch vrf5  cluster 64:0e:94:40:00:02 no     5       vrouter yes
switch vrf6  cluster 64:0e:94:40:00:02 no     6       vrouter yes
switch vrf7  cluster 64:0e:94:40:00:02 no     7       vrouter yes
switch vrf8  cluster 64:0e:94:40:00:02 no     8       vrouter yes
switch vrf9  cluster 64:0e:94:40:00:02 no     9       vrouter yes
```

```
CLI (network-admin@switch) > vrouter-vrf-show vrouter-name leaf1_vr1 format vrf,hw-vrid,bgp-as,bgp-max-paths,bgp-bestpath-as-path,bgp-ibgp-multipath

vrouter-name  vrf    hw-vrid  bgp-as  bgp-max-paths  bgp-bestpath-as-path  bgp-ibgp-multipath
------------  -----  -------  ------  -------------  --------------------  ------------------
leaf1_vr1     vrf1   1        12101   16             multipath-relax       16
leaf1_vr1     vrf2   2        12102   16             multipath-relax       16
leaf1_vr1     vrf3   3        12103   16             multipath-relax       16
leaf1_vr1     vrf4   4        12104   16             multipath-relax       16
leaf1_vr1     vrf5   5        12100   16             multipath-relax       16
leaf1_vr1     vrf6   6        12106   16             multipath-relax       16
leaf1_vr1     vrf7   7        12107   16             multipath-relax       16
leaf1_vr1     vrf8   8        12108   16             multipath-relax       16
leaf1_vr1     vrf9   9        12109   16             multipath-relax       16
leaf1_vr1     vrf10  10       12110   16             multipath-relax       16
leaf1_vr1     vrf11  11       12111   16             multipath-relax       16
leaf1_vr1     vrf12  12       12112   16             multipath-relax       16
leaf1_vr1     vrf13  13       12113   16             multipath-relax       16
leaf1_vr1     vrf14  14       12114   16             multipath-relax       16
leaf1_vr1     vrf15  15       12115   16             multipath-relax       16
```

```
CLI (network-admin@switch) > vrouter-interface-show vrouter-name leaf1_vr1 vrf vrf1 format nic,ip,mac,vlan,vlan-type,nic-state,vrf

vrouter-name nic       ip           mac               vlan vlan-type nic-state vrf
------------ --------- ------------ ----------------- ---- --------- --------- -----
leaf1_vr1    eth0.110  11.1.0.2/24  66:0e:94:1b:c5:21 110  public    up        vrf1
leaf1_vr1    eth1.110  11.1.0.1/24  00:00:5e:00:01:79 110  public    down      vrf1
leaf1_vr1    eth0.111  11.1.1.2/24  66:0e:94:1b:c5:21 111  public    up        vrf1
leaf1_vr1    eth1.111  11.1.1.1/24  00:00:5e:00:01:79 111  public    down      vrf1
leaf1_vr1    eth0.112  11.1.2.2/24  66:0e:94:1b:c5:21 112  public    up        vrf1
leaf1_vr1    eth1.112  11.1.2.1/24  00:00:5e:00:01:79 112  public    down      vrf1
leaf1_vr1    eth0.113  11.1.3.2/24  66:0e:94:1b:c5:21 113  public    up        vrf1
leaf1_vr1    eth1.113  11.1.3.1/24  00:00:5e:00:01:79 113  public    down      vrf1
leaf1_vr1    eth0.114  11.1.4.2/24  66:0e:94:1b:c5:21 114  public    up        vrf1
leaf1_vr1    eth1.114  11.1.4.1/24  00:00:5e:00:01:79 114  public    down      vrf1
```

```
leaf1_vr1     eth2.3001 11.1.254.3/29 66:0e:94:1b:c5:21 3001 public     up         vrf1

CLI (network-admin@switch) > vrouter-bgp-neighbor-show vrouter-name leaf1_vr1 remote-
router leaf2_vr1 vrf vrf1 format neighbor,remote-as,msg_rcvd,msg_sent,up/down,remote-
router,vrf

vrouter-name  neighbor    remote-as  msg_rcvd  msg_sent  up/down   remote-router  vrf
------------  ----------  ---------  --------  --------  --------  -------------  -----
leaf1_vr1     11.1.254.4 12101      7133      7147      4d22h42m leaf2_vr1      vrf1

CLI (network-admin@switch) > vrouter-bfd-neighbor-show vrouter-name leaf1_vr1 remote-
router leaf2_vr1 vrf vrf1 format out-addr,neighbor,state,interface,vrf,flap-count,remote-
router

vrouter-name out-addr    neighbor    state  interface  vrf       flap-count  remote-router
------------  ----------  ----------  -----  ---------  --------  ----------  -------------
leaf1_vr1     11.1.254.3 11.1.254.4 up     eth2.3001 vrf1      0           leaf2_vr1
```

Configuring Multicast Listener Discovery (MLD)

In IPv4, Layer 2 switches can use IGMP snooping to limit the flooding of multicast traffic by dynamically configuring Layer 2 interfaces so that multicast traffic is forwarded to only those interfaces associated with IP multicast address. In IPv6, MLD snooping performs a similar function. With MLD snooping, IPv6 multicast data is selectively forwarded to a list of ports that want to receive the data, instead of being flooded to all ports in a VLAN. This list is constructed by snooping IPv6 multicast control packets.

MLD is a protocol used by IPv6 multicast routers to discover the presence of multicast listeners (nodes configured to receive IPv6 multicast packets) on its directly attached links and to discover which multicast packets are of interest to neighboring nodes. MLD is derived from the IGMP protocol. MLD version 1 (MLDv1) is equivalent to IGMPv2, and MLD version 2 (MLDv2) is equivalent to IGMPv3. MLD is a sub-protocol of Internet Control Message Protocol version 6 (ICMPv6), and MLD messages are a subset of ICMPv6 messages, identified in IPv6 packets by a preceding Next Header value of 58.

The switch can snoop on both MLDv1 and MLDv2 protocol packets and bridge IPv6 multicast data based on destination IPv6 multicast MAC addresses. The switch can be configured to perform MLD snooping and IGMP snooping simultaneously.

To display MLD routers on the network, use the `mld-router-show` command:

```
CLI (network-admin@switch) > mld-router-show

group-ip:
node-ip:
vlan:
port:
source:
node-type:
expires:
```

The show output displays the following information:

- Multicast group IP address in IPv6 format
- Host node IP address in IPv6 format
- Host VLAN ID
- Port number
- Multicast traffic source IP address in IPv6 format
- Node type as host or router
- Expires as the age-out time

To display MLD group membership on the network, use the `mld-show` command:

```
CLI (network-admin@switch) > mld-show

group-ip:
```

```
node-ip:
vlan:
port:
source:
node-type:
expires:
```

The show output displays the following information:

- Multicast group IP address in IPv6 format
- Host node IP address in IPv6 format
- Host VLAN ID
- Port number
- Multicast traffic source IP address in IPv6 format
- Node type as host or router
- Expires as the age-out time

To enable or disable MLD snooping or modify the scope, use the `mld-snooping-modify` command:

```
CLI (network-admin@switch) > mld-snooping-modify
```

To modify the scope from fabric to local, use the following syntax:

```
CLI (network-admin@switch) > mld-snooping-modify scope fabric
```

To display information about MLD snooping, use the `mld-snooping-show` command.

Configuring an IGMP Querier IP Address

You can configure an IGMP querier IP address for a VLAN or as a global IGMP querier. The IGMP querier sends IGMP General Query messages. on the network.

If you do not specify a querier IP address, then Netvisor ONE uses 0.0.0.0 as the default value. There can be an unique querier IP for each VLAN, or you can configure the same Querier IP address for all the VLANs participating in IGMP snooping. The Querier IP address should have a local scope and every switch should have a unique Querier IP address.

With a valid source IP address on IGMP Query packets, Netvisor ONE adds the VLAN receiving the Query to an IGMP Snoop switch list, and now reflects in the `igmp-switches-show` output and the IGMP queries sent to the peer switch as well. This solicits a report from the hosts listening on the peer switch.

Use these Netvisor ONE commands to configure an IGMP querier IP address.

`igmp-querier-ip-modify`	Modify IGMP Querier IP configuration
`querier-ip` *`ip-address`*	Specify the Snooping Querier IP address
`vlans-on-querier-ip` *`vlan-list`*	Specify the VLAN map.
`igmp-querier-ip-show`	Display IGMP Querier IP config
`querier-ip is`	Specify the Snooping Querier IP address
`vlans-on-querier-ip` *`vlan-list`*	VLAN MAP

Configuring Multicast Listener Discovery (MLD) Snooping per VLAN

MLD snooping provides support per individual VLANs. In addition to current global enable and disable support, you can do the following using the `mld-snooping-modify` command:

- Specify a range of VLANs on which MLDv1 and MLDv2 messages are used. These two VLAN ranges are mutually exclusive. When a MLDv1 query is received on a VLAN configuredforMDv2, the MLDv2 query is moved to a VLAN configured with MLDv1 if there is only one multi-cast router for this VLAN. If a MLDv2 message is later received for the same VLAN, existing entries are removed and the supported version is changed to MLDv2.

- Specify VLAN ranges for snooping link-local addresses and ND Solicited Node addresses. You must include these VLANs in one MLDv1 and MLDv2 VLAN list.

Use these command options for the `mld-snooping-modify` command:

```
CLI (network-admin@Spine1) > mld-snooping-modify
```

`mld-snooping-modify`	Enables or disables Multicast Listener Discovery (MLD) snooping
One or more of the following options:	
`scope local|fabric`	Specify the MLDsnooping scope - fabric or local
`enable|disable`	Enable or disable MLD snooping
`mldv1-vlans vlan-list`	Specify the VLANs to enable snooping and use MLDv1 protocol. Default: none
`mldv2-vlans vlan-list`	Specify the VLANs on which to enable snooping and use MLDv2 protocol. Default 1 - 4092
`snoop-linklocal-vlans vlan-list`	Allow snooping of link-local groups(ff02::/16) on these VLANs. Default 1 - 4092
`snoop-nd-vlans vlan-list`	Allow snooping of ND SN Multicast addresses (ff02::1:ff/104) on these VLANs. Default 1 - 4092

The `mld-snooping-modify` show format all command displays the following sample output:

```
CLI (network-admin@Spine1) > mld-snooping-show format all
```

`switch:`	Name of Switch
`enable:`	no
`mldv1-vlans:`	none
`mldv2-vlans:`	1 - 4092
`snoop-linklocal-vlans:`	1 - 4092
`snoop-nd-vlans:`	1 - 4092
`nvOS-managed-vlans:`	none
`interop-v1-vlans:`	none
`vlans:`	1 - 4092

Creating MLD Static Sources and Static Groups

To determine how to forward multicast traffic, a switch with MLD snooping enabled maintains information about the following interfaces in its multicast forwarding table:

- **Multicast-router interfaces** — These interfaces lead toward multicast routers or MLD queriers.
- **Group-member interfaces** — These interfaces lead toward hosts that are members of multicast groups.

The switch learns about these interfaces by monitoring MLD traffic. If an interface receives MLD queries, the switch adds the interface to the multicast forwarding table as a multicast-router interface. If an interface receives membership reports for a multicast group, the switch adds the interface to the multicast forwarding table as a group-member interface.

Table entries for interfaces that the switch learns about are subject to aging. For example, if a learned multicast-router interface does not receive MLD queries within a certain interval, the switch removes the entry for that interface from the multicast forwarding table.

You can create MLD static sources using IPv6 addresses and then create static groups using the static sources.

To create an MLD static source for IPv6 address, `ff02::1:ff11:111` as the group, and IPv6 `2001:db8::2:1` as the source on `VLAN 25`, `port 44-45`, use the following syntax:

```
CLI network-admin@switch > mld-static-source-create source-ip
2001:db8::2:1 group-ip ff02::1:ff11:111 vlan 25 ports 44-45
```

The parameter, `ports`, is an optional parameter. You can delete an MLD static source, but you cannot modify the parameters.

To display MLD static sources, use the `mld-static-source-show` command.

To create an MLD static group for IPv6 address, `ff02::1:ff11:1111`, on `VLAN 25, ports 44-45`, use the `mld-static-group-create` command:

```
CLI network-admin@switch > mld-static-group-create group-ip
ff02::1:ff11:1111 vlan 25 ports 44-45
```

You can delete an MLD static group, but you cannot modify the parameters. To display MLD static groups, use the `mld-static-group-show` command.

Displaying MLD Statistics for a VLAN

To display MLD statistics for a VLAN, use the `mld-stats-show` command:

```
CLI network-admin@switch > mld-stats-show

switch:
vlan:
v1-queries:
v2-queries:
v1-member-reports:
v1-done-group:
v2-member-reports:
queries-sent:
drops:
ignored:
```

Configuring and Administering the Pluribus Fabric

This chapter provides information about Pluribus Adaptive Cloud Fabric and how to configure the fabric using the Netvisor ONE CLI.

Pluribus Networks offers a unique and highly differentiated approach to software-defined networking (SDN), called Adaptive Cloud Fabric. The distributed architecture enables organizations to build scalable private and public clouds with improved ease of management, reliability, security and performance. Pluribus Networks innovative Netvisor® ONE software virtualizes open networking hardware and builds a holistic, standard-based distributed network, referred to as a fabric, which provides improved management, automation, telemetry and resiliency.

Understanding the Netvisor® ONE Adaptive Cloud Fabric™

Pluribus Networks offers a unique and highly differentiated approach to software-defined networking (SDN), called *Adaptive Cloud Fabric.* The distributed architecture enables organizations to build scalable private and public clouds that enjoy improved ease of management, reliability, security and performance.

Pluribus Networks' innovative Netvisor® ONE software *virtualizes open networking hardware* to build a holistic, standard-based *distributed network*, referred to as '*a fabric*', which provides improved management, automation, telemetry and resiliency.

These enhancements are achieved thanks to the adoption of an advanced network virtualization paradigm.

In a Pluribus fabric every node behaves like a *'virtual module'* within a *logically-unified physically-distributed* '*virtual chassis*' which abstracts the *network topology*[1] . Each fabric node shares a common view of the network, including MAC and IP addresses, connections and application flows for management as well as redundancy purposes.

In addition, thanks to advanced embedded telemetry technology, the Netvisor ONE software provides *fabric-wide traffic visibility* to reveal network congestion issues and application performance bottlenecks so as to speed up troubleshooting, improve operational efficiency and strengthen security.

Pluribus Adaptive Cloud Fabric is a distributed application on top of a standard Layer 2/Layer 3 network that unifies the management plane for all the switches of the fabric (see figure below) and at the same time enhances the network control plane with the ability to automate and simplify several network functions.

> **Note**: [1]The Adaptive Cloud Fabric supports any network topology, including ring, leaf-spine and multi-site.

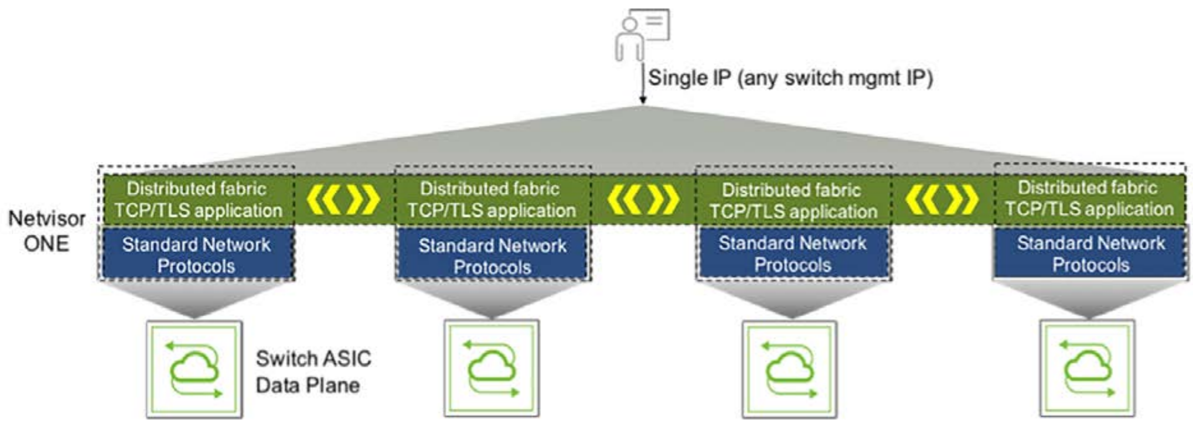


Figure 6 - 1: Adaptive Cloud Fabric Simplified Management with Single IP to Configure and Monitor the Fabric

This distributed control plane is *fully symmetrical* (or *peer-to-peer*) so that any node can act as a single point of management for the entire fabric. Therefore, *it does not require any controller entity* to guarantee the proper operation of the network and hence does not suffer from the intrinsic limits of a centralized control plane SDN architecture (such as *split brain* problems). At the same time, it is also able to inter-operate with a centralized orchestration system or controller through RESTful APIs or an OVSDB interface. This enables additional powerful management strategies when leveraging popular platforms such as Ansible or OpenDaylight.

Adaptive Cloud Fabric's advanced transactional model guarantees that device configuration is maintained consistent across fabric nodes and supports also rollback capabilities. Therefore, *a single point of provisioning* provides 'atomic' fabric-wide configuration with commands that can operate on a list of dispersed fabric devices (instead of simply on individual ones).

Since Adaptive Cloud Fabric does not inherently require special controllers to operate (i.e., uses a *controller-less, de-centralized* model), and since it leverages standard protocols (instead of proprietary technologies) it is fully interoperable with devices from other vendors.

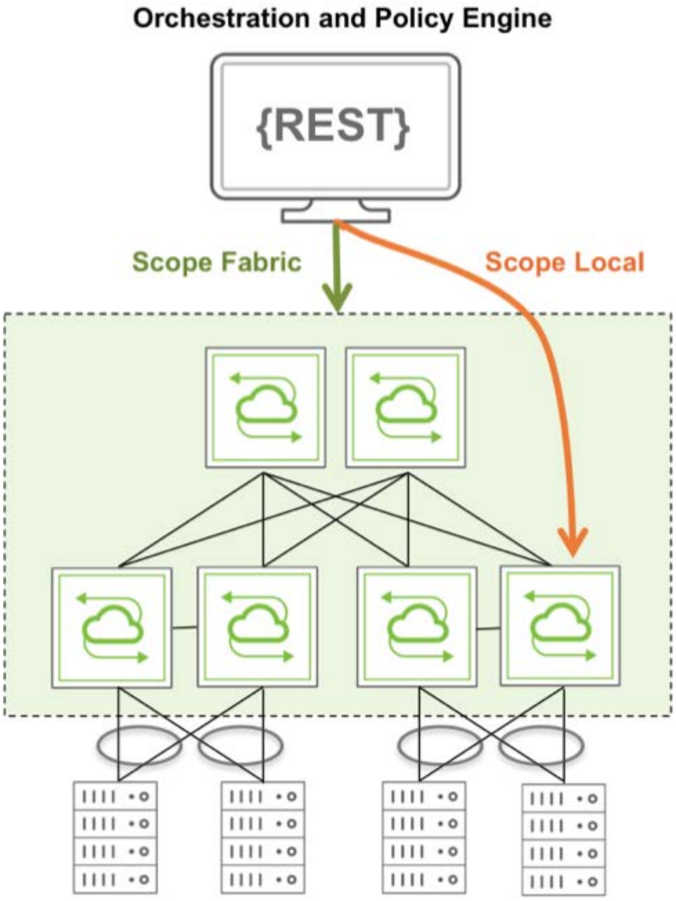


Figure 6 - 2: Network Orchestration with Adaptive Cloud Fabric

Adaptive Cloud Fabric's open architecture offers users a far superior degree of interoperability compared to centralized SDN architectures, while at the same time providing support for powerful market-leading network-wide analytics.

While each node can belong to only one fabric, multiple fabric domains can be part of the same network so as to implement more granular management domain segregation.

For example, in a typical leaf and spine data center configuration, it is often preferred to provision one management domain for all leaf switches and one separate domain for all spine switches, so as to preserve homogeneity as well as provisioning and monitoring simplicity within each functional domain.

The following picture (***Figure 6-3***) depicts an example of data center 'pod' topology comprising two management domains corresponding to *two separate fabric* instances: one for all the leaf switches and one for the two spine switches.

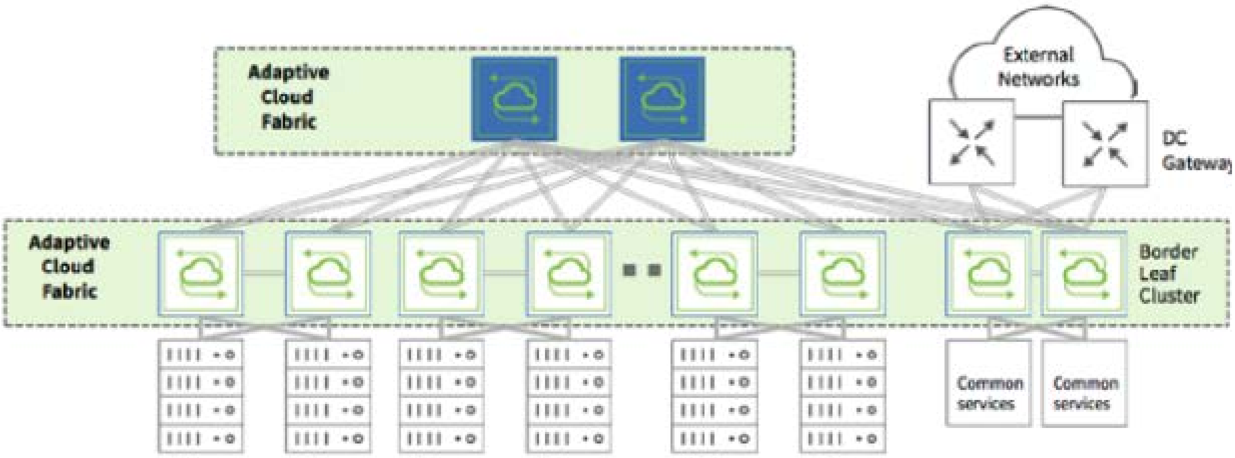


Figure 6 - 3: Two Fabric Instances to Achieve Two Management Domains

The Adaptive Cloud Fabric technology offers many additional benefits (described in more detail in the following chapters) that include more granular management segmentation for multi-tenancy, geographically dispersed data center interconnection (DCI), sophisticated security, etc.

Understanding Fabric Transactions

The Adaptive Cloud Fabric uses *transactions* to synchronize configuration changes across the nodes of the fabric. Netvisor ONE records transactions as *atomic* operations that must either succeed and persist or fail and rollback, across the entire fabric. Transactions cannot be partially completed.

The fabric and Netvisor ONE adheres to the four standard transaction requirements: *atomicity, consistency, isolation and durability* (also collectively known as *ACID*).

Netvisor ONE does not require a fixed master node to coordinate all transactions across the fabric. Transactions start from the node where a command is run. This node is called the *originator node* or the *originator*, and coordinates the transactions with all the other fabric nodes.

Netvisor ONE commands originate from clients such as a CLI user, a RESTful API user or an external orchestration system. The commands are executed on a chosen switch, which becomes the originator node.

The originator first applies the configuration change specified by the command on the local node. If that fails, Netvisor rolls back any partial changes and then returns a failure message to the user. Only after the local change succeeds does the originator start the transaction. Netvisor ONE then atomically sends the configuration change such as create, delete, modify, add or remove commands to other fabric nodes.

Netvisor ONE transmits fabric transactions over a dedicated TCP socket, does not retain it and closes after each phase of the transaction. Transactions are encrypted using the TLS protocol.

All transactions are logged in a log file on a per scope basis in this location: `/var/nvOS/etc/<scope>`, where <scope> is `Local`, `Cluster`, or `Fabric`.

Scope defines the set of nodes participating in a transaction:

- Local — only the local node participates in the transaction.
- Cluster — only two redundant nodes participate in the transaction.
- Fabric — all nodes in the same fabric instance participate in the transaction.

For several commands, you can specify the scope of the intended action and therefore the scope of the ensuing transaction.

If a failure occurs on the fabric, transactions on certain nodes in the fabric can become out of sync. Once transactions become out of sync, no further transactions can be executed across the scope of local, fabric, or cluster.

You can verify the fabric node states with the command, `fabric-node-show`, and review the fab-tid values for matching values.

```
CLI (network-admin@switch) > fabric-node-show format name,fab-name,fab-tid,state,device-state,

name      fab-name   fab-tid state  device-state
--------- ---------- ------- ------ ------------
pnswitch2 pnfabric   2       online ok
pnswitch1 pnfabric   2       online ok
```

The `state` column represents the communication status between members of the fabric and the `device-state` column represents the overall health of each switch. Also note that the fabric transaction ID (2 in this example) is consistent across all members of the fabric.

Mismatching `fab-tid` values for one or more nodes within the same fabric instance represent a corner case that the fabric control logic typically prevents. For more details, see the *Rolling Back and Rolling Forward Transactions* section for more details.

Understanding Fabric Status Updates, vPorts and Keepalives

Instead of transactions, which are reserved for create, delete, modify, add or remove commands, Netvisor ONE uses status update messages to distribute information across the fabric.

Unlike transactions, Netvisor ONE does not strictly guarantee the status update data to be synchronized across the fabric.

Netvisor ONE sends the following states from the local node to the other nodes in the fabric:

- Node State
- Port State
- VLAN State
- Owned vPort State
- Layer 3 Entry State

Netvisor ONE uses vPort (or virtual port) as Layer 2 entries managed by the software and associated to ports where a node performs MAC address learning. vPorts contain information such as the MAC and IP address of a host, the VLAN and the connected port, the state, and other parameters.

In a fabric a node only sends status updates for vPorts that "is part of the fabric, which means that it sends updates only for the states of the hosts directly connected to that node. Netvisor ONE uses the term '*owned vPorts*' to represent directly connected hosts. You can display this information about directly connected hosts using the command, `vport-show`.

For example:

```
CLI (network-admin@switch) > vport-show

mac                vlan  ip            ports  state  migrate
-----------------  ----  --------      -----  -----  ------
00:00:4c:06:91:f8  514   10.81.114.21  61     active   9
```

In addition, Netvisor ONE sends status updates whenever a state changes on the fabric. For example, if a port goes down, or you create a new VLAN, the node with the port or VLAN sends a status update about the specific change.
If sending the update message fails, Netvisor ONE attempts to resend it every 250ms.

With multiple nodes configured in the same fabric instance, switches send out special messages, called *fabric keepalives*, typically every 10 seconds to allow fabric peers to keep track of the online state of other nodes in the same fabric instance.

If a fabric keep-alive message is not received from a specific node for a period of time (30 s) equal to 3 times the transmission interval (10 s), the suddenly-gone-silent node's state is marked as `offline` by its neighbors. This inter-device connectivity/status check is performed with every other node within the same fabric instance.

Understanding the Different Fabric Deployment Models

When you create a fabric instance, by default, Netvisor ONE uses Layer 2 communication over a configurable (user-selectable) VLAN for dedicated messages. The default behavior is the basic mode of operation and is referred to as *Fabric over L2* deployment model.

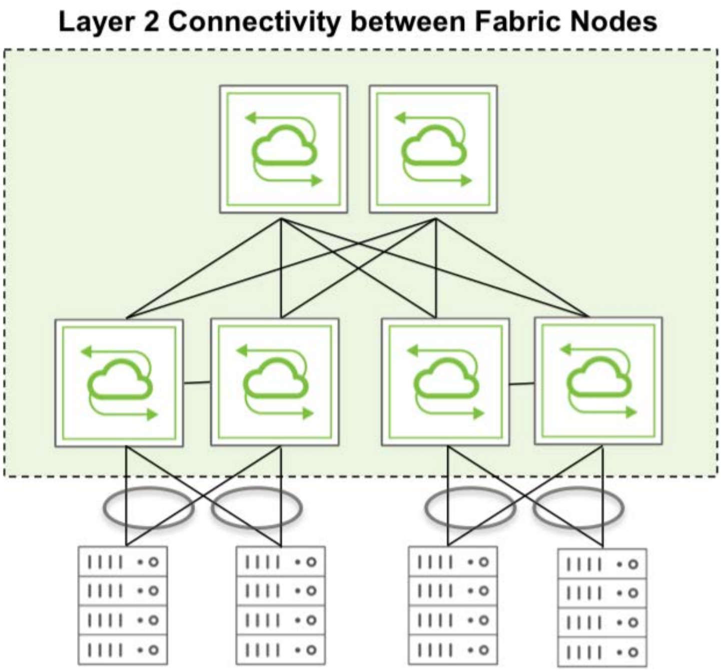


Figure 6 - 4 Fabric over Layer 2 Deployment Model

To perform fabric-related communication between nodes, Netvisor ONE uses different message groups called:

- fabric-network
- control-network

The fabric-network group consists of a number of messages such as transactions, fabric notifications, and proxy I/O messages such as API calls.

The control-network group consists of status updates, cluster synchronization messages, proxy I/O messages and forwarded packets. They may (but don't have to) be configured separately for improved message forwarding flexibility.

In certain network designs, a *dedicated management network* is deployed *in parallel* to the regular network, also referred to as *in-band* network, to interconnect nodes through management interfaces (see ***Figure 6-5***).

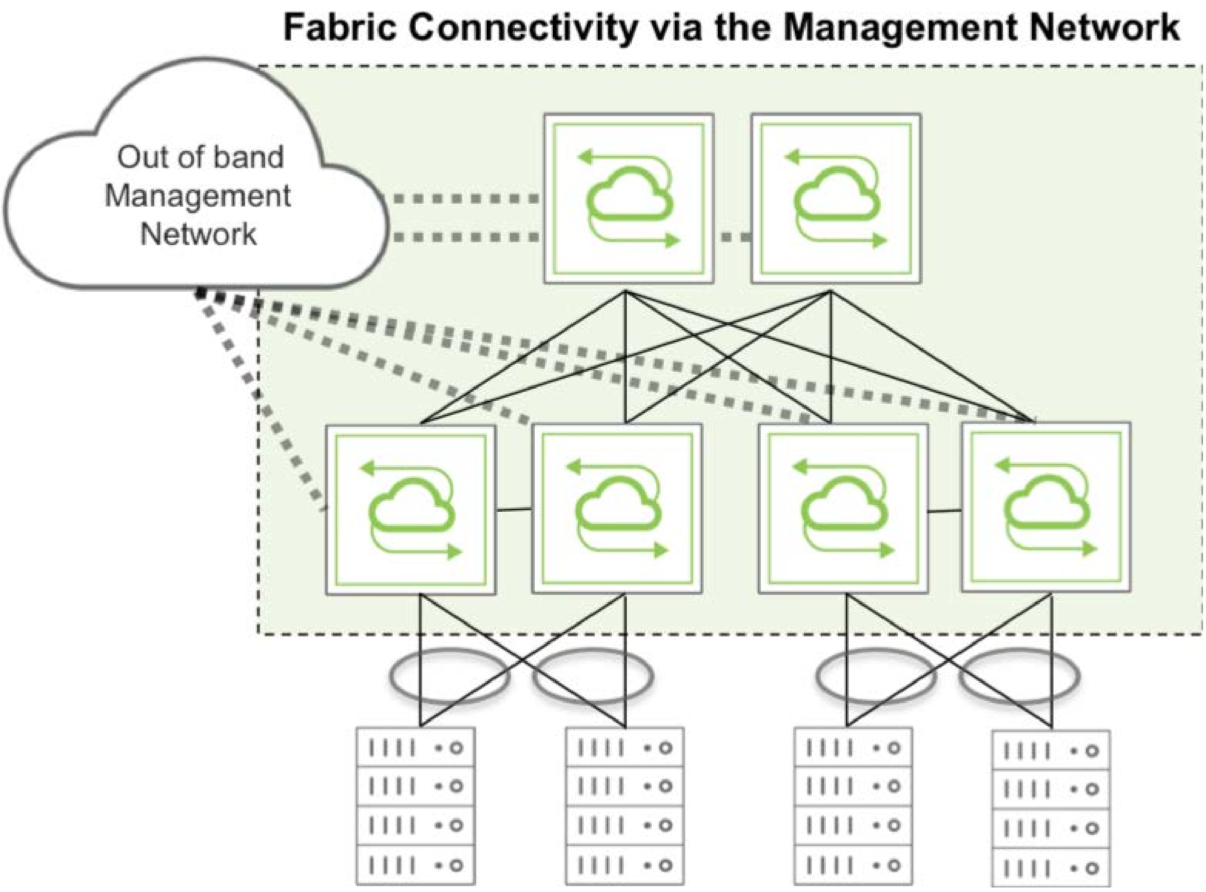


Figure 6-5: Fabric Connectivity over the Management Network

The *out-of-band* management network provides a robust alternate communication path between the nodes unaffected by user data traffic and user-related events.

In such designs a network administrator may leverage the dedicated management network for fabric communication. Therefore, Netvisor ONE allows the network administrator, using the `fabric-create` command, to select if a communication group uses the node management interface or the in-band interface. The fabric deployment model leveraging the management network for communication is called *Fabric over Management Interface*.

In addition to the two described network configurations, a third deployment model exists, *Fabric over L3*, and leverages a Layer 3 network running BGP or OSPF routing protocol to establish point-to-point fabric communication between nodes.

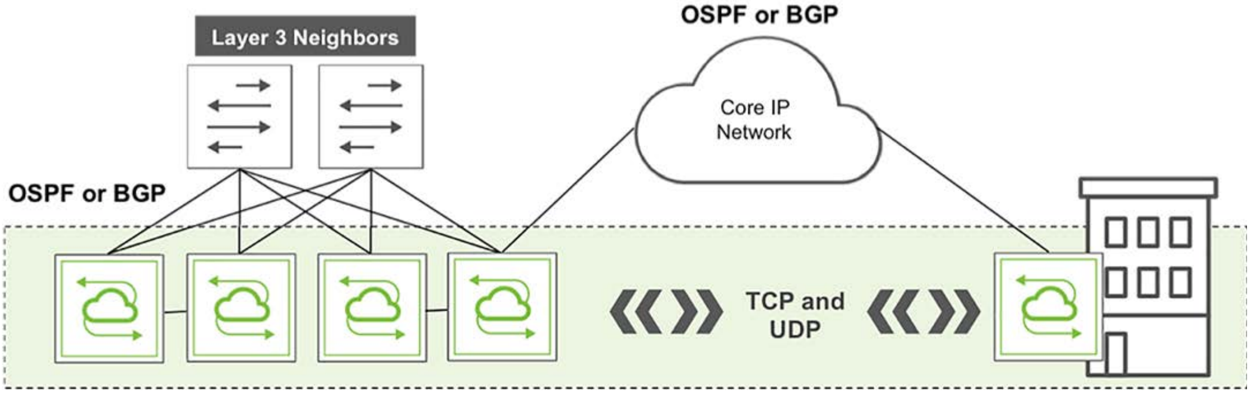


Figure 6-6: Fabric over Layer 3 Deployment

In the *Fabric over L3* deployment, multicast messages cannot be exchanged, as no Layer 2 adjacency exists between the nodes. Direct TCP or UDP communication must be established instead.

Therefore, you must first create the fabric on one node and then all the other nodes connected through Layer 3 can join the fabric one by one by specifying the IP address of the initial node using the command `fabric-join switch-ip`.

Creating an Initial Fabric

After completing the initial setup of a switch, you can create a new `fabric instance` to add the switch, or you can add the switch to an existing fabric.

When multiple switches join a fabric, the switches act as 'virtual modules' of a 'virtually distributed switch' with a single logical management plane. In this mode of operation, switches share status information and exchange commands based on the configured scope.

For example, any command with the scope, `fabric`, executes on each switch belonging to a shared fabric instance. This virtualized management paradigm significantly simplifies the network configuration and speeds up the deployment of complex networks.

A fabric instance can consist of just one individual switch, even though it is more common to have more than one switch, to ensure redundancy. For example, see Figure 6- 3 Two Fabric Instances to Achieve Two Management Domains, where two redundant spine switches belong to a dedicated fabric instance.

Netvisor ONE continues to maintain the sharing of state and scope of a switch as long as the switch belongs to the fabric instance. When a switch leaves one fabric instance to join another one, the switch loses the synchronized fabric state and configuration of the first instance and learns the state and configuration of the second one.

To create a new fabric instance, use the following command:

```
CLI (network-admin@switch) > fabric-create name name-string
```

where *name-string* designates the name of the fabric.

Use the `password` option if you want to assign a password to the fabric instance creation process so that other switches are required to securely join the fabric only if the administrator knows the password.

```
CLI (network-admin@switch) > fabric-create name name-string
password<return>

fabric password: hidden-password-string <return>
confirm fabric password: hidden-password-string <return>
```

For modifying the fabric password, see the Modifying the Fabric Password section in the Installing Netvisor ONE and Initial Configuration chapter.

About the Default Configuration

By default, Netvisor ONE creates a new fabric instance on VLAN 1.

However, VLAN 1 is often the default VLAN in most networks and therefore security best practices recommend using a non-default VLAN, whenever possible, for maximum robustness and error prevention.

To assign a non-default VLAN, for example, a VLAN ID between 2 and 4093, use the command:

```
CLI (network-admin@switch) > fabric-create name name-string vlan vlan-id
```

To change the VLAN ID of an existing fabric, use the command, `fabric-local-modify`.

Use the same command to change the fabric administration network, control plane network, and the network to send fabric advertisements.

```
CLI (network-admin@switch) > fabric-local-modify vlan vlan-id
```

> **Note:** In order to change the VLAN number of an existing instance you must recreate it. Also, a switch can belong to only one fabric instance.

When you create a fabric, Netvisor ONE uses the in-band network for fabric communication by default.

To create a simple fabric of two switches in the same subnet with in-band connectivity, follow the steps below:

Assign IP addresses to the in-band network on the switches by using the commands:

```
CLI (network-admin@switch1*) > switch-setup-modify in-band-ip 192.168.0.1/30
```

```
CLI (network-admin@switch2*) > switch-setup-modify in-band-ip 192.168.0.2/30
```

You can also specify an IPv6 addresses for in-band network by providing the `in-band-ip6` parameter.

Create the fabric:

```
CLI (network-admin@switch1) > fabric-create name fabric1
```

Display the fabric configuration:

```
CLI (network-admin@switch1) > fabric-show
name             id               vlan fabric-network control-network tid fabric-advertisement-network
---------------- ---------------- ---- -------------- --------------- --- ----------------------------
fabric1          b002698:6078060b 1    in-band        in-band         2   inband-mgmt
```

As seen from the output, the fabric and control networks are auto-configured to use the in-band network.

As the fabric uses VLAN 1 by default, verify the configuration using the `vlan-show` command:

```
CLI (network-admin@switch1) > vlan-show id 1
id type   auto-vxlan replicators scope description active stats ports    untagged-ports active-edge-ports
-- ------ ---------- ----------- ----- ----------- ------ ----- -------- -------------- -----------------
1  public no         none        local default-1   yes    yes   0-72,272 0-72,272       0,2,272
```

You can verify that the ports that connect the two switches are untagged and belong to VLAN 1.

Displaying Fabric Instances

To show all the fabric instances and their specific details, use the `fabric-show` command:

```
CLI  network-admin@switch  >  fabric-show
```

```
name         id                    vlan  fabric-network  control-network   tid   fabric-advertisement-
network
------   ---------------- ----  -------------- ---------------   ---
------------------------------
Fabric1  b000707:59b6a9ef   0       mgmt                 mgmt               inba48d-mgmt
Fabric2  90004eb:59b7da05   0       mgmt                 mgmt               inba8nd-mgmt
```

Netvisor ONE discovers all available fabric instances by sending out special multicast messages, called *global discoveries*, whenever a physical port becomes forwarding or on demand.

For example, when you execute a `fabric-show` command, Netvisor ONE sends discovery messages over in-band as well as over the management interface.

After receiving a global discovery message the receiving device responds with a *global keep-alive* message containing the required fabric and node information.

This local multicast-based discovery mechanism implies that direct Layer 2 connectivity exist between the discoverer and the polled switches.

Adding Switches to an Existing Fabric

To add a switch to an available fabric instance, use the following command:

```
CLI (network-admin@switch) > fabric-join name name-string
```

For example:

```
CLI (network-admin@switch) > fabric-join name MyFabric
```

In case of directly connected switches as in ***Figure 6-7***, switch B learns about available fabrics from switch A and then sends a message to join the selected fabric.

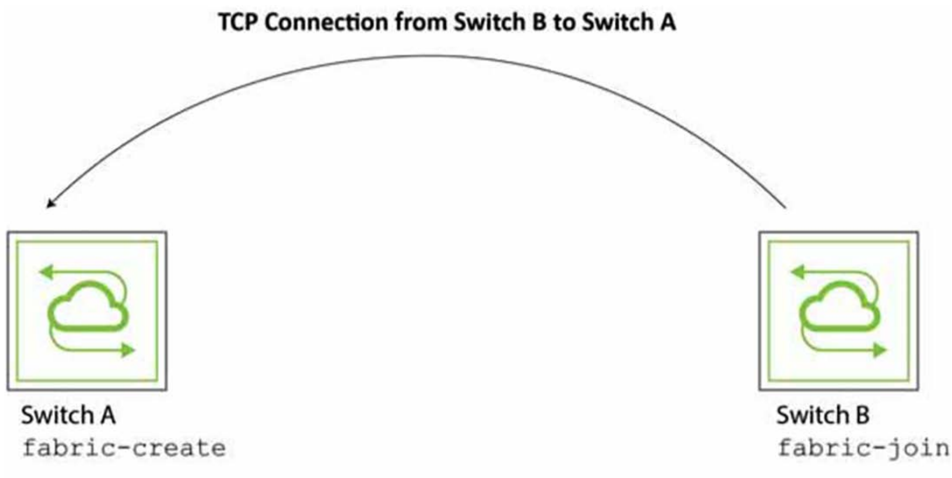


Figure 6 -7 Directly Connected Switch Joining a Fabric

Using the Tab key, Netvisor ONE displays all fabrics configured in the local network as options.

A switch joins the fabric either by using a discovered fabric name or by using a switch IP address. To join a remote fabric, use the `fabric-join` command with a remote switch IP address:

```
CLI (network-admin@switch) > fabric-join switch-ip 192.168.2.2
Joined fabric MyFabric. Restarting nvOS...
```

In addition, the Netvisor ONE software can use the password set up during the fabric creation process to encrypt communication between the nodes in the fabric.

In such cases, when the switch joins a fabric instance from a node, you must type in the password to join it.

> **Note:** Avoid creating fabrics with the same name to prevent conflicts.

Once a new switch joins an existing fabric, the new switch downloads all fabric configuration from the existing fabric switch and restarts the nvOSd (reboots).

After the switch is rebooted and is up and running, the new switch becomes part of the existing fabric.

Configuring the Fabric Over the Management Interface

Fabric configuration information can be exchanged over the network through in-band communication. However, occasional disruption to in-band traffic occurs due to factors such as network re-convergence, port flapping, power system transients, and other events. Therefore, an alternative method is to configure fabric communication over the management interface for a dedicated communication channel.

This can be achieved while creating the fabric, for example:

```
CLI (network-admin@switch) > fabric-create name MyFabric
fabric-network  mgmt
```

When you create a fabric over the management interface, any other node joining the fabric inherits this setting. In other words, all nodes within the same fabric communicate through the same network type with fabric peers. You cannot have mixed fabric configurations using both management interfaces and in-band communication.

Therefore, Netvisor does not display fabrics over an incompatible networks when you execute the `fabric-join` command. This prevents a switch from joining an incompatible fabric.

When you configure the fabric communication over the management interface, all fabric communication stays on the management network, except the following types of packets:

- Cluster synchronization-related messages and cluster keep-alive packets sent over the in-band interface.
- The fabric advertisements such as fabric keep-alive packets and global-discovery packets are controlled by fabric-advertisement-network, which is configured while creating or modifying a fabric.

While fabric-related communication such as transactions, notifications, file system replication messages, and other communications can be configured to be sent over the management network, for consistency, it is recommended to use the same management network for other purposes or communication types such as network status updates and forwarded packets, collectively referred to as control network and fabric advertisements.

The `fabric-create` command allows you to select the transmission medium for other traffic types using specific parameters named `control-network` and `fabric-advertisement-network`:

```
CLI (network-admin@switch) > fabric-create name MyFabric
[fabric-network  in-band|mgmt]  [control-network  in-band|mgmt]
[fabric-advertisement-network    inband-mgmt|inband-only|mgmt-
only]
```

Displaying Fabric Nodes

Netvisor ONE uses fabric keepalive packets to determine the state of each fabric node. To display the state, use the fabric-node-show command with the syntax:

```
CLI network-admin@switch > fabric-node-show [state offline|
online|in-band-only-online|mgmt-only-online|fabric-joined|
eula-required|setup-required|fabric-required|fresh-install]
```

Netvisor ONE supports monitoring and reporting on both management and in-band network, therefore the node state can be one of the following:

- `online` — reach-ability of node over both management and in-band interfaces
- `In-band-only-online` — reach-ability of node through in-band channel only
- `mgmt-only-online` — reach-ability of node through management network only
- `offline` — no reach-ability over either communication channel.

In this example, Netvisor ONE displays the `online` node state in the command output:

```
CLI (network-admin@switch) > fabric-node-show layout vertical
id:                         167772208
name:                       switch
fab-name:                   MyFabric
fab-id:                     a000030:5537b46c
cluster-id:                  a000030:1
fab-mcast-ip:               ::
local-mac:                   64:0e:94:28:00:8e
fabric-network:             in-band
mgmt-ip:                     10.9.100.100/16
mgmt-mac:                    64:0e:94:28:00:8f
mgmt-l3-port:               0
mgmt-secondary-macs:
in-band-ip:                  192.168.42.10/24
in-band-mac:                 64:0e:94:28:00:8e
in-band-l3-port:            0
in-band-secondary-macs:
fab-tid:                    8
cluster-tid:                1
out-port:                   0
version:                     5.0.0-5000014540
state:                      online
firmware-upgrade:            not-required
device-state:               ok
ports:                      0
```

Also check the `fab-tid` value for consistency on each node. See the *Troubleshooting the Fabric* section for details.

Displaying Fabric Information and Statistics

To display information on the configured fabrics, use the fabric-show command:

```
CLI (network-admin@switch) > fabric-show

 name       id               vlan  fabric-network control-network  tid
------   ----------------   ----  -------------- ---------------  -----
Fabric1  a000030:5537b46c    3     in-band         in-band          365
Fabric2  6000210:566621ee   100    mgmt            in-band          5055
```

To display the information about the fabric instance of the local switch, use the `fabric-info` command:

```
CLI (network-admin@switch) > fabric-info format all layout
vertical

name:  Fabric1
id:  a000030:5537b46c
vlan:  3
fabric-network:  in-band
control-network:  in-band
tid:  365
fabric-advertisement-network:   inband-only
```

To display fabric statistics use the `fabric-stats-show` command:

```
CLI (network-admin@switch) > fabric-stats-show

switch    id  server   storage  VM  vlan  vxlan  tcp-syn  tcp-est  tcp-completed  tcp-bytes  udp-bytes  arp
-------   --  -------  -------  --  ----  -----  -------  -------  -------------  ---------  ---------  ----

pubdev02  0   0        0        0   0     0      14.0k    5        40             125K       0          0

pubdev03  0   0        0        0   0     0      3.85K    3        24             110M       0          0
```

To display fabric statistics in vertical format, use the following command:

```
CLI (network-admin@switch) > fabric-stats-show format all
layout vertical
switch:  sw45
id:  0
servers:  0
storage:  0
VM:  0
vlan:  0
vxlan:  0
tcp-syn:  0
tcp-est:  0
tcp-completed:  0
tcp-bytes:  0
udp-bytes:  0
arp:  0
```

Guidelines and Limitations

The following guidelines and limitations apply while configuring the fabric:

- Pluribus recommends, for security reasons, to change the VLAN ID used to create an in-band fabric over a Layer 2 or Layer 3 network as Netvisor ONE uses a default VLAN ID, VLAN 1.
- A fabric over the in-band network (Layer 2 or Layer 3) does not require a special MTU configuration.
- A fabric over management uses Layer 2 multicast, so be sure you do not filter multicast traffic on your management switches.
- Changing the IP address of a node joined to the fabric may cause the node to appear as offline for other fabric members. Therefore, before changing the IP address, unjoin the fabric, and then rejoin the fabric to avoid any inconsistencies.
- A Pluribus switch can only be part of one single fabric at a time.
- Netvisor ONE supports the following currently validated, tested number of fabric nodes in the same fabric:
    - 24 nodes for non-Pluribus switches
    - 32 nodes for Pluribus Networks switches
- When setting up a fabric, switches can only join the fabric one at a time. If you have a large fabric, you should consider this delay during the provisioning of the fabric.

Configuring Layer 4 Ports for Fabric Communication

Netvisor ONE receives fabric communication messages by using system vFlow entries to match traffic flows based on the IP packet protocol, TCP or UDP, and Layer 4 destination port.

Any existing TCP or UDP traffic across the network using the same Layer 4 destination port may match the vFlows and may potentially cause conflicts.

Table 6-1: Default Port Values for Netvisor ONE

Message Type	Layer 4 Port
`fabric`	23399
`notify`	23398
`proxy`	23397
`fabric-keepalive`	23394
`filesystem-replication`	23392
`cluster-traffic-forwarding`	23391
`vport-statistics`	23390
`l2-encap`	23389
`igmp-encap`	23388
`icmpv6-encap`	23387
`arp-encap`	23386
`cluster-analytics`	23385

To avoid conflicts with generic TCP or UDP traffic, configure an alternate Layer 4 port range for special messages using the command:

```
CLI (network-admin@switch) > fabric-comm-ports-modify
```

You can specify the value for the starting point of the range:

```
range-start 1024..65435 port range start
```

To display the current starting point and range values, use the following command:

```
CLI (network-admin@switch) > fabric-comm-ports-show

switch:                            pnswitch2
range-start:                       23300
fabric-port:                       23399
notify-port:                       23398
proxy-port:                        23397
fabric-keepalive-port:             23394
filesystem-replication-port:       23392
cluster-traffic-forwarding-port:   23391
```

```
vport-statistics-port:                    23390
l2-encap-port:                            23389
igmp-encap-port:                          23388
icmpv6-encap-port:                        23387
arp-encap-port:                           23386
cluster-analytics-port:                   23385
```

When you modify the port range, you must configure each node in the fabric individually.

This change temporarily interrupts fabric communication until you have completed the configuration of each node with the same port range.

There is no loss of switched traffic if the interruption is brief.

Because application of this command prevents communication with other nodes, you must log into each node directly and separately apply the `fabric-comm-ports-modify` command.

Configuring a Fabric Over a Layer 3 Network

As described in previous sections, you can create a Netvisor ONE fabric over the management network or over in-band, i.e., between switches with direct (Layer 2) connectivity.

Another option is to establish Netvisor ONE fabric over a Layer 3 network. Netvisor ONE supports this capability over a Layer 3 network running either the *BGP* or the *OSPF routing protocol*.

Before you can configure this feature on your network, make sure you configure BGP or OSPF routing on your switches. For more information on Layer 3 configuration, refer to the *Configuring Layer 3 Features* section.

In a simple topology with a network of two BGP neighbors as in ***Figure 6-8.*** Netvisor ONE uses in-band communication to establish TCP sessions between the two switches to exchange fabric messages.

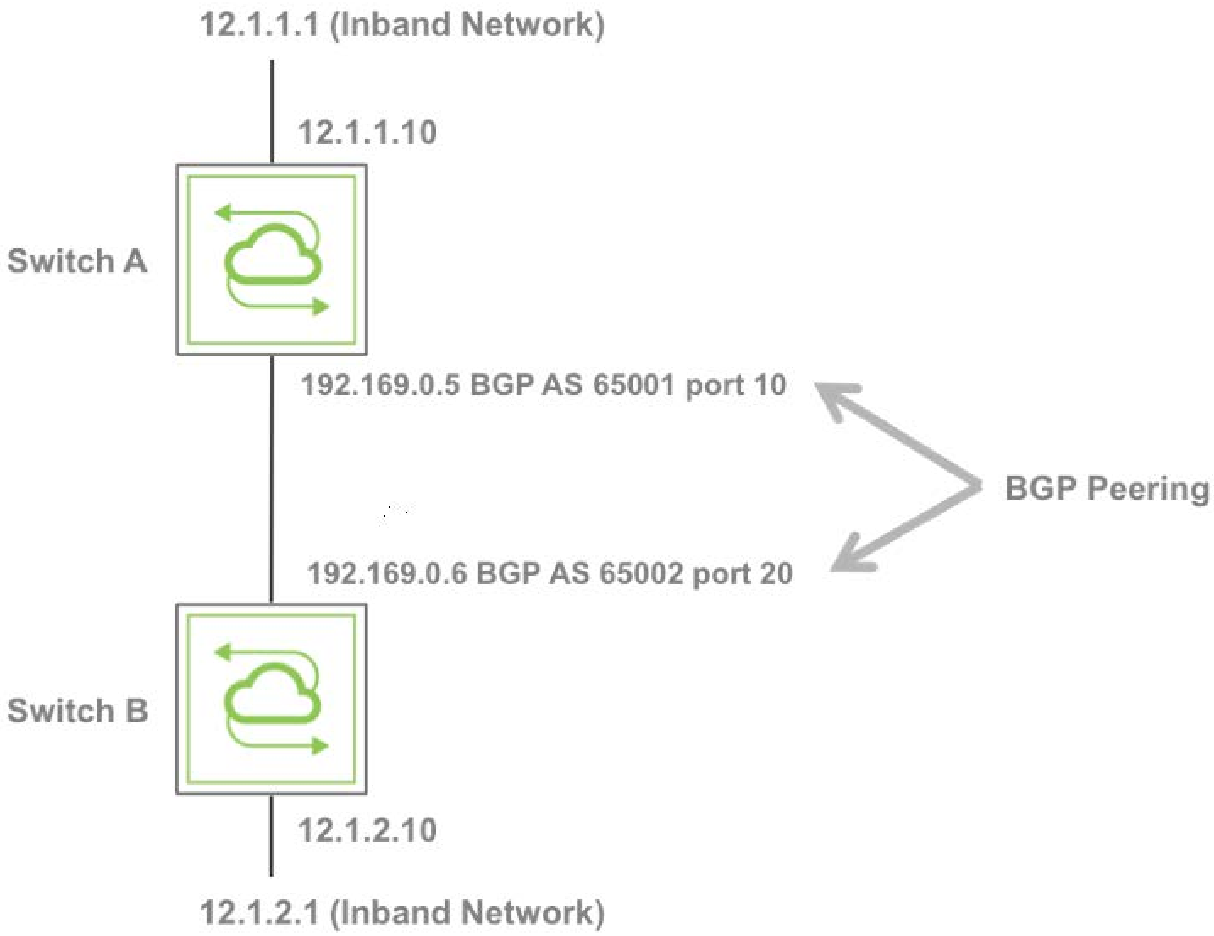


Figure 6-8: Example Network of Two BGP Neighbors Topology

To achieve the BGP-based configuration and establish fabric communication between the two switches, you must perform the following steps:

1) Modify the in-band IP in the same subnet of in-band-nic-ip address.
2) Create a vRouter on each switch.
3) Setup BGP peering and redistribute routes.
4) Setup up global static routes using the respective vRouter as the gateway. You must perform this step because the routes reside inside the vRouter table and each switch must have an appropriate route to reach the in-band network of another switch.
5) Add global static route on switch B to reach switch A in-band network with switch B in-band-nic-ip as the gateway IP address.
6) Then you can configure switch B to join the fabric previously created by switch A.

Use the following commands to accomplish the necessary configuration:

Creating a vRouter for Fabric Communication

Use the `fabric-comm-vrouter-bgp-create` command to create a vRouter for fabric communication.

This command has numerous options including the following:

`name`	Name of the fabric communication vRouter.
`bgp-as`	BGP Autonomous System number of the vrouter from 1 to 4294967295.
`bgp-nic-vlan`	Interface VLAN number between 0 and 4095. You can enable BGP over VLAN interface also.
`bgp-redistribute`	BGP route redistribution. The default value is connected.
`bgp-max-paths`	Maximum BGP paths.
`bgp-ibgp-multipath`	Number of IBGP multipath connections.
`bgp-nic-ip`	IP address of the peering interface.
`bgp-nic-netmask netmask`	BGP NIC netmask.
`bgp-nic-linklocal ip-address`	IPv6 link local address.
`bgp-nic-vnet`	Interface VLAN vNET.
`bgp-nic-bd`	Interface bridge domain.
`bgp-nic-vlan-type`	Interface VLAN type.
`bgp-nic-l3-port`	Layer 3 port
`bgp-nic-mtu`	Interface MTU
`bgp-nic-if-nat-realm`	NAT interface realm
`in-band-nic-ip`	IP address range of the in-band management interface.
`remote-as`	BGP remote AS number from 1 to

	4294967295
`neighbor`	IP address of the BGP neighbor.

The BGP protocol reserves Autonomous System (AS) numbers 64512–65534 for private use and the example below uses some of the private AS numbers.

This dedicated CLI performs the majority of the actions in the logical steps 1-4 described in the *Configuring a Fabric Over a Layer 3 Network* section above. However, it does not change the inband IP address or create the fabric.

After creating the fabric, the root switch, Switch A, does not have to specify the fabric network in the switch configuration, but the switch must create a route to the other inband network on the switch with the `fabric-in-band-network-create` command.

Switch B, a non-root switch, does need to specify the fabric network by using the `fabric-network` parameter:

See an example on how to establish fabric communication between two switches (switch A and switch B) detailed in steps 1 through 6 above.

Switch A

```
CLI (network-admin@switch) > switch-setup-modify in-band-ip 12.1.1.1/24

CLI (network-admin@switch) > fabric-comm-vrouter-bgp-create name vrouter-a bgp-nic-l3-port 10 bgp-as 65001 bgp-nic-ip 192.169.0.5/30 in-band-nic-ip 12.1.1.10/24 remote-as 65002 neighbor 192.169.0.6 bgp-redistribute connected fabric-network 12.1.1.0/24

CLI (network-admin@switch) > fabric-in-band-network-create network 12.1.2.1/24
```

Switch B

```
CLI (network-admin@switch) > switch-setup-modify in-band-ip 12.1.2.1/24

CLI (network-admin@switch) > fabric-comm-vrouter-bgp-create name vrouter-b bgp-nic-l3-port 20 bgp-as 65002 bgp-nic-ip 192.169.0.6/30 in-band-nic-ip 12.1.2.10/24 remote-as 65001 neighbor 192.169.0.5 bgp-redistribute connected fabric network 12.1.2.0/24

CLI (network-admin@switch) > switch-route-create network 12.1.1.0/24 gateway-ip 12.1.2.10
```

```
CLI (network-admin@switch) > fabric-join switch-ip 12.1.1.1

CLI (network-admin@switch) > Joined fabric myfabric.
Restarting nvOS...
```

Connecting Multiple Fabric Nodes over a Layer 3 Fabric

In a topology with more than two switches configured for BGP, the first peer for each switch can be created using the `fabric-comm-vrouter-bgp-create` command. You must create the other switches separately.

See ***Figure 6-9*** where a third switch, Switch C, is added to the previous two-switch topology.

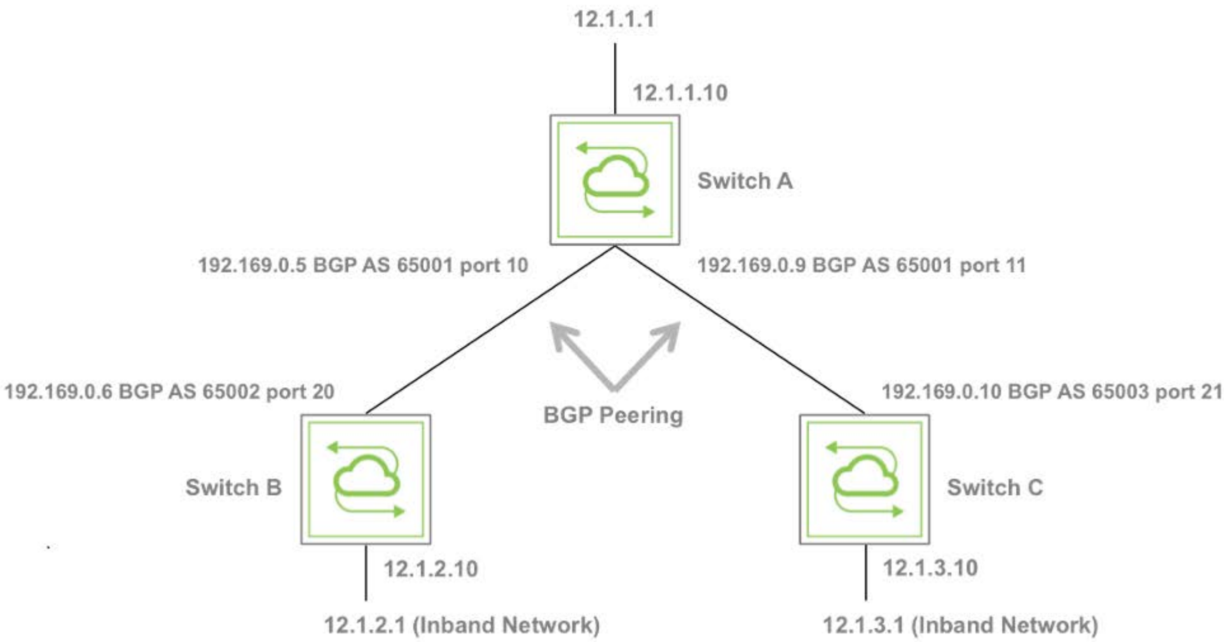


Figure 6-9: An Example of Fabric over Layer 3 Topology

The configuration for this example follows the same scheme as the two switch topology. However, Netvisor ONE requires the following additional steps:

1) On Switch A, configure BGP peering with Switch C and create a static route to reach the inband network on Switch C. To extend this configuration with more than three-switch example, use this step on every switch with more than one BGP peer.

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vrouter-a ip 192.169.0.9/30 l3-port 11

CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
vrouter-a neighbor 192.169.0.10 remote-as 65003

CLI (network-admin@switch) > fabric-in-band-network-create
network 12.1.3.0/30
```

2) On Switch C, use the `fabric-comm-vrouter-bgp-create` command and connect:

```
CLI (network-admin@switch) > switch-setup-modify in-band-ip
12.1.3.1/24
```

```
CLI (network-admin@switch) > fabric-comm-vrouter-bgp-create
name vrouter-c bgp-nic-l3-port 21 bgp-as 65003 bgpnic-ip
192.169.0.10/30 in-band-nic-ip 12.1.3.10/24 remote-as
65001neighbor 192.169.0.9 fabric-network 12.1.1.0/24 bgp-
redistribute connected fabric-network 12.1.3.0/24

CLI (network-admin@switch) > switch-route-create network
12.1.1.0/24 gateway-ip 12.1.3.10

CLI (network-admin@switch) > switch-route-create network
12.1.2.0/24 gateway-ip 12.1.3.10

CLI (network-admin@switch) > switch-route-create network
12.1.3.0/24 gateway-ip 12.1.2.10

CLI (network-admin@switch) > fabric-join switch-ip 12.1.1.1

Joined fabric myfabric. Restarting nvOS...
```

Limiting the Transaction Log File Size

In releases prior to Netvsior ONE version 6.1.0, Pluribus had not restricted the size of the transaction log files, due to which the transaction files increased in size occasionally on some customer premises, causing memory issues.

This issue occurs when some commands such as `stp-port-modify` and `transaction-settings-modify` commands are executed in a loop. These commands do not cause any changes to the configuration after the command is executed for the first time, but the transaction log file is appended every time the command is executed adding duplicate entries and causing the file to grow.

Starting with Netvisor ONE version 6.1.0, this limitation is corrected by enabling you to limit the file size of the transaction logs. You can truncate the transaction log file to a desired number of entries by using the `transactions-settings-modify` command depending upon your configuration. By default, this functionality is disabled.

Depending upon the limit you set (for example *N* entries), the transaction log file limits the log entries to the latest *N* entries. Further, Netvisor ONE adds an additional *X* entries to the threshold limit of N entries you have configured. When the threshold of *N+X* limit is crossed, the first *X* entries gets overwritten by the newest or latest entries.

This functionality is supported only on *local xact log* file (`local` scoped configurations).

Warning: If you set the transaction limit (*N*), you may lose the older entries in the transaction log file and hinder the rollback possibility. However, this feature is available only for local transaction log files.

Note: If you do not set the threshold limit, then this functionality remains disabled and there is no limit enforced on the log file size.

To restrict the transaction log file size, you can set a limit by using the `transactions-settings-modify` command:

```
CLI (network-admin@switch) > transactions-settings-modify max-local-xact-log-entries max-local-xact-log-entries-number
```

Where, the `max-local-xact-log-entries` is the maximum number of entries (*N*) to be added to the transaction log file (`xact_log` file).

Note: The default value of `max-local-xact-log-entries` is 0, which means, the feature is disabled.

As explained earlier, an additional *X* entries are saved by Netvisor ONE before truncating the log file size. Netvisor ONE has set the value of *X* to 100 entries. That is, for example, if you set the `max-local-xact-log-entries` to `500` entries, then an additional `100` entries are also saved (see *N+X* explanation above) to the log file before Netvisor enforces the truncation process of the `local-xact-log` file. When the threshold is crossed, the file gets truncated by deleting the previously stored additional *X* (100) entries.

A warning message is written to the *nvOSd.log/perror.log* file:

- When the entries in the transaction log file exceeds the configured value (*N*).
- When the entries exceed the *N+X* value and Netvisor truncates the *X* entries.

To truncate the `local xact log file` to a given `tid` (*N*), use the command:

```
CLI (network-admin@switch) > transaction-log-file-truncate-to
trunc_tid trunc_tid-number
```

Where the `trunc_tid` is the transaction ID (the latest `tid` entries are retained when this feature is enabled)

> **Note**: All truncated commands are written to a new file `/nvOS/log/xact-truncate.log.`

To view the total entries in the file, use the command:

```
CLI (network-admin@switch) > transaction-show transaction-
scope local count-only
```

Where, `count-only` is the formatting option to display only the number of transaction entries.

General Guidelines while Configuring this Feature:

- Only the transactions in `transaction-show transaction-scope local` output and in `/var/nvOS/etc/Local/xact_config.log` file are removed. All the configurations remain intact.

- Transaction rollback is possible even after the log file is truncated to an available TID. Note that the TIDs get renumbered after truncation.

Sample Configuration

Below is a sample configuration for further understanding:

- First view the transaction details using the command:

```
CLI (network-admin@switch) > transaction-show transaction-scope local
count-only
Count:  3
```

- Use the below command to view the transaction details:

```
CLI (network-admin@switch) > transaction-show transaction-
scope local
start-time:      2021-03-04,16:07:58.030
tid:            1
```

```
trunc_tid:      0
state:          commit
command:         switch-setup-modify eula-accepted true
eula_timestamp  2021-03-04,16:07:57
undo-command:   switch-setup-modify eula-accepted false
eula_timestamp  1969-12-31,16:00:00
------------------------------------------
start-time:      2021-03-09,06:05:23.932
tid:            2
trunc_tid:      0
state:          commit
command:         stp-port-modify port 31 edge
undo-command:   stp-port-modify port 31 no-edge
------------------------------------------
start-time:      2021-03-12,01:56:30.020
tid:            3
trunc_tid:      0
state:          commit
command:         vlan-create id 3040 type public vxlan-mode
standard scope local stats
undo-command:   vlan-delete id 3040
```

- Use the command to set the max-local-xact-log-entries to 50:

```
CLI (network-admin@switch) > transactions-settings-modify max-
local-xact-log-entries 50
```

View the details using the command:

```
CLI (network-admin@switch) > transaction-show transaction-scope local
count-only
Count: 150
```

The count `150` indicates the additional 100 (*N+X*).

You can verify the transactions using REST API commands as well.

Troubleshooting the Fabric

Displaying the Transaction History

When configuring and administering the fabric, you can display the list of executed transactions by using the `transaction-show` command. For example in this case committed transaction 1 corresponds to a command in which a vRouter was created:

```
CLI (network-admin@switch) > transaction-show

start-time:     2020-05-14,15:38:34.622
tid:            1
state:          commit
command:         vrouter-create id b001b66:0 name vr1 scope
fabric vnet test-fab-2-global dedicated-vnet-service locati
on 1 storage-pool rpool zone-id b001b66:1 router-type hardware
router-ipstack frr hw-router-mac 66:0e:94:66:b3:0f clu
ster-active-active-routing hw-vrid 0 hw-vrrp-id -1 bgp-redist-
static-metric none bgp-redist-connected-metric none bgp
-redist-rip-metric none bgp-redist-ospf-metric none bgp-max-
paths 1 bgp-delayed-startup 1 bgp-update-delay-strict 0 b
gp-keepalive-interval 60 bgp-holdtime 180 bgp-global-nh-
preference true ospf-redist-static-metric none ospf-redist-st
atic-metric-type 2 ospf-redist-connected-metric none ospf-
redist-connected-metric-type 2 ospf-redist-rip-metric none
ospf-redist-rip-metric-type 2 ospf-redist-bgp-metric none
ospf-redist-bgp-metric-type 2 ospf-default-information none
  ospf-default-info-originate-metric none ospf-default-info-
originate-metric-type 2
undo-command:   vrouter-delete name vr1
----------------------------------------
start-time:     2020-05-14,15:39:02.820
tid:            2
state:          commit
command:         vrouter-interface-add vrouter-name vr1 nic
eth0.4092 ip 10.0.120.2 netmask 24 mac 66:0e:94:66:b3:0f vl
an 4092 vlan-type public public-vlan 4092 no-exclusive nic-
enable no-pim pim-dr-priority 1 no-pim-cluster no-fabric-n
ic vrrp-priority 100 vrrp-adv-int 1000 l3-port 45 mtu 1500 no-
sriov-vf mirror-traffic false no-priority-tag
undo-command:   vrouter-interface-remove vrouter-name vr1 nic
eth0.4092
```

The Netvisor ONE transaction log file contains the list of commands corresponding to the executed transactions as well as the undo command(s) required to undo each transaction. Commands are shown in the `transaction-show` output for *informational purposes* only.

Each transaction can have a *local*, *cluster* or *fabric* scope. For example acceptance of the EULA is a transaction that is local to each device:

```
CLI (network-admin@switch) > transaction-show transaction-
```

```
scope  local

start-time:      2019-06-02,21:50:35.497
tid:            1
state:          commit
command:         switch-setup-modify eula-accepted true
eula_timestamp   2019-06-02,21:50:35
undo-command:    switch-setup-modify  eula-accepted  false
eula_timestamp   1969-12-31,16:00:00
```

On the other hand, for instance transactions of VLAN creation and deletion are usually (but not necessarily always) executed with a fabric scope. Other objects such as vNETs are created and deleted with a fabric scope too, as shown in the example below:

```
CLI  (network-admin@switch)  >  transaction-show  transaction-
scope  fabric

start-time:      2019-06-02,22:10:54.895
tid:            1
state:           remote-commit
command:         vlan-create id 100 type public vxlan-mode
standard scope  fabric stats
undo-command:   vlan-delete id 100
----------------------------------------

start-time:      2019-06-02,22:11:25.834
tid:            2
state:           remote-commit
command:         vnet-create id c00025b:1 name vn1 scope fabric
vrg c00025b:0 vlan-type public vlans 5 config-admin create-
vnet-mgr  vnet-mgr-storage-pool  rpool  vnet_mgr_id  c00025b:0
vnet_mgr_zone_id  c00025b:1  vnet_mgr_location  1
vrg_created_by_vnet  true  admin_role  c00025b:400
undo-command:   vnet-delete name vn1
----------------------------------------

start-time:      2019-06-02,22:11:36.907
tid:            3
state:           remote-commit
command:        vlan-delete id 100
undo-command:   vlan-create id 100 type public hw-vpn 0 hw-
mcast-group 0 replicators "" repl-vtep :: in_hw false public-
vlan 100 user_public_id 0 public_id_set_by_user false scope
fabric description vlan-100 label "vlan 100" active yes stats
uses_refcnt no refcnt 0 vrg 0:0 ports 1-69 untagged-ports none
send-ports  21,23,31-34,53,57,61,65,69,272-275  active-edge-
ports 272 non-auto-ports none ports-specified false
initialized true flags ""
----------------------------------------

start-time:      2019-06-02,22:11:51.550
tid:            4
state:           remote-commit
```

```
command:        vnet-delete name vn1
undo-command:  vnet-create id c00025b:1 name vn1 scope fabric
vrg c00025b:0 vlan-type public vlans 5 config-admin admin
40000 create-vnet-mgr vnet-mgr-name vn1-mgr vnet-mgr-storage-
pool rpool vnet_mgr_id c00025b:0 vnet_mgr_zone_id c00025b:1
vnet_mgr_location 1 vrg_created_by_vnet true global false
allow_admin_access false admin_role c00025b:400
```

In case of clusters (that is, pairs of redundant devices described in more detail later in this guide) certain transactions are applied to both nodes as if they were a single logical device.

You can choose the transaction information format for a node by typing the `transaction-show` command followed by the `format` parameter to choose a tabular or a vertical output. For example:

```
CLI (network-admin@switch) > transaction-show format all
layout vertical

start-time:    03-19,13:46:42
end-time:      03-19,13:46:43
scope:         fabric
tid:           33
state:         remote-commit
command:       --unrecoverable-- vlan-delete id 22
undo-command: --unrecoverable-- vlan-create id 22 nvid
a000030:16 scope fabric name vlan-22 active yes stats vrg 0:0
ports 1-72,128-129,255 untagged-ports none send-ports
31,41,47-48,51,65-66 active-edge-ports none ports-specified
false flags
----------------------------------------

start-time:    09:36:09
end-time:      09:36:09
scope:         fabric
tid:           34
state:         remote-commit
command:       vlan-create id 35 scope fabric stats ports-
specified true
```

Please note that, in this command's output, the `scope` parameter indicates which set of transactions are displayed, as each scope has an independent set of transactions associated with it. As shown in this example, Netvisor ONE uses `fabric` as the *default scope* unless another scope is specified.

Also note that you should not copy and paste commands and undo-commands from this output because they may include information that does not apply to a different context. As a matter of fact, as mentioned earlier, Netvisor ONE displays the fields for *informational purposes* only so as to allow you to see exactly what happens to the configuration when you roll forward or roll back the transaction ID.

Once you decide which node to modify and the transaction to roll forward or roll back to, you can use the `transaction-rollforward-to` or `transaction-rollback-`

`to` commands to re-run the command (roll forward) or undo the command (roll back) on the node being *troubleshooted*, or even in a broader scope, as described in the following sections.

Keeping Transactions in Sync with Auto-Recovery

When transactions are executed with a fabric scope, they get applied to all nodes that are part of the same fabric instance as the local node. This process requires coordination and synchronization across the nodes.

You can display the ID of the last executed transaction by using the `fabric-node-show` command:

```
CLI (network-admin@pnswitch1) > fabric-node-show format
name,fab-name,fab-tid,state,device-state,

 name       fab-name    fab-tid  state   device-state
--------- ---------- ------- ------  ------------
pnswitch2  pnfabric     2       online    ok
pnswitch1  pnfabric     2       online    ok
```

The ID is the same because the fabric has made sure that the same transaction be executed consistently on all online nodes.

What happens, though, if one of the nodes is temporarily offline and gets out of sync?

Netvisor ONE’s fabric synchronization logic possesses an auto-recovery function (called auto-recover) that makes sure that the transactions get automatically resynchronized when they accidentally go out of sync. This capability is enabled by default:

```
CLI (network-admin@pnswitch1) > transaction-settings-show

switch:                              pnswitch1
allow-offline-cluster-nodes:         on
auto-recover:                        on
auto-recover-retry-time:             5m
reserve-retry-maximum:               10
reserve-retry-interval-maximum(s):   8
```

In special scenarios, this capability can be turned off *on purpose* to force the configuration of a specific node to be rolled back to a previous state:

```
CLI (network-admin@pnswitch1) > transaction-settings-modify
no-auto-recover

CLI (network-admin@pnswitch1) > transaction-settings-show
switch:                              pnswitch1
allow-offline-cluster-nodes:         on
auto-recover:                        off
auto-recover-retry-time:             5m
reserve-retry-maximum:               10
reserve-retry-interval-maximum(s):   8

switch:                              pnswitch2
allow-offline-cluster-nodes:         on
auto-recover:                        on
```

```
auto-recover-retry-time:             5m
reserve-retry-maximum:               10
reserve-retry-interval-maximum(s):   8
```

However, this change is local to the device where the command was issued. Therefore, in those cases in which it is necessary to apply this change to all nodes in the fabric, the `switch *` directive as shown in the following command can be used:

```
CLI (network-admin@pnswitch1) > switch * transaction-settings-modify no-auto-recover

CLI (network-admin@pnswitch1) > transaction-settings-show
switch:                              pnswitch1
allow-offline-cluster-nodes:         on
auto-recover:                        off
auto-recover-retry-time:             5m
reserve-retry-maximum:               10
reserve-retry-interval-maximum(s):   8

switch:                              pnswitch2
allow-offline-cluster-nodes:         on
auto-recover:                        off
auto-recover-retry-time:             5m
reserve-retry-maximum:               10
reserve-retry-interval-maximum(s):   8
```

Rolling Back and Rolling Forward Transactions

Netvisor ONE maintains a log file with the list of transactions with their respective *undo commands* to be able to revert back, when necessary, to a previous state, that is, to *roll back* one or more transactions starting from the latest one. On the other hand, the list of executed commands can be used to redo certain transactions, in other words to *roll forward* one or more transactions.

However, this is only desirable under special circumstances, because the *auto-recover* feature by default automatically makes sure that all nodes are synchronized to the latest transaction.

For example in case of rare conditions in which transactions diverge on different nodes (despite auto-recover), a roll back or roll forward action may be performed manually through the corresponding command.
However, the auto-recover function may need to be *temporarily disabled* on the affected node(s) to permit the desired action.

The `transaction-rollback-to` command is used to roll back to an earlier fabric transaction number. The `transaction-rollforward-to` command is instead used to roll forward to a subsequent fabric transaction number.

For instance, the fabric state gets accidentally out of sync according to the `fabric-node-show` command output with, say, a missing interface addition transaction:

```
CLI (network-admin@pnswitch1) > fabric-node-show format
name,fab-name,fab-tid,state,device-state,

 name      fab-name   fab-tid  state  device-state
--------- ---------- -------   ------ ------------
pnswitch2  pnfabric     1      online    ok
pnswitch1  pnfabric     2      online    ok
```

Hence the state can be rolled back to a previously synced ID to restore fabric-wide (`scope fabric`) consistency:

```
CLI (network-admin@pnswitch1) > transaction-rollback-to scope
fabric tid 1
Warning: rolled back transactions are unrecoverable unless
another fabric node has them. Proceed? [y/n] y
```

After successfully rolling back the transaction (i.e., no error message is printed on the console), the change completes and the transaction is removed from the transaction log.

Alternatively the state can be rolled forward to reattempt to successfully redo the previously failed fabric-wide interface addition:

```
CLI (network-admin@pnswitch1) > transaction-rollforward-to
scope fabric tid 2
Added interface eth2.13
```

After successfully rolling forward a transaction (i.e., no error is printed on the console), the change completes and the transaction log is updated.

If multiple nodes go out of sync, you must *recover each node separately* .

An alternative approach (*usually reserved to customer support for special cases*) is to try to force a roll back or roll forward action when the configuration is in sync but the transaction ID fails to get updated:

```
CLI (network-admin@pnswitch1) > transaction-rollforward-to
scope fabric tid 2 ignore-error
Added interface eth2.13
```

In rare cases when you apply a configuration to the fabric and a node does not respond to the configuration, you may want to evict the node from the fabric to troubleshoot the problem on the specific device.

To evict a node, that node must be offline, otherwise the eviction command will fail. Then you can use the `fabric-node-evict` command to perform the eviction process like so:

```
CLI (network-admin@switch) > fabric-node-evict name pnswitch2
```

or

```
CLI (network-admin@switch) > fabric-node-evict id
b000021:52a1b620
```

Rolling Back the Configuration of the Fabric

In addition to troubleshooting rare conditions, the roll back action can be used in certain circumstances in which it is beneficial to *turn back time* on all the nodes in the same fabric instance.

As discussed in earlier sections, the fabric natively (i.e., by default) stays *synchronized automatically to the last transaction executed*. Therefore, in order to revert all switches to a previous state, it is necessary to temporarily disable this automatic function (auto-recover) like so:

```
CLI (network-admin@pnswitch1) > switch * transaction-settings-
modify no-auto-recover
```

Then it is possible to perform a roll back action to a certain ID on all those switches. You can check the latest transaction ID with the command:

```
CLI (network-admin@pnswitch1) > fabric-node-show format
name,fab-name,fab-tid,state,device-state,

name         fab-name     fab-tid state  device-state
-----------  -----------  ------- ------ ------------
pnswitch1    myfabric     1533    online ok
pnswitch2    myfabric     1533    online ok
```

Let us say you want to roll back all nodes to transaction ID 1530. You can do that with the following command:

```
CLI (network-admin@pnswitch1) > switch * transaction-rollback-
to transaction-scope fabric tid 1530
Warning: rolled back transactions are unrecoverable unless
another fabric node has them.
Please confirm y/n (Default: n):y
CLI (network-admin@pnswitch1) > fabric-node-show format
name,fab-name,fab-tid,state,device-state,

name         fab-name     fab-tid state  device-state
-----------  -----------  ------- ------ ------------
pnswitch1    myfabric     1530    online ok
pnswitch2    myfabric     1530    online ok
```

In this case, though, rolled back transactions are unrecoverable because the fabric logic is forced to *forget* about them on a per node basis where auto-recover was disabled. (So no roll forward is then possible).

Once all the nodes have been rolled back to the chosen transaction, you can re-enable auto-recover to make sure that the fabric stays in sync automatically from that moment onward:

```
CLI (network-admin@pnswitch1) > switch * transaction-settings-
modify auto-recover
```

How to Fix the Cluster Transaction Divergence Issue

When a cluster transaction divergence occur, you cannot execute any further cluster-scoped configurations on either of the cluster nodes. With the release of Netvisor ONE version 5.1.2, we provide a solution to fix the cluster transaction divergence issue.

To ensure high availability, Netvisor ONE allows cluster scope transactions to proceed even when one of the peer nodes in a cluster goes offline (enabled, by default, by using the command: `transaction-settings-modify` with `allow-offline-cluster-nodes` parameter; which can be disabled, you can disable this option, if required) during configuration changes. However, this may cause a transaction divergence as explained in ***Figure 6-10***. For example, consider a cluster with two nodes- node 1 and node2, both are online and configurations commands are executed on both nodes, and the transactions are synchronized until a certain time where the TID=T. After certain time, node2 goes offline, but transactions continue on node1 and the TID on node1 changes to T1. Now, both the nodes go offline and then node2 comes back online, and transactions continue on node2, where the TID changes to T2. Now, when node1 also comes back online, the transactions get diverged as illustrated in ***Figure 6-10***.

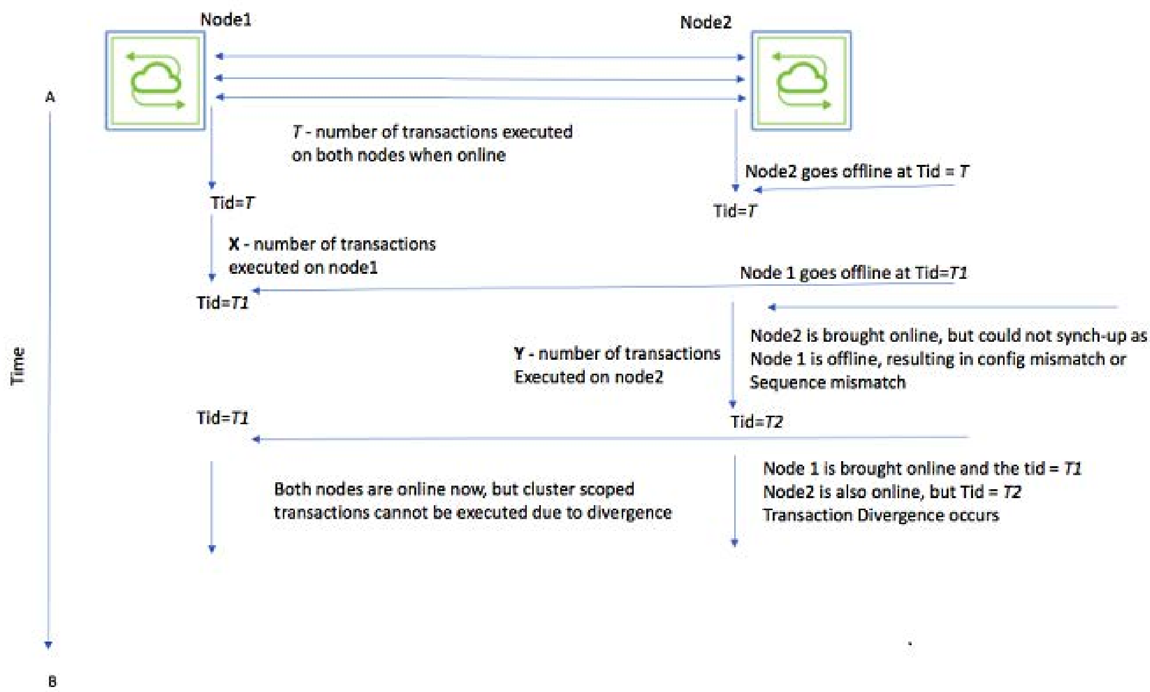


Figure 6-10: Cluster Transaction Divergence

The two possible transaction divergence cases as illustrated in ***Figure 6-10*** include:

- Case 1: Even if X number of transactions and Y number of transactions are the same and is also executed in the same sequence (T1 = T2), still there will be transaction divergence due to the change in cluster-change IDs.
- Case 2: If the X and Y transactions on the nodes are a separate (different) set of commands or is executed in different sequence, then also transaction divergence occurs.

The auto-recovery feature, which is enabled by default on Netvisor ONE, automatically rolls forward the transactions with the peers when the offline cluster node is brought up online when there is no transaction divergence. But, in the case of transaction divergence, you have to manually roll-back to a common transaction point for the auto-recovery feature to synchronize (for details, see the previous sections of *Troubleshooting the Fabric* section) . As this is a manual process, it is error prone (because if you mistakenly roll-back to a different transaction point, then you have to repeat the process to get to the common transaction point) .

To mitigate this issue, Netvisor ONE introduces a new command: `transaction-cluster-divergence-fix`. You can run this `local-scoped` command on any of the cluster nodes. However, Pluribus recommends to run this command on a slave node where the divergence occurred.

In case 1 above, when you run the `transaction-cluster-divergence-fix`. command on a node, Netvisor ONE updates the change ID s of all diverged transaction IDs to match with the peer node.

In case 2 above, when you run the command on a node, Netvisor fetches the transaction details from the cluster peer and rolls-back the configuration to a common transaction ID on the node on which the command is executed. Then, the node re-synchronizes the configuration with the cluster peer configuration if the auto-recovery function (called auto-recover) that makes sure that the transactions get automatically re-synchronized is set to *ON (*This capability is enabled by default). For details on the auto-recovery function, see the Keeping Transactions in Sync with Auto-Recovery section.

> **Note**: It is recommended to take a backup of the current configuration before issuing the `transaction-cluster-divergence-fix` command. Ensure that the fabric communication between the nodes in the cluster is enabled for this functionality to work.

To fix the cluster transaction divergence issue, use the command on the failed cluster node (recommended to run on a slave node):

```
CLI (network-admin@node_slave) > transaction-cluster-divergence-fix
Warning: this will download config from cluster peer and rollback to tid before it is diverged. It is recommended to take config backup before running this command.
Please confirm y/n (Default: n):y
```

Related Commands

```
CLI (network-admin@pn-test-2) > transaction-settings-modify
```

Specify one or more of the following options:	
`allow-offline-cluster-nodes|` `no-allow-offline-cluster-nodes`	Specify to allow transactions to proceed even if a cluster node is offline. By default, the `allow-offline-cluster-nodes` parameter is enabled on nvOS.

`auto-recover|no-auto-recover`	Specify to automatically recover missed transactions.
`auto-recover-retry-time duration: #d#h#m#s`	Specify the retry time for transaction to auto-recover.
`reserve-retry-maximum reserve-retry-maximum-number`	Specify the maximum number of retires for transaction reservation; 0 for infinite.
`reserve-retry-interval-maximum reserve-retry-interval-maximum-number (s)`	Specify the maximum number of seconds to wait between transaction reservation retries.

About the Fabric Default Parameters

The following is a list of Netvisor default port numbers, multicast addresses, and communication information about the fabric:

Internal keepalive message

- Multicast IP: 239.4.9.7
- UDP Destination Port: 23399
- Netvisor sends the packet from the CPU to the internal port to ensure that the CPU path to the switch is working and the internal port is up.

Fabric keepalive message

- UDP Destination Port: 23394
- Point to point UDP fabric keepalives: if Netvisor cannot receive these messages, the fabric node may go into an offline state.

Global discovery message

- Multicast IP: 239.4.9.3
- UDP destination port: 23399
- Each node periodically multi-casts a message about the fabric. This enables the `fabric-show` command on directly connected nodes, Layer 2-adjacent, to display available fabric instances and also enables the `fabric-join name name-string` command.

Proxy commands

- TCP Destination Port: 23397 SSL
- Used for Netvisor ONE-to-Netvisor ONE communication. Used for internal purposes and also to implement commands executed on other switches from a local switch.

Status propagation

- TCP Destination Port: 23398 SSL
- Port changes and vport changes propagated to other nodes in the fabric.

TCP API clients

- TCP Destination Port: 23396 SSL
- API clients connect to this port. Disable using the `admin-service-modify if <mgmt/data> no-net-api` command.

File System replication

- TCP Destination Port: 23392 SSL
- For ZFS send and ZFS receive messages when replicating file systems across the fabric.

L2 ARP/DMAC miss/Broadcast encapsulation

- UDP Destination Port: 23389
- These are special VXLAN-encapsulated packets sent from one management CPU to another management CPU between two Layer 2 adjacent switches.

L3 ARP/DMAC miss/Broadcast encapsulation

- UDP Destination Port: 23388

- These are special VXLAN-encapsulated packets sent from one management CPU to another management CPU between two switches interconnected at Layer 3.

vPORT status
- Multicast IP: 239.4.9.4
- UDP Destination Port: 23390
- vPort update messages associated to status changes to hypervisors or hosts in the fabric.

vFlow CPU packets
- UDP Destination Port: 23398
- These packets are sent point-to-point for vflow-snoop of a fabric-scoped vFlow

> **Note:** All of these messages must not drop or become lost in order to keep a fabric healthy. However, the multicast messages do not propagate through routers and therefore Netvisor ONE does not rely on them for fabrics created over Layer 3 networks.

The `fabric-node-show` command displays information about internal data structures for each node in the fabric, including the node state.

For example:

```
CLI (network-admin@switch) > fabric-node-show

fab-name   mgmt-ip        in-band-ip  in-band-vlan-type fab-tid  version          state
-------- -------------- ----------- ----------------- ------- --------------     ------
WDTest   10.36.10.45/24 10.0.1.1/24   public            7       5.0.0-5000014540  online
```

If Netvisor ONE does not receive any keepalives or other messages from a fabric node for about 30 seconds, then Netvisor marks the node as `offline`.

Anything that prevents keepalives or other kinds of messages from flowing freely between fabric nodes can cause problems for fabric connectivity.

Supported Releases

Command/Parameter	Netvisor ONE Version
`fabric-create` `fabric-show`	Commands added in *version 1.2*
`fabric-network` `control-network`	Parameters added in *version 2.4*
`fabric-advertisement-network`	Parameter added in *version 2.4.1*
`fabric-node-show` `fabric-join`	Commands introduced in *version 1.2*
`fabric-info` `fabric-unjoin`	Commands introduced in *version 1.2.1*
`transaction-show`	Command introduced in *version 2.2.3*
`fabric-comm-vrouter-bgp-create`	Command introduced in *version 2.4.1*
`fabric-comm-ports-show` `fabric-comm-ports-modify`	Commands introduced in *version 3.0.0*

Please also refer to the *Pluribus Command Reference* document.

Related Documentation

Refer to these sections of the Configuration Guides:

- *Implementing a Fabric Upgrade*
- *Configuring Layer 2 Features*
- *Configuring Layer 3 Features*
- *Configuring High Availability*
- *Configuring Virtual Networks (vNETs)*

for further information on concepts mentioned in this section (such as Layer 2, Layer 3, etc.)

Configuring High Availability

This chapter provides information about the High Availability Feature in Netvisor ONE.

Understanding the High Availability Feature in Netvisor ONE

High availability (HA) refers to the characteristic of a system (an individual device or a group of devices) to ensure that service availability (i.e., uptime) is higher than normal and hence downtime is minimized. In case of networking, this is achieved by increasing the resilience (i.e., fault tolerance) of the network so as to be able to provide and maintain an acceptable level of service during faults and challenges to normal operation.

High availability is generally achieved through multiple strategies that include:

- Redundancy of device components (such as power supplies and fans) to maximize the reliability of individual network nodes.
- Device and link redundancy to maximize end-to-end service continuity by eliminating single points of failure and guaranteeing fast re-convergence.
- Simplified operation as well as network automation and orchestration to minimize potential service-disrupting human errors.

Pluribus' Adaptive Cloud Fabric control plane provides intuitive and less error-prone mechanisms to automatically configure and manage a number of physical or logical components as a virtual functional super-entity referred to as a fabric). For details, see the Configuring and Administering the Pluribus Fabric chapter.

Moreover, as part of the redundant fabric architecture, the Netvisor ONE software supports additional advanced capabilities to increase network automation, resiliency and scalability, such as automatic link aggregation and switch clustering with vLAGs.

Understanding Link Aggregation

Link aggregation is a standard technology used to combine multiple network connections in order to provide redundancy in case of single or multiple link failure. The augmented ***data pipe*** generated by aggregating N individual links behaves as a single logical high-bandwidth data path whose capacity can be up to N times the bandwidth of each individual link it comprises. Such logical connection is called a Link Aggregation Group (LAG).

Sometimes it is also called a (port) trunk, link bundle, or port channel as it **bundles** a number of connected physical ports together to implement a single augmented logical communication channel capable of traffic load sharing with fast re-convergence and redundancy.

Therefore, when the number of active bundled ports in a LAG changes for some reason (for example user configuration, hardware fault, etc.), traffic patterns dynamically adapt to reflect the re-balanced state of the LAG with minimal service disruption. Load splitting is achieved by hashing each packet's L2 through L4 headers (when present) to select a physical link to follow.

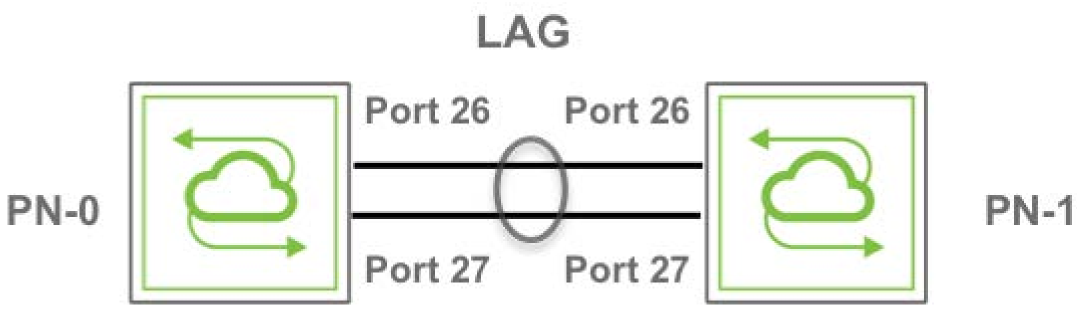


Figure 7-1 - Link Aggregation Group (LAG)

Other terms commonly used to describe this technology included with servers: network interface controller (NIC) bonding or NIC teaming.

Trunks can be either statically set up or dynamically created. In the former case the LAG creation is very fast but it lacks the automation and connectivity checks of the latter case.

For link aggregation the IEEE organization has defined a standard, vendor-independent implementation with the IEEE 802.3ad specification (later transferred to the IEEE 802.1AX-2008 document and superseded by 802.1AX-2014) and has also defined a standard dynamic protocol, called Link Aggregation Control Protocol (LACP), to automate this process.

Understanding the Link Aggregation Control Protocol (LACP)

The IEEE 802.3ad Link Aggregation Control Protocol (LACP) supports the automatic creation of Ethernet LAGs by exchanging special LACP frames (called LACPDUs) down all the links that have the protocol enabled. If it finds an LACP-capable neighbor device (peer) on the other end of the links, it will negotiate the dynamic creation of a LAG comprising all the compatible links (only full-duplex point-to-point Ethernet links running at the same speed can be matched and grouped together).

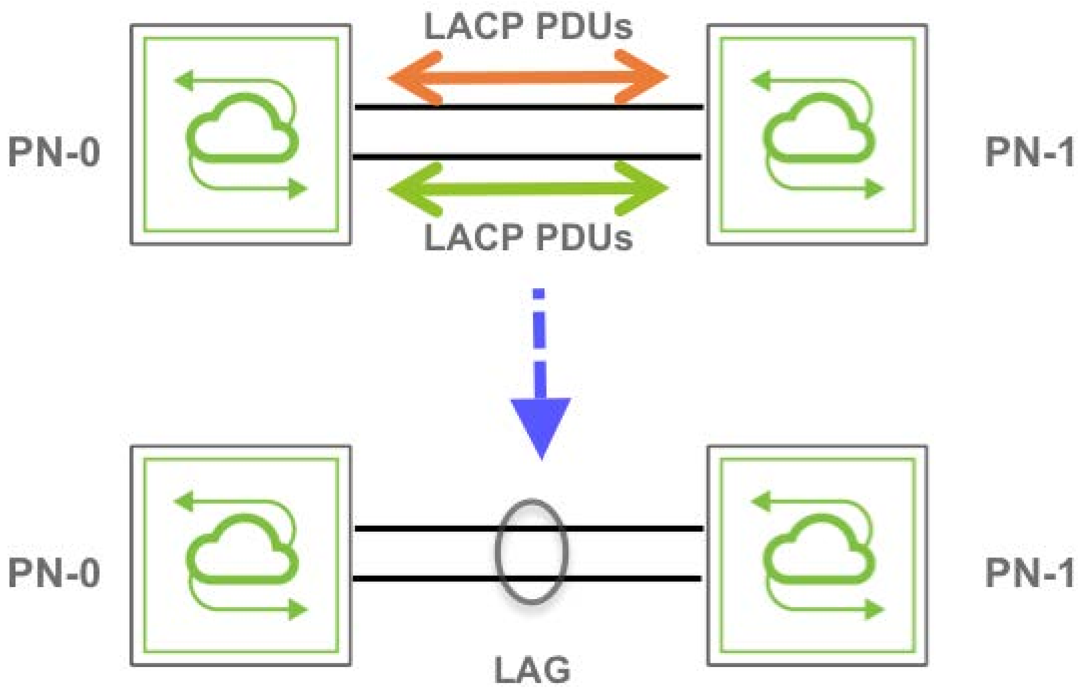


Figure 7-2 - Link Aggregation Control Protocol (LACP)

The LACP dynamic negotiation can be configured in one of two modes: active or passive.

In active mode LACP always (unconditionally) sends frames along the configured links that are intended to be bundled together. In passive mode, instead, LACP does not initiate a conversation/negotiation until it hears from the peer (this is typically the default configuration). Hence, for the negotiation to start at least one of the peers needs to be switched to active mode by the network administrator.

Once the negotiation is complete and the configured number of ports is aggregated, LACP periodically transmits keepalive frames over a LAG to verify connectivity of each link member and to react (i.e., trigger a link failover) in case of detection of a malfunction. LACP can be configured with a slow or fast lacp-timeout value (90s vs 3s) to react more gracefully or more promptly to connectivity changes.

LACP therefore is very helpful with the function of creating and/or augmenting a LAG as it always performs the necessary validations of the added links (such as bidirectional connectivity).

The maximum number (N) of bundled ports in a LAG is typically (4 or) 8. On top of that a significant number of LAGs (L) may need to be provisioned in a large network design to achieve optimal scalability. Therefore, especially in complex deployments with many LAGs and several ports per LAG, the LACP dynamic function plays a really crucial role both in simplifying the port bundling process and in making sure that such process runs smoothly and error free over a large number of network entities (N x L).

In addition, in case of link failure, both LACP and the hardware algorithms will then make sure that the re-convergence/failover process is prompt and minimally impactful for the traffic. (On the other hand, static LAG configuration would not guarantee an equally easy and effective behavior in all possible scenarios.)

In summary, the LACP logic performs the following functions on the switch:

- Maintains configuration and port state information to control link aggregation.
- Exchanges configuration and connectivity information with other peer devices.
- Attaches or detaches ports from LAGs based on the exchanged configuration and state information.

LACP frames are always exchanged between neighboring ports when in active mode, whereas in passive mode frames are exchanged as long as the peer is active. This allows the network admin to leverage the automated LACP negotiation logic to control the LAG bring-up or bring-down process by simply configuring one side of a trunk.

Off mode is instead used to disable the LACP function on a trunk when for example the network admin wants to manage the trunk bring up process manually (however that prevents any dynamic negotiation and link verification).

Furthermore, LACP employs two priority values to determine which ports to aggregate into an active LAG. If for example a hardware limitation prevents all configured compatible ports from aggregating, then the priority values will be used by LACP to select which ports to add and which ports to keep in standby mode.

LAG members in standby mode don't actively participate in traffic forwarding but can later be promoted to forwarding state to be used to replace a failed LAG member.

The LACP logic uses a system priority value, which is generated by the combination of the device MAC address with a user-configurable two-octet priority parameter. It also uses a port aggregation priority value, which is generated by the combination of the port number with a user-configurable two-octet priority parameter. Both priority values are used by LACP to dynamically select which port to aggregate in a bundle and which device (with higher priority) is entitled to that decision. The values for both user-configurable priority parameters can vary from 1 to 65535. Their default configuration is 32768.

Just as their member links, LAGs are point-to-point logical connections, so they can only be as resilient as the networking nodes that they interconnect. In other words, if either peer device at the end of the LAG fails, the entire LAG goes down.
Therefore, in order to further improve the network's fault tolerance, it is of paramount importance to introduce multiple redundant traffic paths in the design (also known as multi-pathing).

This can be achieved in numerous ways at Layer 2 and/or at Layer 3. A very effective

Layer 2 strategy to implement dual fully redundant paths with very fast traffic failover is to extend the capability of LAG across two distinct switches to create a virtual LAG device pair.

In Pluribus terminology this cross-chassis LAG capability is implemented with switch clusters.

Understanding Switch Clusters

In general, in computer science the term ***cluster*** (also known as high-availability/HA cluster or fail-over cluster) is used to identify a group of devices that are functionally equivalent and structurally redundant so that they are able to provide continuity of service (without user intervention) when any component or an entire device fails. Therefore they are used for critical applications when all single points of failure must be eliminated.

Pluribus Networks builds upon this concept to bring end-to-end multi-pathing with advanced redundancy to high-performance networks where HA is a critical requirement, especially in case of mission-critical high-uptime data center and enterprise deployments.

For this reason Pluribus' clustering technology represents a key pillar of Pluribus' Adaptive Cloud Fabric architecture as well as a powerful tool for network designers. From a practical standpoint it allows customers to deploy in many critical points of the network redundant pairs of switches (simply referred to as switch clusters or clusters) with both upstream and downstream traffic load balancing and fast failover capabilities.

A common scenario is depicted in Figure 7-3 below.

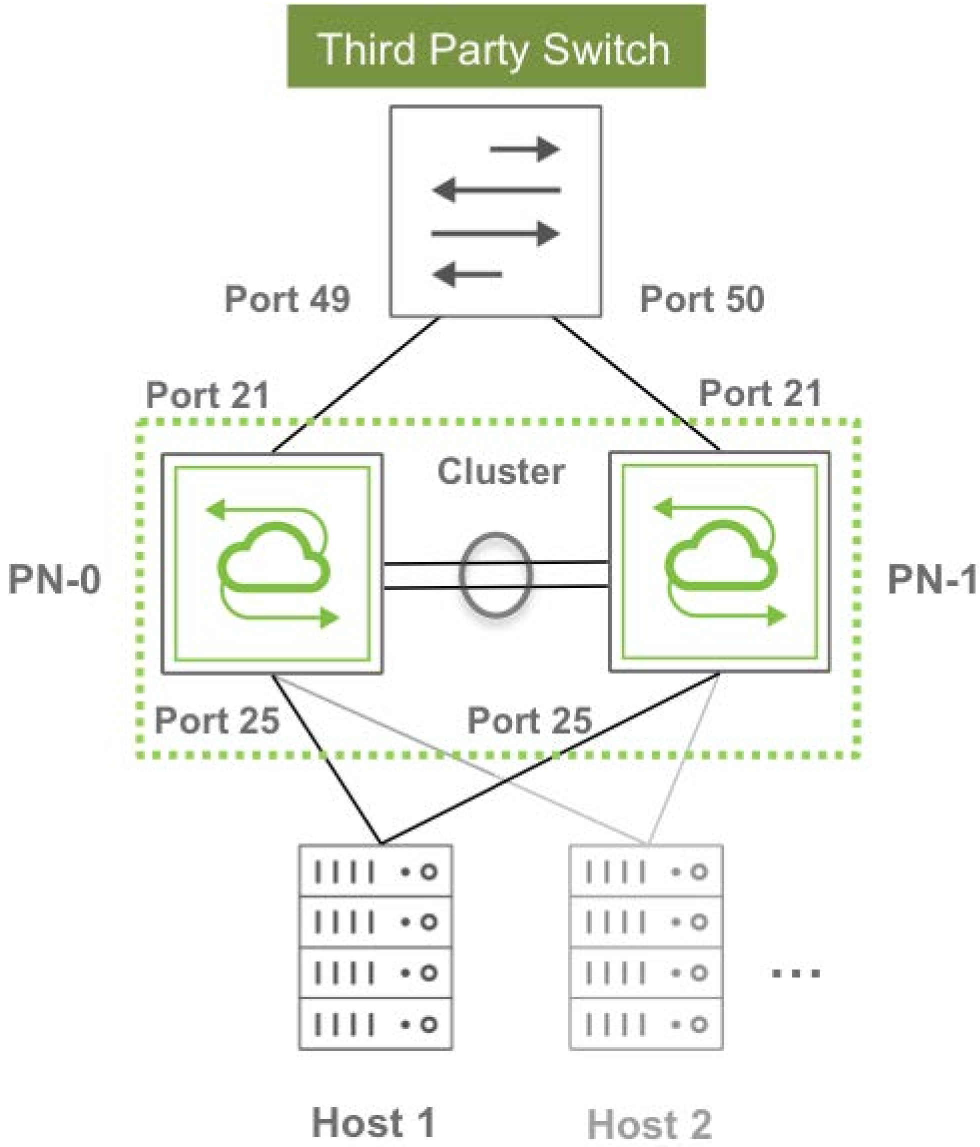


Figure 7-3 - Example of Requirement for Upstream and Downstream Path Redundancy

As seen in the figure above, clusters can interconnect third-party switches as well as servers in a redundant fashion simply by using standard technologies (link bundling or NIC bonding) on those devices.

The key is that each redundant pair of Pluribus switches functions as a single logical entity capable of inter-switch state synchronization to guarantee proper Layer 2 operation as well as traffic load balancing and failover. To external devices this switch pair appears as a single virtual neighbor both for traffic forwarding and for protocol communication purposes.

As a matter of fact, in computer networking an alternate name that is sometimes used for a cluster is virtual chassis. And this latter designation is perhaps more useful to describe the concept: a pair of separate physical switches is joined in a virtual entity that behaves as if ports belonging to each device were unified within a common virtual chassis.

In Pluribus' advanced networking architecture clustering is a natural fit and represents a logical extension of the fabric. The requirement for clustering is in fact that the two switches be members of the same fabric instance.

In addition, due to the asymmetric nature of certain interactions, when you create a cluster you must designate one cluster node as cluster-node-1 (that is, primary node) and the other as cluster-node-2 (that is, secondary node).

In order to set up a cluster, an active link between the primary and the secondary node must exist (as shown above in Figure 3). This is called a “cluster link” and can comprise one or more ports directly connecting the two cluster nodes together. If there are more than one port, they will be automatically bundled and the cluster link will effectively be a “cluster trunk” (that is, the LAG of those ports).

Using an intrinsically redundant cluster trunk for cluster node interconnection is the recommended best practice.

The aggregate bandwidth of such trunk should be such that no major traffic bottleneck is experienced in case of failover scenario and/or in the presence of single-homed upstream or downstream devices (while in the former case the cluster trunk is used as backup path only in case of failure, in the latter case a portion of the traffic is always forced to cross the cluster links). This bandwidth calculation varies depending on the network design, the traffic type, the number and requirements of the single-homed devices, etc.

VLAN 4094 is reserved and is used to carry cluster synchronization traffic. It is automatically added to the in-band interface port and to the cluster link when you create the cluster configuration. This is possible because Netvisor ONE detects cluster links using an extra data set sent in LLDP messages. Therefore, when a cluster link is detected through this mechanism, VLAN 4094 is automatically added to it.

Netvisor ONE performs cluster synchronization over the control network of the fabric. For the in-band interface, synchronization uses VLAN 4094 over the cluster links. For management, synchronization is performed over the management interface.

Each cluster node sends a synchronization message (with cluster state, versioning info, device uptime, etc.) to the peer node every 2 seconds. These messages function also as keepalives: so if three messages in a row are missed, the cluster pair goes offline (that is, symmetrically).

On the other hand, the process of going online for the cluster happens asymmetrically, for two main reasons: to avoid race conditions and to determine an additional important state of each node, the ***master*** or ***slave*** role, for protocol support purposes. Synchronization messages are thus exchanged and used to select the master and slave roles via an internal negotiation algorithm based on parameters like uptime.

When a cluster comes online, it triggers:

- A resend of all status updates to the peer node
- A re-synchronization of all vLAGs
- The transition of STP to run in cluster mode

Synchronization of vLAGs (see also the next sections) is used to make sure that they behave as a single logical entity across both nodes. This is achieved by synchronizing port state, as well as Layer 2 entries when needed.

vLAGs in a cluster can work in active-standby mode (where only the vLAG members on one node are active) or in active-active mode (where all the vLAG members are active and forwarding). The latter mode requires Layer 2 entry/vPort synchronization across nodes.

vLAG state synchronization typically happens from the primary node to the secondary node. However, the secondary node can synchronize a (local) port state when that port comes up. In case of necessity it can also request the primary node to (re)start the synchronization process.

Layer 2 entry synchronization is instead performed symmetrically by both nodes upon detection of a vPort change for performance reasons.

About the Cluster Re-peer Process

When a cluster node dies or needs replacement, it is necessary to use another switch to substitute the failed/missing node to rebuild the cluster pair as soon as possible so as to restore network redundancy.

Initially, the `cluster-repeer` command was used to rebuild a cluster with a new switch node. Subsequently, as an enhancement, the rebuild process was integrated into the fabric join procedure. A cluster pair is now restored via the `fabric-join` command followed by the option:

`repeer-to-cluster-node`	Replace a dead cluster node by restoring against the existing cluster node.

Before adding a new cluster node, though, the node to be replaced must first be evicted from the fabric with the `fabric-node-evict` command.

Then, in order to be able to rebuild a cluster via the `fabric-join` command with the `repeer-to-cluster-node` option, the new node needs to be directly connected to the remaining cluster node that is still active.

The joining node that performs a `fabric-join` to repeer with the cluster's master node will initiate direct communication with it to get up-to-date fabric and cluster configuration files and transaction IDs.

After the joining node installs the new configuration, it transmits a fabric-join transaction to notify all fabric members that it has joined the fabric. In addition, it runs a cluster-update command which rebuilds the cluster pair with itself and the existing cluster peer as members. The existing cluster peer will also modify any cluster objects that may require an update as a consequence of the repeer procedure (for example, trunks).
Finally, the joining node restarts and the process is complete.

The aforementioned procedure implicitly applies to Layer 2-based fabric topologies where direct Layer 2 connectivity with the other fabric nodes is possible for message exchange.

In case of Layer 3 fabric designs, instead, a further enhancement has been introduced in Netvisor ONE release 5.1.0 to perform the repeer operation over a Layer 3 fabric interconnect.

A new `fabric-join` option has been added to allow the users to specify that a cluster pair needs to be rebuilt over a Layer 3 fabric configuration:

`over-l3`	Specify to establish fabric is over layer 3.

In addition, a new `over-l3` flag has been added to the output of the `fabric-info` command to indicate whether it's a Layer 2 or Layer 3 case.

About the Spanning Tree Protocol (STP) in Cluster Mode

In cluster mode Netvisor ONE ensures that the two physical cluster nodes behave as one single logical spanning tree node.

It achieves this by automatically sharing across both devices the same STP bridge ID and STP priorities, and by using dedicated and disjoint STP port ID ranges: STP port IDs on the primary node are 0 to PORTS_MAX – 1 whereas on the secondary node are PORTS_MAX to (2*PORTS_MAX - 1). This happens regardless of the online/offline state of the cluster and thus guarantees protocol ID consistency/persistency and a seamless failover in case of node failure.

In addition, in case of active-active vLAGs (that is, dual-homed links), Netvisor ONE makes sure that they behave as single logical ports in the STP state machine. For this purpose, rather than creating a new port ID range for these logical ports, the master uses its local STP port ID as the logical port ID (which is preserved across failovers). Therefore, in case of single vLAG member link failure no STP re-convergence occurs. (Please note that with active-standby vLAGs a single link failure can cause an STP topology change.)

If an entire cluster node fails and therefore the cluster goes offline, STP will run the STP state machine locally and independently from the (down) peer. This is therefore called *independent mode*.

Then, when the cluster comes back online and needs to run in STP cluster mode, as mentioned in the previous section, the cluster synchronization process is employed to elect a master node (with the non-elected peer becoming the slave).

Only the master node runs the STP state machine, which encompasses all VLANs and all ports, both local (on the master switch) and remote on the slave switch (cluster links are excluded and are managed separately, as described in a subsequent paragraph).

The master's STP state machine, user configuration changes (of the STP mode, MSTP instances, bridge ID, etc.) and vLAG port states are mirrored to the slave node so that, if the master fails, the slave can seamlessly take over from where the master left off.

In conjunction with the ownership of the STP state machine, it's required for the master switch to manage the very important BPDU transmission function, even for any (single-homed) ports belonging to the slave switch. Not all the aggregate burden of this function falls on the master node, though: the slave switch provides some basic PDU relay support to the master to ensure proper load splitting of this function and hence optimal scalability when running in STP cluster mode. In addition, the slave relays to the master all BPDUs it may directly receive.

As for cluster links, they follow specific STP state transitions: when a cluster goes online, the cluster links start in STP blocked state (except for VLAN 4094 used for synchronization) to prevent loops. However, once the state from the newly elected master gets fully synchronized to its slave, the cluster links are put into STP forwarding state to provide a back-up forwarding path for traffic.

In special cases in which the transmission of the synchronization messages from the master to the slave fails (or times out), the cluster links are put back into the STP blocking state until synchronization can complete to avoid potential loops.

If the master node goes offline, the slave will continue running the STP state machine from the last mirrored state. If the former master then comes back online, it is then selected to become the slave and the state of the node that was already up is mirrored to it.

In this way, there is never any interruption in STP state preservation even after multiple failures of either node, as long as one node is always up.

About Split Brain and Detection Script

In Pluribus parlance, a cluster has two switches (nodes) that operate as a single logical switch. These switches periodically as well as on an event driven basis, exchange control messages over the control network to keep the status and tables (such as L2 tables, vLAG, STP, cluster states, etc) between the two switches synchronized. If one of the nodes in the cluster fails to communicate with the peer node for three consecutive cluster-sync messages, then the node sets the cluster to offline mode and attempts to function in an independent mode. If one of the cluster nodes is down, then operating as an independent node helps to maintain continuity.

However, if both nodes are up and the nodes are unable to sync-up (for example, due to the cluster network going down), then operating as an independent node is not desirable. This situation can lead to duplicate packets such as *broadcast-unknown unicast* or *multicast* (BUM) traffic or traffic loss. This condition is known as split brain.

In Netvisor ONE version 6.1.1 HF1, a script is provided as part of Netvisor package for the detection and recovery of split brain.

> **Note:** The control network can be set to *management* or *in-band* using the `fabric-local-modify control-network [in-band|mgmt]` command.

Handling of Split Brain Using Detection Script

> **Caution**: We recommend disabling the *split brain* script before performing any software upgrades on the switches in the cluster.

As a pre-requisite, you must install split brain detection script as a service on both nodes of the cluster pair. Netvisor ONE supports control network over *Management* or over *in-band* IP.

> **Note**: Starting with Netvisor ONE version 6.1.1 HF4, the split brain *install/uninstall* scripts are available in */opt/nvOS/bin/pn-scripts* directory. Having the scripts in */opt/nvOS/bin/pn-scripts* directory enables you to invoke the scripts from both the Netvisor ONE CLI and REST API shell prompt.

When the script is installed on leaf switches:

- The script detects the split brain condition based on the following factors:
  - When the control network is over *management*, losing the management network connection results in split brain.
  - When the control network is over *in-band*, cluster links going down results in split brain
- Once the cause is detected, the script proceeds to quarantine the cluster slave (backup) switch. That is, all ports on the slave switch are brought down except the cluster ports. Disabling of ports is not persistent with switch-reboot, hence no manual intervention to enable ports is required.

To install and run the script as a system service, run the *pn_split_brain_install.sh* command by using Netvisor ONE CLI. The service will persist a switch reboot. It is not required to re-run the script on every reboot or power-cycle. To stop the script from running, use the *pn_split_brain_uninstall.sh* command.

The script can also detect when the cluster is back online.

Below is an example on how to use the script. To install and run the script, use the command:

```
CLI (network-admin@switch*) > pn-script-run name
pn_split_brain_install.sh
Executing   /opt/nvOS/bin/pn-scripts/pn_split_brain_install.sh:
Created symlink from /etc/systemd/system/multi-
user.target.wants/svc-nvOS-split-brain.service
to   /etc/systemd/system/svc-nvOS-split-brain.service.
```

To know or detect the status of the script, use the command:

```
CLI (network-admin@switch*) > exit
root@switch*:~#
root@switch*:~# systemctl status svc-nvOS-split-brain.service
● svc-nvOS-split-brain.service - Service to check for split
brain functionality in cluster-slave and disable ports
    Loaded: loaded (/etc/systemd/system/svc-nvOS-split-
brain.service; enabled; vendor preset: enabled)
   Active: active (running) since Wed 2021-11-17 02:27:24 PST;
7s ago
 Main PID: 25780 (perl)
    Tasks: 2
   Memory: 12.8M
      CPU: 1.697s
    CGroup: /system.slice/svc-nvOS-split-brain.service
            ├─25780 /usr/bin/perl /usr/bin/pn_split_brain.pl
Dec 06 19:39:18 switch* systemd[1]: Started Service to check
for split brain functionality in cluster-slave and disable
ports.
```

To stop the script from running, use the *pn_split_brain_uninstall.sh* command as below:

```
CLI (network-admin@switch*) > pn-script-run name
pn_split_brain_uninstall.sh
Executing  /opt/nvOS/bin/pn-
scripts/pn_split_brain_uninstall.sh:
Removed symlink /etc/systemd/system/multi-
user.target.wants/svc-nvOS-split-brain.service.
```

To know or detect the status of the script, use the command:

```
CLI (network-admin@switch*) > exit
root@switch*:~#
```

```
root@switch*:~# systemctl status svc-nvOS-split-brain.service
● svc-nvOS-split-brain.service
   Loaded: not-found (Reason: No such file or directory)
   Active: inactive (dead)
```

To install the script on all switches of the fabric, use the command:

```
CLI (network-admin@switch*) > switch * pn-script-run name
pn_split_brain_install.sh
```

To uninstall the script on all switches of the fabric, use the command:

```
CLI (network-admin@switch*) > switch * pn-script-run name
pn_split_brain_uninstall.sh
```

Note:

- The `allow-offline-cluster-nodes` command option in the `transaction-settings-modify` command is turned *OFF* by default and further fabric and cluster scoped transactions are not allowed until the cluster node is back online.
- Quarantine of cluster slave (backup) node mitigates the traffic loss due to split brain issue.
- In Fabric over Layer 3, to detect split brain, you should have '*allow-as*' enabled (so that in-band-ip of cluster master is reachable via spine switch) or the *management* link should be present.

Recovery handling

To recover from split brain, the quarantined switch should be brought back to active service after the cluster comes back online. The script detects when the cluster is back online and proceeds to reboot the cluster slave and it comes back to active service with the ports enabled.

To check the status of ports, use the command:

```
CLI (network-admin@switch) > cluster-bringup-show
```

Where the status displays *ports-enabled* indicating that both devices of cluster are now active and up for service.

About Layer 3 Hardware Forwarding in a Cluster

In a cluster, Layer 3 hardware forwarding takes place on both nodes running as a VRRP pair (see also the next sections) even if the local VRRP interface is in standby.

In symmetry of routing each node is expected to forward traffic in hardware on behalf of the peer for any packets destined to the VRRP virtual IP address. This can be achieved by synchronizing L3 entries, L3 adjacencies (vPorts) and vRouter state between the two peers.

For single-homed L3 interfaces, instead, nodes may act independently and may even have an L3 adjacency over the cluster link for failover purposes.

Understanding vLAGs

The virtual chassis logical model can be effectively used to enable an advanced capability called multi-chassis link bundling/port channeling. This feature is also referred to as MC-LAG (Multi-Chassis Link Aggregation Group).

An MC-LAG is a cross-device link bundle (i.e., trunk). It typically has at least one port member on one switch and another port member on a backup switch. It can be facing downstream toward an end point (configured with a regular LAG on its end) or upstream toward another switch or router (also using a regular LAG or even an MC-LAG).

The IEEE 802.1AX-2008 standard for link aggregation (LAG) does not mention MC-LAG but does not preclude it, because the implementation of the required synchronization technology can be vendor-specific without affecting interoperability. Such additional under the hood (i.e., mostly transparent) synchronization technology performs advanced functions such as automatic MAC address learning synchronization across members, sharing of the same switch MAC and STP system ID, sharing of port state and information even during dynamic protocol negotiations, etc.

Pluribus' implementation of MCLAG is called vLAG (Virtual Link Aggregation Group) on a switch cluster. That in practice means that in order to be able to configure a vLAG a cluster pair needs to be set up first.

As mentioned in an earlier section, a necessary requirement for a cluster to be created is to provision a redundant ***horizontal*** connection between the two cluster members: in Pluribus parlance this process is called automatic LAG (link aggregation) of the intra-cluster trunk. As long as at least two ports on both cluster members are physically interconnected, the automatic LAG logic will take care of bundling them together and provisioning them as intra-cluster trunk.

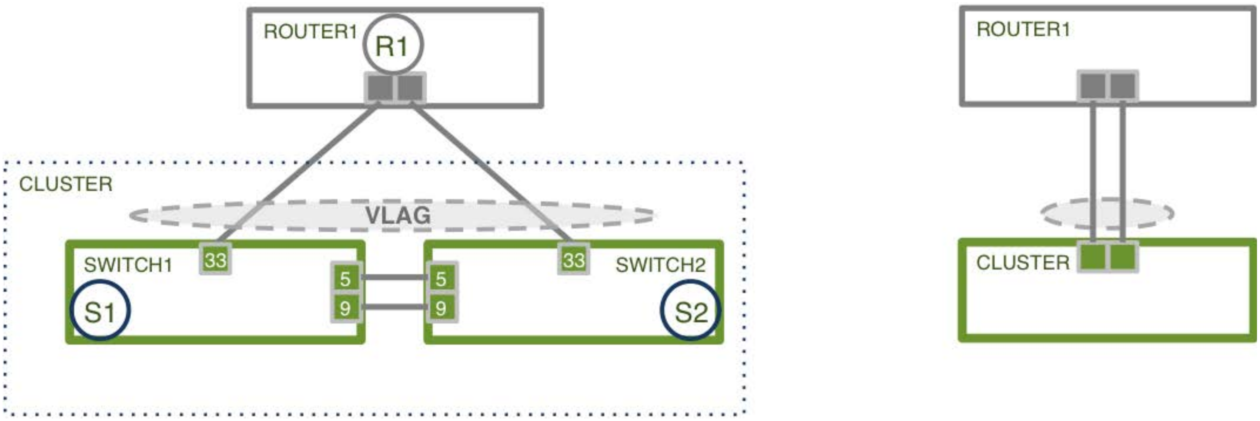
The ***cluster trunk*** is just a regular LAG, but is the pivot around which various important functions revolve. First off, it provides a critical communication channel utilized for cluster synchronization activities as well as protocol exchanges. It is also instrumental for supporting the MC-LAG (a.k.a. vLAG) function on the cluster, as it can function as a backup forwarding path during failover scenarios. (Therefore it must be a fat enough data pipe to prevent potential bottlenecks in case of failures.)

From a high level point of view, a vLAG is a single logical but physically redundant upstream or downstream connection across a pair of cluster switches (see also Figure 4 below). In other words, physically it's a triangular topology that includes the cluster trunk, while logically it appears just as if it were a point-to-point multi-link connection.

This property makes active-active vLAGs ideal for a number of Layer 2 or Layer 3 network designs, where standard port bundling/port channeling technologies (IEEE 802.3ad) can be used for high availability and very fast traffic steering (due to multi-pathing) in case of link failure. (See also the examples in the figures below.)

Using clusters with vLAGs for instance is a technique often chosen to avoid using the Spanning Tree Protocol (STP) for Layer 2 redundancy.

Figure 7-4 below shows how a vLAG is used to present a router/switch with a single logical connection instead of two separate ones. Therefore, in case of a Layer 2



configuration, loop prevention is not needed on that network segment (as no loop is present).

Figure 7-4 - Logical View of a vLAG from an External Device

Furthermore, the same strategy can be used downstream too to interconnect dual-homed servers to leaf switches.

In fact, as long as the neighboring device (whether a router, switch or server) supports the standard LACP protocol, port bundling negotiation is taken care of by the protocol itself automatically even when a vLAG is used on the Pluribus switches' side. (Note that even static trunking can be effectively used in these scenarios, especially when dynamic negotiation is not required.) This is by virtue of the interoperability characteristics built in to the Adaptive Cloud Fabric's control plane.

In general, switch clusters with vLAGs are extremely capable and flexible configurations so they can be employed in a number of network designs in conjunction with other standard technologies.

For example, as shown in Figure 7-5 below, vLAGs can connect to other vLAGs or to other third-party virtual chassis/multi-chassis LAG solutions. This creates a “four-way” bundle with the interconnection of two multi-chassis LAGs on opposite sides.

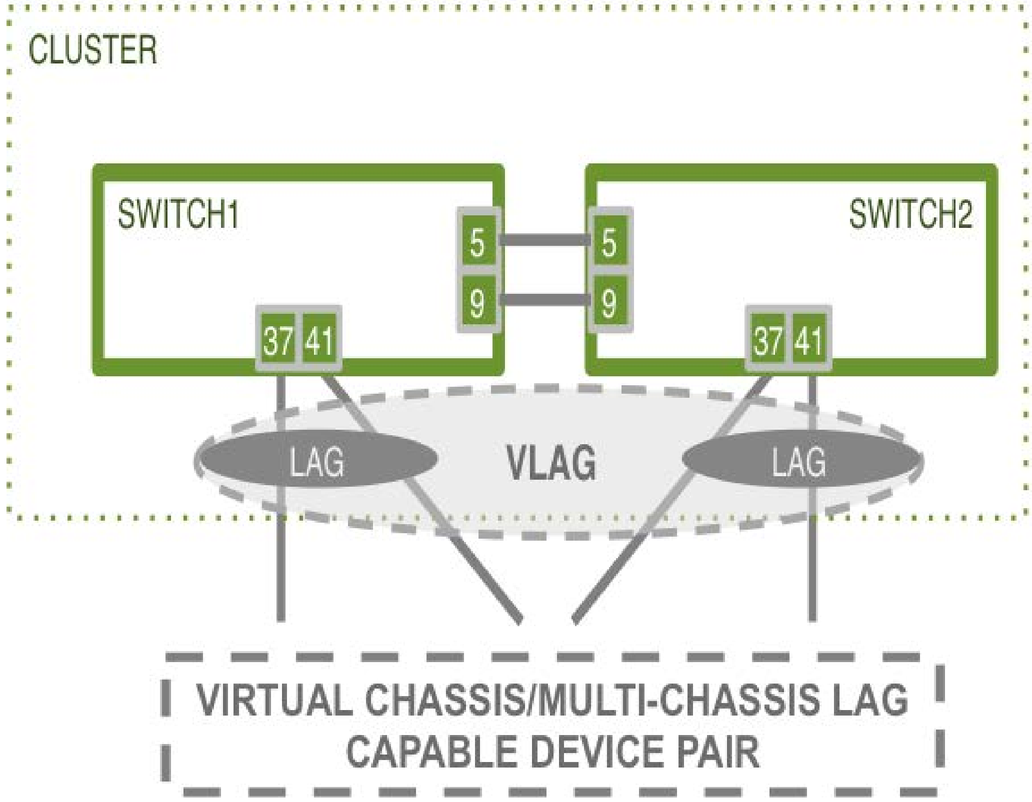


Figure 7-5 - Four-way vLAG between a Pluribus Cluster Pair and Another Multi-chassis LAG

Figure 7-6 below shows the common use case of interconnection of leaf and spline Pluribus clusters to provide high availability using the virtual chassis/four way vLAG technique.

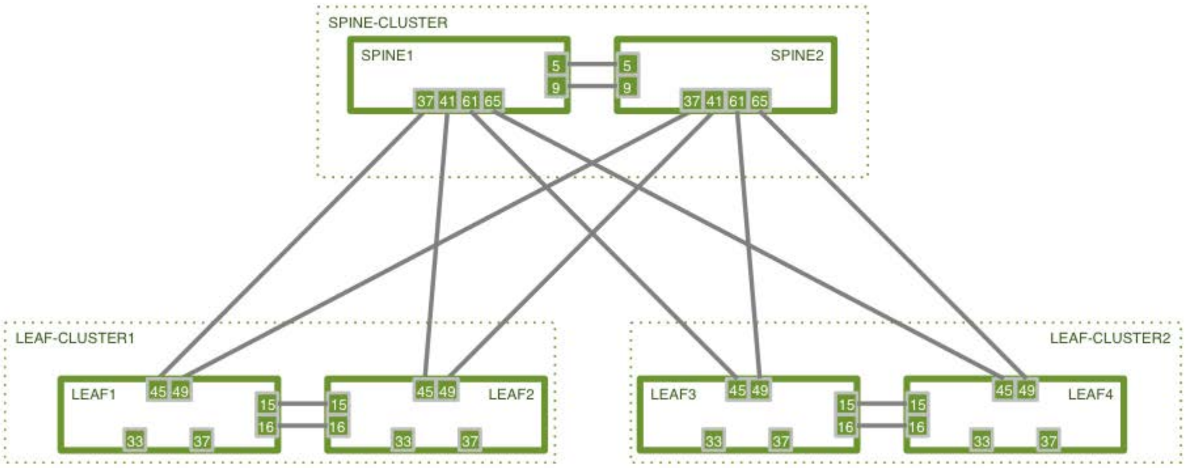


Figure 7-6 - Pluribus High Availability Cluster-based Spine/Leaf Design

In these network designs using active-active vLAGs (and cluster links), to prevent potential Layer 2 forwarding loops Netvisor ONE automatically installs special internal forwarding rules that drop any packets that would egress a vLAG port if the ingress port is found to be the cluster link.

On top of all of the above, clusters and vLAGs can also be used in conjunction with the standard VRRP technology to provide redundant active-active first-hop Layer 3 gateways to multi-homed end-points.

This capability is particularly important in the context of DCI designs, when used in conjunction with another standard technology, VXLAN, as we will see in a subsequent chapter.

Understanding Virtual Router Redundancy Protocol (VRRP)

The Virtual Router Redundancy Protocol (VRRP) is a standard high-availability protocol initially defined by the Internet Engineering Task Force (IETF) in RFC 2338, later superseded by RFC 5798 for version 3 of the protocol with support for both IPv4 and IPv6.

The goal is to eliminate the single point of failure inherent in the first hop router (default gateway) for the connected hosts. Therefore, when at least two potential first hop routers are deployed, VRRP can be used to dynamically assign responsibility for the function of “virtual next hop” to either of the active routers on the (V)LAN. This is done by implementing an election protocol to select a so-called master router out of the two (or more) VRRP-capable routers available.

A master router performs the function of virtual router, i.e., controls the IPv4 or IPv6 address(es) (called virtual addresses or VIPs) used as default gateway(s) by the hosts and forwards packets sent to these address(es).

Non-elected router(s) are called backup router(s). The VRRP logic supports dynamic failover in the forwarding responsibility to a backup router, if the master router becomes unavailable.

- For IPv4, the critical benefit provided by VRRP is a higher-availability default gateway function with a resilient VIP address.
- For IPv6 configurations in which standard IPv6 Neighbor Discovery mechanisms could potentially help with the selection of the default gateway, the key benefit provided by VRRP is to provide a fast failover and a resilient VIP address.

VRRP supports rapid transition from master to backup router in case of node failure. The master router sends VRRP advertisements every second to the backup(s). If the master router’s advertisements are not received within a time window of three seconds, then a backup router is elected as the master. If the failed master router becomes active again, it can reclaim the role of master or allow the former backup to continue as the master router. The role depends on the value assigned to a parameter called VRRP priority.

VRRP routers are configured with a priority of between 1 and 254 and the router with the highest priority will be elected to be the master. The default priority is 100.

At Layer 2 a VRRP virtual router must use an address in the 00-00-5E-00-01-XX Media Access Control (MAC) address range. In particular, the last byte of the address (XX) corresponds to the Virtual Router Identifier (VRID), which is distinct for each virtual router in the network. A VRRP virtual router will reply with this special MAC address when an ARP request is sent for the virtual router's IPv4 address.

As we will see in subsequent sections, having a resilient VIP that survives device failures is critical for simpler and more effective high availability of advanced services.
In Pluribus’ network designs VRRP can be used in conjunction with clusters and vLAG to combine fast switchover capabilities at Layer 2 with a redundant Layer 3 VIP for first hop routing toward the upstream part of the network (i.e., toward spine switches or other network devices).

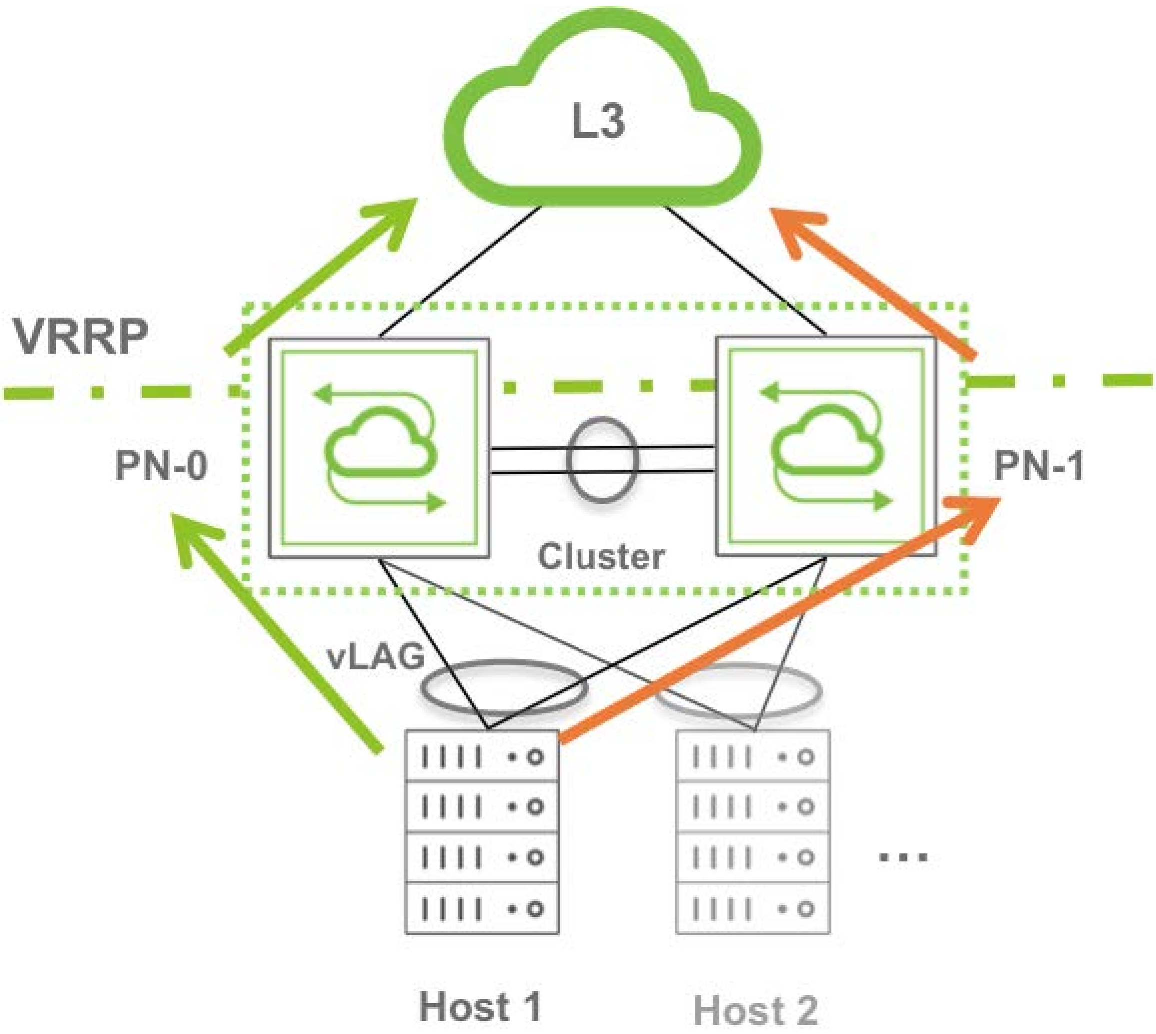


Figure 7-7 - Example of Use of VRRP in Conjunction with a Cluster

In addition, Pluribus' implementation optimizes the performance of this technology combination by supporting active-active Layer 3 forwarding on both VRRP routers in a cluster pair.

In other words, when a VIP is configured, each router is expected to route in hardware on behalf of the other peer for any packets destined to the VIP.

About Cluster Active-Active Routing for IPv6 Addresses

With cluster active-active routing two cluster peers act as forwarding proxies for each other's destination MAC addresses. This works for IPv4 as well as IPv6 traffic.
But if the two routers try to communicate with each other, packets may not route correctly on the network.

In particular, in case of the Neighbor Discovery function IPv6 uses ICMPv6 packets (instead of L2 ARP packets, as in the case of IPv4). Therefore, when one cluster node PN-0 sends a Neighbor Solicitation message to its peer, the other node PN-1 responds with a Neighbor Advertisement message with the destination IP address of the requester (PN-0). When transmitted by PN-1 the Neighbor Advertisement message will have both the destination IP and the destination MAC address of the peer PN-0. Since both nodes act as forwarding proxies for each other, the destination MAC address of the peer will be matched by the hardware of PN-1 and the packet will be routed (back to the CPU of PN-1) without reaching its correct destination (i.e., PN-0). This behavior would therefore break the Neighbor Discovery function of IPv6.

To obviate this problem, Netvisor ONE adds a host route in hardware that matches the link-local IPv6 address of the cluster peer.

This host route entry properly routes packets such as Neighbor Advertisement messages to their destination.

Guidelines and Limitations

For recommended cluster and vLAG design topologies, refer to the section "About Symmetric Routing over vLAGs".

Configuring Static Trunking for Link Aggregation

To statically configure a Link Aggregation Group (LAG), also known as trunk, you can use the `trunk-create` command.

For example, in order to aggregate the three links connected to ports 1, 2, 3 on a switch, use the following steps:

1) Create a trunk called trunk-1 on ports 1, 2, 3 by entering the following command:

```
CLI (network-admin@switch) > trunk-create name trunk-1 ports
1,2,3
```

2) To verify the result of the configuration, use the trunk-show command:

```
CLI (network-admin@switch) > trunk-show

name     port  speed   autoneg  jumbo
------- ---- ------ ------- -----
trunk-1 1-3   10g     off      off
```

3) You can modify the trunk configuration for example by removing port 2 from the group:

```
CLI (network-admin@switch) > trunk-modify name trunk-1 port
1,3
```

4) Verify the updated trunk configuration:

```
CLI (network-admin@switch) > trunk-show

name     port  speed  autoneg  jumbo
------- ---- ----- ------- -----
trunk-1 1,3   10g    off      off
```

Notice that the list of ports has changed from 1-3 to 1,3 indicating that port 2 is no longer a member of the trunk.

To remove the trunk from the switch, use the `trunk-delete` command:

```
CLI (network-admin@switch) > trunk-delete name trunk-1
```

Verify that the trunk configuration is removed again by using the `trunk-show` command.

Configuring Active-Standby Link Failover on Management Interfaces

With switches that have dual management ports, you can aggregate them in a LAG with both of them being active and forwarding. This is useful when increased bandwidth is required for management purposes or when the upstream management network supports solutions like MG-LAG (aka virtual chassis) to remove single points of failure.

Alternatively, when it's desirable that only one of the two management interfaces be forwarding, the so-called "active-standby" or "active-backup" mode of operation is supported for LAG on management ports.

In this case, the management interfaces form a LAG with only one of the two members active at any time. The other link is in standby mode, which means that it becomes forwarding only when the primary link goes down. When the primary link comes back up, it rejoins the LAG and the backup link returns to standby state.

Use the `switch-setup-modify` command to set up a management LAG.

Use the active-standby option to enable the active-backup mode.

```
CLI (network-admin@switch) > switch-setup-modify mgmt-lag
<disable| enable | active-standby>
```

Configuring Link Aggregation Control Protocol (LACP)

The Link Aggregation Control Protocol (LACP) is a dynamic LAG protocol that is controlled by user configuration. The negotiation process and the addition/removal of ports is controlled by parameters like LACP mode (active, passive and off) and LACP priorities.

To dynamically bring up a trunk the ports on at least one of the two peer LACP switches must be set to active mode.

For example use the following command to dynamically bundle ports 20-23:

```
CLI (network-admin@switch) > trunk-create name trunk23 ports
20-23 lacp-mode active
```

To modify the mode of a trunk running LACP, use the following command:

```
CLI (network-admin@switch) > trunk-modify name trunk23 lacp-
mode passive
```

To modify a port configuration with a non default LACP priority, use the following command:

```
CLI (network-admin@switch) > port-config-modify port 33 lacp-
priority 34
```

To enable or disable LACP on a switch, and/or to change the default system priority value, you can use the following command:

```
CLI (network-admin@switch) > lacp-modify enable|disable
system-priority priority
```

The default system-priority value is 32768 with a range of 1 to 65535.

To display LACP information, use the following command:

```
CLI (network-admin@switch) > lacp-show

switch:                 switch
enable:                 yes
system-priority:        32768
systemid:               800640e942c007a
```

Configuring a Cluster

To set up a cluster of two switches, say, `pleiades1` and `pleiades2`, you must first verify that they both belong to the same fabric instance, in this case `corp-fab`:

```
CLI (network-admin@switch) > fabric-node-show layout vertical

id: 184549641
name: pleiades1
fab-name: corp-fab
fab-id: b000109:5695af4f
cluster-id: 0:0
local-mac: 3a:7f:b1:43:8a:0f
fabric-network: in-band
control-network: in-band
mgmt-ip: 10.9.19.203/16
mgmt-mac: ec:f4:bb:fe:06:20
mgmt-secondary-macs:
in-band-ip: 192.168.168.203/24
in-band-mac: 3a:7f:b1:43:8a:0f
in-band-vlan: 0
in-band-secondary-macs:
fab-tid: 1
cluster-tid: 0
out-port: 0
version: 2.4.204009451,#47~14.04.1-Ubuntu
state: online
firmware-upgrade: not-required
device-state: ok
ports: 104
```

To create a cluster configuration, use the following command:

```
CLI (network-admin@switch) > cluster-create name cluster1
cluster-node-1 pleiades1 cluster-node-2 pleiades2
```

To verify the status of the cluster, use the `cluster-show` command:

```
CLI (network-admin@switch) > cluster-show

name       state     cluster-node-1  cluster-node-2
--------  -------  --------------  --------------
cluster1  online    pleiades1           pleiades2
```

To replace a failed cluster node, use the fabric-join `repeer-to-cluster-node` command.

To display information about the cluster, use the `cluster-info` command:

```
CLI (network-admin@switch) > cluster-info format all layout
vertical
```

```
name:                    cluster1
state:                   online
cluster-node-1:          pleiades1
cluster-node-2:          pleiades2
tid:                     2
mode:                    master
ports:                   69-71,129
remote-ports:            69-71,128
```

Performing the Cluster Re-peer Process

In order to rebuild a cluster over a Layer 2 or Layer 3 fabric it's necessary to use the `fabric-join` command with the `repeer-to-cluster-node` option.

For example, if one wants to join `switch1` from `switch3` to rebuild a cluster pair (that previously lost `switch2`), the following commands can be used:

- In case of a Layer 2 fabric:

```
CLI (network-admin@switch3) > fabric-join repeer-to-cluster-
node switch1
```

- In case of a Layer 3 fabric (using for example OSPF or BGP for interconnection), the command changes to:

```
CLI (network-admin@switch3) > fabric-join repeer-to-cluster-
node switch1 ?

password           plain text password
abort-on-conflict  fabric join is aborted
delete-conflicts   conflicts are deleted
over-l3            fabric is over layer 3
```

Note: The *`over-l3`* option is applicable only on Dell and Edgecore switches, where the fabric is over Layer 3 network.

```
CLI (network-admin@switch3) > fabric-join repeer-to-cluster-
node switch1 over-l3

Joined fabric myFabric. Restarting nvOS...
Please enter username and password:
     Username (network-admin):
     Password:
Connected to Switch switch3; nvOS Identifier:0x900093c; Ver:
6.0.1-6000116966
```

You can display the information about the fabric instance of the local switch using the `fabric-info` command:

```
CLI (network-admin@switch3) > fabric-info format all layout
vertical

name:                           myFabric
id:                             a000030:5537b46c
vlan:                           3
fabric-network:                  in-band
control-network:                 in-band
tid:                            365
fabric-advertisement-network:    inband-only
over-l3:                        true
```

Configuring a vLAG

If you want to connect the two cluster nodes to an upstream switch or to a downstream host in a redundant fashion, you can configure a vLAG between the uplinks or the downlinks on the cluster nodes.

For example, if `switch1` has port 53 connected to an upstream switch and switch2 has port 19 connected to the same upstream switch, create a vLAG by executing the `vlag-create` command on either of the cluster switches (switch1 in this example):

```
CLI (network-admin@switch) > vlag-create name uplink port 53
[peer-switch switch2] peer-port 19
```

To verify the configuration, use the following command:

```
CLI (network-admin@switch) > vlag-show
```

```
name   cluster       mode          switch   port    peer-switch    peer-port  status    local-
state  lacp-mode
----   -------       ----          ------   ----    -----------    ---------  ------
-----------   ---------
uplink cluster1      active-acti   switch1  53      switch2       19       normal
enabled       active
```

Note: Before you can create a vLAG, you must configure the two switches in a cluster.

Modifying LACP Mode and Parameters on an Existing vLAG Configuration

You can modify the LACP mode as part of an existing vLAG configuration using the following command to change parameters like LACP mode or timeout:

```
CLI (network-admin@switch) > vlag-modify
```

`name name-string`	Specify the vLAG name.
`failover-move-L2|failover-ignore-L2`	If you specify the parameter failover-move-L2, Netvisor sends gratuitous ARPs.
`lacp-mode off|passive|active`	Specify the LACP mode as off, passive or active.
`lacp-timeout slow|fast`	Specify the LACP timeout as slow (90 seconds) or fast (3 seconds).
`lacp-fallback bundle|individual`	Specify the LACP fallback mode as individual or bundled.
`lacp-fallback-timeout 30..60`	Specify the LACP fallback timeout in seconds. The default is 50 seconds.

Configuring a (v)LAG in LACP fallback mode *individual* (vs. *bundle)* allows it to operate as individual ports in the absence of proper LACP negotiation with a network peer. This configuration is useful with hosts with multiple network interfaces that for example need to boot from a server on the network prior to booting the operating system on the local hard drive (this is known as PXE boot, based on the Pre-Boot Execution Environment). In this scenario the hosts would have to use individual ports until they can boot the operating system and start using LACP.

Once LACP is running and port members receive LACP PDUs from their peers, then the port members of the configured vLAG can get bundled to operate as a trunk.

With this configuration, Netvisor ONE logically prepares the trunk on the switch but does not add any of the port members to it. The ports continue to operate individually until LACP PDUs are heard on them. At that point, the dynamic negotiation process is started, proper compatibility and communication is verified between the peers and the bundling process is carried out if all conditions are met. Only then all member ports cease to operate individually and are aggregated together as an operational trunk.

To give hosts enough time to PXE boot, a fallback timeout interval parameter is used (with a default value of 50 seconds). If no LACP PDUs are received for the number of seconds configured as the fallback timeout, the LACP logic checks if the LACP negotiation interval (`lacp-timeout`) has expired. If it has, then the port members fall back to individual mode. If it has not, another fallback timer is scheduled with a value equal to the fallback timeout.

For example:

- The LACP fallback timeout is set to 50 seconds and the LACP negotiation interval is set to 90 seconds (default).
- After 50 seconds, the fallback timer is rescheduled because the LACP negotiation interval has not expired yet.
- After an additional 40 seconds (90 seconds total), the LACP negotiation interval expires.
- Another 10 seconds pass (100 seconds total) when the fallback timer expires, no LACP PDUs have been received (for example due to the host still booting), then the member ports fall back to individual ports.

Both the negotiation/bundling and the fallback cases described above represent the on-demand characteristic of LACP-based port aggregation process (applicable to both vLAGs and normal trunks).

Configuring the Cluster Slave Switch Bring-up Process

> **Note:** This feature is applied only during the initial start-up of the cluster slave switch.

When a (previously down) slave node comes back up and a cluster is thus restored to online state, it can take measurable time to change the hardware routing and Layer 2 tables. This set-up delay may cause some non-negligible traffic loss on the network if lots of hardware changes are performed in bulk.

Therefore, to minimize service disruption to a negligible interval, the bring-up process is performed in an optimized staggered fashion by incrementally restoring/updating the ports. (This mode can be changed as shown below.) Some delays are also added during the staggered bring-up to make sure that state transitions and synchronization complete before moving to the next set of changes. (Such delays are configurable as shown below.)

In order to minimize any traffic impact, all non-Layer 3 and non-vLAG ports are restored first. This allows the cluster links to activate and the cluster configuration and state to synchronize.

After synchronization is complete, Layer 3 ports are brought up first. After that, Netvisor ONE waits for a configurable `l3-to-vlan-interface-delay` before bringing up vRouter vlan interfaces. This is so that routing protocols can delay advertising directly-attached subnets upstream.

After Layer 3 ports are brought up, Netvisor ONE also waits for another configurable l3-to-vlag-delay to allow time for the routing protocols to converge and program the routes. This time defaults to 15 seconds. After that delay, the vLAG ports are brought up staggered. (Note that `l3-to-vlan-interface-delay` should be less than or equal to `l3-to-vlag-delay`.)

The maximum-sync-delay parameter controls the maximum time to wait for synchronization in the case where the cluster cannot synchronize information.

Note that, if the node coming up is a cluster's master, then no staggering and no Layer 3-to-vLAG delay is applied (because it's not beneficial).

With version 5.1.1, Netvisor ONE also supports the staggered bring up of vRouter VNICs. When configured, the vRouter VNICs, which are not configured on Layer3 ports. are brought up in a staggered manner during the nvOS boot-up on a cluster peer. You can specify the wait time (0-60000 ms) between NIC bring up.

By default, the vRouter interfaces for which the VLAN is up is brought up simultaneously. The bring up can be staggered by specifying a non-zero vrouter-if-staggered-interval. The staggered bring up process is helpful to reduce the traffic loss caused by the simultaneous bring up of all VNICs.

> **Note:** The vRouter interfaces on Layer 3 ports are brought up first and is not

staggered. Also, after bootup, the subsequent VLAN interfaces being down or up is not affected by the staggered configuration.

In most cases it is not necessary to change the default parameter values.

However, in certain scenarios to be able to further optimize the slave bring up process to match one's specific requirements, it is possible to modify the parameters by using the following command:

```
CLI (network-admin@switch) > cluster-bringup-modify
```

You can specify one or more of the following options:

`l3-port-bringup-mode staggered|simultaneous`	Specify the Layer 3 port bring up mode during start up.
`l3-port-staggered-interval duration: #d#h#m#s`	Specify the interval between Layer 3 ports in Layer 3 staggered mode. This can be in days, hours, minutes, or seconds.
`vlag-port-bringup-mode staggered|simultaneous`	Specify the vLAG port bring up mode during start up.
`vlag-port-staggered-interval duration: #d#h#m#s`	Specify the interval between vLAG ports in vLAG duration: This can be in days, hours, minutes, or seconds.
`maximum-sync-delay duration: #d#h#m#s`	Specify the maximum delay to wait for cluster to synchronize before starting Layer 3 or vLAG port bring up. This can be in days, hours, minutes, or seconds.
`l3-to-vlag-delay duration: #d#h#m#s`	Specify the delay between the last Layer 3 port and the first vLAG port bring up. This can be in days, hours, minutes, or seconds. The default value is 15 seconds.
`l3-to-vlan-interface-delay duration: #d#h#m#s`	Specify the delay between last L3 port and vRouter vlan interface bring up. This can be in days, hours, minutes, or seconds.
`port-defer-bringup-delay duration: #d#h#m#s`	Specify the global timer value to be used for port delay-bring up.
`port-defer-bringup-mode staggered|simultaneous`	Specify the port defer bring up mode during start up.
`port-defer-bringup-staggered-interval duration: #d#h#m#s`	Specify the interval between ports in defer bring up mode.
`vrouter-if-bringup-mode staggered|simultaneous`	Specify the vRouter VLAN interface bring up mode.
`vrouter-if-staggered-interval 0..60000`	Specify the interval in ms between vRouter VLAN interface bring up in

	staggered mode. The value ranges between 0-60000 ms.

To display the status of the cluster bring up process, use the `cluster-bringup-show` command:

```
CLI (network-admin@switch) > cluster-bringup-show

state:  ports-enabled
l3-port-bringup-mode:  staggered
l3-port-staggered-interval:  3s
vlag-port-bringup-mode: staggered
vlag-port-staggered-interval:  3s
maximum-sync-delay:  1m
l3-to-vlag-delay:  15s
l3-to-vlan-interface-delay:  0s
```

Restoring Ports for Cluster Configurations

Note: This feature is applied only during the initial start-up of the network.

Cluster configuration supports sub-second traffic loss in case of fail-over events.

There are two types of ports providing redundant data paths:

- Layer 3 ports over ECMP redundant routed paths
- Virtual LAGs (vLAGs) providing redundant Layer 2 paths

During failover and recovery port events, it may take measurable time to change the hardware routing and MAC tables on larger networks. This delay incurs traffic loss on the network. To reduce delay, this feature allows you to incrementally restore the ports at start-up. By incrementally restoring the ports, the changes to the hardware are prevented from contending with each other. This reduces the delay between a port up and the hardware updates with the appropriate Layer 3 and Layer 2 information for the port. This process ensures sub-second fail over.

All non-Layer 3 and non-vLAG ports are restored first. This allows the cluster links to activate and the cluster configuration to synchronize information. Layer 3 and vLAG port restoration starts after the cluster synchronizes. This is predicated on the cluster becoming active, all Layer 2 and Layer 3 entries, such as status updates, exchanged, cluster STP status synchronized, and all router interfaces initialized.

Netvisor ONE enforces the following sequence for port bring up (not guaranteed for first upgrade to Netvisor ONE and is allowed only for subsequent reboots):

1. Cluster ports, VXLAN-loopback-trunk ports, and Loopback ports
2. Layer 3 ports
3. vLAG ports
4. All other ports

The sequence for port bring-down is:

1. Orphan ports (non-vLAG, non-Layer3, and non-Cluster)
2. vLAG ports
3. Layer 3 ports
4. All other ports

If a port is configured with `defer-bringup` parameter, then that port is brought up along with other ports. All ports except cluster ports can be configured for `defer-bringup` using the `port-config-modify` command. You can specify the global timer value for delaying the port bringup by using the `cluster-bringup-modify` command with `port-defer-bringup-delay duration` parameter.

The parameter, `maximum-sync-delay`, controls the maximum time to wait for synchronization in the case where the cluster cannot synchronize information. After synchronization is complete, Layer 3 ports are restored first, since Layer 3 traffic can traverse the cluster link to the peer VLAG port if needed. Currently the reverse is typically not true.

If vLAG ports are restored first, a Layer 3 adjacency between the two cluster nodes may be needed but may not exist in some network configurations. After Layer 3 ports are restored, Netvisor One waits a configurable Layer 3 port to vLAG delay to allow time for the routing protocols to converge and insert the routes. The delay time defaults to 15 seconds.

After the delay, the vLAG ports are restored incrementally and restoring ports incrementally allows enough time to move Layer 2 entries from the cluster link to the port. This incremental restoration of ports also allows the traffic loss to occur in small, 200-300ms per port, rather than one large time span. This is particularly important for server clusters where temporary small losses are not problematic, but fail or timeout for a large continuous traffic loss. If the node coming up is the cluster master, then no staggering and no Layer 3 to VLAG wait is applied. And if the node is the cluster master node, that means the peer is down or coming up, and not handling traffic. Therefore Netvisor ONE safely restores the ports as soon as possible to start traffic flowing between the nodes.

In addition, with version 5.1.1, Netvisor ONE supports the staggered bring up of vRouter vNICs. When configured, the vRouter vNICs, which are not configured on Layer3 ports, are brought up in a staggered manner during the nvOS boot-up on a cluster peer. You can specify the wait time (0-60000 ms) between NIC bring up.

By default, the vRouter interfaces for which the VLAN is up is brought up simultaneously. The bring up can be staggered by specifying a non-zero `vrouter-if-staggered-interval`. The staggered bring up process is helpful to reduce the traffic loss caused by the simultaneous bring up of all VNICs.

> **Note:** The vRouter interfaces on Layer 3 ports are brought up first and is not staggered. Also, after bootup, the subsequent VLAN interfaces being down or up is not affected by the staggered configuration.

To configure or modify the port bring up process, use the command:

```
CLI (network-admin@Leaf1) > cluster-bringup-modify
```

`cluster-bringup-modify`	Modifies the cluster bring up configuration.
Specify one or more of the following options	
`l3-port-bringup-mode staggered|simultaneous`	Specify the Layer 3 port bring up mode during start up.
`l3-port-staggered-iterval duration: #d#h#m#s`	Specify the interval between Layer 3 ports in Layer 3 staggered mode. This can be in days, hours, minutes, or seconds.
`vlag-port-bringup-mode staggered|simultaneous`	Specify the vLAG port bring up mode during start up.
`vlag-port-staggered-interval duration: #d#h#m#s`	Specify the interval between vLAG ports in vLAG staggered mode.

	This can be in days, hours, minutes, or seconds.
`cluster-trunk-port-staggered-interval duration: #d#h#m#s`	Specify the interval between cluster trunk ports in staggered mode. This can be in days, hours, minutes, or seconds.
`maximum-sync-delay duration: #d#h#m#s`	Specify the maximum delay to wait for cluster to synchronize before starting Layer 3 or vLAG port bring up. This can be in days, hours, minutes, or seconds.
`l3-to-vlag-delay duration: #d#h#m#s`	Specify the delay between the last Layer 3 port and the first vLAG port bring up. This can be in days, hours, minutes, or seconds. The default value is 15 seconds.
`l3-to-vlan-interface-delay duration: #d#h#m#s`	Specify the delay between the last Layer 3 port and the vRouter VLAN interface bring up.
`port-defer-bringup-delay duration: #d#h#m#s`	Specify the global timer value to be used for port delay-bring up.
`port-defer-bringup-mode staggered|simultaneous`	Specify the port defer bring up mode during start up.
`port-defer-bringup-staggered-interval duration: #d#h#m#s`	Specify the interval between ports in defer bring up mode.
`vrouter-if-bringup-mode staggered|simultaneous`	Specify the vRouter VLAN interface bring up mode.
`vrouter-if-staggered-interval 0..60000`	Specify the interval in ms between vRouter VLAN interface bring up in staggered mode. The value ranges between 0-60000 milli-seconds.
`start-port-enable-delay 0..240`	Specify the time delay (sec) to start enabling ports (including cluster ports) on the standby switch.

To display the status of the cluster bring up process, use the `cluster-bringup-show` command:

```
CLI (network-admin@Leaf1) > cluster-bringup-show
switch:                                   Leaf1
state:                                    ports-enabled
l3-port-bringup-mode:                     staggered
l3-port-staggered-interval:               3s
vlag-port-bringup-mode:                   staggered
vlag-port-staggered-interval:             3s
maximum-sync-delay:                       1m
l3-to-vlag-delay:                         15s
```

```
l3-to-vlan-interface-delay:                 0s
port-defer-bringup-delay:                   30s
port-defer-bringup-mode:                     staggered
port-defer-bringup-staggered-interval:     0s
vrouter-if-bringup-mode:                     staggered
vrouter-if-staggered-interval(ms):         0
```

To display the status of ports with `defer-bringup` details on select ports, use the command:

```
CLI (network-admin@Leaf1) > port-config-show format
port,cluster-port,defer-bringup,vlag,  port  11,15,42,49

port  cluster-port  defer-bringup  vlag
----  ------------  -------------  ---------
11    no            no             host-vlag
15    no            yes
42    yes           no
49    no            no
```

To view the details of a specified port, use the command:

```
CLI (network-admin@Leaf1) > port-show port 49 format
port,ip,mac,vlan,status,config

port ip         mac               vlan status                                          config
---- ---------- ----------------- ---- ----------------------------------------------- ------
49   50.50.50.2 66:01:01:01:01:01 4092 up,PN-fabric,LLDP,l3-port,remote-l3-port,vlan-up fd,10g
```

Configuring Active-Active vLAGs: a Step-by-Step Example

> **Note:** As displayed in ***Figure 7-8***, there must be a physical connection between PN-0 and PN-1 before you can configure a vLAG.

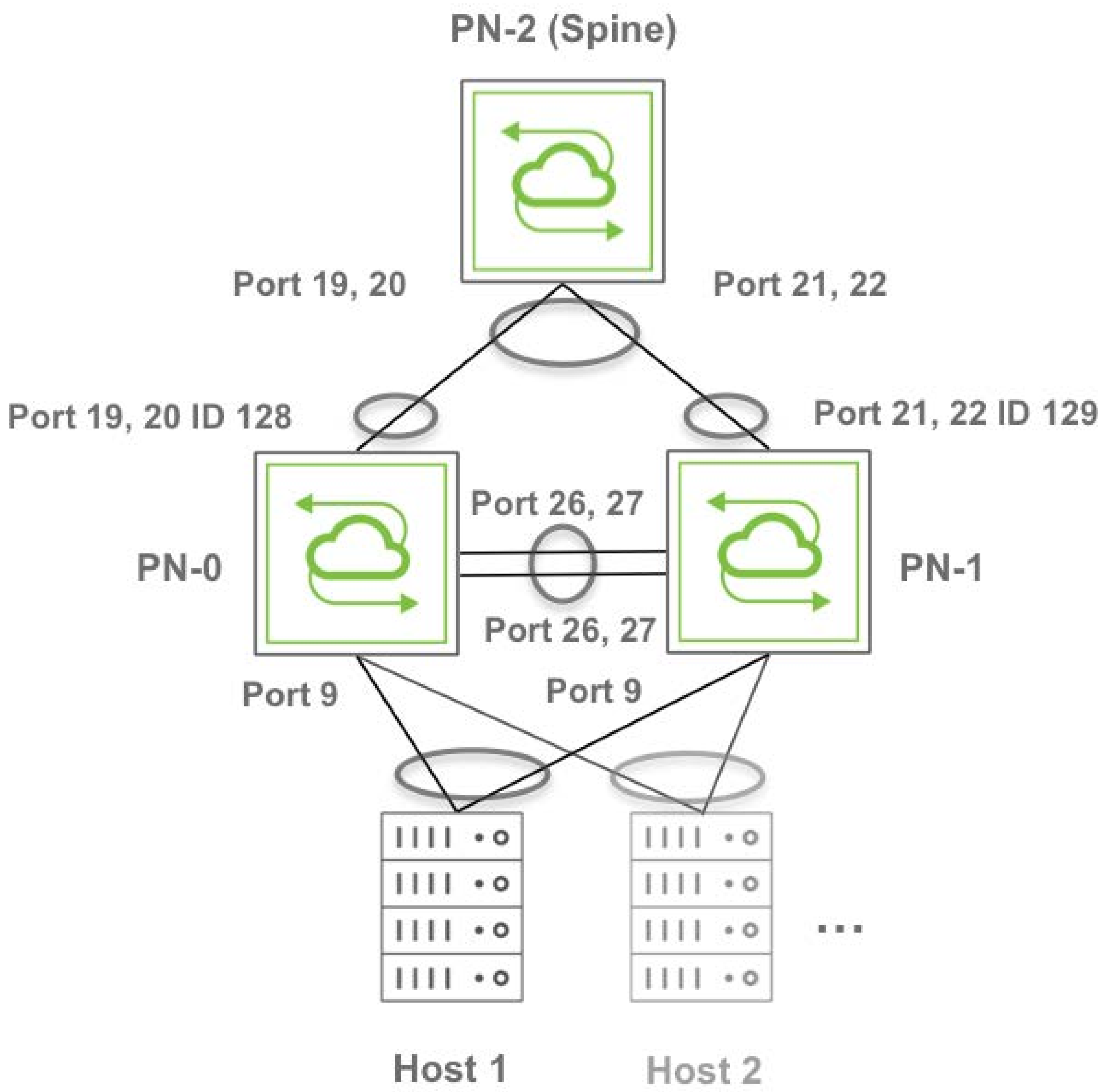


Figure 7-8 - Active-Active vLAGs Toward a Dual-Homed Host and a Spine Switch

The sample topology in Figure: Active-Active vLAGs Toward a Dual-Homed Host and a Spine Switch above comprises three Pluribus switches that are part of the same fabric instance, fab-vLAG. The spine switch is set as RSTP root.

It's important to note that ports 19-20 on PN-0 and ports 21-22 on PN-1 are connected to PN-2 (Spine). Ports 26, 27 interconnect PN-0 and PN-1 for the cluster link configuration required to set up a vLAG.

You can use the following steps to configure the above-pictured configuration with active-active vLAGs.

1) On the spine switch PN-2 use the following command:

```
CLI (network-admin@switch) > stp-modify bridge-priority 4096
```

2) Create the fabric and add the switches to it. On PN-2 use the `fabric-create` command:

```
CLI (network-admin@switch) > fabric-create name fab-VLAG
```

On PN-0 and PN-1 join the fabric:

```
CLI (network-admin@switch) > fabric-join name fab-VLAG
```

```
CLI (network-admin@switch) > fabric-join name fab-VLAG
```

3) Create VLAN connectivity from the spine switch all the way to the host. On PN-2 create for example VLAN 25 with scope fabric:

```
CLI (network-admin@switch) > vlan-create id 25 scope fabric
```

On PN-0 and PN-1 add VLAN 25 and untag the port connected to the host:

```
CLI (network-admin@switch) > vlan-port-add vlan-id 25 untagged
ports 9
```

```
CLI (network-admin@switch) > vlan-port-add vlan-id 25 untagged
ports 9
```

On PN-0 and PN-1 make the port connected to the host be an edge port:

```
CLI (network-admin@switch) > stp-port-modify port 9 edge
```

```
CLI (network-admin@switch) > stp-port-modify port 9 edge
```

4) Create a cluster configuration between PN-1 and PN-0. This creates the cluster link between ports 26, 27. On PN-0 enter the `cluster-create` command:

```
CLI (network-admin@switch) > cluster-create name VLAG cluster-
node-1 PN-0 cluster-node-2 PN-1
```

5) In this example, for simplicity's sake we will use static trunks toward the spine switch to create a vLAG. (LACP's active mode can be used too, instead of off mode.) In this case you would first disable ports between PN-2 and PN-0 and then create a static trunk between them. Therefore, on PN-0 modify the ports facing PN-2 like so:

```
CLI (network-admin@switch) > port-config-modify port 19,20
```

```
disable
```

6) Create a two-port trunk between PN-0 and PN-2 with those ports:

```
CLI (network-admin@switch) > trunk-create name pn0-to-pn2
ports 19,20 lacp-mode off

CLI (network-admin@switch) > trunk-show format all layout
vertical

switch:  PN-0
trunk-id:  128
name:  pn0-to-pn2
ports:  none
speed:  disable
egress-rate-limit:  unlimited
autoneg:  off
jumbo:  on
enable:  off
lacp-mode:  off
lacp-priority:  0
lacp-timeout:  slow
lacp-fallback: bundle
lacp-fallback-timeout:  50
lacp-individual:  none
stp-port-cost:  2000
stp-port-priority:  128
reflect:  off
edge-switch:  no
pause:  no
description:
loopback:  off
receive-only: on
unknown-ucast-level: %
unknown-mcast-level:  %
broadcast-level:  %
lport: 0
rem-rswitch-port-mac:   00:00:00:00:00:00
rswitch-default-vlan:  0
status:
config:
trunk-hw-id:  0
send-port: 4294967295
routing:  yes
host-enable: no
```

From the above output, you can verify the name and ID of the trunk configuration *pn0-to-pn2*. You need this information to create the vLAG.

7) On PN-1 repeat the same commands to create a static two-port trunk (LACP mode off) between PN-1 and PN-2. You would, therefore, disable ports between PN-2 and PN-1 and then create a static trunk between them. On PN-1 modify the ports facing PN-2

like so:

```
CLI (network-admin@switch) > port-config-modify port 21,22 
disable

CLI (network-admin@switch) > trunk-create name pn1-to-pn2 
ports 21,22 lacp-mode off

CLI (network-admin@switch) > trunk-show format all layout 
vertical

switch: PN-1
intf: 129
name: pn1-to-pn2
port: 21-22
speed: 10g
autoneg: off
jumbo: off
enable: off
lacp-mode:  off
lacp-priority: 32768
lacp-timeout: slow
reflect: off
edge-switch: no
pause: no
description:
loopback: off
mirror-only: off
lport: 0
rswitch-default-vlan: 0
port-mac-address: 06:60:00:02:10:80
status:
config:
send-port: 0
```

8) Create the vLAG from the bottom switches going upstream. Keep one side of the vLAG disabled while you configure this step. On PN-0 use the `vlag-create` command:

```
CLI (network-admin@switch) > vlag-create name to-spine port 
128 peer-port 129 peer-switch PN-1 lacp-mode off mode active-
active
```

On PN-2 create a normal 4-way trunk with the name `trunk-pn`:

```
CLI (network-admin@switch) > trunk-create name trunk-pn ports 
19,20,21,22 lacp-mode off
```

9) Enable ports on all switches. On PN-2, PN-0 and PN-1 enter the `port-config-modify` command:

```
CLI (network-admin@switch) > port-config-modify port
```

```
19,20,21,22 enable

CLI (network-admin@switch) > port-config-modify port 19,20
enable

CLI (network-admin@switch) > port-config-modify port 21,22
enable
```

10) As a final step, create the server-facing active-active vLAG. In this case we will make it dynamic (LACP mode active). On PN-0 enter the `vlag-create` command:

```
CLI (network-admin@switch) > vlag-create name to-host port 9
peer-port 9 peer-switch PN-1 lacp-mode active mode active-
active
```

Display and verify the vLAG configuration information:

```
CLI (network-admin@switch) > vlag-show format all layout
vertical

id: a000024:0
name: to-host
cluster: VLAG
mode: active-active
switch: PN-0
port: 9
peer-switch: PN-1
peer-port: 9
failover-move-L2: no
status: normal
local-state: enabled, up
lacp-mode: active
lacp-timeout: slow
lacp-key: 26460
lacp-system-id: 110013777969246
```

Understanding LAG Path Selection and Load Balancing

For Layer 2 back-to-back connectivity, Pluribus Netvisor ONE software supports the standard link aggregation technology in order to combine multiple network connections into a logical pipe called a Link Aggregation Group (LAG), or '(port) trunk', which can provide redundancy in case of single or multiple link failure.

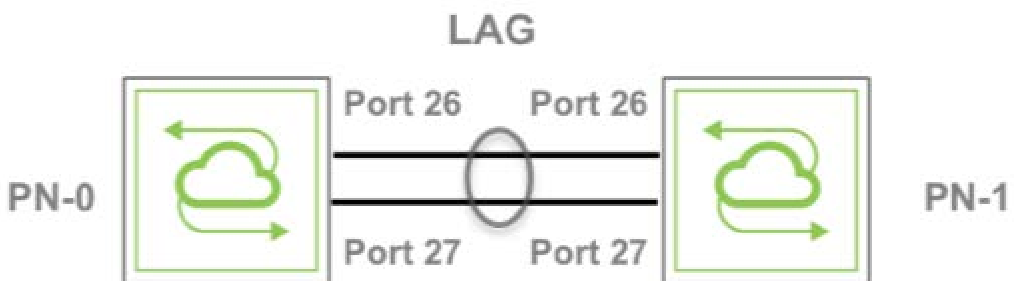


Figure 7-9: Two-port LAG Example

Netvisor ONE also supports link aggregation across two redundant chassis to implement multi-pathing without requiring the creation of Layer 2 loops and the use of the Spanning Tree protocol. This feature is called *vLAG* (Virtual Link Aggregation Group) on a *switch cluster.*

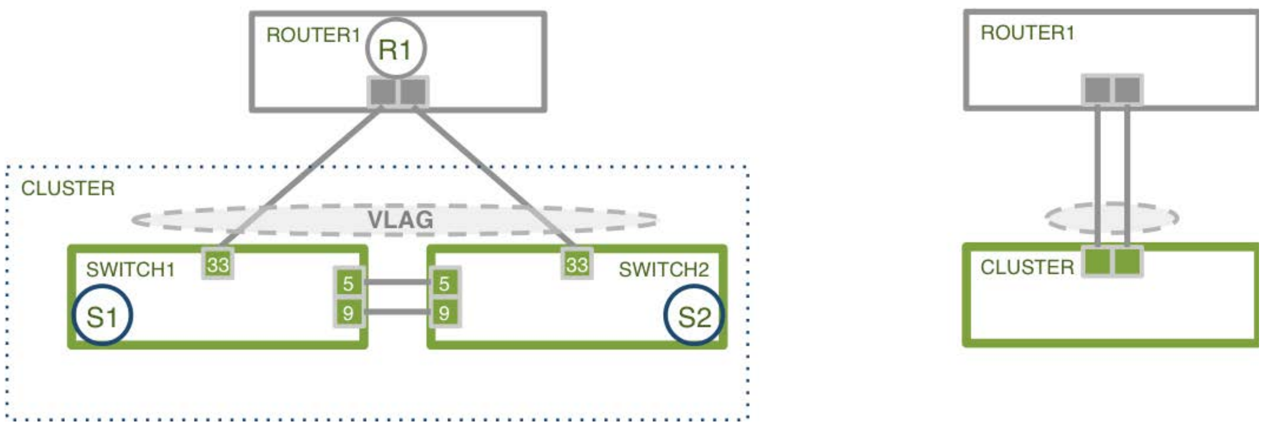


Figure 7-10: Two-port vLAG Example

Both the aforementioned technologies perform path selection in hardware using a high-performance technology called *packet field hashing*.

What that means is that the hardware extracts a number of packet fields and with them performs a special calculation to generate a *hardware index*. This hardware index is then used to select an egress physical port for a (v)LAG. Refer to the *About Layer 2 Hardware Hashing* section for more details on hashing field selection.

Understanding the vLAG Forwarding Rule

In order to prevent potential duplication of multicast or broadcast traffic, a forwarding rule is installed on all ports that are part of vLAGs to drop traffic whose ingress point is the cluster links. This rule is shown in the figure below:

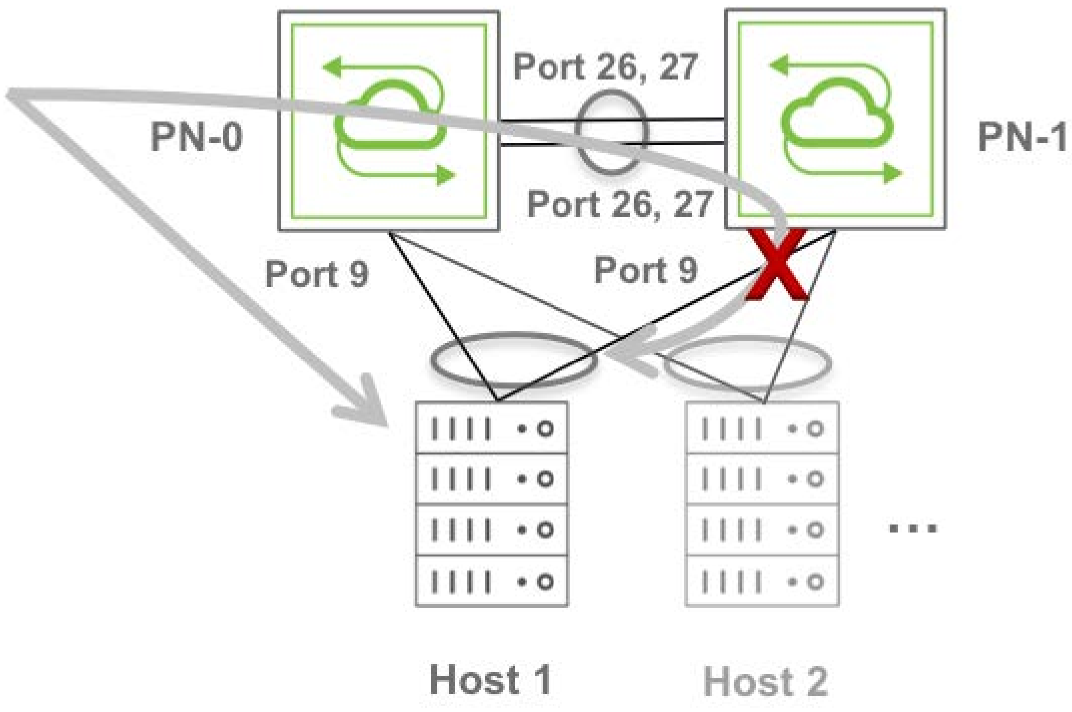


Figure 7-11 - vLAG Forwarding Rule

The figure above shows a packet entering cluster switch PN-0 that needs to be sent out to Host 1 over the vLAG. To prevent duplication of traffic on the vLAG, any traffic traversing the cluster links and egressing on vLAG ports on cluster switch PN-1 is dropped.

Configuring Trunk Hashing

By default, Netvisor ONE supports the trunk hashing algorithm based on the fields listed in the *About Layer 2 Hardware Hashing* section (***Table 4-1***).

Starting from Netvisor ONE release 6.1.0, this default mode is called `enhanced` hashing. Starting from the same release, Netvisor ONE also supports other less granular hashing modes that can be useful in special cases. The supported alternate modes are:

```
l2-src    src mac based hashing
l2-dst    dst mac based hashing
l2         src+dst mac based hashing
l3-src    src ip based bashing
l3-dst    dst ip based hashing
l3         src+dst ip based hashing
```

They can be selected with the new `hash-mode` parameter in the `trunk-create` and `trunk-modify` commands. For example like so:

```
CLI (network-admin@switch) > trunk-modify name trunk1 hash-
mode l3
```

The mode can be verified with the `trunk-show` command:

```
CLI (network-admin@switch) > trunk-show format name,trunk-
id,ports,hash-mode,status

name                 trunk-id ports hash-mode status
-------------------- -------- ----- ---------
----------------------------------------
trunk1               272      65-68 l3        up,PN-switch,PN-
cluster,multicast-router
vxlan-loopback-trunk 397       13-16 enhanced   up,stp-edge-port
```

Configuring Resilient Trunk Hashing

Starting from Netvisor ONE release 6.1.0, the `resilient` hash mode can be configured on trunks to help prevent unnecessary traffic disruption when the number of trunk member ports changes.

Note: Resilient hashing is supported on all platforms except:

- Dell Z9100-ON, S5048F, Z9264-ON
- Freedom F9532L-C/Edgecore AS7712-32X
- Freedom F9532-C/Edgecore AS7716-32X
- Freedom F9572L-V/Edgecore AS7312-54XS
- Freedom F9572-V/Edgecore AS7316-54XS
- Freedom F9532C-XL-R/Edgecore AS7716-32X
- Freedom F9664-C/Edgecore AS7816-64X.

Due to a hardware restriction, this feature cannot be changed on the fly and needs to be configured during trunk creation like so:

```
CLI (network-admin@switch) > trunk-create name trunk2 hash-
mode resilient ports 5,6,7

CLI (network-admin@switch) > trunk-show format name,trunk-
id,ports,hash-mode,status

name                 trunk-id ports hash-mode status
-------------------- -------- ----- ---------
----------------------------------------
trunk1               272      65-68 l3        up,PN-switch,PN-
cluster,multicast-router
trunk2               273      5,6,7 resilient  up,PN-switch
vxlan-loopback-trunk 397       13-16 enhanced   up,stp-edge-port
```

If you then try to dynamically modify resilient mode (for example to revert back to the default enhanced mode), you get an error message:

```
CLI (network-admin@switch) > trunk-modify trunk-id 273 hash-
mode enhanced
trunk-modify: Trunk is configured with resilient hash. Delete
and create trunk to change hash mode
```

So you need to delete the trunk first and then recreate it if modification of resilient mode is required.

Configuring Symmetric Trunk Hashing

When a specific network design or monitoring device requires that the same trunk port be selected for all packets in both directions in a connection, starting from release 6.1.0 Netvisor ONE supports the *Symmetric Trunk Hashing* mode.

Note that:

- Symmetric hashing is agnostic to intrinsically unidirectional parameters, such as the ingress physical interface.
- Symmetric hashing mode is an alternative configuration to the default (asymmetric) mode.
- Configuring symmetric hashing does not require a switch restart.
- You can configure symmetric hashing on a single switch or on all switches of a fabric by prepending the command with switch*.

To configure symmetric hashing, use the following per-device system command:

```
CLI (network-admin@switch) > system-settings-modify
<symmetric-hash | no-symmetric-hash>
```

Where, the `symmetric-hash` parameter enables symmetric trunk hashing on the switch. By default, this feature is disabled. If enabled, you can use the `no-symmetric-hash` parameter to disable it.

To configure symmetric hashing on all switches in a fabric, use the command:

```
CLI (network-admin@switch) > switch * system-settings-modify
<symmetric-hash | no-symmetric-hash>
```

In case of GRE or IPSec traffic, ignoring the unidirectional GRE key or IPSec SPI fields in the symmetric hash computation can be configured using the CLI:

```
CLI (network-admin@switch) >  system-settings-modify <hash-
suppress-unidir-fields  |  no-hash-suppress-unidir-fields>
```

This feature is disabled by default, using the `no-hash-suppress-unidir-fields` parameter.

To verify the configuration details, use the `system-settings-show` command. Below is a sample output, where both `symmetric-hash` and `hash-suppress-unidir-fields` parameters are disabled.

```
CLI (network-admin@switch) > system-settings-show layout
vertical
switch:                                    switch
```

```
optimize-arps:                          off
lldp:                                   on
policy-based-routing:                   off
optimize-nd:                            off
reactivate-mac:                         on
reactivate-vxlan-tunnel-mac:            on
manage-unknown-unicast:                 off
manage-broadcast:                       off
block-loops:                            off
auto-trunk:                             on
auto-host-bundle:                       off
cluster-active-active-routing:          on
routing-over-vlags:                     off
source-mac-miss:                        copy-to-cpu
igmp-snoop:                             use-l3
vle-tracking-timeout:                   3
pfc-buffer-limit:                       40%
cosq-weight-auto:                       off
port-cos-drop-stats-interval(s):        disable
lossless-mode:                          off
snoop-query-stagger:                     no-stagger-queries
host-refresh:                           off
proxy-conn-retry:                       on
proxy-conn-max-retry:                   3
proxy-conn-retry-interval:              500
manage-l2-uuc-drop:                     on
xcvr-link-debug:                        disable
fastpath-bfd:                           off
linkscan-interval:                      150000
linkscan-mode:                          software
single-pass-l2-known-multicast:         off
single-pass-flood:                      off
batch-move-mac-hw-group-for-vlan-only:  off
memory-tracker:                         on
symmetric-hash:                         off
hash-suppress-unidir-fields:            off
```

Configuring Asymmetric Routing over vLAGs

vLAGs are symmetric Layer 2 redundant paths that work best with symmetric traffic flows. In these cases the aforementioned vLAG forwarding rule works fine, as discussed in the next section.

In case of Layer 3 forwarding over vLAGs, there can exist certain corner-case network designs in which a routing protocol (e.g., BGP or OSPF) is used to peer over a vLAG in an asymmetric fashion.

Let’s consider the example in Figure: Asymmetric Routing over a vLAG in which the network admin has chosen to configure BGP peering only with cluster member PN-1. The downstream hosts are dual-homed and are properly connected to the rest of the network via a default gateway (provided by VRRP).

PN-2 is connected via a vLAG as well to the cluster, however is configured with a /30 subnet that is only present on one cluster member (PN-1 in this example, with PN-2 peering with it via BGP and using the address 10.75.1.1/30).

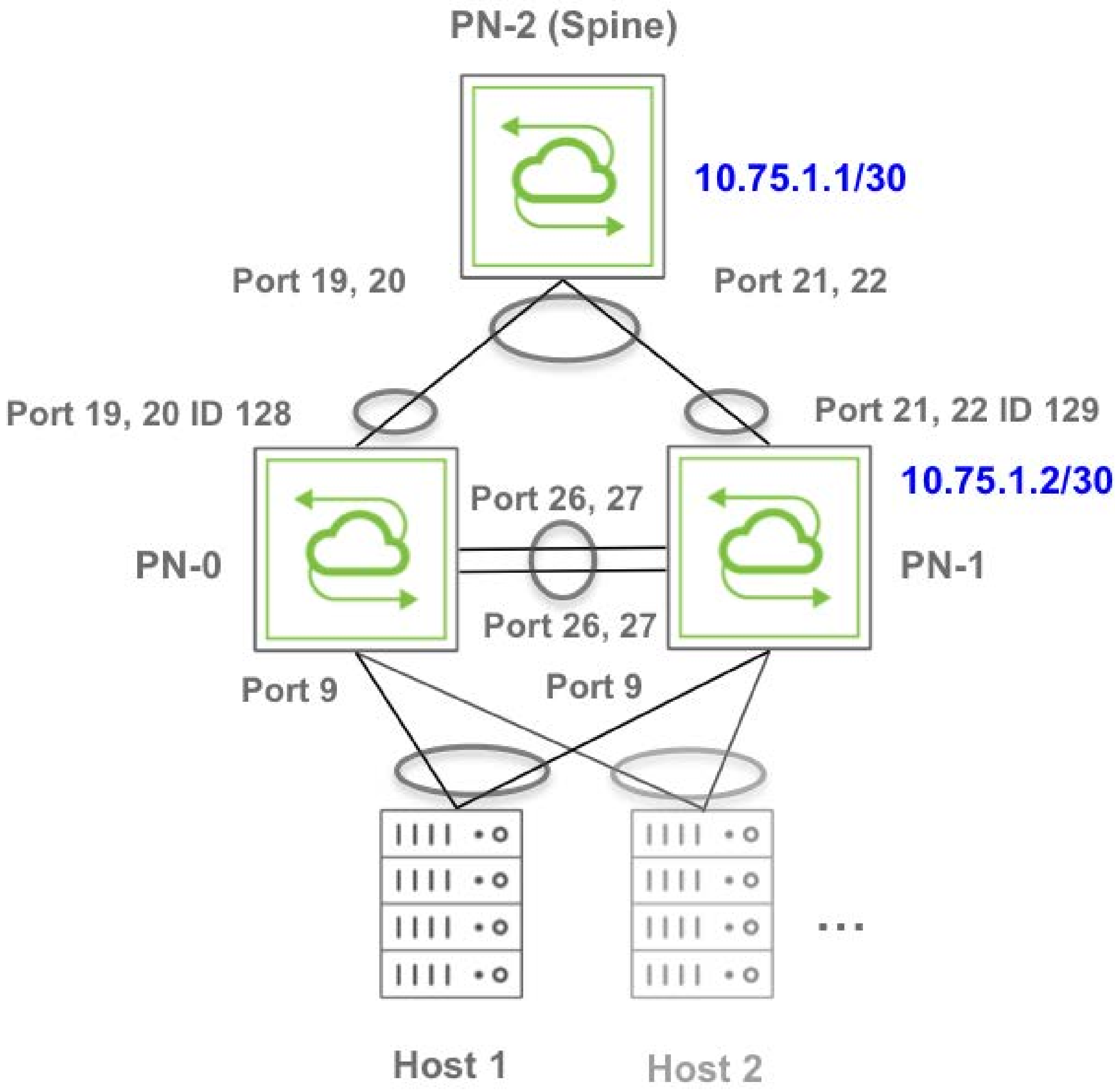


Figure 7-12 - Asymmetric Routing over a vLAG

If Host 1 wants to talk to PN-2's 10.75.1.1 (or to another asymmetric route advertised by it), its traffic can go left or right depending on the vLAG load-balancing algorithm. If it goes right, PN-1 can route it to PN-2. However if the traffic goes left, PN-0 has no route it has learned locally to reach PN-2. Therefore, in the best case it will direct traffic over the cluster link (assuming there is some IGP running over it). However, PN-1 will not be able to send the packet to H1 due to the egress filtering rules enforced on vLAGs (see previous section).

For this reason asymmetric routing configurations should be avoided.

However a knob is provided as a last resort to bypass the cluster egress filtering rules in case the customer still wants to utilize this sub-optimal design, which is not recommended. In general, it is sub-optimal for two main reasons:

- Even when there is no failure (vLAG links are up), traffic is forced to cross the cluster links, thereby potentially oversubscribing them.

- There is no redundancy at L3 level. When BGP peering to cluster member PN-1 fails, there is no backup path to direct the traffic to.

To enable support of this design a new configuration option is provided to allow packets crossing the cluster link to be routed without being dropped when egressing vLAGs.

To modify the default configuration use the `system-settings-modify routing-over-vlags|no-routing-over-vlags` command like so:

```
CLI (network-admin@switch) > system-settings-modify routing-over-vlags
```

You can use this command to verify the configuration change:

```
CLI (network-admin@switch) > system-settings-show

switch:                          PN-1
routing-over-vlags:  on
switch:                             vanquish4
routing-over-vlags:  off
switch:                             vanquish3
routing-over-vlags:  off
```

About Symmetric Routing over vLAGs

As stated above, vLAGs work best with symmetric traffic flows. In order to achieve that with routing, two main designs are recommended: VRRP + ECMP and symmetric VRRP.

The goal of either design is to distribute traffic equally across the different paths both upstream and downstream, making sure that the redundant cluster nodes can steer the traffic to its destination without having to rely upon the cluster links.

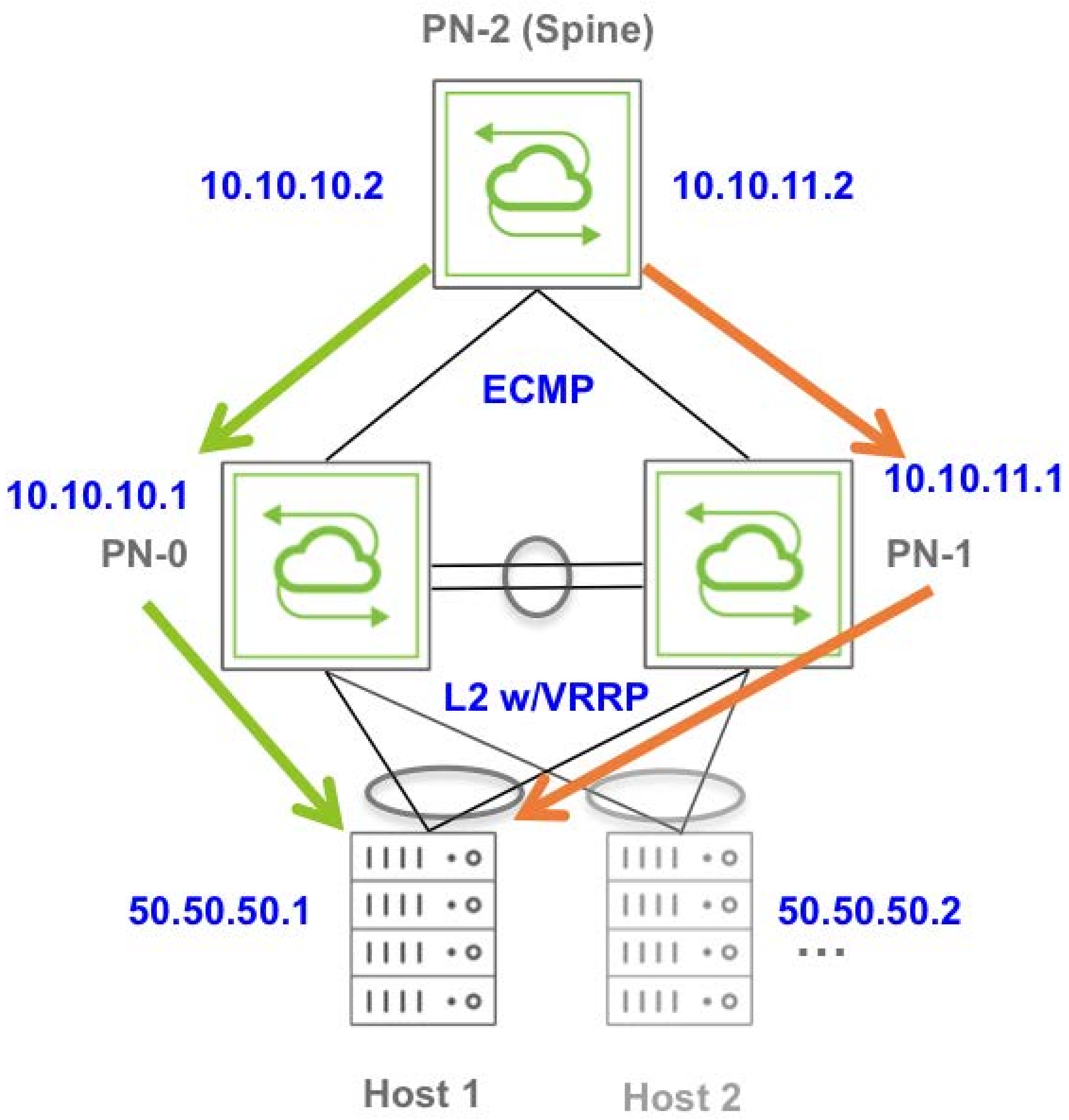


Figure 7-13 - Symmetric Routing over a vLAG with ECMP and VRRP

In this figure traffic is, for example, directed to and from host 50.50.50.1: downstream the spine router/switch has ECMP routes toward both cluster nodes, which have Layer 3 adjacencies to all the hosts, so either of them can properly steer traffic to 50.50.50.1. Upstream they implement the active-active default gateway function via VRRP and support traffic load-balancing with vLAGs from the host(s) toward the spine.

Hence this design implements optimal Layer 3 forwarding both ways (without relying on the cluster links as active paths, only as backups). It also supports running Layer 3 routing protocols on the cluster switches.

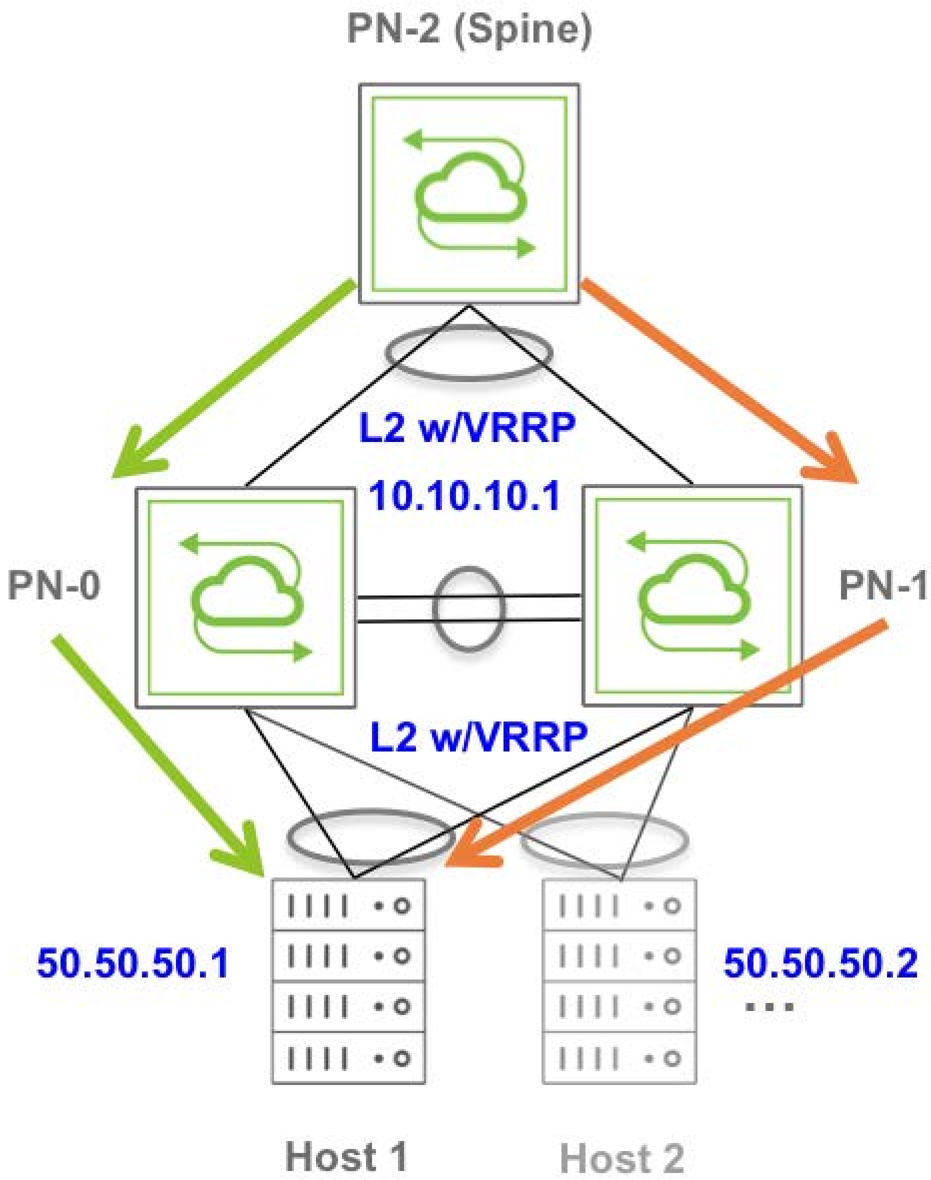


Figure 7-14 - Symmetric Routing over a vLAG with VRRP

In this other scenario two cluster switches run vRouters with active-active VRRP in order to provide redundant Layer 3 next hops (using virtual IPs) to both upstream and downstream devices.

This design achieves symmetric Layer 3 forwarding purely via vLAG load-balancing and VRRP active-active forwarding. However, note that it does not lend itself to the use of dynamic routing protocols on vRouters because with VRRP routing adjacencies would only form on the vRouter acting as VRRP master, preventing the slave vRouter to process and install routes.

Netvisor ONE supports the active-active dual-forwarding logic by default with VRRP. However, if needed, you can disable it or re-enable it on a per vRouter basis with this command:

```
CLI (network-admin@switch) > vrouter-modify name vRouter-PN-0
cluster-active-active-routing|no-cluster-active-active-routing
```

To display the configuration, use the `vrouter-show` command:

```
CLI (network-admin@switch) > vrouter-show format all layout
vertical

switch: PN-0
id: b000f1e:1
name:  vRouter-PN-0
type:  vrouter
scope:  local
vnet:  test
vnet-service:  dedicated
state:  enabled
location:  sw45
zone-id:  b000f1e:2
template:  no
failover-action:  stop-old
router-type:  hardware
fabric-comm:  false
router-ipstack:  frr
hw-router-mac:  66:0e:94:1e:7a:6a
cluster-active-active-routing:  disable
hw-vrid: 0
hw-vrrp-id:  -1
proto-multi:  none
proto-routing:  static,routesnoop
bgp-redist-static-metric:  none
bgp-redist-connected-metric:  none
bgp-redist-rip-metric:    none
bgp-redist-ospf-metric:  none
bgp-dampening:  false
bgp-scantime(s):   60
bgp-delayed-startup(s):  1
bgp-keepalive-interval(s):  60
bgp-holdtime(s):  180
ospf-redist-static-metric:  none
ospf-redist-static-metric-type:  2
ospf-redist-connected-metric:    none
ospf-redist-connected-metric-type:  2
ospf-redist-rip-metric:    none
ospf-redist-rip-metric-type:  2
ospf-redist-bgp-metric:  none
ospf-redist-bgp-metric-type:  2
ospf-stub-router-on-startup:  false
ospf-bfd-all-if: no
ospf-default-information:  none
ospf-default-info-originate-metric:  none
ospf-default-info-originate-metric-type:  2
bgp-snmp:   false
bgp-snmp-notification:  false
ospf-snmp:   false
ospf-snmp-notification:  false
ospf6-snmp:   false
```

```
ospf6-snmp-notification:  false
ip-snmp: false
```

Configuring Active-Active vLAG Forwarding with Loopback Recirculation

In network designs in which vLAG load-balancing with fast failover is required to work in conjunction with dynamic routing protocol peering, the aforementioned vLAG forwarding rule may cause traffic drops.

Therefore, for certain switch models with spare bandwidth an additional configuration option has been implemented.

Let's consider the example in Figure: Symmetric Routing over a vLAG with Loopback Recirculation below where a cluster pair uses standard OSPF peering over a Layer 2 domain represented by a redundant (v)LAG.

To the routing protocol running on PN-2 the (v)LAG looks like a share medium over which both cluster nodes, 10.10.10.1 and 10.10.10.2, are reachable. However, the (v)LAG performs traffic load-balancing: packets sent toward 10.10.10.1 can be steered to either PN-0 or PN-1; likewise, packets sent toward 10.10.10.2 can be steered to either PN-0 or PN-1. When packets are sent to the "wrong" next-hop, the latter will have to use the cluster links to steer the packets back to their "correct" destination.

However, packets traversing the cluster links that need to egress a vLAG (going downstream to reach one of the hosts) are dropped.

For this case, Netvisor ONE supports the configuration of internal loopback recirculation for routed packets entering the switch from cluster links in order to bypass the vLAG forwarding rule.

The approach consists in provisioning a set of physical ports in loopback mode without requiring external cabling. In particular, the Pluribus E28-Q model offers up to 12x10GE ports (that is, which are not exposed to users in the front panel) that can be configured in loopback mode for an additional forwarding capacity of 120 Gbps.

An internal forwarding rule can be manually installed on both cluster nodes to redirect the traffic to the internal loopback when it ingresses from the cluster links with a destination MAC address matching that of the next-hop. When a packet is recirculated by this rule over the loopback, it gets normally routed and hence is not subject to the vLAG forwarding rule (that would otherwise drop it).

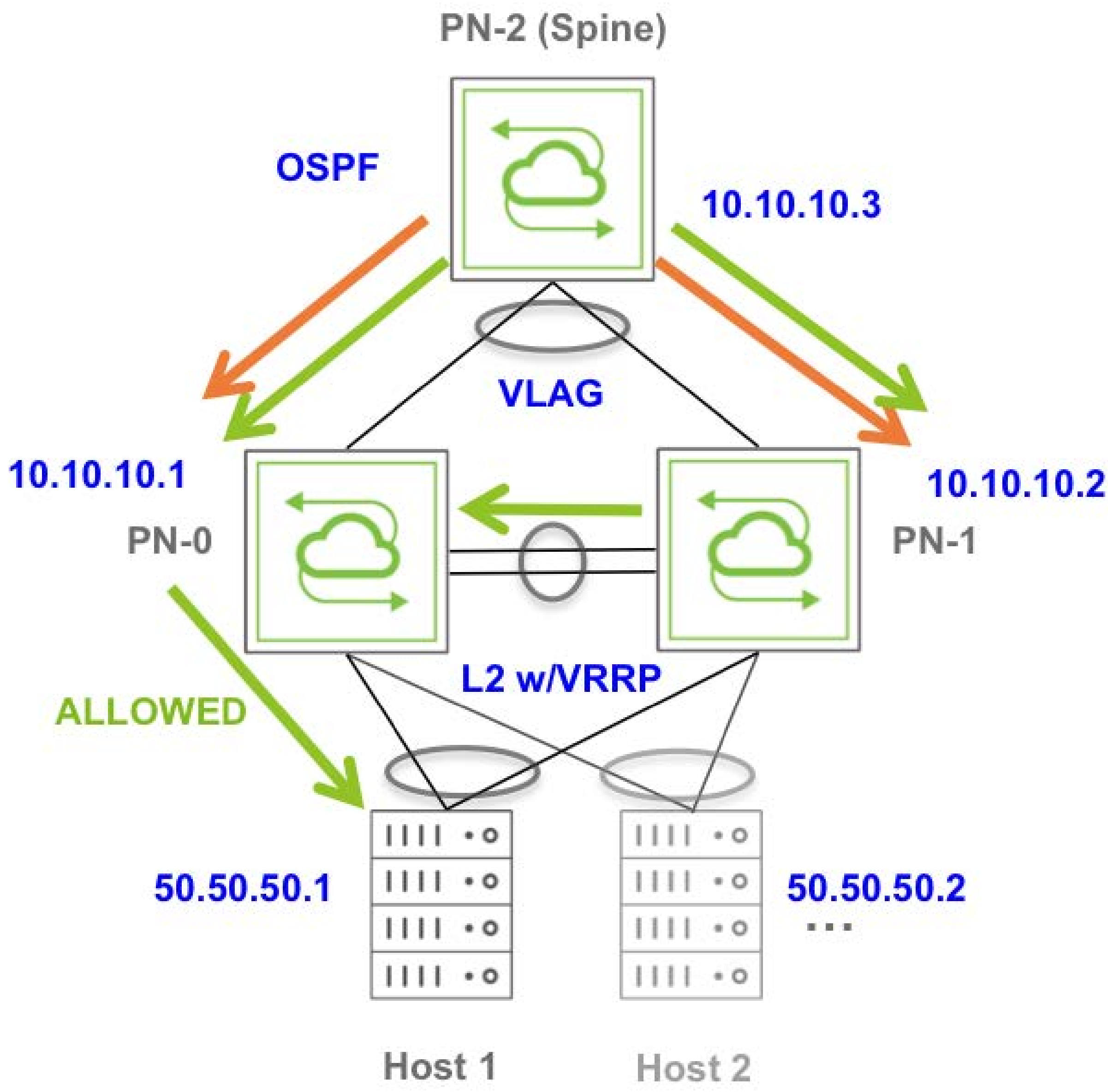


Figure 7-15 -Symmetric Routing over a vLAG with Loopback Recirculation

Note that, when this option is configured, approximately 50% of the traffic traverses the cluster links, which is not ideal, hence it is not recommended as a general solution but can be useful in certain designs.

For each vRouter that needs redirection of the traffic to the internal loopback, first find the MAC addresses of the (two, in case of a cluster) corresponding interfaces using the `vrouter-interface-show` command:

```
CLI (network-admin@switch) > vrouter-interface-show vrouter-
name UP1

vrouter-name: UP1
nic:  eth11.200
ip:  200.200.200.1/24
assignment:  static
mac:  66:0e:94:10:29:e1
```

```
vlan: 200
vxlan: 0
if: data
vm-nic-type: data
exclusive: no
nic-config: enable
nic-state: up
```

In this case the interface MAC address is `66:0e:94:10:29:e1`.

Then configure a loopback (with a single port or a multi-port trunk):

```
CLI (network-admin@switch) > port-config-modify port 89
loopback
```

Or for the trunk case:

```
CLI (network-admin@switch) > port-config-modify port 89-100
loopback
```

```
CLI (network-admin@switch) > trunk-create name loopbackUP
ports 89-100 loopback
```

Then create the special forwarding rule using the `vFlow` command:

```
CLI (network-admin@switch) > vflow-create name LB_vflow scope
local in-port 129 dst-mac 66:0e:94:10:29:e1 action set-dmac-
to-port action-value 89 action-set-mac-value 66:0e:94:10:29:e1
```

Or for the trunk case:

```
CLI (network-admin@switch) > vflow-create name LB_vflow scope
local in-port 129 dst-mac 66:0e:94:10:29:e1 action set-dmac-
to-port action-value 130 action-set-mac-value
66:0e:94:10:29:e1
```

For `action-value` use the loopback port number or the loopback trunk ID (130, in this example, assigned during creation).

For a cluster pair, you must configure each node using the above configuration steps.

Configuring Virtual Router Redundancy Protocol

The configuration of the VRRP protocol is tied to the creation and configuration of vRouters. It requires entering various parameters such as a VRRP priority, a VRRP ID to uniquely identify the virtual router, etc.

Configuring VRRP Priority

The priority is a value used by the VRRP master election process.

The valid priority range is 1-254, where 1 is the lowest priority and 254 is the highest priority.

The default value is 100. Higher values indicate higher priority for the master router election, therefore a backup router (also called a slave) can be configured for example with a priority value lower than the default.

Configuring the VRRP ID

A virtual router is identified by its virtual router identifier (VRID) and by a set of virtual IPv4 and/or IPv6 address(es).

Each virtual IPvX address is paired to a MAC address in the 00-00-5E-00-01-XX address range where the last byte of the address (XX) corresponds to the VRID.

The VRID is also used to tag and differentiate protocol messages exchanged by VRRP routers.

The virtual router identifier is a user-configurable parameter with a value between 1 and 255. There is no default value.

In the configuration this parameter has to be associated to a vRouter entity and to the VRRP interface, as shown in the example below.

Example Configuration

In this example two switches, named switch1 and switch2, are going to share a subnet and VLAN over which to set up VRRP's virtual router function (with an ID of 10):

- VLAN 100 with IP address range 192.168.11.0/24

The corresponding vRouters are going to share a common vNET:

- The vrrp-router vNET with scope fabric

To configure VRRP, start with switch1 and create a vRouter that is associated with the aforementioned vNET and a VRRP ID of 10. Before configuring the vrouter-create command, you must create the corresponding vnet:

```
CLI (network-admin@switch) > vrouter-create name vrrp-rtr1
vnet vrrp-router router-type hardware hw-vrrp-id 10 enable
```

Add a vRouter interface that corresponds to the router's own real IP address:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-name vrrp-rtr1 ip 192.168.11.3 netmask 24 vlan 100 [if data]
```

The above command will output a message such as:

```
Added interface eth0.100 with ifIndex 24
```

You can also use the `vrouter-interface-show` command to check the name of the newly created interface (eth0.100):

```
CLI (network-admin@switch) > vrouter-interface-show

format all layout vertical
vrouter-name: vrrp-rtr1
nic: eth0.100
ip: 192.168.11.3/24
assignment: static
mac: 66:0e:94:dd:18:c4
vlan: 100
vxlan: 0
if: data
alias-on:
exclusive: no
nic-config: enable
nic-state: up
```

Create the VRRP interface on the master switch with virtual IP 192.168.11.2, VRRP ID 10 and default priority (100):

```
CLI (network-admin@switch1) > vrouter-interface-add vrouter-name vrrp-rtr1 ip 192.168.11.2 netmask 24 vlan 100 [if data] vrrp-id 10 vrrp-primary eth0.100 vrrp-priority 100
```

The above command will output a message such as:

```
Added interface eth1.100 with ifIndex 25
```

Then create a vRouter and an interface (with real IP `192.168.11.4`) also on switch2:

```
CLI (network-admin@switch) > vrouter-create name vrrp-rtr2 vnet vrrp-router router-type hardware hw-vrrp-id 10 enable

CLI (network-admin@switch) > vrouter-interface-add vrouter-name vrrp-rtr2 ip 192.168.11.4 netmask 24 vlan 100 [if data]
```

Use the `vrouter-interface-show` command to check the name of the newly created interface (`eth3.100`):

```
CLI (network-admin@switch2) > vrouter-interface-show format all layout vertical
```

```
vrouter-name:  vrrp-rtr2
nic:  eth3.100
ip:  192.168.11.4/24
assignment:  static
mac:  66:0e:94:21:a9:6c
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
```

Create the VRRP interface for the backup switch with the same VIP `192.168.11.2`, same VRRP ID (10) and a lower-than-default priority (say, 50):

```
CLI (network-admin@switch2) > vrouter-interface-add vrouter-name vrrp-rtr2 ip 192.168.11.2 netmask 24 vlan 100 [if data] vrrp-id 10 vrrp-primary eth3.100 vrrp-priority 50
```

Display the information about the VRRP setup:

```
CLI (network-admin@switch2) > vrouter-interface-show format all layout vertical

vrouter-name:  vrrp-rtr1
nic:  eth0.100
ip:  192.168.11.3/24
assignment:  static
mac:  66:0e:94:dd:18:c4
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
vrouter-name:  vrrp-rtr1
nic:  eth1.100
ip:  192.168.11.2/24
assignment:  static
mac:  00:00:5e:00:01:0a
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
vrrp-id:  10
vrrp-primary:  eth0.100
vrrp-priority:  100
```

```
vrrp-state:  master
vrouter-name:  vrrp-rtr2
nic:  eth3.100
ip:  192.168.11.4/24
assignment:  static
mac:  66:0e:94:21:54:07
vlan:  100
vxlan: 0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
vrouter-name:  vrrp-rtr2
nic:  eth4.100
ip:  192.168.11.2/24
assignment:  static
mac:  00:00:5e:00:01:0a
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  down
vrrp-id:  10
vrrp-primary:  eth3.100
vrrp-priority:  50
vrrp-state:  slave
```

When you intentionally disable the master's VRRP interface, the backup interface becomes the new master:

```
vrouter-name:  vrrp-router2
nic:  eth4.100
ip:  192.168.11.2/24
assignment:  static
mac:  00:00:5e:00:01:0a
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  up
vrrp-id:  10
vrrp-primary:  eth3.100
vrrp-priority:  50
vrrp-state:  master
```

When you re-enable the disabled interface on the former master, that interface becomes the master again, and the second interface returns to be a backup (slave):

```
vrouter-name:  vrrp-router2
nic:  eth4.100
ip:  192.168.11.2/24
assignment:  static
mac:  00:00:5e:00:01:0a
vlan:  100
vxlan:  0
if:  data
alias-on:
exclusive:  no
nic-config:  enable
nic-state:  down
vrrp-id:  10
vrrp-primary:  eth3.100
vrrp-priority:  50
vrrp-state:  slave
```

Configuring VRRP Pre-emption Mode

VRRP supports rapid transition from master to backup router in case of node failures. The master router sends VRRP advertisements based on the configured VRRP advertisement interval or a default interval of 1000 ms to the backup router(s). If the master router's advertisements are not received within the configured time window, then a backup router is elected as the master router. If the failed master router becomes active again, it can reclaim the role of master or allow the former backup to continue as the master router. The role depends on the value assigned to a parameter called VRRP priority.

To minimize network traffic, only the master router sends periodic VRRP advertisement messages. A backup router do not attempt to preempt the master unless it has higher priority, thereby eliminating service disruption.

It is also possible to administratively prohibit all preemption attempts. When the master router becomes unavailable due to a node failure or other network issues, then the highest priority backup router transitions to the master role after a short delay, providing a controlled transition of the virtual router responsibility with minimal service interruption.

With Netvisor ONE version 6.0.0, you can enable or disable the *VRRP preempt mode* while configuring a VRRP interface. The preempt (or pre-empt) mode controls when a starting or restarting higher-priority backup router preempts a lower-priority master router.

By default, the preemption mode is enabled on all VRRP instances in Netvisor ONE. Enabling the preemption feature is useful when a high priority router represents a much preferred path and hence takes over the master role whenever it comes back online, albeit with a potential (small) traffic disruption.

On the other hand, by disabling the preemption feature, you can prevent a high priority backup VRRP router from taking over the master router role after a restart (caused for example by a failure or other network issue). In other words, when the VRRP preemption mode is disabled and when a high priority master router becomes unavailable, the next high priority VRRP instance on the backup router assume the role of master router. When the previously unavailable VRRP device is back online and starts receiving advertisements, it does not take over the master role and remains as the backup (slave) router.

However, it is recommended not to disable the preemption mode on all the VRRP instances on a router. For example, if you have seven VRRP instances, you may disable the preemption mode on a few instances (say 3-4 VRRP instances) to maintain load balancing by avoiding a lower priority router to continue as the master router causing the control plane traffic to be handled by a single node.

Disabling the preemption mode is useful in scenarios when a higher priority backup router tries to become the master router, while a master router already exists. For example, when a higher priority master router becomes unavailable and the next high priority router assumes the master role, and later when the original master router comes back online and does not receive any advertisements for a short period (due to any network issue or power failure), then the original master router reclaims the role of master router while the second high priority router continues in the master role. In this case, the higher priority router's claim is accepted and that becomes the master router.

> **Note**: In Netvisor ONE version 6.0.0, you must use the `vrrp-preempt-mode disable` option only when the VRRP is enabled between two switches. This functionality is not applicable for cases where VRRP is enabled on more than two switches.

You can enable or disable preemption feature on IPv4 and IPv6 addresses of the vrouters.

This feature includes the addition of a new OID to the Pluribus proprietary PN-VRRP-MIB, which is mapped to the standard VRRP-MIB v3.

Use either the CLI command or the REST API syntax to enable or disable the preemption feature. To enable or disable the VRRP preemption mode by using the CLI, use the `vrouter-interface-add` or `vrouter-interface-modify` commands:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-name name-string vrrp-priority <0..254> vrrp-preempt-mode disable|enable
```

`vrouter-interface-add`	Adds an interface to a vRouter.
`vrouter-name name-string`	Enter a name for the service configuration.
`vrrp-priority 0..254`	Enter a VRRP priority for the vrouter interface. The default priority is 100.
`vrrp-preempt-mode disable|enable`	Specify one of the options to allow or prevent a high priority Backup router from becoming Master router. The default value is `enabled`.

For example, to add an interface, VR1 with priority 150, and enable the preempt mode, use the command:

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-name vr1 vrrp-priority 150 vrrp-preempt-mode enable
```

To view the details, use the `vrouter-interface-show` or `vrouter-interface-ip-show` commands. The `format all` option displays a separate column '`vrrp-preempt-mode`' with the configured value.

```
CLI (network-admin@switch) > vrouter-interface-show format all
```

To modify an existing vrouter interface, use the command:

```
CLI (network-admin@switch) > vrouter-interface-modify vrouter-name name-string nic nic-string vrrp-preempt-mode disable|enable
```

Assuming that you had already configured other parameters such as `vlan`, `nic`, `ip-address`, and `vrrp-priority` for a vrouter interface (refer to the Configuring VRRP section for details), below is a sample configuration and show output when you enable and disable the `vrrp-preempt-mode` parameter on a vrouter interface.

View the details when the `vrrp- preempt-mode` is enabled on a VLAN:

```
CLI (network-admin@switch) > vrouter-interface-show vlan 2
format   nic,nic-state,vlan,ip,vrrp-priority,vrrp-state,vrrp-
preempt-mode,

vrouter-name  nic   nic-state vlan    ip         vrrp-priority vrrp-state vrrp-preempt-
mode
------------ ------ --------- ---- ------------- ------------- ----------
-----------------
ghq-spine1   eth0.2  up        2    10.10.2.2/24
ghq-spine1   eth1.2  down      2    10.10.2.1/24  100           slave      enable
ghq-spine2   eth2.2  up        2    10.10.2.3/24
ghq-spine2   eth3.2  down      2    10.10.2.1/24  110           slave      enable
uss-spine1   eth4.2  up        2    10.10.2.4/24
uss-spine1   eth5.2  down      2    10.10.2.1/24  120           slave      enable
uss-spine2   eth6.2  up        2    10.10.2.5/24
uss-spine2   eth7.2  up        2    10.10.2.1/24  130           master     enable
```

Disable the VRRP preempt by using the `vrouter-interface-modify` command on vrouter instances:

```
CLI (network-admin@ghspine01-new) > vrouter-interface-modify vrouter-name ghq-
spine1 nic eth1.2 vrrp-preempt-mode disable

CLI (network-admin@ghspine01-new) > vrouter-interface-modify vrouter-name ghq-
spine2 nic eth3.2 vrrp-preempt-mode disable

CLI (network-admin@ghspine01-new) > vrouter-interface-modify vrouter-name uss-
spine1 nic eth5.2 vrrp-preempt-mode disable

CLI (network-admin@ghspine01-new) > vrouter-interface-modify vrouter-name uss-
spine2 nic  eth7.2 vrrp-preempt-mode disable
```

View the details after disabling the VRRP preemption mode:

```
CLI (network-admin@ghspine01-new)  >  vrouter-interface-show
vlan  2  format  nic,nic-state,vlan,ip,vrrp-priority,vrrp-
state,vrrp-preempt-mode,

vrouter-name  nic   nic-state vlan    ip         vrrp-priority vrrp-state vrrp-preempt-
mode
-----------  ------ --------- ---- ------------- ------------- ----------
-----------------
ghq-spine1   eth0.2  up        2   172.16.2.2/24
ghq-spine1   eth1.2  down      2   172.16.2.1/24  100           slave      disable
ghq-spine2   eth2.2  up        2   172.16.2.3/24
ghq-spine2   eth3.2  down      2   172.16.2.1/24  110           slave      disable
uss-spine1   eth4.2  up        2   172.16.2.4/24
uss-spine1   eth5.2  down      2   172.16.2.1/24  120           slave      disable
uss-spine2   eth6.2  up        2   172.16.2.5/24
uss-spine2   eth7.2  up        2   172.16.2.1/24  130           master     disable
```

Troubleshooting High Availability

A trunk (also called LAG or port channel) can be configured automatically or can be defined manually with or without the LACP protocol.

Due to their resiliency and traffic load balancing, trunks can be used for inter-switch communication within a cluster (auto-LAG) or for general network connectivity (user-configured LAG).

You can verify a trunk (LAG) status with the command `trunk-show`:

```
CLI (network-admin@switch) > trunk-show format
switch,name,ports,speed,lacp-mode,status
```

switch	name	ports	speed	lacp-mode	status
pnswitch1	ports1-4	1-4	10g	off	up
pnswitch1	ports5-8	5-8	10g	off	up
pnswitch1	ports9-12	9-12	10g	off	up
pnswitch1	ports13-16	13-16	10g	off	up

Trunks can be configured with or without LACP. The following example shows the LACP options available when creating a trunk:

```
CLI (network-admin@switch) > trunk-create name port1-4 ports
1,4 lacp-mode
```

`Off`	LACP is off
`Passive`	LACP passive mode
`Active`	LACP active mode

When LACP is set to active or passive mode it helps detect link and configuration changes, whereas in off mode it is up to the network admin to deal with the trunk bring up process and to avoid configuration mistakes/oversights (such as asymmetries in the configuration).

Clusters and vLAGs provide the underlying redundancy structure for network communications. You can check that a cluster and a vLAG are functioning properly with the following commands. First verify the cluster status (online or offline) with the command `cluster-show`:

```
CLI (network-admin@switch) > cluster-show
```

```
name          state  cluster-node-1  cluster-node-2  tid  ports     remote-ports
-----------   ----   -------------   -------------   ---  -----     ------------
pnclusterodd  online pnswitch1       pnswitch3        15  4,36,128  4,36,129
pnclustereven online pnswitch2       pnswitch4         0  4,8,128   4,8,129
```

Then verify the vLAG status(es) with the command `vlag-show`:

```
CLI (network-admin@pnswitch1) > vlag-show layout vertical

name:         pnvlag1
cluster:      pnclusterodd
mode:         active-active
switch:       pnswitch1
port:         trunk-to-plus
peer-switch:  pnswitch3
peer-port:    trunk-to-plus
status:       normal
local-state:  enabled
lacp-mode:    up  off

name:         pnvlag2
cluster:      pnclustereven
mode:         active-active
switch:       pnswitch2
port:         49
peer-switch:  pnswitch4
peer-port:    18
status:       normal
local-state:  enabled
lacp-mode:    up  active
```

A vLAG is a logical entity that relies upon its port members (physical ports with an operational Layer 1 status) and upon the underlying cluster.

Therefore, first check that the vLAG status is normal and the state is “enabled,up”.

If there are problems with the vLAG, work back through the objects it depends on the cluster, and ultimately the physical ports and the cables.

Supported Releases

Command/Parameter	Netvisor ONE Version
trunk-create, trunk-modify (with LACP parameters and loopback)	Commands with parameters first supported in version 2.1
cluster-create	Command added in version 1.2
cluster-bringup-modify	Command added in version 2.5.4
l3-to-vlan-interface-delay	Parameter introduced in version 2.6.2
vlag-create, vlag-modify (with parameters for mode lacp-mode, active-standby and active-active)	Commands with parameters first supported in version 2.2
lacp-mode, lacp-fallback, and lacp-fallback-timeout	Parameters introduced in version 2.4
lacp-port-priority	Parameter introduced in version 2.5
hw-vrrp-id	Parameter introduced in version 2.2 for vrouter-create
vrrp-id, vrrp-priority, and vrrp-primary	Parameters introduced in version 2.2 for vrouter-interface-modify

Refer to the Pluribus Networks Command Reference documents for more details on the commands.

Related Documentation

For more information on concepts mentioned in this section (such as Layer 2, Layer 3, and the Fabric), refer to below topics from the Configuration Guide:

- Configuring Layer 2 Features
- Configuring Layer 3 Features
- Configuring and Administering the Pluribus Fabric

Configuring VXLAN

This chapter provides information about understanding and configuring the VXLAN features on a Netvisor ONE switch using the Netvisor ONE command line interface (CLI).

Understanding VXLAN

In modern networks, Virtual eXtensible Local Area Network (VXLAN) has become a key technology enabler for advanced data center network designs such as those employed by cloud service providers and large enterprises. RFC 7348 is the IETF *informational* document that describes in detail the VXLAN encapsulation scheme.

Historically, the primary need for the introduction of a new encapsulation scheme originated in the data center where high server density on top of server virtualization placed increased demands on the available physical and logical resources of the network.

In particular, each virtual machine (VM) requires its own Media Access Control (MAC) address. Therefore, highly scalable data centers with N VMs running on M servers would require MAC address tables potentially larger (N x M) than what is available in a switched Ethernet network.

In addition, bare metal servers as well as VMs in a data center need to be grouped and isolated according to various management and security policies: this is usually achieved by assigning them to Virtual LANs (VLANs). However, the maximum number of VLANs is limited to 4094 and hence it's inadequate for the largest network designs, especially when *multi-tenancy* and *VLAN reuse* are required.

In fact, data centers are often required to host multiple tenants, which must have their own isolated management and data forwarding domains. This means that each tenant should be able to independently assign MAC addresses and VLAN IDs without causing resource conflicts in the physical network. In order to achieve this, an extra *layer of network virtualization* is required.

While various solutions for each aforementioned resource limitation/challenge have been proposed in the past, thanks to its flexibility and ample software and hardware support VXLAN has risen above all alternatives to become the *solution of choice* to address all of the above limitations. Moreover, its powerful UDP-based encapsulation has been leveraged to enable novel capabilities as well as to replace legacy solutions for highly scalable network designs (as further discussed in the paragraphs below).

One important use case is when virtualized environments require having Layer 2 forwarding capabilities scale across the entire data center or even between different data centers for efficient allocation of compute, network and storage resources. A solution that enables a network to scale across data centers is oftentimes referred to as *Data Center Interconnect* (*DCI*) and is an important high availability design.

In the DCI scenario traditional approaches that use the Spanning Tree Protocol (STP) or an MPLS-based technology (such as VPLS) for a loop-free topology are not always optimal or flexible enough. In particular, network designers typically prefer to use an *IP transport for the interconnection, redundancy and load balancing of resources and traffic*.

Nonetheless, despite the preference for a Layer 3-based interconnect, in VM-based environments there is often a need to preserve Layer 2-based connectivity for inter-VM communication. How can both models coexist then?

VXLAN is the answer to this question: it employs a UDP-based header format which can be used to route traffic within a physical Layer 3 network (also called an *underlay*) while its encapsulation capabilities can seamlessly *preserve and augment* Layer 2's inherent characteristics (such as MAC addresses and VLANs) and communication rules.

From this point of view VXLAN marries the best of both worlds. Hence it can be used to implement a virtual Layer 2 network (a so-called *Layer 2 overlay*) on top of a traditional Layer 3 network design.

This capability is also an ideal fit for example for DCI deployments where a Layer 2 overlay is required to carry the Ethernet traffic to and from geographically dispersed VMs.

The approach of transporting Layer 2 traffic in a UDP-encapsulated format is akin to a logical 'tunneling function'.

However, VXLAN's informational RFC does not enforce any particular control-plane and data-plane scheme (like a tunnel-like model), nor does it limit the number of possible use cases. (It simply illustrates how to overcome certain limitations while suggesting one communication scheme for unicast traffic and one for multicast/broadcast/unknown unicast traffic).

In practical terms, then, VXLAN is primarily an encapsulation format. The way the control plane uses it varies from vendor to vendor, sometimes with fully proprietary implementations and sometimes with open software components based on common interoperability standards.

Despite this heterogeneity and flexibility of implementation, the VXLAN format has become widely popular: it is supported in hardware by most data center switches and it is also supported in software on virtualized servers running for example an open virtual switch.

Most hardware vendors however don't implement verbatim the entire RFC in particular with regard to the 'flood and learn' data plane mechanism described in it, because deemed not scalable enough.

The following sections will describe Pluribus Networks' innovative VXLAN integration with the *Adaptive Cloud Fabric* (ACF, or simply the *fabric*), the related optimizations and use cases, and their configuration.

About VXLAN's Packet Format and Its Implications

From a pure encapsulation perspective, the VXLAN format has a few important general implications related to the specific fields that it adds as well as to the UDP encapsulation.

The VXLAN header is shown in ***Figure 8-1*** below.

```
VXLAN Header:
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|R|R|R|R|I|R|R|R|            Reserved                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                VXLAN Network Identifier (VNI) |   Reserved    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Inner Ethernet Header:
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Inner Destination MAC Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Inner Destination MAC Address | Inner Source MAC Address      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Inner Source MAC Address                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|OptnlEthtype = C-Tag 802.1Q    | Inner.VLAN Tag Information    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Payload:
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Ethertype of Original Payload |                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               |
|                                  Original Ethernet Payload    |
|                                                               |
|(Note that the original Ethernet Frame's FCS is not included)  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Frame Check Sequence:
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   New FCS (Frame Check Sequence) for Outer Ethernet Frame     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 8-1: VXLAN Header Added on Top of a Plain UDP Packet (Ethernet + IP + UDP)

VXLAN requires the addition of a variable number of extra octets (i.e., overhead) to all the frames it encapsulates: as shown above, Inner Ethernet Header + Payload + FCS represent the Ethernet frame that originates in the underlay network from a host (virtualized or not). Such original frame is then encapsulated into an 8-octet VXLAN header, which is then encapsulated into a regular UDP (+ IP + 802.3) packet. An outer IEEE 802.1Q VLAN tag is optional and, when present, adds *four additional octets* to the total.

For example, in case of UDP over IPv4, this equates to a total of 50/54 additional octets of VXLAN encapsulation overhead. In case of UDP over IPv6 an additional 20 octets (compared to IPv4's case) have to be added due to the longer IPv6 header (for 70/74 bytes of total extra overhead).

About the MTU Configuration

The first obvious implication is that, in order to make sure that variable-length VXLAN encapsulated packets can be successfully carried across a generic Ethernet underlay network, the *Maximum Transmission Unit* (*MTU*) size must be properly increased end-to-end on all the physical and logical interfaces connecting the network nodes.

In the IPv4 case the MTU needs to be raised to at least *1554 octets* (from the standard 1500 value). In the IPv6 case it needs to be set to at least *1574 octets*.

In an Ethernet network, usually this requirement is supported for both cases by enabling *jumbo frame forwarding* on the device interfaces (at Layer 2 and 3) that have to carry any VXLAN traffic.

About the VXLAN IDs

The second important implication of the VXLAN packet format is that it includes a very useful 24-bit field called *VXLAN Network Identifier* (*VNI*). Per the definition in RFC 7348:

> *VXLAN Segment ID/VXLAN Network Identifier (VNI): this is a 24-bit value used to designate the individual VXLAN overlay network on which the communicating VMs are situated. VMs in different VXLAN overlay networks cannot communicate with each other.*

Traditional network segmentation at Layer 2 is implemented with IEEE 802.1Q VLANs to provide logical segmentation of the traffic in different broadcast domains. The use of VLANs, however, imposes a number of limiting factors, especially in large network designs, for example in large multi-tenant data centers.

By leveraging the VNI field as well as a number of VXLAN-based forwarding optimizations it is possible to provide the same Ethernet Layer 2 network services as VLANs but with greater extensibility and flexibility.

In particular, the 24-bit VNI field supports 16 million possible IDs, which is usually considered more than sufficient for the largest network designs.

When compared to VLANs, VNIs offer the following benefits:

- *Increased scalability* to address more Layer 2 segments as it is possible to map such segments to up to 16 million IDs that can coexist in the same administrative domain.

- *Flexible allocation* of segment IDs in multi-tenant environments, as it is possible to map each VLAN ID to different unique VNIs (that is, VLAN ID reuse is easily supported). Furthermore, VXLAN's UDP transport enables the *flexible interconnect* of data center pods across a generic IP underlay, even when the pods are geographically distributed for redundancy and load sharing purposes.

- *Standard routing technologies* (Layer 3 forwarding and equal-cost multipath (ECMP) load-balancing) are applied to VNI-based segments in the underlying IP network thanks to VXLAN's UDP-based encapsulation. This can translate into better network utilization, simpler interoperability in heterogeneous networks and greater scalability enabled by *hardware-based forwarding and replication*.

About VXLAN's Layer 2 Extension

The third important implication of the VXLAN packet format is that it can be used to transport Layer 2 traffic from a source to a destination where both source and destination use a single MAC address each (or a limited number of addresses). That is why VXLAN is often likened to a 'tunnel' from a source to a destination that carries traffic from any number of end devices.

In more general terms, as we will see in the following, it's a *versatile Layer 3 forwarding path* from a source to a destination.

Both source and destination are called *VXLAN Tunnel End Points* (VTEPs) per the RFC.

One important challenge in today's virtualized environments is that there is increased demand on MAC address tables of switches that connect to servers. Instead of learning one MAC address per physical server, the switch now has to learn the MAC addresses of the individual VMs, and if the MAC address table overflows, the switch will stop learning new MAC addresses until idle entries age out.

With VXLAN's *end points using a single MAC address*, only that address gets exposed to and learned by adjacent transit switches. Therefore, there is no requirement for global learning of all MAC addresses anymore (like in a flat Layer 2 network), and *MAC address scalability* is only limited by the table size of the switch where the VTEP is configured.

Furthermore, the VNI identifies the scope of the inner MAC frame originated from each host. Therefore, it is possible to utilize overlapping MAC addresses across segments without conflict since, just like with VLANs, the traffic is logically isolated by using different identifiers (the VNIs in case of VXLAN segments).

The aforementioned advantageous implications bring even more benefits to network designers when combined with Pluribus Network's innovative *Adaptive Cloud Fabric* and its advanced feature set.

In the following sections we will describe Pluribus' distinctive implementation of the VXLAN technology, its forwarding optimizations and benefits, as well as its specific configuration steps.

About Pluribus' VXLAN Implementation and Benefits

If a network designer were tasked with selecting the best and most desirable technology among a number of implementation options, he or she would be hard pressed not to go with an open and standard approach. That is simply because a standard technology can maximize interoperability and hence offer network designers a wealth of software and hardware choices.

In contrast to other closed proprietary approaches, which require significant investments in complex and rigid hardware, Pluribus Networks has chosen the user-friendly path of a *software-defined networking technology* based on the VXLAN industry standard, where the fabric and its features seamlessly integrate with the advanced capabilities enabled by the VXLAN transport. (For more details on Pluribus' fabric configuration, refer to the *Setting up and Administering the Pluribus Fabric* chapter.)

In particular, Pluribus has integrated the VXLAN implementation with the fabric's capability of distributed MAC learning and VLAN transport, its redundant path support through vLAGs, virtual addresses and vRouters, as well as with the fabric VRFs' distributed forwarding capability for maximum redundancy and scalability.

The power of the *Adaptive Cloud Fabric* distributed control plane has been leveraged to greatly augment and simplify VXLAN's basic capabilities without requiring complex proprietary (and potentially not inter-operable) enhancements. *Fabric VRFs and distributed multicast forwarding* (described later in this section) are two examples of the powerful synergies that have been achieved.

As part of the Adaptive Cloud Fabric, two inter-related logical layers have to be designed and configured: the underlay and the overlay network.

Let's look at each one individually.

About the Underlay Network's Architecture

For flexibility and openness reasons, Pluribus engineers have decided to support a spectrum of different options based on *standard protocols* for fabric underlay architectures: they can be built using Layer 2 only, or with a combination of Layer 2 and Layer 3, or only with Layer 3, as shown in ***Figure 8-2*** below.

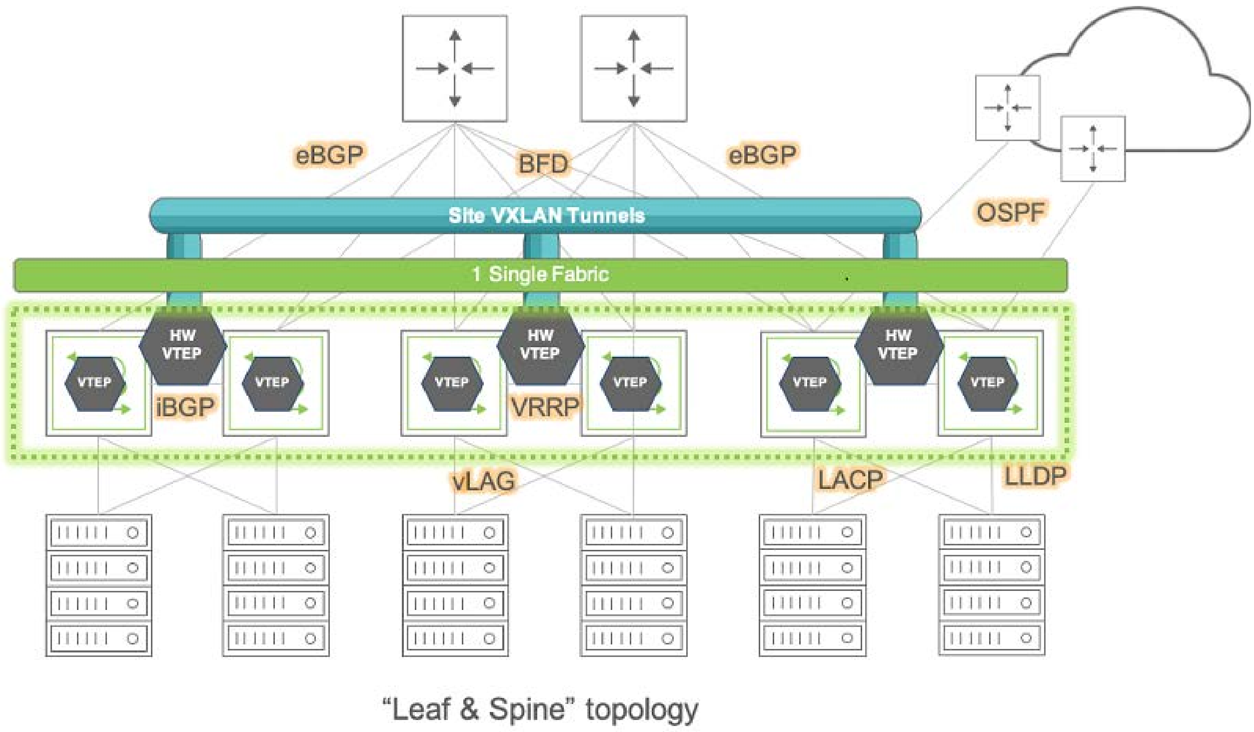


Figure 8-2: Pluribus Fabric Over Any Underlay Network

As depicted above, network underlays typically include both path and device redundancy.

As explained in the *Configuring High Availability* chapter, either with Layer 2 or with Layer 3 designs Pluribus supports switch clustering and vLAGs in order to minimize reliance on the Spanning Tree Protocol (in case of Layer 2 networks) as well as to optimize redundancy and failover speed.

For Layer 3 underlay networks Pluribus also supports standard routing protocols for device interconnection (such as OSPF and BGP) as well as the VRRP protocol when default gateway redundancy is required.

In particular, having the possibility of leveraging an IP-based routed transport for intra-DC and inter-DC interconnection makes the entire architecture more open and leaner, with the option to use any switch vendor in the core (since any vendor nowadays can provide a broad, inter-operable and robust support of Layer 3 technologies).

In summary, for the network underlay the designer will have to decide which topology and forwarding scheme to use, which devices to deploy in each network location, and, as explained earlier, will have to enable jumbo frames wherever the VXLAN transport is required (typically it is required end-to-end for pervasive deployment models).

Pluribus Networks' open networking switches can be used as both leaf and spine switches, and can be connected to 3rd party switches, routers and appliances using just the aforementioned standard underlay technologies (whose configuration is described in detail in other chapters of this guide).

About the VXLAN Fabric Overlay and End Points

Regarding the VXLAN transport's architecture and configuration, network designers have to decide where to place the VXLAN end points, i.e., the sources and the destinations of the VXLAN forwarding paths (referred to as *tunnels* in the RFC).

This decision depends on many different factors (such as level of software and hardware support, scalability, virtualization, traffic patterns, etc.) but the choice usually falls on the edge nodes of the fabric (whether hardware or software-based).

Redundancy can also be a key decision factor, as discussed in the next section.

A common scalable choice for end point (VTEP) placement is represented by the leaf switch(es), that is, the first-hop switches physically connected to the hosts (bare metal servers or VMs).

Furthermore, when configured in redundant pairs, leaf switches are the ideal locations for VTEP placement for improved service continuity, as shown in the figure below. (On the other hand, it is also possible that in certain other designs the VTEPs can be placed on spine switches, if so required by design prerequisites and/or network constraints.)

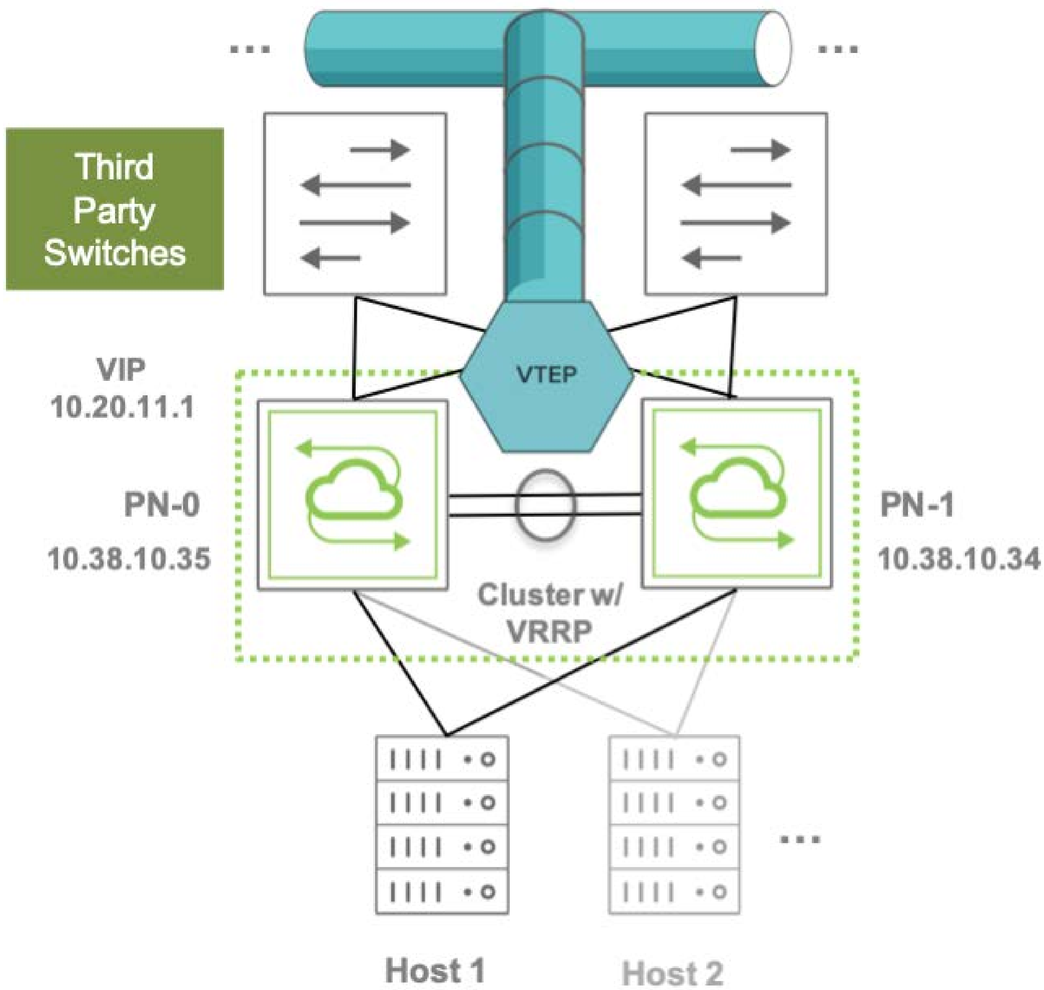


Figure 8-3: VTEP Placement on Leaf Switch Clusters

Pluribus switches support flexible VTEP placement. For example, VTEPs can be placed on pairs of Pluribus leaf switches that are connected to a third-party Layer 3 core network (as shown in the figure above), or they can be placed on pairs of Layer 3 Pluribus spine switches that interconnect two DC sites (or pods) over a generic IP-based network, or the design choice can even be a combination of the two above.

In any of these cases, the VXLAN traffic flows are terminated on the switches, which are responsible for encapsulating packets that arrive from servers or hosts on a Layer 2 network and transmitting them over to their destination. Similarly, the VXLAN packets arriving from the opposite direction are decapsulated and the inner packets are forwarded over to their destination end devices. The switches also collect traffic statistics, optimize ARP requests and MAC learning.

In addition to the above, Pluribus also supports scenarios in which VXLAN is not terminated on the switch itself, that is, in which the switch does not participate in the encapsulation and/or decapsulation of the VXLAN traffic.

In such case a host would typically implement a VTEP in software and therefore the switch would act mainly as an underlay node for the pass-through VXLAN traffic directed to that host.

On that VXLAN traffic, though, Netvisor ONE can still perform an important function:

> Analytics collection: All TCP control packets as well as ARP packets traversing a tunnel are captured. By default, the ARP and TCP packets are captured only at the ingress and egress tunnel switches. With inflight analytics enabled, the analytics are captured on the traversing packets as well. These packets are used to build connection statistics and provide visibility as to which VXLAN nodes are on specific ports. With inflight analytics enabled, analytics packets are captured on the traversing packets.

About VTEP High Availability

A critical design requirement for various DC networks is to deploy the VXLAN transport in conjunction with a *high availability (HA) configuration* at the edge of the fabric. This guarantees path redundancy and service continuity in case of link or device failure at the edge.

In VXLAN parlance edge redundancy support is known as *VXLAN Tunnel Endpoint High Availability* (*VTEP HA*).

Pluribus switches support VTEP HA through the combination of multiple features: in particular, Pluribus implements a VTEP HA switch pair by harnessing the power of switch clustering in conjunction with the vLAG technology and with the standard VRRP protocol (these features are described in detail in the *Configuring High Availability* chapter).

This feature combination enables the configuration of redundant active-active Layer 3 switches that function as VRRP peers (with mutual liveliness checks) and that can provide a common *virtual IP* (*VIP*) address as active-active default gateway.

Thanks to the cluster synchronization function, a VTEP pair can act as a single logical

VXLAN end point using a single shared VIP as source address. Similarly, a destination VXLAN end point can be reached by using its HA pair's common VIP as destination address.

This interconnection of virtual IPs is exemplified in the figure below.

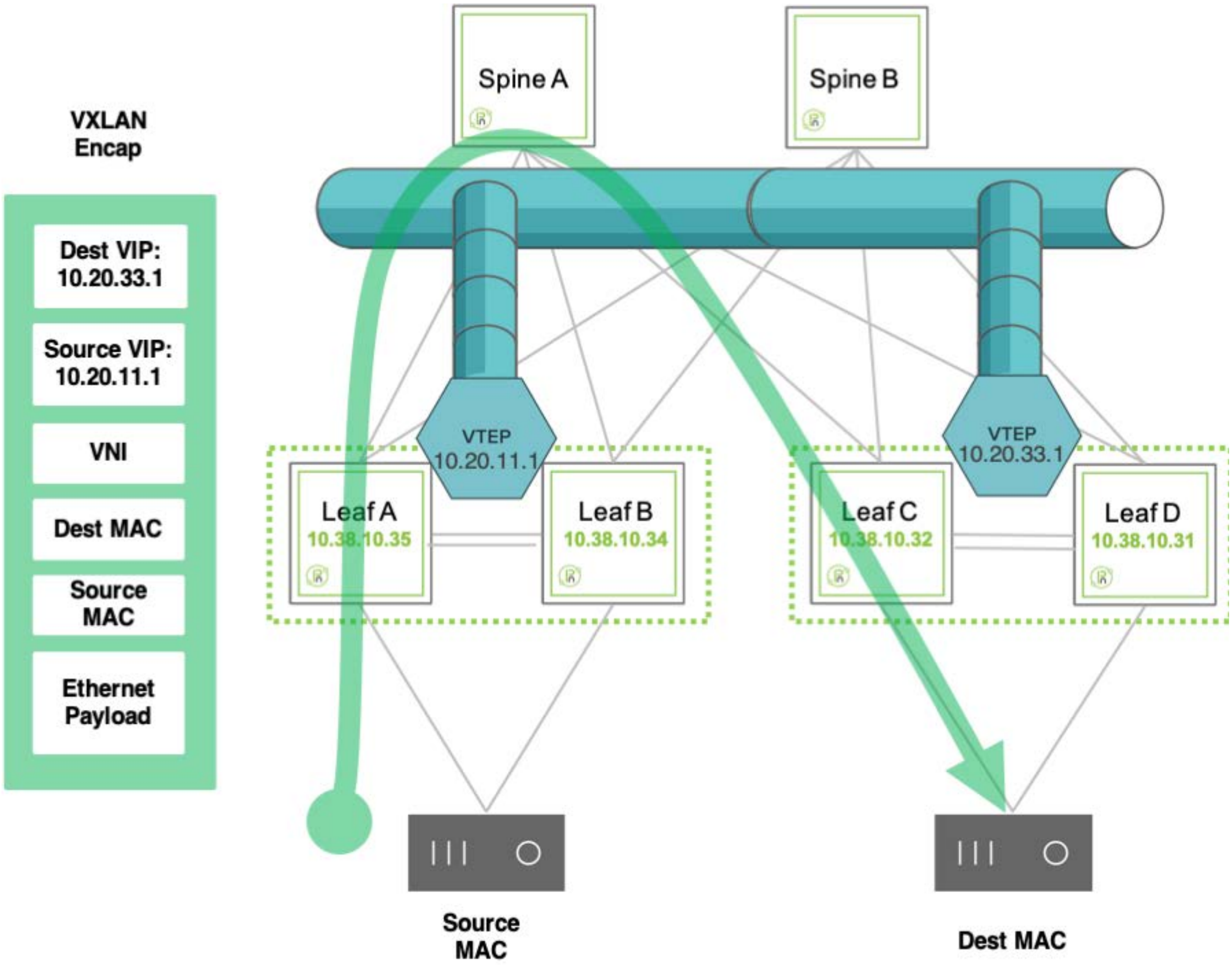


Figure 8-4: VIP Use for Inter-VTEP Communication

Setting up multiple of the above logical pairs enables the creation of an overlay network of *interconnected VXLAN end points* based on virtual (not physical) addresses which offers *embedded physical as well as logical redundancy*.

Configuration of these VXLAN pairs can be performed manually for each individual source and destination VTEP. However, Pluribus can further leverage the power of the Adaptive Cloud Fabric's distributed control plane to automate this tedious and potentially error prone process (for more details refer to the VTEP configuration section below).

Similarly, configuration of VLAN extensions over a VXLAN fabric requires a standard VLAN ID to VXLAN Network ID (VNI) mapping scheme. This ID mapping process too can be repetitive and error-prone, but with Pluribus' distributed control plane such global configuration can be propagated to all the nodes belonging to the same fabric instance, thus saving significant time and effort.

About the VXLAN Fabric Overlay and its Forwarding Optimizations

A fabric overlay comprises a number of VXLAN end point pairs, as mentioned above, whose interconnection is used to transport end stations' traffic end-to-end based on their VLAN-to-VNI mappings.

A typical example of the logical overlay interconnect (of leaf switches in this instance) that VXLAN can be used to create over a physical underlay network is depicted in the figure below:

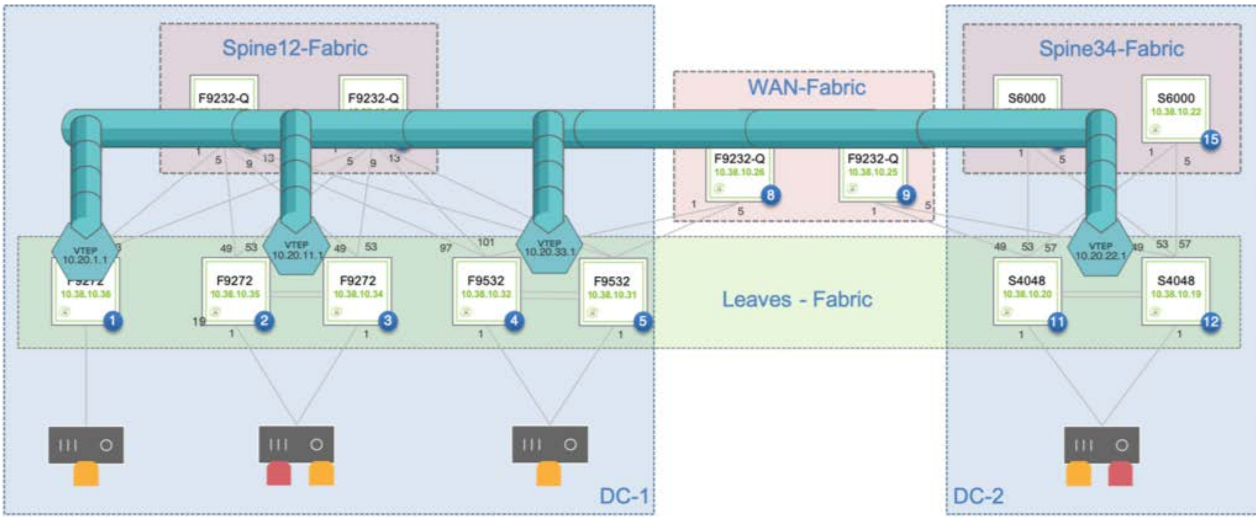


Figure 8-5: Overlay Network Interconnecting Single and Redundant VTEPs

Pluribus' forwarding logic and distributed control plane employ the standard *split horizon algorithm* to create a loop-free logical forwarding topology in the fabric overlay network so as to steer any VXLAN traffic over it without creating potential switching loops.

Furthermore, the implementation of the forwarding logic does not require complex address tracking and propagation mechanisms (such as IETF's MP-BGP-based EVPN solution). Pluribus instead uses its own *native address* registration and tracking technology, called *vPort database*, which is particularly useful to track host moves.

While a plain-vanilla hardware Layer 2 table is limited in its capacity by a switch's dedicated ASIC memory size, the Netvisor ONE software runs in the control plane processor's much larger DRAM memory space and hence is capable of tracking a large list of Layer 2 entries, much larger than what can fit into the limited space of a hardware table.

This logical software extension of the Layer 2 table is the vPort database, which can be considered as the *authoritative distributed endpoint directory and switching activity history book* of the entire Pluribus fabric.

In addition, as an optimization option (disabled by default), the fabric can use vPort information in conjunction with the *ARP optimization technology* to help manage the dynamic process of binding MAC/IP address pairs.

Pluribus' ARP optimization technology harnesses the versatility of the vPort database to perform the dynamic endpoint discovery and ARP proxy functions that are required to support the mobility of end-points across the fabric, as described in the figure below.

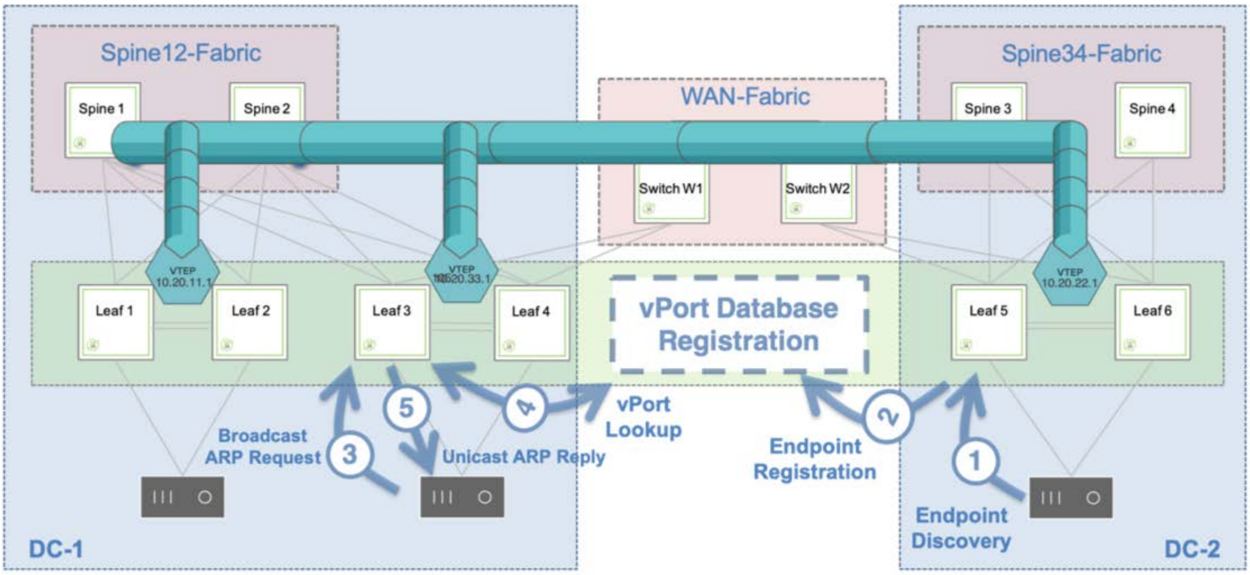


Figure 8-6: ARP Optimization Process

In the figure above, on the right-hand side a host is discovered through the traffic exchange with its neighboring switch. As a consequence, its information is recorded in the vPort database.

On a remote switch (on the left-hand side of the figure) whenever someone sends a broadcast ARP request to learn about the MAC address associated with the IP address of the newly discovered host, an *ARP suppression function* is executed.

In other words, the ARP response comes *proxied* from the fabric based on the contents of the distributed vPort database, which is available on all fabric nodes. Therefore, there is no need for any direct ARP communication between requester and registered host, nor for any flooding of broadcast ARP packets.

> **Note:** The ARP optimization can be useful in various scenarios but may also impact the CPU utilization of the switches. Therefore, it is disabled by default and its use needs to be evaluated on a case-by-case basis.

Moreover, starting from release 2.6.0, Pluribus has added a further under-the-hood enhancement to the fabric's control plane logic that significantly reduces the need for the less-than-optimal 'flood and learn' scheme for unknown destination traffic.

This enhancement, called *vPort forwarding*, implements a more optimized forwarding logic thanks to the versatility of the vPort database: this logic is analogous to ARP optimization's use of the vPort database information to avoid unnecessary ARP flooding, but it's applied to the general case when the destination Layer 2 address of a generic packet can be successfully looked up in the distributed vPort database so as to avoid having to flood the packet to all its possible destinations.

About ECMP Load Distribution for VXLAN Traffic

Equal-cost multi-path routing (ECMP) is a routing strategy where next-hop packet forwarding can occur over multiple paths on a per flow basis.

Hardware platforms usually perform a hash function on a number of packet fields to perform path selection and determine the load balancing traffic distribution.

In case of VXLAN-encapsulated traffic, for backward-compatibility purposes, the same *legacy* ECMP algorithm can be applied to VXLAN packets too without requiring deeper inspection.

This is because the VXLAN RFC recommends that the encapsulation function add some amount of *entropy* to a VXLAN packet by generating a variable source UDP port:

> *Source Port: It is recommended that the UDP source port number be calculated using a hash of fields from the inner packet -- one example being a hash of the inner Ethernet frame's headers. This is to enable a level of entropy for the ECMP/load-balancing of the VM-to-VM traffic across the VXLAN overlay.*

In other words, that recommendation makes sure that some amount of variability is present when creating VXLAN connections so that they can be easily load-balanced using most ECMP functions implemented by networking platforms.

In particular, any ECMP algorithm that takes into account (also) the *Layer 4 source port* for path determination will be able to take advantage of the level of entropy added to the VXLAN packets as per the RFC.

In case of Netvisor ONE this is achieved *by default* by implementing a granular *7-tuple h*ashing scheme that uses the following fields: source IP address, destination IP address, VLAN number, destination Layer 4 port, *source Layer 4 port*, IP protocol number, source physical port.

Other networking devices may use a simpler ECMP configuration referred to as *5-tuple hashing*, which includes just the source and destination IP addresses, the protocol type, and the source and destination Layer 4 ports for UDP or TCP flows.

Adding VXLAN traffic entropy and applying ECMP hashing are basic hardware functions supported by default on Pluribus switches. These functions are supported by most 3rd party switches and routers as well.

See also the *Displaying ECMP Load Balancing Info for VXLAN* section.

About VXLAN Routing

In most designs the VXLAN overlay network requires that overlay traffic be routed as well as bridged.

This is typically required for the host traffic to be routed across VNI-mapped VLANs and/or to reach the data center gateways, firewalls (or other L3/L4 appliances), so as to be forwarded to the Internet. The reverse path from the Internet also requires that the traffic be routed as well to reach the hosts.

> **Note**: Pluribus also refers to VXLAN routing with the acronym RIOT, which stands for Routing In and Out of Tunnels.

For hosts on different VLANs to communicate with each other and with the Internet, a cluster of *border leaf switches* is deployed for redundancy and load splitting purposes to become the overlay network's default gateway. VLAN interfaces are configured as required by the network administrator on the cluster's vRouters (up to 32 vRouters are supported).

This model is sometimes referred to as *centralized routing* for the VXLAN fabric (as opposed to the *distributed routing* model implemented with VRFs, as explained in a subsequent section).

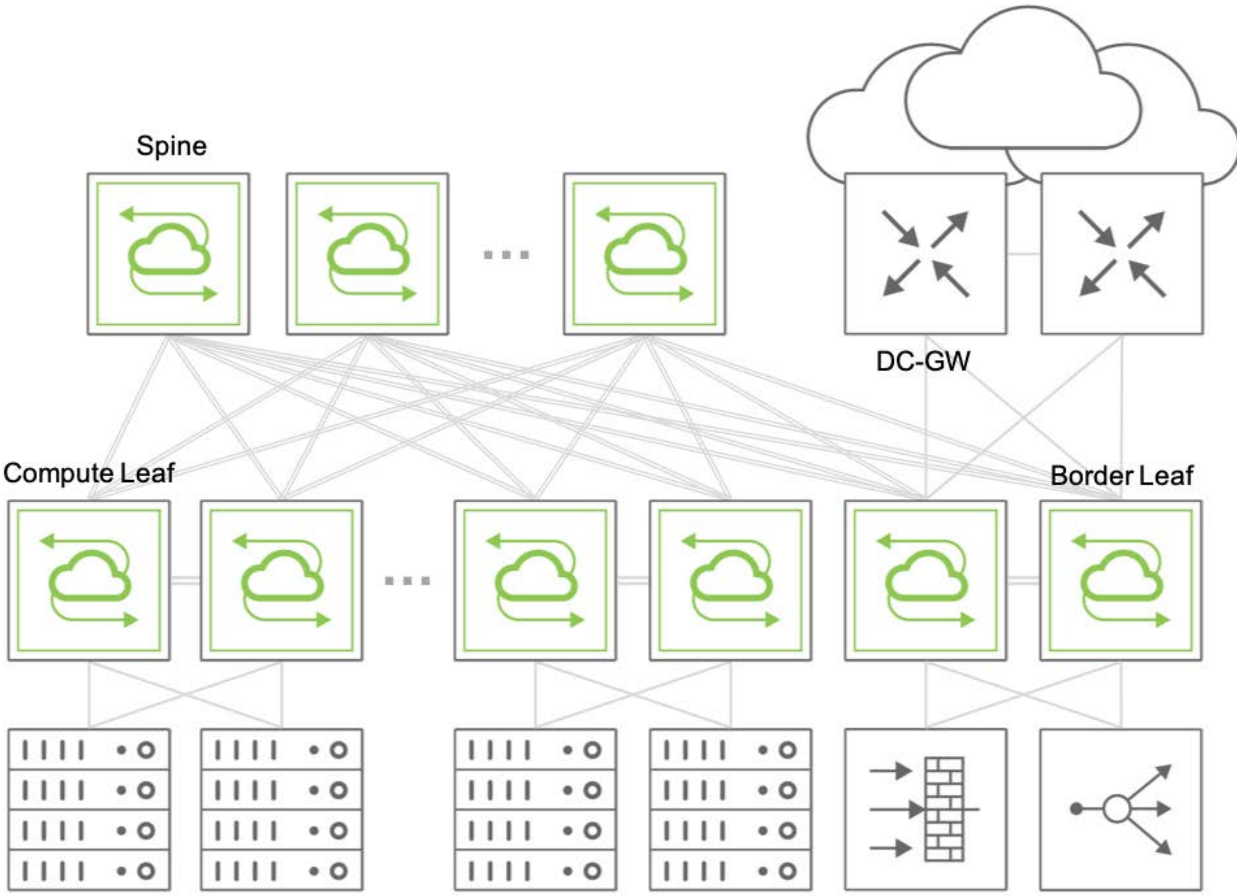


Figure 8-7: Example of Fabric Design Using Centralized Routing

In the centralized routing model, any fabric packets that need to be routed between two hosts in different VNI-mapped VLANs are sent to a centralized overlay vRouter and then VXLAN-encapsulated or -decapsulated depending on source and/or destination's host location.

When multiple sequential hardware operations are required, such as in the forwarding –> decapsulation –> routing sequence, or in the reverse routing –> encapsulation –> forwarding sequence (or also when any packet replication is needed), Pluribus leverages the hardware's capabilities to implement *multiple packet lookup and rewrite passes* using a technology called *recirculation* (or hardware loopback).

This technique is used whenever a certain switch model is incapable of applying all the necessary operations to certain traffic in a single instance (that is, in a single pass). Hence, such traffic will have to be recirculated at least once through the hardware forwarding engine.

Pluribus supports the recirculation technique with the dedicated `vxlan-loopback-trunk` configuration.

About the VXLAN Loopback Trunk

Netvisor ONE uses the `vxlan-loopback-trunk` configuration command to set aside a number of (internal or front-panel) ports that are configured as a logical group (i.e., a dedicated port channel) for recirculation.

This special trunk link is auto-created and is reserved to be used to carve out the necessary amount of bandwidth required for the recirculation of packets.

Typically, the network administrator allocates a number of ports (e.g., 2 or more for redundancy purposes) to a VXLAN loopback trunk that is sufficient to provide an amount of aggregate bandwidth *in excess of* what is required for routing and/or replication of all Broadcast/Unknown Unicast/Multicast (BUM) VXLAN traffic.

From an operational standpoint, if a packet needs to be recirculated after decapsulation as part of the routing operation, Layer 2 entries for the vRouter MAC address or the VRRP MAC address on VNI-mapped VLANs are programmed to point to the `vxlan-loopback-trunk` link in hardware.

Therefore, to verify that the traffic can be recirculated, the network administrator can simply look at output of the `l2-table-show` command, which should display a special `vxlan-loopback` flag to indicate the recirculation-related hardware state (see also the Checking VXLAN Recirculation L2 and L3 Entries section below).

In summary, it is important to size the VXLAN loopback trunk appropriately and, in certain cases, it may be helpful to verify the operational state of the Layer 2 entries associated to it in the hardware tables.

When monitoring the fabric, it is also useful to periodically check the hardware recirculation counters (as discussed in the *Showing VXLAN Trunk Replication Counters* below) so that the network admin can stay abreast on the peak recirculation bandwidth needs of the various fabric switches.

For sizing purposes, note that the VXLAN loopback infrastructure is used for routing traffic before VXLAN encapsulation and/or after VXLAN decapsulation. It is also used for bridging broadcast , unknown unicast or multicast (BUM, in short) traffic in the overlay network.

On the other hand, non-routed known unicast traffic is forwarded and encapsulated, or decapsulated and forwarded, in one single pass *without requiring the VXLAN loopback trunk*.

Starting from Netvisor ONE releases 6.0.0 and 6.0.1 new single-pass configurations are supported on certain switch models using newer hardware forwarding engines. In particular, it is possible to enable single-pass unicast VXLAN routing, single-pass broadcast/unknown unicast and multicast flooding, as well as single-pass distributed multicast bridging. Therefore, by leveraging these hardware capabilities when supported, it is possible to eliminate the need for loopback trunks in certain configurations. For more details, refer to the Configuring the VXLAN Loopback Trunk section.

About the VXLAN Configuration Models

Netvisor ONE offers three powerful VXLAN configuration models.

The first model is aimed at full configuration automation and therefore is likely to be used more often. It leverages a special configuration abstraction called a *VTEP object*. When VTEP objects are created on the nodes, they trigger the automatic creation of VXLAN tunnels from such nodes, thus creating a full mesh of bidirectional connections between the nodes. In addition, starting from Netvisor ONE release 6.0.0 it is possible to automatically add a certain VLAN/VNI pair to all the VXLAN connections with the `auto-vxlan` keyword (note that, if the VNI value is not specified by the user, it is picked automatically by the system provided that the configuration scope is *fabric*.)

This any-to-any model is the most convenient one to quickly set up a full VXLAN fabric between multiple leaf nodes and associate to it all of the configured VLAN/VNI mappings. For more details, refer to the Configuring VTEP Objects with Automatic Fabric Connections section.

Figure 8-8 shows an example of mesh with three leaf nodes configured with three VTEP objects.

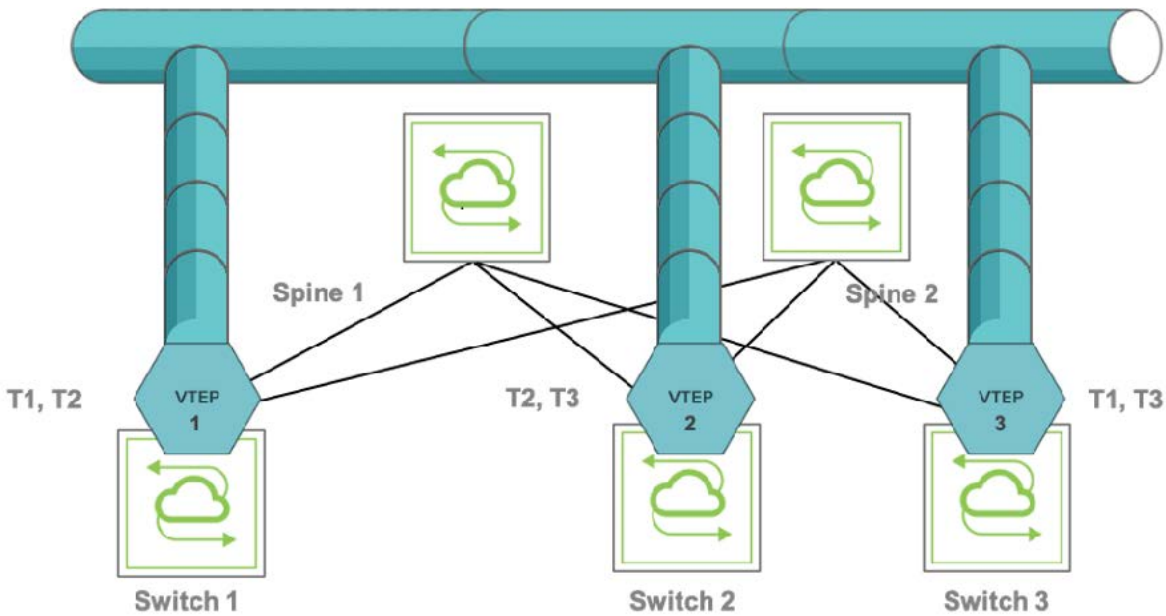


Figure 8-8: Example of VTEP Object Configuration

Bidirectional connections T1 through T3 are called *auto-tunnels* because they are automatically configured by the system when the VTEP objects are created with the `vtep-create` command. See the *Configuring VTEP Objects with Automatic Fabric Connections* section below for the naming of the tunnels automatically generated for the topology in ***Figure 8-8***.

The second model is more granular because it requires more explicit configuration, as it doesn't use the `auto-vxlan` feature (which also means it does not require release 6.0.0 or later).

In this scenario, the user may not want to extend all the VNIs to all the VTEPs and their mesh of VXLAN connections. The user may instead want to extend a VNI, say, to VTEP1 and VTEP2 only (in the figure above) by using the `vtep-vxlan-add` command *selectively*. In such case, only two tunnels are automatically created between VTEP1 and VTEP2 for the chosen VNI (the two auto-tunnels are represented by the bidirectional T2 connection in the figure above), whereas T1 and T3 would not be created for the specific VNI per explicit user choice.

In this model, semi-manual establishment of VXLAN connections is required since the user is responsible to explicitly select which VNIs should be added to each VTEP.

Starting from Netvisor ONE release 6.0.1 a third model has been introduced: it's the *hub-and-spoke configuration* model. When used in conjunction with bridge domains, it mimics the behavior of the Metro Ethernet Forum (MEF) *E-Tree service*.

This model leverages a new keyword, `isolated`, and is not compatible with the `auto-vxlan` assignment. The VTEP on the hub node is configured normally, just as in case 2 above, whereas the VTEPs on the spokes are configured with the `isolated` keyword because they are not supposed to communicate with each other.

Figure 8-9 below shows an example of hub-and-spoke VXLAN topology where the hub node has bidirectional connections to the spokes but the spokes don't have connections between each other.

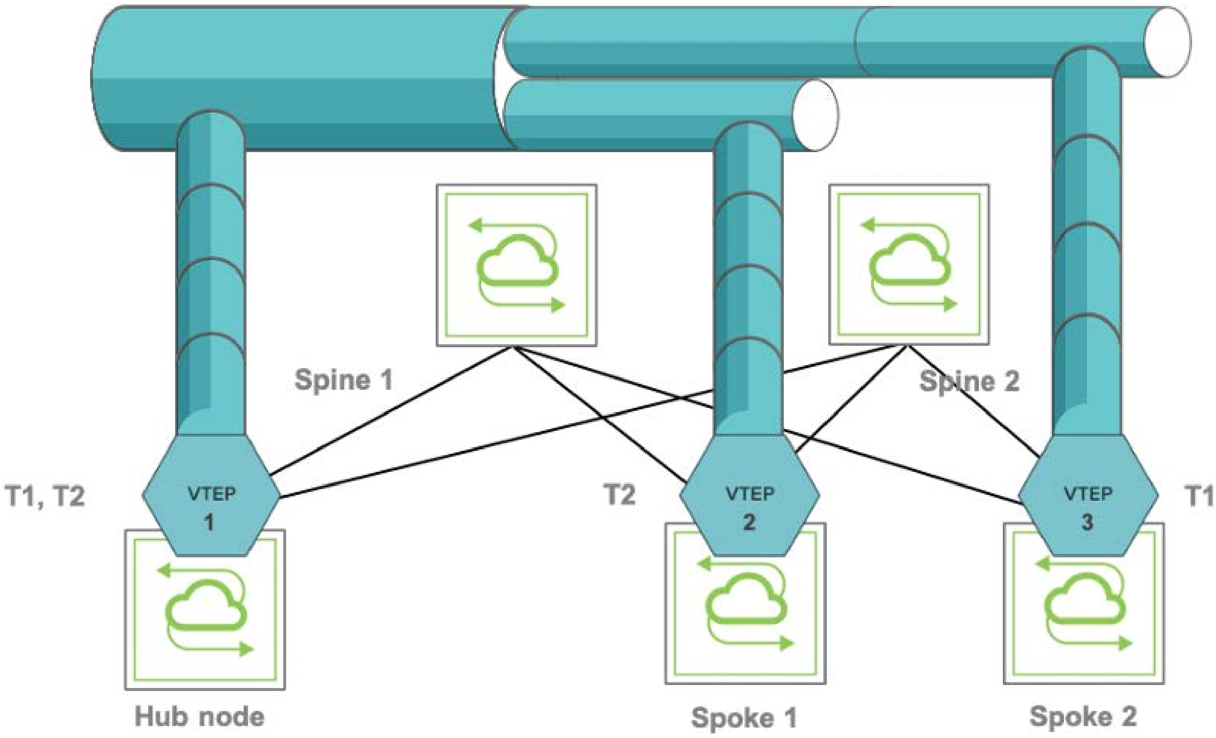


Figure 8-9: Example of Hub-and-spoke VXLAN Configuration

> **Note:** The above two figures actually show a *virtual connection view on a per-VNI basis*: that means that tunnels are automatically created but then it's the per-VNI connectivity policy that determines whether nodes associated with each VNI are actually connected in a virtual mesh or in a virtual hub-and-spoke configuration.

For configuration details and examples, refer to the Configuring VTEP Objects with Automatic Fabric Connections section below.

About Unicast Fabric Virtual Routing and Forwarding (VRF) with Anycast Gateway

Netvisor ONE Adaptive Cloud Fabric adds Layer 3 segmentation to VXLAN interconnections with the support of VRF (Virtual Routing and Forwarding) instances, complementing the vRouter construct and offering a highly scalable distributed routing solution to network architects.

Netvisor supports VRF as a hardware technology allowing multiple routing spaces to coexist on the same distributed fabric architecture. Furthermore, with the addition of the Anycast Gateway functionality, the Adaptive Cloud Fabric enables distributed forwarding at the first hop router as well as intrinsic VM mobility capabilities across complex multi-site data center designs. This guarantees the maximum VRF scalability possible, limited only by the specific forwarding ASIC capabilities.

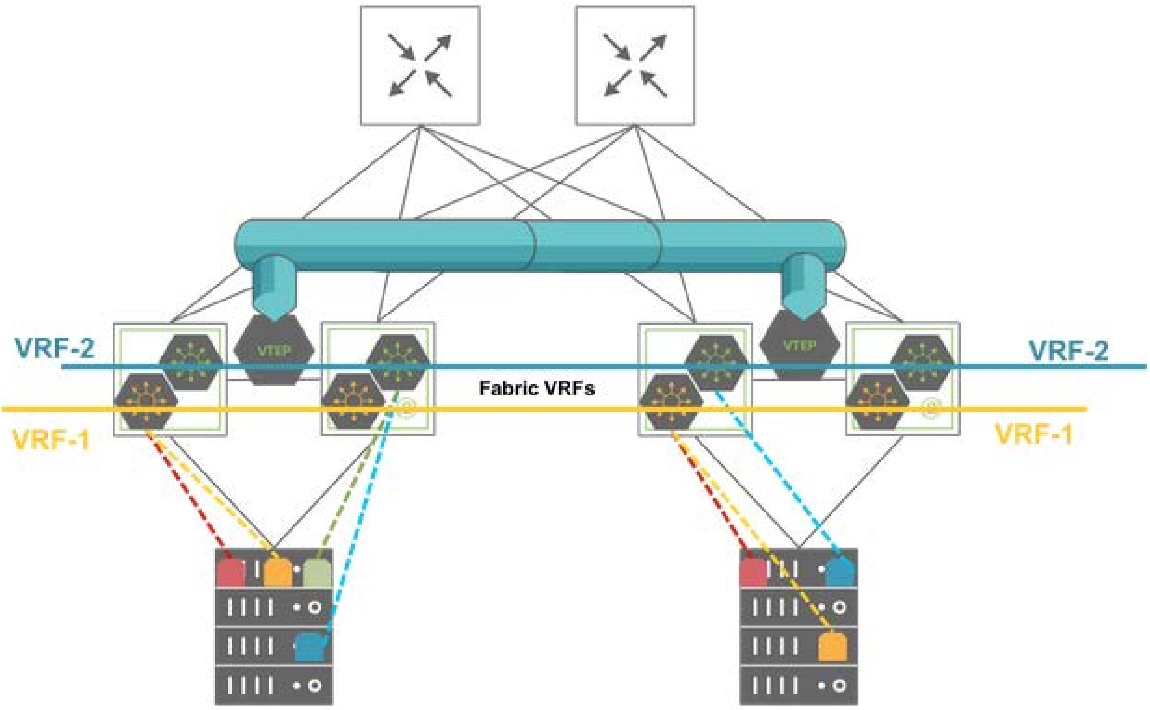


Figure 8-10: East-West Traffic Segmentation with Multiple VRF Instances

Netvisor Fabric VRFs have the following advantages:

- High scalability with support for a large number of VRF instances on a single fabric node (in the order of thousands depending on hardware capacity especially with newer ASICs and as an aggregate number fabric-wide).
- High performance distributed routing of East-West traffic at the Top-of-Rack (ToR) switch level. The distributed routing capability hosted on each leaf node avoids the need for hair pinning traffic to a centralized vRouter.
- Small forwarding state to manage on each node.

- Native redundancy without needing dedicated redundancy protocols (and potentially extra overhead).

- Dual stack support for IPv4 and IPv6 subnets.

- Simple fabric-wide configuration and management (typical provisioning overhead is proportional to: (number_of_VRFs + number_of_VLANs + number_of_switches) instead of the industry average of up to (number_of_VLANs * number_of_switches).

- IPv4 and IPv6 subnets can be automatically stretched to multiple locations without extra configuration.

- Starting from Netvisor ONE release 6.0.1, subnet prefixes can be imported/exported between VRFs by using an innovative feature called virtual service group (vSG).

Fabric VRFs are lightweight distributed atomic constructs created without the need for a local vRouter and they do not currently support any routing protocols on VRF instances. This choice enables very high scalability and very low overhead in the management of the distributed segmentation and routing function.

You can connect fabric VRFs to third party VRF routers or gateways either directly using static routing or through a redundant group of border leaf switch(es) running the vRouter function mapping 1:1 to the Fabric VRF instances. In the latter case, border leaf switches can run any supported IGP protocol to interconnect with third party VRF routers or gateways.

For redundancy purposes, you can configure two VRF routers or gateways, sometimes referred to as *DC gateways*, can be configured per VRF (`vrf-gw` and `vrf-gw2`).

To be more precise, these two important configuration parameters represent two static default routes for northbound traffic. They can be quite flexible: after VRF global creation, they can be locally modified by using the `vrf-modify` command and allowing the implementation of different exit points for a VRF depending on the switch location.

In addition, static routing (with the `vrf-route-add` command) can be leveraged to augment them, for example, to install more than two routes or to change the VRF exit point for specific destination prefixes.

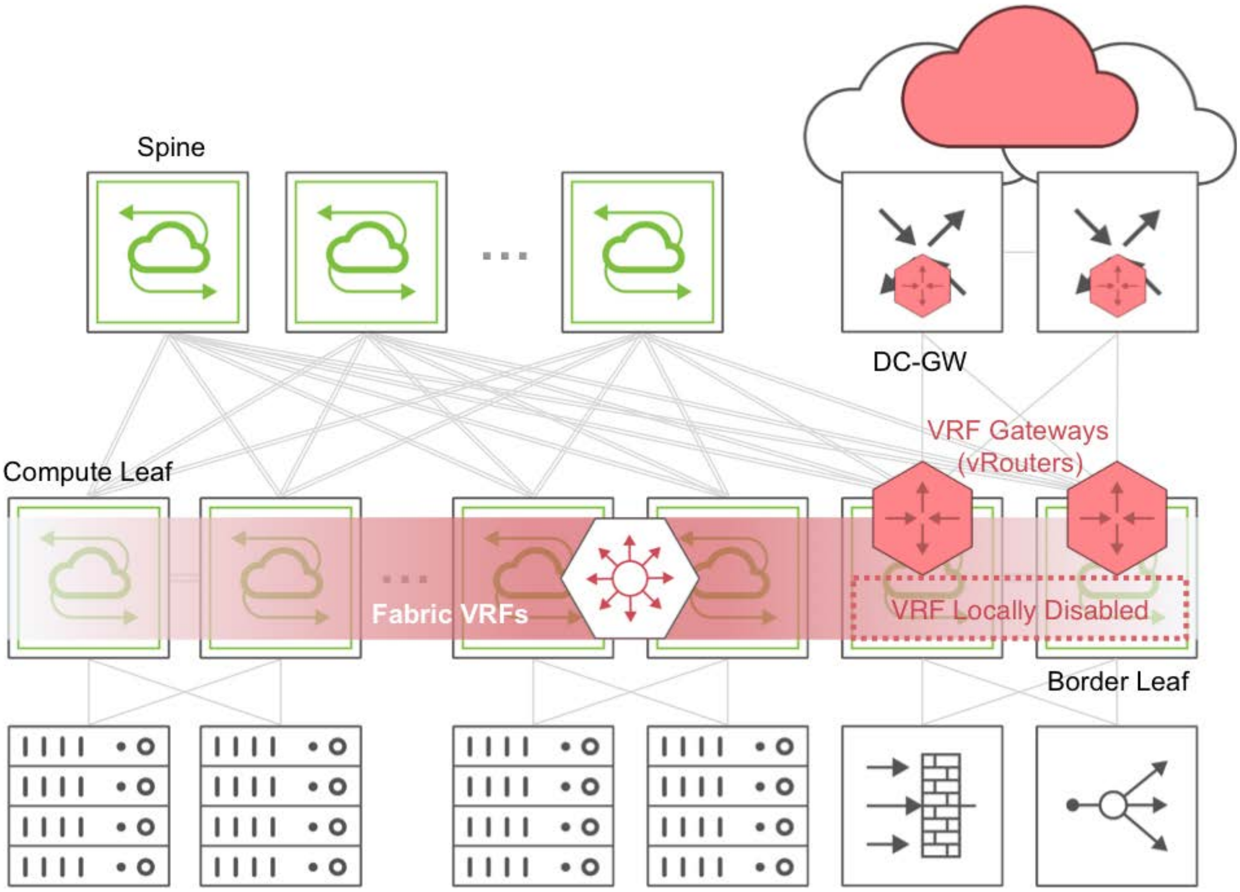


Figure 8-11: East-West Traffic Segmentation with North-South VRF (DC) Gateways

As part of the Fabric VRFs configuration, you can create IPv4 and IPv6 subnets, which are atomic objects in the Fabric data plane to associate to the VRF instances in order to implement distributed traffic segmentation.

In particular, Fabric leaf switches use subnet objects for management purposes to represent groups of directly connected hosts with a fabric wide scope across the VXLAN interconnect. Netvisor ONE also uses them to program subnet routes into the hardware to send Layer 3 packets corresponding to unresolved adjacencies to the software so that next-hop resolution through ARP requests can be performed. When a host responds to the ARP request(s), more specific Layer 2 and Layer 3 host entries are configured in the hardware so that end-to-end forwarding ensues.

In addition, Netvisor ONE supports the anycast gateway routing function for the Fabric VRFs to enable distributed first-hop routing, redundancy and mobility. This capability uses a dedicated virtual MAC address, called the anycast gateway MAC address, which gets associated with configurable anycast gateway IP addresses as part of the subnet object configuration.

The default MAC address for the anycast gateway function is 64:0e:94:40:00:02. It can be displayed with the `fabric-anycast-mac-show` command. If necessary, you can also modify it using the `fabric-anycast-mac-modify` command. Furthermore, as a key VRF-aware service, Netvisor ONE supports end host address assignment through the DHCP packet relay function for up to two DHCP servers.

About IGMP Snooping Support with VXLAN

Starting with version 3.1.1, Netvisor ONE adds support for selective replication of (instead of always flooding) multicast traffic based on IGMP join messages received over ports and tunnels.

With this enhancement multicast traffic belonging to a group is forwarded only to member ports and relevant remote VTEPs.

This feature uses the head-end replication (HER) model for replication of packets to be sent over to remote VTEPs. Netvisor ONE also forwards IGMP join messages over VXLAN tunnels, for other fabric switches to see those messages and as a consequence build the group membership list accordingly.

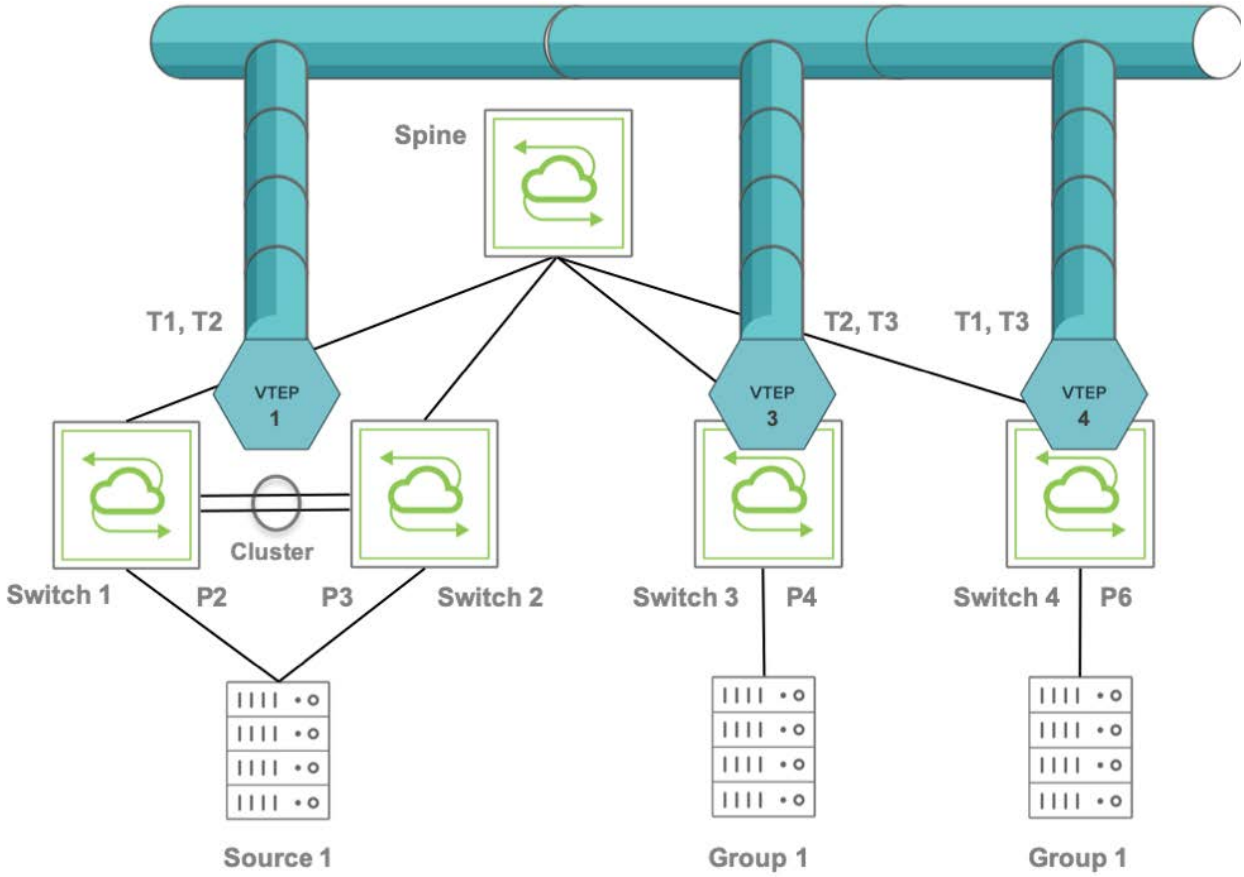


Figure 8-12: Example of Fabric Topology with Multicast Distribution

The topology in the ***Figure 8-12*** includes Switch 1 and Switch 2 configured as a cluster pair that uses a common virtual IP address (VIP) as the source for two tunnels T1 and T2.

The cluster pair, Switch 1 and Switch 2, appears as one logical switch with a common VXLAN endpoint VTEP1. Two tunnels, T1 and T2, are created with the same local VIP toward the other two end points, VTEP3 and VTEP 4.

The spine switch hashes the traffic from Switch 3 or Switch 4 to the cluster pair, load balancing between Switch 1 and Switch 2.

The above topology includes Switches 1, 2, 3, and 4 with ports 2,3,4, and 6, as part of the same broadcast domain (say, VXLAN ID 10).

Initially, port 4 sends an IGMP join messages for the G1 multicast group. Hence Switch 3 adds local port 4 (P4) as an IGMP member for Layer 2 multicast group G1.

In addition, Switch 3 floods IGMP packets to the remote VTEPs 1 and 4. Hence the remote switches associated with those VTEPs receive IGMP packets and add G1 as Layer 2 multicast group.

On VTEP1's cluster the flooded IGMP join message is also forwarded (synced) to the cluster peer through the out-of-band channel so that both cluster peers can see and program the same Layer 2 multicast group entry.

Next, P6 joins group G1 too, and the IGMP join packet is flooded to the remote VTEPs 1 and 3.

Now the group membership is:

- On both Switch 1 and Switch 2, VTEP 3 and 4
- On Switch 3, local port P4 and VTEP4
- On Switch 4, local port P6 and VTEP 3

Then, if source S1 sends multicast traffic on P3, that traffic matches the MAC address corresponding to G1's DMAC on VXLAN ID 10 in the Layer 2 table therefore the hardware bridges that traffic to the remote VTEPs 3 and 4. After receiving it, Switch 3 and Switch 4 check the Layer 2 table and forward the traffic to local receivers on P4 on Switch 3 and on P6 on Switch 4.

Refer to the *Configuring IGMP Snooping with VXLAN* section for the configuration details.

About Distributed Multicast Forwarding with Fabric VRFs

> **Note**: This feature is supported only on certain switch models as described in the section Configuring Multicast Fabric VRFs below.

By leveraging the distributed control plane of the Adaptive Cloud Fabric, Pluribus has extended unicast Fabric VRFs (as described above) to also include multicast routing support.

This enhancement is referred to as *Multicast Fabric VRFs with distributed routing support*.

It leverages Pluribus fabric's native capabilities to route multicast traffic without employing a multicast routing protocol (such as PIM) in the underlay or overlay networks.

In particular, Multicast Fabric VRFs are a *logical extension* of the IGMP Snooping feature described in the previous section.

That is because Multicast Fabric VRFs use techniques analogous to IGMP Snooping to handle and selectively forward multicast traffic.

In particular, with Multicast Fabric VRFs, the multicast forwarding logic is enhanced to also handle inter-VLAN forwarding and replication.

These are the lookup steps that are implemented.

First, multicast traffic may need to be locally bridged and/or remotely forwarded to multicast receivers in the same VXLAN ID-mapped VLAN on the other overlay nodes.

In addition, multicast receivers may be located locally in one or more distinct VLANs and hence multicast traffic may need to be routed and replicated to those VLANs as well.

Pluribus leverages Layer 2 hardware table entries to point to local ports and tunnels (represented by logical ports, as seen in the previous section). Those entries point to a loopback trunk to implement a *second pass lookup*. This pass corresponds to a hardware (*, G, VLAN) L3 multicast lookup for any of the local receiver ports located in different output VLANs.

Furthermore, once a multicast packet reaches a remote VTEP in the overlay network, it is decapsulated and then L3 multicast entries route the traffic locally on that node. The decision to which VXLAN ID(s) to replicate the decapsulated packets is based on the IGMP snooping logic (which knows where all receivers attached to the node are).

Refer to the Configuring Multicast Fabric VRFs section for more details on how to enable the feature and to configure the appropriate loopback trunk.

About Pluribus Open Networking Multi-site Fabric

Data Center Interconnect (DCI) is the process of connecting two or more geographically distributed data center locations (also known as *multi-site fabric network designs*).

It is employed to ensure that data is exchanged consistently and in a timely manner among different locations for redundancy, high availability and load sharing purposes, to support a number of important design requirements that include: service resiliency (i.e., fault tolerance), performance and scale, disaster recovery, operational efficiency, local country regulations.

A multi-site Adaptive Cloud Fabric design is Pluribus' best-in-class standards-based solution to address customer requirements for multi-site data center connectivity. It leverages the VXLAN-based feature set to be able to extend across a generic IP transport core network, as depicted in the ***Figure 8-13*** below.

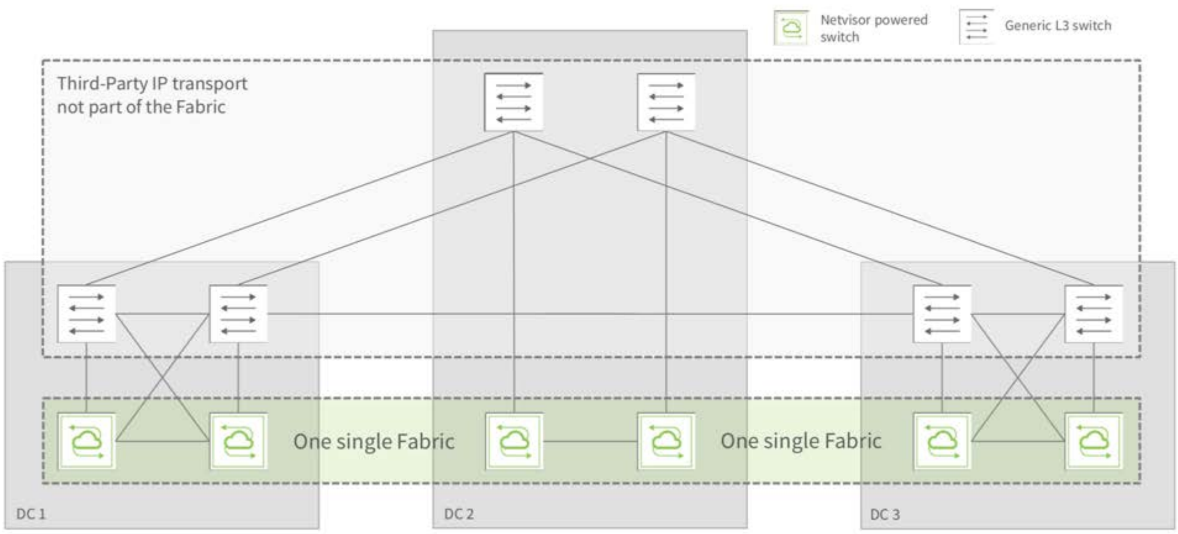


Figure 8-13: Multisite Fabric Topology Over an Agnostic IP-routed Core

Thanks to VXLAN, it boasts a number of very desirable characteristics: it's simple, very high performance, highly redundant and can scale up to support dozens of sites, while providing high availability (HA) with ~200 ms failover times.

It's flexible, multi-tenant, interoperable and topology agnostic: it works with any L3 core/underlay and uses sophisticated VXLAN-based Layer 2 extension and pseudo-wire technologies to achieve transparent inter-site communication with end-point tracking.

This enables the support for important use cases such as *VM mobility* for business continuity and geographical load sharing. In addition, it natively supports end-to-end visibility of client-server application traffic as well as of server-to-server communication flows.

In order to implement an Open DCI architecture that can scale to a multi-site design it is important to bring together all the foundational technologies discussed in the previous sections:

- Adaptive Cloud Fabric's distributed control plane
- Switch clusters with vLAGs
- Fabric traffic optimizations
- Virtual Networks (vNETs)-based network provisioning
- Analytics collection

Pluribus provides support for different underlay architectures as well as for different routing options (centralized or distributed) for the fabric overlay.

Distributed forwarding with *Fabric VRFs* represents the most scalable multi-site DC design option (with both unicast and multicast support), whose configuration steps are detailed in the following sections.

Guidelines and Limitations

For most fabric designs the general recommendation is to implement a Layer 3 underlay for scalability and ease of interoperability: BGP and OSPF are solid and mature protocols that in a great number of scenarios offer the most effective way to design and run a fabric.

Whenever possible, for redundancy, scalability and optimal trunk load splitting it is recommended to allocate at least 50% extra bandwidth to VXLAN loopback trunks in excess of the peak aggregate bandwidth expected to be used by all the fabric traffic when recirculated.

These are some common limitations to consider when planning and configuring VXLAN deployments:

1. For VXLAN centralized routingdesigns up to 32 vRouters are supported (the actual maximum number is platform-dependent).
2. For Fabric VRF distributed designs the number of supported VRFs is in in the order of thousands, depending on the specific switch model's hardware capacity.

Configuring the VXLAN Underlay Network

Configuring the underlay network involves the configuration of (at least) the following base features:

- Layer 2
- Layer 3
- The fabric
- Clustering
- vLAGs
- Optionally (even though it's highly recommended), traffic analytics

Readers are referred to the respective configuration sections of each feature for more details.

In addition, on Pluribus switches jumbo frame support can be enabled on the appropriate interfaces to accept frames with an MTU larger than 1500 bytes (namely, with a 'jumbo' size). Refer to the *Enabling Jumbo Frame Support* section earlier in this guide for details.

This guarantees that all standard maximum size packets to be transmitted in the overlay network are not dropped by the underlay.

Moreover, starting from release 2.5.0, Netvisor ONE enforces a routing MTU size in hardware, which can be set with the `mtu` option when adding vRouter interfaces (see examples below).

Therefore, in order to avoid large frames to be dropped during Layer 3 forwarding or during encapsulation, in addition to enabling jumbo frames on physical interfaces, it is also important to *configure routed interfaces with the proper MTU settings* (typically between 1580 and 9398 bytes).

Changes to interface attributes (such as the MTU) are recommended to be applied in the initial phases of the underlay configuration. Moreover, changing the MTU on certain higher-level entities such as trunk ports may require more specific commands (such as `trunk-modify` instead of the basic `port-config-modify` command).

Configuring the Overlay: VTEP Interconnections and VNIs

VTEPs can be configured as individual vRouter interfaces. However, as discussed in the *About VTEP High Availability* section, VTEPs are more commonly configured on switch pairs running VRRP to support redundant logical VIPs for VXLAN termination.

In this latter case, the first step is to create a VIP instead of a regular interface.

Both cases are exemplified below (a. and b.) in the list of steps required to set up the overlay:

1. First configure the underlay's vRouter interfaces, with the proper MTU:

   a) Create a vRouter and add a vRouter interface for each VTEP:

   ```
   CLI (network-admin@switch) > vrouter-create name <vr-name> vnet <vnet-name> router-type hardware hw-vrrp-id <id>
   ```

   ```
   CLI (network-admin@switch) > vrouter-interface-add vrouter-name <vr-name> ip <network/netmask> vlan <y> mtu <mtu>
   ```

   b) For VTEP HA instead add a vRouter interface using VRRP:

   ```
   CLI (network-admin@switch) > vrouter-interface-add vrouter-name <vr-name> ip <network/netmask> vlan <y> vrrp-id <id> vrrp-primary <ethz.y> mtu <mtu>
   ```

   `<mtu>` can be set for example to 1580 bytes (or more).

2. Once the VTEPs are created, configure the VTEP connections (also referred to as 'tunnels') from sources to destinations. On non-redundant switches, the tunnel is created with scope `local` whereas on redundant switches the tunnel is created with scope `cluster`:

   ```
   CLI (network-admin@switch) > tunnel-create name <tunnel-name> local-ip <ip1> remote-ip <ip2> scope local vrouter-name <vr-name>
   ```

   ```
   CLI (network-admin@switch) > tunnel-create name <tunnel-name> local-ip <vip1> remote-ip <vip2> scope cluster vrouter-name <vr-name> peer-vrouter-name <peer-vr-name>
   ```

3. Then create the mappings between VNIs and VLANs on the respective switches:

   ```
   CLI (network-admin@switch) > vlan-create scope <scope> id <vlan-id> vxlan <vnid>
   ```

> **Note:** A VLAN can be associated to a VNI when created on a VTEP HA pair with the

> `vlan-create scope cluster id <vlan-id> vxlan <vnid>` command. Also, the mappings can be set up also with the `vlan-modify id <vlan-id> vxlan <vnid>` command *after VLAN creation*.

Then, to add ports to a VLAN created with `vlan-create` command, use the `vlan-port-add` command, for example:

```
CLI (network-admin@switch) > vlan-port-add vlan-id <vlan-id>
ports <port numbers>
```

To delete a VLAN with its mapping, use the `vlan-delete` command.

Lastly, to display the information about a VLAN, for example to verify a VNI mapping and the list of ports added to it, use the `vlan-show` command:

```
CLI (network-admin@switch) > vlan-show id 70 format id, type,
vxlan, scope, description, ports, untagged-ports layout
vertical

id:  70
type:     public
vxlan:    70000
scope:    cluster
description:   vlan-70
ports:    0-2, 5-48, 50-52, 54-56, 63-70,272-273, 275-276,
278-280, 397
untagged-ports:  none
```

4. Add the required VNI mappings to the VXLAN connections:

   ```
   CLI (network-admin@switch) > tunnel-vxlan-add name <tunnel-
   name> vxlan <vnid>
   ```

5. For monitoring VXLAN specific states and statistics, use the following commands:

`vlan-show`	Displays the VXLAN ID associated with the VLAN ID.
`tunnel-show`	Displays the configured tunnel and the state.
`trunk-show`	Displays the port used for BUM traffic re-circulation.
`port-stats-show`	Displays statistics for each port.
`tunnel-stats-show`	Displays statistics for each tunnel.
`vxlan-stats-show`	Displays statistics for each VXLAN ID.

> **Note**: The above configuration model is called ‘manual VXLAN tunnel creation’ and is

preferred for example when the user needs to have maximum control and granularity of configuration. On the other hand, when more automation is needed, an alternate configuration model is available and is described below in the *Configuring VTEP Objects with Automatic Fabric Connections* section.

Configuring the VXLAN Loopback Trunk

In order to perform routing on the overlay and to replicate Layer 2 broadcast, unknown unicast and multicast (BUM) traffic over multiple VXLAN tunnels on Pluribus switches, you must add ports to a `vxlan-loopback-trunk` using the following command:

```
CLI (network-admin@switch) > trunk-modify name vxlan-loopback-trunk ports <list of ports> jumbo
```

Where `<list of ports>` may vary based on the hardware architecture of the switch (on most models it is likely to be a list of front panel ports set aside for this use.)

Check the data sheet of your switch model to verify the number of internal ports as well as front-panel ports available and their respective speeds. Depending on the expected peak amount of routed and BUM traffic, you can use either N x 10 GbE ports or two (or more) 40 GbE ports (or even 100 GbE).

The above command also prints out the following informational message:

```
!!!! Ports updated on vxlan-loopback-trunk. Ports added only support vxlan recirculation. Any features configured on these ports may not work. Please update the necessary config. Any ports removed need necessary adjustment on autoneg,jumbo,etc !!!
```

If you create a VLAN with associated VXLAN ID when `vxlan-loopback-trunk` is without any active ports, you will get this warning message:

```
CLI (network-admin@switch) > vlan-create id 100 scope local vxlan 1001000

!!!! Vlan 100 created, but there are no ports configured in vxlan-loopback-trunk. vxlan forwarding may not function correctly. !!!!
```

Single-pass VXLAN Forwarding

Starting from Netvisor ONE release 6.0.0, on NRU03 and NRU-S0301 platforms and on the Dell S5200 Series, more advanced hardware capabilities enable the switches to perform routing in and out of tunnels (RIOT) in a single pass (that is, without requiring the loopback trunk).

> **Note**: On the Dell S4100 series single pass RIOT is supported for distributed VXLAN routing with Unicast Fabric VRFs, however single pass RIOT is not supported for centralized VXLAN routing on a DC Gateway border leaf.

On the supported platforms, this capability can be enabled with the command:

```
CLI (network-admin@switch) > system settings-modify no-single-
```

```
pass-riot|single-pass-riot
```

The default setting is `no-single-pass-riot`. A reboot is required for the configuration change to take effect and an appropriate message is displayed to remind the user of this requirement.

Furthermore on all hardware platforms, starting from Netvisor ONE release 6.0.0, a new global command is introduced to enable single-pass replication (i.e., flooding) of Layer 2 broadcast, unknown unicast and multicast (BUM) traffic over multiple VXLAN tunnels: `system-settings-modify no-single-pass-flood|single-pass-flood`.

By default, `single-pass-flood` mode is disabled. A reboot is required for the configuration change to take effect and an appropriate message is displayed to remind the user of this requirement.

For example:

```
CLI (network-admin@switch2) > system-settings-modify single-
pass-flood
!!!! Please reboot the system for the new single-pass-flood
setting to take effect correctly !!!!

CLI (network-admin@switch2) > system-settings-show format
single-pass-flood
single-pass-flood:  on

CLI (network-admin@switch2) > switch-reboot
```

After the reboot, the `tunnel-show flood-nexthop` command can be used to display the path that is selected as next hop for flooded traffic out of the available ECMP paths, when `single-pass-flood` is enabled:

```
CLI (network-admin@switch2) > tunnel-show flood-nexthop

switch   name   flood-nh-ip  flood-nh-vlan  flood-nh-port  flood-nh-mac        flood-nh-egress-
id
-------  -----  -----------  -------------  -------------  ----------------  ------------------
switch1
switch2 tnl2   12.12.12.7    4088            70           66:0e:94:1a:e3:d3    100008
switch2 tnl1   10.10.10.7    4092            69           66:0e:94:1a:e3:d3    100007
```

In the above output `switch1` has no info as that node is not in `single-pass-flood` mode.

> **Note** that, due to a hardware limitation in single-pass mode, ECMP load balancing of flooded traffic is only performed on a per-tunnel basis. In other words, flooded traffic for a specific tunnel will always take the same active ECMP path, which is selected at random out of the available ECMP next hops.

The `port-stats-show` command can be used to display the traffic statistics on the loopback ports and on tunnel ports:

```
CLI (network-admin@switch2) > port-stats-show
```

```
time  port description ibits iUpkts iBpkts iMpkts iCongDrops ierrs obits oUpkts oBpkts oMpkts oCongDrops 
oerrs mtu-errs
------ ---- ----------- ----- ------ ------ ------ ---------- ----- ----- ------ ------ ------ 
---------- ----- --------
18:28:56 1                0     0      0      0      0          0     0     0      0      0      0

18:28:56 49               110K   0      85     58     0          0     174K  0      104    127    0 0
 0
18:28:56 69               41.8K  0      0      10     0          0     119K  85     0      11     0 0
 0
```

In this example, port 1 is the VXLAN loopback port (with a zero packet count, as the switch is in `single-pass-flood` mode), while port 49 is the input port where the broadcast packets are received and port 69 is the tunnel output port where the encapsulated flooded packets are sent to. The same packet count (along with the corresponding byte count) is displayed in the `HER-pkts` and `HER-bytes` fields of `tunnel-stats-show`:

```
CLI (network-admin@switch2) > tunnel-stats-show format 
switch,HER-pkts,HER-bytes

switch          HER-pkts HER-bytes
------------- -------- ---------
switch2        85       98K
```

Starting from Netvisor ONE release 6.0.1, analogously to the BUM traffic replication case described above, support for single-pass Layer 2 forwarding of *known* multicast traffic is introduced.

IGMP snooping is used to determine the output interfaces corresponding to the multicast receivers as described in the section titled Configuring IGMP Snooping with VXLAN (refer to that section for configuration details). A new parameter is introduced to perform single-pass L2 forwarding for this multicast traffic with *known* receivers:

```
CLI (network-admin@switch) > system-settings-modify no-single-
pass-l2-known-multicast | single-pass-l2-known-multicast
```

The `no-single-pass-l2-known-multicast` is the default setting. A reboot is required for a change in setting to take effect, as reminded by the message shown below:

```
CLI (network-admin@switch) > system-settings-modify single-
pass-l2-known-multicast
!!!! Please reboot the system for the new single-pass-l2-
known-multicast setting to take effect correctly !!!!

CLI (network-admin@switch) > system-settings-show format 
single-pass-l2-known-multicast
single-pass-l2-known-multicast:  on
```

Note: that as in the BUM forwarding case, due to a hardware limitation in single-pass mode, ECMP load balancing of multicast traffic is only performed on a per-tunnel basis. In other words, forwarded multicast traffic for a specific tunnel will always take the same active ECMP path, which is selected at random out of the available ECMP next hops.

Note: On capable devices, single-pass features can be used to avoid consuming front panel ports for the recirculation function.

Configuring VLAN 1 with VXLAN

VLAN 1 is also known as the *default VLAN*, as it is assigned by default to switch ports. It is also used by default on Pluribus switches to transport fabric-specific traffic.

In general, it is a common best practice to not use VLAN 1 network-wide to carry user traffic, especially to avoid potential misconfigurations due to user error.

However, in certain cases, it is required to use and transport VLAN 1 over a VXLAN-based fabric and hence it needs to be associated with a VNI. Before Netvisor ONE release 6.0.0 attempting to map VLAN 1 to a VNI would be rejected, like so:

```
CLI (network-admin@switch) > vlan-modify id 1 vxlan 123
vlan-modify: Vlan id 1 is not a valid vlan, or is a reserved
vlan
```

Starting from release 6.0.0, if the fabric VLAN is modified to a value different from 1, it is then possible to map VLAN 1 to a VNI like so:

```
CLI (network-admin@switch) > fabric-local-modify vlan 100

CLI (network-admin@switch) >  vlan-modify id 1 vxlan 123
vlan-modify: ports 13,25-26,69-Disabling MAC Address
Learning72 are tagged in vlan 20, but untagged in vlan 1 with
vxlan not allowed, Adjust the port membership and retry the
vxlan configuration
```

Note that the `fabric-local-modify` command is—as the name implies—*local to each node* and hence it needs to be executed on all the nodes that are part of the fabric (for example, with the `switch *` command prefix). Moreover, although `fabric-local-modify` was available even before release 6.0.0, the VLAN 1 to VNI mapping was not allowed until version 6.0.0.

Also note that, as shown above, if the *untagged port membership* of VLAN 1 comprises any ports, due to a hardware limitation, the `vlan-modify id 1 vxlan <value>` command will still fail. You need to make sure there are no ports using VLAN 1 as untagged VLAN in order for the command to succeed:

```
CLI (network-admin@switch) >  vlan-modify id 1 vxlan 123
!!!! Vlan has vxlan, but there are no ports configured in
vxlan-loopback-trunk. vxlan forwarding may not function
correctly. !!!!
```

The printed message means that VLAN 1 was successfully associated to a VXLAN ID. As explained in the previous section, in order for VXLAN forwarding to be fully functional, you also need to make sure that ports are added to the `vxlan-loopback-trunk`.

Once VLAN 1 is mapped to a VNI, you cannot change the fabric VLAN back to 1, as that would create a conflict:

```
CLI (network-admin@switch) > fabric-local-modify vlan 1
fabric-local-modify: vlan 1 has VXLAN 123, unconfigure and
```

```
retry
```

However, you may at some point decide to unmap VLAN 1 from the associated VNI (in other words, “unconfigure” it as suggested in the message above), by using the command:

```
CLI (network-admin@switch) > vlan-modify id 1 vxlan 0
```

As explained in the command help, as shown below, the VNI value 0 is used to *unconfigure*, that is, to remove a VLAN/VNI mapping:

```
CLI (network-admin@switch) > vlan-modify id 1 vxlan
```

`vlan-modify`	modify a VLAN
`id 0..4095`	VLAN ID
between 1 and 4 of the following options:	
`description description-string`	VLAN description
`vxlan 0..16777215`	VXLAN identifier for tunnel, **value 0 indicates unconfigure vxlan**
`replicators vtep-group name | none`	Replicator Group
`vnet vnet name`	VNET for this VLAN
`public-vlan 0..4095`	Public VLAN for VNET VLAN

Checking VXLAN Recirculation's L2 and L3 Entries

As discussed earlier, when implementing RIOT at least a recirculation pass is used. That requires that Layer 2 and Layer 3 entries be programmed appropriately to point to the loopback trunk.

With the `l2-table-show` command it's possible to verify that a specific VNI-mapped VLAN is configured to point to the VXLAN loopback trunk to forward and then encapsulate the upstream traffic at the ingress VTEP.

```
CLI (network-admin@switch) > l2-table-show vlan 200

mac:                    00:00:5e:00:01:0a
vlan:                   200
vxlan                   10000
ip:                     2.2.2.2
ports:                  69
state:                  active,static,vxlan-loopback,router
hostname:               Spine1
peer-intf:              host-1
peer-state:
peer-owner-state:
status:
migrate:
```

When VTEP HA is implemented, the same command can be used to show that the VLAN is configured with VRRP and that it points to the VLAN loopback trunk. For example:

```
CLI (network-admin@Spine1) > l2-table-show vlan 200

mac:                      00:00:5e:b9:01:b0
vlan:                     200
vxlan                     10000
ip:                       2.2.2.2
ports:                    69
state:                    active,static,vxlan-loopback,router,vrrp
hostname:                 Spine1
peer-intf:                            host-1
peer-state:               active,vrrp,vxlan-loopback
peer-owner-state:
status:
migrate:
```

Similarly, in order to decapsulate and router the VXLAN traffic originated from a source VTEP, at the destination VTEP at least two passes are required. Therefore, a Layer 3 entry is programmed to point to the `vxlan-loopback-trunk`.

The `l3-table-show` command can be used to verify that the hardware state is properly set with the `vxlan-loopback` flag:

```
CLI (network-admin@Spine4) > l3-table-show ip 3.3.3.2 format
```

```
all

mac:                  00:00:c0:00:07:75
ip:                   3.3.3.2
vlan:                 200
public-vlan:          200
vxlan:                10000
rt-if:                eth5.200
state:                active,vxlan-loopback
egress-id:            100030
create-time:          16:46:20
last-seen:            17:25:09
hit:                  22
tunnel:               Spine1_Spine4
```

Showing VXLAN Trunk Replication Counters

It is possible to display statistics (incoming and outgoing bytes, packets, etc.) for VXLAN connections (simply called tunnels) that also include the amount of head-end replication (HER) applied to the VXLAN traffic.

Currently, Netvisor ONE uses `vxlan-loopback-trunk` port stats counters for HER replication statistics; therefore, they are cumulative not granular, but may provide a useful tool to measure the amount of `vxlan-loopback-trunk` bandwidth required in real world conditions.

The `tunnel-stats-show` command can be used to output all the statistics including the number of head-end replicated packets and the number of head-end replicated bytes. It can also be executed periodically with the `show-interval seconds-interval` option as shown in the example below:

```
CLI (network-admin@Spine1) > tunnel-stats-show show-interval 1
format all
```

```
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:03 pip         8.41K     9        3.44K     0         0                4.37M    0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:04 pip         0         0        1         0         0                1        0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:05 pip         1         0        1         0         0                1        0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:06 pip         0         0        1         0         0                1        0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter   ...   HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:07 pip         0         0        2         0         0                57.1K    0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:08 pip         0         0        1         0         0                76.2K    0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:10 pip         0         0        1         0         0                75.6K    0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:11 pip         0         0        1         0         0                76.6K    0
time     tunnel-name sw-inpkts sw-opkts sw-idrops sw-odrops counter         HER-pkts HER-bytes
-------- ----------- --------- -------- --------- --------- -------         -------- ---------
11:28:12 pip         0         0        1         0         0                67.0K    0
```

Figure 8-14: Wide Multi-Column Output of VXLAN Head End Replication Counters

Displaying ECMP Load Balancing Info for VXLAN

As discussed in the earlier sections, equal-cost multi-path (ECMP) load balancing defines a routing strategy in which next-hop packet forwarding to a single destination can occur over multiple paths.

In case of VTEP interconnections, it is possible to verify that multiple next hops are available with the `tunnel-show` command.

It is also possible to verify that ECMP is applied in hardware (provided multiple next hops exist) and to display the selection of the next hops by checking the RIB table with the `vrouter-rib-routes-show` command.

For example, the user has configured a tunnel called `leaf1toleaf2` with a local IP address `22.3.11.1` and a remote IP address `32.4.11.1`. The network design provides *two next hops* to route the VXLAN traffic from the local VTEP to the remote one: `192.178.0.6` and `192.178.0.2`.

The `tunnel-show` and `vrouter-rib-routes-show` commands can be used to display the tunnel's specific next hops as well as the route info for the remote end point (`32.4.11.0/24`) in the RIB table, as shown below:

```
CLI (network-admin@leaf1) > tunnel-show name leaf1toleaf2
ecmp-nexthops layout vertical

scope:              local
name:               leaf1toleaf2
type:               vxlan
vrouter-name:       scorpius-vxlan-01
local-ip:           22.3.11.1
remote-ip:          32.4.11.1
router-if:          eth0.3
next-hop:           192.178.0.6
next-hop-mac:       66:0e:94:f7:31:f0
nexthop-vlan:       4091
active:             yes
state:              ok
bfd:                disabled
bfd-state:          not-replicator-vtep
route-info:         17.60.11.0/30
ports:              49
auto-tunnel:        static
scope:              local
name:               leaf1toleaf2
type:               vxlan
vrouter-name:       scorpius-vxlan-01
local-ip:           17.60.13.1
remote-ip:          17.60.11.1
router-if:          eth0.3
next-hop:           192.178.0.2
next-hop-mac:       66:0e:94:b7:95:c3
```

```
nexthop-vlan:       4092
active:             yes
state:              ok
bfd:                disabled
bfd-state:           not-replicator-vtep
route-info:          17.60.11.0/30
ports:              272
auto-tunnel:         static

CLI (network-admin@leaf1) > vrouter-rib-routes-show ip
32.4.11.0

vrid ip           prelen number-of-nexthops nexthop      flags      vlan  intf_ip      intf-
id
---- ----------   ------ ------------------ ----------- ---------- ----- -----------
-------
0    17.60.11.0  30     2                   192.178.0.6 ECMP,in-hw 4091  192.178.0.5  1
0    17.60.11.0  30     2                   192.178.0.2 ECMP,in-hw 4092  192.178.0.1  0
```

Configuring VTEP Objects with Automatic Fabric Connections

Based on the command sequence in the earlier section, *Configuring the Overlay: VTEP Interconnections and VNIs*, configuring a series of unidirectional end-point interconnections (even in a simple triangular topology) requires the network administrator to manually issue a long list of explicit (and hence tedious) `tunnel-create` commands.

Therefore, starting from release 2.6.0, Pluribus has introduced an additional user-friendly operational simplification element called a *logical VTEP configuration object* that leverages the intelligence of the fabric's distributed control plane to automate the aforementioned tedious connection setup process.

With this configuration paradigm, instead of having to create individual unidirectional connections between the end points (i.e., the `tunnel-create` model), a user can simply create a single VTEP object per endpoint with the `vtep-create` command and then map the required VXLAN identifiers to it.

This in turn triggers the *automatic creation* of all the required VXLAN connections in both directions between endpoints, yielding a *significant amount of configuration and time savings*.

An example of VTEP object configuration syntax is displayed below:

```
CLI (network-admin@switch) > vtep-create name <vtep-object-name> vrouter-name <vrouter name> ip <primary IP> virtual-ip <vip> [location <switch name>]

CLI (network-admin@switch) > vtep-vxlan-add name <vtep-object-name> vxlan <vnid1>

CLI (network-admin@switch) > vtep-vxlan-add name <vtep-object-name> vxlan <vnid2>

CLI (network-admin@switch) > vtep-vxlan-add name <vtep-object-name> vxlan <vnid3>
```

And so on...

VTEP objects can also be displayed or deleted with the `vtep-show` and `vtep-delete` commands, respectively.

Auto-VXLAN

Starting from Netvisor ONE release 6.0.0 the `auto-vxlan` parameter is supported as an option of the VLAN creation process and can be used to automate the `vtep-vxlan-add` operations.

The `auto-vxlan` parameter can be used either in combination with an *explicit VNI* *value* or implicitly *without specifying it*. In both cases any created VLAN/VNI mapping is automatically added to all the existing VTEP objects. Additionally, in the latter case, the VNI value is automatically picked and assigned out of a *predefined range*.

Therefore, to automatically assign a certain *user-defined* VLAN/VNI mapping to all VTEP objects in the fabric, you can use the following command:

```
CLI (network-admin@switch) > vlan-create id 1234 scope fabric
vxlan 5001234 auto-vxlan
```

If you want the software to automatically pick and assign the VNI too, you can simply enter the shorter command below, which requires the `scope` to be set to `fabric` (as the VNI assignment can only be fabric-wide):

```
CLI (network-admin@switch) > vlan-create id 1234 scope fabric
auto-vxlan
```

The above `vlan-create` commands with `auto-vxlan` automatically configure the following (assuming there are 3 VTEPs in the fabric, VTEP1 through VTEP3):

```
CLI (network-admin@switch) > vtep-vxlan-add name VTEP1 vxlan
5001234

CLI (network-admin@switch) > vtep-vxlan-add name VTEP2 vxlan
5001234

CLI (network-admin@switch) > vtep-vxlan-add name VTEP3 vxlan
5001234
```

where 5001234 is the VNI value either entered explicitly by the user or automatically selected from the `vtep-auto-vxlan` range.

The range used for automatic VNI assignment can be controlled and modified, if needed, with the `vtep-auto-vxlan-show` and `vtep-auto-vxlan-modify` commands.

> **Note:** You can use the `vlan-create` command with `auto-vxlan` in `local` and `cluster` scope too *provided the VNI is explicitly specified*. If it's not, an error message is printed:

```
CLI (network-admin@switch) > vlan-create id 1000 scope cluster
auto-vxlan
vlan-create: auto-vxlan only allowed for fabric scope

CLI (network-admin@switch) > vlan-create id 1000 scope local
auto-vxlan
vlan-create: auto-vxlan only allowed for fabric scope
```

Also starting from Netvisor ONE release 6.0.0 the `vlan-show` command output displays when `auto-vxlan` is used:

```
CLI (network-admin@switch) > vlan-show id 1234 format id,
type, vxlan, auto-vxlan, scope, description, active, stats,
```

```
ports

id   type    vxlan    auto-vxlan  scope  description  active  stats  ports
---- ------  -------  ----------  -----  -----------  ------  -----  -------------
1234 public  5001234  yes         local  vlan-1234    yes     no     0-48,50-52
```

If an associated VNI value needs to be changed after a VLAN has been created using the `auto-vxlan` option, the `vlan-modify` command can be used for that purpose like so:

```
CLI (network-admin@switch) > vlan-modify id 1234 vxlan 4001234
```

For VLANs created with the `auto-vxlan` option, the new VNI will replace the old VNI in the VTEP connections.

Starting from Netvisor ONE release 6.0.0, when a VLAN is deleted, if it was previously created with the `auto-vxlan` option, the VLAN/VNI mapping will be removed from all the VTEP objects automatically.

In the example of ***Figure 8-8*** above, the following commands can be used to create three VTEP objects on three nodes:

```
CLI (network-admin@Switch1) > vtep-create name VTEP1 vrouter-
name vr1 ip 1.1.1.1 location Switch1

CLI (network-admin@Switch2) > vtep-create name VTEP2 vrouter-
name vr2 ip 2.2.2.2 location Switch2

CLI (network-admin@Switch3) > vtep-create name VTEP3 vrouter-
name vr3 ip 3.3.3.3 location Switch3

CLI (network-admin@Switch1) > vlan-create id 10 scope fabric
vxlan 10010 auto-vxlan
```

The command sequence above automatically creates bidirectional VXLAN connections between the three nodes and also automatically adds VNI 10010 to all of them, thanks to the `auto-vxlan` keyword, as shown in the following outputs:

```
CLI (network-admin@Switch1) > tunnel-vxlan-show

switch     name                          vxlan
---------  --------------------------    -----
Switch1    auto-tunnel-1.1.1.1_2.2.2.2   10010
Switch1    auto-tunnel-1.1.1.1_3.3.3.3   10010
Switch2    auto-tunnel-2.2.2.2_1.1.1.1   10010
Switch2    auto-tunnel-2.2.2.2_3.3.3.3   10010
Switch3    auto-tunnel-3.3.3.3_1.1.1.1   10010
Switch3    auto-tunnel-3.3.3.3_2.2.2.2   10010
```

```
CLI (network-admin@Switch1) > vtep-vxlan-show

name  vxlan
----- -----
VTEP1 10010
VTEP2 10010
VTEP3 10010
```

Inter-fabric VTEP Connections

Starting from Netvisor ONE release 6.0.0, the automatic VTEP object creation functionality is further extended to include an additional parameter that can be used to connect a VTEP in one fabric instance to another one in a different fabric instance. In other words, this new capability enables *inter-fabric VTEP connections*.

As part of the VTEP object creation, a new reserved location keyword, called `host-external`, is introduced to enable inter-fabric connectivity, as shown in the command output below:

```
CLI (network-admin@switch1) > vtep-create name ext-VTEP location
     host-external
     switch1
     switch2
```

Specifying the `host-external` keyword in the command identifies an external VTEP, whose corresponding *unique IP address* should then be specified as part of the command like so:

```
CLI (network-admin@switch1) > vtep-create name FAB2-VTEP1
location host-external ip 20.1.1.1 description
"RemoteFabricName:FAB2, SwitchName: FAB2-switch2"
```

> **Note:** The `virtual-ip` option is not supported with external VTEPs (it's meant to be used only with regular VTEPs). For redundancy, the ip option can simply point to the VRRP VIP (virtual IP) of the external VTEP.

Also note that a good practice (which is not enforced in the CLI but is recommended) is to name external VTEPs in a user-friendly and precise way, for example, with the following naming structure: `<fabric-name>-vtep-name`, or with any other suitable structure that allows the naming to *unequivocally and uniquely identify a specific VTEP*.

As shown in the example above, a `description` field is also added to the `vtep-create` command, which can be used to store additional details about the precise remote VTEP location including switch name, fabric name, switch vendor, etc.

External VTEPs can be displayed along with regular VTEPs in the `vtep-show` command like so:

```
CLI (network-admin@switch1) > vtep-show format all name FAB2-
VTEP1

scope  name       location      vrouter-name ip         virtual-ip description
------ ---------- ------------- ------------ ---------- ---------- -----------
fabric VTEP1      switch1       vr1          190.11.1.2 190.11.1.1
fabric VTEP2      switch2       vr2          190.11.1.3 190.11.1.1
fabric VTEP3      switch3       vr3          190.12.1.3 190.12.1.1
fabric VTEP4      switch4       vr4          190.12.1.2 190.12.1.1
fabric FAB2-VTEP1 host-external              20.1.1.1
```

```
RemoteFabricName: FAB2, SwitchName: FAB2-switch2
```

Hub-and-spoke VXLAN Connectivity

Starting from Netvisor ONE release 6.0.1, a new keyword is introduced to support a *hub-and-spoke* VXLAN connectivity model in which a hub node is connected to all the spokes bidirectionally, but the spokes are not connected to each other (see an example in ***Figure 8-9*** above).

> **Note**: This feature is supported only on Dell, Edgecore, and Freedom series switches.

The new `isolated` keyword is used along with manual VNI assignment in the `vtep-vxlan-add` command. Therefore, it is applied on a *per-VNI per-VTEP mapping basis*.

The `isolated` keyword is used to configure the spoke nodes, whereas the hub nodes are configured normally. In the example of ***Figure 8-9*** above, the following sequence can set up one hub and two spoke/isolated nodes for VNI 10030:

```
CLI (network-admin@Switch1) > vlan-create id 30 scope fabric
vxlan 10030

CLI (network-admin@Switch1) > vtep-vxlan-add name VTEP1 vxlan
10030
CLI (network-admin@Switch2) > vtep-vxlan-add name VTEP2 vxlan
10030 isolated
CLI (network-admin@Switch3) > vtep-vxlan-add name VTEP3 vxlan
10030 isolated
```

Due to the hub-and-spoke nature of the configuration, bidirectional VXLAN connections are only created (automatically) between the hub node (Switch1) and the spokes (Switch2 and Switch3), but not between the spokes as shown below:

```
CLI (network-admin@Switch1) > tunnel-vxlan-show

Switch    name                           vxlan
--------  ---------------------------    -----
Switch1   auto-tunnel-1.1.1.1_2.2.2.2    10030
Switch1   auto-tunnel-1.1.1.1_3.3.3.3    10030
Switch2   auto-tunnel-2.2.2.2_1.1.1.1    10030
Switch3   auto-tunnel-3.3.3.3_1.1.1.1    10030
```

The default configuration mode is `not-isolated` (in other words, the `isolated` keyword is not assigned by default to any VNI mappings). Also, `not-isolated` is an *optional* keyword so it can be omitted. Note that, if users need to change a VNI from isolated to not-isolated/normal mode, they need to first execute the `vtep-vxlan-remove` command in order to delete the VNI assignment and subsequently they can add it back with the default/normal mode.

The per-VNI isolated configuration can be checked with the `vtep-vxlan-show` command as shown below:

```
CLI (network-admin@switch) > vtep-vxlan-show
name vxlan isolated
---- ----- --------
vt1  10021 no
vt1  10020 yes
vt1  10023 yes
vt1  10025 no
vt1  10022 no
vt1  10024 yes
vt2  10021 no
vt2  10020 yes
vt2  10023 no
vt2  10025 no
vt2  10022 yes
vt2  10024 yes
vt3  10021 no
vt3  10020 yes
vt3  10023 yes
vt3  10025 yes
vt3  10022 yes
vt3  10024 no
```

Disabling VXLAN Termination

It is possible, for security purposes, to disable VXLAN termination on certain ports that are not supposed to source VXLAN-encapsulated traffic.

This prevents any malicious host from generating VXLAN encapsulated packets that would normally be subject to (unwanted) VXLAN tunnel termination and subsequent forwarding. For example, the following command disables the termination on port 35:

```
CLI (network-admin@switch) > port-config-modify port 35 no-
vxlan-termination
```

It can be re-enabled, if necessary, like so:

```
CLI (network-admin@switch) > port-config-modify port 35 vxlan-
termination
```

The default settings are:

- vNETs with `vlan-type private` rely on the VXLAN functionality to implement their private characteristics. Therefore, when a port is configured to be a managed port with `vlan-type private`, VXLAN termination is disabled by default.
- Underlay ports have VXLAN termination on by default and can use the `port-config-modify` command to disable VXLAN termination as deemed to enforce port level security.

Disabling MAC Address Learning

In certain fabric topologies, the MAC address learning function can be disabled in order to achieve better scalability, or because it is not strictly required (for example on point-to-point connections).

For these cases, starting from Netvisor ONE release 6.0.0, it is possible to disable MAC address learning as part of the VXLAN configuration. For this purpose, a new configuration option is added, `mac-learning | no-mac-learning`, to the following commands:

- `tunnel-create`
- `tunnel-modify`
- `vtep-create`
- `vtep-modify`

In the above commands, `mac-learning` is the default setting. The `tunnel-show` and `vtep-show` commands are extended to display the learning state in a new column. For example:

```
CLI (network-admin@switch) > tunnel-create name tun1 scope local local-ip 1.1.1.1 remote-ip 1.1.1.2 vrouter-name vr1 no-mac-learning

CLI (network-admin@switch) > tunnel-show format name,local-ip,remote-ip,mac-learning,

name  local-ip  remote-ip mac-learning
----- -------- ---------- ------------
tun1  1.1.1.1    1.1.1.2     off
```

Then to re-enable MAC address learning, you can use:

```
CLI (network-admin@switch) > tunnel-modify name tun1 mac-learning

CLI (network-admin@switch) > tunnel-show format name,local-ip,remote-ip,mac-learning,

name  local-ip  remote-ip  mac-learning
----- -------- ---------- ------------
tun1  1.1.1.1   1.1.1.2     on
```

Similarly, in case of VTEP object creation to disable MAC address learning you can use:

```
CLI (network-admin@switch) > vtep-create name VTEP-01 location switch vrouter-name vr1 ip 10.16.111.2 virtual-ip 10.16.111.1 no-mac-learning

CLI (network-admin@switch) > vtep-show

scope  name     location vrouter-name    ip         virtual-ip  mac-learning
------ ------- -------- ------------ ----------- ----------- ------------
```

```
fabric  VTEP-01   switch     vr1         10.16.111.2  10.16.111.1    off
```

To re-enable it:

CLI (network-admin@switch) > vtep-modify name VTEP-01 mac-learning

CLI (network-admin@switch) > vtep-show

```
scope   name      location  vrouter-name   ip            virtual-ip   mac-learning
------  -------   --------  ------------  -----------   -----------  ------------
fabric  VTEP-01   switch     vr1         10.16.111.2  10.16.111.1   on
```

> **Note:** Disabling MAC address learning at the tunnel or VTEP level means that the learning function is disabled for all of the associated VNIs.

Configuring Unicast Fabric VRFs with Anycast Gateway

The following commands are used for the configuration of VRF instances and of the associated VRF gateway (`vrf-gw` and `vrf-gw2`) IP addresses:

```
CLI (network-admin@switch) > vrf-create
```

`name name-string`	Specify a name for the VRF.
`vnet vnet-name`	Specify the name of the vNET to assign the VRF. If you only have a global vNET configured, omit this parameter.
`scope local|cluster|fabric`	Specify the scope for the VRF.
`vrf-gw ip-address`	Specify the gateway IP address.
`vrf-gw2 ip-address`	Specify the second gateway IP address.
`vrf-gw-ipv6 ip-address`	Specify the IPv6 gateway address.
`vrf-gw2-ipv6 ip-address`	Specify the second IPv6 gateway address.
`enable|disable`	Specify to enable or disable VRF routing.
`description` *`description-string`*	Specify a VRF description. The maximum number of allowed characters is 59.

```
CLI (network-admin@switch) > vrf-delete
```

`name name-string`	Specify VRF name that you want to delete.
`vnet vnet-name`	Specify the name of the vNET assigned to the VRF.

```
CLI (network-admin@switch) > vrf-modify
```

`name name-string`	Specify a name for the VRF.
`vnet vnet-name`	Specify the name of the vNET to assign the VRF.
`scope local|cluster|fabric`	Specify the scope for the VRF.
`vrf-gw ip-address`	Specify the gateway IP address.
`vrf-gw2 ip-address`	Specify the second gateway IP address.
`vrf-gw-ipv6 ip-address`	Specify the IPv6 gateway address.
`vrf-gw2-ipv6 ip-address`	Specify the second IPv6 gateway address.
`enable|disable`	Specify to enable or disable VRF routing.

`description` *`description-string`*	Specify a VRF description. The maximum number of allowed characters is 59.

```
CLI (network-admin@switch) > vrf-show
```

`name name-string`	Displays the name of the VRF.
`vnet vnet-name`	Displays the name of the vNET assigned the VRF.
`scope local|cluster|fabric`	Displays the scope of the VRF.
`vrf-gw ip-address`	Displays the gateway IP address.
`vrf-gw2 ip-address`	Displays the second gateway IP address.
`vrf-gw-ipv6 ip-address`	Displays the IPv6 gateway address.
`vrf-gw2-ipv6 ip-address`	Displays the second IPv6 gateway address.
`enable|disable`	Displays the status of VRF routing as enable or disable.
`description` *`description-string`*	Displays the VRF description.

The following commands are used for the configuration of subnet objects for the associated anycast gateway addresses and the associated VNIs:

```
CLI (network-admin@switch) > subnet-create
```

`name name-string`	Specify the name of the subnet.
`description` *`description-string`*	Specify the subnet description. The maximum number of allowed characters is 59.
`scope local|cluster|fabric`	Specify the scope for the VRF.
`vnet vnet-name`	Specify the name of the vNET to assign the VRF.
`vxlan vxlan-id`	Specify the VXLAN ID to assign to the subnet.
`vrf vrf name`	Specify the VRF to which the subnet belongs to.
`network ip-address`	Specify the IPv4 network IP address.
`netmask netmask`	Specify the netmask for the IPv4 address.
`anycast-gw-ip ip-address`	Specify the anycast gateway IPv4 address for the subnet.
`network6 ip-address`	Specify the IPv6 subnet network

	address.
`netmask6 netmask`	Specify the IPv6 subnet netmask address.
`anycast-gw-ip6 ip-address`	Specify the anycast gateway IPv6 address for the subnet.
`packet-relay enable|disable|none`	Enable or disable the packet relay.
`forward-proto dhcp`	Specify the protocol type to forward the packets.
`forward-ip ip-address`	Specify the forwarding IPv4 address.
`forward-ip2 ip-address`	Specify the second forwarding IPv4 address.
`forward-ip6 ip-address`	Specify the forwarding IPv6 address.
`forward-ip6-2 ip-address`	Specify the second forwarding IPv6 address.
`flood enable|disable|none`	Specify the flooding state of BUM traffic
`enable|disable`	Specify to enable/disable subnet routing.

```
CLI (network-admin@switch) > subnet-delete
```

`name name-string`	Specify the name of the subnet.
`vnet vnet-name`	Specify the name of the vNET to assign the VRF.
`vrf name-string`	Specify the VRF to assign the subnet.

```
CLI (network-admin@switch) > subnet-modify
```

`name name-string`	Specify the name of the subnet.
`description` *`description-string`*	Specify the subnet description. The maximum number of allowed characters is 59.
`vnet vnet-name`	Specify the name of the vNET to assign the VRF.
Specify one or more of the following options:	
`network ip-address`	Specify the IPv4 network IP address.
`netmask netmask`	Specify the netmask for the IPv4 address.
`anycast-gw-ip ip-address`	Specify the anycast gateway IPv4 address for the subnet.
`network6 ip-address`	Specify the IPv6 subnet network

	address.
`netmask6 netmask`	Specify the IPv6 subnet netmask address.
`anycast-gw-ip6 ip-address`	Specify the anycast gateway IPv6 address for the subnet.
`packet-relay enable|disable|none`	Enable or disable the packet relay.
`forward-proto dhcp`	Specify the protocol type to forward the packets.
`forward-ip ip-address`	Specify the forwarding IPv4 address.
`forward-ip2 ip-address`	Specify the second forwarding IPv4 address.
`forward-ip6 ip-address`	Specify the forwarding IPv6 address.
`forward-ip6-2 ip-address`	Specify the second forwarding IPv6 address.
`enable|disable`	Specify to enable/disable subnet routing.

```
CLI (network-admin@switch) > subnet-show
```

`name name-string`	Displays the name of the subnet.
`description` *`description-string`*	Displays the subnet description.
`scope local|cluster|fabric`	Displays the scope for the VRF.
`vnet vnet-name`	Displays the name of the vNET to assign the VRF.
`vlan vlan-id`	Displays the VLAN ID to assign to the subnet.
`vxlan vxlan-id`	Displays the VXLAN ID to assign to the subnet.
`vrf name-string`	Displays the VRF to assign the subnet.
`network ip-address`	Displays the network IPv4 address.
`netmask netmask`	Displays the netmask for the IPv4 address.
`anycast-gw-ip ip-address`	Displays the anycast gateway IPv4 address.
`network6 ip-address`	Displays the IPv6 subnet network address.
`netmask6 netmask`	Displays the IPv6 subnet netmask address.
`anycast-gw-ip6 ip-address`	Displays the anycast gateway IPv6

	address for the subnet.
`linklocal ip-address`	Displays the IPv6 Link Local address.
`packet-relay enable|disable|none`	Displays the packet relay mode.
`forward-proto dhcp`	Displays the protocol type forwarding the packets.
`forward-ip ip-address`	Displays the forwarding IPv4 address.
`forward-ip2 ip-address`	Displays the second forwarding IPv4 address.
`forward-ip6 ip-address`	Displays the forwarding IPv6 address.
`forward-ip6-2 ip-address`	Displays the second forwarding IPv6 address.
`state init|ok|vxlan not found|vxlan deactivated|not-in-hw|vrouter interface exists`	Displays the subnet state.
`hw-state|no-hw-state`	Displays if there is a hardware state present.
`enable|disable`	Displays the state of the subnet routing.
`format fields-to-display`	Display output using a specific parameter. Use all to display all possible output.
`parsable-delim character`	Display output formatted for machine parsing using a specified delimiter.
`sort-asc`	Display output in ascending order.
`sort-desc`	Display output in descending order.
`show dups`	Display duplicate entries in the output.
`layout vertical|horizontal`	Format the output in a vertical or horizontal layout.
`show-interval seconds-interval`	Repeat the show command at a specified interval.
`show-headers|no-show-headers`	Display column headers or not.
`limit-output number`	Limit the display output to a specific number of entries.
`count-output`	Display the number of entries in the output. This is useful with vRouter show commands.
`count-only`	Displays the number of entries only.
`unscaled`	Display full values in the output instead

	of scaled approximate values.
raw-int-values	Display integer values instead of mapped values

The following commands allow you to modify and display anycast gateway information on the fabric:

```
CLI (network-admin@switch) > fabric-anycast-mac-show
```

format fields-to-display	Display output using a specific parameter. Use all to display all possible output.
parsable-delim character	Display output formatted for machine parsing using a specified delimiter.
sort-asc	Display output in ascending order.
sort-desc	Display output in descending order.
show dups	Display duplicate entries in the output.
layout vertical|horizontal	Format the output in a vertical or horizontal layout.
show-interval seconds-interval	Repeat the show command at a specified interval.
show-headers|no-show-headers	Display column headers or not.
limit-output number	Limit the display output to a specific number of entries.
count-output	Display the number of entries in the output. This is useful with vRouter show commands.
count-only	Displays the number of entries only.
unscaled	Display full values in the output instead of scaled approximate values.
raw-int-values	Display integer values instead of mapped values

```
CLI (network-admin@switch) > fabric-anycast-mac-modify
```

mac mac-address	Modify the MAC address for anycast. The default MAC address is 64:0e:94:40:00:02.

For example, the following `vrf-create` command can be used to create `VRF-1`:

```
CLI (network-admin@switch) > vrf-create name VRF-1 scope fabric
```

The vrf-create command can be issued to configure for instance 1000 VRFs on a single node, as shown in this output:

```
CLI (network-admin@switch) > vrf-show count-output

name    vnet scope  anycast-mac       vrf-gw vrf-gw2 active hw-router-mac     hw-vrid
------- ---- ------ ----------------- ------ ------- ------ ----------------- -------
VRF-1   0:0  fabric 64:0e:94:40:00:02  ::     ::      no    00:00:00:00:00:00 -1
VRF_2   0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:59:47  1
VRF_3   0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:6c:91  2
VRF_4   0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:76:3d  3
VRF_5   0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:7f:e2  4
VRF_6   0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:89:87  5
...
VRF_999 0:0  fabric 64:0e:94:40:00:02  ::     ::      yes   66:0e:94:1b:aa:8a   999

Count: 999
```

> **Note:** The newer ASICs can support an even higher count. The maximum number is ASIC *limited*.

The following commands can be used to create two subnet objects associated with VRF-1 for East-West traffic segmentation:

```
CLI (network-admin@switch) > vlan-create id 12 vxlan 500012
scope fabric ports none

CLI (network-admin@switch) > vlan-create id 13 vxlan 500013
scope fabric ports none

CLI (network-admin@switch) > subnet-create name subnet-vxlan-
500012 scope fabric vxlan 500012 network 172.10.2.0/24
anycast-gw-ip 172.10.2.1 vrf VRF-1

CLI (network-admin@switch) > subnet-create name subnet-vxlan-
500013 scope fabric vxlan 500013 network 172.10.3.0/24
anycast-gw-ip 172.10.3.1 vrf VRF-1
```

> **Note**: Starting from Netvisor ONE release 6.0.0, the VNI assignment in vlan-create can be automated with the auto-vxlan keyword.

Finally, the following commands can be used to create two smaller subnets (/29) to provide North-South reach-ability in and out of VRF-1 to/from VRF gateways 172.10.0.2 and 172.10.1.2:

```
CLI (network-admin@switch) > vlan-create id 10 vxlan 500010
scope fabric ports none

CLI (network-admin@switch) > vlan-create id 11 vxlan 500011
scope fabric ports none
```

```
CLI (network-admin@switch) > subnet-create name subnet-vxlan-500010 scope fabric vxlan 500010 network 172.10.0.0/29 anycast-gw-ip 172.10.0.1 vrf VRF-1

CLI (network-admin@switch) > subnet-create name subnet-vxlan-500011 scope fabric vxlan 500011 network 172.10.1.0/29 anycast-gw-ip 172.10.1.1 vrf VRF-1
```

> **Note:** The scope of the VRF and subnet objects typically would be `fabric`; however, to cater to specific needs and designs it is also possible to configure *local VRFs* and *subnets* in certain cases.

The next step is to configure the VRF gateways for `VRF-1`:

```
CLI (network-admin@switch) > switch <switch_list> vrf-modify name VRF-1 vrf-gw 172.10.0.2 vrf-gw2 172.10.1.2
```

Figure 8-15: Fabric VRFs with Border Leaves Connecting External Network

In this example it is assumed that the connectivity is implemented with static routing on the DC gateways (for example, third-party devices). To provide inbound reach-ability for VRF-1, the DC gateways must be provisioned with static routes for the VRF subnets receiving traffic from external networks, using the adjacent anycast gateway addresses as next-hop:

```
DC-Gateway-1# ip route vrf VRF-1 172.10.2.0/23 172.10.0.1
DC-Gateway-1# ip route vrf VRF-1 172.10.2.0/23 172.10.1.1
DC-Gateway-2# ip route vrf VRF-1 172.10.2.0/23 172.10.0.1
DC-Gateway-2# ip route vrf VRF-1 172.10.2.0/23 172.10.1.1
```

In addition, you can also leverage the `vrf-route-add` command to add static routes to specific VRF-enabled networks when required:

```
CLI (network-admin@switch) > vrf-route-add
vrf-route-add                                    add vrf route
     one of the following vrf selectors:
     vrf-name name-string                        vrf name
     vrf-vnet vnet name                          VNET for the VRF
     the following route arguments:
     network ip-address                          IP address
     netmask netmask                             netmask
     gateway-ip ip-address                       gateway IP address
```

`vrf-route-remove` and `vrf-route-show` commands are also available.

Configuring the Anycast Gateway MAC Address as Source Address

Starting from Netvisor ONE release 6.1.0, it is possible to select the Anycast Gateway MAC address as source address used for distributed routing of traffic across subnets. (When the Anycast Gateway function is not used or when this capability is not enabled, Netvisor ONE only employs the router MAC address as source address.)

This feature is useful when some downstream device (for example, a firewall) gleans the source MAC address from a routed packet to use it for various reasons, such as for example in the response to the original packet.

The default source MAC address used for the Anycast Gateway function is the common router MAC address. During VRF creation or modification, by using the following command it is possible to specify to use the Anycast Gateway MAC address instead:

```
CLI (network-admin@switch) > vrf-create name vrf1 anycast-mac-for-forwarding
```

```
CLI (network-admin@switch) > switch * vrf-modify name vrf1 {anycast-mac-for-forwarding | no-anycast-mac-for-forwarding}
```

The default setting is `no-anycast-mac-for-forwarding`.

> **Note**: To modify this capability fabric-wide, use `switch * vrf-modify` as shown above, because `scope fabric` is not supported.

```
CLI (network-admin@switch) > vrf-show format name,anycast-mac,active,hw-router-mac,anycast-mac-for-forwarding
```

```
name  anycast-mac       active hw-router-mac     anycast-mac-for-forwarding
----- ----------------- ------ ----------------- --------------------------
VRF-1 64:0e:94:40:00:02 yes    66:0e:94:b5:9e:c2 yes
VRF-4 64:0e:94:40:00:02 yes    66:0e:94:b5:d5:fb yes
VRF-2 64:0e:94:40:00:02 yes    66:0e:94:b5:be:8c yes
VRF-3 64:0e:94:40:00:02 yes    66:0e:94:b5:6c:97 yes
```

You can verify that the vFlow entry is properly installed with the command:

```
CLI (network-admin@switch) > vflow-show format name,src-mac,action | grep Anycast
```

```
name                          src-mac           action
----------------------------- ----------------- --------------------
Anycast-Src-Miss-Cancel-ToCpu 64:0e:94:40:00:02 cancel-switch-to-cpu
```

Configuring Virtual Service Groups

> **Note**: This feature is supported only on Dell, Edgecore, and Freedom series switches.

Starting from Netvisor ONE release 6.0.1 it is possible to import/export subnet prefixes between Unicast Fabric VRFs. This operation is sometimes informally referred to as 'prefix leaking'.

To implement this functionality a new innovative entity called *Virtual Service Group* (vSG) is introduced: it's an abstraction that defines in an intuitive and user-friendly way the policies by which prefixes are shared.

> **Note:** As of Netvisor ONE release 6.0.1, this functionality applies only to Unicast Fabric VRFs and not to vRouter-based VRFs.

First a vSG is created with the `vsg-create` command, specifying a name and optionally (but conveniently) a description string:

```
CLI (network-admin@switch) > vsg-create name <vsg-name>
[description  <description>]
```

Similarly, an existing vSG can be deleted or its description can be modified with the `vsg-delete` and `vsg-modify` commands, respectively.

A newly created vSG is a grouping that is meant to contain a list of VRFs, which can be added individually with the command:

```
CLI (network-admin@switch) > vsg-vrf-add name <vsg-name> vrf
<name> [type promiscuous | isolated] [vnet]
```

The `vsg-vrf-add` command enables the user to optionally specify the *type of prefix sharing* to apply to each VRF as well as an associated vNET. The `promiscuous` keyword (i.e., the *default* option) identifies VRFs whose prefixes can be freely shared with any other VRF. Instead, the `isolated` keyword identifies VRFs whose prefixes can only be shared with VRFs marked as promiscuous. So when the type is not specified, it defaults to promiscuous.

Analogously to the `vsg-vrf-add` command, VRF removal is performed with the `vsg-vrf-remove` command.

The last vSG configuration step is to identify which subnet(s) and/or prefix(es) to share for each VRF with the command:

```
CLI (network-admin@switch) > vsg-network-add name <vsg-name>
vrf <vrf-name> network <prefix/mask>|subnet <name> [vnet]
```

If all (current and future) subnets within a VRF have to be shared, you can use the handy shortcut: `subnet all`.

Once added, subnets/prefixes can be removed with the corresponding `vsg-network-remove` command.

The sharing of the added prefixes/subnets between VRFs follows the rules dictated by the respective promiscuous/isolated markings, which is a very simplistic configuration model but can also be rather powerful.

Going through a few examples of use cases is the best way to describe the flexibility of such configuration model, as discussed in the following.

Example 1: Full-mesh Connectivity Model

In this scenario there are for example two tenants who share a common service. The three network entities are associated to three VRFs respectively: TENANT-GREEN, TENANT-GREY and SERVICE-AMBER. All three VRFs need to share at least one subnet with the others for proper connectivity.

This is an any-to-any communication model, in which you can use the promiscuous keyword to (explicitly) state that sharing is allowed. Then you can specify which subnets are shared. For example, TENANT-GREEN and TENANT-GREY share one of their subnets with SERVICE-AMBER like so:

```
CLI (network-admin@switch) > vsg-create name GROUP-A
description ANY-TO-ANY-SHARING
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-A vrf
TENANT-GREY type promiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-A vrf
TENANT-GREEN type promiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-A vrf
SERVICE-AMBER type promiscuous
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-A
vrf TENANT-GREY subnet SUBNET-11
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-A
vrf TENANT-GREEN subnet SUBNET-21
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-A
vrf SERVICE-AMBER subnet SUBNET-1
```

SUBNET-11 corresponds to 10.0.11.0/24, SUBNET-21 to 10.0.21.0/24 and SUBNET-1 to 10.1.1.0/24.

```
CLI (network-admin@switch) > vsg-show
switch name    description
------ ------- -------------------
switch GROUP-A ANY-TO-ANY-SHARING

CLI (network-admin@switch) > vsg-vrf-show
switch vsg-name vnet vrf           type
------ -------- ---- ------------- -----------
switch GROUP-A  0:0  TENANT-GREY   promiscuous
switch GROUP-A  0:0  TENANT-GREEN  promiscuous
switch GROUP-A  0:0  SERVICE-AMBER promiscuous
```

```
CLI (network-admin@switch) > vsg-network-show
switch vsg-name vrf            vnet subnet    network
network_state
------ -------- ------------- ---- --------- ---------------
-------------
switch GROUP-A  TENANT-GREY    0:0  SUBNET-11 10.0.11.0/24
ok
switch GROUP-A  TENANT-GREEN   0:0  SUBNET-21 10.0.21.0/24
ok
switch GROUP-A  SERVICE-AMBER 0:0  SUBNET-1  10.1.1.0/24
ok
```

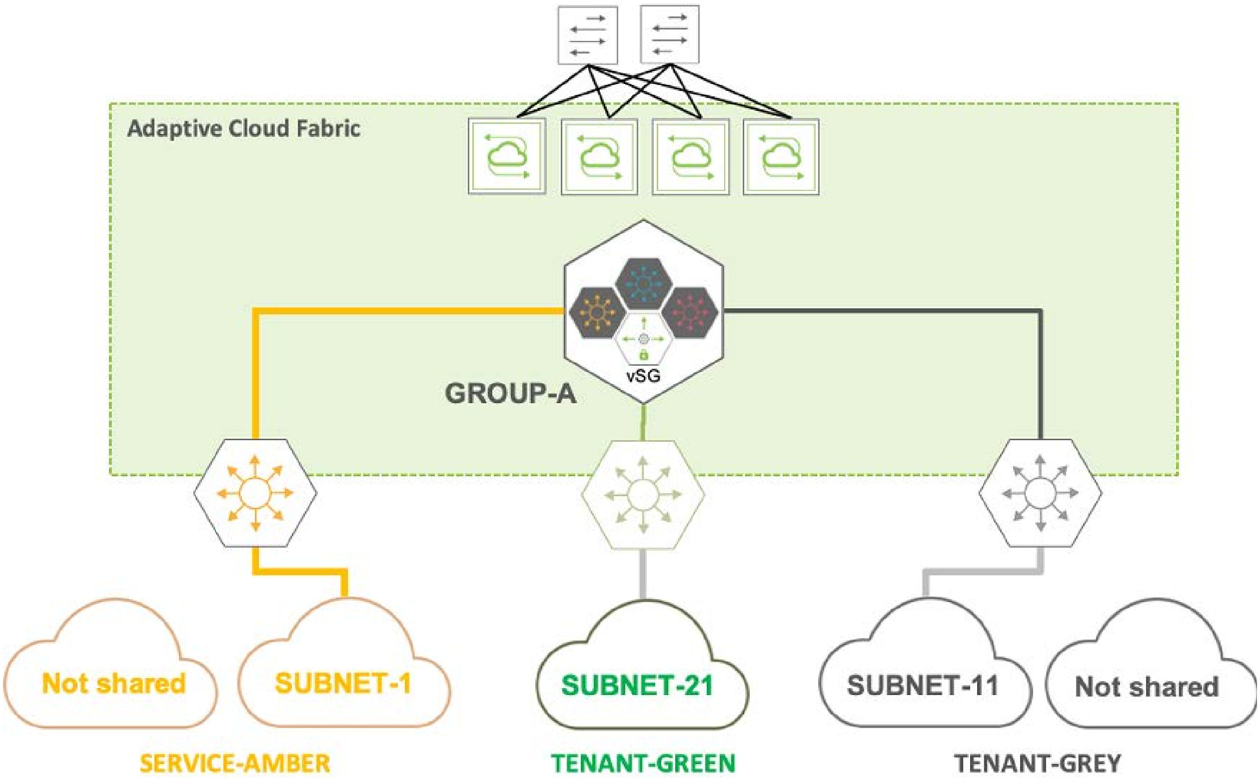


Figure 8-16 – Virtual Service Group Example

Example 2: Hub-and-spoke Connectivity Model

In this scenario, the ‘hub’ VRF is the one that needs to share its subnet(s) with all other vSG members without distinction. In other words, it’s the *promiscuous VRF*. A good example would be a common shared service. Instead, *isolated VRFs (spokes)* don’t need to share subnets between each other, they only need to share them with the promiscuous VRF. A common case would be different tenants (say, GREEN and GREY) that require routing segregation without any mutual prefix sharing, like so:

```
CLI (network-admin@switch) > vsg-create name GROUP-B
description  HUB-AND-SPOKE-SHARING
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-B vrf
```

```
SERVICE-BLUE type promiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-B vrf
TENANT-GREY type isolated
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-B vrf
TENANT-GREEN type isolated
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-B
vrf TENANT-GREY subnet SUBNET-12
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-B
vrf TENANT-GREEN subnet SUBNET-22
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-B
vrf SERVICE-BLUE subnet SUBNET-2
```

Example 3: Hierarchical Connectivity Model

This example is analogous to #1 above but applies the vSG grouping function to separate service VRFs (say, AMBER, BLUE and CRIMSON). This allows the user to create a hierarchy where the vSG corresponds to the superset (i.e., the union) of multiple VRFs that remain separate. The advantage of this approach compared to having a single merged 'fat' VRF is that keeping service VRFs separate can enable better granularity in assigning subnets/prefixes, policies or different vNETs:

```
CLI (network-admin@switch) > vsg-create name GROUP-C
description VRF-UNION
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-C vrf
SERVICE-BLUE type promiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-C vrf
SERVICE-AMBER type promiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-C vrf
SERVICE-CRIMSON type promiscuous
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-AMBER subnet SUBNET-1
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-BLUE subnet SUBNET-2
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-CRIMSON subnet SUBNET-3
```

The `vsg-network-add` enables full granularity of prefix sharing depending on the specific network requirements. If all current and future subnets have to be shared, then you can use these shortcuts instead:

```
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-AMBER subnet all
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-BLUE subnet all
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-C
vrf SERVICE-CRIMSON subnet all
```

Example 4: Unidirectional Connectivity Model

This example is less common because it is more typical for traffic to flow bidirectionally and hence routing to be applied in both directions. However, it is possible that in some scenarios only unidirectional communication is required, for example, in certain service chaining cases.

To support this use case, you can configure certain VRFs to act only as *traffic sources* (hence not sharing subnets) and other VRFs to act only as *traffic receivers* (hence sharing subnets). In other words, in order to accommodate the unidirectional flow scenario, only partial subnet sharing can be configured like so:

```
CLI (network-admin@switch) > vsg-create name GROUP-E
description  UNIDIRECTIONAL-SHARING
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-E vrf
RECEIVE type typepromiscuous
CLI (network-admin@switch) > vsg-vrf-add vsg-name GROUP-E vrf
SOURCE  promiscuous
CLI (network-admin@switch) > vsg-network-add vsg-name GROUP-E
vrf RECEIVE subnet SUBNET-RCV
```

Furthermore, sharing of subsets is possible too by using the `network` keyword in `vsg-network-add` (say, there are two subnets, 100.1.1.0/24 and 101.1.1.0/24, but only four prefixes have to be shared respectively: 100.1.1.0/30 and 101.1.1.0/30):

```
CLI (network-admin@switch) > vsg-network-add vsg-name vsg1 vrf
vrf1 network 100.1.1.0/30
CLI (network-admin@switch) > vsg-network-add vsg-name vsg1 vrf
vrf2 network 101.1.1.0/30

CLI (network-admin@switch) > vsg-network-show

Switch vsg-name vrf  vnet subnet network      network_state
------ -------- ---- ---- ------ ------------ -------------
switch vsg1     vrf1 0:0         100.1.1.0/30 ok
switch vsg1     vrf2 0:0         101.1.1.0/30 ok
```

Configuring vSG Route Sharing

In certain configurations it can be convenient to implement the automatic sharing of one or more routes in accordance with the vSG rules. For example, a firewall (or a DC gateway or another similar device) may be a common next hop for all the end devices across the entire vSG. Such device (or devices) is typically deployed to enable shared service(s): in the case of a firewall, it supports external connectivity, security policies, etc.

In these configurations with shared services, it can be convenient to add routes directly to the vSG so that they get automatically shared to *all* the members based on the vSG rules chosen by the user.

Starting from Netvisor ONE release 6.1.0 a new capability is introduced to add routes to the vSG, which can save significant configuration overhead especially in large vSG configurations.

For example, let's consider a scenario in which there are two isolated VRFs (`blue` and `red`) that need to communicate through a firewall. (For the sake of simplicity, the example only uses two VRFs but it can be scaled to N VRFs making the new automation even more advantageous.)

The firewall is in a subnet associated with a promiscuous VRF called `transit`. `blue` and `red` are isolated VRFs that share one subnet each (10.1.1.0/24 and 20.1.1.0/24) with `transit`, which uses a third subnet. In particular, the firewall is the actual common service to be shared in such subnet and uses the address 30.1.1.2.

This is the corresponding configuration of the vSG:

```
CLI (network-admin@switch) > vrf-create name blue
CLI (network-admin@switch) > vrf-create name red
CLI (network-admin@switch) > vrf-create name transit vrf-gw
30.1.1.2

CLI (network-admin@switch) > subnet-create name vlan_10 vrf
blue vlan 10 network 10.1.1.0/24 anycast-gw-ip 10.1.1.1
CLI (network-admin@switch) > subnet-create name vlan_20 vrf
red vlan 20 network 20.1.1.0/24 anycast-gw-ip 20.1.1.1
CLI (network-admin@switch) > subnet-create name vlan_30 vrf
transit vlan 30 network 30.1.1.0/29 anycast-gw-ip 30.1.1.1

CLI (network-admin@switch) > vsg-create name vSG-1 description
"Firewall Access"
CLI (network-admin@switch) > vsg-vrf-add name vSG-1 vrf blue
type isolated
CLI (network-admin@switch) > vsg-vrf-add name vSG-1 vrf red
type isolated
CLI (network-admin@switch) > vsg-vrf-add name vSG-1 vrf
transit type promiscuous

CLI (network-admin@switch) > vsg-network-add name vSG-1 vrf
blue subnet vlan_10
CLI (network-admin@switch) > vsg-network-add name vSG-1 vrf
```

```
red subnet vlan_20
CLI (network-admin@switch) > vsg-network-add name vSG-1 vrf
transit network 30.1.1.2/32
```

In this example, the need is to automatically share across all the VRFs in the vSG the default gateway route (0.0.0.0/0) pointing to the firewall's IP address (30.1.1.2/32). That could be achieved by manually configuring in both blue and red the same route by using the `vrf-route-add` command twice.

Alternatively and more conveniently, starting from release 6.1.0 a single command, `vsg-route-add`, can be used to share the default route across *all* of the VRFs that are part of a vSG, like so (by virtue of the promiscuous nature of `transit`):

```
CLI (network-admin@switch) > vsg-route-add vsg-name vSG-1 vrf
transit network 0.0.0.0/0 gateway-ip 30.1.1.2
```

> **Note**: The `gateway-ip` address (i.e., the next hop) in the vSG route must be shared from the promiscuous VRF prior to the `vsg-route-add` command. Hence the sequence of commands is in the order displayed above with the network highlighted in bold. If by mistake this requirement is not met, the `vsg-route-add` command will produce an error message: `network 30.1.1.2 not leaked from vrf transit`

> **Note**: The network in the vSG route should not overlap with local subnets or shared prefixes. For example, the command: `vsg-route-add name vsg1 vrf transit network 10.1.1.2/30 gateway-ip 30.1.1.2` produces the error message: `vsg-route-add: !! Overlapping subnet found for network 10.1.1.2 in vrf blue` because 10.1.1.2 overlaps with the local subnet of VRF `blue`.

To verify that a vSG route was correctly added, you can use the `vsg-route-show` command:

```
CLI (network-admin@switch) > vsg-route-show
switch name vrf     vnet network   gateway-ip
------ ---- ------- ---- --------- ----------
switch vsg1 transit 0:0  0.0.0.0/0 30.1.1.2
```

Moreover, to verify the entire vSG configuration the following commands can be used:

```
CLI (network-admin@switch) > subnet-show
switch name    scope vlan vrf     network     anycast-gw-ip
packet-relay forward-proto state enable
------ ------- ----- ---- ------- ----------- ------------
------------ ------------- ----- ------
switch vlan_10 local 10   blue    10.1.1.0/24 10.1.1.1
disable      dhcp          ok    yes
switch vlan_20 local 20   red     20.1.1.0/24 20.1.1.1
disable      dhcp          ok    yes
switch vlan_30 local 30   transit 30.1.1.0/24 30.1.1.1
disable      dhcp          ok    yes
```

```
CLI (network-admin@switch) > vsg-vrf-show
switch vsg-name vnet vrf     type
------ -------- ---- ------- -----------
switch vsg1     0:0  blue    isolated
switch vsg1     0:0  red     isolated
switch vsg1     0:0  transit promiscuous
```

```
CLI (network-admin@switch) > vsg-network-show
switch vsg-name vrf     vnet subnet  network     network-state
------ -------- ------- ---- ------- ----------- -------------
switch vsg1     blue    0:0  vlan_10 10.1.1.0/24 ok
switch vsg1     red     0:0  vlan_20 20.1.1.0/24 ok
switch vsg1     transit 0:0  vlan_30 30.1.1.2/32 ok
```

Once added, a vSG route can also be removed with the corresponding `vsg-route-remove` command:

```
CLI (network-admin@switch) > vsg-route-remove name vsg1 vrf
transit network 0.0.0.0/0 gateway-ip 30.1.1.2
```

Configuring IGMP Snooping with VXLAN

By snooping IGMP messages it is possible to determine the (local) port membership for multicast groups. It is also possible to include the logical ports associated with VXLAN tunnels and their remote VTEPs when IGMP messages are snooped on remote overlay network nodes.

The following command supports this feature:

```
CLI (network-admin@switch) > igmp-snooping-modify vxlan|no-vxlan
```

`vxlan|no-vxlan`	Enable IGMP on VXLAN. Disabled by default.

```
CLI (network-admin@switch) > igmp-snooping-modify vxlan

CLI (network-admin@switch) > igmp-snooping-show

enable:                         yes
vxlan:                          yes
enable-vlans:                   1-4092
snoop-link   local-vlans:                 none
```

To disable it:

```
CLI (network-admin@switch) > igmp-snooping-modify no-vxlan

CLI (network-admin@switch) > igmp-snooping-show
enable:                  yes
vxlan:                   no
enable-vlans:            1-4092
snoop-linklocal-vlans:   none
```

Informational Note: IGMP Snooping is enabled by default while the VXLAN option is disabled by default.

Let us consider an example: Assume that IGMP join messages for group `239.1.1.1` (from source `10.1.1.2`) are received on a tunnel associated with VLAN `10` (with VNI `10`), as shown in the command output below:

```
CLI (network-admin@switch) > vlan-show vxlan 10

id type   vxlan vxlan-type replicators scope description active stats     ports
untagged-ports   active-edge-ports
-- ------ ----- ---------- ---------- ----- ----------- ------ ----- --------------
------------   ------------
10 public 10    user       none       local  vlan-10     yes    no    9,41,69-72,253   9
          9
```

Group IP `239.1.1.1` is associated to source IP `10.1.1.2` and its port membership list only contains the logical port ID (*12755068416*) associated with a VXLAN tunnel:

```
CLI (network-admin@switch) > igmp-show group-ip 239.1.1.1

group-ip  node-ip  vnet vxlan bd vlan port       source node-type expires(s)
--------- -------- ---- ----- -- ---- ---------- ------ --------- ---------
239.1.1.1 10.1.1.2            10  12 12755068416 0.0.0.0 host      0
```

You can check the tunnel info (such as its associated VTEP IP addresses) corresponding to logical port *1275068416* with the following command:

```
CLI (network-admin@switch) > tunnel-show tunnelID 1275068416

scope:              local
name:               auto-tunnel-70
type:               vxlan
vrouter-name:       vr1
local-ip:           70.1.1.2
remote-ip:          80.1.1.2
router-if:          eth1.4092
next-hop:           70.1.1.1
next-hop-mac:       66:0e:94:70:61:7f
remote-switch:      0
active:             yes
state:              ok
bfd:                disabled
bfd-state:          unknown
error:
route-info:         80.1.1.0/24
ports:              19
auto-tunnel:        auto
```

You can also verify that the L2 table contains the MAC address corresponding to group IP `239.1.1.1` (i.e., 01:00:5e:01:01:01):

```
CLI (network-admin@switch) > l2-table-hw-show mac
01:00:5e:01:01:01

mac               vlan  vxlan  ports  state             hw-flags  mc-index
----------------- ----- -----  -----  ----------------  -------- ---------
01:00:5e:01:01:01  10    10    none   active,static,hit           201326595
```

Configuring Distributed VRF-aware vFlow

Netvisor ONE version 6.0.0 introduces Virtual Routing and Forwarding (VRF) -aware vFlows, which enables vFlows to operate at scale in a distributed VRF environment. This feature extends support for Policy Based Routing (PBR) in a VRF. By using the VRF-aware vFlow enhancement, you can implement L3 or L4 security access lists, micro-segmentation, QoS, and monitoring features in a fabric with distributed VRFs.

Configuring Distributed VRF-aware Policy Based Routing

Distributed PBR enables service insertion (adding services into the forwarding path of traffic) of constructs such as firewalls. When a firewall is inserted into a network, the traffic originating from a VRF instance needs to be redirected to the firewall or DC gateway through a next-hop address or an ECMP group.

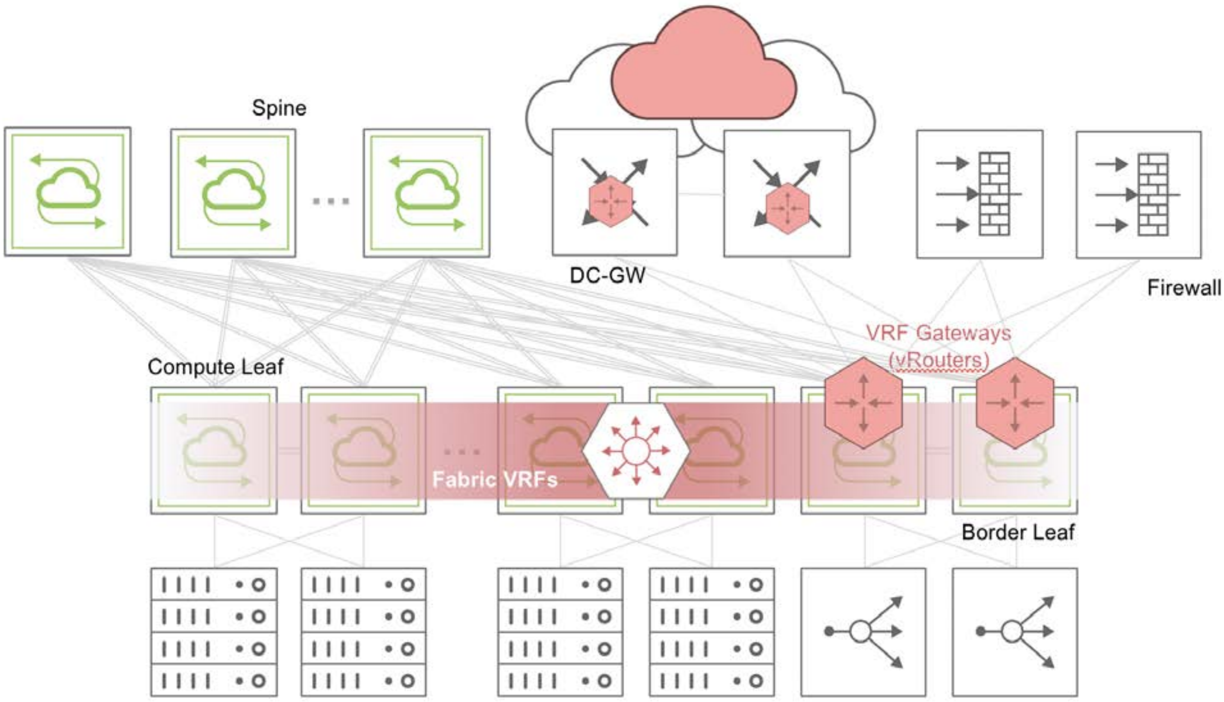


Figure 8-17 - Distributed VRF-aware Policy-based Routing

For instance, in a spine-leaf topology as shown in ***Figure 8-17***, if traffic with a source IP address of 100.1.1.10 in a VRF needs service insertion of a firewall, you can create a vFlow to redirect the traffic to a next hop address or ECMP group. When the traffic matches the source IP address of 100.1.1.10, traffic is sent to the next hop or ECMP group indicated in the vFlow, instead of being forwarded based on the Layer 3 routing entries.

You must enable PBR globally to create vFlows . You can enable PBR by using the command:

```
CLI (network-admin@switch1) > system-settings-modify policy-
based-routing
Note: nvOSd must be restarted for this setting to take effect
```

Now, create a vFlow to send the packets from the source IP address to the required next hop IP address by using the command:

```
CLI (network-admin@switch1) > vflow-create name flow1 scope
local vrf vrf-1 src-ip 100.1.1.10 action to-next-hop-ip
action-to-next-hop-ip-value  150.1.1.2
```

To view the details of the vFlow, use the command `vflow-show`:

```
CLI (network-admin@switch1) > vflow-show layout vertical
name:                          flow1
scope:                         local
type:                          pbr
src-ip:                        100.1.1.10
vrf:                           vrf-1
burst-size:                    auto
precedence:                    default
action:                        to-next-hop-ip
action-to-ecmp-group-value:    150.1.1.2
enable:                        enable
table-name:                     System-L3-L4-PBR-1-0
```

If there are multiple plausible next hop IP addresses to reach a firewall, you can perform load balancing by creating a static ECMP group and adding the next hop addresses (up to 16) to the ECMP group. Then, configure a vFlow to send the required traffic to the ECMP group and in turn, to the firewall. For details regarding configuration of ECMP groups, refer to the *Sending Network Traffic to an ECMP Group with PBR* section.

For example, to create a vFlow to send packets to a pre-configured ECMP group named `vrf_ecmp` (previously created with the `static-ecmp-group-create` command), use the `vflow-create` command with the action keyword `to-ecmp-group`:

```
CLI (network-admin@switch1) > vflow-create name flow2 scope
local in-port 23 src-ip 10.0.11.100 src-ip-mask 255.255.255.0
dst-ip 10.0.12.100 dst-ip-mask 255.255.255.0 vrf vrf-2 action
to-ecmp-group  action-to-ecmp-group-value  vrf_ecmp
```

To view the configuration details, use the `vflow-show` command:

```
CLI (network-admin@switch1)  > vflow-show
name:                          flow2
scope:                         local
type:                          pbr
in-port:                       23
src-ip:                         10.0.11.100/255.255.255.0
dst-ip:                         10.0.12.100/255.255.255.0
vrf:                           vrf-2
burst-size:                    auto
precedence:                    default
action:                        to-ecmp-group
action-to-ecmp-group-value:    vrf_ecmp
enable:                        enable
table-name:                     System-L3-L4-PBR-1-0
```

Configuring Distributed VRF-aware Security Access Lists

Netvisor ONE supports L3 and L4 security access lists for traffic in a VRF. The keywords `drop` or `none` can be supplied to the `action` parameter in the `vflow-create` command, to drop or allow packets.

For example, to drop all packets from the source IP address 100.1.1.10 in a VRF, use the command:

```
CLI (network-admin@switch1) > vflow-create name flow10 scope
local src-ip 100.1.1.10 vrf vrf5 action drop
```

To view the vFlow details, use the command `vflow-show`:

```
CLI (network-admin@switch1)  > vflow-show  layout  vertical
name:                          flow10
scope:                         local
type:                          pbr
src-ip:                        100.1.1.10
dst-ip:                        none
vrf:                           vrf5
burst-size:                    auto
precedence:                    default
action:                        drop
action-value:                  none
metadata:                      none
enable:                        enable
table-name:                     System-L3-L4-PBR-1-0
```

Configuring Distributed VRF-aware Micro-segmentation

Micro-segmentation is the process of creating secure zones within a fabric to isolate workloads. The distributed VRF-aware vFlow feature allows you to create security zones in a fabric. You can configure micro-segmentation by creating L3 or L4 filters for internal tagging during ingress and making an aggregated egress decision.

For example, define a security zone (A) in a VRF. The zones can be based on various source IP address criteria, such as, across subnets, external subnets, and intra-subnet.

Create vFlows that define zone A as the source:

```
CLI (network-admin@switch1) > vflow-create name ZONE-A-SOURCE-10.1 scope
fabric vrf VRF-1 src-ip 10.10.1.0/24 action set-metadata action-value 10
precedence 5

CLI (network-admin@switch1) > vflow-create name ZONE-A-SOURCE-10.1 scope
fabric vrf VRF-1 src-ip 10.10.128.0/20 action set-metadata action-value 10
precedence 5

CLI (network-admin@switch1) > vflow-create name ZONE-A-SOURCE-10.3 scope
```

```
fabric vrf VRF-1 src-ip 10.10.33.0/24 action set-metadata action-value 10
precedence 5

CLI (network-admin@switch1) > vflow-create name ZONE-A-SOURCE-10.4 scope
fabric vrf VRF-1 src-ip 10.10.64.0/20 action set-metadata action-value 10
precedence 5
```

Create vFlows that define zone A as the destination. These vFlows are given a lower precedence in this example.

```
CLI (network-admin@switch1) > vflow-create name ZONE-A-DESTIN-11.1 scope
fabric vrf VRF-1 dst-ip 10.10.1.0/24 action set-metadata action-value 11
precedence 3

CLI (network-admin@switch1) > vflow-create name ZONE-A-DESTIN-11.1 scope
fabric vrf VRF-1 dst-ip 10.10.128.0/20 action set-metadata action-value 11
precedence 3

CLI (network-admin@switch1) > vflow-create name ZONE-A-DESTIN-11.3 scope
fabric vrf VRF-1 dst-ip 10.10.33.0/24 action set-metadata action-value 11
precedence 3

CLI (network-admin@switch1) > vflow-create name ZONE-A-DESTIN-11.4 scope
fabric vrf VRF-1 dst-ip 10.10.64.0/20 action set-metadata action-value 11
precedence 3
```

Zone A uses metadata 10 for traffic that leaves specific IP addresses and metadata 11 for traffic that arrives at specific IP addresses. Now, you can create egress micro-segmentation rules based on the security zone. The metadata values are among the parameters that define the egress policies, and these values help in making the egress decision to send the packets out.The egress policies are defined in Egress-Table-1-0 or the Egress Content Aware Processing (ECAP) hardware filter table.

For example, to allow UDP traffic from zone A to the destination IP address 172.10.0.0/8, use the following command:

```
CLI (network-admin@switch1) > vflow-create name ZONE-A-172.10-UDP-PASS table-
name Egress-Table-1-0 vrf VRF-1 metadata 10 dst-ip 172.10.0.0/8 proto 17
action none
```

To allow TCP traffic from zone A to the destination IP address 172.10.0.0/8 and the reverse, use the set of following commands:

```
CLI (network-admin@switch1) > vflow-create name ZONE-A-172.10-TCP-PASS table-
name Egress-Table-1-0 vrf VRF-1 metadata 10 dst-ip 172.10.0.0/8 proto 6 action
none

CLI (network-admin@switch1) > vflow-create name 172.10-ZONE-A-TCP-PASS table-
name Egress-Table-1-0 vrf VRF-1 metadata 11 src-ip 172.10.0.0/8 proto 6 action
none
```

Configuring Distributed VRF-aware QoS Policies

You can use vFlows to set Differentiated Services Code Point (DSCP) and VLAN priority values for traffic in a VRF. For example, to set a DSCP value of 10 for traffic originating from 10.10.1.0/24, use the command:

```
CLI (network-admin@switch1) > vflow-create name flow5 scope
local vrf VRF_2 src-ip 10.10.1.0 action set-dscp action-value
10
```

To view the details, use the `vflow-show` command:

```
CLI (network-admin@switch1) > vflow-show layout vertical
name:                          flow5
scope:                         local
type:                          pbr
src-ip:                        10.10.1.0
dst-ip:                        none
vrf:                           vrf_2
burst-size:                    auto
precedence:                    10
action:                        set-dscp
action-value:                  10
metadata:                      none
enable:                        enable
table-name:                     System-L3-L4-PBR-1-0
```

To set a VLAN priority value of 5 for traffic from 10.10.1.1/24, use the command:

```
CLI (network-admin@switch1) > vflow-create name flow6 scope
fabric vrf VRF_3 src-ip 10.10.1.1/24 action set-vlan-pri
action-value  5
```

Configuring Distributed VRF-aware vFlow-based Monitoring

You can copy packets to a port or CPU for traffic monitoring by using the action keywords `copy-to-cpu` and `copy-to-port.`

For example, to copy the packets with the source IP address of 10.1.1.1 in vrf10 to the CPU, use the command:

```
CLI (network-admin@switch1) > vflow-create name flow5 scope
local vrf vrf10 src-ip 10.1.1.1 action copy-to-cpu
```

Use the `vflow-show` command to view the details:

```
CLI (network-admin@switch1) > vflow-show layout vertical
name:                          flow5
scope:                         local
type:                          pbr
src-ip:                        10.1.1.1
vrf:                           vrf10
burst-size:                    auto
precedence:                    default
action:                        copy-to-cpu
action-value:                  none
```

```
enable:                    enable
table-name:                System-L3-L4-PBR-1-0
```

To copy packets with a source IP 10.1.1.2 in vrf10 to port 25, use the command:

```
CLI (network-admin@switch1) > vflow-create name flow7 scope
local vrf vrf10 src-ip 10.1.1.2 action copy-to-port action-to-
ports-value 25
```

For details on vFlows, see the *Configuring and Using vFlows* chapter.

Configuring Multicast Fabric VRFs

Note: Starting from Netvisor ONE release 6.0.1, this feature is supported on NRU03 and NRU-S0301 platforms and on the Dell S4100 and S5200 Series.

Starting from Netvisor ONE release 6.1.0, this feature is supported also on the following platforms:

- Dell Z9100-ON, S5048F
- Freedom F9532L-C/Edgecore AS7712-32X
- Freedom F9532-C/Edgecore AS7716-32X
- Freedom F9572L-V/Edgecore AS7312-54XS
- Freedom F9572-V/Edgecore AS7316-54XS
- Freedom F9532C-XL-R/Edgecore AS7716-32X

The CLI commands to configure and verify distributed multicast forwarding with Multicast Fabric VRFs are described below:

```
CLI (network-admin@switch) > vrf-multicast-show
enable: yes
```

```
CLI (network-admin@switch) > vrf-multicast-modify
```

`scope local|fabric`	Specify the scope - fabric or local
`disable`	Specify to disable flooding over tunnels in DM Forwarding
`enable`	Specify to enable flooding over tunnels in DM Forwarding

Enabling or disabling Multicast Fabric VRFs takes effect only after a reboot. For example, this command disables the feature:

```
CLI (network-admin@switch) > vrf-multicast-modify disable
System must be REBOOTED for this setting to take effect
```

The above command is analogous to IGMP Snooping's insofar as you can modify the feature's state with a local or fabric scope.

With Multicast Fabric VRFs enabled, to optimize certain network designs, in more recent Netvisor ONE releases BUM traffic is *not* flooded to tunnels *by default*. However, you can use the modify command below to enable/disable flooding of BUM traffic on tunnels to cater to your network design's specific requirements. First check what is the current setting, and then modify it if needed:

```
CLI (network-admin@switch) > vrf-multicast-flood-show
enable: no

CLI (network-admin@switch) > vrf-multicast-flood-modify
scope   scope - fabric or local
disable disable flooding over tunnels in DM Forwarding
enable  enable flooding over tunnels in DM Forwarding

CLI (network-admin@switch) > vrf-multicast-flood-modify enable
```

The `vrf-mroute-show` command, can be used to show the L3 entries dynamically created to implement L3 multicast forwarding:

```
CLI (network-admin@switch) > vrf-mroute-show

srcip    group     vxlan  vlan vrid hw-group-id send-vlan ports  flags
------- --------- ----   ---- ---- ----------- --------- -----  ------
0.0.0.0 224.1.1.1 10501  501  0     0x200098a    0         none  Active
0.0.0.0 224.1.1.1 10501  501  1     0x200098a    506       1     Active
```

This command can be used to check the list of multicast destination groups, incoming VLANs, outgoing ports and egress VLANs.

The above output shows (*, 224.1.1.1, 501) with port 1 as outgoing port and 506 as egress VLAN. Note that this kind of L3 entry will only contain routed ports in the egress VLAN(s) (instead, a separate L2 entry will bridge in the ingress VLAN).

The `igmp-show` command offers a high-level view of the dynamic behavior of the feature (in this example, port 15 is the *loopback port*):

```
CLI (network-admin@switch) > igmp-show

group-ip  node-ip   vnet bd vlan port       source  node-type expires(s)
--------- --------- ---- -- ---- ---------- ------- --------- ----------
<snip>
225.1.1.1 ::                10   1275068416 0.0.0.0 host      0
225.1.1.1 ::                10   15         0.0.0.0 host      0
225.1.1.1 40.1.1.5          30   19         0.0.0.0 host      279
```

The first line is a Layer 2 entry for group 225.1.1.1 that corresponds to a logical port (1275068416), namely, to a VXLAN tunnel to replicate the multicast traffic to (as it has at least a receiver in the same VNI-mapped VLAN). More than one tunnel may be listed in this position.

The second line is dynamically programmed by the software to send a copy of the multicast traffic for group 225.1.1.1 in VLAN 10 to a special loopback port (see below) so that a second (routing) pass after recirculation can be performed. This means that there is a source sending traffic to the group on the ingress VLAN, therefore a L3 lookup can happen for local routing.

The third line (in the show output above) shows IGMP membership on port 19 in egress VLAN 30 (which needs to be routed to).

The loopback port(s) used by Multicast Fabric VRFs are called `mlb-loopback-trunk`, which is an additional loopback trunk for L3 multicast traffic only. The `vxlan-loopback-trunk` instead continues to be used for unicast traffic. While `vxlan-loopback-trunk` is auto-created, `mlb-loopback-trunk` needs to be manually created by the user.

Furthermore, under certain circumstances it may be necessary to use the following commands to add, show or delete a static IGMP entry on a port/trunk:

```
CLI (network-admin@switch) > igmp-static-group-create group-ip
239.1.1.1 vlan 10 ports 14

CLI (network-admin@switch) > igmp-static-group-show
group-ip  bd vlan ports
--------- -- ---- -----
239.1.1.1    10   14

CLI (network-admin@switch) > igmp-static-group-delete group-ip
239.1.1.1 vlan 10
```

In this example, the commands are useful for interoperability purposes when you need to simulate an IGMP join on a certain port (in this case port 14, to which a multicast receiver is indirectly connected through a third-party network). Then, when the receiver no longer needs to receive the multicast traffic, the static IGMP entry can be deleted.

Configuring Multiple VXLAN Next Hops on a Single Egress Port

Prior to the Netvsior ONE 6.1.0 release, a hardware limitation on the Broadcom ASICs allowed Netvisor ONE to configure only one egress port to next hop index (NHI) mapping per physical egress port or trunk port. This limitation obstructed the creation of multiple VXLAN tunnels in the hardware if the respective next hops resolved on the same physical port or trunk port.

From Netvisor ONE version 6.1.0 onward, you can create multiple VXLAN tunnel next hops on the same egress trunk port or physical egress port due to a resolution in the hardware restriction.

This feature is available on the following Trident3, Trident2+, and Maverick platforms of Pluribus switches:

• S5248F-ON	• S4128F-ON	• AS5812-54X
• S5224F-ON	• S4128T-ON	• AS5812-54T
• S5232F-ON	• S4112F-ON	• F9372-X
• S4148-ON	• S4112T-ON	• F9372-T
• S4148F-ON	• NRU03	
• S4148T-ON	• NRU03-S0301	

For example, consider a basic sample topology (***Figure 8-18***) consisting of four switches interconnected through physical and trunk ports. Each switch is connected to other three switches using a trunk port or a physical port (trunk port 1/ports 5, 6 in the diagram). They are also inter-connected via a layer 2 network. To build a VXLAN-based fabric, you can configure a full mesh of VXLAN tunnels connecting all the switches to one another.

Prior to Netvisor ONE version 6.1.0, the switches were unable to establish three separate VXLAN tunnels to other three switches because their next hops were all routed through the same trunk port. In other words, you could achieve only a one-to-one mapping of egress ports to VXLAN next hops.

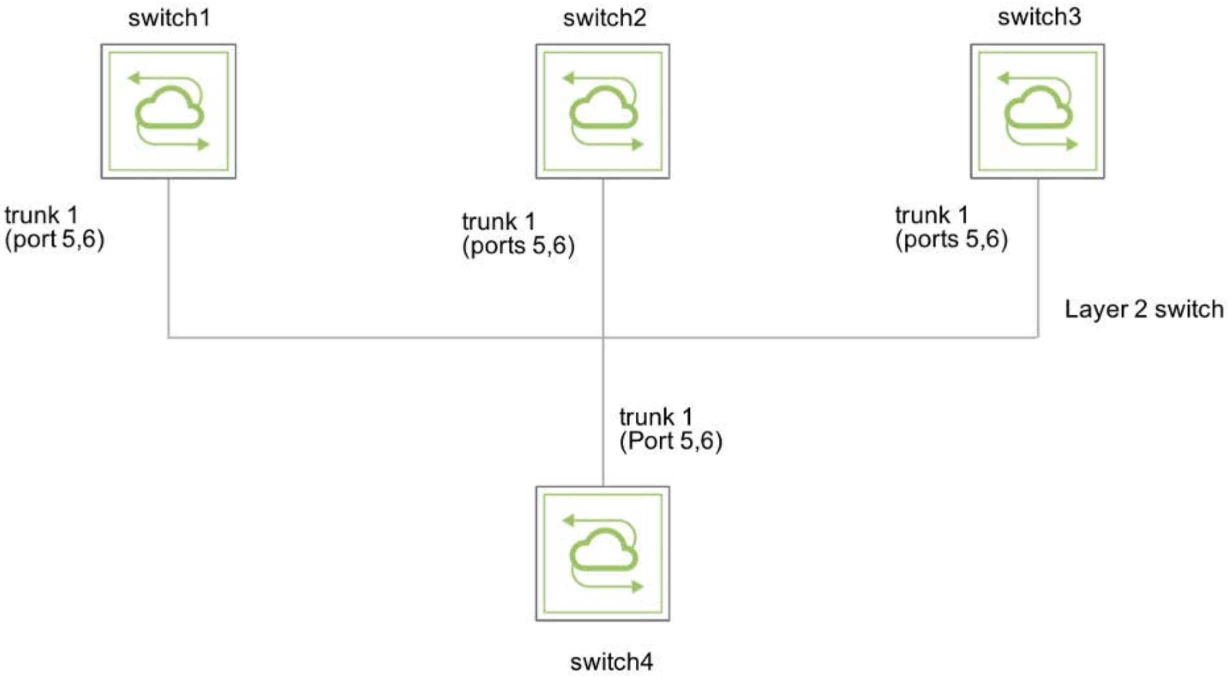


Figure 8-18 - Topology with Physical Egress Ports or Trunk Ports

With Netvisor ONE 6.1.0, you can configure a one-to-many mapping of:

- Physical egress ports to VXLAN next hops, or
- Trunk egress ports to VXLAN next hops

To configure multiple VXLAN tunnels, use the command:

```
CLI (network-admin@switch4) > tunnel-create
```

`tunnel-create`	This command creates a tunnel between two switches.
`scope local|cluster`	Specify the scope.
`name <name-string>`	Enter the name of the tunnel you want to configure.
Specify any of the following options:	
`vrouter-name <vrouter name>`	Specify the name of the vRouter service
`local-ip <ip-address>`	Specify the local IP address.
`remote-ip <ip-address>`	Specify the remote host IP address.

As an example, in the above topology (***Figure 8-18***), configure three static VXLAN tunnels to connect switch4 to switch1, switch2, and switch3 by using the commands:

```
CLI (network-admin@switch4*) > tunnel-create scope local name
tun20-9-3 vrouter-name vr-tucana local-ip 20.20.20.9 remote-ip
20.20.20.3
```

```
CLI (network-admin@switch4*) > tunnel-create scope local name
tun50-9-3 vrouter-name vr-tucana local-ip 50.50.50.9 remote-ip
50.50.50.3
```

```
CLI (network-admin@switch4*) > tunnel-create scope local name
tun80-9-3 vrouter-name vr-tucana local-ip 80.80.80.9 remote-ip
80.80.80.3
```

View the configuration details using the command:

```
CLI (network-admin@switch4*) > tunnel-show
```

scope	name	type	vrouter-name	local-ip	remote-ip	router-if	next-hop	next-hop-mac	nexthop-vlan	active	state	bfd	bfd-state	route-info	ports	auto-tunnel	mac-learning
local	tun20-9-3	vxlan	vr-tucana	20.20.20.9	20.20.20.3	eth0.20	20.20.20.3	66:0e:94:b7:e8:6b	20	yes	ok	disabled	not-replicator-vtep	20.20.20.0/24	272	static	on
local	tun50-9-3	vxlan	vr-tucana	50.50.50.9	50.50.50.3	eth1.50	50.50.50.3	66:0e:94:b7:e8:6b	50	yes	ok	disabled	not-replicator-vtep	50.50.50.0/24	272	static	on
local	tun80-9-3	vxlan	vr-tucana	80.80.80.9	80.80.80.3	eth0.80	80.80.80.3	66:0e:94:b7:e8:6b	80	yes	ok	disabled	not-replicator-vtep	80.80.80.0/24	272	static	on

The output above shows that the VXLAN tunnels are created and are functional as in ***Figure 8-19***.

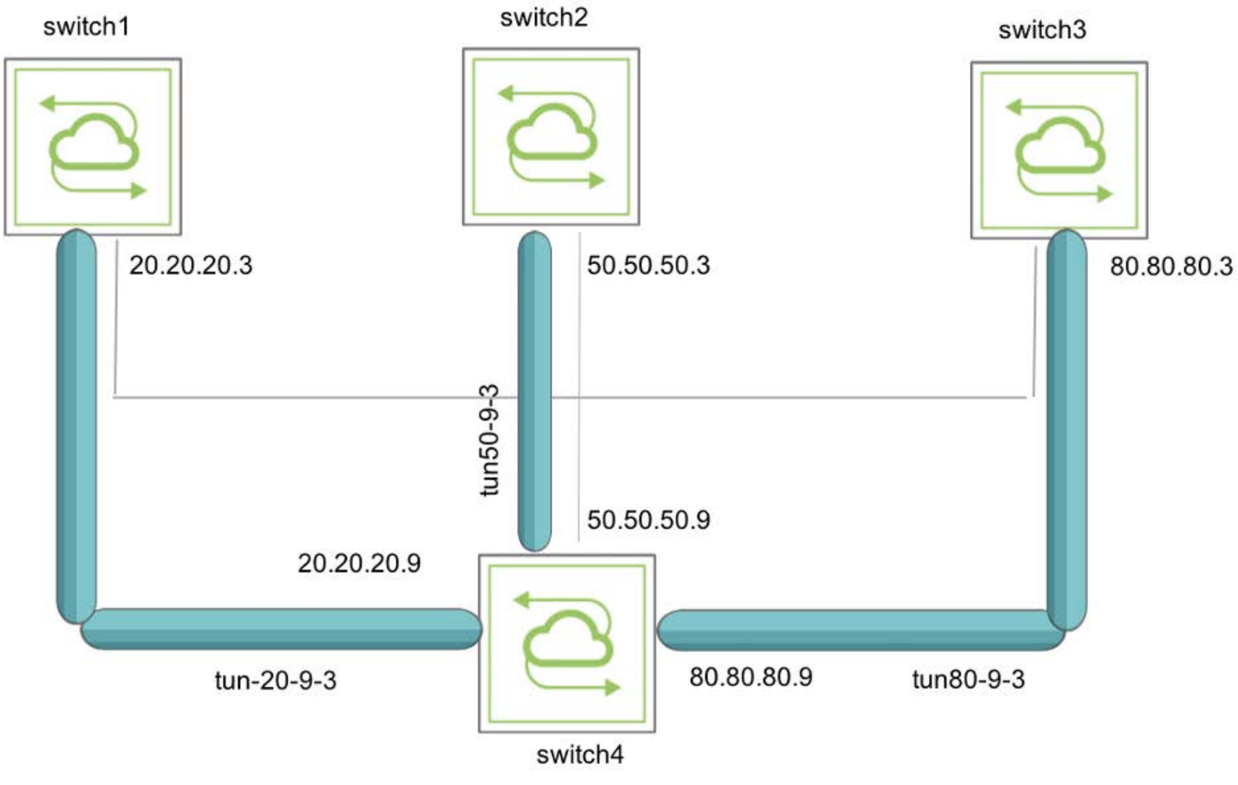


Figure 8-19 - Topology with VXLAN tunnels

To view the details of each tunnel, use the following commands:

```
CLI (network-admin@switch*) > vlan-show id 20

id type   auto-vxlan replicators scope description active stats ports       untagged-
ports active-edge-ports
-- ------ ---------- ----------- ----- ----------- ------ ----- ----------
-------------- -----------------
20 public no         none        local vlan-20     yes    yes   0-1,125,272 none
  0,272
```

```
CLI (network-admin@switch4*) > vlan-show id 50

id type   auto-vxlan replicators scope description active stats ports       untagged-
ports active-edge-ports
-- ------ ---------- ----------- ----- ----------- ------ ----- -----------
-------------- ----------------
50 public no         none        local vlan-50     yes    yes   0-1,125,272 none
  0,272

CLI (network-admin@switch*) > vlan-show id 80

id type   auto-vxlan replicators scope description active stats ports       untagged-
ports active-edge-ports
-- ------ ---------- ----------- ----- ----------- ------ ----- -----------
-------------- ----------------
80 public no         none        local vlan-80     yes    yes   0-1,125,272 none
  0,272
```

Supported Releases

Command/Parameter	Netvisor ONE Version
`trunk-modify name vxlan-loopback-trunk`	Commands with parameters first supported in *version 2.4*
`tunnel-create`	Command added in *version 1.2*. The option, `cluster`, was added to scope and the parameters, `vrouter-name` and `peer-vrouter-name`, were added in *version 2.4*.
`tunnel-vxlan-add`	*In version 1.2 the command was introduced. In version 2.4 the parameter, vxlan, was added.*
`vtep-create, vtep-delete, vtep-show`	Commands introduced in *version 2.6.0.*
`vtep-vxlan-add, vtep-vxlan-remove, vtep-vxlan-show`	Commands introduced in *version 2.6.0.*
`vrf-create, vrf-delete, vrf-modify, vrf-show, subnet-create, subnet-delete, subnet-modify, subnet-show`	Commands introduced in *version 3.0.0*
`igmp-snooping-modify vxlan|no-vxlan`	Parameter introduced in *version 3.1.1*
`vrf-multicast-modify, vrf-mroute-show`	Commands introduced in *version 5.1.0*
`vle-create, subnet-delete, subnet-modify, subnet-show`	Commands introduced in *version 2.5.4*
`vlan-create vxlan-mode standard|transparent`	In *version 2.5.2* the parameter `vxlan-mode` was added.
`vlan-create auto-vxlan`	In version 6.0.0 the parameter `auto-vxlan` was added.
`mac-learning | no-mac-learning`	Parameter introduced in version 6.0.0
`system settings-modify riot-single-pass`	Command introduced in version 6.0.0
`system-settings-modify no-single-pass-flood|single-pass-flood`	Command introduced in version 6.0.0

`system-settings-modify no-single-pass-l2-known-multicast | single-pass-l2-known-multicast`	Command introduced in version 6.0.1
`isolated`	VTEP parameter introduced in version 6.0.1
`vsg-create|delete|modify, vsg-vrf-add|remove, vsg-network-add|remove, vsg-show, vsg-vrf-show, vsg-network-show`	Commands introduced in version 6.0.1
`type isolated, promiscuous`	vSG parameters introduced in version 6.0.1
`vsg-route-add, vsg-route-remove, vsg-route-show`	Commands introduced in version 6.1.0
`anycats-mac-for-forwarding/no-anycast-mac-for-forwarding`	VRF parameters introduced in version 6.1.0

Please also refer to the Pluribus *Command Reference* document.

Related Documentation

Refer to these sections in the Configuration Guide:

- Configuring Layer 2 Features
- Configuring Layer 3 Features
- Setting up and Administering the Pluribus Fabric
- Configuring High Availability

for further information on concepts mentioned in this section (such as Layer 2, Layer 3, the fabric, clusters, vLAGs, VRRP, etc.)

Configuring VXLAN Ethernet VPN (EVPN)

This chapter provides information about the configuration of the Ethernet VPN feature on a Netvisor ONE switch using the Netvisor ONE command line interface (CLI).

Understanding EVPN

Ethernet VPN (EVPN) is a standard technology that was created to overcome some of the limitations of a popular MPLS-based technology called *Virtual Private LAN Service (VPLS)*, as specified in the respective IETF RFCs for MAN/WAN use. In particular, for example for data center deployments, it became imperative to address certain *VPLS limitations* in areas such as multihoming and redundancy, provisioning simplicity, flow-based load balancing, and multipathing.

Hence, as an evolution of VPLS, EVPN was born as a multi-protocol (MP) BGP- and MPLS-based solution in RFC 7432 (later updated by RFC 8584) to implement the requirements specified in RFC 7209.

The initial implementation of EVPN was intended to leverage the benefits of an MPLS Label Switched Path (LSP) infrastructure, such ss fast reroute, resiliency, etc. Alternatively, the EVPN RFC includes support also for an IP or IP/GRE (Generic Routing Encapsulation) tunneling infrastructure.

As a further evolution, in RFC 8365 EVPN was expanded to support various other encapsulations including a VXLAN-based transport (called overlay encapsulation type 8). By that time VXLAN had become the prevalent transport in the data center to implement virtual Layer 2 bridged connectivity between fabric nodes. So EVPN could then be used as an MP BGP-based control plane for VXLAN, with support for specialized Network Layer Reachability Information (NLRI) to communicate both Layer 2 and Layer 3 information for forwarding and tunneling purposes.

In EVPN parlance, VXLAN is a Network Virtualization Overlay (NVO) data plane encapsulation solution with its own identifiers, the VNIs (also called NVO instance identifiers). VNIs can be mapped one-to-one or many-to-one to EVPN instances (EVIs). VNIs can be globally unique identifiers (in a typical use case), but the EVPN RFC also includes support for the case when they are used as locally significant values (to mimic MPLS labels).

In a VXLAN network using EVPN, a VTEP node is called a Network Virtualization Edge (NVE) or Provider Edge (PE) node. An NVE node may be a Top-of-Rack (ToR) switch or a virtual machine, but—as we will see below—it can also be a border node.

For more details on EVPN, refer to the following IETF standards and drafts:

- RFC 7209 "Requirements for Ethernet VPN (EVPN)"
- RFC 7432 "BGP MPLS-Based Ethernet VPN"
- RFC 8365 "A Network Virtualization Overlay Solution Using Ethernet VPN (EVPN)"
- The draft-ietf-bess-evpn-prefix-advertisement-11, “IP Prefix Advertisement in EVPN”

Understanding Pluribus VXLAN EVPN Technology

Pluribus Networks' *Adaptive Cloud Fabric* offers a highly flexible approach to software-defined networking (SDN) with native support for the VXLAN transport with an optimized control plane.

As described in the *Configuring VXLAN* chapter earlier, the Pluribus fabric uses the VXLAN overlay technology for *intra-fabric connectivity*. It supports the creation of static VXLAN-based tunnels using the `tunnel-create` command. It also supports automatic tunnel creation through the *VTEP object* construct and its associated commands.

VTEP objects are fabric-scoped, making all the nodes aware of each other's VTEPs and their VNIs. Furthermore, fabric-wide Layer 2 and Layer 3 reachability information is propagated to each node inside a fabric through vPort data synchronization. Remote reachability data is leveraged to avoid the need to *flood and learn* packets. Hence, traffic forwarding is optimized.
Multi-tenancy is supported too by using highly scalable hardware-based VRF segmentation.

In this context, the EVPN technology's BGP-based control plane offers a unique opportunity to further augment the fabric's flexibility and provisioning simplicity in complex multi-pod data center network designs.

As we will describe in the following, the Pluribus Adaptive Cloud Fabric has been extended to integrate the EVPN standard as a means to improve the fabric's scalability and interconnection options between data center pods, as well as to support *multi-vendor interoperability*.

Starting from Netvisor ONE release 6.1.0, Pluribus Networks implemented the EVPN technology to interconnect multiple fabric pods and to extend the VXLAN overlay across them, supporting both IPv4 and IPv6. EVPN's powerful control plane enables network architects to build larger scale multi-pod designs, where each pod can comprise up to 32 leaf nodes. It also allows a Pluribus pod to interoperate with pods using third party vendors' nodes.

In this implementation, VTEP objects, subnets, VRFs are naturally extended to communicate across pods. To do that, Netvisor ONE leverages EVPN in a *pragmatic, integrated and standards-compatible* way to implement a BGP-based control plane that enables multi-hop VXLAN-based forwarding across pods using a number of key fabric enhancements, described in the following.

About EVPN Border Gateways

In Pluribus' fully interoperable implementation, EVPN's message exchange is supported *only* on specially designated *border nodes*, deployed individually or in redundant pairs (i.e., in clusters running VRRP).
Such border nodes are commonly called *Border Gateways (BGW)*, as they implement the *EVPN Border Gateway functions* (which we will describe in detail in the following sections). In essence, they are in charge of exchanging messages with external EVPN-capable nodes (Pluribus or other vendors' devices) and of propagating and translating external EVPN routes, where needed, within each pod, as depicted in the figure below.

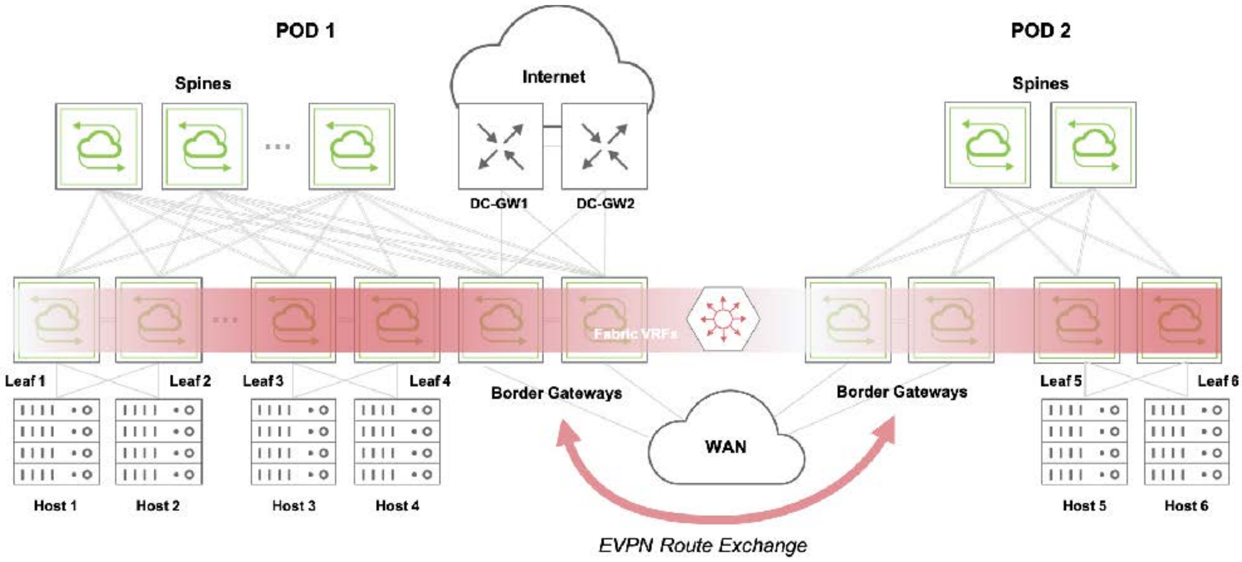


Figure 9-1: Border Gateways and EVPN Route Exchange

Border gateway nodes are identified by a special vRouter configuration that includes two steps: the vRouter must be configured with the `evpn-border` parameter and must have at least one BGP neighbor set to `l2vpn-evpn`, as described in more detail in the configuration section below.

> Note: The VXLAN EVPN border gateway functions are supported only on NRU03 and NRU-S03 platforms and on the Dell S5200 Series.

> Note: As of Netvisor ONE release 6.1.0, only leaf nodes can be designated as border gateways.

About Border Gateway Functions

EVPN border gateways implement a number of key control plane and data plane functions that guarantee multi-fabric interconnection and interoperability.

By leveraging them, Netvisor ONE can seamlessly extend VTEP objects, VNIs, subnets and VRFs across fabrics by simply leveraging the EVPN control-plane capabilities. Such capabilities are based on special *route types* specified by the standards.

Netvisor ONE supports the following EVPN route types:

- **Type 2 routes**, i.e., *MAC/IP advertisement routes*, as defined in RFC 7432. They are required to propagate MAC learning information (and optionally associated IP addresses) for device reachability purposes over a so-called *Layer 2 VNI (L2VNI)*. Additionally, MAC/IP advertisements are used to propagate host route information.

- **Type 3 routes**, i.e., *Inclusive Multicast Ethernet Tag* routes, as defined in RFC7432. They are required for Broadcast, Unknown Unicast and Multicast (BUM) traffic delivery across EVPN networks. They are used to propagate VTEP and VNI information.

- **Type 5 routes**, i.e., *IP Prefix routes*, as defined in the *EVPN Prefix Advertisement* Internet Draft. This new type was added to advertise IP prefixes independently from MAC addresses (i.e., without relying on type 2 routes). They are used to advertise subnets and VRF information (the so-called L*ayer 3 VNIs*).

The above standard route types are used to implement various networking functions:

Type 2 Route Translation Function

For inter-fabric broadcast domain and Layer 2 learning extension, border gateways translate Type 2 routes received from their peers to Netvisor ONE's vPort synchronization messages within the local fabric. Vice versa, they also translate local vPort synchronization messages to Type 2 routes and then send them over to their peers.

In other words, they act as 'language translators' because they import and export Layer 2 information to and from external EVPN nodes to keep both local and remote fabric nodes in sync.

Type 3 Route Distribution Function

To implement VXLAN-based connectivity, Netvisor ONE supports special configuration constructs called VTEP *objects*, which automatically create a mesh of tunnels between each other to establish a fabric overlay network.

VTEPs can be configured within a fabric pod or can be *external to a pod* (in which case their location is called `host-external`). See the *Configuring VTEP Objects with Automatic Fabric Connections* section for more details.

Border gateways act as proxies for the communication of the local fabric with remote VTEP objects, for the inter-pod automatic tunnel creation and the VNI configuration.

They leverage EVPN T*ype 3 routes* to propagate VTEP and VNI information within BGP messages.

Such information is used with a `local scope` by border gateways to *automatically* create `host-external` VTEPs to *locally* represent the remote border gateways' VTEP objects. In other words, these special VTEPs are proxy representations of the neighbor VTEPs in the local border gateways (for an example, refer to the configuration section below).

The name of the Type 3 route-derived *external* VTEPs contains the `__evpn__` prefix string to make them easily identifiable (and also to distinguish them from manually created `host-external` VTEPs). The name also contains the (virtual) IP address of the corresponding remote VTEP object.

The VNI information exchanged in Type 3 routes is used to compare the VNIs configured on the local VTEPs with those configured on the remote ones. If there is at least one local VNI matching an external one, VXLAN tunnels are automatically established with the neighbor EVPN VTEPs from the local ones (see ***Figure 9-2*** below for a visual representation). The automatic tunnel naming scheme prefixes the `auto-tunnel-` string to the source and destination VTEP IPs. (For more details and examples, see the configuration section below.) VNIs are added and removed dynamically based on receipt of Type 3 routes.

In summary, once VTEP objects are configured by the user in the different pods, border gateways act as inter-fabric translators of Type 3 routes to and from Netvisor ONE synchronization messages. This guarantees the full automation of the overlay creation process, not just within a single local pod but also across pods.

In addition, border gateways act as (individual or redundant) traffic forwarders for bridged traffic within the same broadcast domains.

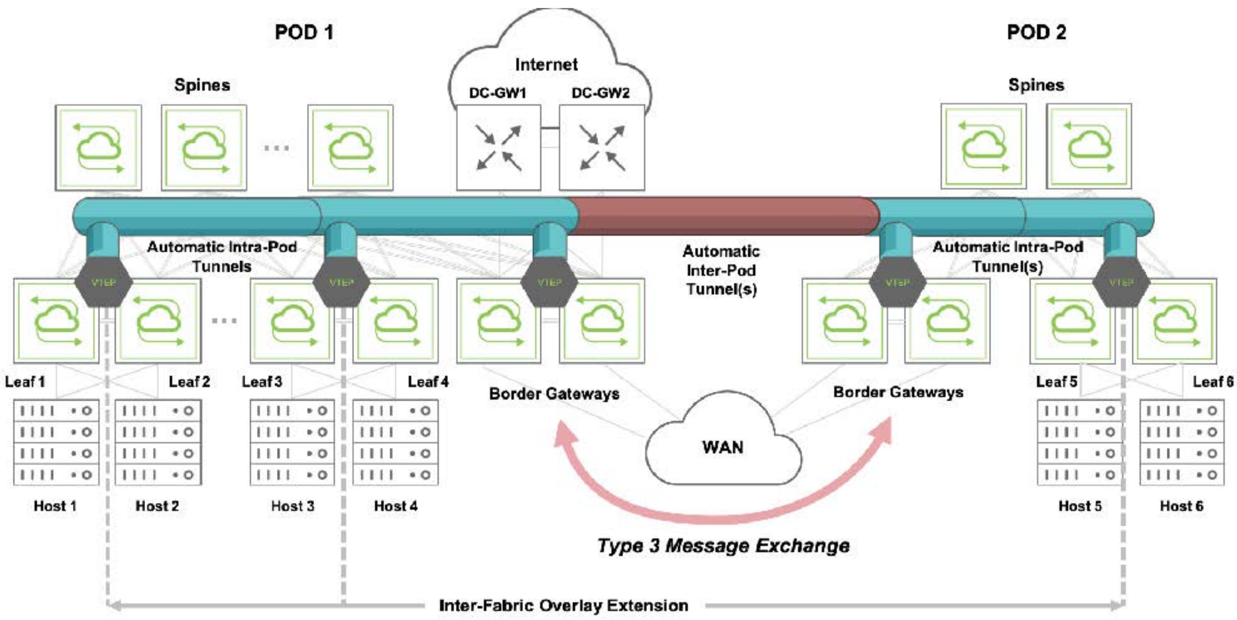


Figure 9-2: Inter-pod VXLAN Connections

Border gateways can also act as traffic forwarders for routed traffic, but that requires an additional key function as described next.

Type 5 Route Distribution Function

Netvisor ONE supports the configuration of subnet objects and VRF instances as a way to perform distributed VXLAN routing in hardware with multitenancy, as described in the *Configuring Unicast Fabric VRFs with Anycast Gateway* section.

EVPN border gateways can be used to extend subnets and associated VRFs across fabrics. For that purpose, they employ type 2 and type 5 routes which they send to their remote gateway peers to notify them of remote subnets and hosts. As a consequence, the remote border gateways can install into their routing tables *prefix routes* and *host routes* corresponding to any active remote subnets and known hosts.

In addition, subnets are associated to VRFs for route table entry segregation purposes. With EVPN, these VRFs have to be uniquely identified as part of the inter-fabric synchronization process: this task is achieved by introducing a new type of VNI, called *Layer 3 VNI*, which is uniquely associated to each VRF and is exchanged through EVPN messages between border gateways.

About Inter-Pod VXLAN Routing with Subnet Objects

When deploying subnets in a multi-pod topology running EVPN, in Pluribus parlance subnets can be of three types:

- *local* (when present only in the local pod relative to a border gateway)
- *remote* (when located on a pod different from the local one)
- *stretched* (when present in two or more pods).

> **Note**: Having a stretched subnet does not necessarily mean that there are hosts in that subnet connected to all nodes. Hosts can be connected only to a subset of the nodes.

VXLAN routing between them is possible provided certain basic configuration rules are observed:

- A local subnet must be present on all leaf nodes: for ease of configuration, that can be achieved by using `fabric scope` in the subnet creation command.
- Subnets' L2 VNIs and prefix lengths must be configured consistently across all pods.
- VRFs' L3 VNIs must be configured consistently across all pods.
- As shown in ***Figure 9-3*** below, if needed, data center gateways should be connected to the border gateways for routing of North-South traffic.

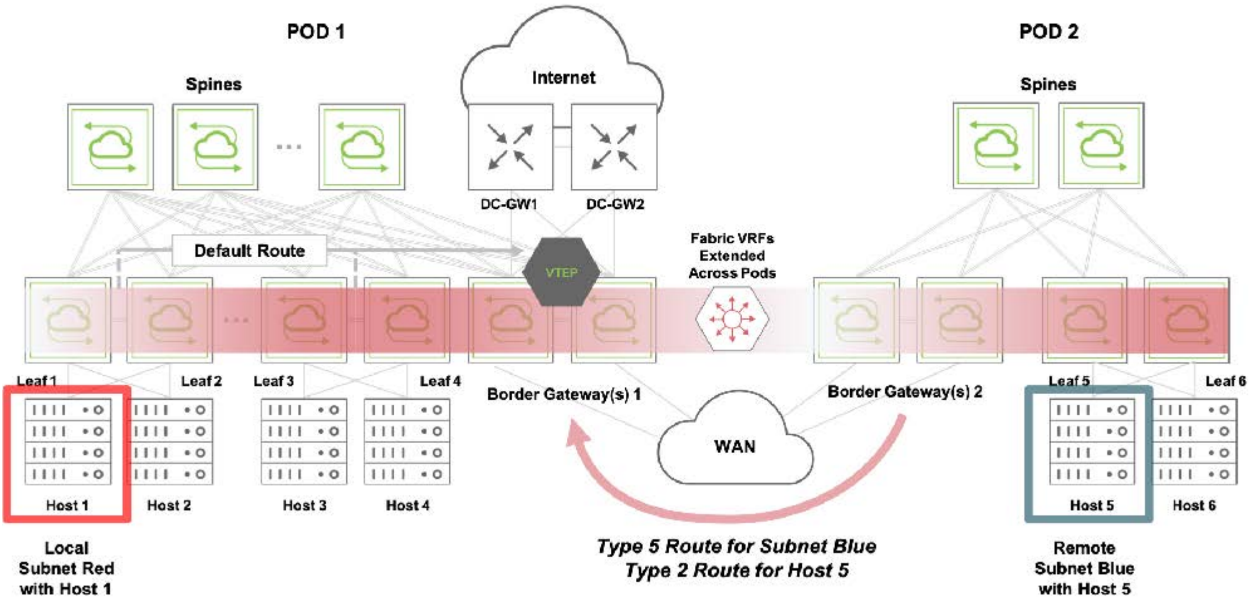


Figure 9-3: Control Plane for Inter-Pod VXLAN Routing (from Host 1 to Host 5)

In addition to the above configuration guidelines, some key automation is performed by the fabric when subnets are created: as depicted in ***Figure 9-3***, border gateways propagate local subnet information with Type 2 and Type 5 messages to their EVPN peers. Such peers then send special messages to their local fabric nodes (that are not border gateways) to automatically install a *default route* pointing to their border gateways' VTEP IP address. VXLAN traffic can then be routed to any remote pod (for example from Host 1 to Host 5, as depicted the figure above) using the *two hop model* described in the following section.

About Packet Flows for Inter-Fabric Forwarding

Let's analyze how forwarding is performed from a local subnet to a remote one, and then from a local subnet to a stretched one.

Local to Remote Subnet Forwarding

In this forwarding example, Host 1 in the local subnet (*Red*) needs to send a packet to Host 5 in a remote subnet (*Blue*), as already shown in ***Figure 9-3***.

In this scenario, as explained earlier, Border Gateways 2 (configured as a redundant pair) send Type 2 and Type 5 information to Border Gateways 1 regarding Host 5 and subnet Blue.

The fabric automation also makes sure that a default route points to Border Gateways 1's VTEP virtual address on leaf nodes 1, 2, 3 and 4. So when a packet needs to be sent from Host 1 to Host 5, a two hop forwarding process is performed as described in the next figure:

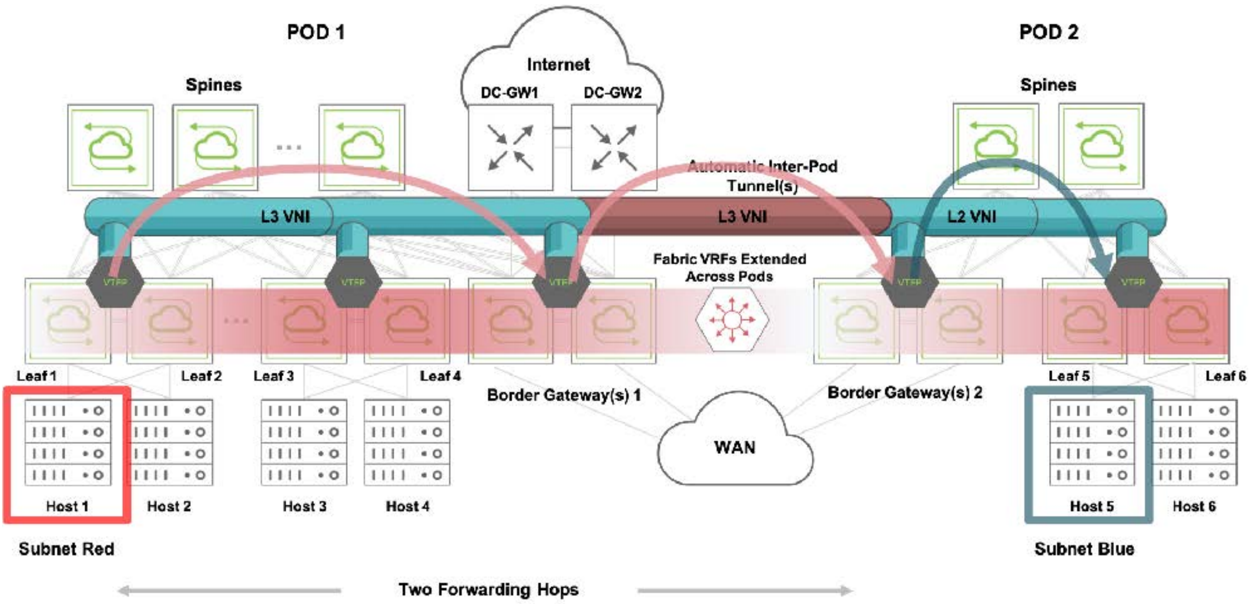


Figure 9-4: Two Hop VXLAN Routing

The packet from Host 1 is first routed to redundant Border Gateways 1 (per default route) over a VXLAN tunnel based on the VRF's L3 VNI.

Then, using the same L3 VNI, the packet is routed over a different tunnel to redundant Border Gateways 2 as the next hop. This intermediate tunnel is automatically created between the peer VTEPs of Border Gateways 1 and 2.

Lastly, when the packet reaches Border Gateways 2, the final routing from L3 VNI to subnet Blue is performed over a tunnel using subnet Blue's L2 VNI. In case the adjacency for Host 5 is not yet resolved, an ARP request is broadcast by the border gateway to all the devices in the subnet to learn about the destination address.

This multi-hop routing lookup model is also known as symmetric routing. The split horizon rule must be followed when forwarding VXLAN traffic in and out of tunnels to avoid traffic looping.

Local to Stretched Subnet Forwarding

When a subnet is present in two (or more) pods, it is called a *stretched subnet*: this case is handled differently from the above one, as shown in ***Figure 9-5*** below.

In this scenario, as seen earlier, Border Gateways 2 need to send a Type 5 route to Border Gateways 1 to advertise subnet Blue.

Moreover, since now the subnet exists in Pod 1 too (it's a *stretched subnet*), Border Gateways 1 also need to send a Type 5 route to Border Gateways 2. (In addition, subnet Red is advertised with a Type 5 route by Border Gateways 1 to Border Gateways 2.)

As soon as Host 5 is learned by its corresponding leaf node (Leaf 5), its MAC address and IP address information is sent by Border Gateways 2 to Border Gateways 1 with a Type 2 route. From there, the MAC/IP information is propagated to the rest of Pod 1 via *vPort updates*.

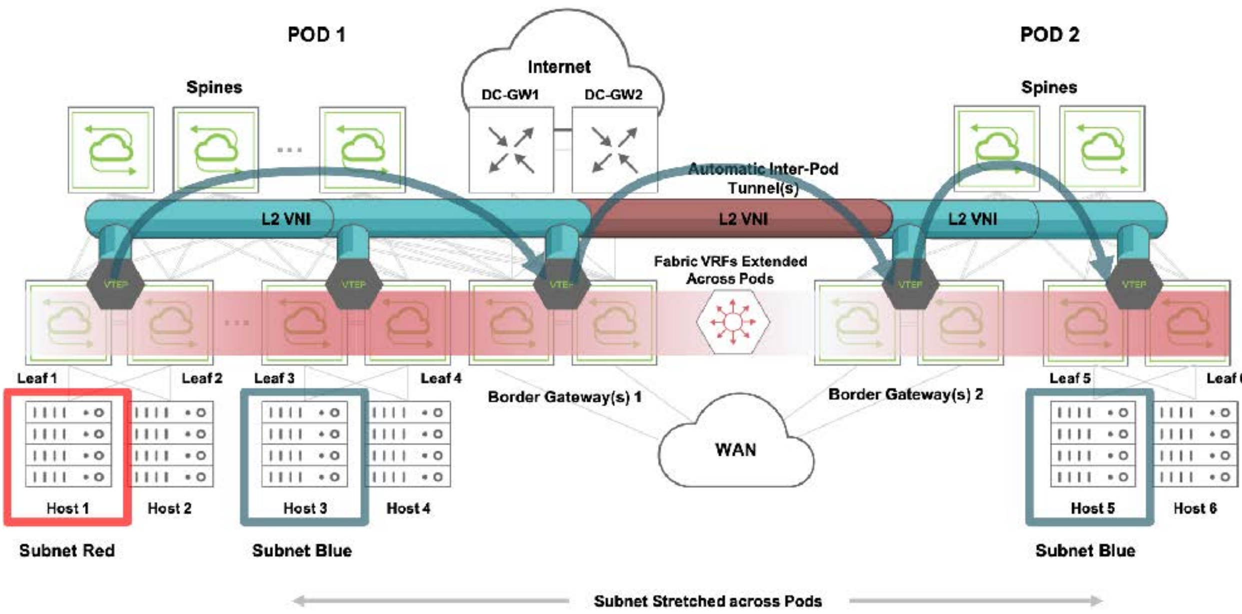


Figure 9-5: Local to Stretched Subnet Forwarding

As depicted in Figure 9-5 above, in this scenario when a packet from Host 1 needs to be routed to Host 5, it is rewritten with the destination address of Host 5 and then sent over a tunnel using *subnet Blue's* L2 VNI from the ingress node's VTEP to the local fabric's Border Gateways 1. This is also referred to as the *asymmetric routing* model. Then, using the same L2 VNI, the packet is bridged over a different tunnel to redundant Border Gateways 2.

Lastly, when the packet reaches Border Gateways 2, the usual (and final) bridging step on subnet Blue is performed over a tunnel also using subnet Blue's L2 VNI.

In the reverse direction a response from Host 5 to Host 1 would follow the packet flow described in Figure 9-4 (non-stretched case).

Since two extra hops (using border gateways) are introduced, the model is also called the *two hop VXLAN forwarding model* for EVPN multi-pod integrated routing and bridging scenarios.

In a scenario with three or more (N) pods, it's possible for a subnet to be stretched only on two (or fewer than N) pods. So a *stretched subnet* can also be a *remote subnet* for at least one pod. When a host in that pod sends traffic to the remote stretched subnet, the destination border gateways in the remote pods *may not* have an adjacency resolved for the traffic destination. In such cases, as normal, the adjacency is resolved by the border gateways by broadcasting an ARP request throughout the stretched subnet (that is, *across multiple pods*) and by learning about the destination from the ARP response. Once a destination host is discovered through this mechanism, the packet flow is the same as in ***Figure 9-4***.

About Border Gateway High Availability

Any leaf node within a fabric can be made a border gateway, as long as it has BGP connectivity to EVPN nodes outside of the fabric.

A border gateway acts as a proxy for all the VTEPs in the fabric. As seen in the previous sections, it translates Type 2, Type 3, Type 5 routes to and from the EVPN peers. That means, in Pluribus parlance, that a border gateway *assumes ownership* of the translated vPort, VTEP, VNI and prefix/VRF route information gleaned from the external messages.

There can be multiple border gateways in a fabric to act as redundant nodes to proxy all of the above information. However, to avoid conflicts, it's important to keep *sole ownership* for that information within the fabric. For that purpose, a *primary border gateway* is elected.

From a control plane perspective, border gateway nodes in cluster pairs inherit the *master* or *backup state* from the VRRP interfaces configured for their VTEPs. A fabric node state change on the primary causes the secondary border node to become primary. Upon a border gateway state change triggered by a VRRP state change, the new primary node refreshes its routes without altering the BGP neighbor state.

Similarly, from a traffic forwarding perspective, VRRP is used for the selection of the master/backup roles and for the definition of a common virtual IP (VIP) address. BGP neighborship, instead, uses each node's physical IP (PIP) address.

The elected primary border gateway is in charge of injecting vPort/VTEP/VNI information learned from its EVPN peers. It can also deactivate such information as a consequence of a remote configuration change.

The secondary node is fully active too. It can advertise local VTEP/VNI information as part of the proxying process toward the external EVPN nodes. What a secondary node cannot do, however, is to inject (or deactivate) external vPort information into the fabric. That's reserved to the primary node, that is, to the *sole owner* of such translated/proxied information.

A secondary node also periodically monitors the primary node for any loss of connectivity or possible malfunction. If an issue is detected (for example, the primary border gateway goes offline unexpectedly), the secondary node takes over the role of primary node and maintains any learned vPort database information with its newly acquired ownership. This means that there is no disruption to already established tunnels and to the traffic that is traversing such tunnels to reach external VTEPs.

About the VXLAN Loopback Trunk with EVPN

VXLAN forwarding requires hardware functions like multiple lookups, encapsulation and decapsulation operations, packet replication, etc., even more so with EVPN's two hop forwarding model. This can be implemented using the VXLAN loopback trunk (i.e., the default option).

Starting from release 6.0.0, Netvisor ONE supports single-pass VXLAN forwarding and flood as an alternative to using the VXLAN loopback trunk. With EVPN, customers using the VXLAN loopback trunk in prior releases can still use it for backward compatibility. On the other hand, single pass mode can be used on supported platforms for instance to optimize the two hop forwarding model on non-border gateway nodes.

> **Note**: As of Netvisor ONE release 6.1.0, Dell S4100, S5200 and NRU03 platforms can be used in single pass mode as non-border gateway nodes. Refer to the *Configuring the VXLAN Loopback Trunk* section in the *Configuring VXLAN* chapter for details on the configuration and platform support of single pass mode.

For nodes to be configured as border gateways and to use single pass forwarding, the node's hardware must be able to support both single pass mode and border gateway functions (for the latter refer to the platform list in the *About EVPN Border Gateways* section above).

About MAC Mobility with EVPN

A MAC address can be learned in one pod and then it can move to another pod, for example, when a virtual machine is migrated across locations. This is referred to as a 'MAC move'. Netvisor ONE supports the standard RFC 7432's *MAC Mobility Extended Community* functionality to automatically deal with MAC moves between pods.

This specialized Extended Community is added by the EVPN control plane in MAC/IP Advertisement (i.e., Type 2) routes when a MAC move is detected. It comprises a list of fields, including flags and a sequence number. The sequence number is particularly important to ensure that border gateways retain the most recent MAC/IP Advertisement route when multiple updates occur for the same MAC address.

RFC 7432 also specifies how to deal with scenarios in which MAC moves are too frequent, for instance due to a mis-configuration. In these scenarios, it is possible that MAC address duplication occurs, and hence very frequent MAC moves are triggered for an extended period of time.

In order to perform MAC address duplicate detection per the RFC, the following configuration parameters are used in conjunction with a remediation action:

- Max moves (N MAC moves, with a default value of N = 5)
- Moves duration (M-second timer, with a default value of M = 180)

The RFC states that a node must start an M timer whenever it detects a MAC move: then, if it detects N MAC moves before the timer expires, it concludes that MAC address duplication has occurred. Consequently, the node must take a remediation action (such as alerting the operator) and must stop sending and processing any BGP MAC/IP Advertisement routes for that MAC address until a corrective action is taken.

As part of this corrective action, it's possible to configure a third parameter to stop the MAC address flapping for a configurable period of time. This additional parameter defaults to 180 seconds and is called:

- Freeze duration

For more details on the configuration of the above parameters, refer to the configuration section below. (Instead, for intra-pod MAC move protection, refer to the Configuring Excessive MAC or IP Move Protection section of the *Configuration Guide*.)

About IGMP Snooping with EVPN

In case of an EVPN multi-pod network, basic IGMP Snooping support for VXLAN needs to be extended so that IGMP messages are propagated *across pods*. This is achieved as an extension of the local IGMP flooding process to forward the messages across the inter-pod automatic tunnels.

Whenever a multicast destination host sends an IGMP join or leave message for a multicast group, Netvisor ONE running on a border gateway notices that the message originated from within the pod and so floods it across the automatic tunnels between the local pod and the peer ones. Then, when the flooded IGMP message arrives at the neighbor border gateways, they in turn flood it to all the local VTEPs over the intra-pod tunnels. This results in the IGMP messages propagating to all the nodes, both intra- and inter-pod, within a flood domain. This allows the distributed control plane to learn about all the (local or remote) hosts that want to join or leave a multicast group.

As a consequence, L2 data plane forwarding rules are applied in hardware to known multicast traffic so as to limit head-end replication only to the inter-pod tunnels over which at least one remote host has indicated interest in a multicast group.

Guidelines and Limitations

As discussed above, the user should follow these basic guidelines to avoid connectivity issues:

- A local subnet must be present on all leaf nodes within the pod, which can be achieved by using *fabric scope* in the subnet creation command. (See the *Configuring VXLAN* chapter for configuration details.)
- Subnets' L2 VNIs and prefix lengths must be configured consistently across all pods.
- VRFs' L3 VNIs must be configured consistently across all pods.
- Create *fabric scoped* VLANs associated to VNIs by using the `auto-vxlan <vni-id>` keyword to automatically map them to tunnels (no need to manually configure them with the `vtep-vxlan-add` command)
- For high availability enable the `evpn-border` option on both of the clustered border gateway nodes. Only one pair of border gateway nodes is supported in a fabric pod.
- Data center gateways should be connected to the border gateways for routing of North-South traffic.

In addition, the following limitations currently exist:

- Multiple vNETs are not supported in conjunction with the EVPN border gateway configuration.
- Bridge domains and the vSG feature are only supported within a pod, i.e., they do not span across EVPN pods.

EVPN's Route Distinguisher and Route Target fields are currently propagated but are not used for filtering or other purposes.

Configuring EVPN

The configuration of EVPN revolves around the selection of the border gateway nodes and the configuration of associated VNIs for the VRFs.

In addition, the fabric automation takes care of transparently performing various configurations, which can be verified with new show commands or with new parameters of existing commands, as shown in the examples below.

Configuring the Border Gateways

The first step involves configuring the vRouters on at least two nodes across two pods to make them border gateways. That is achieved with the `vrouter-create` command using the `evpn-border/no-evpn-border` parameter. In case of an existing vRouter, the `vrouter-modify` command can be used instead.

For example:

```
CLI (network-admin@switch) > vrouter-create name vRouter1
fabric-comm enable location border-switch router-type hardware
evpn-border bgp-as 5200 router-id 10.30.30.30
```

Then the `vrouter-show` command can be used to verify the current EVPN parameter configuration:

```
CLI (network-admin@switch) > vrouter-show name vRouter1 format
all layout vertical
id:                          c00029d:0
name:                        vRouter1
type:                        vrouter
scope:                       fabric
vnet:
location:                    switch
zone-id:                     c00029d:1
router-type:                 hardware
evpn-border:                 enable
```

The second step is for the user to configure an MP BGP neighbor with the `l2vpn-evpn` parameter to point to an external EVPN border gateway:

```
CLI (network-admin@switch) > vrouter-bgp-add vrouter-name
vRouter1 neighbor 190.12.1.3 remote-as 65012 ebgp-multihop 3
update-source 190.11.1.3 multi-protocol l2vpn-evpn
```

This configuration enables the use of the standard EVPN NLRI, which is carried using BGP *Multiprotocol* Extensions with an Address Family Identifier (AFI) of 25 (*L2VPN*) and a Subsequent Address Family Identifier (SAFI) of 70 (*EVPN*).

Configuring L3 VNIs

To uniquely identify VRF instances with EVPN it is necessary to specify a new `l3-vni` parameter during creation (or modification), like so:

```
CLI (network-admin@switch) > vlan-create id 1000 auto-vxlan
101000 scope fabric ports none
```

```
CLI (network-admin@switch) > vrf-create name VRF1 l3-vni
101000
```

As explained in more detail in the *Configuring VXLAN* chapter, subnets can be mapped to VRFs with the `subnet-create` command, for example:

```
CLI (network-admin@switch) > vlan-create id 12 auto-vxlan
500012 scope fabric
```

```
CLI (network-admin@switch) > subnet-create name subnet-vxlan-
500012 scope fabric vxlan 500012 network 172.10.2.0/24
anycast-gw-ip 172.10.2.1 vrf VRF1
```

L3 VNIs also enable a new forwarding mode (see the two hop model described above), which is used for inter-pod VXLAN routing.

Once configured, you can check the VRFs with the `vrf-show` command:

```
CLI (network-admin@switch) > vrf-show format
name,vnet,anycast-mac,l3-vni,active,hw-router-mac,hw-
vrid,flags,enable
```

```
name vnet anycast-mac       l3-vni active hw-router-mac     hw-vrid flags
enable
---- ---- ----------------- ------ ------ ----------------- ------- ------
------
VRF1 0:0  64:0e:94:40:00:02 101000 yes    66:0e:94:48:68:a7 1       subnet yes
```

Note that the user doesn't need to confgure `vrf-gw` and `vrf-gw2` with EVPN except on border gateways connected to DC gateways for North South traffic. Traffic reaches the border gateways with the default route described in ***Figure 9-3*** above.

Configuring and Displaying MAC Mobility

MAC mobility is handled automatically by the EVPN control plane. However, it is important to deal with duplicate MAC address scenarios appropriately. Therefore, some special parameters are available to help with the remediation in such scenarios, as explained in the *About MAC Mobility with EVPN* section above.

You can (optionally) configure the three duplicate MAC address parameters on a per vRouter basis with the following command:

```
CLI (network-admin@switch) > vrouter-create name <vr-name>
```

```
evpn-dup-addr-max-moves  <count>  evpn-dup-addr-moves-duration
<seconds>  evpn-dup-addr-freeze  <seconds>
```

When not specified, the default values are:

- evpn-dup-addr-max-moves: 5
- evpn-dup-addr-moves-duration: 180
- evpn-dup-addr-freeze: 180

You can also modify those parameters with the `vrouter-modify` command.

For example, let's consider the case in which those three parameters are modified from the default values and are configured to 8, 401 and 301, respectively. You can display the new values with the following condensed command:

```
CLI (network-admin@switch*) > vrouter-show format name,evpn-
border,evpn-dup-addr-max-moves,evpn-dup-addr-moves-
duration,evpn-dup-addr-freeze,evpn-border
```

```
name      evpn-border  evpn-dup-addr-max-moves(s)  evpn-dup-addr-moves-duration(s)  evpn-dup-
addr-freeze
--------  -----------  -------------------------   ------------------------------
--------------------
vRouter1 enable      8                          401                                301
vRouter1 enable      8                          401                                301
```

In this case, if 8 MAC moves are detected in a 401 second time window, the duplicate MAC address entry is frozen for 301 seconds to facilitate the operator in the remediation. The frozen entry and the corresponding sequence number received before the 8th MAC move can be displayed with the following command:

```
CLI  (network-admin@switch)  >  vrouter-evpn-duplicate-mac-show
switch       vrouter-name     host-mac          seq
------------ -------------- ----------------- ---
switch       vRouter1        00:12:c0:80:33:6a 7
```

This output will clear after *dup-addr-freeze* (180, by default) seconds have elapsed.

Furthermore, the total MAC move count can be periodically checked in the MM (MAC Move) field with this command:

```
CLI (network-admin@switch) > switch * vrouter-evpn-bgp-routes-
show route-type 2 format vrouter-name,rd,vni,mac,route-
type,next-hop,extended-community
```

```
switch  vrouter-name rd         vni    mac               route-type next-hop  path  extended-community
------- ------------ --------- ------ ----------------- ---------- --------- ----- ------------------------
switch  vr2          2.2.0.1:2 100100 2e:d7:27:b9:11:6d 2          20.0.12.1 66001 RT:465:100100 ET:8 MM:48
switch1 vr1          2.2.0.1:2 100100 2e:d7:27:b9:11:6d 2          20.0.12.1 66001 RT:465:100100 ET:8 MM:48
```

In addition, typically for troubleshooting purposes, you can see each MAC move being notified and logged on a node by using the following command and looking for the string `action  MAC_MOVE`:

```
CLI (network-admin@switch) > vrouter-log-show vrouter-name vr2
protocol  evpnsnoop
```

```
log-message

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
--------------------------------------------------------------
-------------------------------------------------------------------------------
-----------------------------
<snip>
2021-05-21,05:24:26.075.:rs_msg.c:624:rs_msg_vport_update_event_cb    L2_UPDATE
mac: 2e:d7:27:b9:11:6d,  log_type l2-modify caller cluster-status: vxlan
100100, vlan 100 reason:modify,evpn-mac-move owner_flags 0x0, over_
tunnel 1791,  2e:d7:27:b9:11:6d action MAC_MOVE ip 10.0.100.30
<snip>
```

which shows the MAC move happening due to a certain host configured with a certain MAC and IP address pair. That information can be compared to the same command output obtained on the other node where the address duplication is also happening.

Displaying VXLAN Features with EVPN

A multi-pod EVPN configuration requires the extension of the intra-pod features commonly used for single-fabric setups. Therefore, before proceeding, refer to the VXLAN commands described in the *Configuring VXLAN* chapter above for reference.

VTEPs are the VXLAN termination points: Netvisor ONE provides a CLI construct called *VTEP object* to automatically set up a mesh of bidirectional connections between the end points.
Multi-pod EVPN designs comprise two or more pods in which at least one node per pod is designated as *border gateway*, as explained earlier. Border gateways are interconnected by EVPN-derived automatic VXLAN tunnels, as shown in dark red color in the figure below for POD 1 and POD 2.

In the network design in ***Figure 9-6***, for redundancy, two pairs of clustered leaf nodes are selected as border gateways (highlighted in yellow and green).

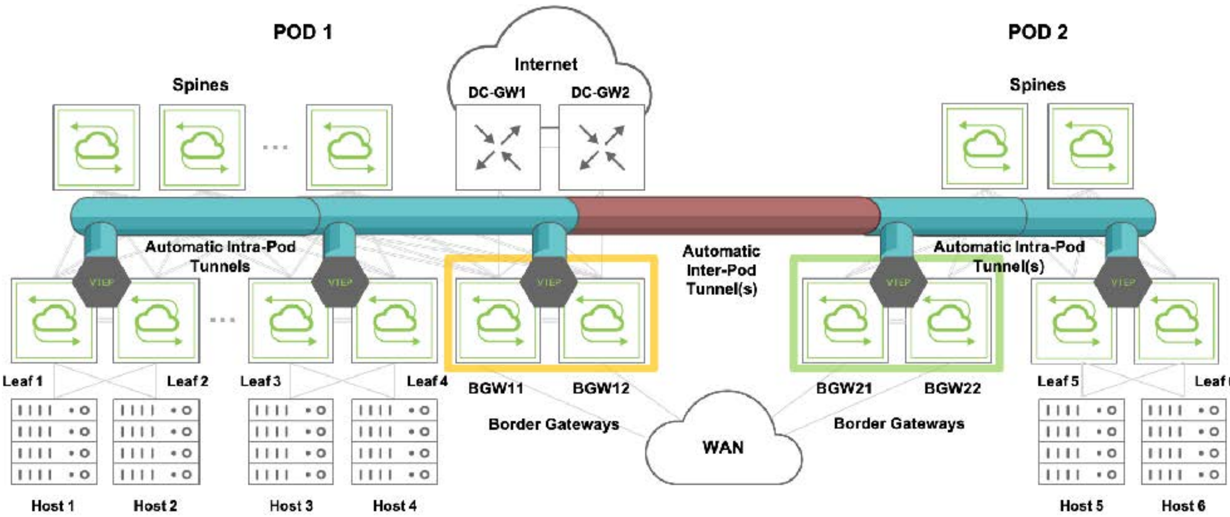


Figure 9-6: Border Gateways vs. Non-Border Gateways

Displaying VTEPs

VTEPs can be created normally in each pod on all the leaf node pairs to automatically set up the intra-pod tunnels (in blue color in the figure above).
However, when the border gateways are configured and actively exchanging EVPN messages a pair of automatic VTEP objects (and the corresponding tunnels) are created as displayed in the output below:

```
CLI (network-admin@bgw11) > vtep-show format
switch,scope,name,location,vrouter-name,ip,virtual-ip,

switch scope  name                 location      vrouter-name    ip           virtual-ip
------ ------ -------------------- ------------- --------------- ------------ ------------
       fabric vtep-leaf1           leaf1         vrouter-leaf-1  172.16.128.1 172.16.128.3
```

```
       fabric vtep-leaf2          leaf2         vrouter-leaf-2  172.16.128.2 172.16.128.3
       fabric vtep-leaf3          leaf3         vrouter-leaf-3  172.16.129.1 172.16.129.3
       fabric vtep-leaf4          leaf4         vrouter-leaf-4  172.16.129.2 172.16.129.3
       fabric vtep-leaf5          leaf5         vrouter-leaf-5  172.16.130.1 172.16.130.3
       fabric vtep-leaf6          leaf6         vrouter-leaf-6  172.16.130.2 172.16.130.3
       fabric vtep-bgw11          bgw11         vrouter-bgw-11  172.16.133.1 172.16.133.3
       fabric vtep-bgw12          bgw12         vrouter-bgw-12  172.16.133.2 172.16.133.3
bgw11  local  __evpn__172.16.134.3 host-external                172.16.134.3 ::
bgw12  local  __evpn__172.16.134.3 host-external                172.16.134.3 ::
```

Each automatic VTEP is created with a local scope and the `host-external` location string on the two border gateways only. The name starts with the __evpn__ string followed by the (virtual) IP address of the neighboring border gateway (pair).

EVPN VTEPs can be displayed with the following command and identified from their name and from the `vtep-source` column:

```
CLI (network-admin@bgw11*) > vtep-show format name,vtep-source
name                  vtep-source
--------------------  -----------
vtep-bgw11            config
__evpn__172.16.134.3  evpn
```

Displaying Automatic Tunnels

Tunnels are created automatically between border gateways for inter-pod communication. They can be identified from the `type` column in the following command:

```
CLI (network-admin@bgw11*) > tunnel-show format name,type,
name                                    type
-------------------------------------   ----------
auto-tunnel-190.11.1.1_65.1.1.10        vxlan
auto-tunnel-172.16.133.3_172.16.134.3   vxlan-evpn
```

Displaying EVPN Border Gateways

The role of border gateway, as configured by the user, can be shown with the expanded `vtep-show format all` command that includes the `evpn-border` column:

```
CLI (network-admin@bgw11) > vtep-show format all
```

```
switch scope  name                 location     vrouter-name   ip          virtual-ip   mac              description
mac-learning evpn-border
------ ------ ------------------- ------------ -------------- ----------- ----------- ----------------- -----------
------------ -----------
       fabric vtep-leaf1          leaf1        vrouter-leaf-1  172.16.128.1 172.16.128.3 00:00:5e:00:01:01            on
          false
       fabric vtep-leaf2          leaf2        vrouter-leaf-2  172.16.128.2 172.16.128.3 00:00:5e:00:01:01            on
          false
       fabric vtep-leaf3          leaf3        vrouter-leaf-3  172.16.129.1 172.16.129.3 00:00:5e:00:01:02            on
          false
       fabric vtep-leaf4          leaf4        vrouter-leaf-4  172.16.129.2 172.16.129.3 00:00:5e:00:01:02            on
          false
       fabric vtep-leaf5          leaf5        vrouter-leaf-5  172.16.130.1 172.16.130.3 00:00:5e:00:01:03            on
          false
       fabric vtep-leaf6          leaf6        vrouter-leaf-6  172.16.130.2 172.16.130.3 00:00:5e:00:01:03            on
          false
       fabric vtep-bgw11          bgw11        vrouter-bgw-11  172.16.133.1 172.16.133.3 00:00:5e:00:01:06            on
          true
       fabric vtep-bgw12          bgw12        vrouter-bgw-12  172.16.133.2 172.16.133.3 00:00:5e:00:01:06            on
          true
bgw11  local  __evpn__172.16.134.3 host-external               172.16.134.3 ::          00:00:00:00:00:00            on
          false
bgw12  local  __evpn__172.16.134.3 host-external               172.16.134.3 ::          00:00:00:00:00:00            on
          false
```

The role of a border gateway can also be verified by using the `vrouter-show` command; however, the basic command may not be sufficient. To obtain additional info, you may use the `format-all` option. Alternatively, you can use the `evpn-border` filter to display only the border gateway node(s) for example like so:

```
CLI (network-admin@bgw11) > vrouter-show format name,hw-
router-mac,evpn-border
```

```
name             hw-router-mac     evpn-border
--------------- ----------------- -----------
vrouter-bgw-11  66:0e:94:14:f3:5b enable
vrouter-bgw-12  66:0e:94:22:d7:1c enable
vrouter-leaf-1  66:0e:94:ad:d4:41 disable
vrouter-leaf-2 66:0e:94:95:f9:74  disable
<snip>
```

The border gateway role is also reflected in the BGP configuration, as discussed above and as shown in this command output:

```
CLI (network-admin@bgw11*) > vrouter-bgp-show multi-protocol
l2vpn-evpn
```

```
vrouter-name    neighbor     remote-as next-hop-self prepend replace-as ebgp-multihop update-source route-reflector-client
override-capability soft-reconfig-inbound max-prefix-warn-only bfd multi-protocol weight default-originate neighbor-
keepalive-interval(s) neighbor-holdtime(s) dup-addr-max-moves(s) dup-addr-moves-duration(s) dup-addr-freeze connect-retry-
interval(s) send-community allowas-in allowas-in-origin as-override advertisement-interval(s) description
-------------- ------------ --------- ------------ ------- ---------- ------------ ------------ ---------------------
------------------ -------------------- ------------------- --- ------------- ------ ----------------
```

```
---------------------------- ------------------- -------------------- ------------------------- --------------
------------------------ ------------- ---------- ---------------- ---------- ------------------------ ----------
vrouter-bgw-11  172.16.134.1 66611     no           yes     no        4           172.16.133.1  no
no                  yes                  no                    no  l2vpn-evpn     none   no                 60
             180                 5                     180                        180            15
  yes            no         no                no         0                        none
vrouter-bgw-11  172.16.134.2 66611     no           yes     no        4           172.16.133.1  no
no                  yes                  no                    no  l2vpn-evpn     none   no                 60
             180                 5                     180                        180            15
  yes            no         no                no         0                        none
```

The above verbose command output can be compacted, for example like so, to get an abridged overview of the EVPN neighborship:

```
CLI (network-admin@bgw11*) > vrouter-bgp-show format
,neighbor,remote-as,update-source,multi-protocol

vrouter-name   neighbor      remote-as update-source multi-protocol
-------------- ------------ --------- ------------- --------------
vrouter-bgw-11 172.16.0.161 64311                   ipv4-unicast
vrouter-bgw-11 172.16.2.161 64312                   ipv4-unicast
vrouter-bgw-11 172.16.4.161 64313                   ipv4-unicast
vrouter-bgw-11 172.16.6.161 64314                   ipv4-unicast
vrouter-bgw-11 172.16.133.2 64518                   ipv4-unicast
vrouter-bgw-11 101.1.1.1    60000                   ipv4-unicast
vrouter-bgw-11 172.16.134.1 66611     172.16.133.1  l2vpn-evpn
vrouter-bgw-11 172.16.134.2 66611     172.16.133.1  l2vpn-evpn
```

Displaying VNIs

VTEPs' VNI associations can be displayed with the `vtep-vxlan-show` command locally on the border gateway(s):

```
CLI (network-admin@bgw11*) > vtep-vxlan-show
name                 vxlan  isolated
-------------------- ------ --------
vtep-leaf1           10201  no
vtep-leaf1            103501 no
vtep-leaf1           10403  no
vtep-leaf2           10201  no
vtep-leaf2            103501 no
vtep-leaf2           10403  no
vtep-leaf3           10201  no
vtep-leaf3            103501 no
vtep-leaf3           10403  no
vtep-leaf4           10201  no
vtep-leaf4            103501 no
vtep-leaf4           10403  no
vtep-leaf5           10201  no
vtep-leaf5            103501 no
vtep-leaf5           10403  no
vtep-leaf6           10201  no
vtep-leaf6            103501 no
vtep-leaf6           10403  no
vtep-bgw11           10201  no
vtep-bgw11            103501 no
```

```
vtep-bgw11             10403  no
vtep-bgw12             10201  no
vtep-bgw12             103501 no
vtep-bgw12             10403  no
__evpn__172.16.134.3  10201   no
__evpn__172.16.134.3  103501  no
```

In the above example, note that VNIs 10201 and 103501 are present on all the leaf nodes including the border gateways' VTEPs and the automatically created `host-external` ones.
In other words, this command can be used to verify that the inter-pod VNIs are configured consistently on each pod's VTEPs and that, as a consequence, the common VNIs get added to the automatic inter-pod tunnels too.

Let's suppose the number of VNIs grows pretty large. Then, you can limit the output of the display for example to a particular EVPN VTEP of interest, like so:

```
CLI (network-admin@bgw11*) > vtep-vxlan-show name
__evpn__172.16.134.3
name                  vxlan  isolated
--------------------  ------ --------
__evpn__172.16.134.3  10201   no
__evpn__172.16.134.3  10202   no
__evpn__172.16.134.3  10203   no
__evpn__172.16.134.3  10204   no
__evpn__172.16.134.3  10205   no
...
```

Displaying EVPN Route Types

In order to display the supported EVPN route types for VXLAN (encapsulation type 8) received by a border gateway node, you can use the following command:

```
CLI (network-admin@bgw11*) > vrouter-evpn-bgp-routes-show
format   vrouter-name,rd,vni,network,route-type,next-
hop,path,extended-community
```

```
vrouter-name   rd            vni    network                 route-type next-hop     path extended-community
------------- ------------- ------ ----------------------- ---------- ------------ ----
------------------------------------------
vrouter-bgw-11 0.0.0.0:2      103501 [24]:[10.2.3.0]         5          172.16.133.3      ET:8 RT:64518:103501
Rmac:00:00:5e:00:01:06
vrouter-bgw-11 0.0.0.0:2      103501 [24]:[10.2.4.0]         5          172.16.134.3      RT:1075:103501 ET:8
Rmac:00:00:5e:00:01:01
vrouter-bgw-11 0.0.0.0:2      103501 [24]:[10.2.4.0]         5          172.16.134.3      RT:1075:103501 ET:8
Rmac:00:00:5e:00:01:01
vrouter-bgw-11 192.168.0.11:3 10201  [48]:[00:3b:01:00:00:01] 2         172.16.133.3      ET:8 RT:64518:10201
vrouter-bgw-11 192.168.0.11:3 10201  [32]:[172.16.133.3]     3          172.16.133.3      ET:8 RT:64518:10201
vrouter-bgw-11 192.168.0.11:4 10403  [32]:[172.16.133.3]     3          172.16.133.3      ET:8 RT:64518:10403
vrouter-bgw-11 192.168.0.13:3 10404  [32]:[172.16.134.3]     3          172.16.134.3      RT:1075:10404 ET:8
vrouter-bgw-11 192.168.0.13:4 10201  [48]:[00:3d:01:00:00:01] 2         172.16.134.3      RT:1075:10201 ET:8
vrouter-bgw-11 192.168.0.13:4 10201  [32]:[172.16.134.3]     3          172.16.134.3      RT:1075:10201 ET:8
vrouter-bgw-11 192.168.0.14:3 10404  [32]:[172.16.134.3]     3          172.16.134.3      RT:1075:10404 ET:8
vrouter-bgw-11 192.168.0.14:4 10201  [48]:[00:3d:01:00:00:01] 2         172.16.134.3      RT:1075:10201 ET:8
vrouter-bgw-11 192.168.0.14:4 10201  [32]:[172.16.134.3]     3          172.16.134.3      RT:1075:10201 ET:8
```

Note that the route type is listed in a separate column. The EVPN route contents are shown in the `network` column (IP addresses for type 5, MAC addresses for type 2, etc.).

Also note that EVPN Route Targets (RT) and Route Distinguishers (RD) are displayed. The RT field is used to transport the *VNI values*.
You can selectively display a single route type with these commands:

```
CLI (network-admin@bgw11*) > vrouter-evpn-bgp-routes-show
route-type 2 format vrouter-name,rd,vni,network,route-
type,next-hop,path,extended-community
```

```
vrouter-name   rd             vni   network                 route-type next-hop     path
extended-community
------------- ------------- ----- ----------------------- ---------- ----------- ----
-------------------
vrouter-bgw-11 192.168.0.11:3 10201 [48]:[00:3b:01:00:00:01] 2          172.16.133.3
 ET:8 RT:64518:10201
vrouter-bgw-11 192.168.0.13:4 10201 [48]:[00:3d:01:00:00:01] 2          172.16.134.3
 RT:1075:10201 ET:8
vrouter-bgw-11 192.168.0.14:4 10201 [48]:[00:3d:01:00:00:01] 2          172.16.134.3
 RT:1075:10201 ET:8
```

```
CLI (network-admin@bgw11*) > vrouter-evpn-bgp-routes-show
route-type 3 format vrouter-name,rd,vni,network,route-
type,next-hop,path,extended-community
```

```
vrouter-name   rd             vni   network             route-type next-hop     path
extended-community
------------- ------------- ----- ------------------ ---------- ----------- ----
-------------------
vrouter-bgw-11 192.168.0.11:3 10201 [32]:[172.16.133.3] 3          172.16.133.3      ET:8
RT:64518:10201
vrouter-bgw-11 192.168.0.11:4 10403 [32]:[172.16.133.3] 3          172.16.133.3      ET:8
RT:64518:10403
vrouter-bgw-11 192.168.0.13:3 10404 [32]:[172.16.134.3] 3          172.16.134.3
RT:1075:10404 ET:8
vrouter-bgw-11 192.168.0.13:4 10201 [32]:[172.16.134.3] 3          172.16.134.3
RT:1075:10201 ET:8
vrouter-bgw-11 192.168.0.14:3 10404 [32]:[172.16.134.3] 3          172.16.134.3
RT:1075:10404 ET:8
vrouter-bgw-11 192.168.0.14:4 10201 [32]:[172.16.134.3] 3          172.16.134.3
RT:1075:10201 ET:8
```

```
CLI (network-admin@bgw11*) > vrouter-evpn-bgp-routes-show
route-type 5 format vrouter-name,rd,vni,network,route-
type,next-hop,extended-community
```

```
vrouter-name   rd        vni    network         route-type next-hop     extended-community
------------- --------- ------ --------------- ---------- ------------ ----------------------------------------
vrouter-bgw-11 0.0.0.0:2 103501 [24]:[10.2.3.0] 5          172.16.133.3 ET:8 RT:64518:103501 Rmac:00:00:5e:00:01:06
vrouter-bgw-11 0.0.0.0:2 103501 [24]:[10.2.4.0] 5          172.16.134.3 RT:1075:103501 ET:8 Rmac:00:00:5e:00:01:01
vrouter-bgw-11 0.0.0.0:2 103501 [24]:[10.2.4.0] 5          172.16.134.3 RT:1075:103501 ET:8 Rmac:00:00:5e:00:01:01
```

Displaying VRFs

VRF information, including the associated L3 VNIs, can be displayed with the command:

```
CLI (network-admin@bgw11*) > vrf-show
```

```
name       vnet scope  anycast-mac       vrf-gw vrf-gw2 vrf-gw-ip6 vrf-gw2-ip6 l3-vni active hw-router-mac     hw-vrid flags
 enable description
---------- ---- ------ ---------------- ------ ------- ---------- ----------- ------ ------ ---------------- -------
------ ------ -----------
vrf-pod1-1 0:0  fabric 64:0e:94:40:00:02 ::     ::      ::         ::          103501 yes    66:0e:94:13:bd:c8 1
subnet yes
```

Subnet information, including the associated VRF, can be displayed with the command:

```
CLI (network-admin@bgw11*) > subnet-show
```

```
name       scope   vlan vxlan vrf          network      anycast-gw-ip packet-relay forward-
proto state  enable
-------- ------ ---- ----- ---------- ----------- ------------- ------------
------------- ----- ------
vlan-403 fabric 403  10403 vrf-pod1-1 10.2.3.0/24 10.2.3.1       disable       dhcp
  ok    yes
```

Displaying Routing Information

To verify the RIB routes associated with EVPN, you can use either of the following commands:

```
CLI (network-admin@bgw11*) > vrouter-rib-routes-show vrid 1
```

```
vrid ip        prelen number-of-nexthops nexthop      flags                vnet bd vlan
intf-ip   intf-id
---- -------- ------ ------------------ ------------ ------------------ ---- -- ----
-------- -------
1    10.2.4.0 24     1                  172.16.134.3 in-hw,evpn                 3501 ::
     10
1    10.2.3.0 24     1                  10.2.3.1     in-hw,local-subnet         403
10.2.3.1  11
```

CLI (network-admin@bgw11*) > vrouter-rib-routes-show vrid 1 flags evpn

```
vrid ip        prelen number-of-nexthops nexthop      flags      vnet bd vlan intf-ip
intf-id
---- -------- ------ ------------------ ------------ ---------- ---- -- ---- -------
-------
1    10.2.4.0 24     1                  172.16.134.3 in-hw,evpn       3501 ::      10
```

On non-border gateway nodes (such as Leaf 1), you can verify the presence of an automatically created default route pointing to the border gateway(s) with either of the following commands:

```
CLI (network-admin@leaf1*) > vrouter-rib-routes-show vrid 1
```

```
vrid ip        prelen number-of-nexthops nexthop      flags                vnet bd vlan
intf-ip   intf-id
```

```
---- -------- ------ ----------------- ----------- ----------------- ---- -- ----
-------- -------
1    0.0.0.0  0      1                 172.16.133.3 in-hw,evpn           3501 ::
     8
1    10.2.3.0 24     1                 10.2.3.1     in-hw,local-subnet       403
10.2.3.1  9
```

```
CLI (network-admin@leaf1*) > vrouter-rib-routes-show vrid 1
flags evpn
```

```
vrid ip       prelen number-of-nexthops nexthop       flags       vnet bd vlan intf-ip intf-
id
---- ------- ------ ----------------- ----------- ---------- ---- -- ---- -------
-------
1    0.0.0.0 0      1                 172.16.133.3 in-hw,evpn         3501 ::      8
```

In this case the default gateway points to a VIP address of a redundant border gateway pair, which can be displayed like so:

```
CLI (network-admin@bgw11*) > vrouter-interface-show is-vip
true
```

```
vrouter-name   nic        ip              mac              vlan vlan-type nic-state is-vip vrrp-id vrrp-primary vrrp-state
mtu  priority-tag
------------- ---------- -------------- ---------------- ---- --------- ---------   ------ ------- -----------
---------- ---- ------------
vrouter-bgw-11 eth21.3808 172.16.133.3/29 00:00:5e:00:01:06 3808 public    up        true   6       eth20.3808   master
9216 off
```

Displaying BGP Neighbor Information

To display BGP neighbors associated with EVPN, you can use the following command:

```
CLI (network-admin@bgw11*) > vrouter-evpn-bgp-neighbor-
summary-show format all
```

```
vrouter-name    neighbor      ver as     msg-rcvd msg-sent Tb/Ver InQ OutQ up/down   state
     pfxrcd
-------------- ------------ --- ----- -------- -------- ------ --- ---- --------
----------- ------
vrouter-bgw-11 172.16.134.1 4   65011 122       226       0       0   0    00:00:39 Connect
    0
vrouter-bgw-11 172.16.134.2 4   65011 83        190       0       0   0    00:07:36
Established  4
```

Displaying vPort Information

On a non-border gateway node such as Leaf 1, you can verify the vPort database information associated with the EVPN control plane by using the following command:

```
CLI (network-admin@leaf1*) > vport-show state evpn
```

```
owner mac               vxlan  state vtep-ip
----- ----------------- ------ ----- ------------
leaf1 64:0e:94:40:00:02 10201  evpn  172.16.133.3
leaf1 64:0e:94:40:00:02 103501 evpn  172.16.133.3
```

Displaying Additional BGP Control Plane Information

EVPN uses BGP as control plane to exchange various kinds of information that are necessary for proper network functioning, such as VNI values, MAC/IP address pair entries (as found in ARP caches), and Layer 2 address information.

Note that the EVPN control plane in Netvisor ONE is divided into two layers. The higher layer comprises the familiar Netvisor ONE commands, which provide a holistic view on the network entities as described in the above sections. Instead, the lower layer (also known as FRR) provides a low-level 'raw' view on certain control plane functions.

For troubleshooting purposes, it can be useful to check that the upper layer and the lower layer information match.

For instance, it is possible to verify the list of active VNIs on a Border Gateway with the familiar 'high-level' `vtep-vxlan-show` command. For example, on `bgw21` (limited to `vtep-leaf2` for brevity's sake) the command output shows:

```
CLI (network-admin@bgw21*) > vtep-vxlan-show name vtep-leaf2
sort-asc vxlan,

name       vxlan  isolated
---------- ------ --------
vtep-leaf2 10110  no
vtep-leaf2 10112  no
vtep-leaf2 10120  no
vtep-leaf2 10121  no
vtep-leaf2 10122  no
vtep-leaf2 10130  no
vtep-leaf2 10131  no
vtep-leaf2 10140  no
vtep-leaf2 10145  no
vtep-leaf2 10146  no
vtep-leaf2 10147  no
vtep-leaf2 10148  no
vtep-leaf2 10149  no
vtep-leaf2 10150  no
```

The same VNI information can be checked also in the low-level 'raw' control plane view with the `vrouter-evpn-bgp-vni-show` command, which additionally shows that the VNIs are transported in the RT values. The command also shows that Netvisor ONE imports and exports all RTs from/to neighbor switches:

CLI (network-admin@bgw21*) > vrouter-evpn-bgp-vni-show sort-asc vni,

```
switch vrouter-name vni    type rd         import-rt    export-rt
------ ------------ ------ ---- ---------- ------------ ------------
bgw21  bgw21-vr     10110  2    2.4.0.1:15 65012:10110  65012:10110
bgw21  bgw21-vr     10112  2    2.4.0.1:27 65012:10112  65012:10112
bgw21  bgw21-vr     10120  2    2.4.0.1:30 65012:10120  65012:10120
bgw21  bgw21-vr     10121  2    2.4.0.1:35 65012:10121  65012:10121
bgw21  bgw21-vr     10122  2    2.4.0.1:39 65012:10122  65012:10122
bgw21  bgw21-vr     10130  2    2.4.0.1:16 65012:10130  65012:10130
bgw21  bgw21-vr     10131  2    2.4.0.1:17 65012:10131  65012:10131
```

```
bgw21  bgw21-vr     10140  2    2.4.0.1:20 65012:10140  65012:10140
bgw21  bgw21-vr     10145  2    2.4.0.1:33 65012:10145  65012:10145
bgw21  bgw21-vr     10146  2    2.4.0.1:13 65012:10146  65012:10146
bgw21  bgw21-vr     10147  2    2.4.0.1:19 65012:10147  65012:10147
bgw21  bgw21-vr     10148  2    2.4.0.1:32 65012:10148  65012:10148
bgw21  bgw21-vr     10149  2    2.4.0.1:12 65012:10149  65012:10149
bgw21  bgw21-vr     10150  2    2.4.0.1:28 65012:10150  65012:10150
```

Similarly, it is possible to check the Layer 3 table's contents (MAC/IP address pairs) populated by EVPN and then also verify that the low-level entries match. For that you can use the following two commands (in this example, for the sake of brevity, only the entries associated with VLAN 211 and VNI 10211 are shown):

```
CLI (network-admin@bgw21*) > l3-table-show vlan 211

mac                ip                 vlan vxlan state
-----------------  -----------------  ---- ----- -----------
00:11:01:00:00:06 100.0.211.6          211  10211 active,evpn
00:11:01:00:00:02 2000::100:0:211:2 211  10211 active,evpn
00:11:01:00:00:0a 2000::100:0:211:a 211  10211 active,evpn
00:11:01:00:00:04 100.0.211.4          211  10211 active,evpn
00:11:01:00:00:03 2000::100:0:211:3 211  10211 active,evpn
00:11:01:00:00:07 100.0.211.7          211  10211 active,evpn
00:11:01:00:00:05 2000::100:0:211:5 211  10211 active,evpn
00:11:01:00:00:08 2000::100:0:211:8 211  10211 active,evpn
00:11:01:00:00:07 2000::100:0:211:7 211  10211 active,evpn
00:11:01:00:00:09 100.0.211.9          211  10211 active,evpn
00:11:01:00:00:05 100.0.211.5          211  10211 active,evpn
00:11:01:00:00:04 2000::100:0:211:4 211  10211 active,evpn
00:11:01:00:00:08 100.0.211.8          211  10211 active,evpn
00:11:01:00:00:02 100.0.211.2          211  10211 active,evpn
00:11:01:00:00:03 100.0.211.3          211  10211 active,evpn
00:11:01:00:00:0a 100.0.211.10         211  10211 active,evpn
00:11:01:00:00:06 2000::100:0:211:6 211  10211 active,evpn
00:11:01:00:00:09 2000::100:0:211:9 211  10211 active,evpn
```

The corresponding low-level command is:

```
CLI (network-admin@bgw21*) > vrouter-evpn-arp-cache-show vni
10211

name     vni   ip                mac               remote-vtep type   state
remote-seq  local-seq
-------- ----- ----------------- ----------------- ----------- ------ ------
----------  ---------
bgw21-vr 10211 2000::100:0:211:8 00:11:01:00:00:08 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.7       00:11:01:00:00:07 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.6       00:11:01:00:00:06 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:9 00:11:01:00:00:09 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:a 00:11:01:00:00:0a 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.3       00:11:01:00:00:03 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:6 00:11:01:00:00:06 7.1.1.1     remote active 0
```

```
         0
bgw21-vr 10211 100.0.211.2       00:11:01:00:00:02 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:7 00:11:01:00:00:07 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:4 00:11:01:00:00:04 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.10      00:11:01:00:00:0a 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.8       00:11:01:00:00:08 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:2 00:11:01:00:00:02 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.4       00:11:01:00:00:04 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.5       00:11:01:00:00:05 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.1       00:11:01:00:00:01 7.1.1.1     remote active 0
         0
bgw21-vr 10211 100.0.211.9       00:11:01:00:00:09 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:3 00:11:01:00:00:03 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:1 00:11:01:00:00:01 7.1.1.1     remote active 0
         0
bgw21-vr 10211 2000::100:0:211:5 00:11:01:00:00:05 7.1.1.1     remote active 0
         0
```

Furthermore, to check the Layer 2 table's contents (e.g., the MAC addresses learned locally and remotely via EVPN) and then also to verify that the low-level entries match, you can use the following two commands (in this example, for the sake of brevity, only the entries associated with VNI 10211 are displayed):

```
CLI (network-admin@bgw21*) > l2-table-show vlan 211 format
mac,vlan,vxlan,ip,state,peer-state,peer-owner-state,status
```

```
mac               vlan vxlan ip                  state       peer-state  peer-owner-state
status
----------------- ---- ----- ------------------- ----------- ----------- ----------------
------
00:11:01:00:00:01 211  10211 2000::100:0:211:1   tunnel,evpn evpn-wo-bgp

00:11:01:00:00:04 211  10211 2000::100:0:211:4   tunnel,evpn

00:12:01:00:00:08 211  10211 2000::100:0:211:107 tunnel      tunnel      active
 host
00:11:01:00:00:08 211  10211 2000::100:0:211:8   tunnel,evpn

00:11:01:00:00:07 211  10211 2000::100:0:211:7   tunnel,evpn

00:12:01:00:00:01 211  10211 2000::100:0:211:100 tunnel      tunnel      active
 host
00:11:01:00:00:05 211  10211 2000::100:0:211:5   tunnel,evpn

00:12:01:00:00:06 211  10211 2000::100:0:211:105 tunnel      tunnel      active
 host
00:11:01:00:00:03 211  10211 2000::100:0:211:3   tunnel,evpn

00:11:01:00:00:02 211  10211 2000::100:0:211:2   tunnel,evpn

00:12:01:00:00:02 211  10211 2000::100:0:211:101 tunnel      tunnel      active
 host
```

```
00:11:01:00:00:06 211  10211 2000::100:0:211:6   tunnel,evpn

00:12:01:00:00:07 211  10211 2000::100:0:211:106 tunnel      tunnel      active
 host
00:12:01:00:00:05 211  10211 2000::100:0:211:104 tunnel      tunnel      active
 host
00:12:01:00:00:0a 211  10211 2000::100:0:211:109 tunnel      tunnel      active
 host
00:11:01:00:00:0a 211  10211 100.0.211.10        tunnel,evpn

00:12:01:00:00:03 211  10211 2000::100:0:211:102 tunnel      tunnel      active
 host
00:12:01:00:00:04 211  10211 2000::100:0:211:103 tunnel      tunnel      active
 host
00:11:01:00:00:09 211  10211 2000::100:0:211:9   tunnel,evpn

00:12:01:00:00:09 211  10211 2000::100:0:211:108 tunnel      tunnel      active
 host
```

In the above command output it's possible to look at the state of a MAC address entry to check if it's learned from a local `tunnel` and/or from the `evpn` control plane. When the `peer-state is evpn-wo-bgp`, it means that the entry was learned (initially) directly from the data plane.

The corresponding low-level command to check the Layer 2 entries is:

```
CLI (network-admin@bgw21*) > vrouter-evpn-vni-mac-show vni 
10211

vrouter-name  vni    mac                type    intf/remote-vtep vlan  local-seq  remote-seq
------------  -----  -----------------  ------  ---------------- ----  ---------  ----------
bgw21-vr      10211  00:12:01:00:00:02  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:12:01:00:00:0a  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:05  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:11:01:00:00:0a  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:07  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:02  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:09  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:07  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:11:01:00:00:04  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:03  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:08  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:08  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:01  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:11:01:00:00:03  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:06  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:12:01:00:00:01  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:09  remote  7.1.1.1          0     0          0
bgw21-vr      10211  00:12:01:00:00:05  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:12:01:00:00:04  local   9000becvni10211  0     0          0
bgw21-vr      10211  00:11:01:00:00:06  remote  7.1.1.1          0     0          0
```

Displaying EVPN Route History Information

Displaying EVPN route history information is useful to verify the inter-pod information exchanged over type 2, 3 and 5 messages and for forensic tracing.

To display the type 2 route history, you can use the `vport-history-show` command. For example, to display the injected (i.e., created/added) vPorts, you can use:

```
CLI (network-admin@bgw21) > vport-history-show caller inject,
within-last 2d

time           log-type  reason owner mac               vxlan state vtep-ip
-------------- --------- ------ ----- ----------------- ----- ----- ---------
01-18,06:33:40 l2-modify create bgw21 66:0e:94:3f:64:4a 40400 evpn  20.0.12.1
```

Or you can use this command to show all the latest actions, for example limited to a certain VNI:

```
CLI (network-admin@bgw21*) > vport-history-show within-last 2d
vxlan 100200 state evpn-wo-bgp,

time           log-type  reason owner mac               vlan vxlan  state
hostname  status
-------------- --------- ------ ----- ----------------- ---- ------ ------------------
--------  -----------
01-18,06:23:37  l2-modify  modify  bgw21  20:04:0f:12:95:62  200   100200  tunnel,evpn-wo-bgp
bgw21      PN-internal
01-18,06:23:52  l2-modify  modify  bgw21  50:9a:4c:d3:fd:f0  200   100200  tunnel,evpn-wo-bgp
bgw21      PN-internal
01-18,06:29:34  l2-modify  flush   bgw21  20:04:0f:12:95:62  200   100200  evpn-wo-bgp
        bgw21     PN-internal
01-18,06:29:34  l2-modify  flush   bgw21  50:9a:4c:d3:fd:f0  200   100200  evpn-wo-bgp
        bgw21     PN-internal
```

You can display the type 5 route history with the following command, for example filtered for a specific address:

```
CLI (network-admin@bgw21) > vrouter-rib-history-show within-
last 2d flags evpn, ip 200.1.1.0

time           caller reason vrid ip        prelen nexthop    flags      vlan intf-ip
-------------- ------ ------ ---- --------- ------ ---------- ---------- ---- --------
01-17,17:12:12 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,20:17:32 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,20:26:39 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,20:56:09 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,21:09:06 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,21:23:45 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,21:32:43 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,21:36:37 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,21:42:27 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,22:50:22 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,23:32:06 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,23:32:07 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
01-17,23:35:48 vrf    add    1    200.1.1.0 24     190.12.1.1 in-hw,evpn 3434 33.3.3.3
```

Furthermore, to see the type 3 message-triggered VTEP changes you can filter the audit log with grep, for example like so:

```
CLI (network-admin@bgw21*) > log-audit-show name user_command
format message, | grep evpn

message

-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
-------------------------------------------------------
```

```
----------------------------------------------------------------------
Command "vtep-create scope local vtep-source evpn name __evpn__190.12.1.1 location
16777214 ip 190.12.1.1" result success

Command "vtep-vxlan-add name __evpn__190.12.1.1 vxlan 10400" result success

<snip>
```

Supported Releases

Command/Parameter	Netvisor ONE Version
`evpn-border/no-evpn-border, l2vpn-evpn, l3-vni, state evpn`	Parameters added in version 6.1.0
`vrouter-evpn-bgp-routes-show, vrouter-evpn-bgp-neighbor-summary-show, vrouter-evpn-bgp-vni-show, vrouter-evpn-arp-cache-show, vrouter-evpn-vni-mac-show`	Commands added in version 6.1.0
`evpn-dup-addr-max-moves, evpn-dup-addr-moves-duration, evpn-dup-addr-freeze`	Parameters added in version 6.1.1
`vrouter-evpn-duplicate-mac-show`	Command added in version 6.1.1

Please also refer to the *Pluribus Command Reference* document.

Related Documentation

For further information on concepts mentioned in this section, refer to these sections of the Configuration Guide:

- *Configuring Layer 3 Features*
- *Configuring and Administering the Pluribus Fabric*
- *Configuring High Availability*
- *Configuring VXLAN*

for further information on concepts mentioned in this section (such as Layer 2, Layer 3, etc.)

Configuring Advanced Layer 2 Transport Services

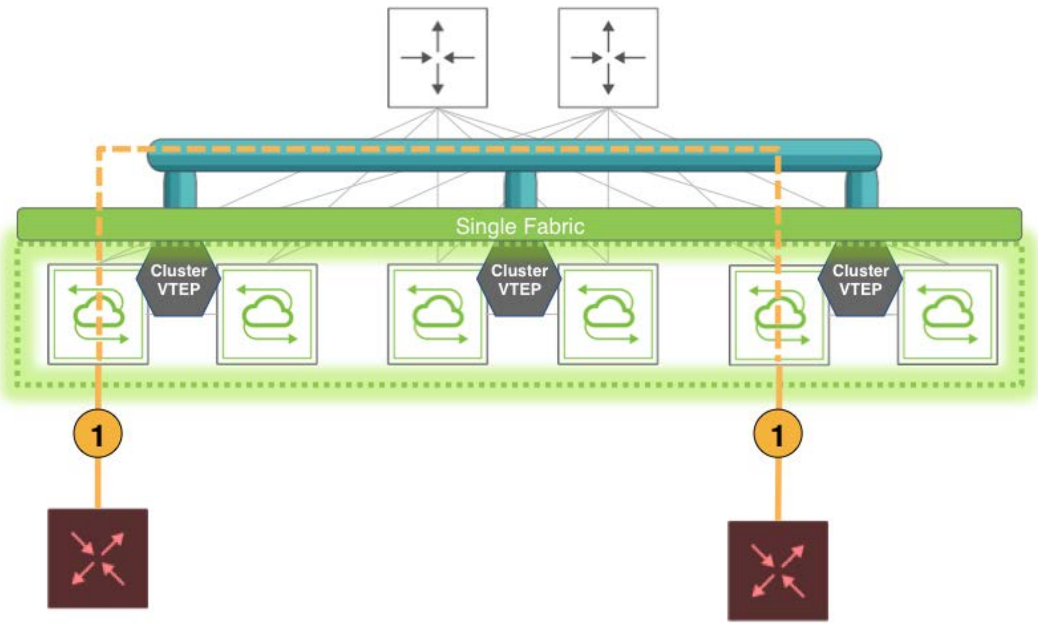
This chapter provides information about the Advanced Layer 2 Transport Services on a Netvisor ONE switch using the Netvisor ONE command line interface (CLI).

Understanding Virtual Link Extension (vLE)

Pluribus Networks offers a highly flexible approach to software-defined networking (SDN), called *Adaptive Cloud Fabric*, which leverages a sophisticated distributed architecture in order to enable organizations to build scalable private and public clouds with the very desirable benefits of ease of management, reliability, security and performance.

With regard to ease of management and flexibility, the VXLAN technology described in the *Understanding VXLAN* chapter augments the Adaptive Cloud Fabric with a plethora of advanced capabilities. Among such features is the ability to natively transport traffic across the VXLAN fabric for end-to-end data center connectivity through overlay bridging and distributed routing.

Furthermore, in certain scenarios, network administrators have the requirement for the VXLAN fabric to be able to transport traffic *transparently* between two different ports as if interconnected through a *virtual pipe*: in other words, what comes in on one end goes out of the other end. This capability is often referred to as a '*pseudo-wire*' in the literature. Pluribus calls it a *virtual wire*.
Pluribus Virtual Link Extension (vLE) implements a transparent point-to-point virtual link over the VXLAN fabric to emulate the connectivity of an actual wire interconnecting any two fabric ports selected by the user, as shown in ***Figure 10-1*** below.



Logical View of a vLE

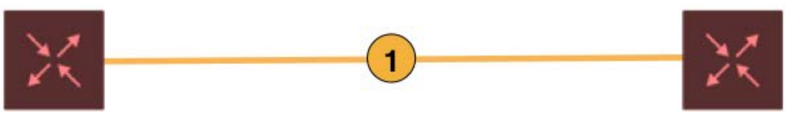


Figure 10-1: Virtual Link Extension over the VXLAN Fabric

The key characteristic of a vLE is its ability to take what comes in on the local end of the virtual pipe and send it to the remote end. That includes regular data plane traffic as well as Layer 2 PDUs.

Hence, one application of Pluribus' Virtual Link Extension feature is the remote monitoring of traffic between two fabric ports.

Another common use case is *lab automation*, i.e., the flexible interconnection of lab equipment through the fabric: with multiple vLEs the port interconnections can be dynamically (for example, programmatically) managed by the lab administrator through the creation of ad-hoc virtual pipes.

This type of use case is sometimes also referred to as '*IP Virtual Wire*' (as it runs on top of a VXLAN overlay) or '*Virtual Wire+*' to distinguish it from the regular (Layer 1) VirtualWire™ functionality (refer to the *Configuring VirtualWire Deployment Guide*). It is usually deployed with *error transparency* enabled (see below for more details).

From an implementation perspective, it should be noted that the Adaptive Cloud Fabric can transport multiple vLEs across a common high-performance VXLAN-based interconnect, thus enabling a very high degree of configuration flexibility and scalability. The main network constraint is the maximum bandwidth available on any of the shared physical links, which however can be scaled using higher speed Ethernet ports or trunks to avoid any chokepoints.

From a network design standpoint, in terms of ease of configuration, vLEs can use manual or automatic VXLAN tunnels to piggyback the mirrored traffic end-to-end and thus they enjoy the same wide-spanning benefits of any other VXLAN-based feature. The only constraint is that they cannot share the same VXLAN tunnels with other features.

Alternatively, the Pluribus UNUM™ management platform can be leveraged to very effectively perform the provisioning of the entire vLE deployment in very few steps. First, a Layer 3 fabric can be deployed from a UNUM Layer-3 Playbook. Then, *Manager --> Services --> Manage VLE* can be used to create and manage one or more vLEs through user-friendly configuration forms. (Refer to the UNUM Fabric Manager documentation for more details.)

Finally, programmatic creation and management of vLEs can be performed through REST APIs.

About Virtual Link Extension State Tracking

Just as in the case of physical back-to-back Ethernet connections, it is usually desirable that if one end of a vLE goes down the peer end mirrors that state change.

This behavior is called *link state tracking*. With such symmetric behavior, link state changes can be propagated end-to-end and hence network nodes or endpoints are able to react to them.

In other words, when a vLE is created with tracking enabled between two physical ports of two switches, the vLE remains up as long as both physical ports are in the link up state.

When a vLE is created with tracking enabled between two trunk ports (a.k.a. port channels), the vLE stays up as long as at least one member port in the trunk is up and the remote trunk is also up. When the last trunk member goes down, the vLE is brought down. (Note that when you configure vLE tracking on a trunk port, you cannot configure tracking on individual trunk members.)

In the CLI link state tracking can be enabled/disabled over each vLE individually through the `tracking|no tracking` option. (In fact, having tracking enabled may not be required in all cases, such as for troubleshooting purposes.) Similarly, in the Pluribus UNUM management platform the `tracking|no tracking` option corresponds to a true/false configuration checkbox to be ticked by the user.

For more CLI configuration details refer to the *Configuring Virtual Link Extension State Tracking* section below. Refer to the UNUM Fabric Manager documentation for the specific pane and dashboard layout details for the link state tracking configuration checkbox.

The `node-1-port` and `node-2-port` are the names of the two vLE endpoints whose link state can be tracked. When `node-1-port` goes down the `vle-show` command can be used to check and display the overall vLE state, which is `local-down`. When `node-2-port` goes down, instead, the `vle-show` command displays the `remote-down` state.

If needed, as part of the vLE configuration, it is also possible to tweak the timing to be used by the tracking logic to detect a port down state and to trigger a (virtual) link down event.

For more details refer to the following sections.

About Virtual Link Extension Between Two Ports of the Same Switch

In earlier versions of Netvisor ONE, the vLE implementation supported only one vLE endpoint per node. With version 5.1.1, both vLE endpoints can be part of the same node. This configuration is referred to as *local vLE*.

A vLE can have two ports in the same node only if the corresponding vLE's VXLAN ID is not already mapped to a tunnel. Similarly, a tunnel can be mapped to a vLE's VXLAN ID if there is at most one local port in the vLE. In the case of auto-tunnels, a VXLAN ID can be mapped to a VTEP only if there is at most one local port in the node associated with that VTEP.

Netvisor ONE allows the users to track the vLE port status when part of a local vLE. In such case, the `node-1` and `node-2` labels refer to the same switch. However, for consistency reasons, the `node-2-port` is still considered as '*remote port*' in the `vle-show` output, even though in actuality both the vLE ports are on the same switch.

Let us assume, for example, that port 30 (`node-2-port`) goes down, the vLE status is displayed as `remote-down` (see example below) so the user can understand exactly which port is causing the vLE to be down. Instead, if port 22 (`node-1-port`) is down, then the vLE status is displayed as `local-down`.

```
CLI (network-admin@switch) > vle-show layout vertical
name:                  vle1
```

```
vnet:
node-1:              vanquish1
node-2:              vanquish1
node-1-port:         22
node-2-port:         30
status:              remote-down
tracking:            enabled
ports-state:         override
create-time:         09:44:56
```

Use the `port-show` command to check if the `node-2-port` status is `down` or `vle-wait`. The `vle-wait` state indicates that the port is brought down due to remote port being down

About Virtual Link Extension Redundancy with Clusters

In network designs using pseudo-wires, link redundancy can be achieved by creating trunks using (at least) pairs of pseudo-wires as shown below. Such trunks originate and terminate on the *end devices*.

That can be conveniently achieved in fabric designs that leverage pairs of leaf switches (called *clusters* in Pluribus parlance) to provide redundancy for Layer 2 and Layer 3 last-hop traffic: as shown in ***Figure 10-2*** below, when vLEs are configured, vLE redundancy can be implemented by setting up *one vLE per cluster switch* and *by leveraging port channeling* or *NIC teaming* (depicted with an ellipse in the diagram) on the end devices to implement end-to-end *vLE trunks*.

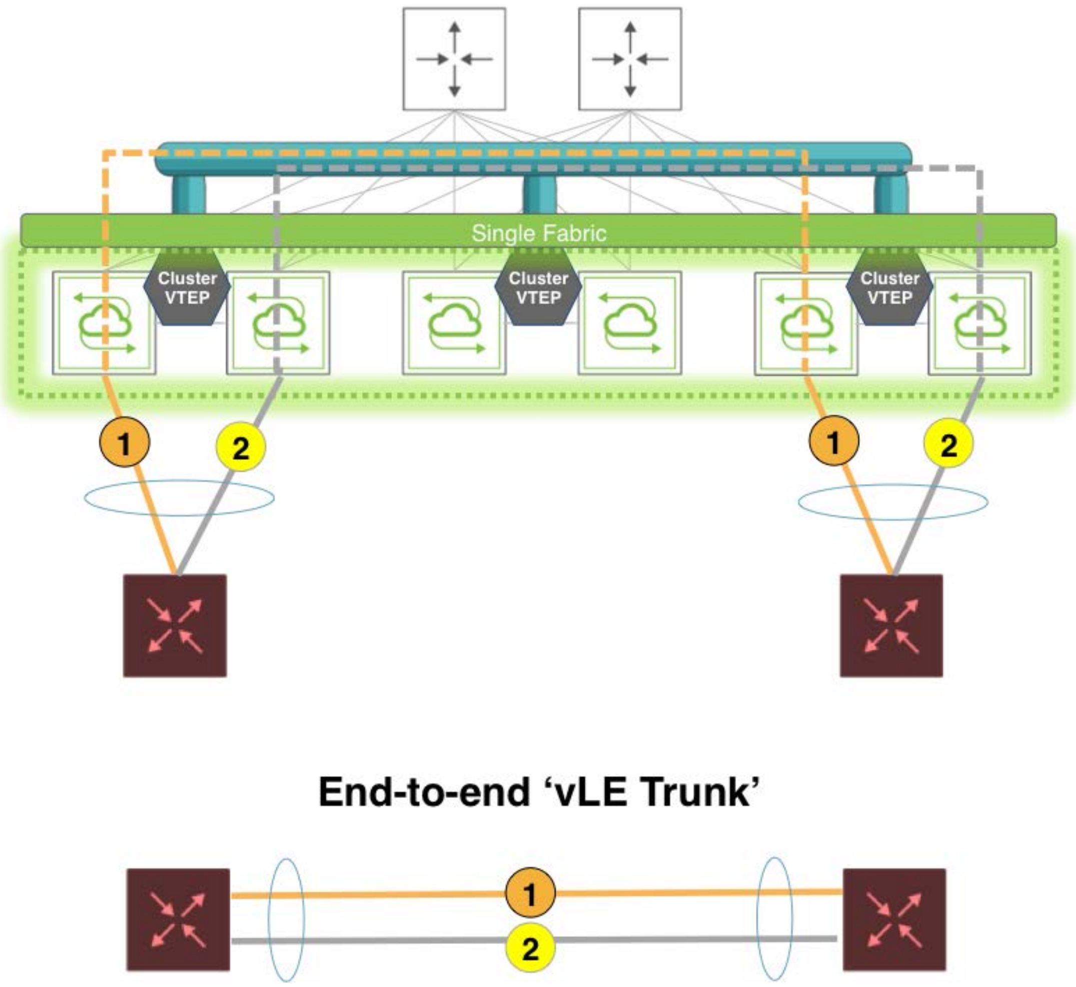


Figure 10-2: Virtual Link Extension End-to-end Redundancy

Leaf switches don't need to implement load balancing and failover for the vLE trunks as vLEs are in essence just end-to-end transparent pipes, which transport all the traffic and propagate port state changes through link state tracking. Hence, vLE-attached end devices can just use standard 802.3ad link bundling, static or dynamic with the LACP protocol, to manage the aggregation and the failover of the virtual wires.

vLE redundancy has the following characteristics:

- Failover between VTEPs used by vLEs is not required.
- Hence VTEPs associated with vLEs do not use a VRRP virtual IP address. They use a primary IP address, instead, or the real IP address of a dedicated interface.
- L2 PDUs such as LACP messages on vLE transparent VLANs are not sent to a fabric node's management CPU, as they need to be passed transparently through the virtual wire.

In the example topology shown above in Figure 9-2, two generic switches are connected respectively to two cluster leaf nodes. There is no vLAG on such nodes as it is not required. Both generic switches are configured with the LACP protocol on their trunk links to run connectivity checks and to form the trunk dynamically. Hence, they are directly in charge of link redundancy and failover management, whereas the leaf nodes are responsible for *transparent end-to-end traffic transport*.

About Virtual Link Extension Error Transparency

In lab automation deployments employing vLE it is usually required to not only transport valid data plane frames and PDUs but also to include potential malformed frames that are received on a vLE port.

Starting from Netvisor ONE release 5.1.1, with the optional configuration for *error transparency*, a vLE can be configured to transport also bad CRC frames as well as runts (i.e., undersized frames). Transported runt frames are padded with zeros up to a length of 64 bytes and their CRC is zeroed out, which can be used to recognize an undersized frame on the receiving end.

Error transparency is hardware-dependent (on newer ASICs) and thus works only on the following capable platforms:

- Dell S4100 Series
- Dell S5048
- Dell S5200 Series
- Dell Z9100
- Freedom F9372-X and F9372-T

In particular, on these platforms undersized frames with a *minimum* length of *50 bytes* are supported.
Furthermore, full jumbo frame transport is also supported in Netvisor ONE version 5.1.1 by upping the maximum supported MTU size to 9398 bytes.

Refer to the *Enabling Jumbo Frame Support* section of this Configuration Guides for command details.

Error transparency is enabled globally to minimize the configuration steps required in lab automation setups. However, since it disables CRC checks even on inter-switch links, it can be turned off on a per port basis wherever it's not required.

About Virtual Link Extension Traffic Analytics

Netvisor ONE does not make copies of vLE-transported control frames (such as LLDP, etc.) to the switch management CPU. Any inner VLAN tag, if present, is also preserved. This is achieved by installing a system vFlow entry called *Virtual-Link-Extend* with the highest priority of 15 with no action specified so that control frames are not terminated and sent to CPU.

In addition, to support *vLE traffic analytics*, a few additional system vFlow entries (named *System-vLE-x*, where *x* can be *S* or *F* or *R*) are installed with the same priority as the Virtual-Link-Extend entry in order to copy TCP SYN/FIN/RST packets to the management CPU. This ensures that any SYN/FIN/RST packets carried by vLE can be used for *TCP flow analysis*.

The `vflow-show` command can be used to display such system entries used for transparency and flow analysis:

CLI (network-admin@switch) > vflow-show format name,scope,type,proto,tcp-flags,precedence,action,enable

```
name             scope type    proto tcp-flags precedence action      enable
-------------------  ----- ------  ----- --------- ---------- ----------- ------
System-vLE-S       local system  tcp   syn     15       copy-to-cpu enable
System-vLE-F       local system  tcp   fin     15       copy-to-cpu enable
System-vLE-R       local system  tcp   rst     15       copy-to-cpu enable
Virtual-Link-Extend  local system              15       none       enable
```

```
CLI (network-admin@switch) > connection-show layout vertical

vnet:     100
vlan:     100
vxlan:    10100
src-ip:   20.20.20.1
dst-ip:   20.20.20.2
dst-port: http
cur-state:     fin
syn-resends:   0
syn-ack-resends:    0
latency:  74.8us
obytes:   149
ibytes:   311
total-bytes:   460
age: 2h11m21s
```

Understanding VXLAN-based Bridge Domains for IEEE 802.1Q and QinQ Internet-working

With the IEEE 802.1Q standard a network design is constrained to 4094 possible VLAN numbers. When more Layer 2 identifiers are needed, and a hierarchy of network entities can be established, the *VLAN stacking technology* (informally also called *QinQ*, after the name of Cisco's original implementation, also known as 802.1Q Tunneling) can be utilized to scale up to 16 million (4094 x 4094) identifiers using *two* (*concatenated*, i.e., '*stacked*') *VLAN tags instead of one.*

The IEEE organization has standardized the VLAN stacking technology with the *Provider Bridges* standard, also known as *IEEE 802.1ad*, which was later incorporated into the IEEE 802.1Q-2011 revision of the LAN/MAN standard.

IEEE 802.1ad refers to providers of services, such as Transparent LAN Services in Metro networks. There are also a number of data center designs that can tap the scalability of the VLAN stacking technology: for example data center networks in which one tag (the so-called *outer tag*) is used to identify a data center customer, while the second tag (the so-called *inner tag*) is used to identify a customer service.

With this technology it is possible to identify up to 16 M services for up to 4K customers. The double-tagged traffic is oftentimes handed off to a provider (for example a cloud exchange provider) which can terminate it for end-to-end connectivity. Hence, this scheme can be used to deploy *hybrid cloud designs* in which private clouds integrate with external clouds.

In practice in such designs QinQ (i.e., VLAN stacking) augments the basic 802.1Q capabilities by massively scaling the number of usable network identifiers organized in a hierarchy.

Pluribus combines this technology with the VXLAN-based Adaptive Cloud Fabric to yield an even higher degree of scalability and flexibility. In fact, VXLAN IDs (a.k.a. VNIs) are 24-bit long (vs. 12-bits of VLAN IDs) and therefore are a perfect match for double-tagging Layer 2 network transports.

In addition, VLAN ID to VXLAN ID mappings enable a great degree of flexibility for network designers that Pluribus substantiates with a new type of configuration object called *VXLAN-based bridge domain* (BD).

VXLAN-based bridge domains will be supported in a future release of Netvisor ONE: they can be mapped to single or multiple 802.1Q VLANs as well as to dual IEEE 802.1ad VLAN tags, covering all possible design requirements.

The different available configuration models for VXLAN-based bridge domains are:

- *Single tag mapping*, in which an outer VLAN tag (for example, a customer ID) is mapped to a VNI on an IEEE 802.1ad port and the inner VLAN tags are preserved inside the VXLAN encapsulation. This type of mapping can be used on customer facing 'QinQ access' interfaces.
- *Double tag mapping*, in which an outer VLAN + inner VLAN tag pair is mapped to a VNI on an IEEE 802.1ad port (traffic is received double-tagged in ingress and is marked

with two tags in egress after VXLAN decapsulation). This type of mapping can be used on multi-VLAN ports (sometimes called *QinQ trunks*) facing for example an external cloud provider.

- *Single 802.1Q tag mapping*, in which a single 802.1Q VLAN (or multiple 802.1Q VLANs) are mapped to a common VNI (for example, for inter-DC communication within the same customer's private cloud network).

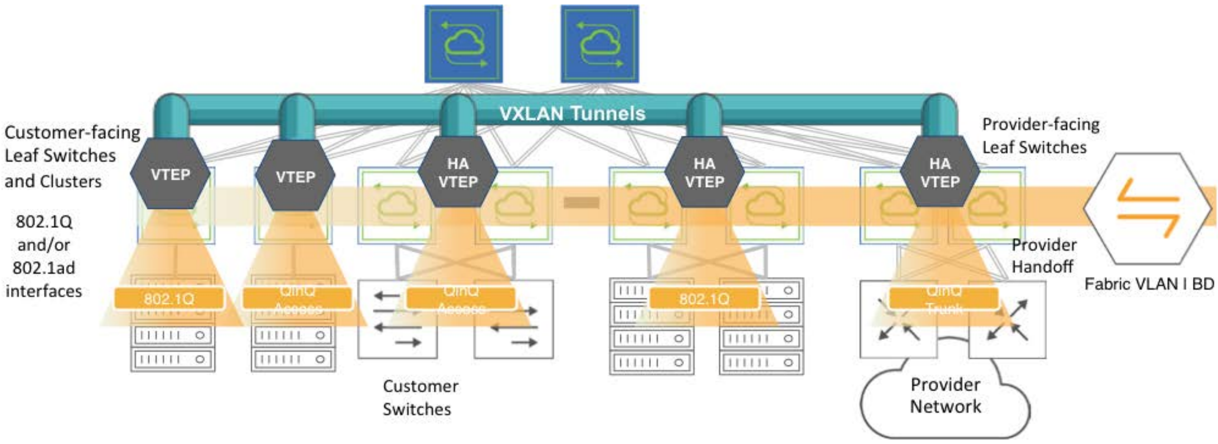


Figure 10-3: Hierarchical Fabric Structure Using Bridge Domains for Intra- and Inter-DC Connectivity

The various configuration models of bridge domains yield an unprecedented level of flexibility in terms of advanced Layer 2 transport services, with the ability of re-using VLANs across tenants, supporting QinQ hierarchies and handoff links, as well as aggregating multiple VLANs in the same overlay construct (thus supporting high-scale L2 tenant services).

Configuring Virtual Link Extension

The vLE configuration revolves around the creation and transport over VXLAN of one or more transparent VLANs using the transparent option of the `vlan-create vxlan-mode standard|transparent` command. To explain how that is implemented, let's first refer to ***Figure 10-4*** below which shows an example with port 10 and 17 as ingress/egress vLE ports on two fabric leaf switches that are supposed to be connected transparently through a vLE pseudo-wire:

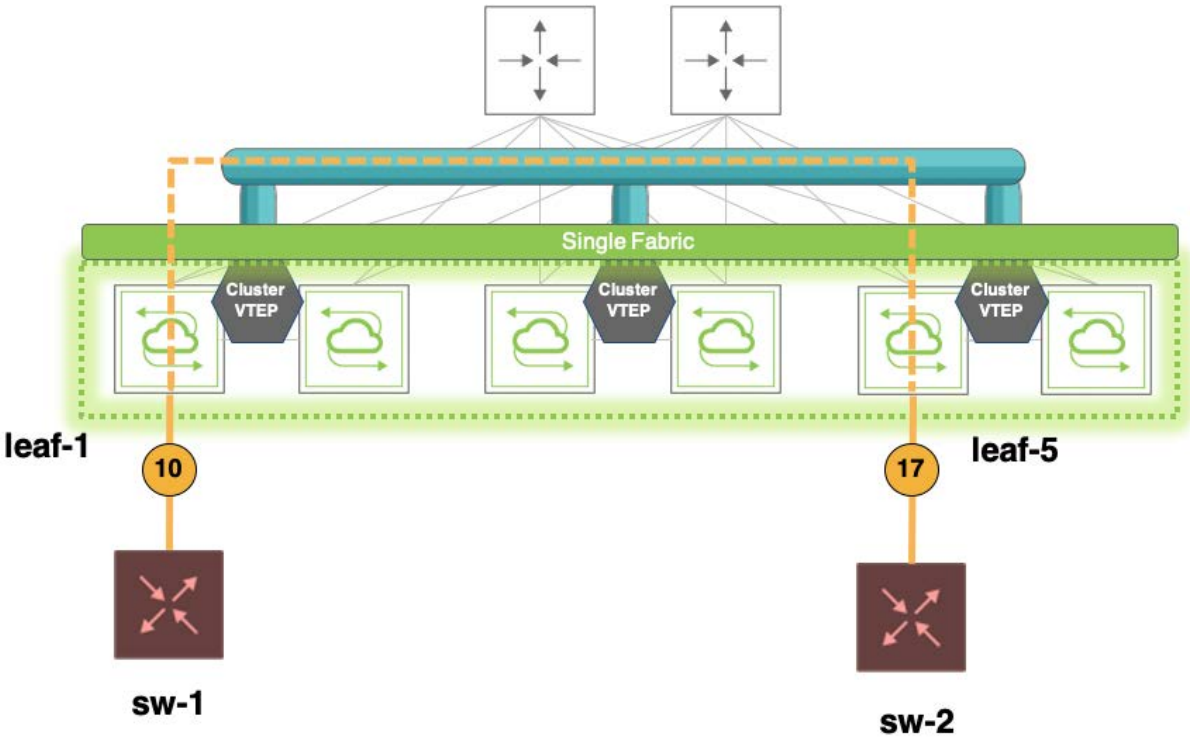


Figure 10-4. Two Ports Interconnected Through a vLE Pseudo-wire

Establishing such vLE pseudo-wire transport requires multiple configuration steps:

1. Configuration of jumbo frames on all the required ports (ingress and egress ports, as well as all inter-switch ports that are used to transport vLE traffic)
2. Creation of Layer 3 VLANs (or of routed ports) that are used as tunnel end points (with an MTU configuration suitable to route jumbo frames)
3. Set up of dedicated VXLAN connections. Typically, manual tunnels are created and set aside for vLE use.
4. Creation of a VXLAN-mapped *transparent VLAN* to transport the traffic over vLE.
5. Addition of the transparent VLAN's VXLAN ID to the allocated tunnels.

Let us look at one configuration example for each of the above steps.

Step 1 requires adding the jumbo option as part of the port configuration with the following command(s):

```
CLI (network-admin@leaf-1) > port-config-modify port 10 jumbo
```

In this example, as shown in the figure above, port 10 on leaf-1 is a vLE port. Jumbo (i.e., oversized) frame support should be enabled if mirroring of ingress frames with a (typical) MTU of 9216 bytes is required.

This option is usually already configured end-to-end on inter-switch links if a VXLAN transport is used in the fabric (refer to the *Configuring VXLAN* section).

Otherwise, the following commands can be used to enable the transport of oversized frames on inter-switch links (individual ports or trunks):

```
CLI (network-admin@leaf-1) > port-config-modify port <inter-switch port-list> jumbo
```

```
CLI (network-admin@leaf-1) > trunk-modify name <trunkname> jumbo
```

Step 2 requires the creation of the *Layer 3 routing endpoints*, in this case VLAN interfaces (a.k.a. SVIs), on the switches where the ingress and egress vLE ports are located:

```
CLI (network-admin@leaf-1)> vlan-create id 1021 scope local description VLE-VTEP ports none
```

```
CLI (network-admin@leaf-1)> vrouter-interface-add vrouter-name Leaf-1 vlan 1021 ip 10.21.1.1/30 mtu 9398
```

```
CLI (network-admin@leaf-5)> vlan-create id 1021 scope local description VLE-VTEP ports none
```

```
CLI (network-admin@leaf-5)> vrouter-interface-add vrouter-name Leaf-5 vlan 1021 ip 10.21.7.1/30 mtu 9398
```

Then the VLAN(s) can be checked with the following command:

```
CLI (network-admin@leaf-1)> vlan-show id 1021

switch     id   scope  description active
---------- ---- ------ ----------- -----
leaf-1     1021 local  VLE-VTEP    yes
leaf-5     1021 local  VLE-VTEP    yes
```

Step 3 involves the creation of the *VXLAN tunnels*:

```
CLI (network-admin@leaf-1)> tunnel-create name VLE_L1_to_L5 scope local local-ip 10.21.1.1 remote-ip 10.21.7.1 vrouter-name Leaf-1
```

```
CLI (network-admin@leaf-5)> tunnel-create name VLE_L5_to_L1 scope local local-ip 10.21.7.1 remote-ip 10.21.1.1 vrouter-name Leaf-5
```

The tunnel creation can be checked with the following commands:

```
CLI (network-admin@leaf-1) > tunnel-show local-ip 10.21.1.1
format   switch,scope,name,type,vrouter-name,local-ip,remote-ip

switch     scope name         type  vrouter-name local-ip  remote-ip
---------- ----- ------------ ----- ------------ --------- ---------
leaf-1     local VLE_L1_to_L5 vxlan Leaf-1       10.21.1.1 10.21.7.1
```

```
CLI (network-admin@leaf-5) > tunnel-show local-ip 10.21.7.1
format   switch,scope,name,type,vrouter-name,local-ip,remote-ip

switch     scope name         type  vrouter-name local-ip  remote-ip
---------- ----- ------------ ----- ------------ --------- ---------
leaf-5     local VLE_L5_to_L1 vxlan Leaf-5       10.21.7.1 10.21.1.1
```

Step 4 requires the creation of a *transparent VLAN* per vLE:

```
CLI (network-admin@leaf-1)> vlan-create id 3001 scope local
description VLE-1 vxlan-mode transparent vxlan 3001000 ports
10
CLI (network-admin@leaf-5)> vlan-create id 3001 scope local
description VLE-1 vxlan-mode transparent vxlan 3001000 ports
17
```

The VLAN's creation can be checked with the following command:

```
CLI (network-admin@leaf-1)> vlan-show id 3001 format
switch,id,type,vxlan,scope,description,active,ports

switch     id   type   vxlan   scope description active ports
---------- ---- ------ ------- ----- ----------- ------ -----
leaf-1     3001 public 3001000 local VLE-1       yes    10
leaf-5     3001 public 3001000 local VLE-1       yes    17
```

Finally, in *step 5* the above VXLAN ID(s) of the transparent VLAN(s) are mapped to the tunnel(s):

```
CLI (network-admin@leaf-1)> tunnel-vxlan-add name VLE_L1_to_L5
vxlan 3001000
CLI (network-admin@leaf-5)> tunnel-vxlan-add name VLE_L5_to_L1
vxlan 3001000
```

The VXLAN tunnels and their mappings can be checked with the following command:

```
CLI (network-admin@leaf-1)> tunnel-vxlan-show vxlan 3001000

switch     name         vxlan
---------- ------------ -------
leaf-1     VLE_L1_to_L5 3001000
leaf-5     VLE_L5_to_L1 3001000
```

> **Note**: Starting from Netvisor ONE release 6.1.1, to prevent the misconfiguration of a vLE port which may get assigned to another VLAN by mistake, a new configuration

check was added. The restriction is that a port assigned to a regular VLAN cannot be assigned to a vLE VLAN (i.e., in transparent mode) and vice versa.

Let's suppose VLAN 1 (the default VLAN) and VLAN 100 are assigned to port 1, as shown below:

```
CLI (network-admin@switch) > port-vlan-show ports 1
switch port vlans untagged-vlan description active-vlans
------ ---- ----- ------------- ----------- ------------
switch 1    1,100 1                         none
```

An attempt to assign this port to a vLE VLAN (VLAN 555 in transparent mode) is rejected:

```
CLI (network-admin@switch) > vlan-create id 555 scope local
ports 1 vxlan-mode transparent vxlan 666666
vlan-create: vle port 1 cannot be member of other vlans
```

If you want to unassign the port and then reassign it to a vLE VLAN, you can go through a two-step process. First, remove the port from the specific VLAN (VLAN 100 in the above example, or from `vlans all`):

```
CLI (network-admin@switch) > port-vlan-remove port 1 vlans 100
```

```
CLI (network-admin@switch) > port-vlan-show ports 1
switch port vlans untagged-vlan description active-vlans
------ ---- ----- ------------- ----------- ------------
switch 1    1     1                         none
```

Then you can assign it to a vLE VLAN like so:

```
CLI (network-admin@switch) > vlan-create id 555 scope local
ports 1 vxlan-mode transparent vxlan 666666
Vlans 555 created
```

```
CLI (network-admin@switch) > port-vlan-show ports 1
switch port vlans untagged-vlan description active-vlans
------ ---- ----- ------------- ----------- ------------
switch 1    555   555                       none
```

Configuring Virtual Link Extension State Tracking

In addition to the above configuration steps, it is often common to also turn on state tracking in order to make sure that link state changes are mirrored:

```
CLI (network-admin@leaf-1)> vle-create name VLE-1 node-1 leaf-
1 node-1-port 10 node-2 leaf-5 node-2-port 17 tracking
```

This configuration step requires specifying the two vLE nodes (leaf-1 and leaf-5) as well as their respective ports in addition to the tracking option by following this syntax:

```
CLI (network-admin@leaf-1)> vle-create
```

`vle-create`	Create VLE configuration.
`name name-string`	Specify the VLE name.
`vnet` *`vnet-name`*	Specify the vNET assigned to this vLE.
`node-1 fabric-node name`	Specify the VLE node 1 name.
`node-2 fabric-node name`	Specify the VLE node 2 name.
`node-1-port node-1-port-number`	Specify the VLE node-1 port.
`node-2-port node-2-port-number`	Specify the VLE node-2 port.
`status unknown|remote-down|local-down|up|down|disabled`	Specify the VLE status.
`[tracking|no tracking]`	Enable or disable tracking between VLE ports.
`ports-state override|enable|disable`	Specify the ports admin control state.

The link state tracking configuration can be verified with the `vle-show` command:

```
CLI (network-admin@leaf-1) > vle-show layout vertical
name:          VLE-1
vnet:
node-1:         leaf-1
node-2:         leaf-5
node-1-port:   10
node-2-port:   17
status:        up
tracking:      enabled
ports-state:   override
create-time:   08:47:56
```

Furthermore, since a vLE transparently transmits PDUs over to the other end, it is possible to test state tracking by leveraging for example the LLDP protocol messages exchanged between two test switches (sw-1 and sw-2 in the figure above) connected to the vLE ports 10 and 17.

The two test switches exchange LLDP messages by default, so the LLDP peer relationship can just be shown with the command:

```
CLI (network-admin@sw-1) > lldp-show

switch local-port chassis-id port-id  port-desc        sys-name
------ ---------- ---------- -------  ---------------- --------
sw-1     1         0b0012c0   1      PN Switch Port(1)  sw-2
```

Then, if a vLE port is disabled (in this case, port 10), the peer relationship is lost and `lldp-show` does not display a neighbor anymore. The test switch's port also goes down thanks to vLE state tracking. Once the port is re-enabled, the neighboring relationship is re-established:

```
CLI (network-admin@leaf-5) > port-config-modify port 17
disable

CLI (network-admin@sw-1) > port-phy-show port 1

switch port state speed eth-mode   max-frame learning def-vlan
------ ---- ----- ----- ---------- --------- -------- --------
sw-1     1  down  10000 10Gbase-cr 1540      off      0

CLI (network-admin@sw-1) > lldp-show

CLI (network-admin@leaf-5) > port-config-modify port 17 enable

CLI (network-admin@leaf-5) > port-phy-show port 17

port state speed eth-mode max-frame learning def-vlan
---- ----- ----- -------- --------- -------- --------
17   up    10000 10G-SFI   1540      off      0

CLI (network-admin@sw-1) > port-phy-show port 1

switch   port state speed eth-mode   max-frame learning def-vlan
-------- ---- ----- ----- ---------- --------- -------- --------
sw-1     1    up    10000 10Gbase-cr  1540      off      1

CLI (network-admin@sw-1) > lldp-show

switch  local-port chassis-id port-id port-desc        sys-name
------- ---------- ---------- ------- ---------------- --------
sw-1     1          0b0012c0   1      PN Switch Port(1) sw-2
```

To enable or disable tracking between existing vLE ports, use the `vle-modify` command:

```
CLI (network-admin@switch) > vle-modify name name-string
tracking|no tracking
```

`vle-modify`	Modify virtual link extension tracking
`name name-string`	The vLE name to be modified
`tracking|no tracking`	Enable or disable tracking between vLE ports

To delete a state tracking configuration, use the vle-delete command:

```
CLI (network-admin@switch) > vle-delete name name-string
```

Configuring vLE in vNET

Starting from Netvisor ONE version 6.1.0, you can configure a vLE on vNET managed ports. This enhancement enables you to separate the management of the feature on a per tenant basis.

To configure a vLE in a vNET, follow the steps from step 1 to step 4 discussed in the *Configuring Virtual Link Extension* section. You can then use the `vle-create` command to configure the vNET and enable state tracking. For example, as an extension of step 4, you can assign the vNET `vnet1` to the vLE `VLE-1` and enable state tracking by using the command:

```
CLI (network-admin@switch) > vle-create name VLE-1 vnet vnet1
node-1 leaf-1 node-1-port 10 node-2 leaf2 node-2-port 17
tracking
```

> **Note:** vLE creation is not allowed on vNET shared ports.

Use the `vle-show` command to display the configuration.

```
CLI (network-admin@switch) > vle-show
```

`vle-show`	Display vLE configuration.
`name name-string`	The vLE name.
`id`	The ID assigned to the vLE.
`vnet` *`vnet-name`*	The vNET assigned to this vLE.
`node-1` *`fabric-node-name`*	vLE node 1 name.
`node-2` *`fabric-node-name`*	vLE node 2 name.
`node-1-port` *`node-1-port-number`*	vLE node-1 port.
`node-2-port` *`node-2-port-number`*	vLE node-2 port.
`status unknown|remote-down|`	The vLE status.

`local-down|up|down|disabled`	
`[tracking|no tracking]`	Enable or disable tracking between vLE ports.
`ports-state override|enable|disable`	Ports admin control state.
`create-time` *date/time: yyyy-mm-ddTHH:mm:ss*	Time at which the vLE was created.
`elapsed-time` *duration: #d#h#m#s*	Time duration since the vLE was created.
`up-time` *duration: #d#h#m#s*	Time since the last instance at which the vLE came online.

```
CLI (network-admin@leaf-1) > vle-show format all layout
vertical
name:          vle1
id:            900ad7:0
vnet:          vnet1
node-1:        leaf-1
node-2:        leaf-2
node-1-port:   10
node-2-port:   17
status:        up
tracking:      enabled
ports-state:   override
create-time:   09:44:56
elapsed-time:  11m37s
up-time:       0s
```

Configuring Virtual Link Extension Error Transparency

In order to be able to preserve bad CRC and undersized packets as part of the vLE transport, a new fabric-wide *error transparency* configuration option has been added:

```
CLI (network-admin@leaf-1) > vle-transparent-modify mode
enable

CLI (network-admin@leaf-1) > vle-transparent-show
fabric: Transparent VLE mode is enabled

CLI (network-admin@leaf-1) > vle-transparent-modify mode
disable

CLI (network-admin@leaf-1) > vle-transparent-show
fabric: Transparent VLE mode is disabled
```

However, since disabling CRC checks is not necessarily desirable on all links, some ports can be excluded (for example certain edge ports and inter-switch links) with a local scope command:

```
CLI (network-admin@leaf-1) > vle-transparent-modify mode
enable

CLI (network-admin@leaf-1) > vle-transparent-port-remove port
18,45

CLI (network-admin@leaf-1) > vle-transparent-port-show
switch: leaf-1
leaf-1: ports removed from VLE transparent mode: 18,45

CLI (network-admin@leaf-1) > vle-transparent-port-add port
18,45

CLI (network-admin@leaf-1) > vle-transparent-port-show
switch: leaf-1
leaf-1: ports removed from VLE transparent mode: none
```

> **Informational note**: Transparency exclusion should be applied to ports that are not in the end-to-end vLE transport path through the fabric, which needs to be based on supported switches that are capable of error transparency to preserve bad frames.

Configuring Virtual Link Extension Redundancy with Clusters

The configuration of redundant vLE pseudo-wires requires the replication of the configuration steps described in the above sections. In addition, the endpoints (for example two switches as in the figure below) need to have link bundling enabled (static or dynamic LACP-based negotiation) in order to manage end-to-end path redundancy.

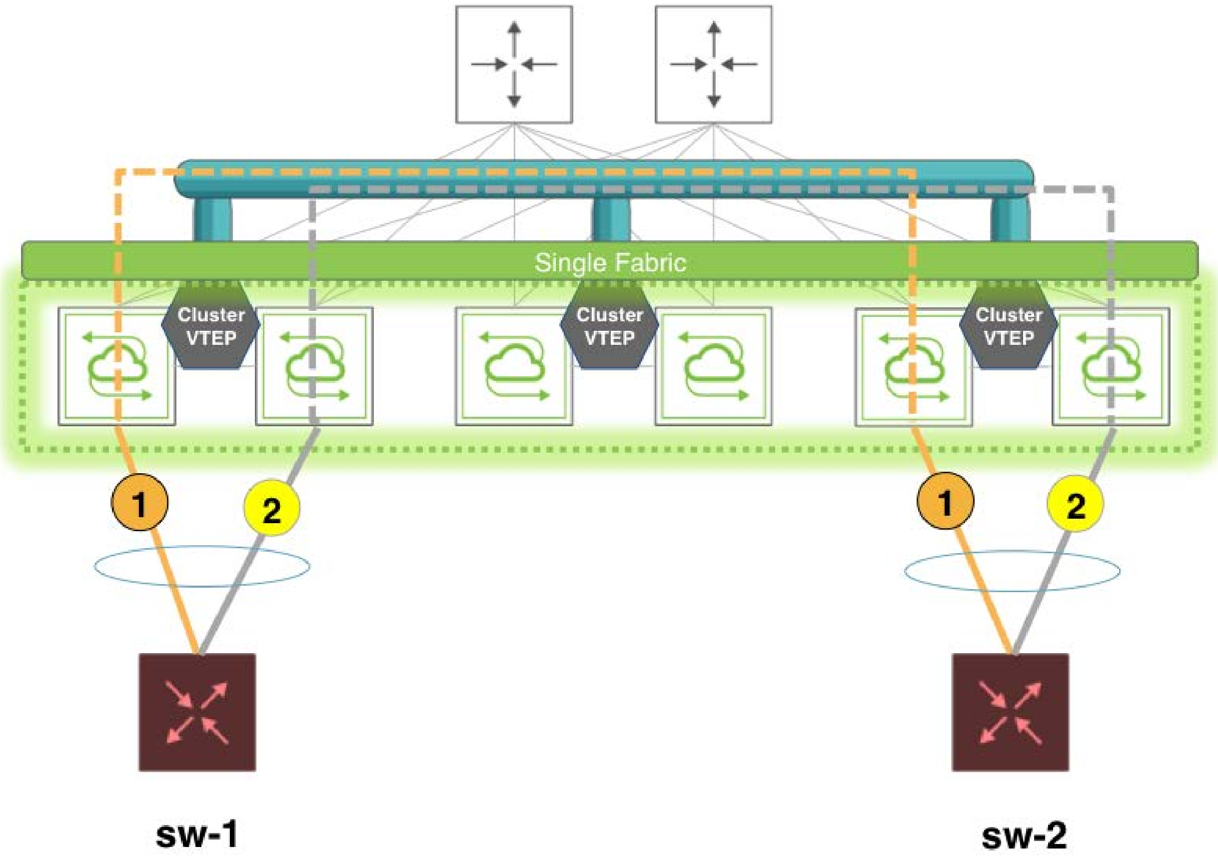


Figure 10-5: Virtual Link Extension End-to-end Redundancy

In this example, let us assume that both test switches, `sw-1` and `sw-2`, are configured with the LACP active negotiation option.

Then, every vLE configuration step needs to be replicated twice to create VLE-1 and VLE-2 (based on two transparent VLANs and four VTEPs):

1. Creation of Layer 3 VLANs that are used as tunnel end points
2. Set up of dedicated VXLAN connections
3. Creation of VXLAN-mapped *transparent VLANs*
4. Addition of the transparent VLAN's VXLAN ID to the allocated tunnels.

The distinctive configuration step is the creation of the VTEPs (step 2 above): VTEP HA is not required and not supported in case of vLE redundancy (namely, the virtual IPs cannot be used). The four VTEPs can be created instead with each cluster member's primary IP address like so:

```
CLI (network-admin@leaf-1) > tunnel-create scope local name
VTEP1 vrouter-name vr-s1 local-ip 10.10.11.1 remote-ip
```

```
10.10.15.1

CLI (network-admin@leaf-2) > tunnel-create scope local name
VTEP2 vrouter-name vr-s2 local-ip 20.20.22.1 remote-ip
20.20.26.1

CLI (network-admin@leaf-5) > tunnel-create scope local name
VTEP3 vrouter-name vr-s3 local-ip 10.10.15.1 remote-ip
10.10.11.1

CLI (network-admin@leaf-6) > tunnel-create scope local name
VTEP4 vrouter-name vr-s3 local-ip 20.20.26.1 remote-ip
20.20.22.1
```

Note that `10.10.11.1` and `10.10.15.1` are primary IP addresses used for VLE-1 on leaf-1 and leaf-5 respectively while `20.20.22.1` and `20.20.26.1` are primary IP addresses used for VLE-2 on leaf-2 and leaf-6.
The remaining four steps are the same as those described in the previous sections, replicated for both VLE-1 and VLE-2.

vLE tracking is also greatly beneficial in order to implement redundancy on Netvisor ONE nodes as it propagates link state changes and helps client side's LACP with timely link up/link down detection.

Showing Virtual Link Extension Between Ports on the Same Switch

In certain network configurations, both vLE ports should be part of the same node. This case is supported by Netvisor ONE and is referred to as *local vLE*.

In the example below `node-1` and `node-2` refer to the same switch in the local vLE, in which port 30 is displayed as remote port in the `vle-show` output, even though both the vLE ports are on the same node.

Port 30 went down, therefore the vLE status is shown as `remote-down` (see command output below) so you can understand exactly which port caused the vLE to be down:

```
CLI (network-admin@switch) > vle-show layout vertical
name:          vle1
vnet:
node-1:        vanquish1
node-2:        vanquish1
node-1-port:   22
node-2-port:   30
status:        remote-down
tracking:      enabled
ports-state:   override
create-time:   09:44:56
```

You can use the `port-show` command to check if the `node-1-port` status is `down` or `vle-wait`. The `vle-wait` state indicates that the port was brought down due to the remote port being down.

Configuring Keep-Alive Timeout for Virtual Link Extension

As part of the vLE link state tracking logic each node hosting a vLE endpoint sends *fabric fast keepalive messages* every second to its peer node that hosts the other endpoint.

A node considers its peer node down if a keepalive is not received from the remote node within 3 seconds (which is the default *vLE tracking timeout*). If that happens, the local port is brought down and the vLE state reflects both ports' down state.

However, in some deployments (for example with frequent link flaps), a three second timeout may not be enough to avoid false positives. Therefore, it can be modified with the following command:

```
CLI (network-admin@switch) > system-settings-modify vle-
tracking-timeout  seconds
```

You can configure a value *from 3 to 30 seconds*. (Note that the fast keepalive transmission frequency remains one second. Only the timeout value is adjusted to the configured value.) The configured value can be checked with the `system-settings-show` command.

> **Note:** The default 3 second keepalive timeout is automatically configured when vLE link state tracking is enabled. When it is disabled, the standard fabric message timeout interval is 21 seconds as shown for the three leaf switches below that don't use tracking:

```
CLI (network-admin@switch) > fabric-node-show format
name,keepalive-timeout

name             keepalive-timeout
--------------   -----------------
leaf-1          21
leaf-2          21
leaf-3          21
switch          3

CLI (network-admin@switch) > system-settings-show format vle-
tracking-timeout
vle-tracking-timeout:  3
```

When tracking gets disabled, the fabric keepalive timeout goes back to 21 seconds:

```
CLI (network-admin@switch) > vle-modify name vLE no-tracking

CLI (network-admin@switch) > fabric-node-show format
name,keepalive-timeout

name             keepalive-timeout
--------------   -----------------
leaf-1          21
leaf-2          21
```

```
leaf-3          21
switch          21
```

```
CLI (network-admin@switch) > system-settings-show format vle-tracking-timeout,
vle-tracking-timeout:  3
```

When it is necessary to change the administrative vLE keepalive timeout value, the fabric keepalive timeout reflects the new value when tracking is enabled, as shown below:

```
CLI (network-admin@switch) > system-settings-modify vle-tracking-timeout 30
```

```
CLI (network-admin@switch) > fabric-node-show format name,keepalive-timeout

name             keepalive-timeout
--------------  -----------------
leaf-1          21
leaf-2          21
leaf-3          21
switch          30
```

Enabling and Disabling a Virtual Link Extension End-to-End

At times, whether in the CLI or in the Pluribus UNUM GUI, it can be convenient to manage vLE ports in *pairs* as a single entity (instead of doing so individually). Starting from Netvisor ONE release 6.0.0, a new end-to-end vLE configuration option can be used to enable or disable both vLE ports at the same time as part of the `vle-create` command.

The new `ports-state` option can have three values:

- `override` is the default setting which means that, as usual, each individual port state configuration takes precedence
- `disable` means that both vLE ports get disabled together and this option takes precedence over each individual port state
- `enable` means that both vLE ports get enabled and this option takes precedence over each individual port state.

For example:

```
CLI (network-admin@swi01) > vle-create name vle-test node-1
swi01 node-2 swi02 node-1-port 13 node-2-port 13 no-tracking
ports-state disable
```

> Note: If `node-1` and `node-2` are the same switch, then it becomes a local vLE configuration.

The `vle-modify` command can be used to further change the end-to-end vLE configuration after the initial `vle-create`.

For example, after setting `ports-state` to disable in `vle-create`, the user can revert to the default behavior in which local port configuration takes prececence with the following command:

```
CLI (network-admin@swi01) > vle-modify name vle-test ports-
state override
```

In case of responsibility conflict in the CLI a message is printed out to explain what is taking precedence and to suggest a possible course of action.

For example, when a user tries to disable a vLE port when `ports-state` is set to `enable`, the following message is printed:

```
CLI (network-admin@swi01) > vle-show layout vertical
name:          vle-test
vnet:
node-1:        swi01
node-2:        swi02
node-1-port:   13
node-2-port:   13
status:        up
tracking:      enabled
ports-state:   enable
create-time:   08:47:56
```

```
CLI (network-admin@swi01) > port-config-modify port 13 disable
port-config-modify: could not disable port 13 as it is VLE
vle-test administratively enabled port. Use the following cli
to override: vle-modify name vle-test ports-state override
```

Similarly, when a user tries to enable a vLE port when `ports-state` is `disable`:

```
CLI (network-admin@swi01) > vle-show layout vertical
name:          vle-test
vnet:
node-1:        swi01
node-2:        swi02
node-1-port:   13
node-2-port:   13
status:        disabled
tracking:      enabled
ports-state:   disable
create-time:   08:47:56

CLI (network-admin@swi01) > port-config-modify port 13 enable
port-config-modify: could not enable port 13 as it is VLE vle-
test administratively disabled port. Use the following cli to
override: vle-modify name vle-test ports-state override
```

Even when the user configuration intent is the same (both in the local configuration and the vLE configuration), but there is still a responsibility conflict, a message is also printed out. For example, when a user tries to disable a vLE port when `ports-state` is `disable`:

```
CLI (network-admin@swi01) > vle-show layout vertical
name:          vle-test
vnet:
node-1:        swi01
node-2:        swi02
node-1-port:   13
node-2-port:   13
status:        disabled
tracking:      enabled
ports-state:   disable
create-time:   08:47:56

CLI (network-admin@swi01) > port-config-modify port 13 disable
port-config-modify: could not disable port 13 as it is VLE
vle-test administratively disabled port. Use the following cli
to override: vle-modify name vle-test ports-state override
```

Or when a user tries to enable a vLE port when `ports-state` is `enable`:

```
CLI (network-admin@swi01) > vle-show layout vertical
name:          vle-test
vnet:
node-1:        swi01
```

```
node-2:         swi02
node-1-port:   13
node-2-port:   13
status:        up
tracking:      enabled
ports-state:   enable
create-time:   08:47:56

CLI (network-admin@swi01) > port-config-modify port 13 enable
port-config-modify: could not enable port 13 as it is VLE vle-
test administratively enabled port. Use the following cli to
override: vle-modify name vle-test ports-state override
```

Configuring VXLAN-based Bridge Domains for 802.1Q and QinQ Internetworking

Bridge domains' configuration process is based upon the deployment of a VXLAN transport as described in the *Configuring VXLAN* chapter of this guide.

Subsequently, switch ports can be selectively added to a BD to accept either 802.1Q frames or double-tagged 802.1ad frames based on the connected device(s) and/or network(s), as depicted in the ***Figure 10-6***.

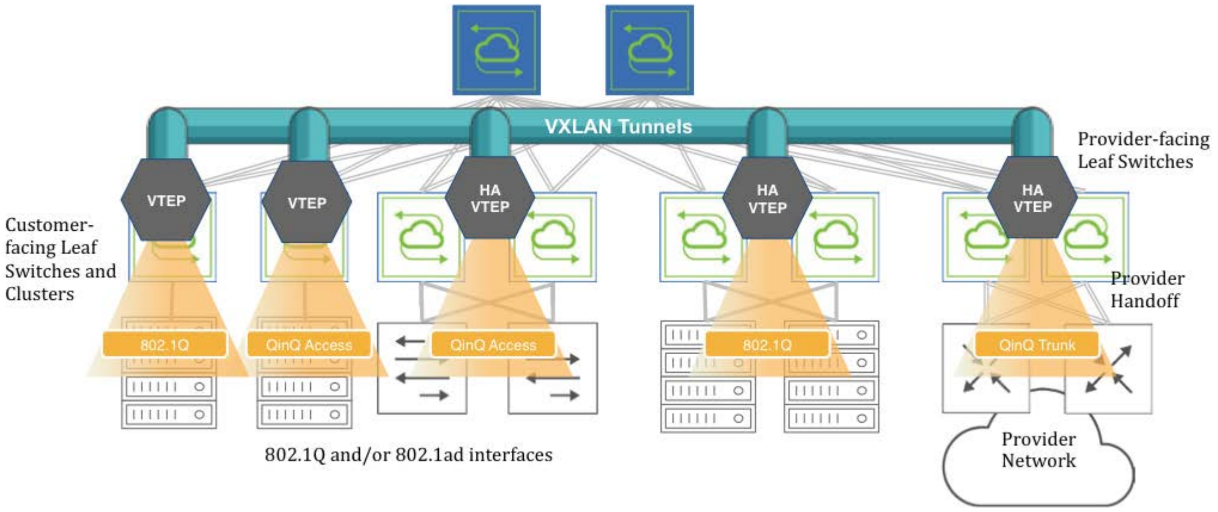


Figure 10-6: VXLAN-based BD Internetworking

Switch ports can be connected to either servers/hosts or switches/provider gateways as shown above.

In case of interconnection with an external cloud provider's gateway devices, as shown on the right hand side of ***Figure 10-6***, the connectivity is based on double-tagged 802.1ad frames, as it is required to preserve all 16M (4094 x 4094) possible combinations of user IDs and service IDs.

On the other hand, connectivity to servers can be based on a single 802.1Q VLAN tag. This case is useful in private cloud networks for direct server-to-server connectivity (for example a Web services node that needs to communicate with a database node).

Alternatively, server NICs can be configured with both an outer VLAN and an inner VLAN ID. In such case, the inner VLAN represents for example the service implemented on such server. Certain network designs employ this double-tagging scheme to be able to scale the number of supported services to 16M. In this case, switch ports have to be configured in 802.1ad mode to preserve the inner tag.

The 802.1Q ports can also be used to connect to customer switches and traffic can be double tagged by the fabric leaf nodes themselves.

> **Informational note**: BD ports can be configured in 802.1Q mode or in 802.1ad/QinQ

mode but not in both on the same switch for the same BD. Starting from Netvisor ONE release 6.1.1, in `remove-tags` mode, this restriction has been lifted (see the following sections for more details).

Before adding ports to any of the aforementioned scenarios, the first basic configuration step is the creation of a VXLAN-based bridge domain entity with the command:

```
CLI (network-admin@leaf-5) > bridge-domain-create
```

`bridge-domain-create`	Create a bridge domain.
`name` *`name-string`*	Specify the name for the bridge domain.
`scope` *`local|cluster|fabric`*	Specify the bridge domain scope.
Specify any of the following options:	
`vnet` *`vnet-name`*	Specify the vNET for this bridge domain.
`vxlan` *`0..16777215`*	Specify the VXLAN identifier for the tunnel.
`auto-vxlan|no-auto-vxlan`	Specify the options to automatically assign VXLAN and/or assign to VTEPs.
`description` *`description-string`*	Add a bridge domain description.
`rsvd-vlan` *`1..4093`*	Specify the fabric reserved VLAN for cluster switches for bridge domain.
`local-rsvd-vlan` *`1..4093`*	Specify the local reserved VLAN for cluster switches for bridge domain.
`mac-learning|no-mac-learning`	Specify if you want to enable or disable MAC address learning.

```
CLI (network-admin@leaf-5) > bridge-domain-create name bd1000
scope fabric vxlan 10000 rsvd-vlan 4002
```

A bridge domain's scope can be `fabric`, `cluster`, or `local`.

The `bridge-domain-create` command uses a manually assigned VNI to uniquely identify the bridge domain at the hardware level.
Moreover, with `fabric` and `cluster` scope, it must set aside a VLAN ID as reserved for supporting *switch clusters*:

```
CLI (network-admin@leaf-5) > bridge-domain-create name bd1000
scope fabric vxlan 10000 rsvd-vlan 4002
```

This command reserves VLAN 4002 on all *cluster switches* in the fabric for BD's internal use, so it can no longer be configured as a regular VLAN number. (The same requirement applies to `bridge-domain-create scope cluster` commands).

If for a particular pair of cluster switches the reserved VLAN has to be modified, on any one of the two switches you can use the following command:

```
CLI (network-admin@leaf-5) > bridge-domain-modify name bd1000
local-rsvd-vlan 4006
```

Note that the above command requires both cluster switches to be rebooted to take effect. Before rebooting, both VLAN 4002 and 4006 are no longer available but only 4006 is reserved on the cluster switches after reboot.

Also note that in a cluster both switch members are required to use the same mode for a port, either QinQ or 802.1Q, for the same BD.

Bridge domains can also be created with a textual description to provide more context like so:

```
CLI (network-admin@leaf-5) > bridge-domain-create name bd1000
scope fabric vxlan 10000 description business rsvd-vlan 4002
```

```
CLI (network-admin@leaf-5) > bridge-domain-show

name   scope  vxlan auto-vxlan description ports cluster-name
------ ------ ----- ---------- ----------- ---- ------------
bd1000 fabric 10000 no         business    13
```

Starting from Netvisor ONE release 6.0.0 the `auto-vxlan` parameter is supported as an option of the BD creation process.

This new parameter can be used either in combination with an explicit VNI value or implicitly without specifying it. In both cases any created BD or VNI mapping is automatically added to all the existing VTEP connections. Additionally, in the latter case, the VNI value is automatically picked and assigned out of a predefined range (see also the examples below) when `scope fabric` is used.

The next configuration step is to set up the fabric overlay either with manual tunnel creation or with VTEP object configuration. The latter way is *preferred*.

In order to manually create a VXLAN tunnel, say, on cluster member `leaf-5` in the ***Figure 10-6***, the following commands can be used:

```
CLI (network-admin@leaf-5) > tunnel-create scope cluster name
tunnel-5 vrouter-name vr5 peer-vrouter-name vr1 local-ip
20.20.25.1 remote-ip 20.20.27.1
```

```
CLI (network-admin@leaf-5) > trunk-modify name vxlan-loopback-
trunk ports 17 jumbo
```

The same steps are required on the other leaf switches to deploy an overlay comprising a full mesh of VXLAN-based interconnections.

Alternatively, VTEP objects can be configured so that a full mesh of VXLAN interconnections is brought up automatically without requiring manual configuration.

This is the command required to create a VTEP object on a non-clustered switch:

```
CLI (network-admin@leaf-1) > vtep-create name vtep1 vrouter-name vr1 ip 20.20.25.1
```

which can be used to create each fabric termination point (vtep1, vtep2, etc. on each leaf switch).

In case of clustered switches using a common VIP, the following command pairs should be used:

```
CLI (network-admin@leaf-5) > vtep-create name vtep5 vrouter-name vr5 ip 103.103.103.250 virtual-ip 103.103.103.10
```

```
CLI (network-admin@leaf-6) > vtep-create name vtep6 vrouter-name vr6 ip 103.103.103.251 virtual-ip 103.103.103.10
```

The next configuration step is to associate the BD's VXLAN ID (e.g., `10000`) to the newly created tunnel(s) or VTEP objects. For example, this command implements the association with a tunnel:

```
CLI (network-admin@leaf-1) > tunnel-vxlan-add name tunnel-1 vxlan 10000
```

whereas this command implements the association with a VTEP object:

```
CLI (network-admin@leaf-1) > vtep-vxlan-add name vtep1 vxlan 10000
```

As mentioned above, starting from Netvisor ONE release 6.0.0, as an alternative to the manual assignment, you can automatically assign a certain user-defined BD or VNI mapping to *all tunnels* with the following command:

```
CLI (network-admin@leaf-5) > bridge-domain-create name bd5001234 scope fabric vxlan 5001234 auto-vxlan
```

Instead, if you want the software to automatically pick and assign the VNI, you can simply enter the following shorter command that requires `scope` to be `fabric`:

```
CLI (network-admin@leaf-5) > bridge-domain-create name BD-VNI-SELF scope fabric auto-vxlan
```

The range used for automatic VNI assignment can be controlled and modified, if needed, with the `vtep-auto-vxlan-show` and `vtep-auto-vxlan-modify` commands.

Once the VXLAN overlay deployment is complete and the BD's VXLAN ID is (manually or automatically) associated to it, then it is possible to start adding switch ports.

Informational note: Before Netvisor ONE release 6.1.1., when a port is assigned to a BD (as in the examples below) it cannot be associated with a regular VLAN configured with the `vlan-create` command, and vice versa. The restriction has been lifted in release 6.1.1.

In order to add a port connected to the cloud provider network to the BD, you can use the following command that explicitly maps both inner and outer VLANs to the BD:

```
CLI (network-admin@leaf-7) > bridge-domain-port-add name
bd1000 port 13 outer-vlan 13 inner-vlan 100
```

This configuration also means that a frame's MAC lookup in the Layer 2 table is performed including both the outer VLAN and the inner VLAN.

The same configuration can be used to add a port connected to an 802.1ad-configured server to the BD:

```
CLI (network-admin@leaf-2) > bridge-domain-port-add name
bd1000 port 11 outer-vlan 13 inner-vlan 100
```

In order to add a port connected to an 802.1Q network to the BD, you can use the following command that explicitly maps only the outer VLAN to the BD (and preserves the inner VLAN):

```
CLI (network-admin@leaf-2) > bridge-domain-port-add name
bd1000 port 15 outer-vlan 19
```

This configuration also means that a frame's MAC lookup in the Layer 2 table is performed including only the outer VLAN while the inner VLAN is ignored.

In order to add a port connected to an 802.1Q server to the BD, you can use the following command that explicitly associates one or more VLANs on the same switch port to the same BD:

```
CLI (network-admin@leaf-1) > bridge-domain-port-add name
bd2100 port 10 vlans 210,310
```

> **Note**: The multiple VLAN IDs on the same port can be part of the same bridge domain. However, VLAN IDs added to a BD cannot be reused with another BD on the same port. Also note that MAC addresses associated with these two VLAN IDs must be unique within the BD.

Finally, you should also configure all cluster ports/trunks and ports in QinQ mode to work with the 802.1ad TPID (i.e., 0x88A8) with the following command:

```
CLI (network-admin@switch) > port-config-modify port
<port_number> allowed-tpid q-in-q
```

Port removal from a BD and BD deletion follow the reverse order compared to the addition process described in the above steps.
Ports have to be removed first with the command:

```
CLI (network-admin@leaf-2) > bridge-domain-port-remove name
bd1000 port 15
```

Then a BD's VXLAN ID may be manually removed from the associated tunnel(s):

```
CLI (network-admin@leaf-2) > tunnel-vxlan-remove name tunnel-2
vxlan 10000
```

or from the corresponding VTEP objects like so:

```
CLI (network-admin@leaf-2) > vtep-vxlan-remove name vtep2
vxlan 10000
```

Finally, the BD can be deleted with the following command:

```
CLI (network-admin@leaf-2) > bridge-domain-delete name bd1000
```

Starting from Netvisor ONE release 6.0.0, when a BD is deleted, if it was previously created with the `auto-vxlan` option, the BD or VNI mapping gets removed from all the tunnels automatically, so you don't need to do it manually.

From Netvisor ONE version 6.1.0, the `vxlan-stats-show` command displays the statistics for VXLANs associated with bridge domains.

For example, to view the VXLAN statistics for the bridge domain BD100, use the following command:

```
CLI (network-admin@switch) > vxlan-stats-show bd BD100 layout
vertical
time:         03:23:19
vnid:         12591499
vxlan-name:
vnet:
bd:           BD100
ibytes:       7.60T
ibits:        66.8T
ipkts:        3.59G
idrops-pkts:  0
obytes:       7.54T
obits:        66.5T
opkts:        3.59G
odrops-pkts:  0
```

Configuring Bridge Domains in vNETs

Netvisor ONE version 6.1.0 supports the configuration of bridge domains in vNETs. This enhancement enables vNET users to configure bridge domains on vNET ports so that they can be managed on a per tenant basis.

To configure bridge domains in a vNET, you should first specify the number of allowed bridge domains in the vNET when creating it. Also, you must specify the `vlan-type` as `private,` because the default `vlan-type` is `public` but bridge domains are supported only in global or private vNETs. For example:

```
CLI (network-admin@switch) vnet-create name vnet1 scope fabric
vlan-type private vlans 300-400 num-bridge-domains 3 vxlans
10100 vxlan-end 10200
```

You can now create a bridge domain in `vnet1` by using the command:

```
CLI (network-admin@switch) bridge-domain-create name bd1 scope
fabric vxlan 10100 vnet vnet1
```

View the bridge domain configuration by using the command:

```
CLI (network-admin@switch) > bridge-domain-show layout
vertical
name:                  bd1
vnet:                  vnet1
scope:                 fabric
vxlan:                 10100
auto-vxlan:            no
rsvd-vlan:             2833
vxlan-inner-packet:    auto
qinq_rsvd_vlan:        2833
mac-learning:          on
```

Note:You cannot specify a reserved VLAN for a bridge domain in a vNET configuration as the reserved VLAN is automatically selected from the `vtep-auto-vlan` range. Since this VLAN range is common to all vNETs, you cannot create bridge domains in a vNET if this pool is exhausted.

The `vtep-auto-vlan` range has 500 VLANs allocated by default:

```
CLI (network-admin@switch) > vtep-auto-vlan-show
vlans:     2500-2999
```

You can widen this range, for example, by 11 VLANs by using the command:

```
CLI (network-admin@switch) > vtep-auto-vlan-modify vlans 2500
vlan-end 3010
```

`vtep-auto-vlan-modify`	Modify the VLAN ID range for automatic assignment to VTEPs at the fabric level.
`vlans` *`0..4095`*	Specify the starting VLAN ID for `vtep-auto-vlan` range.
`vlan-end` *`0..4095`*	Specify the ending VLAN ID for `vtep-auto-vlan` range.

Note: The `vtep-auto-vlan` reserved range and the VLAN range manually allocated to each vNET must be mutually exclusive.

Add ports to `bd1` by using the `bridge-domain-port-add` command:

```
CLI (network-admin@switch) > bridge-domain-port-add name bd1
```

```
port 33 vlans 100
```

> **Note:** You can only add vNET managed ports to the bridge domain. However, there is no restriction on assigning VLANs that are not part of the vNET to the bridge domain.

View the configuration using the command:

```
CLI (network-admin@switch) > bridge-domain-port-show
switch name port vlans   l2-learning
------ ---- ---- ------- -----------
switch bd1  33   100     none
```

To complete the configuration, as demonstrated earlier, associate the bridge domain's VXLAN ID with a tunnel by using the command:

```
CLI (network-admin@switch) > tunnel-vxlan-add name t1 vxlan
10100
```

You can also associate the bridge domain's VXLAN ID with a VTEP by using the `vtep-vxlan-add` command as shown earlier.

Configuring Transparent and Remove Tags Modes for Bridge Domain

Starting from Netvisor ONE release 6.1.0, a new VXLAN transport mode, `transparent` has been added to the bridge domain configuration. This new mode can be used when end-to-end VLAN tag and CoS field (priority bits) transparency (i.e., preservation) is required.

Starting from the same release, there is an additional `remove-tags` mode, which can be used when 802.1Q tag preservation is not required. The typical use case is when an untagged host needs to talk to a VLAN-tagged one or with one configured with two tags.

> **Note**: In this mode `outer-vlan` is not supported as standalone parameter and produces an error if used in the configuration of bridge domain ports. The user can instead specify both the `outer-vlan` and `inner-vlan` parameters in the port configuration.

Furthermore, starting from Netvisor ONE release 6.1.1 the `remove-tags` mode has been extended to support all port types with the same bridge domain (with the above exception of `outer-vlan` mode): untagged, tagged or double-tagged.

In this mode, when a packet is received on a port, the hardware removes all the VLAN tags flagging it as "untagged" and keeping it untagged also during VXLAN encapsulation. Then, after being decapsulated and when going out of the egress port, zero, one or two tags will be added to the packet depending on the egress port type. In this mode, CoS field (priority bits) configuration has been added too, as discussed below.

> **Note**: Supporting multiple BD modes provides flexibility for numerous use cases, however BD modes *must be configured consistently across bridge domain end points*. In other words, a BD end point configured with local scope in `remove-tags` mode will not talk to another end point on a different switch configured with local scope in, say, `auto` mode.

First off, use the `vxlan-inner-packet` parameter to select a mode or modify it:

```
CLI (network-admin@switch) > bridge-domain-create name <name> scope <scope> vxlan <vxlan-id> vxlan-inner-packet auto|remove-tags|transparent

CLI (network-admin@switch) > bridge-domain-modify name <bridge-domain-name> vxlan-inner-packet auto|remove-tags
```

`Auto` is the implicit default transport mode, which represents the pre-6.1.0 mode of operation. In the VXLAN transport it removes the outer VLAN tag for 802.1ad-tagged packets and retains the VLAN tag for 802.1Q-tagged packets.

Instead, the new `transparent` and `remove-tags` modes must be configured explicitly by the user to be applied to the VXLAN transport.

When a bridge domain is created in transparent mode there are some important configuration limitations/requirements to keep in mind:

- Transparent mode is supported only with ports configured with the `vlans` or `outer-vlan` parameter, but **not** with both for the same bridge domain.
- The `bridge-domain-modify` command is not supported. Instead, you must delete the BD followed by adding the BD again by using the commands, `bridge-domain-delete`, followed by `bridge-domain-add`.
- The `bridge-domain-port-modify` command is not supported. Instead, use `bridge-domain-port-remove` followed by `bridge-domain-port-add` commands.
- Untagged ports are not supported.
- For 802.1ad-tagged (QinQ) ports, use `outer-vlan <vlan-id>` parameter only. The `inner-vlan` parameter is not supported while using the `bridge-domain-port-add` command.
- On all the ports of a transparent bridge domain the user needs to configure a common global VLAN, which needs to be set aside specifically for that use in the fabric.
- The user does not need to configure a special `rsvd-vlan` on clusters. Netvisor ONE takes care of that automatically.
- `Local` scope is not supported.
- The user needs to add both `vlan` and `q-in-q` TPIDs on cluster links.
- Netvisor ONE supports both the parameters: `mac-learning|no-mac-learning` to enable or disable MAC learning on a bridge domain. However, we recommend enabling MAC learning. If you disable MAC learning by using the parameter, `no-mac-learning`, then it may lead to unnecessary flooding including to *cluster* and *CPU port*.
- The `port congestion` displayed in the `port-stats-show port 0` (CPU port) reflects packets dropped by the hardware *rate-limiter* that exceeds the configured Q threshold to protect the CPU. This includes flooded (BUM) traffic.

Here is an example of transparent bridge domain creation:

```
CLI (network-admin@switch) bridge-domain-create name
transparent-bd scope fabric vxlan-inner-packet transparent
vxlan 10000

CLI (network-admin@switch) > bridge-domain-show

Switch  name           scope  vxlan auto-vxlan vxlan-inner-packet mac-learning
------- -------------- ------ ----- ---------- ------------------ ------------
switch  transparent-bd fabric 10000  no         transparent        on
```

Once the bridge domain is created, you can assign a port configured with a regular 802.1Q VLAN (say, 100) to the transparent bridge domain like so:

```
CLI (network-admin@switch) > bridge-domain-port-add name
transparent-bd port 10 vlans 100
```

Alternatively, if a port needs to receive 802.1ad double-tagged traffic (with outer VLAN 100), you can add it to the transparent bridge domain like so:

```
CLI (network-admin@switch) > bridge-domain-port-add name transparent-bd port 11 outer-vlan 100
```

In the above examples the common global VLAN that gets dedicated to the transparent bridge domain is VLAN 100. The user has to make sure that the same VLAN is used consistently on each transparent bridge domain port. Also, as noted in the limitation list above, ports configured with the `vlans` parameter and ports configured with the `outer-vlan` parameter are *not* allowed to be used in the same transparent bridge domain.

An important requirement with transparent bridge domains is that cluster links (for example, switch ports 8 and 9 on a cluster pair) be manually configured to carry both 802.1Q and 802.1ad TPIDs (namely, 0x8100 and 0x88a8) like so:

```
CLI (network-admin@switch) > port-config-modify ports 8,9 allowed-tpid vlan,q-in-q
```

To view the statistics (byte, packet, unicast, multicast, broadcast, input, output, drops) use the following commands:

- To view per tunnel statistics, use the `tunnel-stats-show` command.
- To view the per VNI (tied to VLAN or bridge-domain) statistics, use the `vxlan-stats-show` command.
- To view the per port statistics , use the `port-stats-show` command.
- To view the per port per CoS statistics, use the `port-cos-stats-show` command.

Use the `show-diff-interval <interval-in-secs>` formatting option with the above commands to monitor the real-time statistics every `<interval-in-secs>` seconds. For example,

```
CLI (network-admin@switch) > tunnel-stats-show show-diff-interval 2
```

```
time     tunnel-name                    ibits iUpkts iBpkts iMpkts iCongDrops ierrs obits oUpkts oBpkts oMpkts oCongDrops oerrs mtu-errs
-------- ------------------------------ ----- ------ ------ ------ ---------- ----- ----- ------ ------ ------ ---------- ----- --------
16:21:17 VLE-TUNNEL                     0     0      0      0      0          0     40.8M 8.01K  0      0      0          0     0
16:21:17 auto-tunnel-11.0.0.1_14.0.0.1  9.27M 0      0      10.9K  0          0     0     0      0      0      0          0     0
16:21:17 auto-tunnel-11.0.0.1_13.0.0.1  31.9M 0      0      37.4K  0          0     0     0      0      0      0          0     0
16:21:17 auto-tunnel-11.0.0.1_16.0.0.1  6.85M 0      0      8.04K  0          0     0     0      0      0      0          0     0
16:21:17 auto-tunnel-11.0.0.1_15.0.0.1  27.5K 0      0      33     0          0     0     0      0      0      0          0     0
time     tunnel-name                    ibits iUpkts iBpkts iMpkts iCongDrops ierrs obits oUpkts oBpkts oMpkts oCongDrops oerrs mtu-errs
-------- ------------------------------ ----- ------ ------ ------ ---------- ----- ----- ------ ------ ------ ---------- ----- --------
16:21:19 VLE-TUNNEL                     0     0      0      0      0          0     0     0      0      0      0          0     0
16:21:19 auto-tunnel-11.0.0.1_14.0.0.1  0     0      0      0      0          0     0     0      0      0      0          0     0
16:21:19 auto-tunnel-11.0.0.1_13.0.0.1  0     0      0      0      0          0     0     0      0      0      0          0     0
16:21:19 auto-tunnel-11.0.0.1_16.0.0.1  0     0      0      0      0          0     0     0      0      0      0          0     0
16:21:19 auto-tunnel-11.0.0.1_15.0.0.1  0     0      0      0      0          0     0     0      0      0      0          0     0
```

Use the `format all` option to view detailed statistics.

Starting from Netvisor version 6.1.1, the `remove-tags` mode supports all port types at the same time on the same physical interface. You can use different bridge domains or even the same bridge domain configured in all modes on the same port.

Note: As with `transparent` mode, the `bridge-domain-port-modify` command is not supported. Instead, use `bridge-domain-port-remove` followed by the `bridge-domain-port-add` command to change port mode.

To configure `remove-tags` mode use the command:

```
CLI (network-admin@switch) > bridge-domain-create name <new-
name> scope <scope> vxlan <vxlan-id> vxlan-inner-packet
remove-tags
```

Or, for an existing bridge domain, use the command:

```
CLI (network-admin@switch) > bridge-domain-modify name
<bridge-domain-name> vxlan-inner-packet remove-tags
```

For example, you can configure multiple port modes on bridge domain BD2 in `remove-tags` mode like so:

```
CLI (network-admin@switch) > bridge-domain-show

name  scope   ports  vxlan-inner-packet  mac-learning  l2-tunneling
----  ------  -----  ------------------  ------------  ------------
BD1   local          auto                on            none
BD2   local   20     remove-tags         on            none

CLI (network-admin@switch) > bridge-domain-port-add name BD2
port 20 untagged-port-vlan 200
CLI (network-admin@switch) > bridge-domain-port-add name BD2
port 20 vlans 300
```

The result of the port configuration can be displayed with the command:

```
CLI (network-admin@switch) > bridge-domain-port-show

name  port  vlans  untagged-port-vlan  l2-learning
----  ----  -----  ------------------  -----------
BD2   20           200                 none
BD2   20    300                        none
```

You can also configure different BDs on the same port in different modes, for example like so:

```
CLI (network-admin@switch) > bridge-domain-show

Switch  name  scope  vxlan-inner-packet  mac-learning  l2-tunneling
------  ----  -----  ------------------  ------------  ------------
switch  bd1   local  remove-tags         on            none
switch  bd2   local  remove-tags         on            none
switch  bd3   local  remove-tags         on            none

CLI (network-admin@switch) > bridge-domain-port-show
```

```
switch  name  port  outer-vlan  vlans  untagged-port-vlan  inner-
vlan  l2-learning
------  ----  ----  ----------  -----  ------------------
----------  -----------
switch  bd1   30                       500
 none
switch  bd2   30                300
 none
switch  bd3   30   2000                                      1000
 none
```

It is also possible to configure multiple VLANs on the same port for the same bridge domain:

```
CLI  (network-admin@switch)  >  bridge-domain-port-show

name  port  outer-vlan  vlans  untagged-port-vlan  inner-vlan  l2-
learning
----  ----  ----------  -----  ------------------  ----------
-----------
BD1   25               103                                     none
BD1   25               104                                     none
```

And it is possible to configure multiple combinations of inner and outer VLANs on the same port for the same bridge domain, as shown below:

```
CLI  (network-admin@switch)  >  bridge-domain-port-show

switch  name  port  outer-vlan  vlans  untagged-port-vlan  inner-
vlan  l2-learning
------  ----  ----  ----------  -----  ------------------
----------  -----------
switch  BD1   9    2000                                      1000
 none
switch  BD1   9    2001                                      1001
 none
switch  BD1   9    2002                                      1002
 none
```

Furthermore, it is possible to configure the egress CoS field value (priority bits) to include in the packet tag by using one of the following commands depending on the egress port type:

- Double-tagged traffic port:

```
CLI  (network-admin@switch)  >  bridge-domain-port-add  name  bd1
port 10 outer-vlan 10 outer-cos 7 inner-vlan 100 inner-cos 5
```

- Single-tagged traffic port:

```
CLI  (network-admin@switch)  >  bridge-domain-port-add  name  bd1
port 20 vlans 200 cos 3
```

Note: The `bridge-domain-port-modify` command cannot be used to change CoS values.

Configuring a Bridge Domain and a VLAN on the Same Port

Before Netvisor ONE release 6.1.1, a bridge domain and a VLAN were not allowed to be configured on the same port. They were mutually exclusive.

A port can be added to a bridge domain with the `bridge-domain-create` plus `bridge-domain-port-add` command sequence. On the other hand, a port can be added to a VLAN with the `vlan-create` plus `vlan-port-add` command sequence.

In the latter case above, when a VLAN was already configured on a port (say, port 20), attempting to configure a bridge domain on the same port would have produced the following error:

```
vlan/vxlan is already configured on port 20, remove it to
configure Q-in-Q
```

Vice versa, on a port (say, port 21) already configured with a bridge domain (with the first sequence described above), attempting to configure a VLAN on the same port would have produced the following error:

```
Ignoring port (21) addition to vlan 10 since these port are
part of Q-in-Q
```

Starting from Netvisor ONE release 6.1.1, these checks (and the corresponding errors) are removed as it is now possible to configure both a VLAN and a BD on the same port.

However, there are still some *restrictions* that must be considered:

- A bridge domain and a VLAN are not allowed to share the same (port, VLAN ID) value pair. So, for example, if (port 20, VLAN 100) is already part of `BD1`, then the VLAN configuration cannot use the same (port 20, VLAN 100) pair. If a conflicting pair is used by mistake in the configuration, it will be rejected.
- Since a port can only have one untagged VLAN, it can either be used by a bridge domain (in untagged mode) or as a port's native VLAN. The same VLAN ID cannot be used in both configurations. Therefore, a conflicting configuration will be rejected.
- If vLE is configured on a port, the same port cannot be used for VLAN or BD configuration.
- VLAN and bridge domain configuration cannot be done on a port that is configured as a Network Packet Broker (NPB) port.

Configuring Layer 2 Protocol Tunneling

Starting from Netvisor ONE release 6.1.1, PDU Transparency (a.k.a. Layer 2 Protocol Tunneling) is supported on bridge domains by leveraging hardware forwarding capabilities. With this feature certain protocol packets (i.e., PDUs) are no longer terminated on the ingress switch port and then sent to the CPU for processing. They are instead tunneled over a bridge domain. Currently the feature supports STP, LLDP and LACP PDUs.

Layer 2 Protocol Tunneling can be enabled during or after bridge domain creation with the new `l2-tunneling` keyword. When a bridge domain is created:

```
CLI (network-admin@switch) > bridge-domain-create name <name>
scope <scope> vxlan <vxlan-id> vnet <vnet-id> l2-tunneling
{stp | lacp | lldp | all | none}
```

`none` is the default value when the `l2-tunneling` keyword is not used.

Layer 2 Protocol Tunneling configuration can be modified with the following command:

```
CLI (network-admin@switch) > bride-domain-modify name <name>
l2-tunneling {stp | lacp | lldp | all | none}
```

The `bridge-domain-show` command includes a new column to display the Layer 2 Protocol Tunneling configuration:

```
CLI (network-admin@switch) > bridge-domain-show format
name,vxlan,auto-vxlan,rsvd-vlan,local-rsvd-
vlan,qinq_rsvd_vlan,mac-learning,L2-tunneling,
```

```
switch  name  vxlan   auto-vxlan  rsvd-vlan  local-rsvd-vlan  qinq_rsvd_vlan  mac-learning  L2-
tunneling
------  ----  ------  ----------  ---------  ---------------  --------------  ------------
------------
switch bd1  100101 no         1001      1001                         off          all
switch bd2  100102 no         1002      1002                         on
stp,lldp
switch bd3  100103 no         1003      1003                         on           none
```

Note: Bridge domain PDU transparency leverages the device's hardware capabilities and therefore requires the configuration of a VXLAN Loopback Trunk, even when single pass mode is used.

Disabling MAC Address Learning on Bridge Domains

In certain bridge domains, the MAC address learning function can be disabled in order to achieve better scalability, or because it is not strictly required (for example on point-to-point connections).

For these cases, starting from Netvisor ONE release 6.0.0, it is possible to disable MAC address learning as part of a bridge domain configuration. For this purpose, a new configuration option is added, `mac-learning | no-mac-learning`, to the following commands:

```
bridge-domain-create scope local mac-learning | no-mac-
learning
bridge-domain-modify scope local mac-learning | no-mac-
learning
```

By default, MAC address learning is *enabled* at the bridge domain level.

Moreover, to support more granular per-port configurability, a new option, `l2-learning enable | disable | none`, is also added to the `bridge-domain-port-add` and `bridge-domain-port-modify` commands.

The default configuration is `l2-learning none`. In such case, at the port level the MAC address learning state is directly derived from the one of the encompassing bridge domain.

On the other hand, the `enable` and `disable` options can be used to take precedence over the per-bridge domain configuration to achieve port-level granularity.

The `bridge-domain-show` and `bridge-domain-port-show` commands are extended to
display the `mac-learning/l2-learning` state.

For example, to disable MAC address learning for an entire bridge domain at creation, use the command:

```
CLI (network-admin@switch) > bridge-domain-create name bd1
scope local vxlan 100101 no-mac-learning
```

```
CLI (network-admin@switch) > bridge-domain-show

switch name scope vxlan auto-vxlan rsvd-vlan ports mac-learning
------ ---- ----- ------ ---------- -------- ----  ------------
switch bd1  local 100101 no                        off
```

To reenable MAC address learning only on port 17, while leaving it disabled on port 21, you can use the commands:

```
CLI (network-admin@switch) > bridge-domain-port-add name bd1
port
17 vlans 100 l2-learning enable
```

```
CLI (network-admin@switch) > bridge-domain-port-add name bd1
port 21 vlans 200

CLI (network-admin@switch) > bridge-domain-port-show name bd1

switch   name port vlans l2-learning
------- ---- ---- ----- -----------
switch  bd1   17  100    enable
switch  bd1   21  200    none
```

To re-enable MAC address learning on the entire bridge domain:

```
CLI (network-admin@switch) > bridge-domain-modify name bd1
mac-learning

CLI (network-admin@switch) > bridge-domain-show name bd1

switch name  scope vxlan auto-vxlan ports mac-learning
------ ----- ----- ----- ---------- ----- ------------
switch  bd1  local 100101   no      17,21   on

CLI (network-admin@switch) > bridge-domain-port-show name bd1

switch name   port vlans l2-learning
------ -----  ---- ----- -----------
switch bd1    17   100    enable
switch bd1    21   200    none
```

Then to revert to the default per-port configuration on port 17 you can use:

```
CLI (network-admin@switch) > bridge-domain-port-modify name
bd1 port 17 l2-learning none
```

Displaying vLE Statistics

The vLE statistics information is useful for understanding the data traffic through a vLE. This information includes the number of incoming and outgoing packets (classified as unicast, multicast, and broadcast), bytes dropped, bytes discarded, Head-End-Replicated (HER) packets, and errors. Use the `vle-stats-show` command to display vLE statistics on each VLE port.

```
CLI (network-admin@switch1) > vle-stats-show
```

`vle-stats-show`	Displays port statistics.
`time date/time: yyyy-mm-ddThh:mm:ss`	Specify a time for the packet count statistics using the timestamp format yyyy-mm-ddThh:mm:ss.
`start-time` *`start-time`*	Specify a start time for the packet count statistics using the timestamp format yyyy-mm-ddThh:mm:ss.
`end-time` *`end-time`*	Specify an end time for the packet count statistics using the timestamp format YYYY-MM-DDTHH:MM:SS
`duration` *`duration`*	Specify the duration in seconds.
`interval duration: #d#h#m#s`	Specify the interval between statistics collection.
`since-start|no-since-start`	Specify if the statistics are collected from the start of collecting statistics.
`older-than duration: #d#h#m#s`	Specify if the statistics are older than the duration in days, hours, minutes, and seconds.
`within-last duration: #d#h#m#s`	Specify if the statistics are within the duration in days, hours, minutes, and seconds.
`vle-name` *`vle-name-string`*	Specify the VLE name.
`description` *`description`*	Displays the VLE description.
`counter` *`counter-number`*	Displays the counter number.
`ibytes ibytes-number`	Displays the incoming number of bytes.
`ibits` *`ibits-number`*	Displays the number of incoming bits.
`iUpkts` *`iUpkts-number`*	Displays the number of incoming unicast packets.
`iBpkts` *`iBpkts-number`*	Displays the number of incoming broadcast packets.
`iMpkts` *`iMpkts-number`*	Displays the number of incoming multicast packets.

`iPauseFs` *`iPauseFs-number`*	Displays the number of incoming pause frames.
`iCongDrops` *`iCongDrops-number`*	Displays the number of incoming packets dropped due to congestion.
`idiscards` *`idiscards-number`*	Displays the number of incoming packets discarded.
`ierrs` *`ierrs-number`*	Displays the number of incoming packets with errors.
`obytes` *`obytes-number`*	Displays the number of outgoing bytes.
`oUpkts` *`oUpkts-number`*	Displays the number of outgoing unicast packets.
`oBpkts` *`oBpkts-number`*	Displays the number of outgoing broadcast packets.
`oMpkts` *`oMpkts-number`*	Displays the number of outgoing multicast packets.
`oPauseFs` *`oPauseFs-number`*	Displays the number of outgoing pause frames.
`oCongDrops` *`oCongDrops`*`-number`	Displays the number of outgoing packets dropped due to congestion.
`odiscards` *`odiscards-number`*	Displays the number of outgoing discarded packets.
`oerrs` *`oerrs-number`*	Displays the number of outgoing packets with errors.
`mtu-errs` *`mtu-errs-number`*	Displays the number of MTU errors.
`HER-packets` *`HER-pts-number`*	Displays the number of Head End Replicated (HER) packets.
`HER-bytes` *`HER-bytes-number`*	Displays the number of Head End Replicated (HER) bytes.

Consider for example, a vLE represented by the following `vle-show` output:

```
CLI (network-admin@switch1) > vle-show layout vertical
name:          vle1
vnet:
node-1:         switch1
node-2:         switch2
node-1-port:   12
node-2-port:   23
status:        up
tracking:       enabled
ports-state:    override
create-time:   08:47:56
```

View the statistics for this vLE by using the `vle-stats-show` command:

```
CLI (network-admin@ara00) > vle-stats-show layout vertical
switch:        switch1
time:          06:14:49
vle-name:      vle1
port:          12
description:
ibits:         349M
iUpkts:        184K
iBpkts:        0
iMpkts:        0
iCongDrops:    0
ierrs:         0
obits:         63.3M
oUpkts:        56.2K
oBpkts:        0
oMpkts:        0
oCongDrops:    0
oerrs:         0
mtu-errs:      0
switch:        switch2
time:          06:14:49
vle-name:      vle1
port:          23
description:
ibits:         108M
iUpkts:        0
iBpkts:        0
iMpkts:        141K
iCongDrops:    0
ierrs:         0
obits:         63.3M
oUpkts:        0
oBpkts:        0
oMpkts:        56.3K
oCongDrops:    0
oerrs:         0
mtu-errs:      0
```

You can clear the statistics on the local switch by using the command `vle-stats-clear`.

Troubleshooting vLE

To troubleshoot vLE link state tracking, refer to the examples in the *Configuring Virtual Link Extension State Tracking* section. In particular, for both individual vLE pseudo-wires and redundant vLE trunks protocol messages can be leveraged to verify end-to-end connectivity (or lack thereof). LLDP messages (and LACP messages in case of trunks) show the neighboring port ID(s) and reflect the up/down connectivity status of the pseudo-wire(s). Therefore they are very valuable troubleshooting tools.

With vLE link state tracking enabled, a vLE pseudo-wire can go down (i.e., in vle-wait state) when the remote end of the vLE goes down. However, in some cases, it may be possible that a “false positive” event occurs in which the local vLE port goes down even if the remote end is *physically up*. This could happen if the vLE tracking logic incorrectly believes the remote end to be unreachable. In such case, you can disable vLE tracking, which should bring the local port back up and allow you to check if the traffic is flowing through the vLE pseudo-wire correctly. Increasing the vLE tracking timeout can help to avoid false positives by giving more leeway to the link state tracking software, especially when experiencing frequent link flaps or CPU overload conditions (which could affect the tracking logic negatively).

Guidelines and Limitations

This is a list of guidelines and limitations to keep in mind when configuring bridge domains:

- Currently on bridge domain ports in `auto` mode the QoS default behavior is as follows:
    - o Incoming 802.1Q frames' CoS value (a.k.a. PCP) is preserved along with the VLAN tag when transported in the VXLAN payload
    - o Incoming 802.1ad frames' CoS value from the inner tag is preserved along with the inner VLAN tag when transported in the VXLAN payload
    - o For outgoing 802.1Q frames after VXLAN decapsulation *CoS is set to value 0*
    - o For outgoing 802.1ad frames after VXLAN decapsulation the CoS value carried in the VXLAN packet is preserved and becomes the CoS value of the inner tag. The outer tag instead *carries a CoS value of 0*.

- Before Netvisor ONE release 6.0.0 on the Dell S5232-ON and Dell S5248-ON switch models the QinQ and untagged modes were not supported, while the 802.1Q mode is allowed. Starting from release 6.0.0 support for QinQ and untagged mode was added (however, an untagged host can only communicate to another untagged host in a bridge domain).

- On ports added to a BD, the STP protocol and the IGMP snooping features are not supported.

- Routing on BDs is not supported.

- Before Netvisor ONE release 6.1.0 vNETs were not supported with BDs.

- The LLDP and LACP protocols are supported on BD ports configured in QinQ mode. The trunking and vLAG functionalities are supported too.

- The optimized ARP and optimized ND features cannot coexist with BDs. They should be set to off in the `system-setting-show` output. If the user attempts to enable the feature, a conflict message is printed as below:

```
CLI (network-admin@switch) > system-settings-modify optimize-
arps
system-settings-modify: Cannot turn on optimized ARP as
bridge-domain Q-in-Q is configured
```

When optimized ARP/ND is already configured before a port is added to a BD, a similar conflict message is printed:

```
CLI (network-admin@switch) > bridge-domain-port-add name
bd1000 port 18 outer-vlan 18 inner-vlan 100
bridge-domain-port-add: Cannot add port in Q-in-Q mode to
bridge-domain as optimized ARP or ND configured
```

- The flowtrace function is not supported with VXLAN and BDs.

- The VLAN ID is not shown in the `l2-table-show` output when a L2 entry is associated to a cluster tunnel:

```
CLI (network-admin@leaf1) > l2-table-show bd bd1 format
switch,mac,bd,vlan,vxlan,inrf,ports,tunnel

switch           mac               bd  vlan vxlan  intf ports  tunnel

---------------- ----------------- --- ---- ------ ---- -----
---------------------------------
leaf1            00:12:c0:80:1c:09 bd1 100  101001 274
82
ursa-scale-leaf2 00:12:c0:80:1c:09 bd1 100  101001 274  82
ursa-scale-leaf1 00:12:c0:80:40:52 bd1      101001            auto-tunnel-
10.40.40.1_10.30.40.1
ursa-scale-leaf2 00:12:c0:80:40:52 bd1      101001            auto-tunnel-
10.40.40.1_10.30.40.1
ursa-scale-leaf4 00:12:c0:80:40:52 bd1 100  101001 81   81
```

- When configuring vLE redundancy, if LACP is used for end-to-end connectivity checks (which is usually preferable), a vLE trunk can be set up only with multiple individual virtual pipes using separate VTEPs (e.g., 8 in case of a 4-way vLE trunk). When using static trunks, instead, it is also possible (but generally less desirable) to set up, say, a 4-way vLE trunk with 2 2-way trunks as endpoints (which equates to a 4 x 2-port trunk configuration on leaf switches and a 4-way trunk configuration on end devices).

- For vLE endpoints only use physical IP (PIP) addresses. Do not use VRRP virtual IP (VIP) addresses.

- With the `allowed-tpid  qinq` (i.e., 802.1ad TPID) configuration on a BD port configured in 802.1Q mode, MAC address learning includes both outer and inner VLAN of a double-tagged 802.1ad frame. Instead, for a single-tagged 802.1Q frame MAC address learning is based on just one VLAN. Both types of MAC address entries can be seen with the `l2-table-show` command. The hardware associates a BD and a VNI to a packet based on the port type. For BD ports configured in 802.1Q mode, the hardware lookup does not use the inner VLAN, it uses only the outer VLAN. So for bridge domain-related troubleshooting, use the `l2-table-show` command to focus on the MAC address+VNI pairs, rather than looking at the outer and/or inner VLAN, as the hardware lookup for Layer 2 entries is based on MAC address and VNI value.

Supported Releases

Command/Parameter	Netvisor ONE Version
`vxlan-mode standard|transparent`	Parameter added in version 2.5.2
`vle-create, vle-delete, vle-modify, vle-show`	Command added in version 2.5.4
`vle-tracking-timeout`	Parameter added in version 3.0.0
`vle-transparent-modify, vle-transparent-show, vle-transparent-port-remove, vle-transparent-port-show, vle-transparent-port-add`	Commands introduced in version *5.1.1*
`port-config-modify allowed-tpid q-in-q`	Parameter introduced in version 5.2.0
`bridge-domain-create, bridge-domain-rsvd-vlan-add, bridge-domain-port-add`	Commands introduced in version 5.2.0
`l2-table-show bd bd_name`	Parameter introduced in version 5.2.0
`ports-state`	Parameter introduced in version 6.0.0
`auto-vxlan`	Parameter introduced in version 6.0.0
`mac-learning|no-mac-learning l2-learning enable|disable|none`	Parameters introduced in version 6.0.0
`vnet, create-time, elapsed-time, up-time`	Parameters introduced in version 6.1.0
`vle-stats-show`	Command introduced in version 6.1.0
`vxlan-inner-packet transparent|auto|remove-tags`	Parameters added in version 6.1.0
`outer-cos, inner-cos, cos`	Parameters added in version 6.1.1
`l2-tunneling`	Parameters added in version 6.1.1

Please also refer to the Pluribus Command Reference document.

Related Documentation

For further information on concepts mentioned in this section (such as Layer 2, Layer 3, etc.), refer to these sections of the Configuration Guide:

- Configuring Switch Ports
- Configuring Layer 2 Features
- Configuring Layer 3 Features
- Configuring and Administering the Pluribus Fabric
- Configuring High Availability
- Configuring VXLAN
- Configuring vNETs

Also, refer to the *VirtualWire Deployment* guide.

Configuring and Using Network Management and Monitoring

This chapter provides required information about the Network Management and Monitoring features on a Netvisor ONE switch using the Netvisor ONE Command Line Interface.

Overview

Network Management and Monitoring involves an array of methods and tools that can help to operate and maintain an error-free network. Network management tools primarily cater to the collection and organization of information regarding a network, enabling you to make informed decisions while configuring, troubleshooting, or overseeing the operation of the network. Network management is essential to ensure optimal performance and fault-free operation of network elements. Netvisor ONE provides a handful of methods to manage and monitor a network including different logging schemes, Simple Network Management Protocol (SNMP), mirroring of network traffic, and system statistics.

Supported Network Management Components

Netvisor ONE supports systems statistics, logging, Simple Network Management Protocol (SNMP), and traffic mirroring, as the primary methods of network management and monitoring.

System Statistics: This network monitoring method provides information about the CPU and memory usage of a switch. This gives you an insight into the performance and efficiency of the network device.

Logging: Logs serve as a record of all important events that occur in a network. Netvisor ONE broadly has four types of logging: event logging, audit logging, system logging, and perror logging. Logging tracks activities such as connection state changes, administrative changes, user login or logout, protocol events, and so on. Logging information can be viewed on the switch and can also be sent to dedicated servers from where it can be accessed later through the CLI.

SNMP: Netvisor ONE allows monitoring of network nodes through this protocol. The SNMP manager installed on a server called Network Management Station (NMS) polls the SNMP agents installed on the network devices periodically for information regarding network events. This collected information can be accessed through the CLI. In addition, SNMP traps can be configured to receive instantaneous alerts for desired events, instead of relying solely on periodic SNMP polls.

Traffic Mirroring for Ports and vFlows: This functionality is used to copy packets from one port to another for increased visibility into the network traffic. This feature supports a basic configuration analogous to local Switched Port Analyzer (SPAN) as well as advanced configurations similar to Remote Switched Port Analyzer (RSPAN) and Encapsulated Remote Switched Port Analyzer (ERSPAN).

Understanding System Statistics

Measuring the hardware utilization of each device is the key to evaluate the efficiency of networking infrastructure. The performance of a device is determined primarily by two hardware resources: CPU and main memory. System statistics in Netvisor ONE comprise the CPU and memory usage of the switch.

System statistics on a switch also include memory swapping and paging parameters. Swapping is when an entire process' address space is mapped from the main memory (RAM) to a secondary memory (disk memory) that is used to "swap" pages to or from in order to free up space for the relevant processes in main memory. Paging allows a granular method of copying where, instead of an entire process, frames or pages of a process are copied to and from the main memory. The paging and memory swap parameters are important indicators of performance as consistently high values in these fields are predictors of slowness of the switch.

Configuring and Displaying System Statistics on a Switch

You can display system statistics on a switch using the `system-stats-show` command. This command displays the memory and CPU usage statistics. The parameters under `system-stats-show` command are:

`switch` - The current switch of which the statistics are being displayed.
`uptime` - The amount of time for which the switch has been online.
`used-mem` - Percentage of memory used by the switch.
`used-mem-val` - The amount of memory used by the switch.
`used-swap` - The percentage of swap memory used by the switch.
`used-swap-val` - The amount of swap memory used by the switch.
`paging` - The swap scan rate.
`cpu-user` - The percentage of CPU usage associated with user processes.
`cpu-sys` - The percentage of CPU usage associated with system processes.
`cpu-total` - The total usage of the CPU in percentage.
`cpu-idle` - The percentage of CPU idle time.
`cpu-avg` - The average CPU usage (`cpu-sys` + `cpu-user`) over last 30 seconds.

For example:

```
CLI (network-admin@switch1) > system-stats-show layout
vertical

switch:       switch1
uptime:       7h7m10s
used-mem:     54%
used-swap:    0%
paging:       0
cpu-user:     2%
cpu-sys:      5%
cpu-idle:     92%
cpu-avg:      3%
```

To view all the details, add the parameter `format all`:

```
CLI (network-admin@switch1) > system-stats-show layout
vertical format all

switch:         switch1
uptime:         7h5m41s
used-mem:       54%
used-mem-val:   3.84G
used-swap:      0%
used-swap-val:  0
paging:         0
cpu-user:       4%
cpu-sys:        4%
cpu-total:      9%
cpu-idle:       90%
cpu-avg:        3%
```

To view the system statistics within last 5 minutes, use the command:

```
CLI (network-admin@switch1) > system-stats-show within-last 5m
layout vertical
switch:        switch1
time:          08:06:26
uptime:         3426684193d8h52m32s
used-mem:      63%
used-swap:     0%
paging:        0
cpu-user:      0%
cpu-sys:       99%
cpu-idle:      0%
switch:        switch1
time:          08:07:26
uptime:         3427378633d4h10m24s
used-mem:      63%
used-swap:     0%
paging:        0
cpu-user:      2%
cpu-sys:       2%
cpu-idle:      95%
switch:        switch1
time:          08:08:26
uptime:         3428073072d10h3m41s
used-mem:      63%
used-swap:     0%
paging:        0
cpu-user:      2%
cpu-sys:       1%
cpu-idle:      95%
switch:        switch1
time:          08:09:26
uptime:         3428767511d20h1m42s
used-mem:      63%
used-swap:     0%
paging:        0
cpu-user:      2%
cpu-sys:       2%
cpu-idle:      95%
```

The paging field of the `system-stats-show` command displays the swap scan rate. A non-zero value in this field shows that memory is being paged from the physical memory (RAM) to virtual memory (disk or swap). A consistently high value in this field indicates that all memory, both physical and virtual, is exhausted and the system may stop responding.

Configuring and Displaying System Statistics History

In releases prior to Netvisor ONE version 6.10, the `system-stats-show` command provided instantaneous values of CPU usage, which was not representative of the average CPU usage over a duration. Netvisor ONE release 6.1.0 improves the infrastructure for collecting and displaying system statistics to provide average usage information. Netvisor ONE currently supports viewing of historical CPU and memory usage over the last 24 hours with a granularity of up to 10s.

You can enable system statistics history by using the command:

```
CLI (network-admin@switch1) > system-stats-history-settings-modify enable
```

`system-stats-history-settings-modify`	Modify system statistics history settings.
`enable|disable`	Enable or disable system statistics history. The default status is `enable`.

When you enable the collection of historical system usage data, a new thread is created in nvOSd to collect statistics periodically. You can turn off this thread by using the `disable` option the CLI. If you disable statistics history collection and re-enable the feature, the statistics collection starts from scratch. Also, if you restart nvOSd or reboot the switch while system statistics history is enabled, statistics history is cleared and statistics collection starts afresh.

To view the settings for collection of system statistics history, use the command:

```
CLI (network-admin@switch1) > system-stats-history-settings-show
switch:         switch1
enable:         yes
read-interval:  10s
```

Note that the read interval is set to 10s in the software and is not configurable.

To display system statistics history over the last one minute (with a granularity of 10s), last 1 hour (with a granularity of 1 minute), and last 24 hours (with a granularity of 1 hour), use the command:

```
CLI (network-admin@switch1*) > system-stats-history-show
### Usage over last 1 minute, 60 minutes and last 24 hours ###

time           mem-used(%) cpu-used(%) cpu-peak(%) over-last
-------------- ----------- ----------- ----------- ---------
01:48:24       54          4                       10s
01:48:14       54          3                       10s
01:48:04       54          3                       10s
01:47:54       54          3                       10s
01:47:44       54          3                       10s
01:47:34       54          3                       10s
```

```
01:47:34       54          3           3           1m
01:46:34       53          3           5           1m
01:45:34       53          3           4           1m
01:44:34       53          2           3           1m
01:43:34       53          3           4           1m
01:42:34       53          3           3           1m
01:41:34       53          3           4           1m
01:40:34       53          3           4           1m
01:39:34       53          2           3           1m
.
.
.
00:56:34       53          2           3           1m
00:55:34       53          3           4           1m
00:54:34       53          3           4           1m
00:53:34       53          3           4           1m
00:52:34       53          3           3           1m
00:51:34       53          3           4           1m
00:50:34       53          3           4           1m
00:49:34       53          3           4           1m
00:48:34       53          3           4           1m
01:33:34       53          2           3           1h
00:33:34       53          2           3           1h
02-24,23:33:34 53          2           3           1h
02-24,22:33:34 53          2           3           1h
02-24,21:33:34 53          2           3           1h
```

Note: The system statistics history values are populated with time. For example, if you want to view the statistics history for the last 24 hours, nvOSd must have run for the last 24 hours with system statistics history enabled.

If you disable system statistics history, running the commands `system-stats-history-show` and `sytem-stats-history-average-show` returns an error. For example:

```
CLI (network-admin@switch1) > system-stats-history-settings-modify disable

CLI (network-admin@switch1) > system-stats-history-show
system-stats-history-show: system stats history collection is disabled

CLI (network-admin@switch1) > system-stats-history-average-show over-last 10s
system-stats-history-average-show: system stats history collection is disabled
```

To view the average system usage statistics over the last 10 to 60 seconds, use the command:

```
CLI (network-admin@switch) > system-stats-history-average-show
```

`system-stats-history-average-show`	Display average system statistics over a given duration.
`over-last` *`duration:#s`*	Specify a duration for average usage statistics (in multiples of 10s from 10s up to 60s). **Note:** You cannot specify the duration in days, hours, or minutes.

For example, view the average memory and CPU usage for the last 40s by using the command:

```
CLI (network-admin@switch1*) > system-stats-average-show over-
last 40s
time     mem-used(%) cpu-used(%) over-last
-------- ----------- ----------- ---------
02:00:34 54          3           40s
```

For system statistics older than one day, use the `system-stats-show` `within-last` <#d#h#m#s> command.

Understanding Logging

Netvisor ONE logs all important activities that occur on the switches and fabrics created on them. Logging is enabled by default and can be viewed using the CLI. You can also configure system logging to send syslog-formatted messages to servers configured to receive them, as part of centralized logging and monitoring.

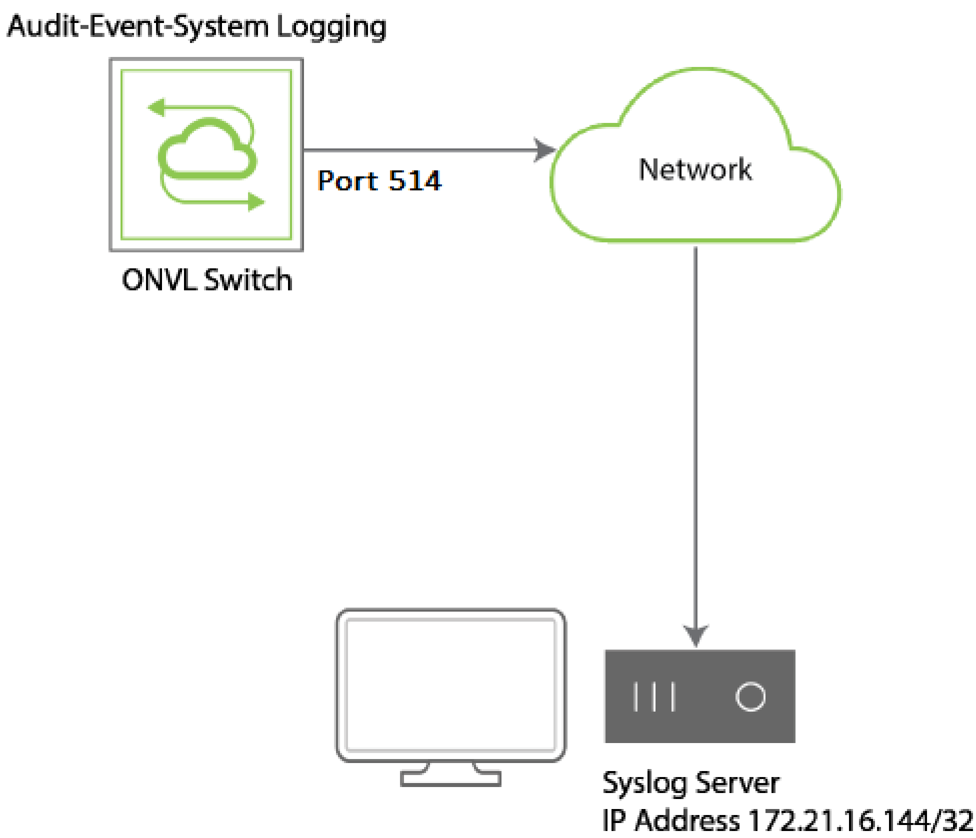


Figure 11-1 - Netvisor One Switch with Syslog Server

The following types of activities are logged:

Log Type	Description
Event	Records action observed or performed by switches. Each Event type can be enabled or disabled. Events are collected on a best effort basis. If events occur too rapidly to be recorded, the event log is annotated with the number of events lost. The following are examples of event types: • Port state changes • TCP connections • STP port changes

Audit	When an administrative change to the configuration is made, an audit log is recorded. An audit log consists of the command and parameters along with the success or failure indication. When a command fails, an error message is also recorded.
System	The system log records error conditions and conditions of interest.
Perror	The Perror log records messages on standard error output, describing the last error encountered.

Each log message includes the following information:

- Category - event, audit, or system
- Timestamp within a microsecond
- Process name and process ID of the process producing the message
- Unique message name
- Unique five digit numerical message code
- Message: additional message-specific parameters and explanation

A log message consists of common parameters separated by spaces and a colon (:), optional parameters, another colon, and then the log-specific message. The optional parameters, which may include the associated VLAN, VXLAN, or switch ports, appear as key/value pairs. An audit log message includes additional information:

- User
- Process ID
- Client IP of the remote computer issuing the command

An event log also includes the event type.

For information about specific log events and their meaning, see the *Netvisor ONE Log Messages Guide*.

The maximum number of repeated messages detected by Netvisor ONE is ten (10). After five seconds, if Netvisor ONE detects repeated messages, then the log prints "Last X messages(s) repeated Y time(s)". If the log message detects "X" and "Y" as both 1, then Netvisor ONE prints the message rather than "Last 1 message(s) repeated 1 time(s)". Log events are printed after a five (5) second delay.

Currently, accessing system log information may require assistance from TAC to retrieve the `logs` from Netvisor ONE. To enable log auditing in Netvisor ONE, use the following command:

```
CLI (network-admin@Leaf1) > log-admin-audit-modify enable|
disable
```

Log auditing is disabled by default. To display auditing status, use the following command:

```
CLI (network-admin@Leaf1) > log-admin-audit-show
switch: Leaf1
enable: yes
```

Using Facility Codes with Log Messages

Netvisor ONE labels log messages with a facility code indicating the area of the software that generated the log message.

The following are the default facility codes:

- `Log_Daemon` for events and system messages
- `Log_AUDIT` for audit messages

The following severity levels are used by default:

- `Log_INFO` = informational
- `Log_Critical` = critical
- `Log_ERROR` = error
- `Log_WARNING` = warn
- `Log_NOTICE` = note

Configuring Event Logging

Event log messages in Netvisor ONE covers events related to the system, protocols (STP, TCP, LLDP, LACP, IGMP), and TACACS+, among others. By default, system, port, LLDP, and TACACS+ events are logged. You can add or remove log events by using the `log-event-settings-modify` command.

`log-event-settings-modify`	Modify log event settings.
Specify one or more of the following options:	
`system|no-system`	Enable or disable system event logging. Enabled by default
`port|no-port`	Enable or disable port event logging. Enabled by default.
`tcp|no-tcp`	Enable or disable TCP event logging.
`stp|no-stp`	Enable or disable STP event logging.
`igmp|no-igmp`	Enable or disable IGMP event logging.
`lldp|no-lldp`	Enable or disable LLDP event logging.
`lacp|no-lacp`	Enable or disable LACP event logging.
`tacacs|no-tacacs`	Enable or disable TACACS+ event logging.Enabled by default.
`mld|no-mld`	Enable or disable MLD event logging.
`mroute|no-mroute`	Enable or disable mroute event logging.
`vport|no-vport`	Enable or disable vPort event logging.
`lacp-port-event|no-lacp-port-event`	Enable or disable LACP port event logging.

For instance, to enable logging of STP events, use the following command:

```
CLI (network-admin@Leaf1) > log-event-settings-modify stp
```

To display log event settings, use the `log-event-settings-show` command:

```
CLI (network-admin@Leaf1) > log-event-settings-show
switch:          Leaf1
system:          on
port:            on
tcp:             off
stp:             on
igmp:            off
lldp:            on
```

```
lacp:            off
tacacs:          on
mld:             off
mroute:          off
vport:           off
lacp-port-event: off
```

Displaying Event Log Information

To view event log information, run the command `log-event-show.`

`log-event-show`	Display event log information.
Specify between zero to two of the following options:	
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the start time for the log file.
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the end time for the log file.
`duration duration: #d#h#m#s`	Specify the duration of the log file.
Specify any of the following parameters to view the information related to those parameters:	
`program` *`program-string`*	Specify the program that generates log messages.
`pid` *`pid-number`*	Specify the product ID generating the log messages.
`name` *`name-string`*	Specify the message name.
`code` *`code-number`*	Specify the message code.
`level critical|error|warn|note|info`	Specify the severity level of event log messages.
`event-type system|port|tcp|stp|igmp|lldp|lacp|vdp|ecp|evb|ptp|storage|tacacs|mld|mroute|vport|lacp-port-event`	Specify one among the options as the log event type.
`vnet` *`vnet-name`*	Specify the associated VNET.
`remote_switch node` *`name`*	Specify the name of the remote switch.
`client-pid` *`client-pid-number`*	Specify the client product ID.
`client-addr` *`ip-address`*	Specify the client IP address.
`port` *`port-number`*	Specify the port number.

`vlan` *vlan-id*	Specify the VLAN ID as a value between 2 and 4092.
`bd` *bridge-domain name*	Specify the bridge domain.
`vxlan` *vxlan-id*	Specify the VXLAN ID.
`count` *number 1..50000*	Specify the number of events to be displayed in a range from 1 to 50000.
`starting-point` *starting-point-number*	Specify the starting point of the log audit.
`length` *length-number*	Specify the length of the log audit.
`reverse|no-reverse`	Use this option to enable or disable displaying the messages in reverse order.

For example:

```
CLI (network-admin@Leaf1) >log-event-show count 3
category time                       name    code level event-type port message
-------- -------------------------- ------- ---- ----- ---------- ---- -------
event    2013-06-04,13:12:18.304740 port_up 62   info  port       62   up
event    2013-06-04,13:12:18.304740 port_up 62   info  port       50   up
event    2013-06-04,13:12:18.304740 port_up 62   info  port       10   up
```

Configuring Audit Logging

Audit logging includes messages for user login or logout, authorization and denial of sessions or commands by TACACS+ server, audit drops, and commands run internally or by the user, among others. To view audit log Information, enter the following command:

```
CLI (network-admin@Leaf1) > log-audit-show
```

`log-audit-show`	Display audit log information.
Specify up to two options from the following:	
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the start time for the log file.
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the end time for the log file.
`duration duration: #d#h#m#s`	Specify the duration of the log file.
Specify any of the following parameters to view the information related to those parameters:	
`program` *`program-string`*	Specify the program that generates log messages.
`pid` *`pid-number`*	Specify the product ID generating the log messages.
`name` *`name-string`*	Specify the message name.
`code` *`code-number`*	Specify the message code.
`level critical|error|warn|note|info`	Specify the severity level of audit log messages.
`vnet` *`vnet-name`*	Specify the associated VNET.
`remote_switch node` *`name`*	Specify the name of the remote switch.
`client-pid` *`client-pid-number`*	Specify the client product ID.
`client-addr` *`ip-address`*	Specify the client IP address.
`port` *`port-number`*	Specify the port number.
`vlan` *`vlan-id`*	Specify the VLAN ID as a value between 2 and 4092.
`bd` *`bridge-domain name`*	Specify the bridge domain.
`vxlan` *`vxlan-id`*	Specify the VXLAN ID.
`count` *`number 1..50000`*	Specify the number of events to be

	displayed in a range from 1 to 50000.
`starting-point` *`starting-point-number`*	Specify the starting point of the log audit.
`length` *`length-number`*	Specify the length of the log audit.
`reverse|no-reverse`	Use this option to enable or disable displaying the messages in reverse order.

For example:

```
CLI (network-admin@leaf1) > log-audit-show count 2 layout
vertical
category:            audit
time:                 2020-07-29,07:21:09.297988-07:00
name:                login
code:                11099
level:               info
user:                network-admin
client-addr:          10.140.0.158
message:             login
category:            audit
time:                 2020-07-29,07:21:25.593283-07:00
name:                user_command
code:                11001
level:               info
user:                network-admin
client-addr:          10.140.0.158
message:              Command "vflow-delete name span1" result
success
```

Exceptions for Audit Logging

When Netvisor ONE supports a command for auditing, the command is added to the audit log and sent to the TACACS+ server as authorization and accounting messages.The commands `log-audit-exception-create`, `log-audit-exception-delete`, and `log-audit-exception-show` are used to control which CLI, shell, and vtysh commands are audited.

```
CLI (network-admin@Spine1) > log-audit-exception-create
```

`log-audit-exception-create`	Create an audit logging exception.
`cli|shell|vtysh`	Specify the type of audit exception.
`pattern` *`pattern-string`*	Specify a regular expression to match exceptions.
`any|read-only|read-write`	Specify the access type to match exceptions.
`scope local|fabric`	Specify the scope of exceptions.

CLI (network-admin@Spine1) > log-audit-exception-delete

log-audit-exception-delete	Delete an audit logging exception.
cli|shell|vtysh	Specify the type of audit exception.
pattern *pattern-string*	Specify a regular expression to match exceptions.
any|read-only|read-write	Specify the access type to match exceptions.

CLI (network-admin@Spine1) > log-audit-exception-show

log-audit-exception-show	Display audit logging exceptions.
cli|shell|vtysh	Display the type of audit exception.
pattern *pattern-string*	Display a regular expression to match exceptions.
any|read-only|read-write	Display the access type to match exceptions.
scope local|fabric	Display the scope of exceptions.

By default, Netvisor ONE audits every command except for read-only CLI commands and shell commands with `^/usr/bin/nvmore` pattern which is the pager for Netvisor ONE CLI:

```
CLI (network-admin@switch) > log-audit-exception-show

switch  type   pattern                    access       scope
------ ----- ---------------- --------- -----
switch  cli                                read-only  local
switch  shell  ^/usr/bin/nvmore  any           local
```

To enable auditing of all CLI commands, you can delete the `cli/read-only` exception:

```
CLI (network-admin@switch) > log-audit-exception-delete cli
read-only
```

Modifying User Roles

You can impart privileges to a user through the `role-create` command. To add shell access to a user's role, use the following syntax:

```
CLI (network-admin@switch) > role-create name role1 scope
local shell
```

role-create	Create a user role.
name *name-string*	Specify a name for the user role.

`scope local|fabric`	Specify a scope for the user role.
Specify one or more of the following options:	
`access read-only|read-write`	Specify the type of access for the user role. The default is read-write.
`running-config|no-running-config`	Specify if the user role allows access to the switch running configuration.
`shell|no-shell`	Specify if the user role allows access to the shell.
`sudo|no-sudo`	Specify if the user role allows the sudo command.

The `role-modify` command can be used to modify a user role configuration.

Configuring System Logging

Netvisor ONE allows you to send log messages to syslog servers over a UDP session or a TCP session with TLS encryption. By default, the messages are sent to syslog servers through UDP.

`CLI (network-admin@Leaf1) > admin-syslog-create`

admin-syslog-create	Use this command to configure syslog parameters.
Specify the following options:	
name name-string	Specify the name for the syslog configuration.
scope local|fabric	Specify one among the options the scope of the syslog.
host *host-string*	Specify the host name.
port *port-number*	Specify the host port number.
transport tcp-tls|udp	Specify TCP with TLS or UDP as the transport protocol for log events. UDP is used by default.
message-format structured|legacy	Specify one among the options as the message format for log events.
export-container-logs|no-export-container-logs	Enable or disable the export of container logs.
export-os-logs|no-export-os-log	Enable or disable the export of OS logs.

For example, to configure the switch to send all log messages to a syslog server with an IP address of `172.16.21.67` through port 10514, use the following command:

```
CLI (network-admin@Leaf1) > admin-syslog-create name <name>
scope fabric host 172.16.21.76 port 10514 message-format
structured
```

To display the configuration, use the `admin-syslog-show` command:

`CLI (network-admin@Leaf1) > admin-syslog-show`

admin-syslog-show	Use this command to view the syslog configuration.
Specify the following options:	
name name-string	Specify the name of the syslog.
scope local|fabric	Specify the scope of the syslog.

`host` *`host-string`*	Specify the host name.
`port` *`port-number`*	Specify the host port number.
`transport tcp-tls|udp`	Specify TCP with TLS or UDP as the transport protocol for log events.
`message-format structured|legacy`	Specify one among the options as the message format for log events.
`status status-string`	Specify the syslog export status.
`export-container-logs|no-export-container-logs`	Enable or disable the export of container logs.
`export-os-logs|no-export-os-log`	Enable or disable the export of OS logs.

```
CLI (network-admin@Leaf1) > admin-syslog-show layout vertical
switch:                 leaf1
name:                   log-all
scope:                  fabric
host:                   172.16.21.76
port:                   10514
transport:              udp
message-format:         structured
export-container-logs:  off
export-os-logs:         off
```

You can send messages to syslog servers using either RFC5424 (structured) or RFC3164 (legacy) formats. To send syslog messages in a legacy format, add the `message-format` parameter to `admin-syslog-modify` command:

```
CLI (network-admin@Leaf1) > admin-syslog-modify name <name>
message-format legacy
```

You can also modify the port that the service listens on by using the `port` option in the CLI.

```
CLI (network-admin@Leaf1) > admin-syslog-modify name <name>
port 22
```

By default, all log messages are sent to syslog servers. Netvisor ONE offers the flexibility of configuring more than one syslog server and sending selective syslog messages to each of them. Filters for forwarding log messages can be created by using the command:

```
CLI (network-admin@Leaf1) > admin-syslog-match-add
```

`admin-syslog-match-add`	Add a syslog event match filter.
`syslog-name` *`name-string`*	Specify the name of the syslog file.
Specify the following match arguments:	

`name` *`name-string`*	Specify a name for the matching scheme.
Specify any of the following options:	
`msg-category event|audit|system|perror|container|os-logs|xact-truncate`	Specify one among the options as the category of the message to match.
`msg-program program-string`	Specify the name of the program used to generate the log messages.
`msg-name` *`name-string`*	Specify the name of the message to match.
`msg-code` *`code-number`*	Specify the message code to match.
`msg-level critical|error|warn|note|info`	Specify one among the options as the severity level to match. By default, all messages are forwarded to the syslog server.
`msg-event-type system|port|tcp|stp|igmp|lldp|lacp|vdp|ecp|evb|ptp|storage|tacacs|mld|mroute|vport|lacp-port-event`	Specify the type of event to match.
`msg-vnet` *`vnet-name`*	Specify the vNET name to match.
`msg-remote_switch` *`node-name`*	Specify the remote switch to match.
`msg-user` *`user-name`*	Specify user name to match.
`msg-client-addr ip-address`	Specify the client IP address.
`msg-port` *`port-number`*	Specify the port number to match.
`msg-vlan` *`0..4095`*	Specify the VLAN to match.
`msg-bd` *`bridge-domain-name`*	Specify the bridge domain to match.
`msg-vxlan` *`vxlan-ID`*	Specify the VXLAN to match.

In the absence of a match condition, Netvisor ONE forwards all messages to the syslog server. However, if you configure a match condition, only the messages that match the specified parameters are forwarded. For example:

```
CLI (network-admin@Leaf1) > admin-syslog-create name to-10.10.10.10 scope fabric host 10.10.10.10 port 10514 message-format structured export-container-logs export-os-logs

CLI (network-admin@Leaf1) > admin-syslog-match-add syslog-name to-10.10.10.10 msg-category event name match-1
```

The above configuration forwards only event log messages to the syslog server, and all other categories are denied.

To display the configuration, use the `admin-syslog-match-show` command:

```
CLI (network-admin@Leaf1) > admin-syslog-match-show
syslog-name    msg-category msg-level name
-------------- ------------ --------- -------
to-10.10.10.10 event                  match-1
```

Displaying Syslog Information

To view system log information, use the command `log-system-show`:

`log-system-show`	Display system log information.
Specify between zero to two of the following options:	
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the start time from which to display the logs.
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the end time for the log file.
`duration duration: #d#h#m#s`	Specify the duration of the log file.
Specify any of the following parameters to view the information related to those parameters:	
`program` *`program-string`*	Specify the program that generates log messages.
`pid` *`pid-number`*	Specify the product ID generating the log messages.
`name` *`name-string`*	Specify the message name.
`code` *`code-number`*	Specify the message code.
`level critical|error|warn|note|info`	Specify one among the options as the level of severity.
`vnet` *`vnet-name`*	Specify the associated VNET.
`remote_switch node` *`name`*	Specify the name of the remote switch.
`client-pid` *`client-pid-number`*	Specify the client product ID.
`client-addr` *`ip-address`*	Specify the client IP address.
`port` *`port-number`*	Specify the port number.
`vlan` *`vlan-id`*	Specify the VLAN ID as a value between 2 and 4092.

`bd` *`bridge-domain name`*	Specify the bridge domain.
`vxlan` *`vxlan-id`*	Specify the VXLAN ID.
`count` *`number 1..50000`*	Specify the number of events to be displayed in a range from 1 to 50000.
`starting-point` *`starting-point-number`*	Specify the starting point of the log audit.
`length` *`length-number`*	Specify the length of the log audit.
`reverse|no-reverse`	Use this option to enable or disable displaying the messages in reverse order.

For example:

```
CLI (network-admin@Leaf1) > log-system-show count 3 layout
vertical
category:          system
time:              2020-04-13,12:36:00.966426-07:00
name:              fabric_node_status
code:              11403
level:             note
message:           pavo-colo-5: Node status changed to mgmt-
only-online
category:          system
time:              2020-04-13,12:36:46.462439-07:00
name:              congestion_relieved_on_port
code:              11402
level:             critical
message:           Congestion relieved on port=0
category:          system
time:              2020-04-13,12:36:46.509220-07:00
name:              congestion_relieved_on_port
code:              11402
level:             critical
message:           Congestion relieved on port=126
```

Note: Prior to Netvisor ONE 6.0.0 release, during MAC and IP move, the nvOSd.log file gets flooded with MAC move notifications. Starting from Netvisor ONE version 6.0.0, the MAC and IP move messages are logged in to the system.log file and can be accessed using the `log-system-show` command. The output of the command is in a summarized format that displays the repetition count instead of printing each message.

Note: Starting from Netvisor ONE version 6.0.1, all system log messages are logged into system.log file. This prevents selective system log messages from being logged into of nvOSd.log or perror.log files.

Displaying Syslog Counters

You can view the number of events that have occurred in the network belonging to the default severity levels by using the `log-system-counters-show` command:

```
CLI (network-admin@Leaf1) > log-system-counters-show layout
vertical
switch:        Leaf1
critical:      0
error:         0
warn:          1061
note:          9
```

To reset the log counters, issue the `log-system-counters-reset` command.

Forwarding Log Files to an External Server

Log messages can be sent to an external Linux server and encrypted using TLS over TCP. Netvisor ONE supports only one external server for TCP-TLS export while the UDP syslog export can be done to more than one server.

Follow the steps below to configure exporting of logs to an external server:

- Enable SFTP import/export using command below:

```
CLI (network-admin@Leaf1) > admin-sftp-modify enable
```

- Create the private key and the Certificate Signing Request (CSR) for the switch using the command `syslog-tls-cert-request-create.`

`syslog-tls-cert-request-create`	This command creates a certificate request for the TLS connection.
`country country-string`	Specify the contact address starting with the country code.
`state state-string`	Specify the state or province.
`city` *`city-string`*	Specify the city.
`organization` *`organization-string`*	Specify the organization.
`organizational-unit` *`organizational-unit-string`*	Specify the organizational unit.
`common-name` *`common-name-string`*	Specify the common name. This name must match the switch hostname.

For example:

```
CLI (network-admin@Leaf1) > syslog-tls-cert-request-create
country US state CA city Palo Alto organization QA
organizational-unit engineering common-name Leaf1
```

This command creates a Certificate Signing Request (CSR) and places it in the directory /sftp/export used by Netvisor ONE. You must get the CSR signed by the Certificate Authority (CA) and import the ca.pem and server-cert.pem files to Netvisor ONE.

- To import the signed certificate and CA root certificate files, you must upload the my-cert.pem and the ca.pem files to `/sftp/import` directory in Netvisor ONE and run the following command:

```
CLI (network-admin@Leaf1) > syslog-tls-cert-import file-ca
ca.pem file-cert my-cert.pem
```

`syslog-tls-cert-import`	Import certificates from /sftp/import directory.
Specify the following options:	
`file-ca` *`file-ca-string`*	Name of the CA certificate file.
`file-cert` *`file-cert-string`*	Name of switch certificate file (signed by CA).

- To enable TLS-TCP logging export, use the following syntax:

```
CLI (network-admin@Leaf1)>admin-syslog-create name audit-logs
scope local host 172.16.21.33 transport tcp-tls port 10514
```

This command can be executed anywhere in the sequence.

- To display and verify the syslog export configuration, use the `admin-syslog-show` command:

```
CLI (network-admin@leo-ext-23) > admin-syslog-show layout
vertical
switch:                  leo-ext-23
name:                    audit-logs
scope:                   local
host:                    172.16.21.33
port:                    10514
transport:               tcp-tls
message-format:           legacy
export-container-logs:   off
export-os-logs:          off
```

To display alert messages related to syslog export, use the command `log-alert-show`. This command displays events such as a disruption in connection to the syslog TLS server and the restoration of the connection. For example:

```
CLI (network-admin@switch1) > log-alert-show
time:          07:31:32
switch:        switch1
code:          20006
name:          syslog_tls_server_down
count:         1
last-message: tcp-tls connection to syslog server=MYTLS down. Logs are not
getting exported
time:          07:32:50
switch:        switch1
code:          20007
name:          syslog_tls_server_down
count:         1
last-message: tcp-tls connection to syslog server=MYTLS restored. Log export
is operational
```

Related Commands

- `syslog-tls-cert-clear`

Use this command to delete imported certificates.

For example:

```
CLI (network-admin@switch1) > syslog-tls-cert-clear
Successfully deleted all certificate files.
```

- `syslog-tls-cert-info-show`

Use this command to display certificate information.

`syslog-tls-cert-info-show`	Display the certificate information.
Specify any of the following options:	
`cert-type ca|intermediate|server`	Specify the one among the options as the certificate type.
`subject` *`subject-string`*	Specify the the subject of the certificate.
`issuer` *`issuer-string`*	Specify the issuer of the certificate.
`serial-number` *`serial-number`*	Specify the serial number of the certificate.
`valid-from` *`valid-from-string`*	Specify the time from which the certificate is valid.
`valid-to` *`valid-to-string`*	Specify the time at which the certificate expires and is no longer valid.

For example:

```
CLI (network-admin@switch1) > syslog-tls-cert-info-show
switch:         switch1
cert-type:      server
subject:          /C=US/ST=CA/L=PA/O=Eng/OU=TT/CN=switch1.pluribu
snetworks.com
issuer:           /C=US/ST=CA/L=PA/O=Eng/OU=TT/CN=switch1.pluribu
snetworks.com
serial-number:  1
valid-from:     Oct 20 09:06:02 2016 GMT
valid-to:       Oct 20 09:06:02 2017 GMT
```

- The `syslog-tls-cert-show` displays the syslog TLS import certificate configuration.

`syslog-tls-cert-show`	Displays the certificate information.
Specify any of the following options:	
`file-ca` *`file-ca-string`*	Specify the name of CA certificate file.
`file-cert` *`file-cert-string`*	Specify the name of switch certificate file (signed by CA).

`cert-ca` *`cert-ca-string`*	Specify the CA certificate.
`cert-switch` *`cert-switch-string`*	Specify the switch certificate.

For example:

```
CLI (network-admin@switch1) > syslog-tls-cert-show
file-ca  file-cert
-------  -----------
ca.pem   my-cert.pem
```

Configuring Pluribus Network Packet Broker

Note: The Pluribus Network Packet Broker solution is available on all platforms except NSU, NRU01, NRU02, NRU03, and NRU-S0301 platforms.

The Pluribus Network Packet Broker solution enables users to deploy modular, scale-out, monitoring fabrics with a distributed architecture that allow sharing of visibility and security tools located anywhere in the network. Simple and global monitoring fabrics deployed as part of Network Packet Broker solution feature centralized management capability and hence function as a 'distributed virtual chassis'. Built on top of Netvisor ONE Adaptive Cloud Fabric, Network Packet Broker does not require specialized software or a proprietary fabric, and consequently provides a high degree of flexibility, resiliency, and operational simplicity.

Using network taps or mirrors, the Network Packet Broker service copies traffic from a production network to the ingress ports of the adaptive monitoring fabric. The monitoring fabric, in turn, redirects the traffic arriving on the ingress ports to monitoring tools which can be located geographically apart. This implementation employs VXLAN overlay to transport packets from ingress ports to monitoring tools and features ECMP in the underlay to address link failures.

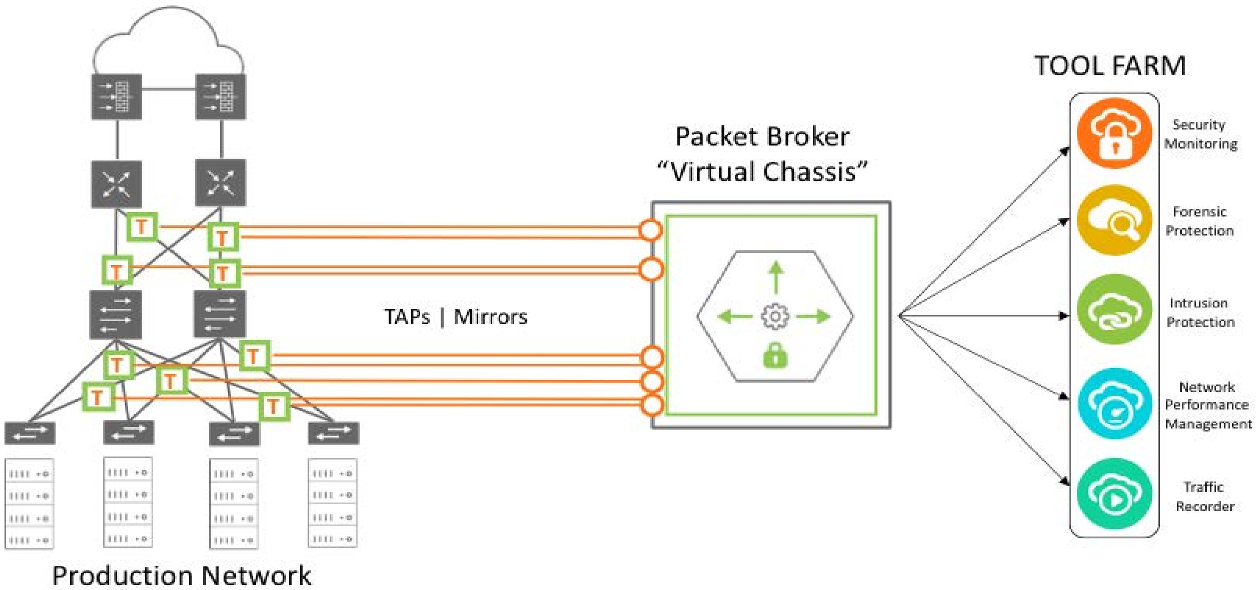


Figure 11-2: Network Packet Broker Architecture

The monitoring fabric can be of any physical topology including leaf-spine, ring, hub-and-spoke, mesh, tree, and others. Netvisor ONE allows you to club the ingress or source ports and the destination ports into Virtual Port Groups (VPGs). The VPG construct permits you to flood the traffic that arrives at select source ports to multiple desired destination ports.

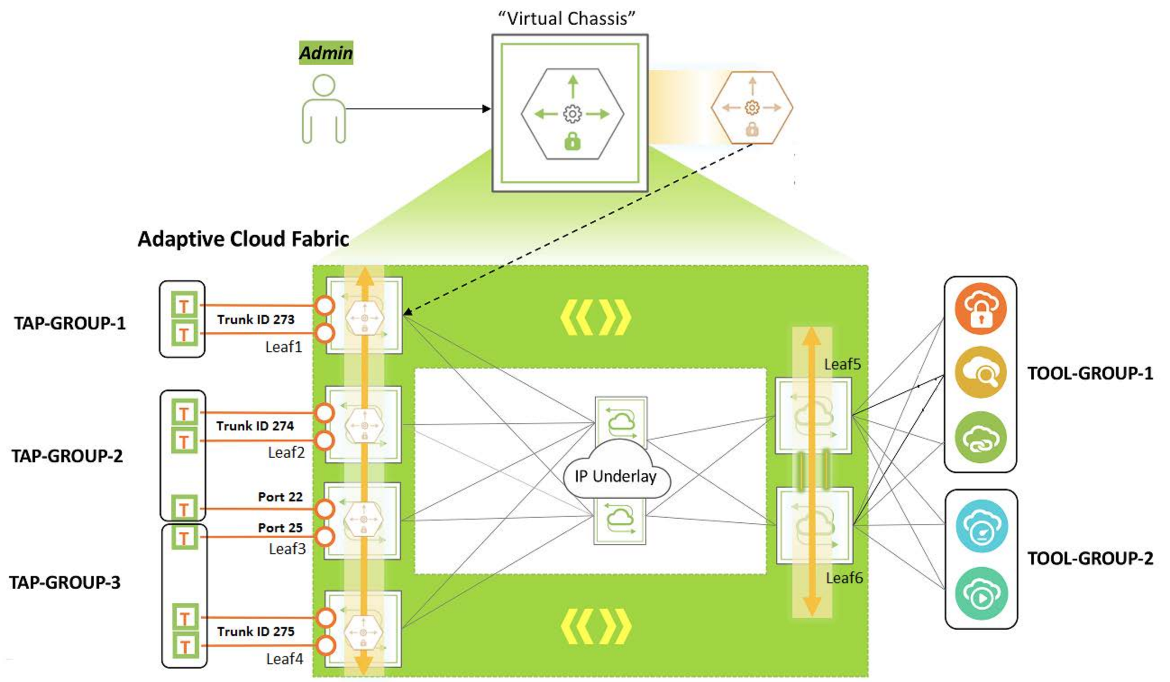


Figure 11-3: Monitoring Fabric Topology

Consider for example, a monitoring fabric with a leaf-spine topology as shown in Figure 10-3. Network taps copy traffic from the production network to the source port or trunk on Leaf1, Leaf2, Leaf3, and Leaf4. These ports constitute the source VPGs: TAP-GROUP-1, TAP-GROUP-2, and TAP-GROUP3. The switches Leaf5 and Leaf6 form a cluster. The monitoring tools are connected to ports on Leaf5 and Leaf6 which constitute the destination VPGs: TOOL-GROUP-1 and TOOL-GROUP-2. This topic describes the steps to configure VPGs and create a forwarding policy.

Before creating the VPGs, you must configure a VXLAN underlay network and VTEPs for the overlay. For details, refer to the sections, '*Configuring the VXLAN Underlay Network*' and '*Configuring the Overlay: VTEP Interconnections and VNIs*' .

Also, to deploy the Packet Broker fabric that spreads across geographical locations, you must create a Fabric over Layer 3 configuration. For details, refer to the section, '*Configuring a Fabric over a Layer 3 Network*'.

Follow the steps below to configure the port groups and to send traffic from a source port group to a destination port group:

1. Configuring Source VPGs

Create VPGs for the source ports of the monitoring fabric, by using the command `vpg-create`.

```
CLI (network-admin@switch1) > vpg-create
```

`vpg-create`	Creates a Virtual Port Group (VPG)
`vnet` *`vnet-name`*	Specify the name of the vNET.

`name` *`name-string`*	Specify the name of the VPG.
`type source|destination|bidirectional`	Specify the type of the VPG as `source`, `destination`, or `bidirectional`.
`ports` *`port-list`*	Specify the ports assigned to the VPG.

```
CLI (network-admin@Leaf1) > vpg-create vnet vnet1 name TAP-GROUP-1 type source

CLI (network-admin@Leaf1) > vpg-create vnet vnet1 name TAP-GROUP-2 type source

CLI (network-admin@Leaf1) > vpg-create vnet vnet1 name TAP-GROUP-3 type source
```

Netvisor ONE version 6.1.0 adds the `vnet` parameter to `vpg-create` and `vpg-show` commands. This feature enables you to configure or manage the NPB solution fabric-wide over vNET managed ports. This feature also helps you to get a segregated view of the NPB solution and supports multi-tenancy.

Netvisor ONE 6.1.0 release also introduces support for bidirectional VPGs. For more information, refer to the topic *Configuring Protocol Transparency and Bidirectional VPGs for NPB*.

Add the source ports to the VPGs by using the `vpg-port-add` command:

```
CLI (network-admin@Leaf1) > vpg-port-add
```

`vpg-port-add`	Adds ports to a VPG.
`vpg-name` *`name-string`*	Specify the name of the VPG.
`ports` *`port-list`*	Specify the ports assigned to the VPG.

The switches Leaf1, Leaf2, and Leaf3 form trunks (Link Aggregation Groups) with network taps, with trunk IDs 273, 274, and 275 as shown in ***Figure 10-2***.

```
CLI (network-admin@Leaf1) > vpg-port-add vpg-name TAP-GROUP-1 ports 273

CLI (network-admin@Leaf2) > vpg-port-add vpg-name TAP-GROUP-2 ports 274

CLI (network-admin@Leaf3) > vpg-port-add vpg-name TAP-GROUP-2 ports 22

CLI (network-admin@Leaf3) > vpg-port-add vpg-name TAP-GROUP-3 ports 25
```

```
CLI (network-admin@Leaf4) > vpg-port-add vpg-name TAP-GROUP-3
ports 275
```

> **Note:** The source VPG can include ports from all the nodes in the fabric. However, this port group can only include at most one port or trunk from each node.

To view the VPG configuration, use the command `vpg-show`.

```
CLI (network-admin@Leaf1) > vpg-show
```

`vpg-show`	Displays VPG configuration details.
`scope`	The scope of the VPG.
`vnet` *`vnet-name`*	The name of the vNET.
`name` *`name-string`*	The name of the VPG.
`type source|destination`	The type of VPG.
`ports` *`port-list`*	The ports assigned to the VPG.
`vni` *`0..16777215`*	The VNI for VXLAN.
`vlan` *`0..4095`*	The VLAN ID.

```
CLI (network-admin@leaf1) > vpg-show
switch  scope  vnet  name        type   ports vni vlan
------  ------ ----- ----------- ------ ----- --- ----
Leaf1   fabric vnet1 TAP-GROUP-3 source none  0   0
Leaf2   fabric vnet1 TAP-GROUP-3 source 25    0   0
Leaf3   fabric vnet1 TAP-GROUP-3 source 275   0   0
Leaf4   fabric vnet1 TAP-GROUP-3 source none  0   0
Leaf5   fabric vnet1 TAP-GROUP-3 source none  0   0
Leaf6   fabric vnet1 TAP-GROUP-3 source none  0   0
Spine1  fabric vnet1 TAP-GROUP-3 source none  0   0
Spine2  fabric vnet1 TAP-GROUP-3 source none  0   0
Leaf1   fabric vnet1 TAP-GROUP-2 source none  0   0
Leaf2   fabric vnet1 TAP-GROUP-2 source 274   0   0
Leaf3   fabric vnet1 TAP-GROUP-2 source 22    0   0
Leaf4   fabric vnet1 TAP-GROUP-2 source none  0   0
Leaf5   fabric vnet1 TAP-GROUP-2 source none  0   0
Leaf6   fabric vnet1 TAP-GROUP-2 source none  0   0
Spine1  fabric vnet1 TAP-GROUP-2 source none  0   0
Spine2  fabric vnet1 TAP-GROUP-2 source none  0   0
Leaf1   fabric vnet1 TAP-GROUP-1 source 273   0   0
Leaf2   fabric vnet1 TAP-GROUP-1 source none  0   0
Leaf3   fabric vnet1 TAP-GROUP-1 source none  0   0
Leaf4   fabric vnet1 TAP-GROUP-1 source none  0   0
Leaf5   fabric vnet1 TAP-GROUP-1 source none  0   0
```

```
Leaf6   fabric vnet1 TAP-GROUP-1 source none  0   0
Spine1  fabric vnet1 TAP-GROUP-1 source none  0   0
Spine2  fabric vnet1 TAP-GROUP-1 source none  0   0
```

2. Configuring Destination VPGs

Create destination tool groups by using the following commands:

```
CLI (network-admin@Leaf5) > vpg-create vnet vnet1 name TOOL-GROUP-1 type destination

CLI (network-admin@Leaf5) > vpg-create vnet vnet1 name TOOL-GROUP-2 type destination
```

> **Note:** For destination VPG creation to be successful, you must add at least one port to the `vxlan-loopback-trunk` on all the nodes of the NPB fabric, including spine switches. For more details, refer to *Configuring the VXLAN Loopback Trunk* topic of the *Configuring VXLAN* chapter.

Add the ports connected to the monitoring tools into the tool groups by using the command `vpg-port-add`:

For example:

```
CLI (network-admin@Leaf5) > vpg-port-add vpg-name TOOL-GROUP-1 ports 22,34,45

CLI (network-admin@Leaf6) > vpg-port-add vpg-name TOOL-GROUP-1 ports 47,50

CLI (network-admin@Leaf5) > vpg-port-add vpg-name TOOL-GROUP-2 ports 17,32

CLI (network-admin@Leaf6) > vpg-port-add vpg-name TOOL-GROUP-2 ports 48,55
```

The `vpg-port-add` commands auto-create bridge domains for TOOL-GROUP1 and TOOL-GROUP-2. These bridge domains flood the arriving traffic to the ports in the respective tool groups.

Use the `vpg-show` command to view the configuration:

```
CLI (network-admin@leaf1) > vpg-show type destination
switch  scope  vnet  name         type        ports    vni      vlan
------  ------ ----- ------------ ----------- -----    -------- ----
Leaf1   fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Leaf2   fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Leaf3   fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Leaf4   fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Leaf5   fabric vnet1 TOOL-GROUP-2 destination 17,32    12666666 2833
Leaf6   fabric vnet1 TOOL-GROUP-2 destination 48,55    12666666 2833
Spine1  fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Spine2  fabric vnet1 TOOL-GROUP-2 destination none     12666666 2833
Leaf1   fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
```

```
Leaf2   fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
Leaf3   fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
Leaf4   fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
Leaf5   fabric vnet1 TOOL-GROUP-1 destination 22,34,45 12000000 2500
Leaf6   fabric vnet1 TOOL-GROUP-1 destination 47,70    12000000 2500
Spine1  fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
Spine2  fabric vnet1 TOOL-GROUP-1 destination none     12000000 2500
```

> **Note:** Netvisor ONE auto-generates a VNI and reserved VLAN ID for the destination VPGs.

3. Configuring the vFlow Policy

As the final step of the configuration, create a vFlow to forward traffic from the desired source port group to a destination port group. For example, use the following command to send SSH traffic from TAP-GROUP-1 to TOOL-GROUP-2:

```
CLI (network-admin@switch1) > vflow-create name TAP1-TOOL2
scope fabric proto tcp src-vpg TAP-GROUP-1 dst-vpg TOOL-GROUP-
2
```

This configuration floods the ingress traffic matching the vFlow to all the ports in TOOL-GROUP-2 over the VXLAN tunnel.

Netvisor ONE version 6.1.0 supports the configuration of a vFlow action along with traffic redirection from a source VPG to a destination VPG, using a single command. In earlier versions of Netvisor ONE, this required two separate vFlow commands: one for configuring source and destination VPGs and one for configuring the action.

For example, with the current release, you can configure an action of `setvlan` to assign a VLAN to all the packets that are copied between the source and destination VPGs:

```
CLI (network-admin@switch1) > vflow-create name TAP1-TOOL2
scope fabric proto tcp src-vpg TAP-GROUP-1 dst-vpg TOOL-GROUP-
2 action setvlan action-value 20
```

The command above assigns VLAN 20 to the copied packets.

> **Note:** The running configuration for the `vflow-create` command has parameters such as `in-port` and `action-set-svp-value`. However, while configuring a vFlow, you should not supply these parameters as these fields are auto-populated.

Additional CLI Commands

1. `vpg-delete`

Use this command to delete a VPG. You cannot delete a VPG that is associated with a vFlow. In such cases, you must delete the vFlow before you delete the VPG.

```
CLI (network-admin@Leaf1) > vpg-delete
```

`vpg-delete`	Deletes a VPG.
`name` *`name-string`*	Specify the name of the VPG.

For example:

```
CLI (network-admin@Leaf1) > vpg-delete name <vpg-name>
```

2. `vpg-port-remove`

Use this command to remove ports from a VPG.

```
CLI (network-admin@Leaf1) > vpg-port-remove
```

`vpg-port-remove`	Removes ports from a VPG.
`vpg-name` *`name-string`*	Specify the name of the VPG.
`ports` *`port-list`*	Specify the ports to be removed from the VPG.

For example:

```
CLI (network-admin@Leaf1) > vpg-port-remove vpg-name <vpg-
name> ports <port-list>
```

> **Note:** For a given switch, if you remove a port or trunk from a source VPG, the associated vFlow on that switch is disabled in hardware but it is retained by the software.

Configuring Protocol Transparency and Bidirectional VPGs for NPB

Netvisor ONE version 6.1.0 introduces protocol transparency for Network Packet Broker (NPB) solution, where you can configure NPB to copy control plane traffic from a desired source to a destination. In the absence of protocol transparency, the control plane traffic that originates from a switch is generally processed or dropped by the next hop switch. With protocol transparency, the traffic belonging to various Layer 2, Layer 3, and Layer 4 protocols can be sent to switches located anywhere but within the fabric. These control plane protocols include:

Layer 2: LLDP, STP, LACP, and VLAN
Layer 3: IPv4 and IPv6
Layer 4: TCP, UDP, and ICMP
Layer 4 ports: HTTP, DNS, and DHCP

Consider the sample topology below:

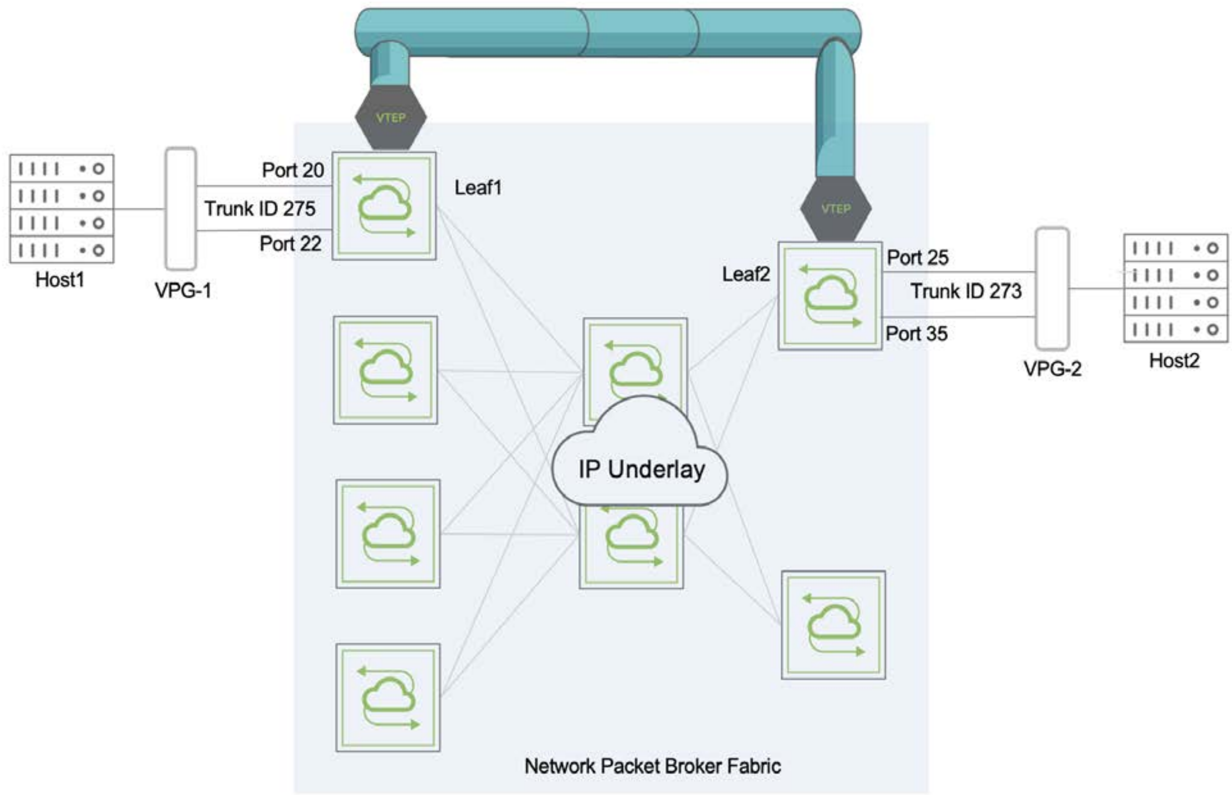


Figure 11-4: Protocol Transparency for Network Packet Broker

In ***figure 11-4*** above, Host1 is connected to VPG-1 which includes the trunk port 275 of Leaf1. Similarly, Host2 is connected to VPG-2 which includes the trunk port 273 of Leaf2. To create the above configuration, follow the steps below:

Configure source and destination VPGs using the `vpg-create` command:

```
CLI (network-admin@Leaf1) > vpg-create name VPG-1 type source
ports 275
```

```
CLI (network-admin@Leaf2) > vpg-create name VPG-2 type
destination ports 273
```

Use the `vpg-show` command to view the configuration.

```
CLI (network-admin@Leaf1) > vpg-show
switch scope  name  type          ports vni      vlan
------ ------ ----- ------------- ----- -------- ----
Leaf1  fabric VPG-2 destination         12500001 2751
Leaf2  fabric VPG-2 destination   273   12500001 2751
Leaf3  fabric VPG-2 destination         12500001 2751
Leaf4  fabric VPG-2 destination         12500001 2751
Leaf5  fabric VPG-2 destination         12500001 2751
Leaf6  fabric VPG-2 destination         12500001 2751
Spine1 fabric VPG-2 destination         12500001 2751
Spine2 fabric VPG-2 destination         12500001 2751
Leaf1  fabric VPG-1 source        275   12500000 2750
Leaf2  fabric VPG-1 source              12500000 2750
Leaf3  fabric VPG-1 source              12500000 2750
Leaf4  fabric VPG-1 source              12500000 2750
Leaf5  fabric VPG-1 source              12500000 2750
Leaf6  fabric VPG-1 source              12500000 2750
SPine1 fabric VPG-1 source              12500000 2750
Spine2 fabric VPG-1 source              12500000 2750
```

To enable protocol transparency while also configuring a vFlow to direct the traffic from VPG-1 to VPG-2, use the `vflow-create` command:

```
CLI (network-admin@Leaf1) > vflow-create
```

`vflow-create`	Create a vFlow
`name`	Specify the name of the vFlow.
`scope`	Specify the scope of the vFlow.
`src-vpg`	Specify the source VPG.
`dst-vpg`	Specify the destination VPG.
`bidir-vpg-1`	Specify the name of the first bidirectional vFlow.
`bidir-vpg-2`	Specify the name of the second bidirectional vFlow.
`transparency enable|disable`	Specify if you want to enable or disable protocol transparency.

```
CLI (network-admin@Leaf1) > vflow-create name flow1 scope
fabric src-vpg VPG-1 dst-vpg VPG-2 transparency
```

A basic vFlow configuration without protocol transparency does not allow control traffic such as LLDP packets from Host1 to reach Leaf2. Therefore, Leaf1 sees just Host1 as its

LLDP neighbor. However, if you enable protocol transparency, Host2 views Host1 as an LLDP neighbor.This is because the protocol transparent vFlow sends all control packets including LLDP packets to Host2.

When you enable protocol transparency, Netvisor ONE automatically configures additional vFlows to ensure that the control traffic reaches the destination VPG. This auto-configuration is necessary as system vFlows generally consume the protocol traffic and therefore, there must be pathways for the control traffic to bypass system vFlows. These additional vFlows and the user-configured vFlow can be viewed by running the `vflow-show` command at the source and destination switches:

```
CLI (network-admin@Leaf1) > vflow-show format all layout vertical
name:                          flow1
id:                            b0022cd:1a9
scope:                         fabric
type:                          vflow
hidden:                        false
in-port:                       275
burst-size:                    auto
precedence:                    3
action-set-svp-value:           0x80000006
log-stats:                     no
stats-interval:                60
hw-stats:                      enabled
src-vpg:                       VPG-1
dst-vpg:                       VPG-2
transparency:                  enable
enable:                        enable
table-name:                    System-VCAP-table-1-0
name:                          npb-system-bypass-proto
id:                            b0022cd:1a8
scope:                         fabric
type:                          vflow
precedence:                    15
action:                        none
metadata:                      1000
hw-stats:                      enabled
enable:                        enable
table-name:                    System-L1-L4-Tun-1-0
```

Note that there is an auto-configured vFlow named `npb-system-bypass-proto` with a high precedence of 15 that bypasses system vFlow treatment for packets at the ingress side.

```
CLI (network-admin@Leaf2) > vflow-show format all layout vertical
name:                          npb-tunnel-decap-flow1
id:                            b0022cf:16e
scope:                         local
type:                          vflow
precedence:                    15
action:                        none
vxlan:                         12666668
from-tunnel-decap:             yes
hw-stats:                      enabled
enable:                        enable
table-name:                    System-L1-L4-Tun-1-0
```

The auto-configured vFlow on the destination switch bypasses system vFlow treatment for the decapsulated packets at the egress end of tunnels. If you delete the vFlows, the auto-configured NPB tunnels are removed.

A basic vFlow configuration without protocol transparency does not allow control traffic such as LLDP packets from Host1 to reach Leaf2. In this bidirectional VPG configuration with protocol transparency, Host1 and Host2 see each other as LLDP neighbors, as LLDP packets are copied in both directions, that is, from Host1 to Host2 and Host2 to Host1.

Configuring Bidirectional VPGs

Netvisor ONE version 6.1.0 also adds bidirectional capability to VPGs, which implies that a VPG now supports both source and destination functionalities. In other words, the same VPG acts as source port group and forms bridge domains for destination port groups.

Considering Figure 10-4 as the sample topology, you can configure bidirectional VPGs by using the commands:

```
CLI (network-admin@Leaf1) > vpg-create name VPG-1 type
bidirectional ports 275

CLI (network-admin@Leaf2) > vpg-create name VPG-2 type
bidirectional ports 273

CLI (network-admin@pavo-dev-leaf2) > vpg-show
switch scope  name  type          ports vni      vlan
------ ------ ----- ------------- ----- -------- ----
Leaf1  fabric VPG-2 bidirectional       12500001 2751
Leaf2  fabric VPG-2 bidirectional 273   12500001 2751
Leaf3  fabric VPG-2 bidirectional       12500001 2751
Leaf4  fabric VPG-2 bidirectional       12500001 2751
Leaf5  fabric VPG-2 bidirectional       12500001 2751
Leaf6  fabric VPG-2 bidirectional       12500001 2751
Spine1 fabric VPG-2 bidirectional       12500001 2751
Spine2 fabric VPG-2 bidirectional       12500001 2751
Leaf1  fabric VPG-1 bidirectional 275   12500000 2750
Leaf2  fabric VPG-1 bidirectional       12500000 2750
Leaf3  fabric VPG-1 bidirectional       12500000 2750
Leaf4  fabric VPG-1 bidirectional       12500000 2750
Leaf5  fabric VPG-1 bidirectional       12500000 2750
Leaf6  fabric VPG-1 bidirectional       12500000 2750
Spine1 fabric VPG-1 bidirectional       12500000 2750
Spine2 fabric VPG-1 bidirectional       12500000 2750
```

You can now configure a vFlow to copy packets between the bidirectional VPGs by supplying the parameters `bidir-vpg-1` and `bidir-vpg-2` to the `vflow-create` command.

```
CLI (network-admin@switch1) > vflow-create name flow2 scope
fabric bidir-vpg-1 VPG-1 bidir-vpg-2 VPG-2
```

To add protocol transparency to the bidirectional VPG configuration, use the command:

```
CLI (network-admin@switch1) > vflow-modify name flow2 scope
fabric transparency enable
```

Use the `vflow-show` command to view the auto-configured and user-configured vFlows:

```
CLI (network-admin@Leaf1) > vflow-show format all layout vertical
name:                         npb-tunnel-decap-flow2-2
id:                           b0022cf:18f
scope:                        fabric
type:                         vflow
precedence:                   15
action:                       none
vxlan:                        12500001
from-tunnel-decap:            yes
hw-stats:                     enabled
enable:                       enable
table-name:                   System-L1-L4-Tun-1-0
name:                         npb-tunnel-decap-flow2-1
id:                           b0022cf:190
scope:                        fabric
type:                         vflow
precedence:                   15
action:                       none
vxlan:                        12666667
from-tunnel-decap:            yes
hw-stats:                     enabled
enable:                       enable
table-name:                   System-L1-L4-Tun-1-0
name:                         npb-system-bypass-proto
id:                           b0022cf:16f
scope:                        fabric
type:                         vflow
precedence:                   15
action:                       none
metadata:                     1000
hw-stats:                     enabled
enable:                       enable
table-name:                   System-L1-L4-Tun-1-0
name:                         flow2
id:                           b0022cd:1e0
scope:                        fabric
type:                         vflow
hidden:                       false
in-port:                      275
burst-size:                   auto
precedence:                   4
action-set-svp-value:         0x80000003
log-stats:                    no
stats-interval:               60
hw-stats:                     enabled
bidir-vpg-1:                  VPG-1
bidir-vpg-2:                  VPG-2
transparency:                 enable
enable:                       enable
table-name:                   System-VCAP-table-1-0
```

Note that there are two auto-configured vFlows for bypassing system vFlow treatment for the decapsulated packets at the egress end of tunnels. There is also the vFlow named `npb-system-bypass-proto` that bypasses system vFlows at the ingress side. This vFlow is created when the first transparent vFlow is created and is shared by the subsequent protocol transparent vFlows. The `npb-system-bypass-proto` vFlow is removed when the last protocol transparent vFlow is removed.

In this bidirectional VPG configuration with protocol transparency, Host1 and Host2 see each other as LLDP neighbors, as LLDP packets are copied in both directions, that is, from Host1 to Host2 and Host2 to Host1.

Guidelines and Limitations

- If you configure a protocol transparent vFlow, you cannot use the `set-metadata` keyword while modifying the vFlow thereafter. Conversely, if `set-metadata` is configured for a vFlow, you cannot enable protocol transparency for that vFlow.

- The metadata value of 1000 is reserved for protocol transparency and you cannot use this metadata value while configuring other vFlows.

- All control plane protocols are tunnel transparent if no additional filters are enabled. However, if you specify a vFlow filter, only the control plane packets pertaining to that filter is copied between the VPGs. For example, if you specify a VLAN filter, only the control plane packets belonging to that VLAN are copied. This limitation applies to the global vNET and any user-defined vNET in which vFlows are created with a VLAN filter. As a consequence of this limitation, adjacency over LLDP or LACP fails to be established.

Configuring IPv6 Filters for Network Packet Broker

Netvisor ONE version 6.1.0 expands IPv6 filtering options for Network Packet Broker. To enable IPv6 filtering for NPB, you must first configure an IPv6 VLAN Content Aware Processing (VCAP) table. This IPv6 VCAP table is created by dividing the 512-entry VCAP table into 256 IPv4 entries and 256 IPv6 entries.

Create an IPv6 VCAP table by using the command:

```
CLI (network-admin@switch) > vflow-table-profile-modify
profile ipv6-vcap hw-tbl switch-main enable
Note: Please reboot the system for this new profile setting to
take effect
```

As seen from the CLI, the switch must be rebooted before the vFlow table profile modification can take effect.

After restarting the switch you can view the vFlow table profile configuration by using the command:

```
CLI (network-admin@switch*) > vflow-table-profile-show layout
vertical
switch:              switch
profile:             ipv6-vcap
hw-tbl:              switch-main
enable:              enable
flow-capacity:       0
flow-slices-needed:  1
flow-slices-used:    0
comment:             VCAP-IPv6
```

View the vFlow table configuration by using the command:

```
CLI (network-admin@switch*) > vflow-table-show
name                  flow-max-per-group flow-used flow-tbl-slices capability     flow-profile
--------------------- ------------------ --------- --------------- -------------- ------------
Egress-Table-1-0      512                1         2               match-metadata system
System-L1-L4-Tun-1-0  2048               55        2               set-metadata   system
System-VCAP-table-1-0 256                0         2               none           system
VCAP-IPv6-table-1-0   256                0         1               none           vcap-v6
```

You can now create a vFlow to direct traffic from a source VPG to a destination VPG with IPv6 filters. For example, direct all traffic with IPv6 address 1000::1/64 from VPG-1 to VPG-10 by using the command:

```
CLI (network-admin@switch) > vflow-create name vpg_v6 scope
local src-ip 1000::1/64 src-vpg VPG-1 dst-vpg VPG-10 table-
name VCAP-IPv6-table-1-0
```

> **Note:** You must specify the table name as `VCAP-IPv6-table-1-0` in the `vflow-create` command to enable IPv6 filtering for NPB.

Use the `vflow-show` command to view the configuration.

```
CLI (network-admin@leo-norma2) > vflow-show name vpg_v6 layout
vertical
switch:                  switch
name:                    vpg_v6
type:                    vflow
src-ip:                   1000::1/ffff:ffff:ffff:ffff::
burst-sizeprecedence:     autodefault
src-vpg:                 VPG-1
dst-vpg:                 VPG-10
enable:                  enable
table-name:               VCAP-IPv6-table-1-0
```

To disable the IPv6 VCAP table, use the command:

```
CLI (network-admin@switch) > vflow-table-profile-modify
profile ipv6-vcap hw-tbl switch-main no-enable
Note: Please reboot the system for this new profile setting to
take effect
```

Understanding Port Mirroring

The port mirroring feature is used to gain visibility into the traffic flowing through the network, which assists in troubleshooting connectivity issues and monitoring the performance of network devices. Port mirroring copies traffic from specific ports on a switch to other ports on the same switch or a different switch. To analyze the traffic, you must configure a destination port for the mirrored traffic where network analyzer tools can be connected. Consider the use case of an application that needs access to data flowing through the switch, but does not want to impede the flow. The port mirroring feature can provide the configuration required by this application.

Netvisor ONE supports three distinct port mirroring functionalities:

Local Switched Port Analyzer (SPAN) mode: The simplest port mirroring configuration which copies traffic from one or more source ports to one or more destination ports on the same switch.

Remote Switched Port Analyzer (RSPAN) mode: An extension of SPAN which copies packets between different switches by using a special user-specified VLAN to carry the traffic. This feature enables remote monitoring of multiple switches.

Encapsulated Remote Switched Port Analyzer (ERSPAN) mode: This configuration transfers mirrored traffic over a routed network (over IP) with GRE encapsulation.

Configuring Port Mirroring

You can create a port mirror and configure the parameters using the `mirror-create` command.

```
CLI (network-admin@switch) > mirror-create
```

`mirror-create`	Create mirrored ports.
`name` *`name-string`*	Specify a mirror name.
Specify the following options:	
`direction [ingress|egress|bidirectional]`	Specify the direction of the traffic on the source port to be mirrored. Use this option to mirror the traffic that is received on source ports or traffic that leaves source ports, or both. The default direction is ingress.
`out-port` *`port-list`*	Specify one or more outgoing traffic ports.
`out-trunk` *`trunk name`*	Specifying outgoing traffic trunk (link aggregation). `out-trunk` option load balances the outgoing traffic among trunk ports. You can either configure an `out-port` or an `out-trunk.`
`in-port` *`port-list`*	Specify one or more incoming traffic ports. The in-ports can overlap among other mirror instances.
`filtering [port|vflow-and-port|vflow-or-port]`	Specify the traffic filter policy. With `vflow-and-port` policy, only if a packet matches both the vFlow and the `in-port` for the mirror will it get mirrored. With `vflow-or-port` policy, the packet gets mirrored if it matches either the vFlow or the `in-port` of the mirror.
`enable|disable`	Enable or disable the mirror. A mirror, once created, is enabled by default.
`other-egress-out [allow|prevent]`	Specify to allow or prevent switching of other traffic to `out-port`. The default status is `prevent`.
`span-encap [none|over-ip|over-vlan]`	Specify the mirror encapsulation type. Specify `over-ip` to enable ERSPAN and `over-vlan` to enable RSPAN. The default is none.
`span-local-ip` *`ip-address`*	Specify the local IPv4 address.
`span-remote-ip` *`ip-address`*	Specify the remote IPv4 address.

`span-src-mac` *`mac-address`*	Specify the source MAC address for the mirror.
`span-dst-mac` *`mac-address`*	Specify the destination MAC address for the mirror.
`span-tagging-vlan` *`vlan-id`*	Specify the mirror SPAN tagging VLAN ID. This VLAN carries the traffic in RSPAN configuration.
`span-tos 0..255`	Specify the mirror SPAN Type of Service (ToS) as a value between 0 and 255.
`nvie-mirror|no-nvie-mirror`	Specify to mark/unmark this mirror as an NVIE mirror used to mirror traffic to NVIE virtual machines.

Configuring Local SPAN

For Local SPAN, the `in-port` and `out-port` are on the same switch. For example:

```
CLI (network-admin@switch) > mirror-create name mirror1
direction ingress in-port 10 out-port 15
```

Netvisor ONE defines a mirror configuration, but does not add any traffic into that mirror. A sniffer tool like Wireshark can capture and analyze the mirrored traffic at the destination port. You can modify a mirror configuration by using the `mirror-modify` command. To view the details of a mirror configuration, use the `mirror-show` command.

For example:

```
CLI (network-admin@switch) > mirror-create name mirror2
direction bidirection out-port 10 in-port 15
```

The details of the mirror configured above can be viewed using the command:

```
CLI (network-admin@switch) > mirror-show layout vertical
name:                 mirror2
direction:            bidirection
out-port:             10
in-port:              15
filtering:            port
enable:               yes
other-egress-out:     prevent
nvie-mirror:          false
```

To modify the above configuration, use the command:

```
CLI (network-admin@switch) > mirror-modify name mirror2 out-
port 20
```

To view the modified configuration, use the command:

```
CLI (network-admin@switch) > mirror-show layout vertical
```

```
name:                  mirror2
direction:              bidirection
out-port:              20
in-port:               15
filtering:             port
enable:                yes
other-egress-out:      prevent
nvie-mirror:            false
```

Use the following command to modify a configuration and setup mirroring to send traffic from a range of data ports to a destination SPAN port.

```
CLI (network-admin@switch) > mirror-modify mirror25 in-port 1-
5 out-port 50
```

To disable the configuration, use the following command:

```
CLI (network-admin@switch) > mirror-modify mirror25 in-port 1-
5 out-port 50 disable
```

By default, a port configured as `out-port` of a mirror only functions as egress port for mirrored traffic. The `out-port` does not allow transit traffic to flow through which, in certain cases, can lead to traffic black holing. To overcome this problem, the `out-port` may be configured to allow other egress traffic. For example:

```
CLI (network-admin@switch1) > mirror-create name mirror20
direction ingress in-port 81 out-port 86 other-egress-out
allow
```

Configuring Multiple Port Mirrors

Netvisor ONE supports the creation of multiple mirrors. At a time, up to four unidirectional mirrors can be configured on any platform.

For example:

```
CLI (network-admin@switch) > mirror-create name rule1 in-port
1,2 out-port 50 span-encap over-vlan span-tagging-vlan 50
CLI (network-admin@switch) > mirror-create name rule2 in-port
3,4 out-port 51 span-encap over-vlan span-tagging-vlan 50
CLI (network-admin@switch) > mirror-create name rule3 in-port
5,6 out-port 52 span-encap over-vlan span-tagging-vlan 50
CLI (network-admin@switch) > mirror-create name rule4 in-port
7,8 out-port 53 span-encap over-vlan span-tagging-vlan 50
```

> **Note:** All platforms support two bidirectional or four unidirectional mirrors. They also support either an `out-port` or an `out-trunk` per mirror.

Configuring Remote Port Mirroring

Configuring VLAN-based Remote Port Mirroring

Remote port mirroring copies traffic between different switches and the mirrored traffic is carried over a specified VLAN. This functionality is also known as RSPAN.

Take for example, the topology below:

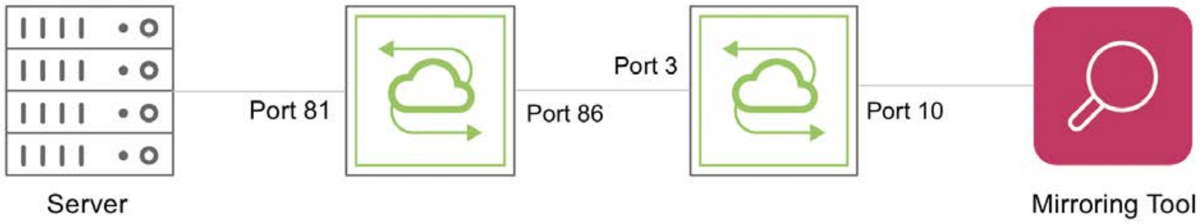


Figure 11-5 - VLAN-based Remote Port Mirroring Topology

To configure remote port mirroring over a VLAN, you must first create a mirror instance on the source switch (switch1). You must also specify `over-vlan` as encapsulation scheme. For example:

```
CLI (network-admin@switch1) > mirror-create name mirror33
direction ingress in-port 81 out-port 86 other-egress-out
allow span-encap over-vlan span-tagging-vlan 200
```

Use the `mirror-show` command to view the configuration:

```
CLI (network-admin@switch1) > mirror-show
name:               mirror33
direction:          ingress
out-port:           86
in-port:            81
filtering:          port
enable:             yes
other-egress-out:   allow
span-encap:         over-vlan
span-tagging-vlan:  200
nvie-mirror:        false
```

This command tags all ingress packets on port 81 with VLAN 200 and these packets are sent out on port 86. If VLAN 200 is not configured on switch2, the packets are dropped at port 3. Thus, VLAN 200 must be configured on port 3 and port 10 of switch2.

```
CLI (network-admin@switch2) > vlan-create id 200 scope local
ports 3,10
```

The alternate method is to configure a mirror on switch2 with a VLAN 200 tagging.

For example:

```
CLI (network-admin@switch2) > mirror-create name mirror35 in-port 3 out-port 10 span-encap over-vlan span-tagging-vlan 200
```

Use the `mirror-show` command to view the configuration:

```
CLI (network-admin@switch2) > mirror-show
name:                 mirror35
direction:            ingress
out-port:             10
in-port:              3
filtering:            port
enable:               yes
other-egress-out:     prevent
span-encap:           over-vlan
span-tagging-vlan:    200
nvie-mirror:          false
```

With this configuration, the mirrored packets can be analyzed at port 10 of switch2 by using a packet analyzer tool.

> **Note**: If the path for the mirrored packets to reach the destination include multiple switches, the SPAN tagging VLAN must be configured on all the intermediate switches.

Configuring IP-based Remote Port Mirroring

Remote port mirroring can be configured to send packets to a destination reachable over Layer 3. This is achieved by encapsulating mirrored packets with an L3 header so that the packets can be routed. This functionality is also known as ERSPAN.

Consider for example, the topology below:

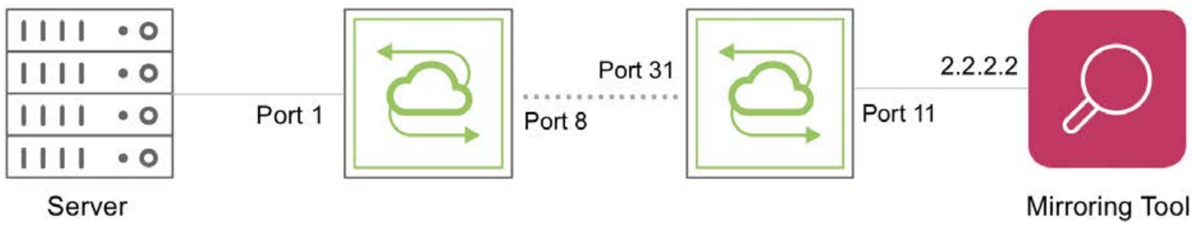


Figure 11-6 - IP-based Remote Port Mirroring Topology

To create a mirror over IP configuration, you must specify `over-ip` as encapsulation scheme.

For example:

```
CLI (network-admin@switch1) > mirror-create name mirror37 in-port 1 out-port 8 span-encap over-ip span-local-ip 1.1.1.1 span-remote-ip 2.2.2.2 span-src-mac 33:44:55:66:77:88 span-dst-mac 99:aa:bb:cc:dd:ee other-egress-out allow
```

To view the configuration, use the `mirror-show` command:

```
CLI (network-admin@switch1) > mirror-show layout vertical
switch:              switch1
name:                mirror37
direction:           ingress
out-port:            8
in-port:             1
filtering:           port
enable:              yes
other-egress-out:    allow
span-encap:          over-ip
span-local-ip:       1.1.1.1
span-remote-ip:      2.2.2.2
span-src-mac:        33:44:55:66:77:88
span-dst-mac:        99:aa:bb:cc:dd:ee
span-tos:            0
nvie-mirror:         false
```

Note that the IP-based configuration has local and remote IP addresses and MAC addresses explicitly specified. VLAN tagging and ToS setting are optional parameters.

- `span-local-ip` and `span-src-mac` can be specified as the router IP and MAC addresses of the local switch on which the mirror is created.
- `span-remote-ip` must be the IP address of the packet analyzer tool.
- `span-dst-mac` must be the next-hop MAC address.
- `other-egress-out allow` must be configured as the L3 protocol fails to come up otherwise.
- `out-port` must be the egress port to reach the next-hop IP address.

> **Note:** The local router should have a route to reach the packet analyzer's IP address.

Configuring vFlow Filters with Port Mirrors for Logging Packets

A vFlow filter, in conjunction with a port mirror, gives granular control over the traffic that is mirrored through SPAN, RSPAN, or ERSPAN configurations. By configuring a vFlow with a mirror, you can select the traffic you need for analysis with precision.

To create a vFlow-mirror, you should first configure a port mirror and you must identify the SPAN port before configuring the port mirror. For example,

To create a port mirror *mirror11*, use:

```
CLI (network-admin@switch) > mirror-create name mirror11 out-port 130 in-port 1-128 filtering vflow-and-port
```

To view the details:

```
CLI (network-admin@switch) > mirror-show

name     direction out-port in-port filtering      enable other-egress-out nvie-mirror
-------- --------- -------- ------- -------------- ------ ---------------- -----------
mirror11 ingress   130      1-128   vflow-and-port yes    prevent          false
```

> **Note**: The SPAN Port is different for each platform. For NRU02 platform, the SPAN port is *port 130*.

To create the corresponding vFlow - *to_mirror*, use the `vflow-create` command:

```
CLI (network-admin@switch) > vflow-create name to_mirror scope local mirror mirror11 src-ip 100.1.1.200 dst-ip 10.0.40.2 precedence default action none
```

The `vflow-create` command allows numerous filtering policies. Refer to the Configuring and Using vFlows chapter for more information.

To view the details, use the command:

```
CLI (network-admin@switch) > vflow-show name to_mirror

name      scope type  dst-ip    precedence action mirror from-tunnel-decap transparency
enable table-name
--------- ----- ----- --------- ---------- ------ ------ ----------------- ------------
------ --------------------
to_mirror local vflow 10.0.40.2  default    none   mirror11 none             disable
enable System-L1-L4-Tun-1-0
```

A logical combination of a port mirror and a vFlow-based one can be configured using the `filtering` parameter in the `vflow-create` command.

- Use the `port` option to consider only the parameters configured in the `mirror-create` command for filtering the traffic.

- Use the `vflow-or-port` option to mirror traffic that meets either the vFlow or the mirror constraints. With this option, packets that match either the vFlow policy or the `in-port` parameter of the mirror get mirrored.

- Use the `vflow-and-port` option to mirror traffic that meets both the vFlow and the mirror constraints. With this option, only packets that match both the vFlow policy and the `in-port` parameter of the mirror get mirrored.

> **Note:** IP-based remote port mirroring supports only sources (`in-port`) in the `ingress` direction with `vflow-and-port` filtering. This limitation applies to all platforms.

For Remote SPAN (RSPAN):

```
CLI (network-admin@switch) > mirror-create name mirror5 out-
port 80 in-port 40 filtering vflow-and-port span-encap over-
vlan span-tagging-vlan 300
```

> **Note**: Port 80 is associated with VLAN 300.

```
CLI (network-admin@switch) > vflow-create name flow1 scope
local dst-ip 10.10.10.10 action none mirror mirror5
```

With the above configuration, only the packets that ingress on port 40 of *switch* with a destination IP address of 10.10.10.10 are mirrored.

For packet logging to local SPAN port on platforms that have rear-facing NICs:

```
CLI (network-admin@switch) > mirror-create name mirror5 out-
port 80 in-port 40 filtering vflow-and-port
```

where out-port parameter is the rear-facing NIC SPAN port.

> **Note**: Use `tcpdump` command on Linux shell with rear-facing NIC SPAN port interface to create a PCAP file or to view the traffic live.

Guidelines to remember while configuring SPAN port:

- To view the SPAN port, use the command:

  ```
  CLI (network-admin@switch*) > port-cos-rate-setting-show
  port span-ports format port,ports,
  port          ports
  ---------- -----
  span-ports 130
  ```

here, `130` is the *SPAN port* for the switch.

* To determine the physical SPAN port interface used for *tcpdump* in Linux shell, use the command:

```
root@switch:~# cat /var/nvos/hw_pid.xml
<?xml version="1.0"?>
<hw_pids>
    <hw_pid code="NRU02-
ONVL" .. mgmt0="em0" mgmt1="em1" data0="em3" data1="em2" dat
a2="" data3="" ports="none" ..
</hw_pids>
```

where, "**data1**" determines the span port physical interface (which is "**em2**" in this case). This "em2" interface must be used along with *tcpdump* to capture the packets.

* You can set the aggregate egress rate limit for traffic to the local SPAN port depending on the CPU utilization and traffic profile. For example, to set the limit to 100 MB, use the command:

```
CLI (network-admin@switch) > port-config-modify port 130
egress-rate-limit 100m

CLI (network-admin@switch) > port-config-show port
130 format intf,switch,port,speed,egress-rate-limit,

intf  switch  port  speed  egress-rate-limit
----  ------  ----  -----  -----------------
130   switch  130   10g    100000000
```

For a more granular rate setting, use the `port-cos-rate-setting-modify` command.

Understanding and Configuring SNMP

This chapter provides information for understanding and configuring SNMP services on Netvisor ONE switches using the Pluribus Networks Netvisor ONE Command Line Interface (CLI).

Overview - Understanding and Configuring SNMP

Simple Network Management Protocol (SNMP) is an application-layer protocol used to manage and monitor network devices and functions. SNMP provides a common language for network devices to relay management information between network elements and monitor the health of network devices such as routers, switches, access points, and even devices such as UPS, printers etc. SNMP is part of the Transmission Control Protocol/Internet Protocol (TCP/IP) protocol suite and comes bundled with an SNMP agent. The SNMP agents are configured and enabled to communicate with the network management system (NMS).

Configuring SNMP

Netvisor ONE supports SNMP v1, v2, and v3 and the implementation is based on Net-SNMP, where the SNMP daemon runs as a service. When an external browser or SNMP collector contacts the SNMP daemon on Netvisor, the SNMP daemon queries the nvOSd for details.

Netvisor ONE uses SNMP only for monitoring the network: that is, you can use the SNMP service for read-only MIB support and does not provide support for managing the network. The following sections explain how to configure access controls and enable SNMP on a switch.

> **Note:** To configure SNMP v1 and v2, you must create community strings and for SNMP v3, you should create users.

Activating the SNMP Service

By default, the SNMP service is disabled on Netvisor ONE. You can enable the SNMP service by using the `admin-service-modify` command. Netvisor ONE retains the status of the SNMP service (enabled or disabled) when you upgrade from one release version to another version.
To enable SNMP service, use the command:

```
CLI (network-admin@switch) admin-service-modify if if-string
snmp|no-snmp
```

`if` *`if-string`*	Specify the administrative service interface. The options are `mgmt` or `data`.
`snmp|no-snmp`	Specify to enable or disable SNMP.

To enable SNMP service through management interface, use the command:

```
CLI (network-admin@switch)admin-service-modify if mgmt snmp
```

To enable SNMP service on data interface, use the command:

```
CLI (network-admin@switch)admin-service-modify if data snmp
```

The above commands launch the daemon, sub-agents, and opens the firewall so that remote queries can reach the daemon. Use the no-snmp parameter for disabling SNMP service on the administrative interface:

```
CLI (network-admin@switch)admin-service-modify if mgmt no-snmp
```

For using SNMP services, you must configure access controls either by creating SNMP communities and/or by creating SNMP users.

Creating SNMP Communities on SNMP V1 and V2

SNMPv1 and v2 protocol uses communities as a method of controlling access to information. A community consists of the community string and community type. You can create a community using the following command:

```
CLI (network-admin@switch) > snmp-community-create community-
string community-string-string community-type read-only|read-
write
```

`community-string community-string-string`	Specify a community name
`community-type read-only|read-write`	Specify the community type having read-only or read-write privileges.

For example, to create a SNMP community string named, **community1**, with read-only privileges, use the following command:

```
CLI (network-admin@switch) > snmp-community-create community-
string community1 community-type read-only
```

In Netvisor ONE, the `snmp-show` command enables an SNMP walk internally on specific MIB tables or MIB elements. You can run an SNMP walk from any host where SNMP software is enabled.

To display the details of a Pluribus custom MIB using SNMP walk, pnFabricTable, use the command:

```
CLI (network-admin@switch) > snmp-show community-string
community1 name pnFabricTable show-type walk
switch         name                   value
------------  ---------------------  -------------------
switch-name   FbIndex.100663455       Gauge32: 100663455
switch-name   NodeName.100663455      STRING: switch.
switch-name   FabricName.100663455    STRING: switch.
switch-name   NodeState.100663455     Gauge32: 1
```

To modify the SNMP community, **community1**, to read-write, use the following command:

```
CLI (network-admin@switch) > snmp-community-modify community-
string community1 community-type read-write
```

To display information about the SNMP community, **community1**, use the following command:

```
CLI (network-admin@switch) > snmp-community-show community-
string community1
```

```
switch  community-string  community-type
------  ----------------  --------------
switch community1         read-write
```

To delete the SNMP community, **community1**, use the following command:

```
CLI (network-admin@switch) > snmp-community-delete community-string community1
```

Enabling SNMP Walk

To run an SNMP walk on the supported switches, you must ensure:

- The SNMP service is enabled on the switch by using the `admin-service-show` command:

```
CLI (network-admin@switch) > admin-service-show
switch     if   ssh nfs web web-ssl web-ssl-port web-port vrrp snmp net-api icmp
---------- ---- --- --- --- ------- ------------ -------- ---- ---- ------- ----
leo-ext-23 mgmt on  off on  off     443          80       off  on   on      on
```

- The community-string is configured correctly on the switch using the command:

```
CLI (network-admin@switch) > snmp-community-show
switch  community-string  community-type
------  ----------------  --------------
switch community1         read-write
```

For more details, see the *Creating SNMP Communities* section.

- To get traps for particular SNMP trap receiver or NMS software, configure the SNMP trap sink host using the command:

```
CLI (network-admin@switch) > snmp-trap-sink-create community <community-string-name> type TRAP_TYPE_V2C_TRAP dest-host <destination-host>
```

For more details, see the *Enabling SNMP Traps* section.

Creating SNMP Users on SNMPv3

The SNMPv3 protocol supports the creation of users and optionally allows the usage of authentication and encryption. Netvisor ONE supports SHA or MD5 as authentication protocols and DES as the encryption algorithm. The default authentication protocol is SHA, however, Netvisor allows you to change the authentication protocol to MD5 by using the CLI.

- You can also create a user without providing the authentication and privilege password options. For example:

```
CLI (network-admin@switch) > snmp-user-create user-name name-
string auth priv
```

- To create a user by providing the authentication and privilege passwords for encryption, use the following command. You must provide a password for authentication (`auth-password`) and encryption (`priv-password`):

```
CLI (network-admin@switch) > snmp-user-create user-name user-
name-string auth-password auth-password-string [auth|no-auth]
[auth-hash md5|sha] priv-password priv-password-string [priv|
no-priv]
```

- To create the user, `pluribus`, with an authentication password and authentication hash as SHA1, use the following command:

```
CLI (network-admin@switch) > snmp-user-create user-name
pluribus auth auth-hash sha

auth password: ********
confirm password: ********
```

The password should have at least eight (8) characters and can be a combination of letters, numbers, and special characters.

- To modify the SNMP user and add privilege with a password, use the following command:

```
CLI (network-admin@switch) > snmp-user-modify user-name
pluribus auth-password auth priv-password priv
priv-password priv
auth password: ********
confirm password: ********
priv password: ********
confirm password: ********
```

To display information about the SNMP user created earlier, use the following command:

```
CLI (network-admin@switch) > snmp-user-show user-name pluribus
user-name auth auth-hash priv
--------- ---- --------- ----
```

```
pluribus  yes   sha      yes
```

- Create another user with user name, `pluribus2` and authentication hash as `MD5`:

```
CLI (network-admin@switch) > snmp-user-create user-name
pluribus2 auth auth-password priv priv-password auth-hash md5

auth password:********
confirm auth password:********
priv password:********
confirm priv password:********
```

To display the details, use the following command:

```
CLI (network-admin@switch) > snmp-user-show

switch   user-name    auth auth-hash priv
------- ----------- ---- --------- ----
switch   pluribus1    yes  sha       yes
switch   pluribus2    yes  md5       yes
```

- To delete the SNMP user, use the `snmp-user-delete` command:

```
CLI (network-admin@switch) > snmp-user-delete user-name
```

- After you create the SNMP user, you must grant permission to view the SNMP objects by using the View Access Control Model (VACM). To grant permission, use the command:

```
CLI (network-admin@switch) > snmp-vacm-create user-name snmp-
user user-type [rouser|rwuser] oid-restrict oid-restrict-
string [auth|no-auth] [priv|no-priv]
```

The parameter, `oid-restrict`, is an optional argument and specifies a MIB sub-tree with a restricted view. In other words, if you specify an OID, you can only see that OID and the descendants in the tree.

- Using the `snmp-vacm-create` command can restrict a particular user, `snmp-user` from accessing a specified OID. For example, to restrict access to sysContact OID, use the command:

```
CLI (network-admin@switch) > snmp-vacm-create user-name snmp-
user user-type rouser oid-restrict sysContact no-auth no-priv
```

- To modify the VACM configuration of the user and to change from no authentication to authentication, use the following command:

```
CLI (network-admin@switch) > snmp-vacm-modify user-name snmp-
user user-type rouser auth
```

To display information about the VACM configuration, use the `snmp-vacm-show` command:

```
CLI (network-admin@switch) > snmp-vacm-show
```

```
user-type  user-name  oid-restrict  view  auth  priv
---------  ---------  ------------  ----  ----  ----
rouser     snmp-user  sysContact          no    no
```

- To delete the VACM of the user from the SNMP configuration, use the `snmp-vacm-delete` command:

```
CLI (network-admin@switch) > snmp-vacm-delete user-name snmp-user
```

Modifying the SNMP Engine ID

Netvisor ONE allows you to modify the SNMP Engine ID and retrieve previous SNMP agent information for a switch that is no longer in use. The SNMP Engine ID is used only by SNMPv3 entities for uniquely identifying the V3 entries.

If you remove a switch due to an RMA or other reasons from the network, you can modify the SNMP Engine ID to use the old SNMP Engine ID. This enables Netvisor ONE to query and maintain the same history records for the new switch. The SNMP engine ID is a unique string of characters specific to a switch and identifies the device for administrative purposes.

After modifying the SNMP engine ID, you must recreate the SNMP user. To modify the SNMP engine ID, use the command:

```
CLI (network-admin@switch) > snmp-engineid-modify engineid
<string>
```

`engineid string`	Specify the 28 character unique ID for the SNMP engine.

For example, to modify the SNMP engine ID, use the steps below:

- View the current SNMP engine ID by using the command:

```
CLI (network-admin@switch) > running-config-show | grep snmp

snmp-engineid-modify  engineid
0x80001f8880077f7820da49395a00000000
```

You can also view the SNMP engine ID using the command:

```
CLI (network-admin@switch*) > snmp-engineid-show
engineid:   0x80001f8880077f7820da49395a00000000
```

The asterisk (*) next to the switch name in the above command indicates a specific local switch.

- To modify the above SNMP engine ID to 0x80001f8880077f7820da49395a00000001, use the command:

```
CLI (network-admin@switch) > snmp-engineid-modify engineid
0x80001f8880077f7820da49395a00000001
Warning: All SNMP users will be erased.

Please confirm y/n (Default: n):y
Modified snmp engineID, Deleted all SNMP users.Please re-
create SNMP users.
```

- View the modified SNMP engine ID using the command:

```
CLI (network-admin@switch) > running-config-show | grep snmp
snmp-engineid-modify  engineid
0x80001f8880077f7820da49395a00000001
```

To display the SNMP engine IDs configured on the switches in a fabric, use the command:

```
CLI (network-admin@aries-vxlan-01) > snmp-engineid-show
switch:    aries-vxlan-01
engineid:   0x80001f8880f3ac9a7e4b3fb15c00000000
switch:    ursa-vxlan-01
engineid:   0x80001f888030aae147f240b15c00000000
switch:    ursa-vxlan-02
engineid:   0x80001f8880cae2b0662f40b15c00000000
```

Supported SNMP MIBs

Netvisor ONE supports several MIBs which are run in a sub-agent to the SNMP daemon (master). Netvisor ONE uses the AgentX protocol for communicating between the SNMP daemon and the sub-agent.
When you issue an `snmp-show` command, the SNMP daemon receives the SNMP walk request and transfers the call to a sub-agent based on the SNMP OID of the request. The sub-agent populates the SNMP container to Netvisor ONE and displays the data.
Netvisor ONE supports the following MIBs:

- IfTable (IF-MIB)
- IfXTable (IF-MIB)
- EntPhySensorTable (ENTITY-SENSOR-MIB)
- BGP MIB. The following BGPv4 tables are supported:
  - bgpPeerTable
  - bgp4PathAttrTable
- OSPF MIB. The following OSPF tables are supported:
  - ospfGeneralGroupTable
  - ospfAreaTable
  - ospfLsdbTable
  - ospfIfTable
  - ospfExtLsdbTable
  - ospfNbrTable
  - ospfIfMetricTable
- OSPFv3 MIB Tables. The following OSPFv3 tables are supported:
  - ospfrv3GenealGroupTable
  - ospfv3AreaTable
  - ospfv3NbrTable
  - ospfv3IfTable
  - ospfv3AreaLsdbTable
  - ospfv3AsLsdbTable
  - ospfv3LinkLsdbTable
- IEEE8021-Q-BRIDGE-MIB (ieee8021QBridgePortVlanStatisticsTable)
- IEEE8021-Q-BRIDGE-MIB (ieee8021QBridgeVlanStaticTable)
- IEEE8021-SPANNING-TREE-MIB (ieee8021SpanningTreePortTable)
- IEEE8021-SPANNING-TREE-MIB (ieee8021SpanningTreeTable)
- IP-MIB (ipv4InterfaceTable, ipv6InterfaceTable)
- DISMAN-EVENT-MIB
- UCD-SNMP-MIB
- Pluribus Enterprise PN-VRRP-MIB (supports IPv6 VRRP state change)
- Pluribus Enterprise PN-HR-MIB (pnHrCPUTable, pnHRMemTable)
- Pluribus Enterprise PN-FABRIC-MIB (pnFabricTable)
- Pluribus Enterprise PN-COS-MIB (pnCosStatsTable, pnCosBezelStatsTable)
- Pluribus Enterprise PN-LOG-MIB (pnLogMatchName, pnLogFileName, pnLogMatchData, pnLogMatchCount)

Note: Pluribus Enterprise PN-LOG-MIB is used for the generation of message-based traps only.

Netvisor ONE version 6.0.0 adds a new OID (pnVrrpPreemptMode.0) to the Pluribus proprietary PN-VRRP-MIB, which is mapped to the standard VRRP-MIB v3. The value of this OID is 'true(1)' when VRRP preempt mode is enabled (default status) and 'false(2)' when VRRP preempt mode is disabled.

The above MIBs consolidate into a single sub-agent, called **nvOS_snmpd** agent, which communicates with the master SNMP daemon and serves requests to the MIBs. All the MIBs except the routing MIBs are part of the **nvOS_snmpd** agent.

Routing MIBs

For the OSPF and BGP routing MIBs, Netvisor ONE hosts the routing protocols inside a vRouter. Use the commands `vrouter-create` and `vrouter-modify` to enable the routing MIBs. You can also enable the SNMP notifications for OSPF and BGP protocols while enabling the routing MIBs. Enabling Routing MIBs is supported only on individual *vRouters* in a *fabric*. You can enable routing MIBs only on one node at a time.

To enable or disable the BGP and OSPF routing MIBs on a vRouter, use the command:

```
CLI (network-admin@switch) > vrouter-create name name-string
```

Specify one or more options:	
`bgp-snmp|no-bgp-snm`	Enable or disable BGP SNMP MIB.
`bgp-snmp-notification|no-bgp-snmp-notification`	Enable or disable BGP SNMP notifications.
`ospf-snmp|no-ospf-snmp`	Enable or disable OSPF SNMP MIB.
`ospf-snmp-notification|no-ospf-snmp-notification`	Enable or disable OSPF SNMP notifications.
`ospf6-snmp|no-ospf6-snmp`	Enable or disable OSPFv3 SNMP MIB.
`ospf6-snmp-notification|no-ospf6-snmp-notification`	Enable or disable OSPFv3 SNMP notifications
`ip-snmp|no-ip-snmp`	Enable or disable ipForward SNMP MIB.

For example, to create a vrouter, **vr1** and to enable the routing MIBs and notifications on **vr1**, use the command:

```
CLI (network-admin@switch) > vrouter-create vr1 bgp-snmp bgp-
snmp-notification ospf-snmp ospf-snmp-notification
```

Use the `vrouter-modify` command to modify or disable the SNMP notifications:

```
CLI (network-admin@switch) > vrouter-modify vr1 bgp-snmp no-
bgp-snmp-notification ospf-snmp no-ospf-snmp-notification
```

Configuring SNMP Traps

To enable SNMP traps, you must:

1. Create an SNMP trap sink (set up a destination host). Use separate commands for SNMPv1 or SNMPv2c and SNMPv3 to setup the destination host.
2. Enable the SNMP traps to be sent.

Configuring SNMP Trap Sink

To set up the destination host for SNMPv1 or SNMPv2c, use the command:

```
CLI (network-admin@switch) > snmp-trap-sink-create community community-string [type TRAP_TYPE_V1_TRAP|TRAP_TYPE_V2C_TRAP|TRAP_TYPE_V2_INFORM] dest-host dest-host-string [dest-port dest-port-number]
```

community *community-string*	Specify the community type.
[type TRAP_TYPE_V1_TRAP|TRAP_TYPE_V2C_TRAP|TRAP_TYPE_V2_INFORM]	Specify the trap type. The default trap is: TRAP_TYPE_V2C_TRAP.
dest-host *dest-host-string*	Specify the destination host. This can be an IP address or a hostname.
[dest-port *dest-port-number*]	Specify the destination port. The default port number is 162.

For example, to create a community *test1*, with destination host as *lyra10.pluribusnetworks.com* and trap type as *TRAP_TYPE_V1_TRAP*, use the command:

```
CLI (network-admin@switch) > snmp-trap-sink-create community test1 dest-host lyra10.pluribusnetworks.com type TRAP_TYPE_V1_TRAP
```

This command sends the SNMPv1 traps to a receiver on the host *lyra10* with the community string *test1*.

To setup the destination host for SNMPv3 trap receiver, use the command:

```
CLI (network-admin@switch) > snmp-v3-trap-sink-create user-name user-name-string [type TRAP_TYPE_V3_TRAP|TRAP_TYPE_V3_INFORM] dest-host dest-host-string [dest-port dest-port-number]
```

user-name *user-name-string*	Specify the user name for the SNMPv3 trap.
[type TRAP_TYPE_V3_TRAP|TRAP_TYPE_V3_INFORM]	Specify the SNMPv3 trap type.

`dest-host` *`dest-host-string`*	Specify the destination host.
`[dest-port` *`dest-port-number`*`]`	Specify the destination port number. The default port number is 162

For example, to configure SNMPv3 traps for user *test2*, with destination host as *lyra10.pluribusnetworks.com* and with authentication enabled, use the command:

```
CLI (network-admin@switch) > snmp-v3-trap-sink-create user-
name test2 dest-host lyra10.pluribusnetworks.com auth
```

This command configures the traps to be sent to *lyra10* with the username *test2*, engine id *0xABCDEF* and with authentication enabled. You will be prompted for an authentication password with this command.

Enabling SNMP Traps

After configuring the destination, you must enable the type of traps to be sent using the command:

```
CLI (network-admin@switch) > snmp-trap-enable-modify
```

Specify one or more of the following options:	
`link-up-down|no-link-up-down`	Enable or disable traps for the port link state changes.
`interface-up-down|no-interface-up-down`	Enable or disable traps for vRouter interface status.
`default-monitors|no-default-monitors`	Enable or disable traps for default monitoring.
`physical-sensors|no-physical-sensors`	Enable or disable physical sensor traps for temperature, fan speed, etc.
`low-disk-space|no-low-disk-space`	Enable or disable traps for low disk space.
`low-disk-space-threshold` *`low-disk-space-threshold-string`*	Specify the Threshold value of low-disk-space in percentage.
`system-usage|no-system-usage`	Enable or disable traps for memory and CPU usage.
`high-system-usage-threshold` *`high-system-usage-threshold-string`*	Specify the Threshold value of system-usage in percentage.
`login-failure|no-login-failure`	Enable or disable traps for incorrect passwords during login.
`cluster-tr-diverge|no-cluster-tr-diverge`	Enable or disable traps when cluster transaction lists diverge.

`lacp-status|no-lacp-status`	Enable or disable traps for LACP status.
`vport-modified|no-vport-modified`	Enable or disable vPort modification traps.
`stp-port-modified|no-stp-port-modified`	Enable or disable STP port modification traps.
`mirror-to-cpu|no-mirror-to-cpu`	Enable or disable traps when mirror to CPU is configured.
`stp-port-state-failed|no-stp-port-state-failed`	Enable or disable STP port state failed traps.
`link-congestion-detected|no-link-congestion-detected`	Enable or disable traps for link congestion detection.
`fabric-node-state-changed|no-fabric-node-state-changed`	Enable or disable traps for fabric node state changes.
`stp-new-root|no-stp-new-root`	Enable or disable traps when new STP root is detected.
`stp-topology-changed|no-stp-topology-changed`	Enable or disable traps for STP topology changes.
`vrrp-new-master|no-vrrp-new-master`	Enable or disable traps for VRRP master changes.
`disable-start-stop|no-disable-start-stop`	Enable or disable traps for disable start/stop.
`cert-expiry|no-cert-expiry`	Enable or disable traps for the expiry of the Netvisor ONE certificates (shipped with the switches) .
`sysup-alert|no-sysup-alert`	Enable or disable traps for system up alert.

The above command enables the notifications to be sent out when a link changes the state to up or down.

Further, You can enable SNMP trap notifications for the following events:

- Physical interface is up/down
- Data/vRouter interface is up/down
- CPU usage is higher than the configured threshold
- Memory utilization is higher than the configured threshold
- Disk utilization is higher than the configured threshold
- STP port is modified
- vPort is modified
- LAG/vLAG status changes
- Mirror-to-CPU vFlow is configured
- Link congestion is detected
- Fabric node state changes

- New STP root is elected
- VRRP master changes
- Disable start/stop
- Netvisor ONE certificate expires
- System up alert

Using Additional SNMP Commands

You can use the following additional SNMP commands to check the details of the SNMP configuration and notifications on the Pluribus switches:

- `snmp-trap-enable-show` — Display enabled SNMP traps.

```
CLI (network-admin@switch1) > snmp-trap-enable-show
switch:                          switch1
link-up-down:                    yes
interface-up-down:               no
default-monitors:                no
physical-sensors:                no
low-disk-space:                  no
low-disk-space-threshold:        %
system-usage:                    no
high-system-usage-threshold:     %
login-failure:                   no
cluster-tr-diverge:              no
lacp-status:                     no
vport-modified:                  no
stp-port-modified:               yes
mirror-to-cpu:                   no
stp-port-state-failed:           no
link-congestion-detected:        no
fabric-node-state-changed:       no
stp-new-root:                    no
stp-topology-changed:            yes
vrrp-new-master:                 no
disable-start-stop:              no
cert-expiry:                     no
sysup-alert:                     no
```

- `snmp-trap-sink-show` — Display SNMP trap sinks.

```
CLI (network-admin@switch) > snmp-trap-sink-show community
community-string [type TRAP_TYPE_V1_TRAP|TRAP_TYPE_V2C_TRAP|
TRAP_TYPE_V2_INFORM] dest-host dest-host-string [dest-port
dest-port-number]
```

`community` *`community-string`*	Specify the community type.
`[type TRAP_TYPE_V1_TRAP|TRAP_TYPE_V2C_TRAP|TRAP_TYPE_V2_INFORM]`	Specify the trap type. The default trap is: TRAP_TYPE_V2C_TRAP.
`dest-host` *`dest-host-string`*	Specify the destination host. This can be an IP address or a hostname.
`[dest-port` *`dest-port-number`*`]`	Specify the destination port. The default port number is 162.

- `snmp-trap-sink-delete` — Delete SNMP trap sinks.

CLI (network-admin@switch) > snmp-trap-sink-delete community *community-string* dest-host *dest-host-string*

The above command deletes the SNMP trap sink for the specified community. For details about the command parameters, see the CLI table for the `snmp-trap-sink-show` command.

- `snmp-v3-trap-sink-create` — Used to specify an SNMPv3 trap receiver.

CLI (network-admin@switch) > snmp-v3-trap-sink-create user-name *user-name-string* [type TRAP_TYPE_V3_TRAP| TRAP_TYPE_V3_INFORM] dest-host *dest-host-string* [dest-port *dest-port-number*]

user-name *user-name-string*	Specify the user name for the SNMPv3 trap.
[type TRAP_TYPE_V3_TRAP| TRAP_TYPE_V3_INFORM]	Specify the SNMPv3 trap type.
dest-host *dest-host-string*	Specify the destination host. This can be an IP address or a hostname.
[dest-port *dest-port-number*]	Specify the destination port number. The default port number is 162.

The above command enables you to create an SNMPv3 trap receiver.

- `snmp-v3-trap-sink-delete` — Used to delete an SNMPv3 trap receiver.

CLI (network-admin@switch) > snmp-v3-trap-sink-delete user-name *user-name-string* dest-host *dest-host-string* [dest-port *dest-port-number*]

The above command deletes the SNMPv3 trap sink for the specified user. For details about the command parameters, see the CLI table for the `snmp-v3-trap-sink-create` command.

- `snmp-v3-trap-sink-show` — Used to display an SNMPv3 trap receiver information.

CLI (network-admin@switch) > snmp-v3-trap-sink-show user-name user-name-string dest-host dest-host-string [dest-port dest-port-number]

The above command displays the SNMPv3 trap receivers for the specified options (see table below). Specify one or more of the formatting options to display the output in the desired format.

Specify one or more options:	

`user-name` *`user-name-string`*	Displays the specified user name.
`engine-id` *`engine-id-string`*	Displays the engine ID.
`[type TRAP_TYPE_V3_TRAP|TRAP_TYPE_V3_INFORM]`	Displays the trap type.
`dest-host` *`dest-host-string`*	Displays the destination host.
`dest-port` *`dest-port-number`*	Displays the destination port.
`auth|no-auth`	Displays the authentication status.
`priv|no-priv`	Displays the privacy status.

- `port-stats-snmp-show` — Used to display the accumulated port statistics for SNMP.

```
CLI (network-admin@switch) > port-stats-snmp-show port port-list port-clear-count port-clear-count-number port-clear-time #d#h#m#s port_clear_time high resolution time: #ns all-ports
```

Specify any of the following options:	
`port` *`port-list`*	Displays one or more switch network data port numbers. The port number must be in the range of 1 to 64. Multiple ports can be specified as a comma-separated list of numbers or a range (-).
`port-clear-count` *`port-clear-count-number`*	Displays the number of times `port-stats-clear` or `trunk-stats-clear` commands were issued on a port or trunk.
`port_clear_time` *`high resolution time: #ns`*	Displays the high resolution time (ns) since the last `port-stats-clear` command.
`port-clear-time` *`duration: #d#h#m#s`*	Displays the time since last `port-stats-clear`. It is initialized with time atnvOS_init by default.
`all-ports`	A flag to specify if you want to view the stats of all ports on the switch. The default view contains only enabled ports.
`counter` *`counter-number`*	Displays the counter number.
`ibytes ibytes-number`	Displays the incoming number of bytes.
`ibits` *`ibits-number`*	Displays the number of bits.
`iUpkts` *`iUpkts-number`*	Displays the number of incoming unicast packets.
`iBpkts` *`iBpkts-number`*	Displays the number of incoming

	broadcast packets.
`iMpkts` *`iMpkts-number`*	Displays the number of incoming multicast packets.
`iPauseFs` *`iPauseFs-number`*	Displays the number of incoming pause frames.
`iCongDrops` *`iCongDrops-number`*	Displays the number of incoming packets dropped due to congestion.
`idiscards` *`idiscards-number`*	Displays the number of incoming packets discarded.
`ierrs` *`ierrs-number`*	Displays the number of incoming errors.
`obytes` *`obytes-number`*	Displays the number of outgoing bytes.
`oUpkts` *`oUpkts-number`*	Displays the number of outgoing unicast packets.
`oBpkts` *`oBpkts-number`*	Displays the number of outgoing broadcast packets.
`oMpkts` *`oMpkts-number`*	Displays the number of outgoing multicast packets.
`oPauseFs` *`oPauseFs-number`*	Displays the number of outgoing pause frames.
`oCongDrops` *`oCongDrops`*`-number`	DisplaysDisplays the number of outgoing packets dropped due to congestion.
`odiscards` *`odiscards-number`*	Displays the number of outgoing discarded packets.
`oerrs` *`oerrs-number`*	Displays the number of outgoing errors.
`mtu-errs` *`mtu-errs-number`*	Displays the number of MTU errors.
`HER-packets` *`HER-pts-number`*	Displays the number of Head End Replicated (HER) packets.
`HER-bytes` *`HER-bytes-number`*	Displays the number of Head End Replicated (HER) bytes.

- `snmp-system-modify` — Modify the system information for the SNMP configuration.

`CLI (network-admin@switch) > snmp-system-modify syscontact` *`syscontact-string`* `syslocation` *`syslocation-string`*

Specify one or more options:	
`syscontact` *`syscontact-string`*	Specify or change the SNMP system contact.
`syslocation` *`syslocation-`*	Specify or change the SNMP system

string	location.

The above command enables you to modify the system details such as the system contact or location for the SNMP configuration.

- `snmp-system-show` — Displays the system details for the SNMP configurations.

```
CLI (network-admin@switch) > snmp-system-show
```

The above command displays the changed or modified system information for the SNMP configuration.

Supported SNMP Notifications (Traps)

Netvisor ONE supports two types of SNMP notifications (a.k.a. traps): event-based and message-based traps.

Event-based traps are the traps generated by the SNMP agent based on specific events when an OID value changes. For example, when there is a change in *link-up-down* or *low-disk-space*. Message-based traps are triggered based on messages logged in the local logging mechanism. For instance, a *login-failure trap* is triggered when a login failure message is saved in the */var/log/auth.log* log file. Message-based traps are of the type `pnLogMatchNotification`. For example, a `link-congestion` relieved trap message is as below:

```
DISMAN-EVENT-MIB::sysUpTimeInstance = Timeticks: (21245)
0:03:32.45
SNMPv2-MIB::snmpTrapOID.0 = OID: PN-LOG-
MIB::pnLogMatchNotification
PN-LOG-MIB::pnLogMatchName.4 = STRING: linkCongestionRelieved
PN-LOG-MIB::pnLogFileName.4 = STRING: /nvOS/log/system.log
PN-LOG-MIB::pnLogMatchCount.4 = Gauge32: 15
PN-LOG-MIB::pnLogMatchData.4 = STRING: 2020-02-
24,19:28:46.985665-08:00 nru03-proto-1 nvOSd(24190) system
congestion_relieved_on_port(11402) : level=critical : port=126
: Congestion relieved on port=126
```

Table 1 explains the supported SNMP notifications.

Table 1: Details of Supported SNMP Notifications

Trap Name	Description	Trap Type	Trigger
link-up-down	Port link is up or down	Event-based	If enabled, SNMP generates a trap when a port is up or down.
default-monitors	Use default SNMP monitoring	Event-based	If enabled, SNMP generates a trap for various error conditions.
physical-sensors	Physical sensors are enabled	Event-based	If enabled, SNMP generates a trap for physical sensors such as power supplies and fans.
low-disk-space	Monitors for low-disk-space	Event-based	If enabled, SNMP generates a trap if disk space is lower than threshold. The threshold can be set using the `low-disk-space-threshold` parameter in `snmp-trap-enable-modify` command. SNMP checks the output of the command,

			`storage-pool-show`.
system-usage	Monitors memory & CPU usage	Event-based	If enabled, SNMP generates a trap if memory and CPU usage [Total CPU = sys + user] is greater than the threshold. The threshold can be set using the `system-usage-threshold` parameter in `snmp-trap-enable-modify` command. SNMP checks the output of the command, `system-stats-show`.
login-failure	Monitors login failures	Message-based	If enabled, SNMP generates a trap when user login with wrong password.
lacp-status	Monitors LACP enable or disable	Message-based	If enabled, SNMP generates a trap when the LACP state changes from enable to disabled or vice versa.
vport-modified	Monitors vPort modifications	Message-based	If enabled, SNMP generates a trap when vPort modifications occur on the switch.
stp-port-modified	Monitors STP port status	Message-based	If enabled, SNMP generates a trap when STP port state is modified using the command, `switch-local stp-port-modify port 1 <block|edge|bpdu|root-guard>`
stp-port-state-failed	Monitors STP port state failures	Message-based	If enabled, SNMP generates a trap when STP port state is modified using the command, `switch-local stp-port-modify port 128 edge bpdu-guard`.
mirror-to-cpu	Monitors mirror-to-cpu configuration	Message-based	If enabled, SNMP generates a trap when created a vflow using the command, `vflow-create name mirror scope local action copy-to-cpu` and also generates a trap for perror.log.
link-congestion-	Monitors congestion	Message-based	If enabled, SNMP

detected	drop at port		generates a trap indicating a link is congested.
fabric-node-state-changed	Monitors fabric node states	Message-based	If enabled, SNMP generates a trap when the a fabric node changes state.
ospfIfStateChange	Monitors OSPF interface states	Event-based	If enabled, this notification is triggered when interface state changes from DR to Down or vice versa. Originator for this trap is by changing router-id.
ospfNbrStateChange	Monitors OSPF NBR states	Event-based	If enabled, this notification is triggered when neighbor state changes from DR to Down or vice versa. Originator for this trap is designated router on broadcast networks.
bgpEstablished	Monitors BGP NBR state	Event-based	If enabled, this notification is triggered when the BGP FSM enters the ESTABLISHED State. Originator for this trap is to bring up BGP session between two BGP Peers.
bgpBackwardTransition	Monitors BGP NBR state transition	Event-based	If enabled, this notification is triggered when the BGP FSM moves from higher number to lower numbered state. Originator for this trap when BGP state changes from active to idle (higher state to lower state).
stp-new-root	Monitors new STP root	Event-based	If enabled, SNMP generates a trap to monitor a new root for STP.
stp-topology-changed	Monitors STP topology change	Event-based	If enabled, SNMP generates a trap to monitor topology changes for STP.
interface-up-down	Monitors vRouter interfaces	Event-based	If enabled, SNMP generates a trap for an interface with the state up or down.
disable-start-stop	Monitors disable traps for start and stop	Event-based	If Enabled, This notification gets

			triggered to disable cold-start notifications. By default cold-start notifications are enabled.
fabric-node-state-changed	Monitors fabric node states	Event-based	If enabled, SNMP generates a trap to monitor fabric node state changes.
vrrp-new-master	Monitors VRRP master changes	Event-based	If enabled, SNMP generates a trap to monitor VRRP master state changes.
ospfv3IfStateChange	Monitors OSPF Interface state changes	Event-based	If enabled, this notification is triggered when interface state changes from DR to Down or vice versa.
ospfv3NbrStateChange	Monitors OSPF neighbor state changes	Event-based	If enabled, this notification is triggered when neighbor state changes from DR to Down or vice versa. Originator for this trap is designated router on broadcast networks.
cluster-tr-diverge	Monitors Cluster Transaction list for divergence	Message-based	If enabled, this notification is triggered when Transaction Diverge message is generated in perror.log.
cert-expiry	Monitors expiry of Switch Certificate	Message-based	If enabled, this notification gets triggered when switch-certificate expires in xx number of days in /nvOS/log/event.log. You can control value of the number of days by using the `cert-expiration-alert-modify <days-before-expiration>` command.
sysup-alert	Monitor whether all the admin up ports are made up. (L3, vLAG, orphan, cluster)	Message-based	If enabled, this notification gets triggered when you reboot the switch or restart nvOS.

Expected Behavior of Link Up/Down Traps

The timing and generation of `link-up-down` traps for data ports are dependent on the sequence in which the ports are brought up and down.

The port bringup sequence when a switch boots up is:
1) Cluster ports, vxlan-loopback-trunk ports, and loopback ports
2) L3 ports
3) vLAG ports
4) Rest of the ports

The port bringdown sequence when a switch goes offline is:

1. Orphan ports (i.e., non-vLAG, non-L3, non-cluster, or any form of loopback ports)
2. vLAG ports
3. L3 ports
4. Rest of the ports (e.g. cluster ports and internal ports)

As can be seen from the bringup and bringdown sequences, cluster ports are the first ports to be brought up when a switch boots up and are among the last ports to go down when a switch goes offline. As the last ports are being brought down, link scan is disabled, implying that Netvisor ONE provides link-up notifications for cluster ports but there are no link-down notifications. Therefore, a mismatch can always be expected in the number of link-up and link-down SNMP traps, with the number of link-up traps being higher than the number of link-down traps.

Currently, `defer-bringup` option in `port-config-modify` command delays the time at which a port is brought up but does not affect the number of SNMP traps in any capacity. `defer-bringup` is enabled for all orphan ports by default. This prevents traffic loss by ensuring that other ports (e.g. cluster, vLAG, and L3 ports) are up and the network is ready before the orphan ports come up.

> **Note:** Management ports, loopback ports, and internal ports do not have SNMP traps for link-up or link-down events.

Additional MIBs Supported in Netvisor ONE

MIB	Description
Entity-Sensor	This module defines Entity MIB extensions for physical sensors. The Entity Sensor MIB contains a single group called, **entitySensorValueGroup**, which allows objects to convey the current value and status of a physical sensor. Click here for the RFC details. **entPhySensorOperStatus** — Object identifies the current operational status of the sensor (as it is known to the agent). For example, entPhySensorUnitsDisplay.1 STRING: Temp Outlet. >60 entPhySensorUnitsDisplay.2 STRING: Temp Inlet. ... entPhySensorUnitsDisplay.22 STRING: PS1 Status.
Host-Resources (For CPU Utilization)	Use this MIB in managing host systems. Click here for the RFC details. • To monitor the CPU utilization of the switch, use the custom MIB: **PN-HR-MIB: PnHrCpuTable** • To monitor the fabric node status change, use the custom MIB: **PN-FABRIC-MIB: PnFabricTable**
IF-MIB, Entity-Sensor-MIB	The MIB module to describe generic objects for network interface sub-layers. This MIB is an updated version of the ifTable for MIB-II, and incorporates the extensions defined in RFC 1229.
Pluribus Enterprise PN-VRRP-MIB	This MIB addresses the information collected with the VRRP master change trap and supports IPv6 VRRP state change.

Sample CLI outputs

To display the SNMP details for the OID Ieee8021SpanningTreeEntry, with the community-string `community1`, use the command:

```
CLI (network-admin@cetus-colo-01) > switch-local snmp-show community-string community1 
name  Ieee8021SpanningTreeEntry show-type walk show-interval 1
switch        name                                              value
------------    ------------------------------------------------
---------------------------------------
cetus-colo-01 ieee8021SpanningTreeProtocolSpecification.1          INTEGER: 0
cetus-colo-01 ieee8021SpanningTreeProtocolSpecification.144        INTEGER: 0
cetus-colo-01 ieee8021SpanningTreeProtocolSpecification.4093       INTEGER: 0
cetus-colo-01 ieee8021SpanningTreePriority.1                        INTEGER: 8193
cetus-colo-01 ieee8021SpanningTreePriority.144                      INTEGER: 8336
cetus-colo-01 ieee8021SpanningTreePriority.4093                     INTEGER: 12285
cetus-colo-01 ieee8021SpanningTreeTimeSinceTopologyChange.1        Timeticks: (0) 
0:00:00.00  centi-seconds
cetus-colo-01 ieee8021SpanningTreeTimeSinceTopologyChange.144      Timeticks: (0) 
0:00:00.00  centi-seconds
cetus-colo-01 ieee8021SpanningTreeTimeSinceTopologyChange.4093     Timeticks: (0) 
0:00:00.00  centi-seconds
cetus-colo-01 ieee8021SpanningTreeTopChanges.1                      Counter64: 0 topology 
changes
cetus-colo-01 ieee8021SpanningTreeTopChanges.144                    Counter64: 0 topology 
changes
cetus-colo-01 ieee8021SpanningTreeTopChanges.4093                   Counter64: 0 topology 
changes
cetus-colo-01 ieee8021SpanningTreeDesignatedRoot.1                 Hex-STRING: 66 0E 94 D2 
AF 08
cetus-colo-01 ieee8021SpanningTreeDesignatedRoot.144               Hex-STRING: 66 0E 94 D2 
AF 08
cetus-colo-01 ieee8021SpanningTreeDesignatedRoot.4093              Hex-STRING: 66 0E 94 D2 
AF 08
cetus-colo-01 ieee8021SpanningTreeRootCost.1                       INTEGER: 0
cetus-colo-01 ieee8021SpanningTreeRootCost.144                     INTEGER: 0
cetus-colo-01 ieee8021SpanningTreeRootCost.4093                    INTEGER: 0
cetus-colo-01 ieee8021SpanningTreeRootPort.1                       Gauge32: 0
cetus-colo-01 ieee8021SpanningTreeRootPort.144                     Gauge32: 0
cetus-colo-01 ieee8021SpanningTreeRootPort.4093                    Gauge32: 0
cetus-colo-01 ieee8021SpanningTreeMaxAge.1                          INTEGER: 20 centi-
seconds
```

To display the SNMP details for the OID, pnHRCpuTable, with the community-string `community1`, use the command:

```
CLI (network-admin@aquila-m) > snmp-show community-string 
community1 name pnHrCpuTable show-type walk
switch   name             value
-------- ---------------  ------------
aquila-m pnHrCpuIdx.0     INTEGER: 0
aquila-m pnHrCpuUsr.0     INTEGER: 0
aquila-m pnHrCpuSys.0     INTEGER: 0
aquila-m pnHrCpuIdle.0    INTEGER: 99
aquila-m pnHrCpuTotal.0   INTEGER: 0
```

To display the system details including the `cpu-total` output, use the command:

```
CLI (network-admin@Leaf1) > system-stats-show format all
```

```
layout  vertical
switch:         Leaf1
uptime:         1d1h42m29s
used-mem:       62%
used-mem-val:   9.19G
used-swap:      0%
used-swap-val:  0
paging:         0
cpu-user:       8%
cpu-sys:        12%
cpu-total:      21%
cpu-idle:       78%
```

To display the accumulated port statistics for SNMP, use the `port-stats-snmp-show` command:

```
CLI (network-admin@switch1) > port-stats-snmp-show
switch:      switch1
port:        12
ibits:       0
iUpkts:      0
iBpkts:      0
iMpkts:      0
iCongDrops:  0
ierrs:       0
obits:       174M
oUpkts:      1.32K
oBpkts:      801
oMpkts:      73.6K
oCongDrops:  0
oerrs:       0
mtu-errs:    0
switch:      switch1
port:        21
ibits:       374M
iUpkts:      37.3K
iBpkts:      579
iMpkts:      199K
iCongDrops:  0
ierrs:       0
obits:       360M
oUpkts:      37.3K
oBpkts:      0
oMpkts:      174K
oCongDrops:  0
oerrs:       0
mtu-errs:    0
....
```

To display the modified system information, for example, if you modified the system contact to `bob@xyz.com` with location as `brisbane`, use the `snmp-system-show` command:

```
CLI (network-admin@switch-04) > snmp-system-show
switch:        switch-04
syscontact:    bob@xyz.com
syslocation:   brisbane
```

You can also view the details using an SNMP walk.

Supported Releases

Command/Parameter	Netvisor ONE Version
snmp-community-create	Command with parameters first supported in version 2.0
snmp-community-delete	Command introduced in version 2.0
snmp-community-modify	Command introduced in version 2.0
snmp-community-show	Command introduced in version 2.0
snmp-engineid-modify	Command introduced in version 3.0.0
snmp-engineid-show	Command introduced in version 2.0
snmp-show	Command introduced in version 1.2.1
snmp-system-clear	Command introduced in version 3.1.0
snmp-system-modify	Command introduced in version 3.1.0
snmp-system-show	Command introduced in version 3.1.0
snmp-trap-enable-modify	Command introduced in version 2.0
snmp-trap-enable-show	Command introduced in version 2.0
snmp-trap-sink-create	Command introduced in version 2.0
snmp-trap-sink-delete	Command introduced in version 2.0
snmp-trap-sink-show	Command introduced in version 2.0
snmp-user-create	Command introduced in version 2.0
snmp-user-delete	Command introduced in version 2.0
snmp-user-modify	Command introduced in version 2.0
snmp-user-show	Command introduced in version 2.0
snmp-v3-trap-sink-create	Command introduced in version 2.0
snmp-v3-trap-sink-delete	Command introduced in version 2.0
snmp-v3-trap-sink-show	Command introduced in version 2.0

Refer to the *Command Reference* document for more details on the commands.

Related Documentation

For more information on concepts mentioned in the SNMP chapter, refer to the documents below:

- Net-SNMP
- RFC2790
- RFC1229
- RFC3433

Configuring and Using vFlows

This chapter provides information for understanding, configuring, and using the vFlow feature in Netvisor ONE using the Netvisor ONE CLI.

Understanding vFlows and vFlow Objects

The vFlow functionality in Netvisor ONE is a unique Pluribus feature, which defines fabric-wide policies (using match conditions) to facilitate the manipulation and redirection of traffic flows using physical or logical filtering methods (using action parameters) at line rate. Netvisor ONE implements vFlow objects in hardware that have no impact on the forwarding performance of the switch.

The vFlows can be applied to traffic flows regardless of the forwarding method or provisioning construct employed. As such, vFlow objects can be implemented for bridging, routing and extended bridging operations and also for transparent forwarding services such as Virtual Wire and Virtual Link extension (vLE).

The vFlows can also be viewed as Access Control Lists (ACL) with advanced capabilities.

The vFlow functionality offers a versatile, programmable, and distributed method for implementing security access control policies, security service insertion, flow monitoring and telemetry, quality of service, and optimized flow-based forwarding.

In Netvisor ONE the vFlow filters operate at wirespeed without any performance degradation because the vflow actions and filtering are applied in the ASIC pipeline at line rate, which ensures no latency or performance degradation.

The vFlow object enables you to:

- Configure traffic filtering based on L2, L3, and L4 layer parameters
- Configure traffic filtering based on action parameters such as blocking and forwarding traffic
- Configure vFlows to copy packets to CPU, packet mirroring, packet classification, traffic metering and bandwidth guarantee
- Gathering statistics for evaluation and analytics

At a high level, vFlow feature supports the following actions, which can be configured using the CLI commands:

- Creating a vFlow Object

```
CLI (network-admin@switch-1) > vflow-create name <vflow-name>
scope [local|fabric] {specify one or more parameters} {specify
any action}
```

- Modifying an existing vFlow Object

```
CLI (network-admin@switch-1) > vflow-modify name <vflow-name>
{specify one or more parameters}
```

- Deleting an existing vFlow Object

```
CLI (network-admin@switch-1) > vflow-delete name <vflow-name>
```

- Displaying the applicable actions and use cases for a selected vFlow Object

```
CLI (network-admin@switch-1) > vflow-show {specify one or more
parameters}
```

These actions are explained in detail in the subsequent sections for configuring vFlow objects with specific parameters.

Elements of a vFlow

Netvisor ONE identifies a vFlow object by a unique name and is composed of the following elements:

- Administrative scope and state
- Implementation stage
- Traffic flow filter
- Forwarding action

Configuring the Administrative Scope and State

The administrative *state* of a vFlow object determines if you enable or disable the corresponding flow policy in the switch hardware, as defined by mutually exclusive keywords `enable` and `no-enable`. By default, Netvisor ONE enables newly created vFlow objects.

The administrative scope defines the set of switches in the fabric where you create the vFlow object, which is controlled by the keyword scope, and can be either `fabric` or `local` scope. The administrative parameters for a `vflow-create` command are:

```
CLI (network-admin@switch-1) > vflow-create name <vflow-name>
scope [fabric|local] [enable|no-enable]
```

`name`	The vFlow object's unique identifier
`scope [fabric|local]`	Defines the scope of the vFlow object. Once a Vflow object is created using either the local or the fabric scope, you cannot modify the scope of the vFlow object later. To modify, you must delete the vFlow object and create a new one.
`enable|no-enable`	Enables or disables the flow policy in hardware. By default, Netvisor enables the vFlow objects. You can disable the vflow policy using the `no-enable` parameter.
`{parameters}`	Specify one or more of the parameters • Table name • Filtering parameters • Action parameters • Flow class For details, see the *Filtering of Traffic Flows*, *Forwarding Action in vFlow Filters*, and *Commands and Parameters Applicable to vFlow Traffic* sections. Also, see the *Command Reference* Guides

Note: You can specify the hardware table name while creating a vFlow object, however, if not specified, Netvisor ONE uses the default table, **System-L1-L4-Tun-1-0**.

Fabric Scope

A fabric-scoped vFlow is a single managed object distributed across all switches that are part of the Adaptive Cloud Fabric in Netvisor ONE. To create a fabric scoped vFlow object, for example, use the command:

```
CLI (network-admin@switch-1) > vflow-create name
example_fabric_scope scope fabric enable {parameters}
```

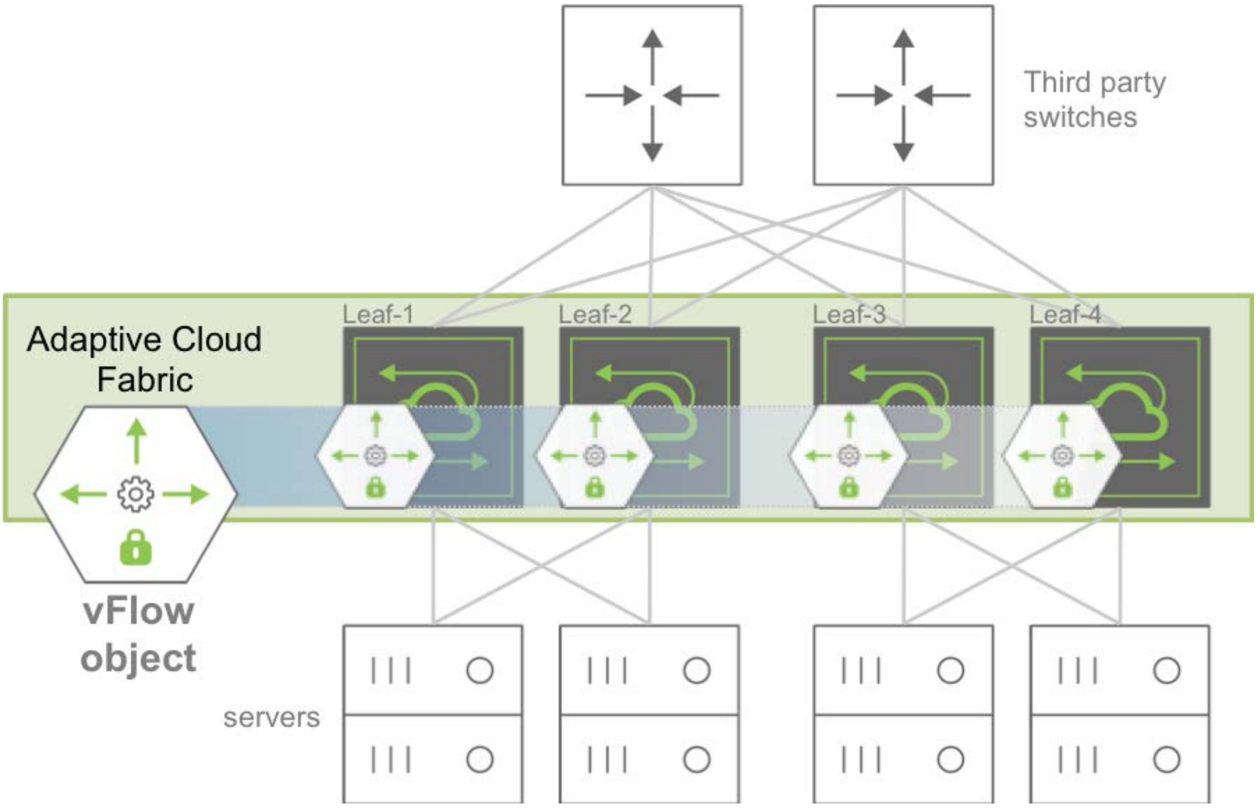


Figure 12-1: Fabric Scoped vFlow Object Example

Figure 12-1 illustrates a fabric scoped vFlow object topology, where a single vFlow object is created on all four switches: Leaf-1, Leaf-2, Leaf-3, and Leaf-4 that are part of the Adaptive Cloud Fabric. The switches in the adaptive cloud fabric are also connected to multiple servers and other third party switches. In this scenario, the fabric-scoped vFlow can be modified concurrently on all switches of the fabric with a single CLI or API command, by referencing the unique name. For example, the below command disables the previously created vFlow object, **example_fabric_scope** for the entire fabric, where Netvisor ONE does not delete the object, but uninstalls the object from the hardware tables.

For example:

```
CLI (network-admin@switch-1) > vflow-modify name
example_fabric_scope scope fabric no-enable
```

Local Scope

A local-scoped vFlow is an object defined and instantiated on one single switch. To create a locally scoped vFlow, for example, use the following command:

```
CLI (network-admin@switch-1) > vflow-create name
```

example_local_scope scope local enable {parameters}

Netvisor ONE allows you to apply or modify the same vFlow policy on multiple switches concurrently using a single CLI or API command by including the `switch` keyword followed by the list of individual switches or switch groups. Below is an example on creating a vFlow object on four switches, leaf-1, leaf-2, leaf-3, and leaf-4:

```
CLI (network-admin@leaf-1) > switch leaf-1,leaf-2 \ vflow-create name example_local_scope scope local
```

```
CLI (network-admin@leaf-1) > switch leaf-3,leaf-4 \ vflow-create name example_local_scope scope local
```

The above commands create the same vFlow object, *example_local_scope* on the four switches, `leaf-1`, `leaf-2`, `leaf-3`, and `leaf-4` (see ***Figure 12-2***).

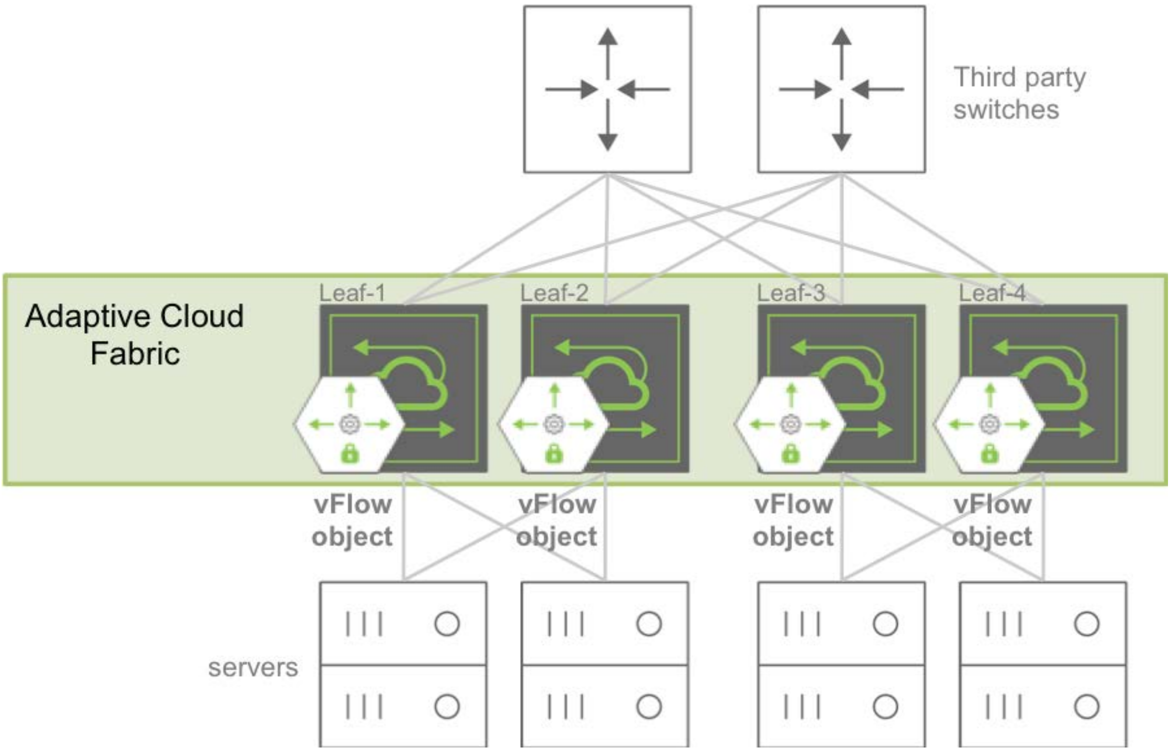


Figure 12-2: Local Scoped vFlow Object Example

You can now modify or delete the vFlow objects on individual switches as explained in the example below:

To disable the vFlow object, `example_local_scope` on the switch, `leaf-1`, use the command:

```
CLI (network-admin@leaf-1) > switch leaf-1 vflow-modify name example_local_scope no-enable
```

To delete the vFlow object, `example_local_scope` on the switch, `leaf-2`, use the command:

```
CLI (network-admin@leaf-1) > switch leaf-2 vflow-delete name
```

example_local_scope

Implementing the vFlow Policies

Netvisor ONE allows you to apply multiple policies in parallel or in series to a particular traffic flow by providing the vFlow construct with two main attributes to control the sequential order of execution relative to other vFlows such as the hardware table and precedence.

The following command keywords enable this functionality:

- `table-name` – hardware vFlow table name
- `precedence` – processing priority value

Hardware Table

Netvisor ONE provides multiple filter tables along the internal flow hardware data path. However, by default, the vFlow is installed in the ingress filter table, but allows you to optionally implement the vFlow in any other available table, although flow filtering, manipulation, and redirection capabilities may become limited. ***Figure 12-3*** describes the available hardware tables with the corresponding vFlow table names and how the tables are concatenated, allowing both cascading and parallel execution policies.

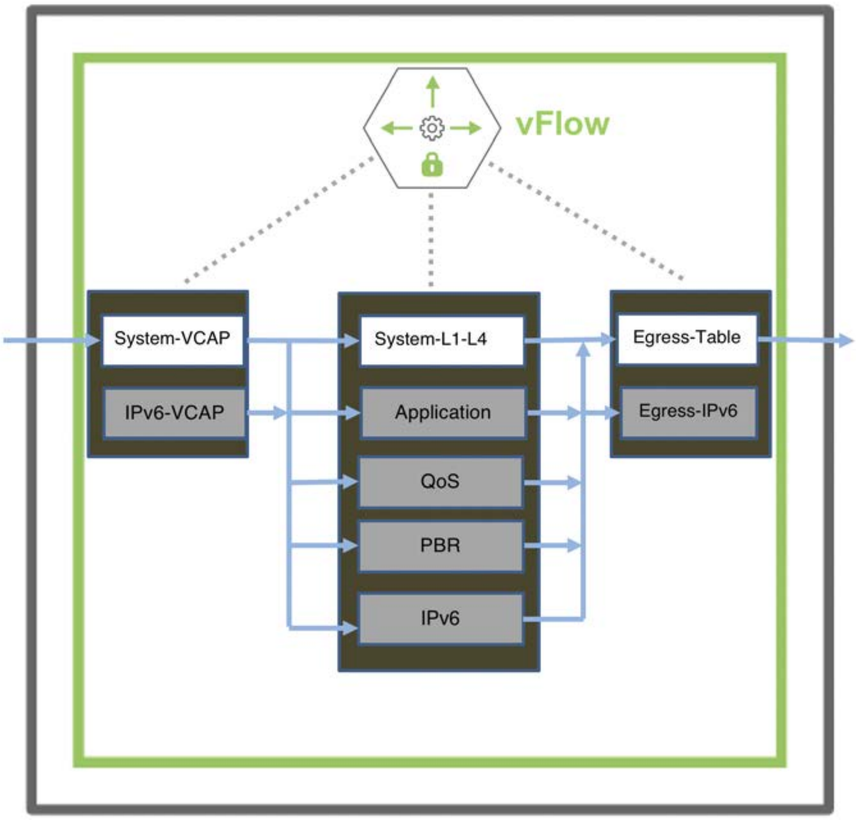


Figure 12-3: Concatenation of vFlow Hardware Tables

Additionally, ***Figure 12-3*** highlights the data-path forwarding stage for each filter table, where some tables are always enabled (displayed in white), while some tables require manual enabling (displayed in grey) such as the Application, QoS, PBR, and IPv6 tables. Use the `table-name` keyword to install or program the vFlow in the specified hardware table.

Table 12-1: Hardware Filter Tables with Descriptions

Hardware Filter Tables	Description
System-VCAP	Where the system VCAP policies are defined at the pre-ingress stage
System-L1-L4	Where the system ingress traffic filtering policies are defined for L2, L3, and L4 packet parameters at the ingress or ICAP table. All system rules are defined in ICAP
Egress-Table	Where the system egress policies are defined at the egress or ECAP table. Supports `drop` and `forward` actions.
Application Table	Where the user application level policies are defined.
QoS Table	Where the ACL policies are defined
PBR Table	Where the policy based routing policies are defined. For details, see the Configuring Policy-Based Routing section.
IPv6 Table	Where IPv6 policies are defined.
IPv6 VCAP Table	Where IPv6 VCAP policies are defined.

You can view the configurable hardware tables by using the command:

```
CLI (network-admin@leaf-1) > vflow-table-profile-show layout vertical
profile:             system
hw-tbl:              switch-main
enable:              enable
flow-capacity:       768
flow-slices-needed:  4
flow-slices-used:    7
comment:              System-L1-L4-flows
profile:             npu-app
hw-tbl:              npu-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  0
flow-slices-used:    0
comment:              L1-L4-flows
profile:              application
hw-tbl:              switch-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  1
flow-slices-used:    0
```

```
comment:              User-Application
profile:             qos
hw-tbl:              switch-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  1
flow-slices-used:    0
comment:             QoS
profile:             ipv6
hw-tbl:              switch-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  2
flow-slices-used:    0
comment:             IPv6
profile:             pbr
hw-tbl:              switch-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  0
flow-slices-used:    0
comment:             PBR
profile:              egress-v6
hw-tbl:              switch-main
enable:              disable
flow-capacity:       0
flow-slices-needed:  1
flow-slices-used:    0
comment:              Egress-IPv6
profile:              ipv6-vcap
hw-tbl:              switch-main
enable:              enable
flow-capacity:       256
flow-slices-needed:  1
flow-slices-used:    1
comment:              VCAP-IPv6
```

Note: The capacity and availability of the hardware tables vary between switch models.

The optional tables (in grey in ***Figure 12-3***) are disabled by default. You can enable optional tables with the `vflow-table-profile-modify` command.

`CLI (network-admin@leaf-1) > vflow-table-profile-modify`

`vflow-table-profile-modify`	Modify vFlow table profiles.
`profile application|ipv6|qos|ipv6-vcap`	Specify the type of vFlow profile.
`hw-tbl switch-main|switch-hash|npu-main|npu-hash`	Specify the hardware used by vFlow.
`enable|no-enable`	Enable or disable vFlow table profile.

For example, enable the qos table using the command:

```
CLI (network-admin@leaf-1) > vflow-table-profile-modify
profile qos enable hw-tbl switch-main
```

Netvisor ONE version 6.1.0 introduces `ipv6-vcap` table profile to enable IPv6 filtering for features like Network Packet Broker. When you enable `ipv6-vcap` table profile, Netvisor ONE constructs an IPv6 VCAP table by allocating half the space in the VCAP table for IPv6 entries.

Enable IPv6 filtering in VCAP table by using the command:

```
CLI (network-admin@leaf-1) > vflow-table-profile-modify
profile ipv6-vcap hw-tbl switch-main enable
```

You must reboot the switch or restart the nvOSd service for the settings to take effect. When you enable optional hardware tables, Netvisor ONE allocates a minimum number of entries in the order of 256 vFlow objects (the number of vFlow objects varies based on the platform and the type of the table). For maximum vFlow scalability, enable hardware tables only when necessary. You can monitor the resource consumption of active hardware tables with the following command:

```
CLI (network-admin@leaf-1) > vflow-table-show layout vertical
name:               Egress-Table-1-0
flow-max-per-group: 512
flow-used:          0
flow-tbl-slices:    3
capability:         match-metadata
flow-profile:       system
name:               System-L1-L4-Tun-1-0
flow-max-per-group: 4096
flow-used:          62
flow-tbl-slices:    4
capability:         set-metadata
flow-profile:       system
name:               System-VCAP-table-1-0
flow-max-per-group: 256
flow-used:          3
flow-tbl-slices:    3
capability:         none
flow-profile:       system
name:               VCAP-IPv6-table-1-0
flow-max-per-group: 256
flow-used:          0
flow-tbl-slices:    1
capability:         none
flow-profile:       ipv6-vcap
```

Precedence

When you implement two or more vFlow objects within the same hardware table, it may be necessary to enforce a particular evaluation order. Use the keyword `precedence` to enforce the evaluation order as Netvisor ONE executes vFlows with higher precedence value first. See a sample configuration below:

Figure 12-4 displays the precedence or evaluation order for different vFlow objects. When a flow matches two or more vFlows with the same precedence, the corresponding vFlow actions are merged and executed together. When you create the vFlow, Netvisor ONE validates that the new object is consistent and can be merged with objects with the same precedence.

The precedence value is within a numerical range of 2 and 15, with 2 as the default value. You cannot configure the evaluation order or `precedence` value beyond 15.

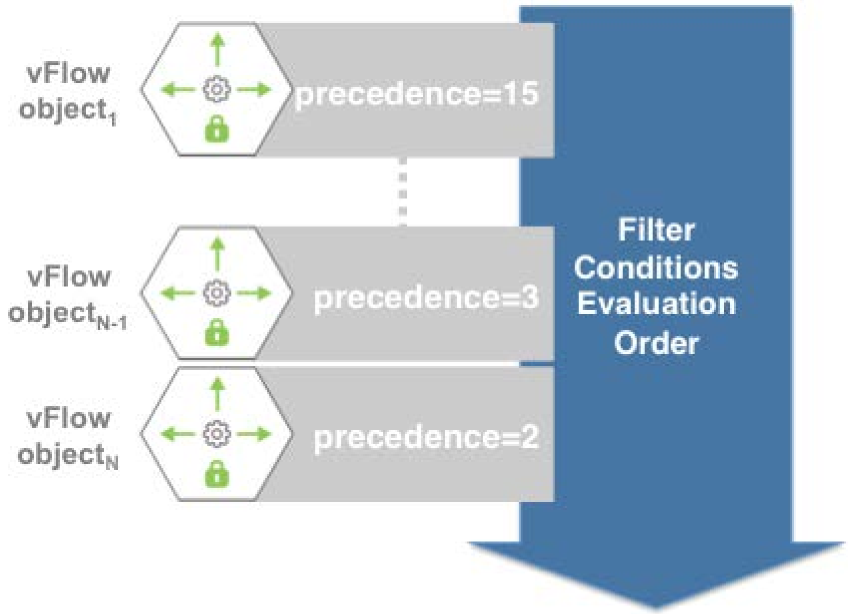


Figure 12-4: Evaluation Order for vFlow Objects with Different Precedence

When you create multiple vflow objects within the same hardware table without specifying the precedence value (default value being 2), Netvisor displays an error message about the vFlow conflicts. For example,

- Create a vFlow:

```
CLI (network-admin@Leaf1) >  vflow-create name example_vflow1
scope fabric  bw flow-class meter bw-max 2g
```

- Create a second vFlow:

```
CLI (network-admin@Leaf1) >  vflow-create name example_vflow2
scope fabric  bw flow-class meter bw-max 5g src-ip
192.168.20.1
```

```
vflow-create: Flow conflicts with Flow example_vflow1, ID68:
specify fields to make flows mutually exclusive or change the
flow precedence
```

The error message is generated because the vFlow configurations conflict with each other. To differentiate between the two vflows, assign a different precedence to example_vflow2:

```
CLI (network-admin@Leaf1) >  vflow-create name example_vflow2
scope fabric  bw flow-class meter bw-max 5g src-ip
192.168.20.1 precedence 5
```

Managing Traffic Classes with vFlow

The vFlow classes indicate the priority assigned to a packet within a switch for internal processing and prioritization and specifies a service type: traffic metering or traffic shaping, bandwidth guarantee. Netvisor ONE supports two types of vFlow classes:

- System Flow Classes
  - Metered flow class, where the traffic is not allowed to exceed a set rate.
  - Guaranteed bandwidth flow class, where the vFlow object guarantees a certain bandwidth and the switch priority is 9.
  - Lossless flow class, where `drop` action is unavailable and the switch priority is 10.
- User Defined Flow Classes
  - Flow classes created by users with priorities between 1 and 8
  - Used for traffic metering
  - Used for traffic shaping and bandwidth guarantee

Filtering of Traffic Flows

In the context of vFlows, filtering describes the traffic characteristics on which the network administrator intends to undertake a certain action. You can define the filter through one of the arbitrary set of matching qualifiers as illustrated in ***Figure 12-5*** and ***Figure 12-6***:

- Operating at an OSI or Internet Protocol layer, which is based on the packet header content

OR

- Based on Netvisor ONE logical constructs, such as vNET, vFlow metadata, or vRouter.

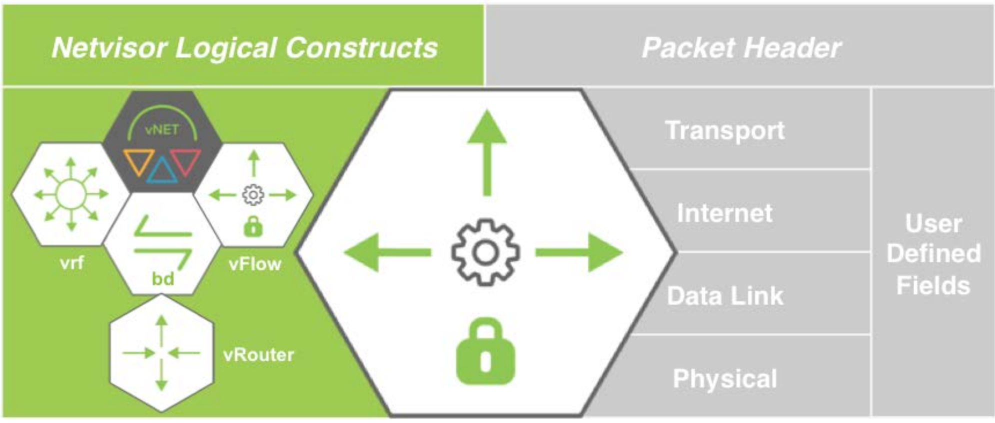


Figure 12-5: vFlow Filtering Using Packet Header Fields and Netvisor Logical Constructs

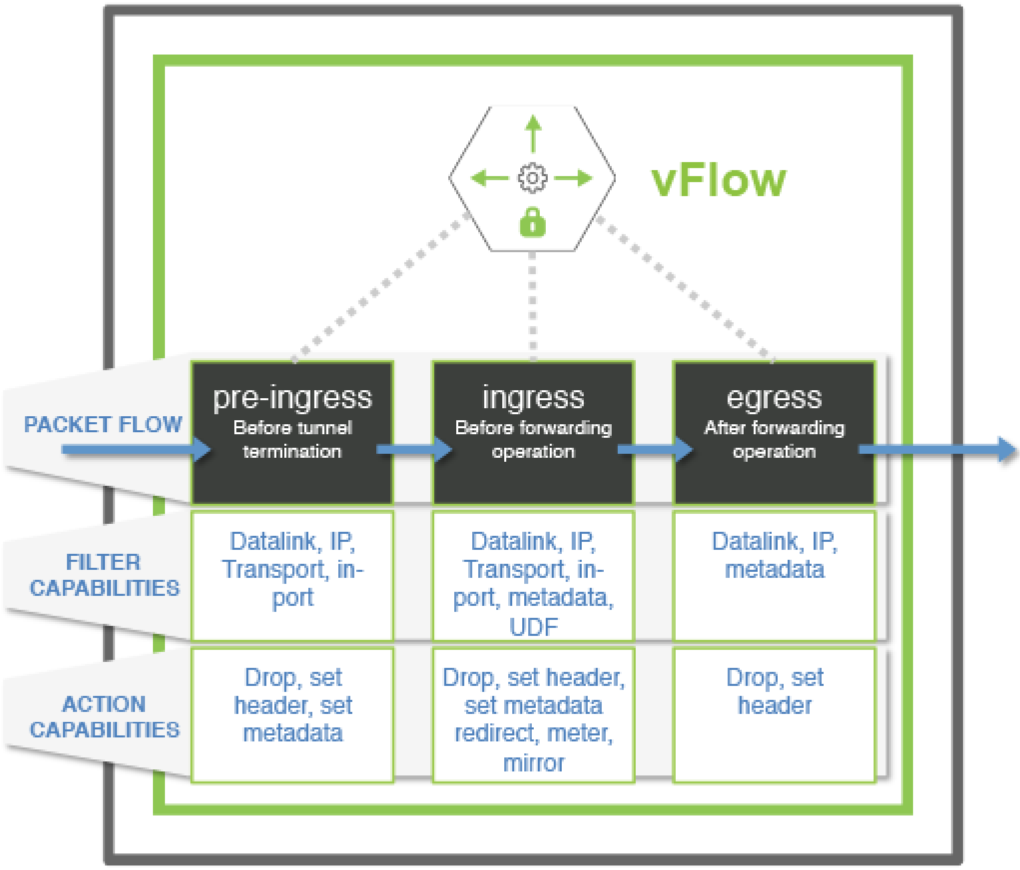


Figure 12-6: vFlow Tables - Packet Forwarding Stage and Filter or Action Capabilities

To define the vFlow filter using the components of OSI layer, use the following keywords or parameters in the `vflow-create` command:

Filtering Qualifiers at Physical Layer

- `in-port` *`port-list`* — ingress physical interface or LAG interface identifiers. Netvisor ONE accepts values as a single value, a dash-separated value range, or comma-separated list of values and ranges.

- `out-port` *`port-list`* — egress physical interface or LAG interface identifier. Netvisor ONE accepts values as a single value, a dash-separated value range, or comma-separated list of values and ranges. This out-port is applicable for Egress_table.

Filtering Qualifiers at Data Link Layer

- `packet-res` — packet resolution in the ASIC. The resolution types can be L2-unicast, L2-unknown-unicast, L2 multicast, L2-unknown-multicast, L2-broadcast. For more details, see the Enhancing the vFlow Capability to Match Forwarding Type and Packet Resolution in ASIC section.

- `fwding-type` — ASIC forwarding type: VLAN, VXLAN, or VLE

- `vlan` — VLAN (Virtual LAN) identifier (IEEE 802.1q). Range is from 0 through 4095.

- `vxlan` —VxLAN Network Identifier or VNI
- `vxlan-ether-type` — Ethernet type such IPv4, ARP, WAKE, RARP, VLAN, IPv6, LACP, MPLS-uni, MPLS-multi, Jumbo, dot1X, AOE, Q-in-Q, LLDP, MACSEC, ECP, PTP, FCOE, FCOE-init, or Q-in-Q-old
- `vxlan-proto` — Protocol type for the VXLAN. Includes TCP, UDP, ICMP, IGMP, IP, ICMPv6
- `src-mac` — Source MAC address
- `src-mac-mask` — Mask for source MAC address
- `dst-mac` — Destination MAC address for the vFlow
- `dst-mac-mask` — Mask for destination MAC address
- `vlan-pri` — Class of Service (CoS) or VLAN priority (IEEE 802.1p), ranges from 0 through 7.

Filtering Qualifiers at Internet Layer

- `src-ip` — Source IP address for the vFlow
- src-ip-mask — Mask for source IP address
- `dst-ip` — Destination IP address
- `dst-ip-mask` — Mask destination IP address
- `ttl` — Packet time-to-live
- `proto` — Layer 3 protocol for the vFlow
- `dscp` — 6-bit Differentiated Services Code Point (DSCP) for Quality of Service (QoS), in the range of 0 to 63
- `dscp-start` — Start value for DSCP
- `dscp-end` — End value for DSCP
- `tos` — Type of Service (ToS) value for Quality of Service (QoS)
- `tos-start` — Start value for Type of Service (ToS) range
- `tos-end` — End value for Type of Service (ToS) range

Filtering Qualifiers at Transport Layer

- `src-port` — Source transport port
- `src-port-mask` — Mask for source transport port
- `src-port-end` — Ending port for a range of source ports. Use this qualifier along with `src-port` to specify a range of ports. This option is mutually exclusive with

src-port-mask

- dst-port — Destination transport port
- dst-port-mask — Mask for destination transport port
- dst-port-end — Ending port for a range of destination ports. Use this qualifier along with dst-port to specify a range of ports. This option is mutually exclusive with dst-port-mask
- tcp-flags — Comma-separated list of TCP control flag values

Filtering Qualifiers at User Defined Fields (UDFs)

- udf-name[1-3] — Reference to a User Defined Field (UDF) object, and defines advanced multi-layer filtering. Up to 3 objects are supported.
- udf-data[1-3] — Data value applied to the corresponding UDF object
- udf-data[1-3]-mask — Mask value applied to the corresponding UDF object

For details on configuring vFlows with UDFs, see the Configuring vFlows with user Defined Fields section.

Netvisor ONE Logical Filtering

To define the vFlow filter using the Netvisor ONE logical constructs, use the following keywords or parameters in the vflow-create command:

- metadata — Metadata tag value assigned to packets along the internal hardware forwarding path, which can be used to correlate different vFlow objects operating at different ingress and egress stages
- bridge-domain — Logical abstraction of data-link learning and forwarding domain, implemented using a combination of physical interfaces, VLANs and VNI
- vrouter-name — Reference to an Internet layer VRF context defined on a local vRouter
- vrf - Parameter used to enable vFlows to operate at scale in a distributed VRF environment.

  For details, see the *Configuring VRF-aware vFlow* section of the *Configuring VXLAN* chapter.
- vnet — Virtual Network (vNET) value, used for identifying traffic belonging to a logical network partition for multi-tenancy and network segmentation purposes.
- src-vpg, dst-vpg, bidir-vpg-1, bidir-vpg-2 — Source, destination, and bidirectional Virtual Port Groups(VPGs) are logical constructs that allows you to club ports together in order to support the Network Packet Broker solution. For details, see the

Configuring Pluribus Network Packet Broker section of the Configuring Network Management and Monitoring chapter.

Configuring vFlows with User Defined Fields (UDFs)

Netvisor allows you to define policy filters through one of the arbitrary set of matching qualifiers as explained in the Filtering of Traffic Flows section. One of the qualifier is the User Defined Field (UDF).

A UDF can match up to 128 bytes of a packet starting from the first byte of the packet. The length of the match can be from 1 to 4 bytes. Hardware with a Trident chip supports the creation of 8 UDF IDs. Each id can match a 2 byte portion of a packet. Creating a UDF with a length of 3 or 4 bytes requires 2 UDF IDs whereas a UDF with length of 1 or 2 bytes required 1 UDF id. The length specified for each UDF determines the total number of UDFs supported by Netvisor One. If you specify a length of 3 or 4 bytes, a maximum of 4 UDFs can be created. If you specify a length of 1 or 2 bytes, a maximum of 8 UDFs can be created.

> **Limitation**: UDF offset range supported for UDF header packet-start type ranges from 0-63. This limitation is applicable for all NRU03 platforms.

A UDF adds a qualifier to the vFlow group, and you should create all UDFs before creating any vFlows. This feature is disabled by default, and you can enable it by using the following command:

```
CLI(network-admin@Spine1) >   vflow-settings-modify  enable-user-defined-flow|no-enable-user-defined-flow
```

`vflow-settings-modify`	Use this command to update a user vflow setting
Specify one of more of the following options	
`enable-user-defined-flow|no-enable-user-defined-flow`	Specify to enable or disable the user defined flows.
`vxlan-analytics|no-vxlan-analytics`	Specify to enable or disable VXLAN analytics. **Note**: You must disable VXLAN analytics before enabling the longlived tcp connection
`inflight-vxlan-analytics|no-inflight-vxlan-analytics`	Specify to enable or disable the inflight VXLAN analytics. **Note**: You must disable inflight VXLAN analytics before enabling the longlived tcp connection.
`longlived-tcp-conn-stats|no-longlived-tcp-conn-stats`	Specify to enable or disable the long-lived TCP connection statistics. **Note**: You must enable the user-defined-flow before enabling the longlived tcp

	connection statistics.

To enable the user defined vflow, use the command:

```
CLI(network-admin@Spine1) >  vflow-settings-modify enable-user-defined-flow
```

To disable the feature, use the command:

```
CLI(network-admin@Spine1) >  vflow-settings-modify no-enable-user-defined-flow
```

> **Note**: Reboot Netvisor OS for the changes (`enable` or `disable` commands) to take effect on the platform.

The command, `udf-create`, adds the qualifier to the UDF group in the hardware. This allocates UDF IDs based on the length. The command, `vflow-create`, has parameter fields to provide the data and mask to be matched by the vFlow. You can create vFlows with either one or two UDFs.

You cannot modify a UDF after adding it to a vFlow. You must delete the vFlow, modify the UDF, and re-create the vFlow with the modified UDF.

New Commands for UDF

To create a new UDF, use the following command:

```
CLI(network-admin@Spine1) >  udf-create name udf1 scope local offset 10 length 2 header packet-start
```

`udf-create`	Create the UDF qualifier list
`name` *`name-string`*	Create the UDF name
`scope local|fabric`	Scope for the UDF
`offset` *`number-bytes`*	The offset in bytes. This is a value between 1 and 128.
`length` *`number-bytes`*	The length in bytes. This is a value between 1 and 4 bytes.
`header [packet-start|l3-outer|l3-inner|l4-outer|l4-inner]`	The header from where offset is calculated.

To delete an UDF command:

```
CLI(network-admin@Spine1) >  udf-delete name udf1
```

`udf-delete`	Delete UDF qualifier list

`name` *`name-string`*	The name of the UDF to delete.

To modify an existing UDF command:

```
CLI(network-admin@Spine1) >  udf-modify name udf1 scope local
offset 20 length 4 header packet-start
```

`udf-modify`	Modify UDF qualifier list
`name` *`name-string`*	The name of the UDF to modify.
One or more of the following options:	
`offset` *`number-bytes`*	The offset in bytes. This is a value between 1 and 128.
`length` *`number-bytes`*	The length in bytes. This is a value between 1 and 4 bytes.
`header  packet-start|l3-outer|l3-inner|l4-outer|l4-inner`	The header from where offset is calculated.

```
CLI(network-admin@Spine1) >   udf-show

switch       name   scope   offset  length   header
------       ----   -----  ------  ------   ------------
spine1     u1     local    20       4        packet-start
spine1     u2     local    24       4        packet-start
```

`switch`	Displays the name of the switch
`udf-show`	Displays the UDF qualifier list
`name` *`name-string`*	Displays the UDF name
`scope  local|fabric`	Displays the scope for the UDF
`offset` *`number-bytes`*	Displays the offset in bytes. This is a value between 1 and 128.
`length` *`number-bytes`*	Displays the length in bytes. This is a value between 1 and 4 bytes.
`header  packet-start|l3-outer|l3-inner|l4-outer|l4-inner`	Displays the header from where the offset is calculated.

The command, `vflow-create`, has the following additional parameters:

`udf-name1` *`udf-name`*	Specify the name of the UDF.
`udf-data1` *`udf-data1-number`*	Specify UDF data1q with the format 0xa0a0a01
`udf-data1-mask` *`udf-data1-mask-number`*	Specify he mask for udf-data with the format 0xffffffff.

`udf-name2` *`udf-name`*	Specify the name of the UDF.
`udf-data2` *`udf-data2-number`*	Specify UDF data2 with the format 0xa0a0a01
`udf-data2-mask` *`udf-data2-mask-number`*	Specify the mask for udf-data with the format 0xffffffff.

For example, to create a vflow with UDF parameters, use the command:

```
CLI(network-admin@Spine1) >  vflow-create name udf1 scope
local udf-name1 udf1 udf-data 0x0a0a0a01 udf-data-mask1
0xffffffff udf-name2 udf2 udf-data2 0x0a0a1400 udf-data-mask2
0xffffff00
```

```
CLI(network-admin@Spine1) >  vflow-show
```

```
name   scope  type   precedence  udf-name1  udf-data1   udf-data-mask1  udf-name2   udf-data2
udf-data-mask2
----  -----  -----  ----------  ---------  ---------   --------------   ---------  ---------
--------------
udf1   local  vflow   default       udf1      0xa0a0a01   0xffffffff     udf2        0xa0a1400
0xffffff00
```

Configuring a UDF vFlow for Filtering ARP Requests

Consider a scenario where you need to allow only the ARP requests destined for Anycast gateway IP (`anycast-gw-ip`) to proceed with ARP processing, while blocking other transit ARP requests. You can create a UDF with a higher precedence value than system vFlows to achieve this. Follow the steps below to create such a configuration:

- First enable UDF by using the command:

```
CLI (network-admin@switch) > vflow-settings-modify enable-
user-defined-flow
```

`udf-name1` *`udf-name`*	Specify the name of the UDF.
`udf-data1` *`udf-data1-number`*	Specify UDF data1q with the format 0xa0a0a01
`udf-data1-mask` *`udf-data1-mask-number`*	Specify he mask for udf-data with the format 0xffffffff.

- Restart the nvOSd.
- Create a UDF, *target-ip*, for the ARP request using the command:

```
CLI (network-admin@switch) > udf-create name target-ip scope
local offset 42 length 4 header packet-start
```

- Create UDF to punt ARP packets to CPU using the command:

```
CLI (network-admin@switch) > vflow-create name UDF-Allow-AnyGW-243 scope fabric precedence 15 action copy-to-cpu udf-name1 target-ip udf-data1 0xa65f302 udf-data1-mask 0xffffffff table-name System-L1-L4-UDF-1-0 flow-cb arp-cb
```

`vflow-create`	Creates a virtual flow definition for L2 or L3 IP.
`name name-string`	Enter a name for the vFlow.
`scope local|fabric`	Specify the scope for vFlow.
`precedence default|0..15`	Specify the traffic priority value between 2 and 15.
`action copy-to-cpu`	Specify the forwarding action to apply to the vFlow, in this case, `copy-to-cpu`.
`udf-name1`	Specify the UDF name created in step c.
`udf-data1 udf-data1-number`	Enter the UDF data (hexa-decimal value equivalent to the IP address of anycast gateway.
`udf-data1-mask udf-data1-mask-number`	Enter the mask for UDF data.
`table-name vflow-table name`	Enter the vFlow table name.
`flow-cb default-cb|arp-cb|bcast-cb|igmp-cb|pim-cb|dhcp-cb|dhcpv6-cb|dmac-miss-cb|l2-miss-cb|no-cb`	Specify the call-back option (here `arp-cb`).

To verify the configuration, use the `vflow-show` command:

```
CLI (network-admin@switch) > vflow-show name UDF-Allow-AnyGW-243

name               scope  type  burst-size precedence action      udf-name1 udf-data1 udf-data1-mask enable table-name
      flow-cb
------------------ ------ ----- ---------- ---------- ----------- --------- --------- ------------- ------
------------------- -------
UDF-Allow-AnyGW-243 fabric vflow auto       15         copy-to-cpu target-ip 0xa65f302 0xffffffff     enable System-L1-L4-
UDF-1-0 arp-cb
```

Forwarding Action in vFlow Filters

The forwarding action defines the switch behavior for traffic that matches with the vFlow filter. Depending on the use case, the possible actions for the traffic flow include:

- Dropping of filtered traffic
- Regular or customized forwarding of filtered traffic
- Redirection or replication of filtered traffic to a switch processor, a physical port, or to an IP address destination.

Access Control

To provide security access control policies that operate on high-speed distributed networks, the switch, which employs low-cost high-capacity technology like ASIC Ternary Content Addressable Memory (TCAM), is the ideal point of insertion. With Pluribus Adaptive Cloud Fabric, high-performance security access control using a **blacklist** or **whitelist** approach can be implemented consistently across the entire network using fabric-wide vFlow policies.

Netvisor ONE provides several vFlow actions for securing the network traffic with Access Control Lists (ACL) as described in the table :

Table 12-2: vFlow Actions Supported in Netvisor ONE

Action	Description
`action none`	Traffic is forwarded (permit filtered traffic) This is the default action.
`action drop`	Traffic matching the filter is removed from traffic path (block filtered traffic)
`action to-port`	Traffic matching the filter is forwarded to specified ports
`action to-cpu`	Traffic matching the filter is sent to CPU only
`action trap`	Traffic matching the filter is trapped to CPU
`action copy-to-cpu`	Traffic matching the filter is forwarded normally and copied to CPU, this action does not affect the traffic policy, but creates a copy of the policy to the CPU
`action copy-to-port`	Traffic matching the filter is forwarded normally and copied to port
`action check`	Traffic matching the filter is verified
`action setvlan`	VLAN ID is set for the traffic matching the filter
`action add-outer-vlan`	New outer VLAN tag is added to the traffic matching the filter
`action set tpid`	Traffic matching the filter is tagged with the provided TPID
`action to-port-set-vlan`	Traffic matching the filter is sent to provided port

	on specified VLAN
`action tunnel-pkt`	Tunnel frame is added for incoming traffic
`action set-tunnel-id`	Tunnel ID is set for the traffic matching the filter
`action to-span`	Traffic matching the filter is forwarded to the span ports
`action cpu-rx`	Stress test for cpu-rx
`action cpu-rx-tx`	Stress test for cpu-rx-tx
`action set-metadata`	Metadata is set for the traffic matching the filter
`action set-dscp`	DSCP value is set for the traffic matching the filter
`action decap`	Decap is set for the traffic matching the filter
`action set-dmac`	Destination MAC is set for traffic matching the filter
`action to-next-hop-ip`	The next hop IP address for traffic redirection
`action set-dmac-to-port`	Destination MAC is set and it is forwarded to port specified
`action to-ports-and-cpu`	Traffic matching the filter is forwarded to ports and CPU
`action set-vlan-pri`	Set VLAN priority for traffic matching the filter
`action tcp-seq-offset`	TCP sequence offset is set for traffic matching the filter
`action tcp-ack-offset`	TCP acknowledgment offset is set for traffic matching the filter
`action l3-to-cpu-switch`	Redirects Layer3 packets to CPU
`action set-smac`	Source MAC is set for the traffic matching the filter
`action drop-cancel-trap`	Traffic matching the flow is dropped and not trapped
`action to-ecmp-group`	ECMP group for traffic redirection
`action redirect-to-vrouter`	Redirect packets to vrouter
`set-dscp`	DSCP value is set for the traffic matching the filter
`decap`	Decap is set for the traffic matching the filter
`set-dmac`	Destination MAC is set for traffic matching the filter
`to-next-hop-ip`	The next hop IP address for traffic redirection
`set-dmac-to-port`	Destination MAC is set and it is forwarded to port specified
`to-ports-and-cpu`	Traffic matching the filter is forwarded to ports and CPU
`set-vlan-pri`	Set VLAN priority for traffic matching the filter
`tcp-seq-offset`	TCP sequence offset is set for traffic matching the filter
`tcp-ack-offset`	TCP ack offset is set for traffic matching the filter
`l3-to-cpu-switch`	Redirects l3 packets to CPU
`set-smac`	Source MAC is set for the traffic matching the filter

`drop-cancel-trap`	Traffic matching the flow is dropped and not trapped
`to-ecmp-group`	ECMP group for traffic redirection
`redirect-to-vrouter`	Redirect packets to vrouter

Typically the action resolution process gathers the actions from each slice match and decides on a collective action. However, when there is an action conflict, the collective action is not possible and the `drop` action takes higher priority. With the implementation of virtual slide mapping feature, action resolution is handled by the precedence or priority value.

Understanding Blacklist Policy

You can implement access control policies using a blacklist approach, that is, approving all traffic by default and explicitly restricting certain traffic categories.

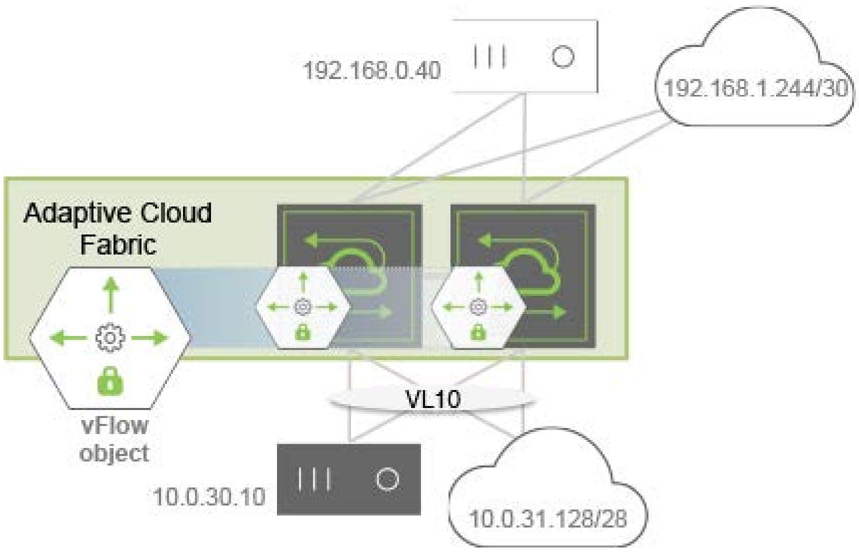


Figure 12-7 - Blacklist Topology Example

For example, as shown in ***Figure 12-7***, you want to block HTTP traffic ingressing the switches in VLAN 10 going from the black host to the white host, while permitting all other traffic. Use the following parameters to configure a vFlow for this purpose:

- vFlow name: `ACL01`
- Filter: `VLAN 10`
- TCP port: `80`
- Source IP address: `10.0.30.10`
- Destination IP address: `192.168.0.40`
- Forwarding Action: `drop`

```
CLI (network-admin@switch) > vflow-create name ACL01 scope
```

```
fabric vlan 10 src-ip 10.0.30.10 dst-ip 192.168.0.40 proto tcp
dst-port 80 action drop
```

For maximum ACL scalability, the blacklist policy can be also implemented using the System-VCAP table (see **Figure 12-8**) and provide additional capacity based on the switch models. In this approach, Netvisor ONE drops the blacklisted traffic at the pre-ingress stage without utilizing the resources in the default ingress table.

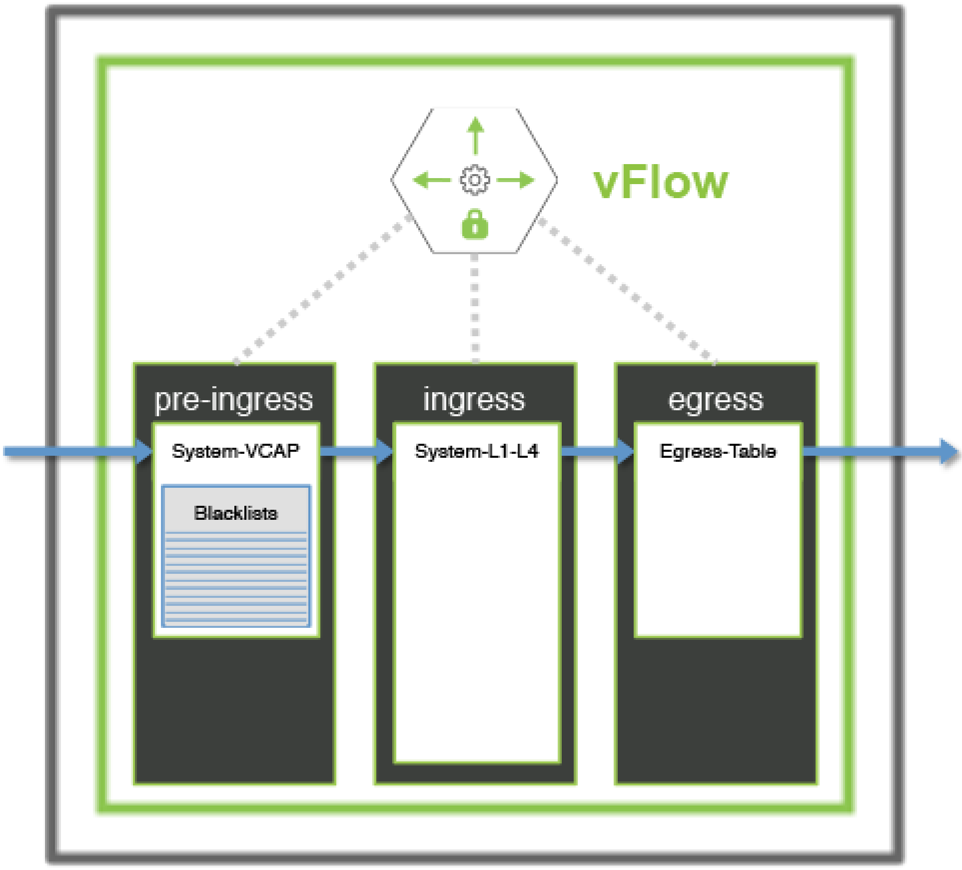


Figure 12-8: Scaling the Blacklist ACLs using a Pre-Ingress Filter

Understanding Whitelist Policy

Contrary to the blacklist policy, the Whitelist model explicitly defines network traffic that is allowed and uses a default permit policy. ***Figure12- 9*** illustrates an example where you want to deny default traffic and approve traffic ingressing the switches on VLAN 10 for the following conditions:

- Traffic between the black hosts
- Traffic between the two subnets (clouds)
- Secure Shell (SSH) traffic between the white hosts where the host below (10.0.31.4) acts as a responder.

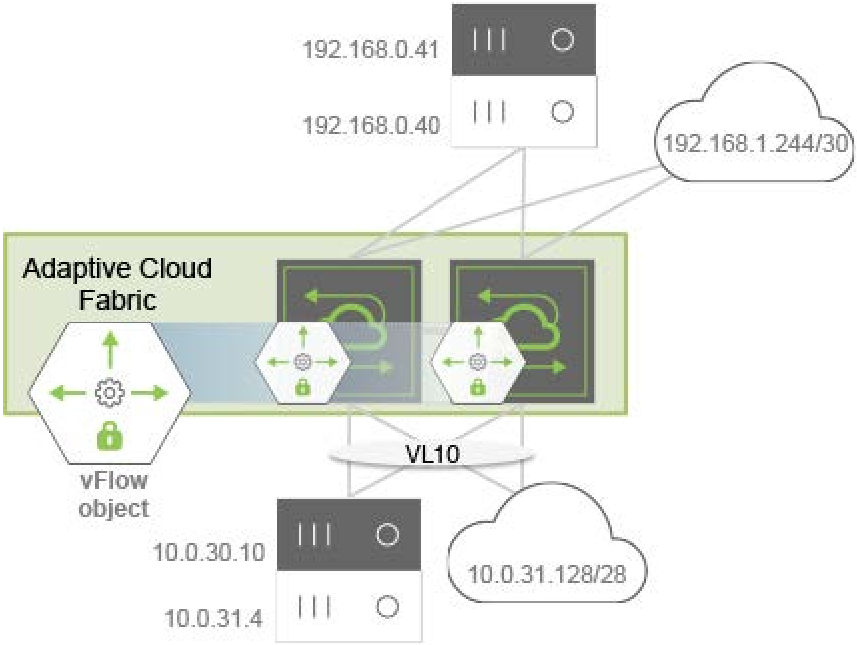


Figure 12-9: Whitelist Topology Example

To implement this policy, create four `fabric`-scoped vFlow objects, with the last one (**vFlow ACL04**) having the least (default) precedence and by using the following parameters:

1. **vFlow ACL01**

   - Filter: VLAN `10`
   - Source IP address: `10.0.30.10`
   - Destination IP address: `192.168.0.41`
   - Forwarding Action: `none`
   - Precedence: `4`

```
CLI (network-admin@switch) > vflow-create name ACL01 scope
fabric vlan 10 precedence 4 src-ip 10.0.30.10 dst-ip
192.168.0.41
```

2. **vFlow ACL02**

   - Filter: VLAN `10`
   - Source IP address: `10.0.31.128/28`
   - Destination IP address: `192.168.1.144/30`
   - Forwarding Action: `none`
   - Precedence: `4`

```
CLI (network-admin@switch) > vflow-create name ACL02 scope
```

```
fabric vlan 10 precedence 4 src-ip 10.0.31.128 src-ip-mask
255.255.255.250 dst-ip 192.168.1.144 dst-ip-mask
255.255.255.252
```

3. **vFlow ACL03**

   - Filter: VLAN `10`
   - TCP port: `22`
   - TCP flags: ACK
   - Source IP address: `10.0.31.4`
   - Destination IP address: `192.168.0.40`
   - Forwarding Action: `none`
   - Precedence: 4

```
CLI (network-admin@switch) > vflow-create name ACL03 scope
fabric vlan 10 precedence 4 src-ip 10.0.31.4 dst-ip
192.168.0.40 proto tcp dst-port 22 tcp-flags ack
```

4. **vFlow ACL04**

   - Filter: VLAN `10`
   - Forwarding Action: `drop`
   - Precedence: 2 (default)

```
CLI (network-admin@switch) > vflow-create name ACL04 scope
fabric vlan 10 action drop
```

For maximum ACL scalability, you can implement the whitelist policy using the System-VCAP table and provide additional capacity for vFlow objects based on the switch models.

In this approach, Netvisor ONE examines Whitelisted traffic and labels the traffic with an arbitrary metadata value at the pre-ingress stage, without consuming resources in the default ingress table. During next ingress stage, Netvisor ONE uses a single vFlow object with highest precedence to permit traffic already allowed at pre-ingress stage. You can also build the same Whitelist policy using both System-VCAP and the default System-L1-L4 tables as shown in ***Figure 12-10***.

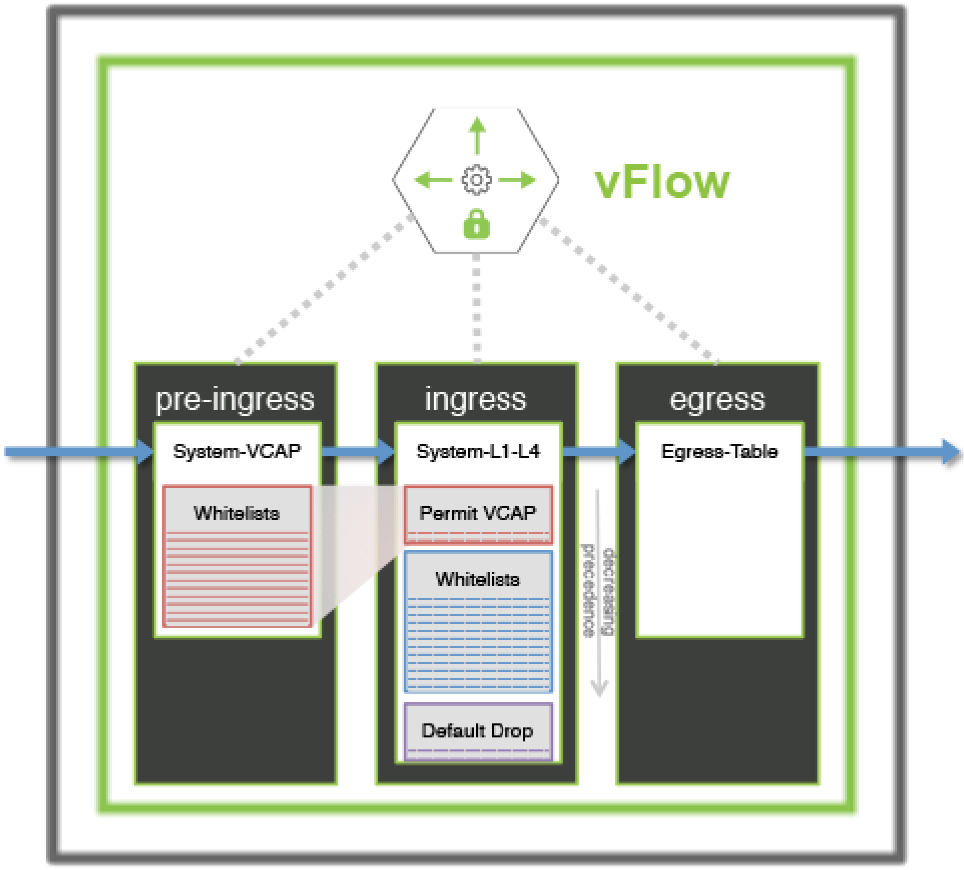


Figure 12-10: Scaling Whitelist ACLs Using a Pre-ingress Filter

Commands and Parameters Applicable to vFlow Traffic

The vFlow feature includes several commands and keyword parameters to configure and monitor various vFlow actions. Some of the important commands and parameters are explained in this section.

- To create a new vFlow object, use the command:

```
CLI (network-admin@switch-1) > vflow-create name <vflow-name>
scope [local|fabric] {parameters}
```

- To modify an existing vFlow object,

```
CLI (network-admin@switch-1) > vflow-modify name <vflow-name>
{parameters}
```

- To delete an existing vFlow object,

```
CLI (network-admin@switch-1) > vflow-delete name <vflow-name>
```

- To display existing vFlow objects,

```
CLI (network-admin@switch-1) > vflow-show {parameters}
```

The key parameters required to create a vFlow object are categorized as:

- Scope (2)
    - local OR
    - fabric

- Tables (4)
    - table-name Egress-Table-1-0
    - table-name System-L1-L4-Tun-1-0
    - table-name System-VCAP-table-1-0
    - table-name VCAP-IPv6-table-1-0

- Match Conditions: Specify one or more match conditions:
    - vlan
    - inner-vlan
    - vnet
    - bd < bridge-domain name>
    - in-port <port>
    - out-port <port>
    - ether-type <type>
    - src-mac <mac> src-mac-mask <mask>
    - dst-mac <mac> dst-mac-mask<mask>
    - src-ip <ip> src-ip-mask <mask>
    - dst-ip <ip> dst-ip-mask <mask>
    - src-port <port> proto <tcp|udp>
    - dst-port <port> proto <tcp|udp>
    - src-port <port> src-port-mask <mask>

- dst-port <port> dst-port-mask <mask>
- src-port <port> src-port-end <port>
- dst-port <port> dst-port-end <port>
- dscp-start <start value> dscp-end <end value>
- tos-start <start value> tos-end <end value>
- tos <tos>
- src-vpg <name> dst-vpg <name>
- bidir-vpg-1 <name> bidir-vpg-2 <name>
- vlan-prio <802.1p priority>
- inner-vlan-pri <priority>
- vrf <name>
- ttl <ttl>
- proto <IP proto>
- tcp-flags <tcp control flags>
- ingress-tunnel <tunnel>
- egress-tunnel <tunnel>
- vrouter-name <vrouter>
- mirror <mirror-name>
- packet-log-max <1..50G>
- metadata <number>
- vxlan <vxlan-id>
- vxlan-ether-type <ether-type for VXLAN>
- vxlan-proto <protocol-type>
- stp-state <state>
- packet-res <packet resolution in ASIC>
- fwding-type <vlan|vxlan>
- udf-name1 <name> udf-data1 <data> udf-data1-mask <mask>
- udf-name2 <name> udf-data2 <data> udf-data2-mask <mask>
- udf-name3 <name> udf-data3 <data> udf-data3-mask <mask>
- if <mgmt|data>
- description <description-string>

Note:

- From Netvisor ONE 6.1.0 onward, the parameters `src-mac` and `dst-mac` are supported in the System-VCAP table in addition to the System-L1-L4 table. This enhancement allows you to use these parameters while configuring the Network Packet Broker (NPB) solution.

- Netvisor ONE version 6.1.0 introduces the `inner-vlan` parameter to support filtering of traffic based on the inner VLAN of a QinQ frame. This parameter is supported by the System-L1-L4 hardware table and can be configured as part of NPB deployments. You can set a metadata value for the NPB vFlow in System-VCAP table, and this value can be supplied along with `inner-vlan` parameter in another vFlow for filtration of NPB traffic based on inner VLAN ID.

- Special Actions
  - burst-size <size>
  - precedence <IP precedence>
  - process-mirror|no-process-mirror
  - log-stats|no-log-stats

- from-tunnel-decap|no-from-tunnel-decap
- log-stats stats-interval <sec> dur <sec>
- set-src <ip> set-src-port <port>
- set-dst <ip> set-dst-port <port>
- dropped|no-dropped
- log-stats|no-log-stats
- transient|no-transient
- enable|no-enable
- transparency <enable|disable>
- flow-cb default-cb|arp-cb|bcast-cb|igmp-cb|pim-cb|dhcp-cb|dhcpv6-cb|dmac-miss-cb|l2-miss-cb|no-cb

- Specific Actions with **Action** Keyword
    - action none
    - action drop
    - action to-port action-to-ports-value <port>
    - action to-cpu
    - action trap
    - action copy-to-cpu
    - action copy-to-port
    - action check
    - action setvlan action-value <vlan>
    - action add-outer-vlan
    - action set-tpid
    - action to-port-set-vlan
    - action tunnel-pkt
    - action set-tunnel-id
    - action to-span
    - action cpu-rx
    - action cpu-rx-tx
    - action set-metadata
    - action set-dscp
    - action decap
    - action set-dmac
    - action to-next-hop-ip action-to-next-hop-ip-value <next-hop-ip>
    - action set-dmac-to-port
    - action to-ports-and-cpu
    - action set-vlan-pri
    - action tcp-seq-offset
    - action tcp-ack-offset
    - action l3-to-cpu-switch
    - action set-smac
    - action drop-cancel-trap
    - action to-ecmp-group action-to-ecmp-group-value <ecmp-group>
    - action to-vp
    - action set-svp action-set-svp-value <svp>
    - action redirect-to-vrouter
    - action-value

- Flow Class
    - flow-class meter
    - flow-class guaranteed_bw
    - flow-class lossless

- flow-class class0
  - flow-class class1
  - flow-class class2
  - flow-class class3
  - flow-class class4
  - flow-class class5
  - flow-class class6
  - flow-class class7
  - flow-class class8
  - flow-class control
  - flow-class control2
  - flow-class control3

Note: The flow classes control2 and control3 are available only on NRU01, NRU02, NRU03, and NRU03-SFF platforms.

- Bandwidth parameters
  - bw-min <min>
  - bw-max <max>

Refreshing vFlow Level Statistics for Long-lived Connections

Prior to Netvisor ONE 5.1.1 release, the connection analytics displayed the connection statistics (incoming bytes, outgoing bytes, total bytes, and the age of the connection) only after the connection is completed, which worked well for short-timed connections. However, for long-lived TCP connections, the connection statistics was unreliable. This was due to the fact that the parameters involved were calculated with reference to the TCP sequence numbers, which, for a long-lived connection, always wrapped around.

To eliminate inaccuracies in long-lived TCP connection statistics, the TCP data packets with sequence numbers that are about to wrap around are sent to the CPU. This is implemented by defining a new vflow rule (policy). Netvisor ONE provides an option to enable this functionality through the `vflow-settings-modify` command. When the feature is active, the `connection-stats-show` and `connection-show` commands show accurate outputs for long-lived TCP connections.

Note:

- To enable *long-lived TCP connection statistics*, you must first enable the *user-defined-flow* knob.
- Disable *vxlan-analytics* before enabling the *long-lived TCP connection statistics* knob.
- You cannot enable *long-lived TCP connection statistics* knob if the *inflight-vxlan-analytics* is enabled or vice-versa.

Note: You must restart nvOSd when you enable or disable the long-lived TCP connection statistics knob.

Use the `vflow-settings-modify` command to enable long-lived TCP connection statistics:

```
CLI (network-admin@switch) > vflow-settings-modify
```

`vflow-settings-modify`	Use this command to update a user vflow setting.
Specify one or more of the following options:	
`enable-user-defined-flow|no-enable-user-defined-flow`	Specify to enable or disable the user defined flows. **Note**: You must enable the user-defined-flow before enabling the longlived tcp connection statistics.
`vxlan-analytics|no-vxlan-analytics`	Specify to enable or disable VXLAN analytics. **Note**: You must disable VXLAN analytics

	before enabling the longlived tcp connection
`inflight-vxlan-analytics|no-inflight-vxlan-analytics`	Specify to enable or disable the inflight VXLAN analytics. **Note**: You must disable inflight VXLAN analytics before enabling the longlived tcp connection.
`longlived-tcp-conn-stats|no-longlived-tcp-conn-stats`	Specify to enable or disable the long-lived TCP connection statistics.

For example, to enable the long-lived TCP connection statistics, use the commands below:

```
CLI (network-admin@Leaf1) > vflow-settings-modify enable-user-defined-flow

CLI (network-admin@Leaf1) > vflow-settings-modify no-vxlan-analytics no-inflight-vxlan-analytics

CLI (network-admin@Leaf1) > vflow-settings-modify longlived-tcp-conn-stats
```

To view the user vflow settings, use the command `vflow-settings-show`. For example, after enabling long-lived TCP connection statistics, the typical output would be:

```
CLI (network-admin@Leaf1) > vflow-settings-show

enable-user-defined-flow:  on
vxlan-analytics:           off
inflight-vxlan-analytics:  off
longlived-tcp-conn-stats:  on
```

To view the connection statistics, use the show commands:

```
CLI (network-admin@Leaf1) > connection-stats-show

vlan    ip        port iconns    oconns ibytes obytes total-bytes
---- ------------ ---- --------- ------ ------ ------ -----------
100  132.10.3.152 32   402617119        813G   809G    1.58T
100  132.10.3.113 32   402439803        822G   818G    1.60T
100  132.10.3.191 32   402379008        828G   822G    1.61T
100  132.10.3.160 32   402531295        828G   824G    1.61T
100  132.10.3.147 32   402620992        833G   829G    1.62T
100  132.10.3.131 32   402466573        840G   836G    1.64T

CLI (network-admin@Leaf1) > connection-show

vlan   src-ip     dst-ip     dst-port cur-state latency obytes ibytes total-bytes age
---- ---------- ----------- -------- --------- ------- ------ ------
```

```
----------- ---
100  132.10.3.2 132.10.3.127 http     fin        67.9us  198     188     386
    1s
100  132.10.3.2 132.10.3.186 http     fin        62.3us  198     188     386
    1s
100  132.10.3.2 132.10.3.153 http     fin        511us   198     188     386
    1s
100  132.10.3.2 132.10.3.205 http     fin        66.4us  198     188     386
    1s
100  132.10.3.1 132.10.3.160 http     fin        305us   198     188     386
    1s
```

Configuring Ingress QoS Policing based on Internal Priority

Internal priority is an intermediary priority value that maps DSCP values to CoS values. Netvisor ONE version 6.1.0 allows you to configure vFlows with internal priority as a filtering parameter. In effect, you can now perform traffic policing for any received traffic based on DSCP values. In earlier versions of Netvisor ONE, you needed to configure at least one vFlow per port per DSCP value or DSCP value range. However, with Netvisor ONE release 6.1.0, you need to configure only one vFlow per internal priority value.

The allowed range of internal priority values is between 0 and 7. For example, you can assign a maximum bandwidth limit of 100Mbps for packets with an internal priority of 1 by using the command:

```
CLI (network-admin@switch) > vflow-create name flow1 scope
local internal-pri 1 bw-max 100M
```

Display the configuration by using the command:

```
CLI (network-admin@switch) > vflow-show
name:          flow1
scope:         local
type:          vflow
in-port:
internal-pri:  1
bw-max:        100M
burst-size:    auto
precedence:    default
action:
packet-res:
fwding-type:
enable:        enable
table-name:     System-L1-L4-Tun-1-0
```

To clear the internal priority field for a vFlow, use the command:

```
CLI (network-admin@switch) > vflow-create name flow1 internal-
pri none
```

Note:

- To achieve filtering of traffic based on the desired DSCP values, you must configure the internal priority value on the basis of the configured DSCP to CoS mapping. For more information, see the *Configuring DSCP to CoS Mapping* section of the *Configuring and Using vFlows* chapter.
- This feature does not support CoS values of 8 and 9 as these queues are used for internal control plane traffic.
- You can configure the `internal-pri` parameter in different hardware filter tables except `System-VCAP-table-1-0` and `VCAP-IPv6-table-1-0`.

Configuring Bridge Domain Aware vFlow

Starting from Netvisor ONE release 6.1.0, you can create vFlows that accept bridge domains as a filtering parameter. This release also allows you to configure vFlows that use the direction of VXLAN traffic as a qualifier.

You can use the `bd` parameter in the `vflow-create` command to filter network traffic based on the bridge domain. For example, to configure a vFlow that drops packets that hits the ingress port 10 of bridge domain `bd1`, use the command:

```
CLI (network-admin@switch) > vflow-create name bd-vflow scope
local bd bd1 in-port 10 action drop

CLI (network-admin@switch) > vflow-show name bd-vflow

switch   name      scope  type   bd   in-port  burst-size  precedence  action  enable
-------  --------  -----  -----  ---  -------  ----------  ----------  ------  ------
switch   bd-vflow  local  vflow  bd1  10       auto        default     drop    enable
```

Use the `in-port` and `from-tunnel-decap` parameters in the `vflow-create` command to filter traffic based on whether VXLAN traffic is entering a port or is decapsulated from a tunnel. For example, to configure a vFlow that copies VXLAN ingress traffic to the CPU, use the parameters `vxlan` and `in-port` in conjunction.

```
CLI (network-admin@switch) > vflow-create name vxlan-ingress-
vflow scope fabric vxlan 10100 in-port 25 action copy-to-cpu

CLI (network-admin@switch) > vflow-show name vxlan-decap-vflow
layout vertical
switch:              switch
name:                 vxlan-ingress-vflow
scope:               fabric
type:                vflow
in-port:             25
burst-size:          auto
precedence:          8
action:               copy-to-cpu
vxlan:               10100
from-tunnel-decap:
enable:              enable
table-name:           System-L1-L4-Tun-1-0
```

Similarly, to configure a vFlow that filters decapsulated VXLAN tunnel traffic, use the `vxlan` and `from-tunnel-decap` parameters together:

```
CLI (network-admin@switch) > vflow-create name vxlan-decap-
vflow scope fabric vxlan 10101 from-tunnel-decap action drop

CLI (network-admin@switch) > vflow-show name vxlan-decap-vflow
layout vertical
switch:              switch
name:                 vxlan-decap-vflow
scope:               fabric
```

```
type:               vflow
burst-size:         auto
precedence:         8
action:             drop
vxlan:              10101
from-tunnel-decap:  yes
enable:             enable
table-name:          System-L1-L4-Tun-1-0
```

Note:

- You can configure the `from-tunnel-decap` parameter only if the `vxlan` parameter is configured.
- The `from-tunnel-decap` and `in-port` parameters are mutually exclusive when used along with the `vxlan` parameter as these parameters pertain to opposite directions of traffic flow.

Displaying Connection Statistics

You can view the statistical data collected while connected to a host by using the command:

```
CLI (network-admin@switch1) > connection-stats-show
```

`connection-stats-show`	Display connection statistics while connected to a host.
`time date/time: yyyy-mm-ddThh:mm:ss`	Specify a time to start statistics collection.
`start-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the start-time for statistics collection.
`end-time date/time:` *`yyyy-mm-ddThh:mm:ss`*	Specify the end-time for statistics collection.
`duration:` *`#d#h#m#s`*	Specify the duration of statistics collection.
`interval duration:` *`#d#h#m#s`*	Specify the interval between statistics collection.
`since-start`	Displays statistics from the start of collection.
`older-than duration: #d#h#m#s`	Displays statistics older than a specified duration.
`within-last duration: #d#h#m#s`	Displays statistics within the last specified duration.
`count` *`count-number`*	Specify a count for connection statistics
`mac` *`mac-address`*	Specify the MAC address of connections
`vnet` *`vnet-name`*	Specify the vNET of connections
`vlan` *`vlan_id`*	Specify the VLAN of connections.
`ip` *`ip-address`*	Specify the IP address of connections.
`port` *`port-number`*	Specify the port number of connections.
`iconns` *`iconns-number`*	Specify the number of incoming connections.
`oconns` *`oconns-number`*	Specify the number outgoing connections.
`obytes`	Specify the number of bytes sent from the client side of the connection.
`ibytes`	Specify the number of bytes received by the client side of the connection.

`total-bytes` *`total-bytes-number`*	Specify the total number of bytes for the connection.
`first-seen date/time: yyyy-mm-ddThh:mm:ss`	Specify the time at which an entry was first seen.
`last-seen date/time: yyyy-mm-ddThh:mm:ss`	Specify the time at which an entry was last seen.
`last-seen-ago duration: #d#h#m#s`	Specify the duration since the statistics was last seen.

To clear connection statistics that was collected while connected to a host, use the command:

```
CLI (network-admin@switch1) > connection-stats-clear
```

To clear the history of connection statistics that was collected while connected to a host, use the command:

```
CLI (network-admin@switch1) > connection-stats-clear-history
```

To modify statistics collection settings, use the command `connection-stats-settings-modify`.

```
CLI (network-admin@switch1) > connection-stats-settings-modify
```

`connection-stats-settings-modify`	Modify connection statistics settings.
`enable|disable`	Enable or disable collecting connection statistics.
`connection-max-memory` *`connection-max-memory-number`*	Specify the maximum memory allowed for connection statistics.
`connection-backup-enable|connection-backup-disable`	Enable or disable backup for connection statistics collection. This option is disabled by default.
`connection-backup-interval duration:` *`#d#h#m#s`*	Specify backup interval for connection statistics collection.
`client-server-stats-max-memory` *`client-server-stats-max-memory-numbe`*	Specify maximum memory for client server statistics.
`client-server-stats-log-enable|client-server-stats-log-disable`	Enable or disable client server statistics logging. This option is disabled by default.
`client-server-stats-log-interval duration:` *`#d#h#m#s`*	Specify the client server statistics logging interval.
`client-server-stats-log-disk-space` *`disk-space-number`*	Specify the disk-space allocated for client server statistics logging.

`connection-stats-max-memory` *`connection-stats-max-memory-number`*	Specify the maximum memory allowed for connection statistics.
`connection-stats-log-enable|connection-stats-log-disable`	Enable or disable connection statistics logging. This option is disabled by default.
`connection-stats-log-interval duration: #d#h#m#s`	Specify the connection statistics logging interval.
`connection-stats-log-disk-space` *`disk-space-number`*	Specify the disk-space allocated for connection statistics logging.
`service-stat-max-memory` *`service-stat-max-memory-number`*	Specify the maximum memory allowed for service statistics.
`fabric-connection-max-memory` *`fabric-connection-max-memory-number`*	Specify the maximum memory allowed for fabric connection statistics.
`fabric-connection-backup-enable|fabric-connection-backup-disable`	Enable or disable backup for fabric connection statistics collection. This option is disabled by default.
`fabric-connection-backup-interval duration:` *`#d#h#m#s`*	Specify the backup interval for fabric connection statistics collection.

In Netvisor ONE version 6.0.1, the logging of connection statistics to disk is disabled by default. Specifically, the options below under the command `connection-stats-settings-modify` are disabled by default.

`connection-backup-enable|connection-backup-disable`

`client-server-stats-log-enable|client-server-stats-log-disable`

`fabric-connection-backup-enable|fabric-connection-backup-disable`

`connection-stats-log-enable|connection-stats-log-disable`

You can, however, enable any of the options above for a limited duration. For example:

```
CLI (network-admin@switch1) > connection-stats-settings-modify connection-stats-log-enable
```

> **Note:** Pluribus recommends disabling connection statistics to minimize disk usage during normal operations.

To view the connection statistics settings, use the command `connection-stats-settings-show`:

```
CLI (network-admin@switch1) > connection-stats-settings-show
switch:                                       switch1
enable:                                       yes
```

```
connection-max-memory:                      50M
connection-max-count:                       52012
connection-current-count:                   28482
connection-backup-enable:                   no
connection-backup-interval:                 1m
connection-backup-used-disk-space:          5.54M
client-server-stats-max-memory:             50M
client-server-stats-max-cnt:                71234
client-server-stats-cur-cnt:                132
client-server-stats-log-enable:             no
client-server-stats-log-interval:           1m
client-server-stats-log-disk-space:         50M
connection-stats-max-memory:                50M
connection-stats-max-cnt:                   82956
connection-stats-cur-cnt:                   108
connection-stats-log-enable:                yes
connection-stats-log-interval:              1m
connection-stats-log-disk-space:            50M
service-stat-max-memory:                    1M
service-stat-max-cnt:                       4681
service-stat-cur-cnt:                       0
fabric-connection-max-memory:               10M
fabric-connection-max-count:                8090
fabric-connection-current-count:            7234
fabric-connection-backup-enable:            no
fabric-connection-backup-interval:          1m
fabric-connection-backup-used-disk-space:   1.46
```

In this example, the software has enabled connection statistics logging for a duration of 1m.

Guidelines and Limitations

When you configure the vFlow policies, it is recommended to follow the guidelines and limitation mentioned in this section.

Guideline: While specifying the `burst-size` in the `vflow-create` and `vflow-modify` commands, ensure that:

- The burst-size is large enough to handle the maximum transmission unit (MTU) size of the packets.
- The `burst-size` limit should not be set lower than 10 times the MTU size of the traffic on the interface to be policed.
  If the configured `burst-size` value is less than ten times the MTU size, then Netvisor ONE takes the default burst-size value for configuration. If you configure the burst-value higher than ten times the MTU size, then the configured value is accepted.

Examples and Use Cases in vFlow

- Supporting TCP Parameters using vFlows
- Configuring Burst Size in vFlow for Maximum Bandwidth
- Configuring Bandwidth Sharing for a Single VLAN
- Enhancing the vFlow Capability to Match Forwarding Type and Packet Resolution in ASIC

Supporting TCP Parameters using vFlows

Packet Broker requires the ability to create flows based on TCP control bits in a packet. The commands, `vflow-create` and `vflow-modify` have a new option `tcp-flags`. The supported TCP control bits include FIN, SYN, RST, PUSH, ACK, and URG.

Setting the ACK bit is supported only if it is combined with other TCP bits such as SYN and FIN and not as a single parameter.

Only `to-port` and `mirror` actions are supported by vFlow with `tcp-flags` filter. The actions added for vFlows with `tcp-flags` configured are mirror-to-port.

If analytics is enabled, then `copy-to-cpu` are also applied on the same vFlow. Also, these flows are created with a precedence of 3 or above.

System vFlows are created with precedence 2 so that analytics can also work even with these vFlows.

To create a vFlow for the default system table, use the following syntax:

```
CLI (network-admin@Spine1) >  vflow-create name Redirect-TCP-Reset tcp-flags RST action to-port

CLI (network-admin@Spine1) >  vflow-create name Redirect-TCP-ECN-Capable tcp-flags ECN,RST action to-port

CLI (network-admin@Spine1) >  vflow-create name Mirror-TCP-Finished tcp-flags FIN action mirror
```

You can use the `vflow-table-show` command to display vFlow tables:

```
CLI (network-admin@Spine1) >  vflow-table-show format all layout vertical

switch:  Spine1
name:  Egress-Table-1-0
id:  a0000d7:1
flow-max:  1024
flow-used: 0
flow-tbl-slices:  1
capability: match-metadata
flow-tbl-bank: Egress
flow-profile: system
switch:  Spine1
name: Decap-Table-1-0
id: a0000d7:2
flow-max: 1024
flow-used: 0
flow-tbl-slices:  2
capability: none
flow-tbl-bank: Match-Metadata
flow-profile: vxlan
```

```
switch:  tac-f64-sw5
name:  OpenFlow-L2-L3-1-0
id:  a0000d7:3
flow-max:  1024
flow-used:  0
flow-tbl-slices:  7
capability:  none
flow-tbl-bank:  Match-Metadata
flow-profile:  openflow
```

Configuring Burst Size in vFlow for Maximum Bandwidth

The `vflow-create` and `vflow-modify` commands support a configurable burst-size parameter. This feature enables you to specify different burst-sizes for different types of metered traffic. For example, you can configure higher burst levels for a metered application that may produce bursty traffic patterns when you click on it, such as a media-rich Web page link.

This feature defaults to burst-size auto, which auto-calculates the burst size based on the maximum bandwidth settings for the vFlow. You can configure a burst-size number between 0 through 134MB.

The command syntax is:

```
CLI (network-admin@switch) > vflow-create name name-string
scope local|fabric in-port port-list bw-max bw-max-
number burst-size number
```

For example, to create a vFlow with a burst size of 12 MB, use the following syntax:

```
CLI (network-admin@switch) > vflow-create name flow1 scope
local in-port 12 bw-max 5G burst-size 12M
```

Configuring Bandwidth Sharing for a Single VLAN

In some instances, you may want to configure bandwidth sharing for a single VLAN with different IP addresses or subnets.

To do this, you must create a VRG with the required bandwidth:

```
CLI (network-admin@Leaf1) >  vrg-create name admin-vrg vlans
100 data-bw-min 1g data-bw-max 2g scope fabric
```

You have now created a VRG with the guaranteed bandwidth of 1 Gbps and limited to a maximum of 2 Gbps. Now, create a vFLow for each IP address:

```
CLI (network-admin@Leaf1) >  vflow-create name vfl-1 scope
fabric vlan 100 src-ip 1.1.1.1

CLI (network-admin@Leaf1) >  vflow-create name vfl-2 scope
fabric vlan 100 src-ip 2.2.2.2

CLI (network-admin@Leaf1) >  vflow-create name vfl-3 scope
fabric vlan 100 src-ip 3.3.3.3

CLI (network-admin@Leaf1) >  vflow-create name vfl-4 scope
fabric vlan 100 src-ip 4.4.4.4
```

In this example, the specified IP addresses each have a guaranteed bandwidth between 1 Gbps and 2 Gbps.

If you want to specify a subnet, 100.100.100.0/28, and VLAN 53 with maximum bandwidth of 50 Mbps, use the following syntax:

```
CLI (network-admin@Leaf1) >  vrg-create name vrg-custom scope
fabric data-bw-min 50M data-bw-max 50M vlan 53

CLI (network-admin@Leaf1) >  vflow-create name vfl-cust scope
fabric src-ip 100.100.100.0 src-ip-mask 255.255.255.240 vlan
53
```

However, later on, you found that sixteen IP addresses were not enough and you needed an additional 8 with the subnet, 101.101.101.8/29 that require the same bandwidth as the previous subnet. Use the following syntax:

```
CLI (network-admin@Leaf1) >  vflow-create name vfl-cust-2
scope fabric src-ip 101.101.101.8 src-ip-mask 255.255.255.248
vlan 53
```

You now have two vFlows on VLAN 53.

Then, you discover that 50 Mbps is not sufficient to support the network traffic affected by the vFlow, and you want to upgrade to 80 Mbps:

```
CLI (network-admin@Leaf1) >  vrg-modify name vrg-custom data-
```

```
bw-min 80M data-bw-max 80M
```

Enhancing the vFlow Capability to Match Forwarding Type and Packet Resolution in ASIC

On certain platforms, where the VXLAN routing is supported using recirculation of packets by leveraging the vxlan-loopback-trunk parameter, the Layer 2 entries for route RMAC address, VRRP MAC address on VXLAN VLAN, or the Virtual Forwarder Interface (VFI) are programmed to point to vxlan-loopback-trunk ports in the hardware. As a result, any Layer 2 unicast packets destined for route RMAC address or the programmed VFIs do not reach the vRouter. Netvisor ONE allows you to mitigate this problem by enabling you to create vFlow objects and specify the desired policy.

To create the vFlow object and to enable the match forwarding and packet resolution capability, use the command:

```
CLI (network-admin@switch) > vflow-create name <name-string>
scope [local|fabric] in-port <port-list> fwding-type [vlan|
vxlan|vle] packet-res [l2-unicast|l2-unknown-unicast|l2-
multicast|l2-unknown-multicast|l2-broadcast] action [none|
drop|to-port|to-cpu|trap|copy-to-cpu|copy-to-port|check|
setvlan|add-outer-vlan|set-tpid|to-port-set-vlan|tunnel-pkt|
set-tunnel-id|to-span|cpu-rx|cpu-rx-tx|set-metadata|set-dscp|
decap|set-dmac|to-next-hop-ip|set-dmac-to-port|to-ports-and-
cpu|set-vlan-pri|tcp-seq-offset|tcp-ack-offset|l3-to-cpu-
switch|set-smac|drop-cancel-trap|to-ecmp-group|redirect-to-
vrouter]
```

`name <name-string>`	Specify the name of the vFlow object.
`scope [local|fabric]`	Specify if the scope of the vFlow object is local or fabric
`in-port <port-list>`	Specify the incoming port for the vFlow object
`fwding-type [vlan|vxlan|vle]`	Specify the ASIC forwarding type
`packet-res [l2-unicast|l2-unknown-unicast|l2-multicast|l2-unknown-multicast|l2-broadcast]`	Specify the packet resolution in the ASIC
`action [none|drop|to-port|to-cpu|trap|copy-to-cpu|copy-to-port|check|setvlan|add-outer-vlan|set-tpid|to-port-set-vlan|tunnel-pkt|set-tunnel-id|to-span|cpu-rx|cpu-rx-tx|set-metadata|set-dscp|decap|set-dmac|to-next-hop-ip|set-dmac-to-port|to-ports-and-cpu|set-vlan-pri|tcp-seq-`	Specify the forwarding action to apply to the vFlow object

offset|tcp-ack-offset|l3-to-cpu-switch|set-smac|drop-cancel-trap|to-ecmp-group|redirect-to-vrouter]	

For example, to create a vFlow object: *vflow1*, scope: *local*, in-port number (port number of vxlan-loopback-trunk): *397*, with forwarding type: *vxlan*, packet resolution in ASIC as *l2-unicast* and forwarding action to be applied to the vFlow object as *redirect-to-vrouter*, use the command:

```
CLI (network-admin@switch) > vflow-create name vflow1 scope local in-port 397 fwding-type vxlan packet-res l2-unicast action  redirect-to-vrouter
```

In the above example, port **397** is the port number of the vxlan-loopback-trunk and the action **redirect-to-vrouter** redirects the packets unmodified to data port.

To view the details, use the command:

```
CLI (network-admin@switch) > vflow-show

name   scope type  in-port burst-size precedence action            packet-res fwding-type enable table-name
----   ----- ----- ------- ---------- ---------- ----------------- ---------- ---------  ------ ----------------
vflow1 local vflow  397     auto       13       redirect-to-vrouter l2-unicast  vxlan      enable System-L1-L4-Tun-1-0
```

Using Application Flows and Statistics

Displaying Statistics for vFlows for all Switches in the Fabric

To create vFlows across the entire fabric, configure the vFlow with the scope `fabric` and stats `enable` option. By using these parameters, you can enable statistics for the flow on all switches that are members of the fabric and you can display the statistics for any switch in the fabric.

For example, to create a vFlow for VLAN1 with the scope fabric, use the following command:

```
CLI (network-admin@Leaf1) >  vflow-create name
example_fabric_flow1 scope fabric log-stats enable vlan 1
```

To display the statistics for the new vFlow for a switch in the fabric, use the following syntax:

```
CLI (network-admin@Leaf1) >  switch switch-name vflow-stats-
show name example_fabric_flow1
```

```
name                    packets         bytes       cpu-packets     cpu-
bytes
----                    -------    -----
-----------  ---------
example_fabric_flow1    51.4K          13.8M       50.1K             13
```

If you omit the switch name, all vFlow statistics for the fabric are displayed.

```
   name                 packets  bytes  cpu-packets cpu-bytes
-----------------       -------  -----  ----------- ---------
example_fabric_flow1  1.32K    305K   1.29K       291K
example_fabric_flow1  910      256K   884         243K
```

Understanding vFlow Statistics

The virtual network-based flows- vflows, display statistics for packet traffic flows on a switch and across the fabric. The vFlows are very powerful and provide many features such as quality of service (QoS), traffic shaping, packet redirect, drop actions, mirror, and capture.

A vFlow can be configured to store log statistics to a file accessible to clients using NFS and SFTP. If statistics logging is enabled, Netvisor ONE periodically polls the switch for the most recent statistics for each flow and saves the statistics to an exported file. Netvisor ONE also saves individual statistics received from other switches in the fabric and combines the statistics from all switches to record aggregate statistics for the entire fabric.

The switch consists of two components, the switch and the server. vFlows with operations such as drop executes within the switch component. Some vFlows operations for QoS take place in the switch component, while others operate within the co-processor by directing pertinent traffic to the co-processor.

There, the traffic is managed and then sent back to the switch component.Other actions such as copy-to-cpu sends the match traffic to the server component where the traffic is managed and then forwards packets for delivery. In general, the details are managed by Netvisor ONE including fabric scope commands that cause all switches within a fabric to participate in an operation and then sends the compiled results to the CLI or to log files.

Before you can access the files, you must enable NFS or SFTP access to the log files by using the `admin-service-modify` command.

```
CLI (network-admin@switch-1) > vflow-share-show

 vnet                     enable                   share-path
 ----                     ------                   ----------
 fab1-global              no                       switch-1://fab1-global
 fab1-global              no                       switch-1://fab1-global
 fab1-global              no                       switch-1:///fab1-global
 fab1-global              no                       switch-1://fab1-global
 fab1-global              no                       switch-1://fab1-global


CLI (network-admin@switch) > vflow-share-modify fab1-global
enable

CLI (network-admin@switch) > vflow-share-show

 vnet                     enable                   share-path
 -----                    ------                   ----------
```

fab1-global	yes	switch-1://fab1-global
fab1-global	yes	switch-1://fab1-global
fab1-global	no	switch-1://fab1-global
fab1-global	no	switch-1://fab1-global
fab1-global	no	switch-1://fab1-global

You can then access the statistics log files using NFS in the following locations:

For the switch scope, the files are located in: `/net/switch-name//-name/flow/flow-name/switch/switch-name/stats`

For the fabric scope, the files are located in: `/net/switch-name//-name/flow/flow-name/fabric/stats`

To create a vFlow for example, Host-Agent-Discover, and measure statistics, enter the following command:

```
CLI (network-admin@switch) > vflow-create name Host-Agent-
Discover scope local system
```

To view all vFlows currently tracked by the switch or fabric, use the vflow-show command:

```
CLI (network-admin@switch) > vflow-show

switch: pleiades24
name: Host-Agent-Discover
scope:  local
type: system
dst-ip: 224.4.9.6
precedence: 2
action: copy-to-cpu
switch: pleiades24
name:  DHCP-client
scope:  local
type: system
in-port: 1-68
src-port: 68
proto: udp
precedence: 2
action: copy-to-cpu
switch: pleiades24
name:  Host-Agent-Discover
scope: local
type:  system
dst-ip: 224.4.9.6
precedence:  2
action:  copy-to-cpu
switch:  pleiades24
name:  DHCP-client
scope:  local
```

```
type:  system
in-port:  1-68
src-port:  68
proto:  udp
precedence:  2
action:  copy-to-cpu
```

From the information displayed in the output, you can review the switch, the name of the vFlow, scope, type of vFlow, destination IP address, precedence, and action for the vFlow.

To display statistics for all vFlows, use the `vflow-stats-show` command:

```
CLI (network-admin@switch) > vflow-stats-show

name                    packets      bytes   cpu-packets   cpu-bytes
---------- -------- ----- ----------- ---------
IGMP-Flow     368K              23.0M   392K                      23.0M
LLDP-Flow  82.9K    26.3M 82.9K       26.0M
Host-Agent 17.8K    1.11M 0           0
ECP                     0                     0             0
```

To monitor statistics of a vFlow and update every 10 seconds, use the following syntax:

```
CLI (network-admin@switch) > vflow-stats-show name flow1 show-
diff-interval 10
```

To log persistent records of flow statistics, use the logging parameter and collect statistics every 10 seconds:

```
CLI (network-admin@switch) > vflow-create name monitor-flow
scope local ether-type arp stats log stats-interval 5
```

You can display the statistics logs for the new flow using the `vflow-stats-show` command.

> **Note:** Conflicting vFlows - Multiple vFlows can be active at once, but cannot apply them at the same time. You can use the precedence parameter to set the order of the vFlows. If you set the precedence to a higher value (0 - 10 with 0 as the lowest precedence), the vFlow has a higher precedence than those with lower values. If you are seeing error messages about vFlow conflicts, try adding a precedence value to new or existing vFlows.

Examples and Use Cases for Network Monitoring and Security

- Using vFlows to Disable Communication for Security Monitoring
- Configuring vFlows to Filter Packets on Management Interfaces
- Configuring vFlow for Analytics

Using vFlows to Disable Communication for Security Monitoring

You can use vFlows to control the traffic by specifying the communications that are not allowed in a switch or a fabric. Use the following steps to create a vFlow as a firewall:

Define a VLAN and destination IP-based flow and specify that the flow is dropped by the switch, with statistics monitoring enabled:

```
CLI (network-admin@Leaf1) > vflow-create name vflow10 scope
local vlan 99 dst-ip 172.168.24.1 action drop stats enable
```

Display the statistics for the new flow above as the traffic is dropped:

```
CLI (network-admin@Leaf1) > vflow-stats-show name vflow10
show-diff-interval 5

switch    name     packets     bytes  cpu-packets  cpu-bytes
-------  ----     --------    -----   -----------  ---------
Leaf1    vflow10   864         116K        0            0
Leaf1    vflow10   5           936K        0            0
```

There are many options available for creating vFlows, and vFlows can be used to shape traffic, capture statistics, capture flow metadata, capture packets, or manage communications. The options include:

- vlan
- in-port
- out-port
- ether-type
- src-mac
- src-mac-mask
- dst-mac
- dst-mac-mask
- src-ip
- src-ip-mask
- dst-ip
- dst-ip-mask
- src-port
- dst-port
- dscp
- tos
- proto
- flow-class
- uplink-ports
- bw-min
- bw-max
- precedence
- action

- `action-value`
- `no-mirror`
- `mirror`
- `no-process-mirror`
- `process-mirror`
- `packet-log-max`
- `stats`
- `stats-interval`
- `duration`
- `no-transient`
- `transient`
- `vxlan`
- `vxlan-ether-type`
- `vxlan-proto`

Configuring vFlows to Filter Packets on Management Interfaces

The Pluribus Networks switches support administrative services and protocols such as SSH, HTTP, SSL, ICMP, etc. (for all supported protocols, see the show command output below). Management vflow feature enables the use of IPTables to support filtering based on filter parameters on management interfaces traffic.
The management traffic on Pluribus switches are handled in two ways:

- Out-of band management interface traffic: Uses IPTables to perform kernel based filtering
- In-band management interface traffic: Uses vflow based programming approach

In dual stack networks, both IPv4 and IPv6 filters can be used on the management port (in-band/out-of-band). By default, the management traffic allows all SSH, NFS, SNMP traffic and denies all web traffic as displayed in the command output below:

```
CLI (network-admin@spine1) > admin-service-show
```

if ----	ssh ----	nfs ----	web -----	web- ssl ------	web- ssl- port ------ ------	web- port ------ --	snmp -----	net- api ------ -	icmp -----
mgmt	on	on	off	off	443	80	on	on	on
data	on	on	off	off	443	80	on	on	on

This feature uses the existing vflow commands to add filters on the out-of-band and in-band management interfaces that are specific for these administrative services. The vflow rules uses precedence numbering to maintain the order of filters and helps in enforcing rules at specific locations in the IPTables. However, when you configure vflow rules, make sure that the vflow rules do not have a conflict with the system rules because the system rules may take precedence over the user configured vflow rules.

While configuring the vflow rules, be aware of the following configuration considerations:

- The parameter if is used to configure management vflows.
- The vflow rules support only permit and drop actions.
- The order of the configuration aligns with the order in which the rules are programmed. However, the user can re-arrange the rules using precedence.
- The vflow rules take precedence in both IPTables and TCAM are:
- By default, the vflow rules have a precedence value of four (4).

- Implicit drop priority is always lower than the user configured management vflows
- IPTables filter is added such that it precedes the existing system rule.
- The following are the applicable scaling numbers:
- For in-band traffic: the egress TCAM table limitation of 256 entries or as per hardware limits.
- For out-of-band traffic: The IPTables scale limitation is applied.

For example, create a vflow with the following parameters, use the command:

```
CLI (network-admin@Spine1) > vflow-create name <mgmt_flow> if
<mgmt|data> scope <local|fabric> src-ip <IP> src-mask <MASK>
dstip <IP> dst-mask <MASK> proto <num_or_name> src-port <src-
port-number> dst-port <dst-port-number> action <permit|drop>
precedence <num>
```

`name`	Name of the vFlow that you are creating
`if`	Specify the vflow administrative service as management or data
`scope`	Specify the scope as local or fabric
`src-ip`	Specify the source IP Address
`src-mask`	Specify the source IP address mask
`dstip`	Specify the destination IP address
`dst-mask`	Specify the destination IP mask
`proto`	Specify the name or number of the protocol
`src-port`	Specify the Layer 3 protocol source port for the vFlow
`dst-port`	Specify the Layer 3 protocol destination port for the vFlow
`action`	Specify the action, whether to drop the packet or allow/permit the flow of packe
`precedence`	Specify the traffic priority value. The default values range between 2 and 15.

To delete a vflow, use the command:

```
CLI (network-admin@spine1) > vflow-delete name <mgmt_flow>
```

To modify the vflow rule, use the command:

```
CLI (network-admin@spine1) > vflow-modify name <mgmt_flow>if
<mgmt|data> src-ip <IP> src-mask <MASK> dstip <IP> dst-mask
<MASK>
proto <num_or_name> src-port <num> dst-port <num> action
<permit|drop> precedence <num>
```

To display the configured vflow rules from the IPTables, use the command:

```
CLI (network-admin@spine1) > vflow-mgmt-show name <string>
```

The following example displays an In-band filter configured in Egress Content Aware Processing (ECAP) TCAM on two IPV4 addresses, where the vflow filters are applied to block the ssh connection from the source IP address, 10.10.10.19 whereas the ssh connection is allowed from the IP address, 10.10.10.20:

```
CLI (network-admin@spine1) > switch-local vflow-show
```

name	scope	type	in-port	src-ip	dst-port	precedence	action	enable
fdata	local	vflow	73	10.10.10.20	22	4	none	enable
fdata1	local	vflow	73	10.10.10.19	22	4	drop	enable
tcp_22	local	vflow	73		22	default	drop	enable

To display the examples for out-of-band management filters.

```
CLI (network-admin@spine1) > vflow-mgmt-show
```

name	scope	type	src-ip	dst-port	precedence	action	enable
data1	local	iptable	153.1.1.120/255.255.255.255	22	15		enable
implicitv4_drop_tcp_22_vmgmt0	local	iptable		22	15	drop	enable
mgmt_ipv4	local	iptable	2.1.1.1		default	none	enable
implicitv4_drop_icmp_vmgmt0	local	iptable		0	15	drop	enable
mgmt1_ipv6	local	iptable	2000::2/ffff:ffff:ffff:ffff::		default	none	enable
mgmt_ipv6	local	iptable	2000::1/ffff:ffff:ffff:ffff::		default	none	enable
implicitv6_drop_ipv6-icmp_vmgmt0	local	iptable		0	15	drop	enable

To display the packets and byte count from the IPTables, use the command:

```
CLI (network-admin@spine1) > vflow-mgmt-stats-show name
<string>
```

```
CLI (network-admin@spine1) > vflow-mgmt-stats-show
```

switch	name	pkts	bytes
spine1	data1	0	0
spine1	implicitv4_drop_tcp_22_vmgmt0	16	976
spine1	mgmt_ipv4	0	0
spine1	implicitv4_drop_icmp_vmgmt0	29	2.38K
spine1	mgmt1_ipv6	0	0
spine13	mgmt_ipv6	0	0
spine1	implicitv6_drop_ipv6-icmp_vmgmt0	0	0

To clear all the IPTable rules, use the command:

```
CLI (network-admin@spine1) > vflow-mgmt-stats-clear name
<string>
```

The following example displays an In-band filter configured in Egress Content Aware Processing (ECAP) TCAM on two IPV4 addresses, where the vflow filters are applied to block the ssh connection from the source IP address, 10.10.10.19 whereas the ssh connection is allowed from the IP address, 10.10.10.20:

```
CLI (network-admin@spine1) > switch-local vflow-show
```

name	scope	type	in-port	src-ip	dst-port	precedence	action	enable	if
fdata	local	vflow	73	10.10.10.20	22	4	none	enable	data
fdata1	local	vflow	73	10.10.10.19	22	4	drop	enable	data
tcp_22	local	vflow	73		22	default	drop	enable	data

Configuring vFlow for Analytics

A vFlow can be used to capture packets for analysis, and you can determine if the vFlow captures packets across the fabric or on a single switch. Packets are captured by forwarding them from the data plane of the switch to the control plane.

Snooping only works if you use the parameters, `copy-to-cpu` or `to-cpu`.

The `copy-to-cpu` parameter ensures that the data plane forwards the packets and sends a copy to the CPU. Use this parameter if you want traffic to flow through the switch.

The `to-cpu` parameter doesn't forward packets and interrupts traffic on the switch. To snoop all application flow packets of protocol type TCP, enter the following CLI commands at the prompt:

```
CLI (network-admin@Leaf1) > vflow-create name snoop_all scope
local proto tcp action copy-to-cpu
```

Then use the following command to display the output:

```
CLI (network-admin@Leaf1) > vflow-snoop

switch: pleiades24, flow: snoop_all, port: 65, size: 66, time:
20:07:15.03867188
smac: 64:0e:94:28:00:fa, dmac: 64:0e:94:2c:00:7a, etype: ip
sip: 192.168.2.51, dip: 192.168.2.31, proto: tcp
sport: 42120, dport: 33399

switch: pleiades24, flow: snoop_all, port: 65, size: 184,
time:  20:07:15.03882961
smac: 64:0e:94:28:00:fa, dmac: 64:0e:94:2c:00:7a, etype: ip
sip: 192.168.2.51, dip: 192.168.2.31, proto: tcp
sport: 42120, dport: 33399

switch: pleiades24, flow: snoop_all, port: 43, size: 66, time:
20:07:15.03893740
smac: 64:0e:94:2c:00:7a, dmac: 64:0e:94:28:00:fa, etype: ip
sip: 192.168.2.31, dip: 192.168.2.51, proto: tcp
sport: 33399, dport: 42120
```

> **Note**: Use the `vflow-snoop` command only on platforms that do not have *rear-facing NICs*.

To restrict the flows captured to TCP port 22, SSH traffic, create the following vFlow:

```
CLI (network-admin@Leaf1) > vflow-create name snoop_ssh scope
local action copy-to-cpu src-port 22 proto tcp vflow-add-
filter name snoop_ssh
```

Then use the `vflow-snoop` command to display the results:

```
switch: pleiades24, flow: snoop_ssh, port: 41, size: 230,
time: 10:56:57.05785917 src-mac: 00:15:17:ea:f8:70, dst-mac:
f4:6d:04:0e:77:60, etype: ip src-ip: 10.9.11.18, dst-ip:
10.9.10.65, proto: tcp src-port: 22, dst-port: 62356
switch: pleiades24, flow: snoop_ssh, port: 41, size: 118,
time: 10:56:57.05922560 src-mac: 00:15:17:ea:f8:70, dst-mac:
f4:6d:04:0e:77:60, etype: ip src-ip: 10.9.11.18, dst-ip:
10.9.10.65, proto: tcp src-port: 22, dst-port: 62356
```

The optional parameter `vflow-add-filter` restricts the output of the `vflow-snoop` command to the packets matching the snoop_ssh flow definition.

To capture traffic packets for a flow across the entire fabric, you create a flow with the scope of fabric:

```
CLI (network-admin@Leaf1) > vflow-create name fab_snoop_all
scope fabric action copy-to-cpu port 22
```

Support for IPv6 Addresses and vFlow Configurations

You must modify the vFlow table profile using the new command, `vflow-table-profile-modify`:

```
CLI (network-admin@Leaf1) > vflow-table-profile-modify profile
ipv6 hw-tbl switch-main
```

You must reboot the switch in order for the settings to take effect. To ensure that the profile is available after rebooting, use the `vflow-table-show` command:

```
CLI (network-admin@Leaf1) > vflow-table-show
```

name	flow-max-per-group	flow-used	flow-tbl-slices	capability	flow-profile
Egress-Table-1-0	256	0	2	match-metadata	system
Egress-Table-v6-1-0	256	0	1	none	egress-v6
IPv6-Table-1-0	1536	0	1	none	ipv6
System-L1-L4-Tun-1-0	1536	57	2	set-metadata	system
System-VCAP-table-1-0	512	1	1	none	system

Examples and Use cases for QoS

- Configuring DSCP to CoS Mapping
- Applying CoS Queue Mapping based on Re-Marked DSCP in vFlow

Configuring DSCP to CoS Mapping

Netvisor One supports creating Quality of Service (QoS) maps that configure hardware based mapping of Differentiated Services Code Point (DSCP) value in a received IP header to a Cost of Service (CoS) priority. This helps in prioritizing traffic based on DSCP markings by using the appropriate egress CoS queues to send packets out.

Netvisor One sets the DSCP value to the 6 upper bits in the 8-bit ToS field of an IP header. Details about the specific values and the proposed traffic disposition can be found in these RFCs :

- RFC 2474 (DS Fields Definitions)
- RFC 2475 (DiffServ architecture)
- RFC 2597 (AF PHB Group)
- RFC 2780 (IANA Allocation Guidelines)

A quick summary of DSCP in Netvisor One:

- DSCP values range from 0 to 63, while packet priorities map to 8 CoS values or priority queues.
- Standards (IANA) include specific values in their guidelines. These values are used by different vendors to facilitate inter-connectivity.
- Class selector code points (CS0 through CS7, multiples of 8) are backwards compatible with IP ToS values. These values also serve as base selectors for other values.
- Assured Forwarding (AF) code points have 4 priority classes, each class has three code points indicating the drop precedence.

    Class1: AF11/12/13 (DSCP 10, 12, 14)

    Class2: AF21/22/23 (DSCP 18, 20, 22)

    Class3: AF31/32/33 (DSCP 26, 28, 30)

    Class4: AF41/42/43 (DSCP 34, 36, 38

- 0 is best effort (CoS 0, default)
- 46 is an Expedited Forwarding (EF) code point, indicating critical traffic.

There are new commands to support this feature:

```
CLI (network-admin@Spine1) >  dscp-map-create
```

`dscp-map-create`	Create a DSCP priority mapping table with default DSCP to priority mappings.
`name` *`name-string`*	Create a name for the DSCP map

`CLI (network-admin@Spine1) > dscp-map-delete`

`dscp-map-delete`	Delete a DSCP priority mapping table.
`name` *`name-string`*	The name of the DSCP map to delete.

`CLI (network-admin@Spine1) > dscp-map-show`

`dscp-map-show`	Display a DSCP priority mapping table
`name` *`name-string`*	Display the name of the DSCP map.

This command displays output only if there are maps configured.

`CLI (network-admin@Spine1) > dscp-map-pri-map-modify`

`dscp-map-pri-map-modify`	Update priority mappings in tables.
`dscp-map selector:` `name` *`name-string`*	Specify the name for the DSCP map to modify.
the following pri-map arguments:	
`pri` *`number`*	Specify a CoS priority from 0 to 7.
`dsmap` *`number-list`*	Specify a DSCP value(s)as a single value, comma separated list, or a number range.

`CLI (network-admin@Spine1) > dscp-map-pri-map-show`

`dscp-map-pri-map-show`	Display priority mappings in tables.
`dscp-map selector:` `name` *`name-string`*	Display the name of the DSCP map.
the following pri-map arguments:	
`pri` *`number`*	Display a CoS priority from 0 to 7.
`dsmap` *`number-list`*	Display a DSCP value(s)a DSCP value(s)as a single value, comma separated list, or a number range.

The `dscp-map-pri-map-show` displays output only if there are maps configured.

The default values are listed in the following `dscp-map-pri-map-show` output:

`CLI (network-admin@Spine1) > dscp-map-pri-map-show name dscp-`

```
map1

switch   name pri dsmap
-------  ---- --- -----------
Spine1   ds2  0    none
Spine1   ds2  1    8,10,12,14
Spine1   ds2  2    16,18,20,22
Spine1   ds2  3    24,26,28,30
Spine1   ds2  4    32,34,36,38
Spine1   ds2  5    40
Spine1   ds2  6    48
Spine1   ds2  7    56
```

The command, `port-config-modify`, has a new parameter, `dscp-map map-name|none` to support this feature.

Using the option `none` deletes or cancels a DSCP map previously configured on the port.

Applying CoS Queue Mapping based on Re-Marked DSCP in vFlow

Currently, Netvisor ONE allows a vFlow to mark or re-mark matched packets with a DSCP value on egress. Netvisor ONE does not prioritize this traffic in terms of the egress port CoS queue selected for transmit. Another feature, *Enabling DSCP to Priority and CoS Mappings* introduces the ability to create DSCP QoS maps and apply to ports, but the maps apply to ingress packets. This feature introduces the ability prioritize traffic based on the remarked DSCP value in a vFlow

Netvisor ONE enables you to create named DSCP maps as independent objects, and applies the maps to ingress ports for prioritization of packets based on the DSCP markings. In this feature, you can apply the same maps in a vFlow. QoS maps can be applied to ports, but not to Flow Processor entries corresponding to vFlows. This implementation does the prioritization explicitly, since flows can be configured with CoSQ values.

The implementation has the following features:

- Verify the DSCP map named in the vFlow exists.
- Determine the priority and CoS for the DSCP value assigned to the vFlow.
- Apply this CoS value to the Flow Processor entry in hardware.
- Reconfigure CoS in the flow when the vFlow DSCP setting changes.
- Prevent deleting a DSCP map in use by a vFlow.
- Update the CoS setting of vFlows using the DSCP map when the DSCP map priority settings are updated.

You can specify the name of a DSCP map in the `vflow-create` command:

`dscp-map dscp-map name | none`	Specify the DSCP map to apply on the flow. Please reapply if map priorities are updated.

Configuring Network Security

This chapter provides information about the Network Security features on a Netvisor ONE switch using the Netvisor ONE command line interface.

About Port Isolation

Port Isolation prevents local switching among ports on a Netvisor ONE switch or on a pair of Netvisor ONE switches configured as a cluster. With Port Isolation, Netvisor ONE disables direct communication with hosts part of same Layer 2 domain connected to isolated ports or to mutually learn the other MAC address. Communication between these hosts occurs through a Layer 3 device. Use this feature to secure bridged east-west traffic through a firewall.

When using this feature on ports within a cluster, you must configure the port-link state association rules between the uplink ports and the downlink isolated ports.

Example Configuration

In a typical scenario, as shown in the ***Figure 13-1*** below, ports 1, 2, and 3 are configured as isolated ports so that the hosts attached to these ports cannot communicate with each other directly, but only through the upstream firewall or router that is connected to port 64.

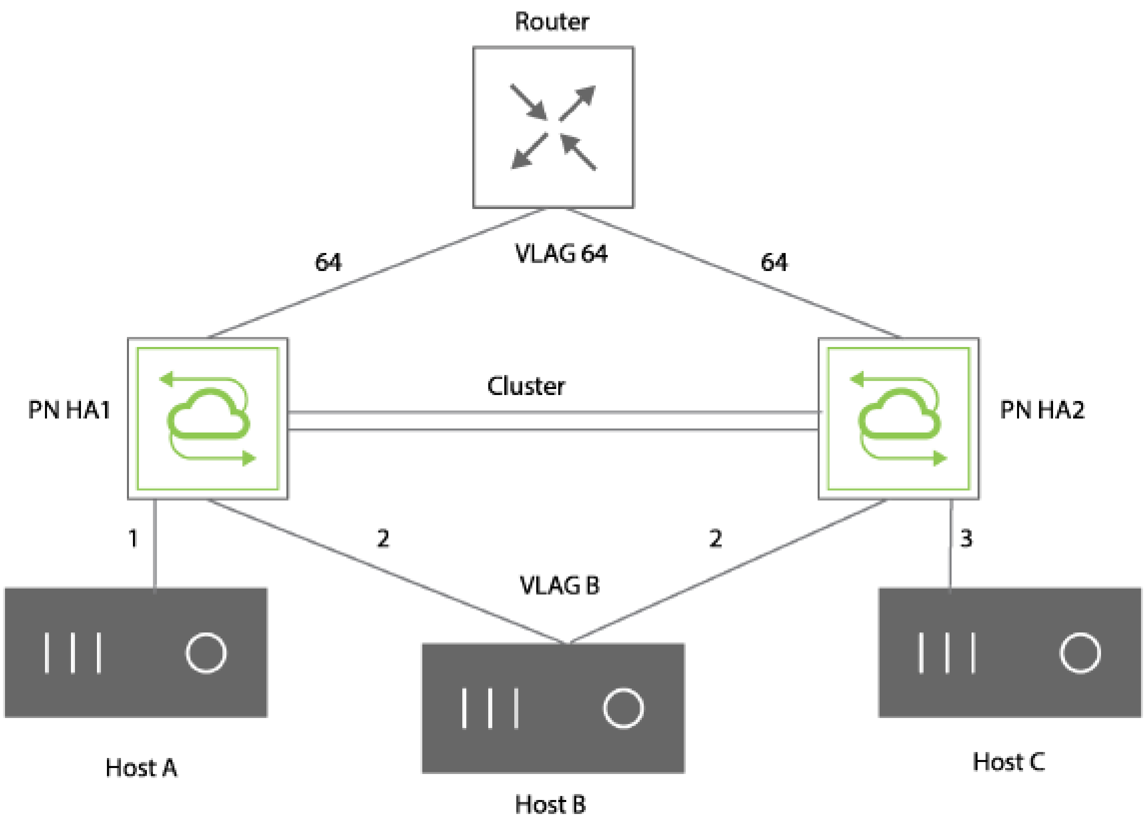


Figure 13-1 - Port Isolation Scenario

As shown in the figure, create the configuration as follows:

PN-HA1

```
CLI (network-admin@Leaf1) > port-config-modify port 1 no-
local-switching
```

```
CLI (network-admin@Leaf1) > port-config-modify port 2 no-local
switching
```

PN-HA2

```
CLI (network-admin@Leaf1) > port-config-modify port 2 no-
local-switching
```

```
CLI (network-admin@Leaf1) > port-config-modify port 3 no-
local-switching
```

Typically, you configure the upstream router or firewall to perform local proxy ARPs and/or NDP proxy and respond to all ARP requests and/or Neighbor Solicitations coming from isolated hosts.

To avoid interfering with local proxy ARPs and NDP proxy, disable ARP and ND Optimization as follows:

```
CLI (network-admin@Leaf1) > system-settings-modify no-
optimize-arps
```

```
CLI (network-admin@Leaf1) > system-settings-modify no-
optimize-nd
```

Configuring Port Isolation

To configure Port Isolation, use the following steps:

1) Configure the isolated ports. In this example, ports 1 and 2:

```
CLI (network-admin@Leaf1) > port-config-modify port 1,2 no-
local-switching
```

2) Optionally, configure the port link state association. A port association is required to match the link state of downlink isolated ports with the one of uplink ports. When all uplink ports are down, downlink isolated ports are administratively disabled until one of the uplinks becomes operational again. In this example, the port association name is PA, uplink (master), ports value is 64, and isolated downlink (slave) ports value are 1, 2.

```
CLI (network-admin@Leaf1) > port-association-create-name PA
master-ports 64 slave-ports 1,2 policy any-master
```

3) Optionally, disable ARP and ND optimization.

```
CLI (network-admin@Leaf1) > system-settings-modify no-
optimize-arps
```

```
CLI (network-admin@Leaf1) > system-settings-modify no-
optimize-nd
```

This feature uses the command `no-local-switching` for the `port-config-modify` command. To configure one or more isolated ports:

```
CLI (network-admin@Leaf1) > port-config-modify port port-list
no-local-switching
```

To view ports that are impacted by the `no-local-switching` command, use the `port-egress-show` command:

switch	port	egress	rx-only	active-active-vlags	loopback	mir-prevent-out	no-local-switching-out
1	0-72	none	none	none	none	none	none
2	0-72	none	none	none	none	none	none
3	0-72	none	none	none	none	none	none
4	0-72	none	none	none	none	none	none
5	0-4,11-72	none	none	none	none	none	5-10
6	0-4,11-72	none	none	none	none	none	5-10

7	0-4,11-72	none	none	none	none	none	5-10
8	0-4,11-72	none	none	none	none	none	5-10

The following Port Isolation options for the `trunk-create`, `trunk-modify`, and `trunk-show` commands are as follows:

```
CLI (network-admin@Leaf1) > trunk-create
```

`trunk-create`	Create a trunk configuration for link aggregation
One or more of the following options:	
`local-switching|no-local-switching`	Specify no-local-switching if you do not want the port to bridge traffic to another no-local-switching port.

```
CLI (network-admin@Leaf1) > trunk-modify
```

`trunk-modify`	Modify a trunk configuration for link aggregation
One or more of the following options:	
`reflect|noreflect`	Specify if physical port reflection is enabled or not.

```
CLI (network-admin@Leaf1) > trunk-show
```

`trunk-show`	Display trunk configuration
One or more of the following options:	
`reflect|noreflect`	Displays if physical port reflection is enabled or not.

Creating and Implementing Access Control Lists (ACLs)

Access Control Lists (ACLs) allow you to configure basic traffic filtering for IP addresses and MAC addresses. The ACL controls if routed packets are forwarded or blocked on the network. The packet is examined by the switch and then determines if the packet is forwarded or dropped based on the criteria configured in the ACLs. nvOS supports Layer 2 (MAC) or Layer 3 (IP) ACLs.

ACL criteria can be based on source or destination addresses or the protocol type. nvOS supports UDP, TCP, IGMP, and IP protocols.

You can use ACLs to restrict contents of routing updates or provide traffic flow control. ACLs can allow one host to access part of your network and prevent another host from accessing the same area. You can also use ACLs to decide what types of traffic are forwarded or blocked.

If you need more background on ACLs and using them on your network, refer to the many networking resources available.

Using and Configuring MAC ACLs

Using MAC ACLs to Deny Network Traffic

You can create ACLs based on MAC addresses to deny network traffic from a specific source. MAC addresses are Layer 2 protocols and most often assigned by the hardware manufacturer.

The ***Figure 12-2*** below shows an example of a MAC address and Ethernet type that you want to block from the network.

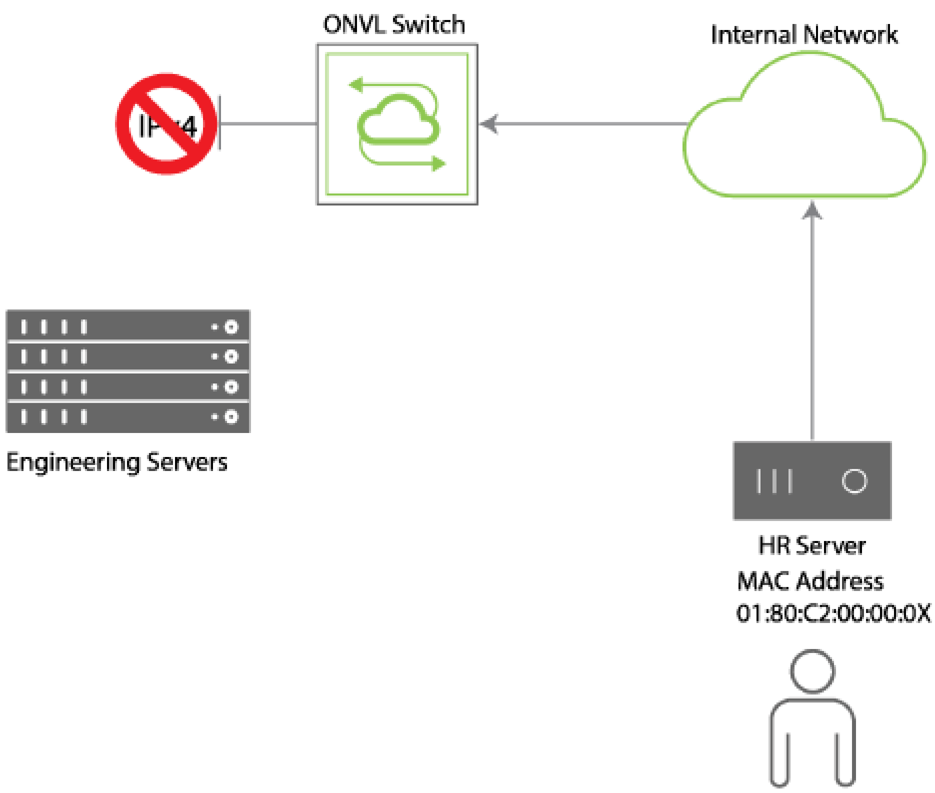


Figure 12-2 - MAC ACL Blocking Access

Configuring a MAC ACL to Deny Network Traffic

To deny IPv4 network traffic from MAC address, `01:80:c2:00:00:0X`, for the scope `fabric`, create the MAC ACL, `deny-MAC`, using the following syntax:

```
CLI (network-admin@Leaf1) > acl-mac-create name deny-mac
action deny src-mac 01:80:c2:00:00:0X ether-type ipv4
 scope fabric
```

To review the configuration, use the `acl-mac-show` command:

```
CLI (network-admin@Leaf1) >acl-mac-show name deny-mac layout
vertical

name:                          deny-mac
```

```
id:                           b000015:12
action:                       deny
src-mac:                      01:80:c2:00:00:0X
dst-mac:                      00:00:00:00:00:00
dst-mac-mask:                 aa:aa:aa:aa:aa:aa
ether-type:                   ipv4
vlan:                         0
scope:                        fabric
port:                         0
```

Using MAC ACLs to Allow Network Traffic

So now that you've blocked the MAC address, let's reverse the scenario and allow IPv4 network traffic from the MAC address to the network.

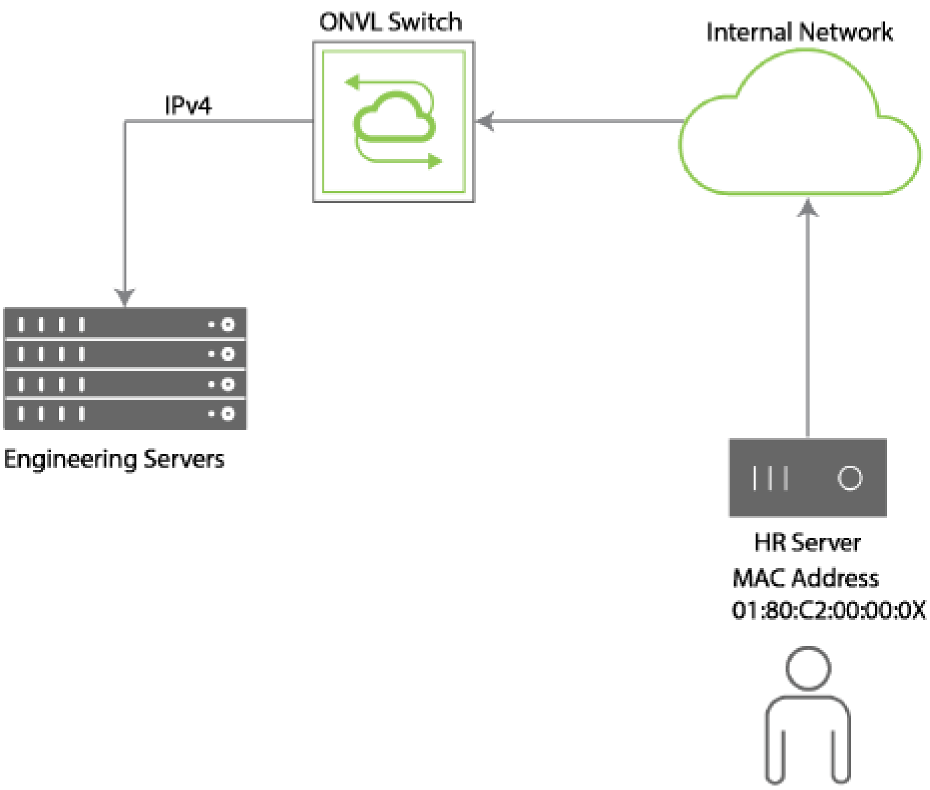


Figure 12-3 - MAC ACL Allowing Access

See Configuring a MAC ACL to Allow Network Traffic to review the example configuration.

Configuring a MAC ACL to Allow Network Traffic

To allow IPv4 network traffic from MAC address, `01:80:c2:00:00:0X`, for the scope `fabric`, create the MAC ACL, `allow-MAC`, using the following syntax:

```
CLI (network-admin@Leaf1) >  acl-mac-create name allow-mac
action permit src-mac 01:80:c2:00:00:0X ether-type ipv4 scope
fabric
```

To review the configuration, use the `acl-mac-show` command:

```
CLI (network-admin@Leaf1) >  acl-mac-show name deny-mac layout
vertical

name:                         deny-mac
id:                           b000015:12
action:                       deny
src-mac:                      01:80:c2:00:00:0X
dst-mac:                      00:00:00:00:00:00
dst-mac-mask:                 aa:aa:aa:aa:aa:aa
ether-type:                   ipv4
vlan:                         0
scope:                        fabric
port:                         0
```

To delete the ACL configuration, use the `acl-mac-delete` command.

To modify the ACL configuration, use the `acl-mac-modify` command.

Configuring a MAC ACL to Deny Network Traffic

To deny IPv4 network traffic from MAC address, `01:80:c2:00:00:0X`, for the scope `fabric`, create the MAC ACL, `deny-MAC`, using the following syntax:

```
CLI (network-admin@Leaf1) >  acl-mac-create name deny-mac
action deny src-mac 01:80:c2:00:00:0X ether-type ipv4 scope
fabric
```

To review the configuration, use the `acl-mac-show` command:

```
CLI (network-admin@Leaf1) >  acl-mac-show name deny-mac layout
vertical

name:                         deny-mac
id:                           b000015:12
action:                       deny
src-mac:                      01:80:c2:00:00:0X
dst-mac:                      00:00:00:00:00:00
dst-mac-mask:                 aa:aa:aa:aa:aa:aa
ether-type:                   ipv4
vlan:                         0
scope:                        fabric
port:                         0
```

Using and Configuring IP ACLs

Configuring IP ACLs

From ***Figure 13-4*** Network Example - IP ACL for Internal Servers, the following information is available:

- Source IP address
- Source netmask
- Destination IP address
- Destination netmask
- Type of protocol to deny - IP
- Ports
- VLAN

Using a Deny IP ACL to Block Network Traffic

In this example, a network is shown with a Finance server on one part of the network, and an Engineering server on another part.

You want to block the Engineering server from the Finance server in order to protect company sensitive information.

See Configuring an Internal Deny ACL to review the configuration sample.

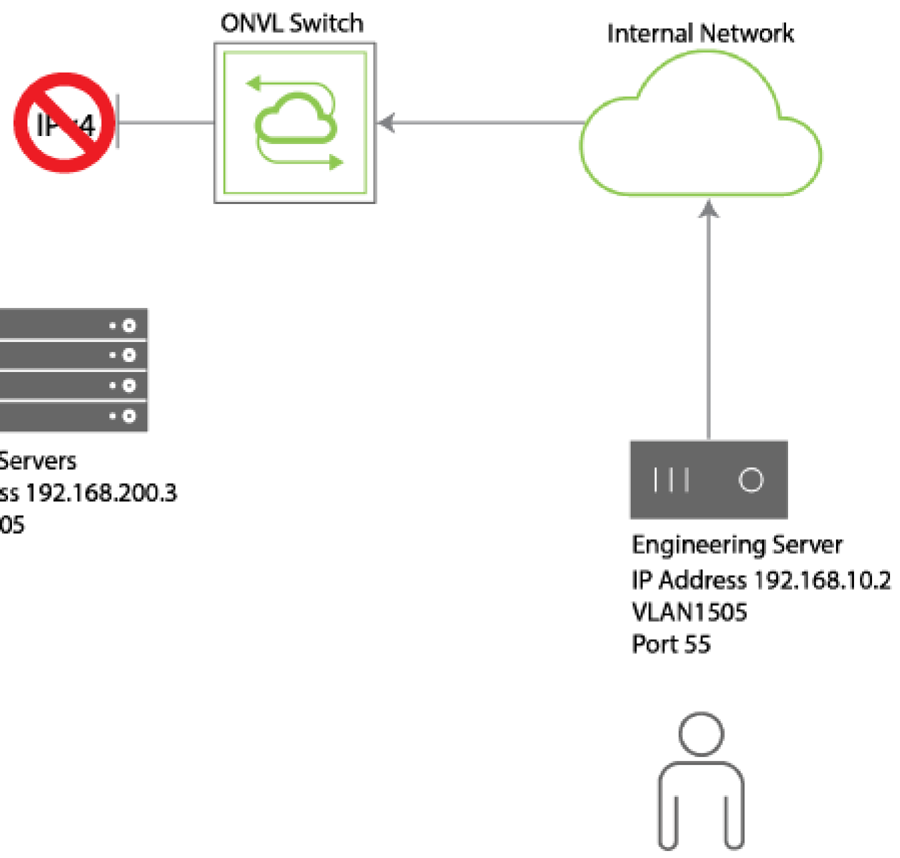


Figure 13-4 - Network Example - IP ACL for Internal Servers

Or, you may discover that an external source is attempting to access your network, and ping your servers for IP addresses.

You can use an ACL to block the specific source using an IP ACL.

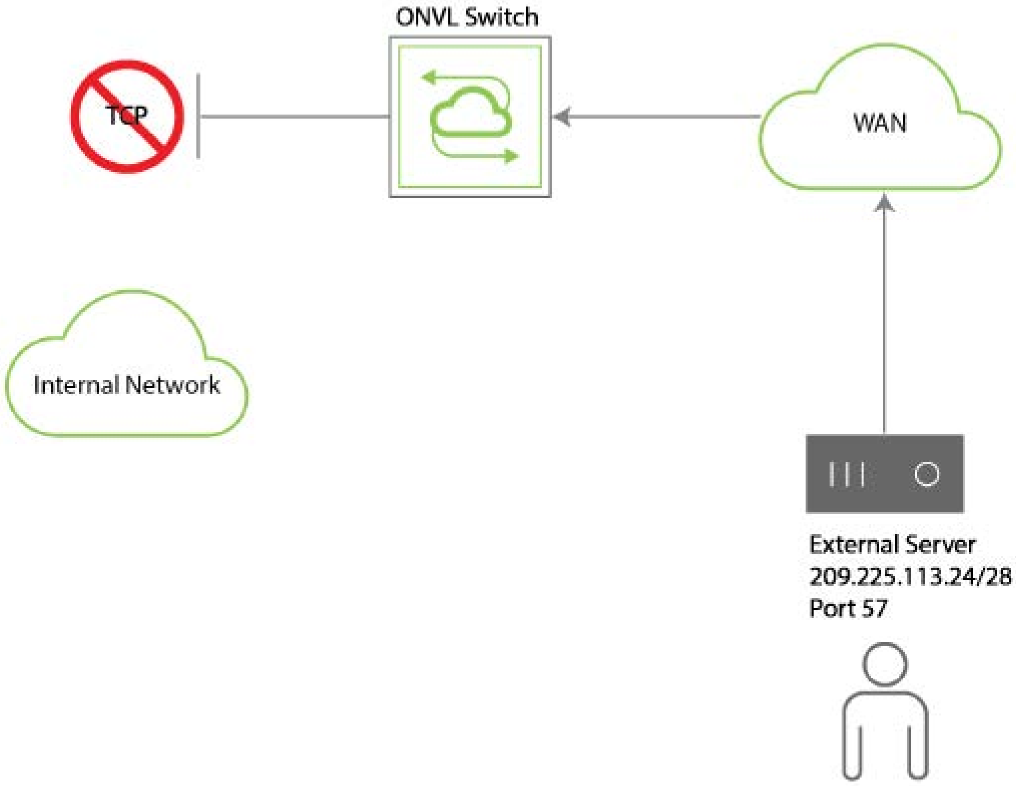


Figure 13-5 - IP ACL Blocking External Access

See Configuring an External Deny ACL to review the configuration example.

Using IP ACLs to Allow Network Traffic

In the same manner, you can allow specific traffic to a destination such as the external server as shown in Figure 2 - IP ACL Blocking External Access.

To allow HTTP traffic to 209.225.113.24, see Configuring an External Allow IP ACL to review the configuration example.

Configuring an Internal Deny ACL

Let's configure the ACL for denying traffic from the Engineering server to the Finance server and name the ACL, `deny-finance`:

```
CLI (network-admin@Leaf1) >  acl-ip-create name deny-finance
action deny scope local src-ip 192.168.10.2 src-ip-mask 24
dst-ip 192.168.200.3 dst-ip-netmask 24 proto ip src-port 55
dst-port 33 vlan 1505
```

To review the configuration, use the `acl-ip-show` command:

```
CLI (network-admin@Leaf1) >  acl-ip-show name deny-hr layout
vertical

name:                    deny-ip
id:                      b00011:20
```

```
action:                deny
proto:                 ip
src-ip:                192.168.10.2/24
src-port:              55
dst-ip:                192.168.200.3/24
dst-port:              33
vlan:                  1505
scope:                 local
port:                  0
```

Now, when you attempt to access the Finance server from the Engineering server, the packets are dropped.

Configuring an External Deny ACL

From Figure 2 IP ACL Blocking External Access, you can see the following information:

- IP Address
- Port Number

To configure an ACL to deny traffic from the external server, use the `acl-ip-create` command to create an ACL named `deny-external`:

```
CLI (network-admin@Leaf1) >  acl-ip-create name deny-external
scope fabric src-ip 209.255.113.24/28
```

To review the configuration, use the `acl-ip-show` command:

```
CLI (network-admin@Leaf1) >  acl-ip-show name deny-external
layout vertical

name:               deny-external
id:                 b000022:20
action:             deny
proto:              tcp
src-ip:             209.225.113.24/28
src-port:           0
dst-ip:             ::/0
dst-port:           0
vlan:               0
scope:              fabric
port:               0
```

Configuring an External Allow IP ACL

To allow HTTP traffic to the external server, `209.225.113.24` with a netmask of `255.255.255.240` and a scope of `fabric`, you can create an IP ACL called `allow-http` using the following syntax:

```
CLI (network-admin@Leaf1) >  acl-ip-create name allow-http
```

```
permit scope fabric src-ip 0.0.0.0. src-ip-mask
255.255.255.255 dst-ip 209.225.113.24 dst-ip-mask
255.255.255.240 protocol tcp dst-port 57
```

To review the configuration, use the `acl-ip-show` command:

```
CLI (network-admin@Leaf1) > >acl-ip-show name allow-http
layout vertical

name:                 allow-http
id:                   b000025:20
action:               allow
proto:                tcp
src-ip:               0.0.0.0/255.255.255.255
src-port:             0
dst-ip:               209.225.113.24/28
dst-port:             57
vlan:                 0
scope:                fabric
port:                 0
```

To delete the ACL configuration, use the `acl-ip-delete` command.

To modify the ACL configuration, use the `acl-ip-modify` command.

Support for DHCP Snooping

Netvisor ONE supports DHCP snooping as a security feature allowing the network to avoid denial-of-service (DoS)attacks from rogue DHCP servers. You define trusted ports to connect to the known DHCP servers. DHCP snooping also maintains a mapping table for current assignments.

In a DHCP packet flow, there are the following packet types:

- DHCPDISCOVER/DHCPREQUEST — Packets from the DHCP client to server (UDP `dest-port = 67`)
- DHCPOFFER/DHCPACK — Packets from the DHCP Server to client (UDP `dest-port = 68`)

Netvisor One must snoop the DHCP packets in order to leverage this feature, and achieves this by installing a `copy-to-cpu` vFlow with the parameter, `bw-max`, to set packet rate limits.

- DHCP-client-vflow — Packets with UDP `dest-port=67`, `copy-to-cpu`
- DHCP-server-vflow — Packets with UDP `dest-port=68`, `copy-to-cpu`

A trusted port is a port receiving the DHCP server messages from a trusted DHCP server. Any DHCP server message, such as OFFER/ACKNOWLEDGE, received from trusted ports are valid. Ports not specifically configured as trusted are untrusted ports.

Netvisor One drops any DHCP server message received from an untrusted port, and ensures that a rogue DHCP server cannot assign IP addresses to devices on your network.

Enable DHCP snooping and specify the list of trusted server ports using the following set of commands:

`CLI (network-admin@Spine1) > dhcp—filter-create name` *`name-string`* `trusted-ports` *`port-list`*

`name` *`name-string`*	Specify a name for the filter.
`trusted-ports` *`port-list`*	Specify a list of trusted ports.

`CLI (network-admin@Spine1) > dhcp-filter-modify name` *`name-string`* `trusted-ports` *`port-list`*

`name` *`name-string`*	Specify the name of the filter to modify.
`trusted-ports` *`port-list`*	Specify a list of trusted ports.

`CLI network-admin@Spine1) > dhcp-filter-delete name` *`name-`*

string

name *name-string*	Specify the name of the filter to delete.

CLI (network-admin@Spine1) > dhcp-filter-show name *name-string* trusted-ports *port-list* vlan *vlan-list*

name *name-string*	Displays the name of the filter.
trusted-ports *port-list*	Specify a list of trusted ports.
vlan *vlan-list*	Displays a list of VLANs.

In order to drop the packets from rogue DHCP servers, connected through untrusted ports, Netvisor One has a new system vFlow, DHCP-LOG-DROP.

The vFlow sends the packets to the CPU, to track the untrusted server messages, and then drop the untrusted DHCP server packets. This is set to a higher precedence than the DHCP trusted ports vFlow. The vFlow includes the untrusted port list for the ingress port.

Untrusted ports typically connect to hosts where DHCP clients can send messages, and Netvisor One ensures the DHCP messages are rate limited using `dhcp` CPU class.

All the DHCP messages use the `dhcp` CPU class. The existing command for `cpu-class-modify` is used:

CLI (network-admin@Spine1) > cpu-class-modify name dhcp rate-limit rate-limit-number

The show output for the command, `dhcp-lease-show`, has two new parameters to display trusted and rogue DHCP servers:

CLI (network-admin@Spine1) > dhcp-lease-show trusted-server|no-trusted-server

CLI (network-admin@Spine1) > dhcp-lease-show

```
  ip                          mac                       port  vnet  vlan  db-state    server  server-ip    s
port  trusted-server  last-msg
------------------- ----------------- ----    ---- ---- --------- ------ ----------
----------- ------------- --------
6053:23a7:0:0:200::  00:12:c0:80:1f:b8   9               1      unknown   10.1.1.100  65               no
             offer
```

Log messages indicate the presence of an unknown or rogue DHCP servers:

```
DHCP server message received from untrusted port=<x> server-ip=<ip-addr>
```

Support for Router Advertisement (RA) Guard

The IPv6 RA Guard feature provides support for allowing the network administrator to block or reject unwanted or rogue RA guard messages arriving at the network device platform. RAs are used by devices to announce themselves on the link. The IPv6 RA Guard feature analyzes these RAs and filters out RAs sent by unauthorized devices. In host mode, all RA and router redirect messages are not allowed on the port. The RA Guard feature compares configuration information on the Layer 2 (L2) device with the information found in the received RA frame. Once the L2 device has validated the content of the RA frame and router redirect frame against the configuration, it forwards the RA to the unicast or multicast destination. If the RA frame content is not validated, the RA is dropped.

Note: Internal ports and cluster ports are not blacklisted.

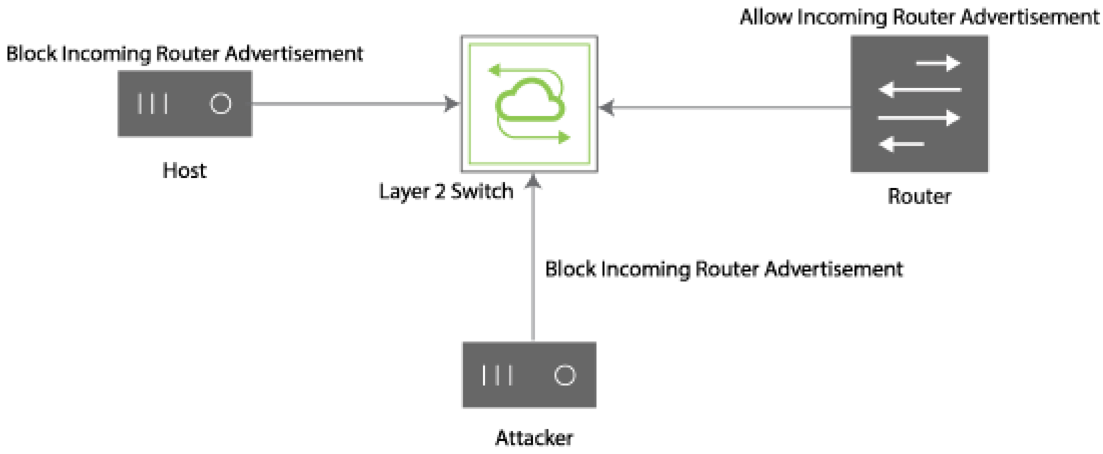


Figure 13-6 - Route Advertisement (RA) Configuration

In ***Figure 12-6***, the Layer 2 device receives a RA from the router and floods the RA on the ports. The attacker host, attempting to gain control over the network, sends a misleading RA with different prefixes, link-local or global IP addresses.The host assumes the attacker to be the router, based on priority or arrival order. When you configure RA Guard, you can disallow any RAs sent from ports connected to host ports using RA policies. The RA sent by the router, the source IP address, from the port and prefixes are whitelisted by the policies defined by the configuration.

To configure the RA Guard feature, follow these steps:

1) Create an access list using the command, `access-list-create`.
2) Create a prefix list using the command, `prefix-list-create`.
3) Create the IPv6 security profile using the command, `ipv6security-raguard-create`.

This creates two vFlows for RA Guard:

- One vFlow drops RAs sent by devices with the role `host` as assigned using the `ipv6security-raguard-create` command.
- The second vFlow sends RAs to the CPU on qualified ports or VLANs with the action, `to-cpu`, and the device role as router.

The RAs are received and examined and the necessary action is taken based on the access and prefix lists or port and VLAN policies. The RA is now accepted and flooded back to all ports.

There are new commands to support this feature:

`CLI (network-admin@Spine1) > access-list-create`

`name` *`name-string`*	Specify a name for the access list.
`scope` *`scope`*	Specify if the scope is local or fabric.

`CLI (network-admin@Spine1) > access-list-delete name` *`name-string`*

`name` *`name-string`*	Specify the name for the access list to delete.
`scope` *`scope`*	Specify if the scope is local or fabric.

```
CLI (network-admin@Spine1) >  access-list-show

switch    name  scope
-------- ---- -----
spine1    test  local
```

`CLI (network-admin@Spine1) > access-list-ip-add`

`name` *`name-string`*	Specify a name for the access list.
`ip` *`ip-address`*	Specify the IP address for the access list.

`CLI (network-admin@Spine1) > access-list-ip-delete name` *`name-string`* `ip` *`ip-address`*

`CLI (network-admin@Spine1) > access-list-ip-show`

```
switch    name  ip
--------  ----  -------
spine1    test  1.1.1.4
```

CLI (network-admin@Spine1) > prefix-list-create

name *name-string*	Specify a name for the prefix list.
scope *scope*	Specify if the scope is local or fabric.

CLI (network-admin@Spine1) > prefix-list-delete name *name-string*

CLI (network-admin@Spine1) > prefix-list-show

name *name-string*	Displays the name for the prefix list.
scope *scope*	Displays if the scope is local or fabric.

CLI (network-admin@Spine1) > prefix-list-network-add

name *name-string*	Specify the name for the prefix network list.
network *ip-address*	Specify the IP address for the network.
netmask *netmask*	Specify the netmask.

CLI (network-admin@Spine1) > prefix-list-network-delete name *name-string*

CLI (network-admin@Spine1) > prefix-list-network-show

name *name-string*	Displays the name for the prefix network list.
network *ip-address*	Displays the IP address for the network.
netmask *netmask*	Displays the netmask.

CLI (network-admin@Spine1) > ipv6security-raguard-create

`name` *`name-string`*	Specify the RA policy name.
`device host|router`	Specify the type of device as host or router.
`router-priority low|medium|high`	Specify the router priority as low, medium, or high.
`access-list` *`name-string`*	Specify the access list name.
`prefix-list` *`name-string`*	Specify the prefix list name.

CLI (network-admin@Spine1) >	ipv6security-raguard-delete
`name` *`name-string`*	Specify the RA policy name.

CLI (network-admin@Spine1) >	ipv6security-raguard-modify
`name` *`name-string`*	Specify the RA policy name.
`device host|router`	Specify the type of device as host or router.
`router-priority low|medium|high`	Specify the router priority as low, medium, or high.
`access-list` *`name-string`*	Specify the access list name.
`prefix-list` *`name-string`*	Specify the prefix list name.

CLI (network-admin@Spine1) >	ipv6security-raguard-show
`name` *`name-string`*	Displays the RA policy name.
`device host|router`	Displays the type of device as host or router.
`router-priority low|medium|high`	Displays the router priority as low, medium, or high.
`access-list` *`name-string`*	Displays the access list name.
`prefix-list` *`name-string`*	Displays the prefix list name.

`CLI (network-admin@Spine1) > ipv6security-raguard-port-add`

`name` *`name-string`*	Specify the name of the RA Guard policy to add ports.
`ports` *`port-list`*	Specify the list of ports to add to the policy.

`CLI (network-admin@Spine1) > ipv6security-raguard-port-remove`

`name` *`name-string`*	Specify the name of the RA Guard policy to remove ports.
`ports` *`port-list`*	Specify the list of ports to remove from the policy.

`CLI (network-admin@Spine1) > ipv6security-raguard-port-show`

`name` *`name-string`*	Displays the name of the RA Guard policy.
`ports` *`port-list`*	Displays the list of ports.

`CLI (network-admin@Spine1) > ipv6security-raguard-vlan-add`

`name` *`name-string`*	Specify the name of the RA Guard policy to add VLANs.
`vlans` *`vlan-id`*	Specify the VLANs to add to the policy.

`CLI (network-admin@Spine1) > ipv6security-raguard-vlan-remove`

`name` *`name-string`*	Specify the name of the RA Guard policy to remove VLANs.
`vlans` *`vlan-id`*	Specify the VLANs to remove from the policy.

`CLI (network-admin@Spine1) > ipv6security-raguard-vlan-show`

`name` *`name-string`*	Displays the name of the RA Guard policy to add VLANs.
`vlans` *`vlan-id`*	Displays the VLANs to add to the policy.

Configuring Control Plane Traffic Protection (CPTP)

About the Importance of Hardening of Network Infrastructure

The network infrastructure is often a prime target for malicious attacks because of the possibility of inflicting the most amount of damage to as many devices as possible (in the worst case scenario, to bring down the entire network and, with it, all the attached devices).

Other reasons to target the network may be to attempt to redirect (for example, through unintended flooding) and snoop traffic to learn about clear-text information and find out possible other weaknesses that can lead to further malicious actions.

Last but not least, network instability sometimes caused by mis-configurations or failures may result in an excessive amount of traffic that can put a strain on the network infrastructure and further exacerbate its stability problems.

Therefore, first and foremost, it is of foundational importance to apply robust control to the traffic that reaches the network devices and to implement appropriate protections against any potentially disruptive traffic.

In particular, this section focuses specifically on the hardware-based protection of the network *control plane*. Other complementary mechanisms, such as hardware-based security and QoS policies described in detail in other topics can be applied to the data plane too for comprehensive network hardening.

About Control Plane Traffic Protection

In any network device there exists a management entity (typically a CPU) that is in charge of communication exchanges with other networking devices as well as of interactions with a portion of the traffic coming from the rest of the network (the so-called *data plane*). In general, all the traffic that is natively directed or purposefully redirected to such management processor is commonly referred to as *control plane traffic*.

When the amount of any class or classes of traffic belonging to the control plane becomes abnormal--e.g., due to a Denial of Service (DoS) attack attempt--then the network device needs to take some containment action.

Hardware-based queuing and rate limiting are two common techniques employed to implement CPU protections, with *different* levels of granularity and control depending on the switch model's hardware capabilities.

About Port-based Control Plane Protection

Certain switch models use an internal Ethernet port to transport a portion of the control plane traffic to the management CPU. This special type of interface is referred to as a *rear-facing interface*. The list of models with a rear facing interface includes the following platforms:

- **Edgecore**: AS7712-32X, AS7312-54XS
- **Pluribus switches**: F9532C-XL-R
- **Ericsson**: NSU, NRU01, NRU02, NRU03

For this case 8 queues are available for control plane traffic segregation and rate-limiting, which Netvisor ONE leverages to protect the CPU from anomalous traffic.

By default, mission-critical control plane traffic is split across 7 weighted queues based on common network management requirements.

In addition, queue 0 is the default 'catch-all' queue that corresponds to all the control plane traffic not specifically segregated into one of the other seven queues.

Any of the eight CPU queues is configured with a default maximum transmission rate suitable to protect the control plane from overloading. If needed, the default rate values may be modified by the network administrator to match specific design requirements.

About Advanced Control Plane Protection

Pluribus Networks has implemented support for *Advanced Control Plane Traffic Protection (CPTP) with Auto-Quarantine*. This feature is supported on the CPU *inband* interface of the Freedom and Edgecore data center platforms, as well as of Dell's Open Networking Switches.

This very granular capability allows the control plane's processing path to be protected against both misbehaving and malicious devices (compromised end-points, rogue network nodes, etc.) that may start pumping an abnormal amount of control plane traffic. In Pluribus parlance, this is also referred to as *CPU hog protection*.

Advanced CPTP operates over 43 independent queues (from 0 to 42) in order to be able to provide separation and granular control over different types of control plane traffic classes. It can be enabled with the `system-settings-modify cpu-class-enable` command.

The Advanced Control Plane Traffic Protection with Auto-Quarantine is not supported on the following platforms:

- NSU
- NRU01
- NRU02
- NRU03

> Note: In Netvisor ONE releases prior to version 6.0.0, the default setting is `no-cpu-class-enable`. To change the setting to `cpu-class-enable` requires a subsequent *system reboot* for the setting to take effect. The default or the modified setting is preserved when upgrading to release 6.0.0 (or later). However, for new installations starting with release 6.0.0, the default setting becomes `cpu-class-`

`enable`.

> Note: CPTP on the inband interface performs CPU traffic classification and queuing in hardware, therefore there is no performance penalty in enabling this feature. CPTP queuing supports round-robin scheduling and rate limiting of individual CPU traffic classes, in addition to guaranteeing minimum buffer space allocation to each class.

CPU resources are protected by segregating into separate queues the following types of traffic by default: various standard network control packets, cluster communication messages, fabric updates as well as regular flooded traffic, packets required for MAC learning and copy-to-cpu packets, analytics, etc.

In addition, custom traffic classes can be added by configuring user-defined CPU policies (for example, for troubleshooting purposes).

> **Note**: Traffic flows that end up sharing a user-defined CPU queue will compete with each other for bandwidth. It is therefore recommended to configure queue-sharing only for traffic that does not constantly compete for CPU time under identical circumstances. Whenever possible, competing classes should be assigned to different queues.

About Auto-Quarantine

Advanced CPTP can be very granular with its innovative *auto-quarantine* (a.k.a. CPU hog protection) mechanism. As a user, you can enable the CPU hog protection capability (through the `cpu-class-modify` command) for the following protocols (in Pluribus' parlance also called *CPU classes*): OSPF, BGP, BFD, LACP, STP, ARP, VRRP, and LLDP.

When auto-quarantine is enabled, the Netvisor ONE software monitors control plane packets arriving at the CPU on a per-source-device basis. Traffic from a source device that is deemed to be consuming too much bandwidth (as per user-configurable `rate-limit` value) is redirected to a dedicated per-protocol `quarantine queue` by installing a hardware policy entry.

At the same time a syslog alert is displayed and the offending source device's subsequent activity is monitored. Quarantine state is left automatically only when the traffic activity returns below acceptable limits for a pre-configured `timeout` time; then a corresponding syslog is displayed. You can view messages using the `log-event-show event-type system` command.

Only certain system-defined protocol queues support hog protection. For these CPU classes the user can choose to enable the CPU hog protection capability, or to select the `enable-and-drop` option. In the latter case, all traffic from the quarantined source with the assigned protocol is dropped during ingress.

Since hardware resources are limited, it is also possible to specify a threshold for the maximum number of acceptable CPU hog violators per port. When reached, such threshold causes that class's auto-quarantine hardware policy to become per switch-port (i.e., less granular) instead of being per-port per-offender.

Configuring Port-based Control Plane Traffic Protection

Certain switch models make use of an internal *rear-facing interface* for CPU communication in addition to a special `control-port`. Other models use the `control-port` only.

For all these cases, by default 8 queues are available for control plane traffic segregation and rate-limiting on a per internal port basis. The corresponding eight default packet rates (pps) can be displayed with the following command:

```
CLI (network-admin@switch) > port-cos-rate-setting-show
layout-vertical

switch:             switch
port:               control-port
ports:              0
cos0-rate(pps):     5000
cos1-rate(pps):     5000
cos2-rate(pps):     5000
cos3-rate(pps):     5000
cos4-rate(pps):     5000
cos5-rate(pps):     5000
cos6-rate(pps):     5000
cos7-rate(pps):     5000
```

Internal (rear facing) data and span ports can be present in a system to carry control plane traffic to the CPU, each using 8 separate queues and rates, as shown below in condensed form:

```
CLI (network-admin@switch) > port-cos-rate-setting-show

port         ports cos0-rate(pps) cos1-rate(pps) cos2-rate(pps) ... cos6-rate(pps) cos7-
rate(pps)
------------ ----- -------------- -------------- -------------- ... --------------
--------------
control-port 0     100000         100000         100000         ... 100000         100000

data-port    117   100000         100000         100000         ... 100000         100000

span-ports   118   100000         100000         100000         ... 100000         100000
```

It is possible to modify the `default` rate settings in packets per second using the `port-cos-rate-setting-modify` command:

```
CLI (network-admin@switch) > port-cos-rate-setting-modify ?
```

`port-cos-rate-settings-modify`	Update the port cos rate limit
`port control-port|data-port|span-ports`	port
Specify at least one of the following options	

`cos0-rate unlimited|0..10000000`	cos0 rate limit (pps)
`cos1-rate unlimited|0..10000000`	cos1 rate limit (pps)
`cos2-rate unlimited|0..10000000`	cos2 rate limit (pps)
`cos3-rate unlimited|0..10000000`	cos3 rate limit (pps)
`cos4-rate unlimited|0..10000000`	cos4 rate limit (pps)
`cos5-rate unlimited|0..10000000`	cos5 rate limit (pps)
`cos6-rate unlimited|0..10000000`	cos6 rate limit (pps)
`cos7-rate unlimited|0..10000000`	cos7 rate limit (pps)

For example, the Class 0 rate for control traffic can be configured using the following command:

```
CLI (network-admin@switch) > port-cos-rate-setting-modify port
control-port cos0-rate <rate>
```

In addition, to show the per-queue *traffic* statistics you can issue the following command:

```
CLI (network-admin@switch) > port-cos-stats-show port 0 layout
vertical

switch:        switch
time:               11:59:15
port:             0
cos0-out:       58.8M
cos0-drops:    180M
cos1-out:       58.8M
cos1-drops:    185M
cos2-out:       0
cos2-drops:    0
cos3-out:       0
cos3-drops:    0
cos4-out:       0
cos4-drops:    0
cos5-out:       0
cos5-drops:    0
cos6-out:       65.5M
cos6-drops:    1.06G
cos7-out:       483K
cos7-drops:    493M
```

To clear the queue statistics on the internal ports, use the `port-cos-stats-clear` command.

Configuring Advanced Control Plane Traffic Protection

To configure this feature, you must first enable it using the `system-settings-modify` command. The command syntax is:

```
CLI (network-admin@switch) > system-settings-modify cpu-class-
enable|no-cpu-class-enable
```

After you enable Advanced Control Plane Traffic Protection (with the `cpu-class-enable` option), Netvisor ONE prompts you to restart the switch.

> **Note**: The alternative 8-queue mode described in the previous section is applied to the main control plane communication channel when `system-settings-modify` is set to `no-cpu-class-enable`.

To show the pre-configured Advanced Control Plane Traffic Protection classes, you can use the `cpu-class-show` command:

```
CLI (network-admin@switch) > cpu-class-show format all count-
output
```

```
name                  scope  rate-limit  hog-protect  hog-protect-support  buffer-pool-ratio
queue
------------------  -----  ----------  -----------  -------------------  -----------------
-----
class0              local  3000       disable     none                3                  0

dmac-miss           local  1000       disable     none                3                  1

smac-miss           local  1000       disable     none                3                  2

l3-miss             local  1000       disable     none                3                  3

l2mc-miss           local  3000       disable     none                3                  4

ttl1                local  1000       disable     none                3                  5

stp                 local  1000       disable     supported           3                  6

lacp                local  1000       disable     supported           3                  7

system-d            local  1000       disable     none                3                  8

igmp                local  1000       disable     supported           3                  9

bcast               local  1000       disable     none                3                  10

icmpv6              local  1000       disable     supported           3                  11

tcp-analytics       local  1000       disable     none                3                  12

kpalv               local  1000       disable     none                3                  13

ecp                 local  1000       disable     none                3                  14

arp                 local  3000       disable     supported           3                  15

lldp                local  1000       disable     supported           3                  16
```

```
dhcp               local 1000      disable     none             3                  17

pim                local 1000      disable     supported        3                  18

local-subnet       local 1000      disable     supported        3                  19

bgp                local 1000      disable     supported        3                  20

ospf               local 1000      disable     supported        3                  21

bfd                local 1000      disable     supported        3                  22

vrrp               local 1000      disable     supported        3                  23

control            local 3000      disable     none             3                  24

dhcp-log-drop      local 1000      disable     none             3                  25

http-rest          local 3000      disable     none             3                  26

vport-messages     local 1000      disable     supported        3                  27

hog-arp            local 100       disable     none             1                  28

hog-ospf           local 100       disable     none             1                  29

hog-bgp            local 100       disable     none             1                  30

hog-bfd            local 100       disable     none             1                  31

hog-lacp           local 100       disable     none             1                  32

hog-stp            local 100       disable     none             1                  33

hog-vrrp           local 100       disable     none             1                  34

hog-lldp           local 100       disable     none             1                  35

hog-local-subnet   local 100       disable     none             1                  36

hog-igmp           local 100       disable     none             1                  37

hog-pim            local 100       disable     none             1                  38

hog-icmpv6         local 100       disable     none             1                  39

hog-vport-messages local 100       disable     none             1                  40
Count:  41
```

This command shows the different categories of control plane traffic that get protected by this feature (for example, `smac-miss` and `dmac-miss` for MAC address learning as part of the vPort database entry creation; or `stp`, `lacp`, and `lldp` for the Layer 2 protocol classes, etc.). It also shows the respective default `rate-limit` values (in packets per second), the queue numbers (0-42, where some queue numbers are *unused by default*) and also whether or not each class supports *auto-quarantine* (`hog-protect-support`).
Auto-quarantine queues are labeled with a special name *hog-<class name>*, such as: `hog-arp, hog-ospf, hog-bgp, hog-bfd, hog-lacp, hog-stp, hog-vrrp, hog-lldp, hog-local-subnet, hog-igmp, hog-pim, hog-icmpv6`.

> **Note**: Starting with Netvisor ONE version 6.0.0, on certain platforms only (due to hardware dependencies) the `l2mc-miss` class is available to control the rate of

incoming unknown multicast packets when Multicast Fabric VRFs are used. Supported platforms are the Dell S4100 and S5200 Series.

Note: Starting from Netvisor ONE release 5.1.0 two new queues, one for CPU-bound REST API traffic (TCP port 80 and 443) and another for vPort database-related messages (UDP port 23398), are added with the names: `http-rest` and `vport-messages`. The default `rate-limit` values are set to 3000 pps and 1000 pps respectively. An auto-quarantine queue is added for the latter: `hog-vport-messages`.

Furthermore, starting from Netvisor ONE release 5.1.0 the default `rate-limit` values for `arp` and `control` have been conservatively lowered to 3000. When upgrading to this release, existing user configuration changes will be honored; however, in the absence of user modified values, the old default values will be replaced with the new more conservative ones.

Note: The total number of CPU classes available for CPTP is limited by the hardware. In case of conflict, system-created CPU classes are prioritized over user-defined ones at bootup. Given that, if all available classes are used up, some user-defined classes will not persist across an upgrade if more system classes are added in the new release. In such cases, users should account for any (potential) CPTP system class differences between releases while planning an upgrade.

Settings of pre-configured system classes (except the catch-all class 0) can be modified with the following command:

```
CLI (network-admin@switch) > cpu-class-modify
```

`cpu-class-modify`	Modify a CPU class.
`name` *`name-string`*	Specify the name of the CPU class.
Specify one of more of the following options	
`rate-limit rate-limit-number`	Specify the cap for the rate limit.
`hog-protect disable|enable|enable-and-drop`	Specify if you want to enable, enable and drop packets, or disable hog protection.

Note: Starting from Netvisor ONE release 5.1.0 the default cos0-rate value is set to 3000 pps automatically when Advanced CPTP is enabled.

Starting with Netvisor ONE release 5.1.1, the `class0` rate can be configured by using the following command:

```
CLI (network-admin@switch) > cpu-class-modify name class0
rate-limit <rate>
```

Configuring User-Defined Traffic Classes

These commands are available to configure custom CPU classes that are added to the default list (shown in previous section) in order to address special user requirements:

To add a CPU class, use the command:

```
CLI (network-admin@switch) > cpu-class-create
```

`name`	Specify a name for the CPU class.
`scope local|fabric`	Specify the scope as local or fabric.
`rate-limit rate-limit-number`	Specify the cap for the rate limit.
`hog-protect disable|enable|enable-and-drop`	Specify if you want to enable, enable and drop packets, or disable hog protection.

The `cpu-class-create` command can be used to allocate new CPU traffic queues for special cases that are identified by user-configurable policies.

For instance, when the culprit of a high CPU utilization issue is being investigated in connection with an errant traffic flow (e.g., FTP), the Pluribus TAC team may recommend configuring a user-defined traffic class with an associated policy to protect the CPU.

In this example a new class `TAC-class` is created and associated to a rate of 100 pps and automatically allocated to free queue 40:

```
CLI (network-admin@switch) > cpu-class-create name TAC-class
scope local rate-limit 100

CLI (network-admin@switch) > cpu-class-show name TAC-class

name       scope  rate-limit  hog-protect  hog-protect-support  queue
-------    -----  ----------  -----------  -------------------  -----
TAC-class  local  100         disable      none                 40
```

TAC also requests to create/modify a vFlow policy to direct FTP packets to the new CPU class (`TAC-class`) queue. vFlow match criteria can be freely chosen to match the specific rate limiting need of the user provided they include a `to-cpu` or `copy-to-cpu` action for packets:

```
CLI (network-admin@switch) > vflow-create name myflow scope
local in-port 10 proto ftp action to-cpu cpu-class TAC-class

CLI (network-admin@switch) > vflow-show

name   scope type  in-port burst-size precedence action enable cpu-class
------ ----- ----- ------- ---------- ---------- ------ ------ ---------
myflow local vflow  10      auto       default   to-cpu enable TAC-class
```

Note: CPTP's vFlow match criteria can be freely chosen to match the specific rate limiting need of the user provided they include a `to-cpu` or `copy-to-cpu action` for packets.

After issue resolution, the user can delete a previously created custom CPU class if no longer needed:

```
CLI (network-admin@switch) > cpu-class-delete
```

`name`	Specify the name of the CPU class to delete.

Or you can modify the CPU class after creating it:

```
CLI (network-admin@switch) > cpu-class-modify
```

`name`	Specify the name of the CPU class.
`rate-limit rate-limit-number`	Specify the cap for the rate limit.
`hog-protect disable|enable|enable-and-drop`	Specify if you want to enable, enable and drop packets, or disable hog protection.

Informational Note: You cannot modify the scope of the CPU class. If you want to change the scope, you must delete the existing CPU class and create a new CPU class with the correct scope.

Configuring Other Advanced CPTP Settings

Various additional settings are available to tweak the behavior of Control Plane Traffic Protection to one's needs (e.g., the threshold for the maximum number of acceptable CPU hog violators per port).

It is possible to show the values of the settings with the following command:

```
CLI (network-admin@switch) > cpu-class-settings-show

switch:                         switch
hog-checker-interval(ms):      100
hog-max-violators-per-port:   50
hog-warning-threshold:         5
hog-violator-timeout(s):       20
```

In this example, the timeout for a violator (which is no longer misbehaving) to be removed from quarantine is 20 seconds. The maximum number of violators per port is set to 50.
These settings can be modified with the following command:

```
CLI (network-admin@switch) > cpu-class-settings-modify
```

hog-checker-interval *hog-checker-interval-number* (ms)	Specify the hog checking interval in milliseconds.
hog-max-violators-per-port *hog-max-violators-per-port-number*	Specify the maximum number of hog violators per port.
hog-warning-threshold *hog-warning-threshold-number*	Specify the number of warnings at which host becomes hog violator.
hog-violator-timeout *hog-violator-timeout-number* (s)	Specify the timeout before restoring the hog violator to normal queue after an idle state.

Showing and Clearing CPTP Statistics

You can view the CPTP statistics, including class 0s by using the following command:

```
CLI (network-admin@switch) > cpu-class-stats-show
```

`name`	Specify the name of the CPU class to clear statistics.
`cos` *`cos-number`*	Specify the CoS value for the CPU class.

Or to clear them:

```
CLI (network-admin@switch) > cpu-class-stats-clear
```

`name`	Specify the name of the CPU class to clear statistics.
`cos` *`cos-number`*	Clear the CoS value for the CPU class.
`hw-out-pkts` *`hw-out-pkts-number`*	Clear the hardware transmitted packet count.
`hw-drop-pkts` *`hw-drop-pkts-number`*	Clear the number of hardware dropped packets.
`sw-pkts` *`sw-pkts-number`*	Clear the number of packets processed in software.
`sw-drops-pkts` *`sw-drops-pkts-number`*	Clear the number of packets dropped in software because the queue is full.
`hog-violations` *`hog-violations-number`*	Clear the number of hog protection host violations and moved to separate queue.
`hog-warnings` *`hog-warnings-number`*	Clear the number of hog protection delegated bandwidth warnings.
`hog-hosts-in` *`hog-hosts-in-number`*	Clear the number of added hosts for hog protection.
`hog-hosts-out` *`hog-hosts-out-number`*	Clear the number of hosts removed from hog protection.
`hog-max-hosts-drops` *`hog-max-hosts-drops-number`*	Clear the number of dropped hosts with hog protection because the maximum number of hosts is reached.

A handy command to periodically check the CPU traffic statistics is the following:

```
CLI (network-admin@switch) > cpu-class-stats-show show-diff-interval 1
```

which refreshes the statistics every second on screen, and thus can be used to observe traffic spikes.

In case of an auto-quarantined traffic source, the violator's information and related statistics can be displayed with the following commands:

`CLI (network-admin@switch) > hog-violator-show`

`mac` *`mac-address`*	Displays the hog violator MAC address.
`vlan` *`vlan-id`*	Displays the hog violator VLAN ID.
`vxlan` *`vxlan-id`*	Displays the hog violator VXLAN ID.
`port` *`port-number`*	Displays the hog violator ingress port.
`cpu-class` *`cpu-class-string`*	Displays the hog violator original class.
`hog-cpu-class` *`hog-cpu-class-string`*	Displays the hog violator hog queue CPU class.
`created date/time:` *`yyyy-mm-ddTHH:mm:ss`*	Displays the time and date when hog violator is created.
`vflow` *`vflow-string`*	Displays the redirect vFlow.
`vflow2` *`vflow-string`*	Displays the redirect vFlow 2.
`vflow3` *`vflow-string`*	Displays the redirect vFlow 3.

`CLI (network-admin@switch) > hog-violator-stats-show`

`time date/time:` *`yyyy-mm-ddTHH:mm:ss`*	Displays the time and date to start statistics collection.
`start-time date/time:` *`yyyy-mm-ddTHH:mm:ss`*	Displays the start time of the statistics collection.
`end-time date/time:` *`yyyy-mm-ddTHH:mm:ss`*	Displays the end time of the statistics collection.
`duration duration:` *`#d#h#m#s`*	Displays the duration of statistics collection.
`interval duration:` *`#d#h#m#s`*	Displays the interval between statistics collection.
`since-start`	Displays the statistics collection since the start time.
`older-than duration:` *`#d#h#m#s`*	Displays the statistics collection older than the time.
`within-last duration:` *`#d#h#m#s`*	Displays the statistics collection within a specified time period.

`name` *`vflow-name`*	Displays the name of the vFlow.
`vnet` *`vnet-name`*	Displays the VNET name of the vFlow.
`id`	Displays the ID assigned to the vFlow.

Configuring and Using Network Telemetry

This chapter provides information about configuring and using the Network Telemetry (Analytics) on a Netvisor ONE switch.

About sFlow

As businesses rely on network services for mission critical applications, small changes in network usage can impact network performance and reliability. These changes can impact a business' ability to conduct important business functions, which can increase the cost of maintaining network services.

sFlow is a technology for monitoring traffic in data networks as defined by the Internet Engineering Task Force (IETF) in RFC 3176 and later superseded by version 5 in sflow_version_5.

The sFlow monitoring system consists of an sFlow Agent, embedded in a switch or a router, and a central sFlow Collector. The architecture and sampling techniques used in the sFlow monitoring system allows continuous monitoring of high speed traffic in data networks.

The sFlow system provides the data required to effectively control and manage network usage and supports application-level traffic flows at wire-speed on all physical interfaces. You can use this information for troubleshooting a network, performing diagnostics, and analyzing the data. This capability ensures that network services provide a competitive edge to the businesses.

In Netvisor ONE, the sFlow monitoring system has two main components: the sFlow Collector and sFlow Agent. As displayed in ***Figure 14-1***, the sFlow Agent runs on Pluribus switches, samples the packets, and sends the packets to the sFlow Collector for further processing.

sFlow Collector: An sFlow Collector is a network device that receives sFlow packets from one or more sFlow Agents.

sFlow Agent: The sFlow Agent is a thread that runs on Pluribus switches and receives the sFlow packets from the hardware, modifies by adding the header and sends the packets to the sFlow Collector.

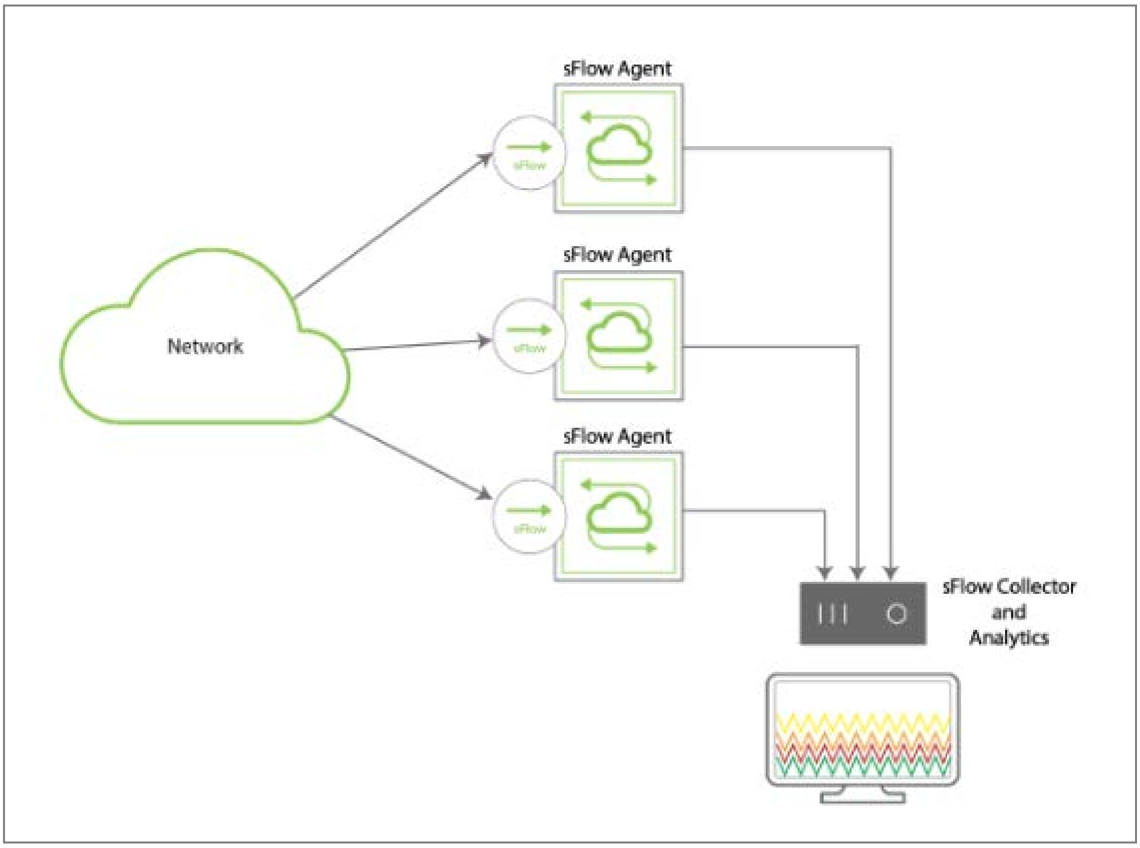


Figure 14-1 - Sample Topology of sFlow Monitoring System

Packet Flow Sampling: Packet Flow Sampling refers to the statistical selection of a fraction of the Packet Flows observed at a Data Source. If the sFlow Agent is configured on Pluribus switches, then, Netvisor ONE performs two sampling mechanisms:

- Sample Rate mechanism - the packets are first sampled by the hardware and is passed onto the software where the sFlow thread adds sample header and sends the same to the Collector. You can configure the number of packets to sample from the total packets using the CLI option, `sample-rate`.
- Counter Polling mechanism - you can configure a timer using the CLI option, `counter-polling-interval`. On expiry of the timer, Netvisor ONE collects the statistics from the hardware and construct a sample with sFlow header and then sends the same to the Collector via the UDP socket.

You can sample different types of packets such as:

- Frames sent to the CPU or interfaces of the switch
- IP Options and MTU violations
- Flooded packets
- Multicast packets

However, the following packet types are not sampled by sFlow:

- LACP frames
- PAUSE frames
- PIM hello packets
- CRC error frames
- Packets dropped by ACLs or due to VLAN violations

The Pluribus switches support sFlow at port level and the sFlow monitoring system supports two types of samplers: (i) Ingress sFlow sampler and (ii) Egress sFlow sampler. You can either configure one of the sampler types on a port or both the sampler types on the Pluribus switches to enable sampling of IN and OUT packets simultaneously.

If the configured sFlow Collector is unreachable due to any connectivity issue, then the sFlow Agent retries to send the packets every 60 seconds. During this time , the packets are recorded as sFlow drop packets. The sFlow packets could get dropped (not sent to sFlow Collector) when:

- the sFlow port is invalid
- the sFlow Agent fails to match the sample port
- there is a network connectivity issue
- the sFlow packets are malformed or are IPv6 packets
- there are malformed VLAN packets or oversized packets
- there are internal Queue drops

To enable sFlow on your switch, you must configure the following (described in subsequent sections):

- *Configuring the sFlow Collector*
- Add Exporter license (see the sFlow sections in the Pluribus *Installation and User Guide* for details on adding the license)
- *Configuring sFlow Agents on the Network*

Guidelines to Remember While Configuring sFlow

There are some guidelines to consider while configuring the sFlow monitoring feature:

- The sFlow monitoring system is a local scoped feature.
- You can configure the sFlow sample rate between the range 256-16000, by default the sample rate is set to 4096. To disable the sFlow sampling, configure the sample rate to zero (0) .
- The sFlow Agent ID is typically a switch management IP address and indicates the originator or sample frames provider.
- The sFlow monitoring system supports only IPv4 sampling.
- The sFlow sample type can be either `raw` or `cooked` mode, and the default mode is `raw`.
- By default, the `counter-polling-interval` is 2 seconds and the available range is 1-120 seconds. However, to disable the counter sampling, you can set the interval to zero (0).
- The CLI parameter, `sample-pkt-cnt` is the actual sampled packets from the sFlow Agent.
- The sFlow Collector configuration requires the Collector IP address and Collector port list.
- The sFlow Collector configuration can be `local` or `fabric` scoped feature.
- You can configure multiple collector configurations, however, the first or the latest available Collector is selected for sending the sampled packets.
- The egress sflow samples do not make modification to the packets in the egress pipeline(for example, VLAN translation, VXLAN header encap).

Configuring the sFlow Collector

You must configure sFlow Collector before configuring the sFlow Agents. The sFlow Collector receives sFlow Datagrams or packets from the sFlow Agents.

To configure a sFlow Collector, use the command:

```
CLI (network-admin@switch) > sflow-collector-create collector-ip ip-address collector-port collector-port-number name name-string scope local|fabric
```

`collector-ip` *`ip-address`*	Specify the IP address of the sFlow Collector.
`collector-port` *`collector-port-number`*	Specify the port number assigned to the sFlow Collector.
`name` *`name-string`*	Specify a name for the sFlow.
`scope local|fabric`	Specify if the scope is local or fabric. **Note**: If the scope is fabric, then the new switches that join the fabric receive the sFlow Collector configuration. If the scope is local, then the sFlow Collector is configured only on the local switch.

Below is an example configuration of an sFlow Collector with IP address 10.10.10.12, on port 2055. The Collector name is *sf_test*, and the scope is *fabric*.

```
CLI (network-admin@switch) > sflow-collector-create collector-ip 10.10.10.12 collector-port 2055 name sf_test scope fabric
```

> **Note**: You can add as many Collectors as needed while configuring the sFlow monitoring system in a datacenter.

To delete an already configured sFlow Collector, use the command:

```
CLI (network-admin@switch) > sflow-collector-delete name name-string
```

> **Note**: While deleting the sFlow Collectors, note that the last available Collector cannot be deleted if an sFlow is still configured and available. That is, if you want to delete all sFlow Collectors, you must first delete all the sFlows before deleting the last available Collector.

To modify an already created sFlow Collector, use the command:

CLI (network-admin@switch) > sflow-collector-modify name *name-string*

name *name-string*	Specify the name of the sFlow you want to modify.
Specify one or more of the following options:	
collector-ip *ip-address*	Specify the change in IP address for the sFlow Collector.
collector-port *collector-port-number*	Specify the change in port number for the sFlow Collector.

Note: You cannot modify the *scope* parameter once the sFlow Collector is configured.

To view the details of existing sFlow collectors, use the `sflow-collector-show` command specifying one or more of the following options:

CLI (network-admin@switch) > sflow-collector-show

Specify one of more of the following options:	
collector-ip *ip-address*	Specify to display the details of the sFlow Collector.
collector-port *collector-port-number*	Specify to display the details.
name *name-string*	Specify to display the details of the specified sFlow.
scope local|fabric	Specify to display the details of either the local scoped or fabric scoped sFlow Collectors.

For example, to view the details of a previously configured sFlow collector, use the command:

CLI (network-admin@switch) > sflow-collector-show

```
collector-ip collector-port name          scope
------------ -------------- ----------    ------
10.10.10.12      2055       sf_test       fabric
10.13.26.75      6343       sflow_collect local
```

Configuring sFlow Agents on the Network

You must first configure the sFlow Collector before configuring the sFlow Agent using the `sflow-create` command. You must configure and enable sFlow Agent on each switch that you want to be part of the sFlow monitoring system to monitor the network traffic.

To configure or enable sFlow Agent on a switch, use the command:

```
CLI (network-admin@switch) >  sflow-create name name-string
```

`name` *`name-string`*	Specify a name for the sFlow.
`type  ingress|egress`	Specify whether the sFlow type is for ingress or egress traffic.
`sample-type  raw|cooked`	Specify the sFlow sample type, the default sample type is `raw`.
`ports` *`port-list`*	Specify the sFlow ports.
`sample-rate` *`256-16000`*	Specify the sFlow sample rate. The value ranges from 256-16000 and the default value is 4096. Enter zero (0) if you want to disable sFlow sampling.
`counter-polling-interval 0..120`	Specify the sFlow interface statistics for counter polling interval. This is the periodic sampling or polling counters associated with a data source.
`trunc-length` *`trunc-length-number`*	Specify the truncated length of the sFlow sample (sample packet size).
`agent-id` *`ip-address`*	Specify the local IP address.

Note: While creating the sFlow, do not configure both the `sample-rate` and `counter-polling-interval` to zero (0). If you do so, an error message: `sflow-create: Sample-rate/counter-polling-interval both can't be 0` is displayed. However, later, you can change both values to zero (0) using the `sflow-modify` command if desired.

Note: When you configure the `sample-rate` and `counter-polling-interval` to zero (0) using the `sflow-modify` command, then no packets are sent out for sFlow monitoring.

Below is an example configuration on a switch to enable the sFlow Agent, *net-monitor*, on the ingress ports *57-59*, with sample type *raw*, sample-rate *4096*, counter-polling-interval of *5* seconds (1 sample in 5 seconds), trunc-length of *160* bytes:

```
CLI (network-admin@switch) >  sflow-create name net-monitor
```

```
type ingress sample-type raw ports 57-59 sample-rate 4096
counter-polling-interval 5 trunc-length 160
```

For deleting an existing sFlow Agent, use the command:

```
CLI (network-admin@switch) >  sflow-delete name name-string
```

To view the sFlow Agent details, use the command:

```
CLI (network-admin@switch) >  sflow-show
```

> **Note**: To view the binding between the sFlows and the nv-message-queues, use the `sflow-thread-binding-show` command. This command helps during debugging process and should be run with the support from Pluribus TAC team. See the *Example: A Sample Configuration* below.

To modify the configuration details for an sFlow Agent, use the command:

```
CLI (network-admin@switch) >  sflow-modify name name-string
```

`name` *`name-string`*	Specify the sFlow name that you want to modify.
Modify one or more of the following options:	
`type ingress|egress`	Specify to change the sFlow type to ingress or egress traffic.
`sample-type raw|cooked`	Specify to change the sample type to raw or cooked. Default value is `raw`.
`ports` *`port-list`*	Specify to change the sFlow ports.
`sample-rate` *`256-16000`*	Modify to change the sFlow sample rate. The default value is 4096.
`counter-polling-interval 0..120`	Modify and change the sFlow interface stats-counter polling interval.
`trunc-length` *`trunc-length-number`*	Modify the truncated length of the sFlow sample.
`agent-id` *`ip-address`*	Modify the local IP address.

For example, to modify and view the `counter-polling-interval` for the sFlow, *net-monitor*, use the command:

```
CLI (network-admin@switch*) >  sflow-modify name net-monitor
counter-polling-interval  120

CLI (network-admin@switch*) > sflow-show format all layout
vertical
name:                        net-monitor
```

```
type:                   ingress
sample-type:            raw
ports:                  1,3,53,57-59
sample-rate:            4096
counter-polling-interval:120
sample-interval:        5
trunc-length:           160
agent id:               10.1.1.200
sample-pkt-cnt:         2845
sample-drops:           87
```

Based on the configuration, the following details are displayed for the sflow-show command:

```
CLI (network-admin@switch*) > sflow-show
```

Specify one or more of the options:	
`name` *`name-string`*	Displays the name for the sFlow.
`type ingress|egress`	Displays whether the sFlow type is for ingress or egress traffic.
`sample-type raw|cooked`	Displays the sFlow sample type.
`ports` *`port-list`*	Displays the sFlow ports.
`sample-rate 256-16000`	Displays the sFlow sample rate.
`counter-polling-interval` *`0..120`*	Displays the sFlow interface stats-counter polling interval.
`trunc-length` *`trunc-length-number`*	Displays the truncated length of the sFlow sample.
`agent-id` *`ip-address`*	Displays the local IP address.
`sample-pkt-cnt sample-pkt-cnt-number`	Displays the sFlow sample packet count.
`sample-drops sample-drops-number`	Displays the sFlow sample dropped packets.
`malformed-packet-drops malformed-packet-drops-number`	Displays the sFlow malformed packet drops.
`malformed-vlan-packet-drops malformed-vlan-packet-drops-number`	Displays the sFlow malformed vlan packet drops.
`malformed-ip-packet-drops malformed-ip-packet-drops-number`	Displays the sFlow malformed ip packet drops.
`internal-q-drops internal-q-drops-number`	Displays the sFlow internal Q drops.

`oversize-packet-drops oversize-packet-drops-number`	Displays the sFlow over size packet drops.
`internal-nq-drops internal-nq-drops-number`	Displays the sFlow internal nQ drops

If all the command parameters are configured for an sFlow Agent, then the `sflow-show` command displays an output as given here:

```
CLI (network-admin@switch*) > sflow-show format all layout
vertical

switch:                        switch
name:                          sf25
type:                          ingress
sample-type:                   raw
ports:                         25
sample-rate:                   4096
trunc-length:                  160
agent-id:                      10.14.22.100
sample-pkt-cnt:                66798
sample-drops:                  0
malformed-packet-drops:             0
malformed-vlan-packet-drops:        0
malformed-ip-packet-drops:     0
internal-q-drops:              0
oversize-packet-drops:         0
internal-nq-drops:             0
```

Example: A Sample Configuration

Below is a set of sample configuration details for the sflows created in Pluribus lab for further understanding.

```
CLI (network-admin@switch*) > sflow-show
```

name	type	sample-type	ports	sample-rate	counter-polling-interval	trunc-length	agent-id	sample-pkt-cnt	sample-drops
s1	ingress	raw	1	4096	2	160	10.13.27.218	2198	89
s2	egress	raw	5	4096	2	160	10.13.27.218	2200	0
s3	ingress	raw	9	4096	2	160	10.13.27.218	4035	92
s4	egress	raw	13	4096	2	160	10.13.27.218	1131	0
s5	ingress	raw	25	4096	2	160	10.13.27.218	3916	88
s6	egress	raw	37	4096	2	160	10.13.27.218	5350	0
s7	ingress	raw	41	4096	2	160	10.13.27.218	2313384	86
s8	egress	raw	49	4096	2	160	10.13.27.218	1051	0
s9	ingress	raw	57	4096	2	160	10.13.27.218	2419	114
s10	egress	raw	65	4096	2	160	10.13.27.218	678	0
s11	ingress	raw	69	4096	2	160	10.13.27.218	71304	64
s12	egress	raw	73	4096	2	160	10.13.27.218	364897	0
s13	ingress	raw	77	4096	2	160	10.13.27.218	817011	112
s14	egress	raw	105	4096	2	160	10.13.27.218	672	0
s15	ingress	raw	109	4096	2	160	10.13.27.218	2698	159

The `sflow-show` command displays 15 sFlows (s1-s15) configured using the `sflow-create` command. In Netvisor ONE, when you configure the sFlows, every six sFlows are bound to one thread (sFlow Agent). To view the details, use the command:

```
CLI (network-admin@switch*) > sflow-thread-binding-show

name  thread-id        nv-msg-queue-name  nv-cache-queue-name
----  ---------------  -----------------  --------------------
s1    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s2    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s3    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s4    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s5    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s6    140323777259264  sflow-packet-q-9   sflow-cache-q-9
s7    140322640197376  sflow-packet-q-10  sflow-cache-q-10
s8    140322640197376  sflow-packet-q-10  sflow-cache-q-10
s9    140322640197376  sflow-packet-q-10  sflow-cache-q-10
s10   140322640197376  sflow-packet-q-10  sflow-cache-q-10
s11   140322640197376  sflow-packet-q-10  sflow-cache-q-10
s12   140322640197376  sflow-packet-q-10  sflow-cache-q-10
s13   140322665375488  sflow-packet-q-11  sflow-cache-q-11
s14   140322665375488  sflow-packet-q-11  sflow-cache-q-11
s15   140322665375488  sflow-packet-q-11  sflow-cache-q-11
```

From the above output, you can see that the first six sFlows (s1-s6) have the same `thread-id`, `nv-msg-queue-name`, and `nv-cache-queue-name` parameters. Similarly, the next six sFlows (s7-s12) have a new set of parameters and so on. This helps in understanding the bindings between the sFlows and the parameters.

In the above output,

- `thread-id`: is the unique identifier of the sFlow Agent that binds the sFlows (in groups of 6)
- `nv-msg-queue-name`: is the actual software queue used for sflow sampling
- `nv-cache-queue-name`: is a pool of buffers. Netvisor ONE allocates one memory block from the cache_queue whenever a sample is received from the hardware, which is then queued to the `nv_queue`.

To view the nv_queue details, use the command:

```
CLI (network-admin@switch*) > nv-queue-stats-show | grep sflow
name               q-high  q-in      q-out     q-delay-high  q-delay-avg  q-overflow  q-underflow
-----------------  ------- --------- --------- ------------- -----------  ---------- -----------
sflow-packet-q-9   2       18571     18571     13.8us        10.1us       0           0
sflow-cache-q-9    100     18571     18571     0.00ns        0.00ns       0           0
sflow-packet-q-10  4       2757320   2757320   141us         13.1us       0           0
sflow-cache-q-10   100     2757320   2757320   0.00ns        0.00ns       0           0
sflow-packet-q-11  2       821132    821132    50.7us        10.8us       0           0
sflow-cache-q-11   100     821132    821132    0.00ns        0.00ns       0           0
```

Adding or Removing Additional Ports to sFlow Configuration

Based on your sample requirements configured in previous section (Configuring sFlow Agents on the Network), you can add additional ports to the sFlow Agent on each switch by using the command:

```
CLI (network-admin@switch) > sflow-port-add sflow-name name-string ports port-list
```

Specify the sflow selector:	
`sflow-name` *`name-string`*	Specify the sFlow name to which you want to add additional ports.
`ports` *`port-list`*	Specify the ports or range of ports.

For example, to add the ports, **61-62**, to the sFlow configuration, use the following command on each switch:

```
CLI (network-admin@switch) >  sflow-port-add sflow-name net-monitor ports 61-62
```

To remove the additional ports from the sFlow configuration, use the `sflow-port-remove` command. For example,

```
CLI (network-admin@switch) >  sflow-port-remove sflow-name net-monitor ports 61-62
```

Supported Releases

Command/Parameter	Netvisor ONE Version
`sflow-thread-binding-show`	Command introduced in version 6.1.0
`counter-polling-interval 0..120`	Parameter introduced in version 6.1.0
`malformed-packet-drops malformed-packet-drops-number`	Parameter introduced in version 6.1.0
`malformed-vlan-packet-drops malformed-vlan-packet-drops-number`	Parameter introduced in version 6.1.0
`malformed-ip-packet-drops malformed-ip-packet-drops-number`	Parameter introduced in version 6.1.0
`internal-q-drops internal-q-drops-number`	Parameter introduced in version 6.1.0
`oversize-packet-drops oversize-packet-drops-number`	Parameter introduced in version 6.1.0
`internal-nq-drops internal-nq-drops-number`	Parameter introduced in version 6.1.0

Please also refer to the Pluribus Command Reference document.

Using Wireshark to Analyze Packets in Real Time

To use Wireshark to interactively analyze packets in real time, you need to capture a packet traffic flow, either on a specific switch or across the entire fabric using the scope option. For example:

```
CLI (network-admin@switch) > vflow-snoop scope fabric src-ip
112.168.3.105 action copy-to-cpu
```

Next, create a fifo on the host running Wireshark.

```
mkfifo  /tmp/pcap
```

Start Wireshark, and select **Options** from the **Capture** menu.

Enter the fifo path that you created in the Interface field: `/tmp/pcap`

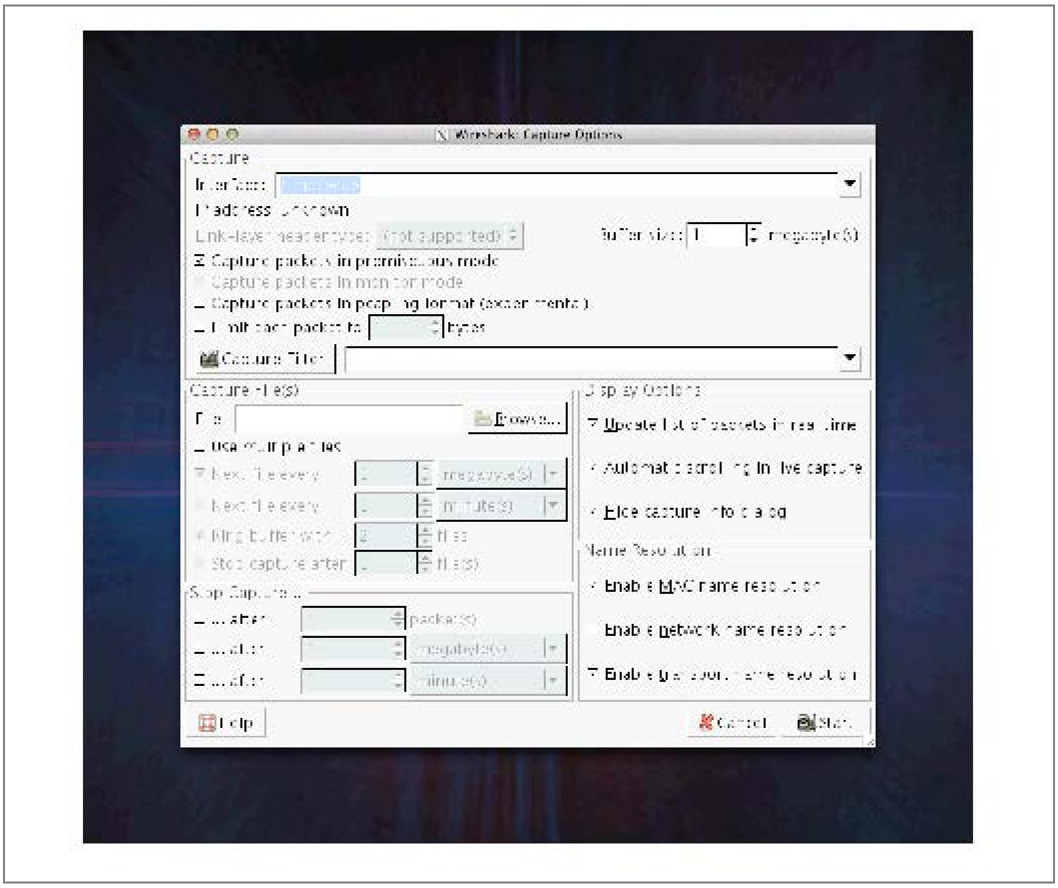


Figure 14-2 - Wireshark Interface

Wireshark Capture Options

Use tail to copy the pcap file to the FIFO:

```
tail +0f \
/net/ServerSw_Name//global/flow/Flow_Name/switch/Switch_Name/p
```

`cap/tmp/pcap`

You need to substitute *ServerSw_Name*, *Flow_Name* and *Switch_Name* to match your environment.

Live capture continues until the packet capture file is rotated. By default, the maximum packet capture file size is 10MB but it is configurable with the `packet-log-max` option of the vflow-create and `vflow-modify` commands.

> **Note:** The `mkfifo` command used in this task is a standard feature of Linux-like operating systems, including MacOS. For Windows platforms, you may need to install the GNU CoreUtils package available at http://gnuwin32.sourceforge.net/packages/coreutils.htm.

Analyzing Live Traffic Using Wireshark

Wireshark is a well known network protocol analyzer and one of many applications used for network protocol analysis.

Wireshark can interactively browse packet data from a live network or from a previously save pcap file.

> **Note:** You can download Wireshark from http://www.wireshark.org

To use Wireshark to decode a previously saved packet flow capture file, export the file from the switch and analyze it with Wireshark.

> **Note:** The path to a Netvisor ONE switch pcap file is: `/net/<ServerSw_Name>/ONVL/global/flow/<Flow_Name>/<Switch_Name>/pcap`

Configuring TACACS+

This chapter provides information about configuring the Terminal Access Controller Access Control System (TACACS+) on a Netvisor ONE switch using the Netvisor ONE command line interface.

Understanding TACACS+

About TACACS+

Terminal Access Controller Access Control System (TACACS+) is an Authentication, Authorization, and Accounting (AAA) protocol that
provides a centralized database to use for authentication and authorization. This protocol uses a client server approach by which the client queries a server and the server replies with a pass or fail for authentication. The communication between the client and server uses TCP as the transport protocol, and requires a secret key.

Netvisor ONE allows you to configure external TACACS+ servers for authentication, authorization, and accounting of sessions. You can configure any number of TACACS+ servers, and each server may be configured to handle any combination of authentication, session authorization, command authorization, session accounting, and command accounting.

Note :

- The default *network-admin* account is exempt from all TACACS+ integration as a fail-safe account for sites without TACACS+ and also to allow access to Pluribus Networks facilities if TACACS+ is unavailable or unreachable. The admin account requires a code from Pluribus Networks Customer Advocacy to login. Because you can access the shell through the CLI, the administrator's account is rarely needed.

- The Pluribus account password is the same as the network-admin password and when the network-admin password is changed, the Pluribus account password also changes. The login shell for the Pluribus account is *nvauditsh* and the same can be used to enable auditing for commands run from the admin account. Logins on both types of accounts are disabled if a TACACS+ server with the parameter `authen-local` is active.

When the TACACS+ server is configured and is working correctly, then the :
- Local users *from /etc/passwd* or */var/nvOS/etc/*/user_config.xml* are not allowed to login
- Authorization and Accounting for shell commands are enabled
- Authorization and Accounting for FRR commands are enabled
- Ability to drop into the shell from the CLI commands are allowed

You can configure TACACS+ by using the `aaa-tacacs-create` command and then, you can login to the switch and get CLI access using an account configured on the specified TACACS+ server.

The parameter `authen-local` controls if a TACACS+ server is used to authenticate local accounts or not. Netvisor ONE tracks errors between Netvisor ONE and the TACACS+ server and if a communication error occurs, then local authentication is allowed until communication with the TACACS+ server is recovered. This functionality enables the recovery of the system during an issue in the TACACS+ server. To allow a local account to authenticate, you must configure all active `aaa-tacacs` instances with `no-authen-local` option.

Local accounts include the accounts configured using the commands, `user-create` and `user-modify`, and the accounts such as admin and pluribus. Logins for both types of accounts are disabled if a TACACS+ server is set with `authen-local` as active.

The `vtysh` command is used to configure FRR for authorization and accounting of FRR commands.

The authentication protocols supported for TACACS+ are:

- PAP
- CHAP
- MS-CHAP

Figure 13-1 illustrates a simple TACACS+ implementation.

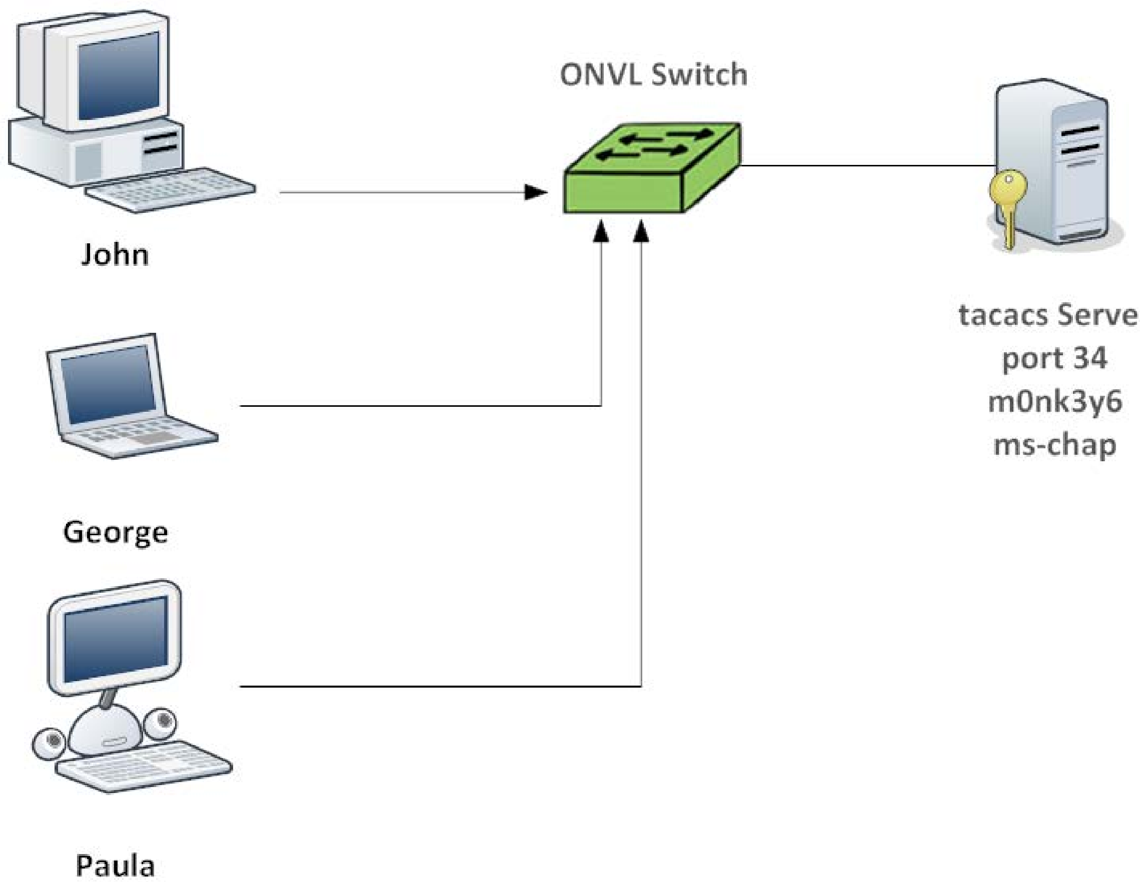


Figure 15-1: TACACS+ Implementation

Configuring TACACS+

To configure or create TACACS+ access on a switch, use the command:

CLI (network-admin@switch-1) > aaa-tacacs-create name *name-string* scope local|fabric server *server-string* [port *port-number*] [secret *secret-string*] [timeout *timeout-number*] [priority *priority-number*] [authen|no-authen] [authen-local|no-authen-local] [authen-method pap|chap|ms-chap] [sess-acct|no-sess-acct] [cmd-acct|no-cmd-acct] [acct-local|no-acct-local] [sess-author|no-sess-author] [cmd-author|no-cmd-author] [author-local|no-author-local] [author-local|no-author-local] [service service-string] [service-shell service-shell-string] [service-vtysh service-vtysh-string]

name *name-string*	Specify the name for TACACS+ config
scope local|fabric	Specify the scope of TACACS+
server server-string	Specify the TACACS+ server string
Specify one of more of the following options	
[port port-number]	Specify the TACACS+ communication port
[secret secret-string]	Specify the shared secret for TACACS+
[timeout timeout-number]	Specify the number of seconds before communication times out
[priority priority-number]	Specify the priority for TACACs+
[authen|no-authen]	Specify whether to use authentication or no authentication
[authen-local|no-authen-local]	Specify if the authentication overrides local users
[authen-method pap|chap|ms-chap]	Specify the authentication methods: PAP, CHAP (default), MS-CHAP
[sess-acct|no-sess-acct]	Specify the session accounting
[cmd-acct|no-cmd-acct]	Specify the command accounting
[acct-local|no-acct-local]	Specify the accounting for local users
[sess-author|no-sess-author]	Specify the authorization sessions
[cmd-author|no-cmd-author]	Specify the command authorization
[author-local|no-author-local]	Specify the authorization for local users
[service service-string]	Specify the service name used for TACACS+ requests sent from Netvisor

	ONE to the TACACS+ server for commands run at the Netvisor CLI and REST APIs. The default value is *shell*.
`[service-shell service-shell-string]`	Specify the TACACS+ service name string for *shell* commands
`[service-vtysh service-vtysh-string]`	Specify the TACACS+ service name string for vtysh commands

For example, to create TACACS+ account, `tac` having scope `local` with *no local authentication* privilege, use the command:

```
CLI (network-admin@switch) > aaa-tacacs-create name tac scope
local server pluribusnetworks.com authen-local
```

To create a secret key, use the command:

```
CLI (network-admin@switch) > aaa-tacacs-modify secret name tac
shared secret:
confirm shared secret:
CLI (network-admin@switch) >
```

To modify the authentication access, use the command:

```
CLI (network-admin@switch) > aaa-tacacs-modify name tac no-
authen-local
```

For a local account to authenticate, all the active `aaa-tacacs` instances must be configured with `no-authen-local` parameter.

Use the parameters `author-local` and `acct-local` to indicate if authorization and accounting messages for locally
authenticated accounts should be sent to the TACACS+ server. For example,

```
CLI (network-admin@switch) > aaa-tacacs-modify name tac
[author-local|no-author-local]
```

```
CLI (network-admin@switch) > aaa-tacacs-modify name tac [acct-
local|no-acct-local]
```

To specify the *service* in authorization and accounting messages for `shell` and `vtysh` commands, use:

```
CLI (network-admin@switch) > aaa-tacacs-modify name tac \
service-shell unix-shell
```

```
CLI (network-admin@switch) > aaa-tacacs-modify name tac \
service-vtysh vtysh-shell
```

If *service-shell* or *service-vtysh* is not specified, then the value of the service option is used.

To delete a specified (for example, `tac`) TACACS+ configuration, use the aaa-tacacs-delete command:

```
CLI (network-admin@switch) > aaa-tacacs-delete name tac
```

To display the status of the TACACS server, use the aaa-tacacs-status command:

```
CLI (network-admin@switch) > aaa-tacacs-show name tac
```

Creating User Roles

The TACACS+ server determines what role a user has by returning a role attribute. The roles include network-admin for full access and read-only-network-admin users who can run only the show commands.

You can create users on the switch and assign roles(based on role created or the default role of network-admin. To create a new user role, use the command:

```
CLI (network-admin@switch-1) > role-create name <name-string>
scope local|fabric access read-only|read-write
```

name *<name-string>*	Specify the role name
scope local|fabric	Specify if the scope is local or fabric
Specify any of the following options:	
access read-only|read-write	Specify the type of access, the default is read-write
running-config|no-running-config	Specify to display running configuration of switch
shell|no-shell	Specify to allow shell command
sudo|no-sudo	Specify to allow sudo from shell

For example, to create a user, newrole, with scope, local and allowing shell command, use the command:

```
CLI (network-admin@switch-1) > role-create name newrole scope
local shell
```

To display the configuration details, use the command:

```
CLI (network-admin@switch-1) > role-show

   name                    scope  vnet-access   access    running-config shell  sudo
------------------------ -----  ----------- ---------- -------------- ------ ----
network-admin            local    all       read-write  permit          deny   deny
read-only-network-admin  local    all       read-only   deny            deny   deny
newrole                  local    all       read-write  deny            permit deny
```

To delete a role, use the command:

```
CLI (network-admin@switch-1) > role-delete name <name-string>
```

To modify a role, use the command:

```
CLI (network-admin@switch-1) > role-modify name <name-string>
access read-only|read-write running-config|no-running-config
shell|no-shell sudo|no-sudo delete-from-users
```

You can create a user and apply an initial role by using the command:

```
CLI (network-admin@switch-1) > user-create name <name-string>
scope local|fabric initial-role <role-name>
```

For example, to create a user, user2 with scope local and initial role as network-admin:

```
CLI (network-admin@switch-1) > user-create name user2 scope
local initial-role newrole
```

```
CLI (network-admin@switch-1) > shell
shell: shell access denied by role
```

The above error message indicates that shell access is denied because the network-admin does not have shell access configured. Hence, when you create a new user, you must assign a new role to the user so as to enable shell access. For example,

```
CLI (network-admin@switch-1) > user-create name user2 scope
local initial-role newrole
```

Exit the configuration and login back to the switch as user2, for shell access to be enabled :

```
jenkins@pn-jenkins2.pluribusnetworks.com:~$ ssh user2@switch-1
Warning: Permanently added 'switch-1,10.14.16.44' (ECDSA) to
the list of known hosts.
* Welcome to Pluribus Networks Inc. Netvisor(R). This is a
monitored system.    *
*                  ACCESS RESTRICTED TO AUTHORIZED USERS ONLY
                  *
* By using the Netvisor(R) CLI,you agree to the terms of the
Pluribus Networks *
* End User License Agreement (EULA). The EULA can be accessed
via                *
* http://www.pluribusnetworks.com/eula or by using the command
"eula-show"      *
user2@switch-1's password:
Netvisor OS Command Line Interface 5.1
Connected to Switch switch-1; nvOS Identifier:0xb0013dc; Ver:
5.1.1-5010115002
CLI (user2@switch-1) > shell
user2@switch-1:~$
user2@switch-1:~$ exit
exit
CLI (user2@switch-1) >
CLI (user2@switch-1) > exit
Connection to switch-1 closed.
```

To delete a user, use the command (add the parameter forcefully to delete a user forcefully):

```
CLI (network-admin@switch-1) > user-delete name <name-string>
scope local initial-role newrole
```

To modify a user, use the command:

```
CLI (network-admin@switch-1) > user-modify name <name-string>
password <password-string>
```

To set a user password, use the command:

```
CLI (network-admin@switch-1) > user-password-set <name-string>
scope local uid uid-number type netvisor|unix|tacacs|web-
token|mfg server aaa-tacacs name initial-role <role-name>
```

`name <name-string>`	Specify the role name
`Specify any of the following options:`	
`scope local|fabric`	Specify if the scope is local or fabric
`uid uid-number`	Specify the user ID
`type netvisor|unix|tacacs|web-token|mfg`	Specify the user type
`server aaa-tacacs name`	Specify the TACACS server
`initial-role <role-name>`	Specify the initial role for the user

Exceptions for Audit Logging

The commands `log-audit-exception-create`, `log-audit-exception-delete`, and `log-audit-exception-show` are used to control which CLI, `shell` and `vtysh` commands are subject to auditing. If a command is subject to auditing, the command is logged in the audit log and sent to the TACACS+ server as authorization and accounting messages.

To create an audit logging exception, use the command:

```
CLI (network-admin@switch) >  log-audit-exception-create cli|
shell|vtysh [pattern pattern-string] [any|read-only|read-
write] scope local|fabric
```

`cli|shell|vtysh`	Specify the type of audit exception
`[pattern pattern-string]`	Specify the regular expression to match exceptions
`[any|read-only|read-write]`	Specify the access type to match exceptions
`scope local|fabric`	Specify the scope (*local* or *fabric*) for exception

To delete an audit logging exception, use the command:

```
CLI (network-admin@switch) > log-audit-exception-delete cli|
shell|vtysh [pattern pattern-string] [any|read-only|read-
write]
```

To display the audit logging exception, use the command:

```
CLI (network-admin@switch) > log-audit-exception-show cli|
shell|vtysh [pattern pattern-string] [any|read-only|read-
write] scope local|fabric
```

By default, every command is audited except for *read-only CLI commands* and the shell command *^/usr/bin/nvmore,* which is the
pager used by nvOS_cli:

```
CLI (network-admin@switch) > log-audit-exception-show

switch type  pattern          access    scope
------ ----- ---------------- --------- -----
switch cli                    read-only local
switch shell ^/usr/bin/nvmore any       local
```

To enable auditing of ALL CLI commands, you can delete the *read-only/CLI* exception:

```
CLI (network-admin@switch) > log-audit-exception-delete cli
read-only
```

Configuring Virtual Networks

This chapter provides information about configuring Virtual Networks on a Netvisor ONE switch using the Netvisor ONE command line interface.

Understanding Virtual Networks (vNETs)

Pluribus Networks supports various network virtualization capabilities as part of a highly flexible approach to software-defined networking (SDN), called *Adaptive Cloud Fabric*.

Pluribus' fabric addresses all the most common network design requirements, including scalability, redundancy, predictable growth capability, fast convergence in case of a failure event, etc. Such requirements also include *multi-tenancy support*.

Therefore, in the data center, by leveraging Netvisor ONE's virtualization features, network designers can implement a variety of multi-tenancy models such as Infrastructure as a Service (IaaS) or Network as a Service (NaaS).

To support multiple tenants, the fabric's data plane segmentation technologies include standard features (such as VLANs) as well as advanced virtualization features such as VXLAN and distributed VRFs, to be able to deploy an open, interoperable, high-capacity and high-scale multi-tenant network. (Refer to the *Configuring VXLAN* section for more details on VXLAN and distributed VRFs).

In addition to data plane segmentation, fabric virtualization also comprises the capability of separating tenants into *isolated management domains*. Pluribus calls this capability *Virtual Networks* (*vNETs* in short).

A vNET is an abstract control plane resource that is implemented globally across the fabric to identify a tenant's domain. By using vNETs, you can segregate a physical fabric into many logical domains, each with separate resources, network services, and Quality of Service (QoS) guarantees. vNETs therefore allow the network administrator to completely separate the provisioning of multiple tenants within the network.

Each vNET has a single point of management. As the fabric administrator, you can create VNETs and assign ownership of each vNET to individuals with responsibility for managing those resources.

You can create separate user names and passwords for each *vNET manager*. Using the separate vNET administration credentials, the vNET admin can use Secure Shell (SSH) to connect to the vNET manager and access a subset of the Netvisor ONE CLI commands to manage a specific vNET. This way, multiple tenants can share a fabric with each managing a vNET with security, traffic, and resource protection from other vNETs.

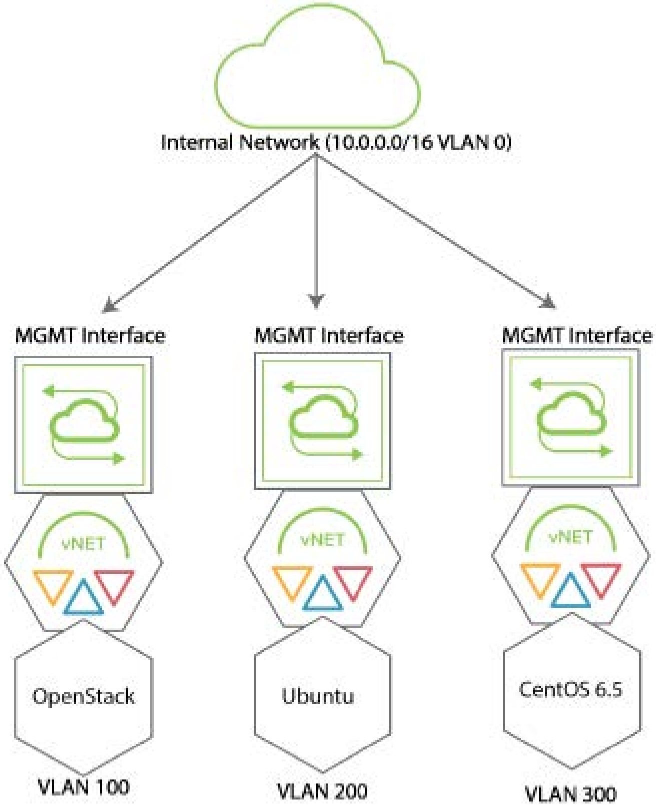


Figure 16-1 - Using vNETs with Netvisor ONE

vNETs are very flexible and can be used to create complex network architectures. For example, a Pluribus Networks switch, or a fabric of switches, can be used to create multiple tenant environments. In ***Figure 16-1*** above there are three vNETs, each one with a management interface and a data interface. Each vNET is assigned an IP address pool used for DHCP assignment of IP addresses to each node, server, or OS component.

Underlying each vNET is the *vNET manager*. Each vNET manager runs in a zone. When services are created for a vNET they occupy the same zone on a switch. This is called a shared service and it is the default when creating services. However, each zone can only support a single instance of a service. If a second service instance is needed for a vNET, then it needs to occupy a separate zone. This is called a dedicated service. In most cases, you can create services as shared resources unless you specifically want to create a dedicated service.

When a fabric is created, a vNET is also automatically created and named `fabric-name-global`. This vNET initially owns all resources within the fabric. As new vNETs are created, resources are moved from the default vNET to the new vNETs. Global services remain in the default vNET unless assigned to a specific vNET.

Creating a Virtual Network (vNET)

To separate resources, including switch ports, IP addresses, VLANs, and VXLAN IDs, into separate management spaces, create (at least) a vNET and associate the desired resources to it (see below for an example of configuration).

The vNET creation is performed with the `vnet-create` command followed by a list of required parameters. Subsequently, you can configure a separate vNET administrator to manage each newly created management domain.

`CLI (network-admin@switch) > vnet-create`

`name` *`name-string`*	Specify the name of the virtual network (vNET).
`scope local|cluster|fabric`	Specify the scope of the virtual network (vNET)
Specify one or more of the following options:	
`vrg` *`vrg-name`*	Specify the name of the virtual resource group (VRG) to be assigned to the vNET.
`vlan-type public|private`	Specify the type of VLAN used by the vNET.
`num-vlans` *`number`*	Specify the number of VLANs to assign to the vNET. Using this parameter allows you to assign a group of VLANs rather than specific VLANs.
`vlans` *`vlan-list`*	Specify the list of VLANs to assign to the vNET. You can specify a list or range of VLANs that the VNET assigns to VNET interfaces.
`public-vlans vlan-list`	Specify the public VLANs assigned to private VLAN vNET.
`num-private-vlans` *`number`*	Specify the number of private VLANs that the vNET administrator can create for the VNET. This is a number between 1 and 4094.
`num-bridge-domains 0..4094`	Specify the number of bridge domains allowed to be created in the vNET.
`vxlans` *`vxlan-id`*	Specify the VXLAN ID assigned to the vNET.
`vxlan-end` *`vxlan-id`*	Specify the last VXLAN ID assigned to the vNET.
`managed-ports` *`port-list`*	Specify the list of managed ports on the vNET.

`shared-ports` *`port-list`*	Specify the shared ports for the vNET.
`shared-port-vlans` *`vlan-list`*	Displays VLANs on the shared ports.
`config-admin|no-config-admin`	Specify an administrator for the vNET. This is optional.
`admin` *`user-name`*	Specify the user name for the admin role.
`create-vnet-mgr|no-create-vnet-mgr`	Specify if you want to create or not create a vNET manager.
`vnet-mgr-name` *`name-string`*	Specify the name of the vNET manager. If you don't specify a name, one is automatically configured.
`vnet-mgr-storage-pool` *`storage-pool-name`*	Specify the storage pool for the vNET.

> **Note**: You cannot create another vNET inside of a vNET.

You can modify a vNET using the `vnet-modify` command.

`CLI (network-admin@switch) > vnet-modify`

`name` *`name-string`*	Specify the name of the virtual network (vNET).
Specify one or more of the following options:	
`vlans` *`vlan-list`*	Specify the list of VLANs to assign to the vNET. You can specify a list or range of VLANs that the VNET assigns to VNET interfaces.
`managed-ports` *`port-list`*	Specify the list of managed ports on the vNET.
`num-private-vlans` *`number`*	Specify the number of private VLANs that the vNET administrator can create for the VNET. This is a number between 1 and 4094.
`public-vlans vlan-list`	Specify the public VLANs assigned to private VLAN vNET.
`shared-ports` *`port-list`*	Specify the shared ports for the vNET.
`vxlans` *`vxlan-id`*	Specify the VXLAN ID assigned to the vNET.
`vxlan-end` *`vxlan-id`*	Specify the last VXLAN ID assigned to the vNET.

`shared-port-vlans` *`vlan-list`*	Specify the vNET shared port VLANs.
`num-bridge-domains` *`0..4094`*	Specify the number of bridge domains allowed to be created in the vNET.

The purpose of vNET objects is to provide independent network domains whose administrators are able to manage a set of dedicated resources without having to involve the fabric administrator, within the constraints that the fabric administrators defines.

Access control is performed based on the scope of a vNET, which includes a number of dedicated ports on which it's possible to apply certain commands/use certain dedicated resources.

For example, the applicable resources include three categories of commands/entities with vNET admin scope, listed below:

Layer 1 commands (i.e., port-related commands):

- `port-show` (shows vNET ports but not internal/cluster ports)
- `port-phy-show`
- `port-config-modify/show`
- `bezel-portmap-show`

Layer 2 commands (i.e., VLAN/LACP/STP/vLAG commands):

- `port-lacp-modify/show`
- `vlag-create/modify/delete`
- `trunk-create/modify/delete`
- stp-port-modify/show/stp-portevent-show
- A vNET admin is not allowed to change the native VLAN on a shared port with the `port-vlan-add` command.

Layer 3 commands (i.e., vRouter commands):

- `static-ecmp-group-show/static-ecmp-group-nh-show`
- `vrouter-ping/traceroute`

Note that if any of the above commands are run on a port not in the scope of a vNET, a *No permission for port 'port = %d'* message is displayed, for example like so:

```
CLI (network-admin@switch) > vlag-create name vl1 port 99
peer-port 99
vlag-create: No permission for port 'port = 99'
```

Let us take a concrete example of vNET creation and see how the above commands behave within it:

```
CLI (network-admin@switch) > vnet-create name vn1 scope
cluster vlan-type private public-vlans 2000-2099 num-private-
vlans 10 vxlans 10000100-10000109 managed-ports 9,17 shared-
ports 18 shared-port-vlans 105-109
```

```
Creating vn1-mgr zone, please wait...
```

With this command the fabric administrator creates a vNET as a dedicated domain comprising a number of managed and shared ports as well as private and public VLANs and VXLAN IDs. In other words, the fabric admin is partitioning the resources to provide a dedicated and *restricted* view on the network.

The following examples show how a vNET's view gets constrained for each command example:

```
CLI (network-admin@switch) > port-show

switch     port bezel-port status      config
--------   ---- ---------- ---------- ------
switch      9    9          up,vlan-up fd,10g
switch      17   17         disabled   fd,10g
switch      18   18         disabled   fd,10g
```

In this example the vNET admin can only show the managed and shared ports chosen as part of the vNET creation process, out of all the front panel ports.

> **Note:** When you run the `port-show` command for a private vNET, only vNET managed ports are displayed. But for a public vNET, all ports except internal ports and cluster ports are displayed.

```
CLI (network-admin@aquarius00) > port-phy-show

switch      port state speed eth-mode    max-frame learning def-
vlan
---------- ---- ----- ----- ---------- --------- --------
--------
switch     9    up    10000 10Gbase-cr 1540       off       0
switch     17   down  10000 10Gbase-cr 1540       off       1
switch     18   down  10000 10Gbase-cr 1540       off       0
```

Also, the front panel and PHY information is constrained to the ports selected as part of the vNET creation process. Port configuration gets constrained too:

```
CLI (network-admin@aquarius00) > port-config-show format
port,enable,

port enable
---- ------
9    on
17   off
```

Regarding the Layer 2 configuration, these commands also get a constrained view:

```
CLI (network-admin@switch) > port-vlan-add port 9 untagged-
vlan 45
```

```
port-vlan-add: No permission to modify untagged-vlan field
```

As shown, untagged VLANs are prevented from being changed.

The vLAGs can be created only using accessible ports (as port 9 in the example below):

```
CLI (network-admin@switch) > vlag-create name vl1 port 9 peer-
port 9
CLI (network-admin@switch) > port-lacp-show layout vertical

switch:   switch
port:     9
name:     vl1
port-type:    vlag
mode:     passive
timeout:  slow
system-id:    66:0e:94:b6:ab:01
lacp-key: 36285
system-priority:   32768
port-priority: 32768
aggregatable:  yes
sync:     yes
coll:     yes
dist:     no
defaulted:    yes
expired:  no
port-state:   0x5c
```

whereas inaccessible ports are blocked in the configuration:

```
CLI (network-admin@aquarius00) > vlag-create name vl1 port 99
peer-port 99
vlag-create: No permission for port 'port = 99'
```

Similarly, a VLAN trunk can be created (and then deleted) using accessible ports 9 and 10 like so:

```
CLI (network-admin@switch) > trunk-create name t ports 9-10
trunk 273 defer-bringup set to 1 based on first port 9
Created trunk t, id 273

CLI (network-admin@switch) > trunk-show format name,trunk-
id,ports

name                  trunk-id ports
--------------------  -------- -----
t                     274      9-10
vxlan-loopback-trunk  397

CLI (network-admin@switch) > trunk-delete name t
```

Furthermore, spanning tree (STP) commands are limited to accessible ports only:

```
CLI (network-admin@switch) > stp-port-show port 10

switch      port block filter edge bpdu-guard root-guard priority cost
----------  ---- ----- ------ ---- ---------- ---------- -------- ----
switch      10   on    off    no   no         no         128      2000
```

```
CLI (network-admin@switch) > stp-port-modify port 53 cost 
10000
stp-port-modify: No permission over ports 53
```

```
CLI (network-admin@switch) > stp-port-event-show

switch   time     port vlan   instance count initial-state other-state final-state
-------  -------- ---- ------ -------- ----- ------------- ----------- -----------
switch   01:13:52  17   1,4094 0        3     Disabled      Disabled    Forwarding
switch   01:15:42  9    1      0        1     Disabled      Disabled    Discarding
switch   01:16:02  9    1      0        1     Discarding    Disabled    Learning
switch   01:16:12  9    1      0        1     Learning      Disabled    Forwarding
switch   01:17:53  17   1      0        1     Forwarding    Disabled    Disabled
switch   01:17:53  9    1      0        1     Forwarding    Disabled    Disabled
switch   01:29:00  17   4094   0        1     Disabled      Disabled    Forwarding
```

The vRouter commands get constrained too (to accessible VLANs and interfaces) like so:

```
CLI (network-admin@switch) > vrouter-create name vr1 vnet vn1 
router-type hardware
Creating vr1 zone, please wait...
vrouter created
```

```
CLI (network-admin@switch) > vrouter-interface-add vrouter-
name vr1 ip 192.168.99.13/24 vlan 100
Added interface eth0.100 with ifIndex 159
```

```
CLI (network-admin@switch) > vrouter-interface-show format 
vrouter-name,ip,vnet,vlan,vlan-type,nic-state,mtu

vrouter-name nic      ip               vnet vlan vlan-type nic-state mtu
------------ -------- ---------------- ---- ---- --------- --------- ----
vr1          eth0.100 192.168.99.13/24 vn1  100  private   up        1500
```

```
CLI (network-admin@switch) > vrouter-ping vrouter-name vr1 
host-ip 192.168.99.13

PING 192.168.99.13 (192.168.99.13) 56(84) bytes of data.
64 bytes from 192.168.99.13: icmp_seq=1 ttl=64 time=0.066 ms
64 bytes from 192.168.99.13: icmp_seq=2 ttl=64 time=0.071 ms
64 bytes from 192.168.99.13: icmp_seq=3 ttl=64 time=0.063 ms
^C
--- 192.168.99.13 ping statistics ---
```

Specifying the Type of vNET Interface

The `mgmt`, `data`, and `span` keywords used in different commands specify the path used to connect to the network service. For example, to specify an out-of-band connection to a management interface of a vNET, the interface is specified using the `mgmt` keyword. If in-band access to that management interface of the vNET is required, then the `data` or `span` keywords are used in the specific command.

The keywords, `data` and `span`, are essentially equivalent but apply to two separate paths. To maximize throughput between the server and the switch components, it is recommended to use both. The `data` keyword applies to port 65, and the `span` keyword applies to port 66.

Each vNET can have one or more isolating zones and network services are applied to each zone. Network services have their own zone or share the zone with the vNET manager which is the zone that the vNET user logs into to manage the vNET. In shared zones, the network interfaces are available to all network services in the shared zones, regardless of the service that created the network interface.

> **Note:** This is an important concept as you can use service commands such as `vnet-manager-interface-add` to add interfaces to a vNET. If you want the service to be specific to a vNET as a dedicated service, then add the interfaces using the `service-interface-add` commands.

Configuring vNET High Availability (HA)

vNET HA provides high availability for switch access through a vNET manager. The vNET manager is a zone, typically with one IP interface, which allows a vNET administrator to log into and administer a vNET using the CLI or a REST API.

Netvisor ONE provides HA functionality by allowing you to create multiple vNET managers. Netvisor ONE enables access to the vNET managers when you add either standard or VRRP VIP interfaces to the vNET managers.

Without vNET HA, vNET administrators have only a single point of access where the vNET manager zone runs on a particular switch. If that switch fails, the administrator cannot log into the fabric and administer the vNET.

This feature provides the following:

- Create or delete a vNET manager zone.
- The `vnet-manager-interface` command accepts VRRP interfaces. This allows you to create VRRP interfaces on vNET manager zones
- The `vnet-create` command provides an option to not create a vNET manager zone when creating a vNET.
- Copy and paste SSH host keys used on different vNET managers. This is needed when using a VRRP VIP to access the vNET managers to avoid SSH host key violations if the VIP fails over to the standby vNET manager. Install these keys on the client machine used to connect to the vNET managers.

Creating a vNET Manager Zone

To create additional vNET manager zones, use the `vnet-manager-create` command.

```
CLI (network-admin@Leaf1) > vnet-manager-create name name-string vnet vnet-name [disable|enable][location fabric-node name][storage-pool storage-pool name]
```

`vnet-manager-create`	Creates a vNET manager
`name name-string`	Specify the name of service configuration.
`vnet vnet-name`	Specify the vNET assigned to the service.
any of the following options:	
`disable|enable`	Specify to enable or disable the service.
`location fabric-node name`	Specify the location of the service.

`storage-pool name`	`storage-pool`	Specify the storage pool assigned to the service.

Deleting a vNET Manager Zone

To delete a vNET manager zone, use the `vnet-manager-delete` command.

```
CLI (network-admin@Leaf1) > vnet-manager-delete name name-string
```

Specify the name of service configuration.

Copying and Pasting SSH Keys

To output SSH host keys to copy and paste to `~/.ssh/known_hosts` file of the client host, use the `vnet-manager-ssh-host-key-show` command.

This allows you to SSH to any vNET manager zone and avoid issues with invalid key hosts.

```
CLI (network-admin@Leaf1) > vnet-manager-ssh-host-key-show [vnet vnet name]
```

`vnet-manager-ssh-host-key-show`	Displays the vNET Manager host keys to copy and past to: `~/.ssh/known_hosts`.
`name name-string`	Displays the name of service configuration.

vNET Manager Command Options

This feature uses a new option `[no-]create-vnet-mgr` which controls whether to create a vNET manager.

The default behavior is creating a vNET manager as this is the current behavior of creating a vNET manager as part of `vnet-create`.

```
CLI (network-admin@Leaf1) > no-create-vnet-mgr
```

`vnet-create`	Creates a virtual network (vNET)
`name` *`name-string`*	Specify the vNET name.
`scope local|cluster|fabric`	Specify the vNET scope as local, cluster, or fabric.
`create-vnet-mgr|no-create-vnet-mgr`	Create or not create a vNET manager service.

VRRP Interfaces Option

This feature now accepts options for VRRP interfaces. This allows you to create VRRP interfaces on vNET manager zones.

CLI (network-admin@Leaf1) > vnet-manager-interface-add vnet-manager-*name name-string* [vrrp-id 0,,255][vrrp-primary *vrrp-primary-string*][vrrp-priority 0..254][vrrp-adv-int 300..40950]

vnet-manager-interface-add	Adds an interface to a vNET manager.
vnet-manager-name *name-string*	Specify the name of service configuration.
vrrp-id 0..255	Specify the ID assigned to VRRP.
vrrp-primary vrrp-primary-string	Specify the VRRP primary interface.
vrrp-priority 0..254	Specify the VRRP priority for the interface.
vrrp-adv-int 300..40950	Specify the VRRP Advertisement Interval in milliseconds. The minimum interval is 300ms and the maximum interval is 40950ms. The default interval is 1000ms.

Related Documentation

For further information on concepts mentioned in this section (such as Layer 2, Layer 3, etc.), refer to these sections of the Configuration Guides:

- Configuring Switch Ports
- Configuring Layer 2 Features
- Configuring Layer 3 Features
- Setting up and Administering the Pluribus Fabric
- Configuring High Availability
- Configuring VXLAN

Overview vCenter

This chapter provides information for understanding and using the Pluribus Networks Netvisor ONE command line interface (CLI) on a Netvisor ONE switch to configure vCenter features.

Understanding vCenter Connection Service

Note: Though you can run vCenter Connection Service (VCCS) on any platform, it is recommended to run VCCS on a virtual Netvisor Switch. For details on configuring the virtual Netvisor switch, see the Deployment Guide for Virtual Networks with Virtual Netvisor.

Connectivity to vCenter allows a network administrator visibility into physical and/or virtual VMware entities behind each port of the Pluribus Adaptive Cloud fabric for operational simplification. You need to configure only one vcenter-connection for a fabric and should enable VCCS only on one of the nodes of fabric (applies to cluster pair also).

Netvisor ONE categorizes the properties of the entities into three classes:

- Server, hypervisor,and one or more physical NICs
- Virtual Machine including guest OS, virtual NIC properties such as MAC address, IP address, and VLAN.
- VM Kernel ports and the associated services like vMotion and vSAN.

Netvisor ONE provides vCenter Connection Service that allows you to connect to VMware vCenter and enables you to do the following tasks:

- Identify the switch port used for each Virtual Machine (VM).
- Track the movement of VMs from one host (ESXi) to another host.
- Identify the VLAN requirements of each VM on the network.
- Track network statistics at a granular level for troubleshooting purposes.
- Track VM configuration changes such as additions, deletions, or modifications of VLANs, and configure VLANs on Netvisor ONE switch ports.
- Track the additions or deletions of VMs and hosts, and configure VLANs on Netvisor ONE switches.
- Track the state of VMs and dynamically provision VLANs on the servers facing physical ports.

vCenter Connection Service also synchronizes with VMware vCenter to obtain the following information:

- The host where the VMs exist.
- The Netvisor ONE switch ports connected to the VM.

- The virtual network interface card (vNIC) that connects the VM to a virtual switch.
- The Power status of the VM as on or off.
- VLAN information of port groups.
- The port groups connected to the VM.

This information is associated with MAC addresses and VLANs on the network.

In Netvisor ONE release 6.1.1, the vCenter Connection Service:

- Supports up to 4 vCenter connections from a switch
- Supported on 5.5, 6.0 and 6.5 versions of ESXi and vCenter Server

You can check the status of the connection. To check the status of the connection, use the `vcenter-connection-show` command.

If the connection status shows an error message with the state as **enabled**, then you should first disable the connection and then enable it to restart the connection service.

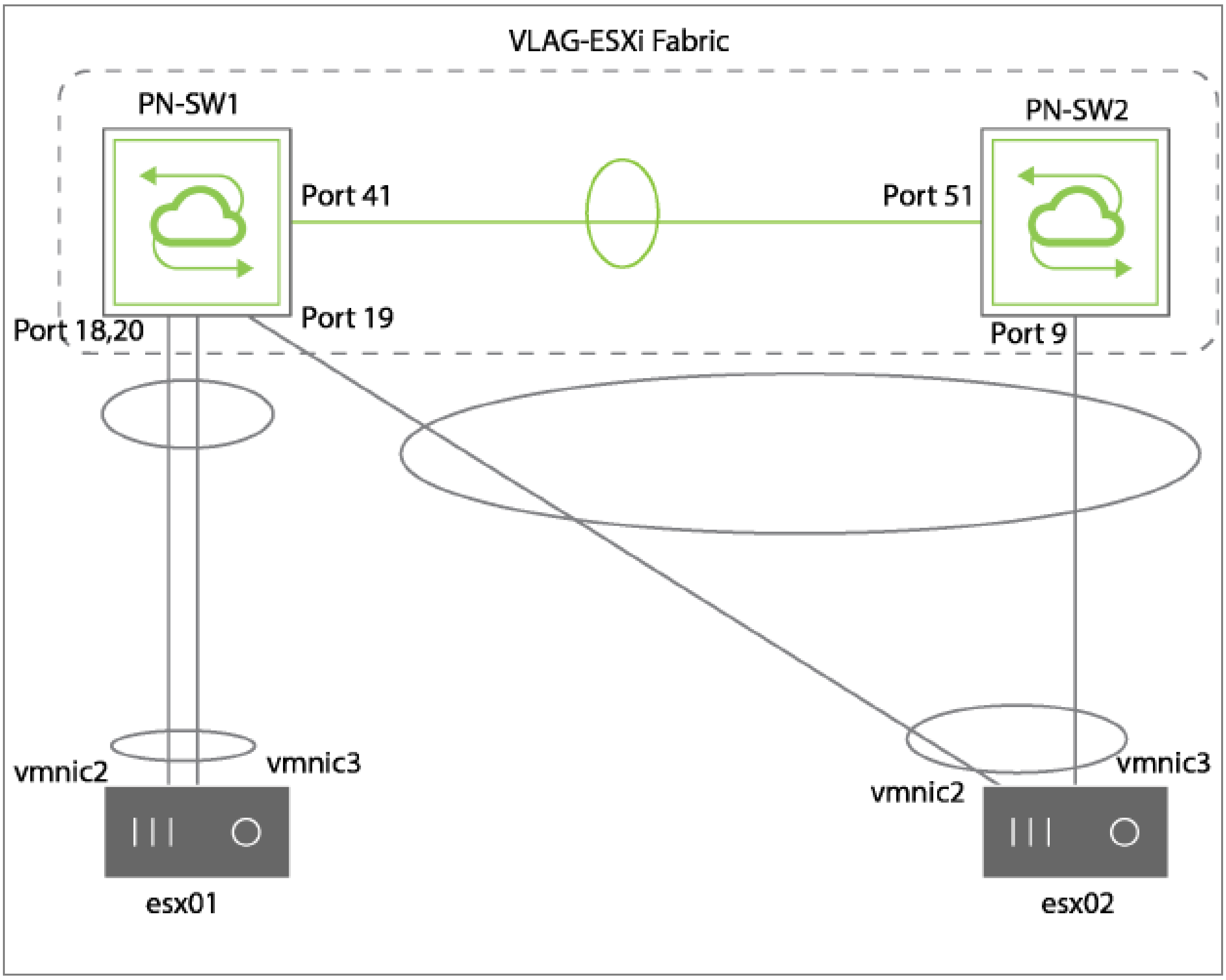


Figure 1 - Example LAG and VLAG Topology for vCenter

Example output with a list of VMs running on the two VMware ESXi servers along with visibility into the associated VLANs, attached port group, vswitches is given for reference:

```
CLI (network-admin@switch) > vport-show status vm format
ip,hostname,entity,power,os,portgroup,pg-vlans,vswitch,vs-type,vnic-
type,status,os

ip          hostname    entity        power      os           portgroup        pg-vlans
vswitch            vs-type         vnic-type status
----------  -----------  ------------  ----------  ------------  ----------------  --------
-----------------  --------------  ---------  -------
195.1.1.10  10.14.30.37  Linux-UNUM-3  powered-on  Ubuntu  Linux  DPortGroup  UNUM1  190-200
DSwitch-UNUM8node  distributed-vs  trunked     host,vm
190.1.1.10  10.14.30.35  Linux-Unum-5  powered-on  Ubuntu  Linux  DPortGroup  UNUM1  190-200
DSwitch-UNUM8node  distributed-vs  trunked     host,vm
```

Note: Some fields like 'os' need VMware tools to be installed on the VMs.

Guidelines and Limitations

Please keep in mind the following guidelines and limitations while configuring VCCS:

- Only one vcenter-connection is needed for a fabric. That is, VCCS should be enabled only on one of the nodes of fabric (includes cluster pair also).
- High Availability (HA) support is not available on VCCS. If an associated switch goes down, vcenter connection service is disrupted until the switch is back online or re-provisioned on a different node of the fabric.
- The network data associated with VMs collected by VCCS in vPort and connection table can be viewed on the UNUM dashboard. For details, see the UNUM documentation.

Configuring a vCenter Service

To create a vCenter service, use the `vcenter-connection-create` command:

```
CLI (network-admin@switch) > vcenter-connection-create name
name-string host host-string user user-string enable|disable
vlans vlan-list network-provisioning none|l2-underlay|l3-
underlay
```

`name name-string`	Specify the name of the vCenter connection.
`host host-string`	Specify the host name of the vCenter to connect with.
`user user-string`	Specify the authorized vCenter user name.
`enable|disable`	Specify to enable to disable the vCenter connection.
`vlans vlan-list`	Specify the vCenter plugin VLANs for provisioning.
`network-provisioning none|l2-underlay|l3-underlay`	Specify if the network provisioning should be none, L2 underlay or L3 underlay.

For example, to configure a vCenter service named *vcenter2*, on VLANs *190-198*, use the below command and enter the password when prompted:

```
CLI (network-admin@switch) > vcenter-connection-create name
vcenter2 host vcenter-server user administrator@lab.pluribus
vlans 190-198 network-provisioning l2-underlay
vCenter user password: <=== password is not visible while
typing
vCenter connection service vcenter2 started.
```

To modify a vCenter service, use the following syntax:

```
CLI (network-admin@switch) > vcenter-connection-modify name
name-string host host-string user user-string password
password-string enable|disable vlans vlan-list network-
provisioning none|l2-underlay|l3-underlay
```

To delete a vCenter service, use the following syntax:

```
CLI (network-admin@switch) > vcenter-connection-delete name
name-string
```

To display information about a vCenter service, use the following syntax:

```
CLI (network-admin@switch) > vcenter-connection-show name
name-string host host-string user user-string state init|ok|
error connected-time connected-time-string connection-error
connection-error-string vlans vlan-list enable|disable
network-provisioning none|l2-underlay|l3-underlay
```

Setting Automatic Link Aggregation on ESXi-facing Ports for vCenter

Currently, automatic Link Aggregation (LAG) is only supported between Pluribus Networks switches. With this feature, automatic Link Aggregation (LAG) includes ports between Pluribus Networks switches and ESXi hosts.

Netvisor ONE implements LLDP and LACP to bundle the ports. Since there are no custom type-length-value (TLV) probes, Netvisor ONE implements standard LLDP TLVs to uniquely identify ESXi hosts. The system description TLV is used to identify ESXi hosts and the system name is used to uniquely identify a specific ESXi host.

LACP mode is enabled and set to active on `auto-lag` with a fallback-option of `individual` to ensure that there is extra robustness in bundling and ensure that ports are bundled only if ESXi host is running LACP to avoid any data path issues.

You can enable or disable trunking towards hosts (default value is `off`).

The current global parameter `auto-trunk` needs to be ON (default) for this new settings to take effect. Setting auto-trunk to off turns off all trunking.

Example output from `trunk-show`, `port-show` and `lldp-show`.

```
CLI (network-admin@Leaf1) > trunk-show format trunk-
id,switch,name,ports,lacp-mode,lacp-fallback,lacp-
individual,status,

trunk-id   name     ports lacp-mode lacp-fallback  lacp-individual status
--------  -------- ----- --------- -------------  --------------- -----------
129        auto-129  42,44  active    individual     none            up,PN-other
```

```
CLI (network-admin@Leaf1) > port-show port 42,44 format all

port  bezel-port            status                                  rswitch  rem-ip       rem-mac
                  lport  config    trunk
----   ----------   ------------------------------------   --------   --------
-----------------    ------    ------    --------
42       42                up,PN-other,LLDP,trunk,LACP-PDUs,vlan-up  2987
      ::                00:00:00:00:00:00  42        fd,10g     auto-129
44       44                up,PN-other,LLDP,trunk,LACP-PDUs,vlan-up  2987
      ::                00:00:00:00:00:00  44        fd,10g     auto-129
```

```
CLI (network-admin@Leaf1) > lldp-show

local-port  chassis-id      port-id                 port-desc                                 sys-
name
----------  ----------  -----------------  -----------------------------
------------------------------
42             vmnic2       00:50:56:98:07:56  port  25  on  dvSwitch  DEV-CN-Tests-1     esx-
dev01.pluribusnetworks.com
44             vmnic3       00:50:56:98:07:57  port  24  on  dvSwitch  DEV-CN-Tests-1     esx-
dev01.pluribusnetworks.com
```

Overview Open Virtual Switch

> **Note**: The OVSDB features area supported only on Ericsson platforms: NSU, NRU02, NRU03, and NRU-S0301.

Open vSwitch is a virtual switch that enables network automation, while supporting standard management interfaces and protocols, like NetFlow. Open vSwitch also supports distribution across multiple physical servers.

In an Open vSwitch implementation, a database server and a switch daemon are used. The OVSDB protocol is used in a control cluster, along with other managers and controllers, to supply configuration information to the switch database server. Controllers use OpenFlow to identify details of the packet flows through the switch. Each switch may receive directions from multiple managers and controllers, and each manager and controller can direct multiple switches.

- Configuring OVSDB with Netvisor ONE
- Using OpenSSL TLS Certificates for OVSDB and other Services
- Open Virtual Switch Database (OVSDB) Error Reporting

Configuring OVSDB with Netvisor ONE

There are a number of steps required to configure OVSDB using Netvisor One.

1. Configure the vNET with the number of private VLANs, VXLANs, and managed ports:

CLI (network-admin@Leaf1) > vnet-create name *name-string* vlans *vlan-range* num-private-vlans *integer* vxlans *vxlan-id* managed-ports *port-list*

2. Configure the underlay network:

CLI (network-admin@Leaf1) > vrouter-create *name-string* vnet *name-string* router type hardware

CLI (network-admin@Leaf1) > vrouter-interface-add vrouter-name *name-string* vlan *vlan-id* ip *ip-address* netmask *netmask*

3. Configure the tunnel:

CLI (network-admin@Leaf1) > vnet-tunnel-network-add name *name-string* network *ip-address* netmask *netmask*

CLI (network-admin@Leaf1) > trunk-modify name *name-string* trunk-id *trunk-id* port *port-list*

4. Create the SSL/TLS certificate:

CLI (network-admin@Leaf1) > cert-create name *name-string* country *country-string* state *state-string* city *city-string* organization *organization-string* organizational-unit *organizational-unit-string* common-name *common-name-string* container zone *name-string*

5. Configure OVSDB:

CLI (network-admin@Leaf1) > openvswitch-create name *name-string* vnet *name-string* global-vtep tunnel-ip *ip-address* dedicated-service cert-name *name-string*

CLI (network-admin@Leaf1) > openvswitch-interface-add ovs-name *name-string* ip *ip-address* netmask *netmask* if data|mgmt vlan *vlan-id*

Configuring the interface as data or management depends on the location of the controller, on the data network or the management network.

If the controller is on a Layer 3 network several hops away, use openvswitch-modify to configure a gateway IP address. This is required in order for the configuration to work properly.

6. Add the hardware VTEP manager:

```
CLI (network-admin@Leaf1) > opensvswitch-hwvtep-manager-add
name name-string manager-type odl|nsx connection-method ssl ip
ip-address username username-string password password-
string port port-number
```

Netvisor automatically establishes the VXLAN tunnel between the local and remote hardware and software VTEPs.

If you connect to VMware NSX controllers, you must use SSL or TLS to securely connect with the hardware VTEP.

Using OpenSSL TLS Certificates for OVSDB and other Services

This feature provides a common Transport Layer Socket (TLS) within Netvisor One that you can use for any service such as the Open vSwitch Database Management Protocol (OVSDB) or a Web service. TLS is needed for any SSL connection to a Netvisor One service. For OVSDB, it is needed to connect to a controller using SSL.

For HTTPS communication between a REST API client and the Tomcat application server which is running a switch, you need to configure and deploy a server certificate in a Tomcat server.

You can create one common certificate for all Netvisor One services or create multiple named certificates. Each service can use a different certificate identified by name or container name or zone.

The Certificate facility keeps track of certificate use by using various applications. It notifies the applications when a certificate is updated and it also prevents a certificate from being deleted if an application is using it.

There are two ways to generate certificates:

- Self-signed certificate
- Certificate signed by a Certificate Authority (CA)

Self-signed Certificate

If you want to generate a self-signed certificate use the cert-create command. This command creates a server certificate and self-signs it.

Certificate signed by a Certificate Authority (CA)

If you want to generate a certificate that is signed by a CA, follow these steps:

1. Create a certificate signing request.
2. Export the certificate signing request and send it to the CA administrator.
3. Import the certificate received from CA administrator against the right certificate signing request.
4. Import the intermediate root and root certificate to the switch, if not done already.

CLI Commands

These commands allow you to manage TLS certificates. These commands are also available for REST API.

To create a server certificate that self-signs, use the `cert-create` command:

```
CLI (network-admin@Leaf1) > cert-create country country-
string state state-string city city-string organization
organization-string organizational-unit organization-unit-
```

```
string common-name common-name-string name name-
string [container/zone name]
```

`cert-create`	Creates a server certificate and self-sign.
`country country-string`	Specify a country name (two letter code).
`state state-string`	Specify a state or province name.
`city city-string`	Specify a city name.
`organization organization-string`	Specify an organization name.
`organizational-unit organizational-unit-string`	Specify an organizational unit name.
`common-name common-name-string`	Specify a common name.
`name name-string`	Specify a certificate name.
any of the following options:	
`container zone name`	Specify a certificate zone name.

To delete a certificate, use the `cert-delete` command:

```
CLI (network-admin@Leaf1) > cert-delete name name-string
[container/zone name]
```

`cert-delete`	Deletes a certificate.
`name name-string`	Specify a country name (two letter code).
any of the following options:	
`container zone name`	Specify a certificate zone name.

To import a CA certificate file, use the `cert-import` command:

```
CLI (network-admin@Leaf1) > cert-import name name-string file-
ca file-ca-string [container zone name][file-inter file-inter-
string]
```

`cert-import`	Imports certificates from the SFTP directory.
`name name-string`	Specify a certificate name.
`file-ca file-ca-string`	Specify the name of CA certificate file.
`file-server file-server-string`	Specify the name of server certificate file.
any of the following options:	

`container zone` *`name`*	Specify a certificate zone name.
any of the following options:	
`file-inter file-inter-string`	Specify the name of intermediate CA certificate file.

To import a server certificate file, use the `cert-import` command:

```
CLI (network-admin@Leaf1) > cert-import name name-string file-
server file-server-string [container zone name][file-ca file-
ca-string]file-inter  file-inter-string]
```

`cert-import`	Imports certificates from SFTP directory.
`name` *`name-string`*	Specify the certificate name.
`file-server` *`file-server-string`*	Specify the name of server certificate file.
`at least one of the following options:`	
`container` *`zone name`*	Specify a certificate zone name.
any of the following options:	
`file-ca` *`file-ca-string`*	Specify the name of the CA certificate file.
`file-inter file-inter-string`	Specify the name of the intermediate CA certificate file.

To create a certificate signing request, use the `cert-request-create` command:

```
CLI (network-admin@Leaf1) > cert-request-create name name-
string [container/zone name]
```

`cert-request-create`	Create a certificate signing request from an existing server certificate.
`name` *`name-string`*	Specify the certificate name.
at least one of the following options:	
`container zone` *`name`*	Specify a certificate zone container name.

To display a certificate signing request, use the `cert-request-show` command:

```
CLI (network-admin@Leaf1) > cert-request-show name name-string
[container/zone name]cert-request cert-request-name

-----------------------------------------------------------------
-----BEGIN CERTIFICATE REQUEST-----
MIICnDCCAYQCAQEwVzELMAkGA1UEBhMCdXMxCzAJBgNVBAgMAmNhMQswCQYDVQQH
DAJtcDELMAkGA1UECgwCcGwxDTALBgNVBAsMBGVuZ2cxEjAQBgNVBAMMCXBsdXJp
```

```
YnVzMTCCASIwDQYJKoZIhvcNAQEBBQADggEPADCCAQoCggEBAMrE6Jowg0VKUw2M
NlL8vp1N8dYE/UL5pvu8FKYWgwG7tC2fjHunZCI0XmssFtZysQul/r9nk+edA5tt
0zIWRmqTB60wnWmzl6uGymeAsC9OSm0ZHFc9zZfUxKjRM/n1dOri3Pw/rODbCjM9
qwO5hsvZc/c1o3ajYFrj1yMlKDIiPW1td1VTpc5TL6wCwnDM697Yb9oQ0cbLKTDl
w5AjQSgJK29rLUl8ptAZXIUkeendpE4MCYrl6Hd+ziOJHXncj65MJyfANTZMrtGD
IJD3m+JsKZt882vMw3AZ3C9WEuE0OZrbabGBHqVKARik2qFhu2bGjlbuj/M6TOf5
Jj1WROUCAwEAAaAAMA0GCSqGSIb3DQEBBQUAA4IBAQCh1YhXRNwkwmw3FVH4H0Xi
rczy0FkyHkdSbIUIf+6n3qroRpBpcEdrx8fREyiw8hLUks9OcUlT+nSshsWIitI7
R5dcFlyo5HUVjqQQVMlSq3j4fM9XE8y8KRMZ3mfLXRTmuFPxbBuE3ZGjlBSLnBgK
ODqHF1gVa4u7l9mO3TRXczLQiAPaw38/kxEwkh4erJp4jjXf8K0h9JMGvYONYWeI
1PbiZpjIWDLNbg6sKqqrPAxEAjzGNMgNPIMXRepmEmnC/BaLVA04noZran8LRLNp
Id41o3TnlXiAodF/Mc7H5fI1hYf0YzWDSfz3PNufn6Dusu5M2ma7jtWlEdBW8huH
-----END CERTIFICATE REQUEST-----
```


To display certificates, use the `cert-show` command:

```
CLI (network-admin@Leaf1) > cert-show [cert-type ca|
intermediate|server] [subject subject-string] [issuer issuer-
string] [serial-number serial-number-number] [valid-from
valid-from-string] [valid-to valid-to-string] [country
country-string] [state state-string] [city city-string]
[organization organization-string] [organizational-unit
organizational-unit-string] [common-name common-name-string]
[ name name-string] [container/zone name]
```

```
name   used-by cert-type container subject
----- ------- --------- --------- ---------------------------------------
cert3                ca                                        /C=us/ST=ca/L=mp/O=pl/OU=engg/C
cert3                server                                 /C=us/ST=ca/L=mp/O=pl/OU=engg/CN=pl
cert1  ovs        ca                           /C=US/ST=CA/L=PA/O=ovs/OU=ou/CN=Pluribus
cert1  ovs         server                        /C=US/ST=CA/L=PA/O=ovs/OU=ou/CN=Pluribus
```

Configuring OpenvSwitch for Certificates

The following openvswitch-create and `openvswitch-modify` command options allow you to specify a certificate name when creating an OpenvSwitch configuration.

```
CLI (network-admin@Leaf1) > openvswitch-create name name-
string [cert-name cert-name string[ [ca-cert-name ca-cert-
name-string] [cert-location none|global|container]
```

`openvswitch create`	Create an OpenvSwitch configuration.
any of the following options:	
`cert-name cert-name-string`	Specify the certificate name for SSL connections.
`ca-cert-name ca-cert-name-string`	Specify the CA Certificate name for SSL connection.
`cert-location none|global|container`	Specify the certificate location - global or within the container.

```
CLI (network-admin@Leaf1) > openvswitch-modify name name-
string [cert-name cert-name string[ [ca-cert-name ca-cert-
name-string] [cert-location none|global|container]
```

`cert-name cert-name-string`	Specify the certificate name for SSL connections.
`ca-cert-name ca-cert-name-string`	Specify the certificate name for SSL connections.
`cert-location none|global|container`	Specify the certificate location - global or within the container.

Open Virtual Switch Database (OVSDB) Error Reporting

Netvisor One now supports an error-reporting mechanism for OVSDB and VTEPs. When an error occurs, Netvisor One sends a schema change to the OVSDB controller.

As more functionality is added to Netvisor One for OVSDB, OVSDB error reporting adds new errors to support the new functionality.

OpenStack ML2 Plugin

The Pluribus Networks OpenStack ML2 Plugin is available from Netvisor ONE 5.2.0 release onward. This feature is available on all whitebox platforms.

To understand and configure the Pluribus Networks OpenStack ML2 plugin, see the Netvisor® ONE Openstack ML2 Plugin Deployment Guide from the Pluribus Networks Website.

Open Source Acknowledgments

The Pluribus Networks Netvisor One Command Line Interface (CLI) used the following Open Source Software:

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@description Paginate, search and sort HTML tables
@version   1.9.4
@file   jquery.dataTables.js
@author   Allan Jardine (www.sprymedia.co.uk)
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jquery.hotkeys.js

jQuery Hotkeys Plugin
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Based upon the plugin by Tzury Bar Yochay:
http://github.com/tzuryby/hotkeys
Original idea by:
Binny V A, http://www.openjs.com/scripts/events/keyboard_shortcuts/

jquery.validate.min.js

Query Validation Plugin 1.8.1
http://bassistance.de/jquery-plugins/jquery-plugin-validation/
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jstree

jsTree 1.0-rc3
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log4j

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qtip 2.0

qTip2 - Pretty powerful tooltips - v2.0.0 - 2012-10-03
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raphael 2.1.0

Raphaël 2.1.0 - JavaScript Vector Library
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Eve 0.4.2 - JavaScript Events Library
Author Dmitry Baranovskiy (http://dmitry.baranovskiy.com/)

Rickshaw v1.1.2

Adapted from https://github.com/Jakobo/PTClass */

Based on Alex Arnell's inheritance implementation.
section: Language
class Class
Manages Prototype's class-based OOP system.
Refer to Prototype's web site for a [tutorial on classes and inheritance] (http://prototypejs.org/learn/class-inheritance).

science.js 1.7.0

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sizzle

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tcl 8.5.9

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tcllib 1.13

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tclreadline 2.1.0

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Underscore.js v1.1.7

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