CUMULUS LINUX BOOTCAMP: LAB GUIDE

Scope

This workbook covers configuration of network protocols on Cumulus Linux Network Operating System.

Audience

This workbook is intended for Technical Training students.

Objectives

By the end of this workbook, students will be able to:

* Configure basic switch functions with Cumulus Linux
* Configure layer 2 and layer 3 protocols with Cumulus Linux
* Verify configuration and connectivity
* Monitor and troubleshoot networking related connectivity issues

Overview

Each student will be using the Cumulus Air © platform, exercises in this workbook on a group of devices (servers and switches).

Notice

Please follow the instructions below carefully to successfully complete the practice.   
If you encounter technical issues, please contact the Nvidia Networking Academy team:   
[nbu-academy-support@nvidia.com](mailto:nbu-academy-support@nvidia.com)

**Release Date**

Revision 2.2 – January 2021

Good Luck,   
NVIDIA Networking Academy team

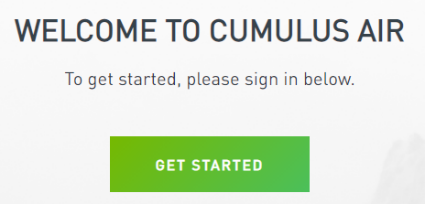
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# PREREQUISITES AND GUIDELINES

Please perform and review the following steps before you start:

1. Enter the Cumulus Air web page : <https://air.cumulusnetworks.com/Login>  
   Click “GET STARTED” button.



* Graphical user interface, text, application, chat or text message

  Description automatically generatedIf you have already created an account,   
  use your credentials to Login.
* To sign up for the first time, click “Register”   
  and fill in your details.

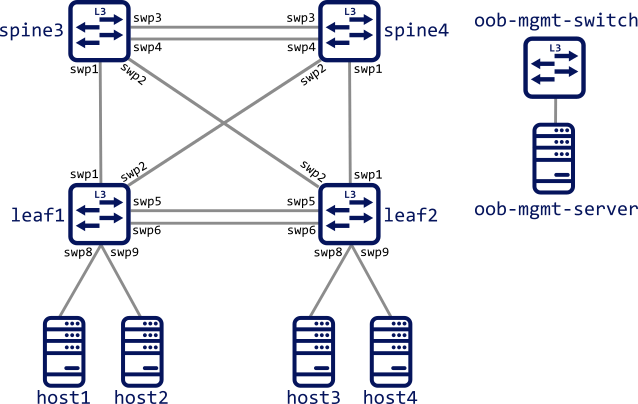
Once completed, a confirmation email will   
be sent, open it to activate your new account.

1. Once you are logged in, you will reach the “Cumulus in The Cloud” dashboard.   
   Wait for the lab to be Loaded.
2. Click on the “Academy ILT” label.



## ACADEMY LAB TOPOLOGY

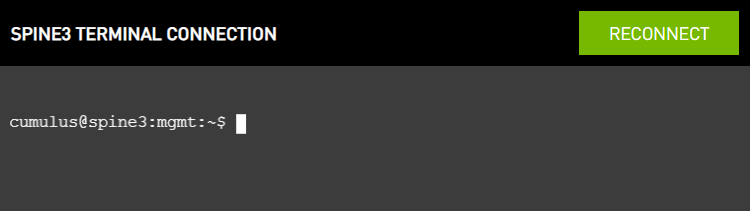
The training lab is organized in the following topology:



## ACADEMY LAB ACCESS

Graphical user interface

Description automatically generatedClick on a NODE to open its console

1. When the login prompt appears, enter the username – “**cumulus**”
2. When the password prompt appears, enter the password– “**Academy123**” and press Enter.
3. You should now be prompted with the node’s name. This indicates that you have successfully accessed the **node**.

## PRACTICE 1: USING THE NCLU

Practice Objectives:

In this practice session you will become familiar with the Cumulus Linux NCLU:

* You will use ‘**net add**’ and ‘**net del**’ commands to change the configuration
* You will use ‘**net commit**’ command to apply configuration changes
* You will use ‘**net show**’ commands to validate the configuration
* Last, you will use ‘**net rollback**’ command to roll back to a previous configuration

Task 1: Retrieve system information

1. Identify the switch image version:

**# net show system**

cumulus@spine3:mgmt:~$ net show system

Hostname......... spine3

Build............ Cumulus Linux 4.2.0

Uptime........... 1:18:20.020000

Model............ Cumulus VX

Memory........... 922MB

Vendor Name...... Cumulus Networks

Part Number...... 4.2.0

Base MAC Address. 44:38:39:00:00:20

Serial Number.... 44:38:39:00:00:20

Product Name..... VX

Task 2: Configure the switch with NCLU

1. Display the switch ports:

**# net show interface**

cumulus@spine3:mgmt:~$ net show interface

State Name Spd MTU Mode LLDP Summary

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

UP lo N/A 65536 Loopback IP: 127.0.0.1/8

lo IP: ::1/128

UP eth0 1G 1500 Mgmt oob-mgmt-switch (swp4) Master: mgmt(UP)

eth0 IP: 192.168.200.5/24(DHCP)

UP mgmt N/A 65536 VRF IP: 127.0.0.1/8

1. Bring up the switch ports:
   * On the spine switches bring up **swp1-4**.

**# net add interface swp1-4**

**# net commit**

cumulus@spine3:mgmt:~$ net add interface swp1-4

cumulus@spine3:mgmt:~$ net commit

cumulus@spine3:mgmt:~$ net show interface

State Name Spd MTU Mode LLDP Summary

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

UP lo N/A 65536 Loopback IP: 127.0.0.1/8

lo IP: ::1/128

UP eth0 1G 1500 Mgmt oob-mgmt-switch (swp4) Master: mgmt(UP)

eth0 IP: 192.168.200.5/24(DHCP)

UP swp1 1G 9216 Default

UP swp2 1G 9216 Default

UP swp3 1G 9216 Default

UP swp4 1G 9216 Default

UP mgmt N/A 65536 VRF IP: 127.0.0.1/8

* + On the leaf switches bring up ports swp1-2,5-6,8-9

**# net add interface swp1-2,5-6,8-9**

**# net commit**

cumulus@leaf2:mgmt:~$ net add int swp1-2,5-6,8-9

cumulus@leaf2:mgmt:~$ net commit

cumulus@leaf2:mgmt:~$ net show interface

State Name Spd MTU Mode LLDP Summary

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

UP lo N/A 65536 Loopback IP: 127.0.0.1/8

lo IP: ::1/128

UP eth0 1G 1500 Mgmt oob-mgmt-switch (swp3) Master: mgmt(UP)

eth0 IP: 192.168.200.4/24(DHCP)

UP swp1 1G 9216 Default spine4 (swp1)

UP swp2 1G 9216 Default spine3 (swp2)

UP swp5 1G 9216 Default leaf1 (swp5)

UP swp6 1G 9216 Default leaf1 (swp6)

UP swp8 1G 9216 Default

UP swp9 1G 9216 Default

UP mgmt N/A 65536 VRF IP: 127.0.0.1/8

1. On switch **leaf1** add an alias to each of the interfaces which are part of the lab topology. The alias should describe the device which is connected to the interface.   
   For example:

* Interface **swp8** is connected to server **host1**
* Interface **swp1** is connected to switch **spine3**

**# net add interface *<INTERFACE>* alias *<TEXT>***

cumulus@leaf1:mgmt:~$ net add interface swp8 alias Connected to host1:Eth2

cumulus@leaf1:mgmt:~$ net add interface swp1 alias Connected to spine3:swp1

1. View the changes in the commit buffer:

**# net pending**

cumulus@leaf1:mgmt:~$ net pending

auto swp1

iface swp1

+ alias Connected to spine3:swp1

auto swp8

iface swp8

+ alias Connected to host1:Eth2

1. Commit the changes with a custom description:

**# net commit description *<TEXT>***

cumulus@leaf1:mgmt:~$ net commit description **Practice-1**

auto swp1

iface swp1

+ alias Connected to spine3:swp1

auto swp8

iface swp8

+ alias Connected to host1:Eth2

net add/del commands since the last "net commit"

================================================

User Timestamp Command

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

cumulus 2020-10-11 09:52:20.747134 net add interface swp8 alias Connected to host1:Eth2

cumulus 2020-10-11 09:52:30.206711 net add interface swp1 alias Connected to spine3:swp1

1. View the NCLU commit history:  
   **# net show commit history**

cumulus@leaf1:mgmt:~$ net show commit history

# Date Description

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

3 2020-10-11 09:43:46 nclu "net commit" (user cumulus)

5 2020-10-11 09:57:55 nclu **Practice-1**

Task 3: Rollback the Configuration

1. Rollback to the last commit:  
   **# net rollback last**

cumulus@leaf1:mgmt:~$ net rollback last

1. Verify rollback was applied successfully:  
   **# net show configuration**

cumulus@leaf1:mgmt:~$ net show configuration

<output omitted>

interface swp1

interface swp8

Please note:

* At this point all configuration is deleted because the configuration has been reverted to a point before any configuration existed.
* Alternatively, you can roll back to any commit by referencing the unique commit number or description.

## PRACTICE 2: BASIC SWITCH FUNCTIONS

Practice Objectives:

In this practice session you will verify IP connectivity between servers in the lab.

* You will configure the servers IP settings – an IP address, a subnet mask and a default gateway.
* You will configure a bridge on each of the Cumulus Linux switches and add switch ports to the bridge.
* You will use **‘ping’** utility to verify communication between servers in your group.
* Last, you will observe how the switch forwarding database – the MAC address table – is built and maintained.

A close up of a sign

Description automatically generatedA close up of a sign

Description automatically generatedTopology Used in this Practice:

**spine3**

**spine4**

A picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generatedA close up of a sign

Description automatically generatedA close up of a sign

Description automatically generated

**leaf2**

**leaf1**

**host3**

**host4**

**host2**

**host1**

**172.16.1.X**

**172.16.1.X**

**Eth2**

**172.16.1.X**

**swp1**  
**trunk**

**swp1**  
**trunk**

**swp2**  
**trunk**

**Eth2**

**Eth2**

**Eth2**

**swp8**  
**access**

**swp9**  
**access**

**swp8**  
**access**

**swp9**  
**access**

**swp2**  
**trunk**

**172.16.1.X**

Task 1: Configure Servers IP Settings

1. Access the servers and check interface **’eth2’** IP settings:

**# ifconfig *<DEV>***

cumulus@host1:~$ ifconfig eth2

eth2: flags=4098<BROADCAST,MULTICAST> mtu 1500

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 0 bytes 0 (0.0 B)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 0 bytes 0 (0.0 B)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

1. Configure an IP address and a subnet mask for interface **’eth2’***.*

Use the following table for IP address assignment.   
Use **/24** as the subnet mask.

|  |  |
| --- | --- |
| Practice Lab Servers Properties | |
| Server | ‘eth2’ IP Address |
| host1 | 172.16.1.1 |
| host2 | 172.16.1.2 |
| host3 | 172.16.1.3 |
| host4 | 172.16.1.4 |

**# ifconfig *<DEV> <IP/MASK>***

cumulus@host1:~$ sudo ifconfig eth2 0.0.0.0

cumulus@host1:~$ sudo ifconfig eth2 172.16.1.1/24

cumulus@host1:~$ ifconfig eth2

eth2: flags=4098<BROADCAST,MULTICAST> mtu 1500

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 0 bytes 0 (0.0 B)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 0 bytes 0 (0.0 B)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0 RX errors 0 dropped 3 overruns 0 frame 0

TX packets 10 bytes 1086 (1.0 KB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0 RX errors 0 dropped 0 overruns 0 frame 0

TX packets 270015 bytes 51701450 (49.3 MiB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

1. Verify a static route entry to **172.16.0.0/16** via interface **’eth2’**:

**# route**

cumulus@host1:~$ route

Kernel IP routing table

Destination Gateway Genmask Flags Metric Ref Use Iface

default \_gateway 0.0.0.0 UG 0 0 0 eth0

172.16.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth2

192.168.200.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0

* If the static route is missing, add it:  
  **# ip route add *<ADDRESS/MASK>* dev *<DEV>***

cumulus@host1:~$ sudo ip route add 172.16.0.0/16 dev eth2

cumulus@host1:~$ sudo ip route add 172.16.0.0/16 dev eth2

cumulus@host1:~$ route

Kernel IP routing table

Destination Gateway Genmask Flags Metric Ref Use Iface

default \_gateway 0.0.0.0 UG 0 0 0 eth0

172.16.0.0 0.0.0.0 255.255.0.0 U 0 0 0 eth2

172.16.1.0 0.0.0.0 255.255.255.0 U 0 0 0 eth2

192.168.200.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0

Task 2: Configure a Bridge

1. Access the switches and reset configuration:

**# net del all**

**# net commit**

cumulus@leaf1:mgmt:~$ net del all

cumulus@leaf1:mgmt:~$ net commit

1. On all four switches – leaves and spines - create a bridge add VLAN1 and set the inter switch links (**swp1** and **swp2**) as trunk ports:

**# net add bridge bridge ports *<PORTS>***

**# net add bridge bridge vids *<VLANS>***

cumulus@leaf1:mgmt:~$ net add bridge bridge ports swp1-2

cumulus@leaf1:mgmt:~$ net add bridge bridge vids 1

1. On the leaf switches only – leaf1 and leaf2 - set the host-facing ports, swp8 and swp9, as access ports in VLAN 1:  
     
   **# net add interface *<PORTS>* bridge access *<VLAN-ID>***

cumulus@leaf1:mgmt:~$ net add bridge bridge ports swp8-9

cumulus@leaf1:mgmt:~$ net add interface swp8-9 bridge access 1

1. Commit changes:  
   **# net commit**

cumulus@leaf1:mgmt:~$ net commit

1. Verify configuration:  
   **# net show configuration**

cumulus@leaf1:mgmt:~$ net show configuration

interface swp8

bridge-access 1

interface swp9

bridge-access 1

interface bridge

bridge-ports swp1 swp2 swp8 swp9

bridge-vids 1

bridge-vlan-aware yes

1. Verify interfaces status:

**# net show interface**

cumulus@leaf1:mgmt:~$ net show interface

State Name Spd MTU Mode LLDP Summary

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

UP lo N/A 65536 Loopback IP: 127.0.0.1/8

lo IP: ::1/128

UP eth0 1G 1500 Mgmt oob-mgmt-switch (swp2) Master: mgmt(UP)

eth0 IP: 192.168.200.3/24(DHCP)

UP swp1 1G 9216 Access/L2 spine3 (swp1) Master: bridge(UP)

UP swp2 1G 9216 Access/L2 spine4 (swp2) Master: bridge(UP)

UP swp8 1G 9216 Access/L2 host1 (44:38:39:00:00:11) Master: bridge(UP)

UP swp9 1G 9216 Access/L2 Master: bridge(UP)

UP bridge N/A 9216 Bridge/L2

UP mgmt N/A 65536 VRF IP: 127.0.0.1/8

Please note:

Even though **swp1-2** were configured in ‘trunk’ mode, they are displayed in the output in ‘Access’ mode. The reason is that currently only VLAN1 is configured and no frames are sent tagged over those ports.   
Once you configure additional VLANs, those ports will be displayed in ‘trunk’ mode indicating they are tagging frames.

Task 3: Observe a Switch’s Forwarding Database

1. Identify the MAC addresses of all four servers in your group.

cumulus@host1:~$ ifconfig eth2

eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500

inet 172.16.1.1 netmask 255.255.255.0 broadcast 172.16.1.255

inet6 fe80::4638:39ff:fe00:11 prefixlen 64 scopeid 0x20<link>

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 1159 bytes 79499 (79.4 KB)

RX errors 0 dropped 182 overruns 0 frame 0

TX packets 71 bytes 13388 (13.3 KB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

Fill in the table with the MAC addresses of **’**eth2**’** interfaces of the servers:

|  |  |
| --- | --- |
| Server | MAC address of interface **’**eth2**’** |
|  |  |
|  |  |
|  |  |
|  |  |

1. Use ‘**ping’** from one server to another server in the lab.   
   For example, ping from server **host1** to server **host3**.

cumulus@host1:~$ ping 172.16.1.3

PING 172.16.1.3 (172.16.1.3) 56(84) bytes of data.

64 bytes from 172.16.1.3: icmp\_seq=1 ttl=64 time=2.99 ms

64 bytes from 172.16.1.3: icmp\_seq=2 ttl=64 time=2.28 ms

1. Display the switch’s MAC address table. Identify on which switch ports the servers’ MAC addresses were learned?  
   **# net show bridge macs**

cumulus@leaf2:mgmt:~$ net show bridge macs

VLAN Master Interface MAC TunnelDest State Flags LastSeen

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

1 bridge swp1 44:38:39:00:00:09 00:00:15

1 bridge swp2 44:38:39:00:00:07 00:00:01

1 bridge swp2 44:38:39:00:00:11 00:01:29

1 bridge swp8 44:38:39:00:00:15 00:00:23

## PRACTICE 3: VLANs AND TRUNKING

Practice Objectives:

In this practice session you will configure and verify VLANs and trunking:

* You will configure two new VLANs and assign switch ports connected to servers to the configured VLANs.
* You will configure SVIs to allow inter-VLAN communication.

Topology Used in this Lab:



**swp1**  
**trunk**

**swp2**  
**trunk**

**swp1**  
**trunk**



**leaf1**

**spine4**

**spine3**

**leaf2**

**swp8**  
**access**

**swp9**  
**access**

**swp8**  
**access**

**swp9**  
**access**



**VLAN2**

**VLAN3**

**VLAN2**

**VLAN3**



Task 1: Configuring VLANs and Trunking

1. Access the switch that was assigned to you and reset configuration:

**# net del all**

**# net commit**

cumulus@leaf1:mgmt:~$ net del all

cumulus@leaf1:mgmt:~$ net commit

1. On all four switches – spines and leaves - create a bridge and set the inter switch links, **swp1** and **swp2**, as trunk ports:

**# net add bridge bridge ports *<PORTS>***

cumulus@leaf1:mgmt:~$ net add bridge bridge ports swp1-2

1. On all four switches – spines and leaves - add VLANs 2-3 to the bridge:

cumulus@leaf1:mgmt:~$ net add bridge bridge vids 2,3

1. On leaf switches only **leaf1** and **leaf2** set the host-facing ports, swp8 and swp9, as access ports and associate them to the appropriate VLAN:   
   interface **swp8** in **VLAN2** and interface **swp9** in **VLAN3**  
   **# net add interface *<PORTS>* bridge access *<VLAN-ID>***

cumulus@leaf1:mgmt:~$ net add bridge bridge ports swp8-9

cumulus@leaf1:mgmt:~$ net add interface swp8 bridge access 2

cumulus@leaf1:mgmt:~$ net add interface swp9 bridge access 3

1. Commit changes:

cumulus@leaf1:mgmt:~$ net commit

1. Verify configuration:

cumulus@leaf1:mgmt:~$ net show configuration

interface swp8

bridge-access 2

interface swp9

bridge-access 3

interface bridge

bridge-ports swp1 swp2 swp8 swp9

bridge-vids 1-3

bridge-vlan-aware yes

1. Verify VLANs configuration:

**# net show bridge vlan**

cumulus@leaf1:mgmt:~$ net show bridge vlan

Interface VLAN Flags

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

swp1 1 PVID, Egress Untagged

2-3 []

swp2 1 PVID, Egress Untagged

2-3 []

swp8 2 PVID, Egress Untagged

swp9 3 PVID, Egress Untagged

Please note:

* Access ports are shown with a single line representing the VLAN associated to the port.
* Trunk ports are shown with multiple lines representing the VLANs associated with the trunk port.

Task 2: Servers’ IP settings

Access the servers and configure an IP address for interface **‘eth2’** according to the table below.  
  
Servers in the same VLAN will be configured with IP addresses in the same subnet, hence they will be able to communicate over the layer 2 network.

|  |  |  |
| --- | --- | --- |
| VLAN ID | Server | ‘eth2’ IP Address |
| VLAN 2 | host1 | 172.16.2.18/24 |
| VLAN 3 | host2 | 172.16.3.19/24 |
| VLAN 2 | host3 | 172.16.2.28/24 |
| VLAN 3 | host4 | 172.16.3.29/24 |

1. Configure the server’s IP address and subnet mask:

* Clear existing IP configuration:  
  **# ifconfig eth2 0.0.0.0**
* Configure an IP address and a subnet mask:

**# ifconfig eth2 *<IP/MASK>***

* Verify IP configuration:

**# ifconfig eth2**

cumulus@host1:~$ sudo ifconfig eth2 0.0.0.0

cumulus@host1:~$ sudo ifconfig eth2 172.16.2.18/24

cumulus@host1:~$ ifconfig eth2

eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500

inet 172.16.2.18 netmask 255.255.255.0 broadcast 172.16.2.255

inet6 fe80::4638:39ff:fe00:11 prefixlen 64 scopeid 0x20<link>

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 2946 bytes 202184 (202.1 KB)

RX errors 0 dropped 182 overruns 0 frame 0

TX packets 190 bytes 38098 (38.0 KB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

1. Verify a static route entry to network **172.16.0.0/16** via the default gateway’s address. Use the default gateway address in the following table:

|  |  |
| --- | --- |
| VLAN ID | Default gateway address |
| VLAN 2 | 172.16.2.254/24 |
| VLAN 3 | 172.16.3.254/24 |

**# ip route add *<NET\_ADDRESS/MASK>* dev *<DEV>* via <*IP>***

cumulus@host1:~$ sudo ip route add 172.16.0.0/16 dev eth2 via 172.16.2.254

cumulus@host1:~$ route

Kernel IP routing table

Destination Gateway Genmask Flags Metric Ref Use Iface

default \_gateway 0.0.0.0 UG 0 0 0 eth0

172.16.0.0 172.16.2.254 255.255.0.0 UG 0 0 0 eth2

172.16.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth2

192.168.200.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0

1. Use ‘**ping’** to check communication between servers in the same VLAN.   
   For example servers **host1**and **host3**.

[cumulus@host1 ~]# ping 172.16.2.28

PING 172.16.2.28 (172.16.2.28) 56(84) bytes of data.

64 bytes from 172.16.2.28: icmp\_seq=1 ttl=64 time=4.11 ms

64 bytes from 172.16.2.28: icmp\_seq=2 ttl=64 time=2.58 ms

Task 3: Configuring SVIs for inter-VLAN routing

1. On switch **spine3** configure two SVIs (Switch VLAN Interfaces) that will be used for routing between VLAN2 and VLAN3:
   * Interface **vlan2** will serve as the default gateway for **VLAN2**
   * Interface **vlan3** will serve as the default gateway for **VLAN3**

Use the following table for IP address assignment:

|  |  |
| --- | --- |
| Interface vlan 2 | 172.16.2.254/24 |
| Interface vlan 3 | 172.16.3.254/24 |

**# net add vlan *<VID>* ip address *<IP/MASK>***

cumulus@spine3:mgmt:~$ net add vlan 2 ip address 172.16.2.254/24

cumulus@spine3:mgmt:~$ net add vlan 3 ip address 172.16.3.254/24

cumulus@spine3:mgmt:~$ net commit

1. Use ‘**ping’** and ‘**traceroute’** utilities to verify communication between hosts in different VLANs. For example, ping from server ‘**host1’** in **VLAN2** to server ‘**host2’** in **VLAN3**.

[cumulus@host1 ~]# ping 172.16.3.19

PING 172.16.3.19 (172.16.3.19) 56(84) bytes of data.

64 bytes from 172.16.3.19: icmp\_seq=1 ttl=63 time=0.155 ms

64 bytes from 172.16.23.19: icmp\_seq=2 ttl=63 time=0.192 ms64 bytes from 172.16.23.254: icmp\_seq=2 ttl=64 time=0.362 ms

[cumulus@host1 ~]# traceroute 172.16.3.19

traceroute to 172.16.3.19 (172.16.3.19), 30 hops max, 60 byte packets

1 172.16.2.254 (172.16.2.254) 1.340 ms 1.633 ms 1.607 ms

2 172.16.3.19 (172.16.3.19) 4.043 ms 4.023 ms 3.999 ms 2 172.16.3.19 (172.16.3.19) 0.155 ms 0.152 ms 0.137

## PRACTICE 4: CONFIGURING MLAG and VRR

Practice Objectives:

In this practice session you will configure the spine switches, **spine3** and **spine4**, with MLAG and VRR towards the leaf switches.

* MLAG will make the spine switches to look and behave like a single Layer 2 switch towards the Layer 2 network.
* VRR will make the spine switches to look and behave like a single router providing default gateway redundancy***.***
* Interface ‘**clag 1***’* will aggregate **swp1** on **spine3** and **swp2** on **spine4**connected to switch **leaf1**.   
  Switch **leaf1**will be configured with a regular LAG.
* Interface ‘**clag 2**’ will aggregate **swp2** on **spine3** and **swp1** on **spine4**connected to switch **leaf2**.   
  Switch **leaf2**will be configured with a regular LAG.

Topology used in this lab:



**swp1**

**swp1**

**swp2**

**Eth2**

**Eth2**

**Eth2**

**Eth2**

**access  
VLAN2**

**swp2**

**172.16.2.X**

**172.16.3.X**

**172.16.2.X**

**172.16.3.X**



**swp8**

**swp9**

**access  
VLAN3**

**swp8**

**swp9**

**access  
VLAN3**

**access  
VLAN2**

**swp1**

**swp2**

**swp1**

**swp2**

**VRRR**

**spine4**

**spine3**

**leaf1**

**leaf2**

**host1**

**host3**

**host2**

**host4**

Task 1: LAG Configuration – Leaf Switches

1. Access the leaf switches **leaf1** and **leaf2** and reset configuration:

**# net del all**

**# net commit**

cumulus@leaf1:mgmt:~$ net del all

cumulus@leaf1:mgmt:~$ net commit

1. Create a bond named ‘**BOND-TO-SPINES’**, where bonds slaves are interfaces **swp1** and **swp2**.

**# net add bond *<BOND-NAME>* bond slaves *<PORTS>***

cumulus@leaf1:mgmt:~$ net add bond BOND-TO-SPINES bond slaves swp1-2

cumulus@leaf1:mgmt:~$ net commit

1. Verify bonds configuration:

cumulus@leaf1:mgmt:~$ net show interface bonds

Name Speed MTU Mode Summary

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

DN BOND-TO-SPINES N/A 9216 802.3ad Bond Members: swp1(UP), swp2(UP)

**Please note:**

The bond interface is down because its peer (the MLAG peer) was not configured yet.

1. Create a bridge and add the bond interface, **BOND-TO-SPINES**, and the host facing interfaces, **swp8**and **swp9**, to the bridge:

cumulus@leaf1:mgmt:~$ net add bridge bridge ports swp8-9,BOND-TO-SPINES

1. Configure VLANs 2-3 and associate **swp8** to **VLAN2** and **swp9** to **VLAN3**:

cumulus@leaf1:mgmt:~$ net add interface swp8 bridge access 2

cumulus@leaf1:mgmt:~$ net add interface swp9 bridge access 3

cumulus@leaf1:mgmt:~$ net commit

**Please note:**

Commands are demonstrated on switch **leaf1**.   
Switch **leaf2** should be configured similarly.

Task 2: Configuring MLAG – spine switches

1. Access the switches and reset the configuration:

**# net del all**

**# net commit**

cumulus@spine3:mgmt:~$ net del all

cumulus@spine3:mgmt:~$ net commit

* Write down, on a side note, the IP addresses of the management ports, **eth0**. Those IP addresses will be configured as the MLAG backup-IPs.

cumulus@spine4:mgmt:~$ net show interface eth0

Name MAC Speed MTU Mode

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

UP eth0 44:38:39:00:00:22 1G 1500 Mgmt

IP Details

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

IP: **192.168.200.6/24**

cumulus@spine3:mgmt:~$ net show interface eth0

Name MAC Speed MTU Mode

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

UP eth0 44:38:39:00:00:20 1G 1500 Mgmt

IP Details

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

IP: **192.168.200.5/24**

1. Configure the spine switches, **spine3** and **spine4**, as MLAG peers.

**# net add clag peer sys-mac *<MAC>* interface *<PEERLINK-INTERFACES>* *<ROLE>* backup-ip *<IP>***

**Please note:**

* Interfaces **swp3** and **swp4** will be configured as the MLAG **peerlink**.
* Switch **spine3** is configured as the MLAG **primary** and **spine4** as the **secondary*.***
* On switch **spine3** use **spine4’s** IP as the backup-IP and vice-versa.

cumulus@spine3:mgmt:~$ **net add clag peer sys-mac 44:38:39:FF:00:01 interface swp3-4 primary backup-ip 192.168.200.6 vrf mgmt**

cumulus@spine4:mgmt:~$ **net add clag peer sys-mac 44:38:39:FF:00:01 interface swp3-4 secondary backup-ip 192.168.200.5 vrf mgmt**

1. Configure bridge settings – VLANs and STP priority:

cumulus@spine3:mgmt:~$ net add vlan 2-3

cumulus@spine3:mgmt:~$ net add bridge stp treeprio 4096

cumulus@spine4:mgmt:~$ net add vlan 2-3

cumulus@spine4:mgmt:~$ net add bridge stp treeprio 4096

1. Commit the changes:

cumulus@spine3:mgmt:~$ net commit

cumulus@spine4:mgmt:~$ net commit

Task 3: Configuring CLAG interfaces - spine switches

1. Configure two CLAG interfaces on each of the spine switches.

* Interface **‘clag 1’**will aggregate**swp1**on**spine3**and**swp2**on**spine4**which are connected to switch **leaf1**



**swp2**

**swp1**

**leaf1**

**spine4**

**spine3**



**swp2**

**swp1**

# **net add clag port bond *<BONDNAME>* interface *<PORTS>* clag-id *<ID>***

cumulus@spine4:mgmt:~$ net add clag port bond LEAF1 interface swp2 clag-id 1

cumulus@spine3:mgmt:~$ net add clag port bond LEAF1 interface swp1 clag-id 1

* Interface ‘**clag 2**’ will aggregate **swp2** on **spine3** and **swp1** on **spine4** which are connected to switch **leaf2**.



**swp1**

**swp2**

**swp1**

**swp2**



**spine4**

**spine3**

**leaf2**

cumulus@spine4:mgmt:~$ net add clag port bond LEAF2 interface swp1 clag-id 2

cumulus@spine3:mgmt:~$ net add clag port bond LEAF2 interface swp2 clag-id 2

1. Commit the changes:

cumulus@spine3:mgmt:~$ net commit

cumulus@spine4:mgmt:~$ net commit

1. View MLAG resulting configuration:

cumulus@spine3:mgmt:~$ net show configuration

interface LEAF1

bond-slaves swp1

clag-id 1

interface LEAF2

bond-slaves swp2

clag-id 2

interface bridge

bridge-ports peerlink LEAF1 LEAF2

bridge-vids 2-3

bridge-vlan-aware yes

mstpctl-treeprio 4096

interface peerlink

bond-slaves swp3 swp4

interface peerlink.4094

clagd-backup-ip 192.168.200.6 vrf mgmt

clagd-peer-ip linklocal

clagd-priority 1000

clagd-sys-mac 44:38:39:FF:00:01

1. Verify that MLAG protocol is up:  
   **# net show clag**

cumulus@spine3:mgmt:~$ net show clag

The peer is alive

Our Priority, ID, and Role: 1000 24:8a:07:cf:6a:50 primary

Peer Priority, ID, and Role: 2000 24:8a:07:cf:6d:d0 secondary

Peer Interface and IP: peerlink.4094 169.254.1.2

Backup IP: 10.143.33.188 (active)

System MAC: 44:38:39:ff:00:01

CLAG Interfaces

Our Interface Peer Interface CLAG Id Conflicts Proto-Down Reason

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

LEAF1 LEAF1 1 - -

LEAF2 LEAF2 2 - -

Task 4: Servers’ IP settings

|  |  |  |
| --- | --- | --- |
| VLAN ID | Server | ‘eth2’ IP Address |
| VLAN 2 | host1 | 172.16.2.18/24 |
| VLAN 3 | host2 | 172.16.3.19/24 |
| VLAN 2 | host3 | 172.16.2.28/24 |
| VLAN 3 | host4 | 172.16.3.29/24 |

1. Access the servers and configure an IP address for interface **‘eth2’** (see tables below).

Configure the server’s IP address and subnet mask:

* Clear existing IP configuration:  
  **# ifconfig eth2 0.0.0.0**
* Configure an IP address and a subnet mask:

**# ifconfig eth2 *<IP/MASK>***

* Verify IP configuration:

**# ifconfig eth2**

cumulus@host1:~$ sudo ifconfig eth2 0.0.0.0

cumulus@host1:~$ sudo ifconfig eth2 172.16.2.18/24

cumulus@host1:~$ ifconfig eth2

eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500

**inet 172.16.2.18** netmask 255.255.255.0 broadcast 172.16.2.255

inet6 fe80::4638:39ff:fe00:11 prefixlen 64 scopeid 0x20<link>

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 3 bytes 180 (180.0 B)

1. Verify a static route entry to network 172.16.0.0/16 via the default gateway’s address.

Use the following table for default gateway assignment.

|  |  |
| --- | --- |
| VLAN ID | Default gateway address |
| vlan 2 | 172.16.2.254/24 |
| vlan 3 | 172.16.3.254/24 |

**# ip route add *<NET\_ADDRESS/MASK>* dev *<DEV>* via *<IP>***

cumulus@host1:~$ sudo ip route add 172.16.0.0/16 dev eth2 via 172.16.2.254

cumulus@host1:~$ route

Kernel IP routing table

Destination Gateway Genmask Flags Metric Ref Use Iface

default \_gateway 0.0.0.0 UG 0 0 0 eth0

**172.16.0.0 172.16.2.254 255.255.0.0 UG 0 0 0 eth2**

172.16.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth2

192.168.200.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0

1. Use ‘**ping’** to check communication between servers in the same VLAN.   
   For example, server **host1**and **host3** in VLAN2.

[cumulus@host1 ~]# ping 172.16.2.28

PING 172.16.2.28 (172.16.2.28) 56(84) bytes of data.

64 bytes from 172.16.2.28: icmp\_seq=1 ttl=64 time=2.60 ms

64 bytes from 172.16.2.28: icmp\_seq=2 ttl=64 time=1.83 ms

1. Verify that the MLAG switches have their MAC address tables synchronized.

cumulus@spine4:mgmt:~$ net show bridge macs

VLAN Master Interface MAC TunnelDest State Flags LastSeen

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

2 bridge LEAF1 44:38:39:00:00:11 00:00:49

2 bridge LEAF2 44:38:39:00:00:15 00:00:52

3 bridge LEAF1 44:38:39:00:00:13 00:02:05

3 bridge LEAF2 44:38:39:00:00:17 00:02:05

cumulus@spine3:mgmt:~$ net show bridge macs

VLAN Master Interface MAC TunnelDest State Flags LastSeen

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

2 bridge LEAF1 44:38:39:00:00:11 00:00:49

2 bridge LEAF2 44:38:39:00:00:15 00:00:52

3 bridge LEAF1 44:38:39:00:00:13 00:02:05

3 bridge LEAF2 44:38:39:00:00:17 00:02:05

**Please note:**

* Once the MLAG configuration is completed, the spine switches appear as a single   
  Layer 2 switch towards to Layer 2 network. Hence, they are capable to provide an efficient load balancing and better network utilization for the layer 2 network.
* In the following task additionally, the spine switches will be configured as VRR routers. Thus, they will provide default gateway redundancy and efficient load balancing towards the layer 3 network.

Task 5: Configuring VRR

**Topology used in this task:**

**leaf2**

**leaf1**

**spine4**

**spine3**

Vlan 3 VIP: 172.16.3.254

Vlan 2 VIP: 172.16.2.254



**swp1**

**swp1**

**swp2**

**Eth2**

**Eth2**

**Eth2**

**Eth2**

**access  
VLAN2**

**swp2**

**172.16.2.X**

**172.16.3.X**

**172.16.2.X**

**172.16.3.X**



**swp8**

**swp9**

**access  
VLAN3**

**swp8**

**swp9**

**access  
VLAN3**

**access  
VLAN2**

**swp1**

**swp2**

**swp1**

**swp2**

**swp4**

**swp3**

1. Configure two SVIs (Switch Virtual Interfaces) on each of the spine switches, interface vlan 2 and interface vlan 3.
   * Configure an IP for each of the vlan interfaces.
   * Configure a VIP (Virtual IP) and a VMAC (Virtual MAC).
   * Use the following table for address assignment. Use /24 as the subnet mask.

|  |  |  |  |
| --- | --- | --- | --- |
| SWITCH SPINE3 | | | |
| VLAN | SVI | VIP | VMAC |
| vlan 2 | 172.16.2.252/24 | 172.16.2.254/24 | 00:00:5e:00:01:02 |
| vlan 3 | 172.16.3.252/24 | 172.16.3.254/24 | 00:00:5e:00:01:03 |
| SWITCH SPINE4 | | | |
| VLAN | SVI | VIP | VMAC |
| vlan 2 | 172.16.2.253/24 | 172.16.2.254/24 | 00:00:5e:00:01:02 |
| vlan 3 | 172.16.3.253/24 | 172.16.3.254/24 | 00:00:5e:00:01:03 |

**# net add vlan *<VLAN\_ID>* ip address *<IP/MASK>***

**# net add vlan *<VLAN\_ID>* ip address-virtual *<VMAC>* *<VIP/MASK>***

cumulus@spine4:mgmt:~$ net add vlan 2 ip address 172.16.2.253/24

cumulus@spine4:mgmt net add vlan 2 ip address-virtual 00:00:5e:00:01:02 172.16.2.254/24

cumulus@spine4:mgmt net add vlan 3 ip address 172.16.3.253/24

cumulus@spine4:mgmt net add vlan 3 ip address-virtual 00:00:5e:00:01:03 172.16.3.254/24

cumulus@spine4:~$ net commit

cumulus@spine3:mgmt:~$ net add vlan 2 ip address 172.16.2.252/24

cumulus@spine3:mgmt:~$ net add vlan 2 ip address-virtual 00:00:5e:00:01:02 172.16.2.254/24

cumulus@spine3:mgmt:~$ net add vlan 3 ip address 172.16.3.252/24

cumulus@spine3:mgmt:~$ add vlan 3 ip address-virtual 00:00:5e:00:01:03 172.16.3.254/24

cumulus@spine3:mgmt:~$ commit

1. Verify VRR configuration:

cumulus@spine3:mgmt:~$ net show interface vlan2-v0

Name MAC Speed MTU Mode

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

UP vlan2-v0 00:00:5e:00:01:02 N/A 9216 Interface/L3

IP Details

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

IP: 172.16.2.254/24

cumulus@spine3:mgmt:~$ net show interface

State Name Spd MTU Mode LLDP Summary

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

UP vlan2 N/A 9216 Interface/L3 IP: 172.16.2.252/24

UP vlan2-v0 N/A 9216 Interface/L3 IP: 172.16.2.254/24

UP vlan3 N/A 9216 Interface/L3 IP: 172.16.3.252/24

UP vlan3-v0 N/A 9216 Interface/L3 IP: 172.16.3.254/24

1. Verify VRR operation.  
   Use ‘**ping’** and ‘**traceroute’** utilities to verify communication between hosts in different VLANs.   
   For example, from ‘**host1’** in **VLAN 2** to ‘**host2’** in **VLAN 3**.

[cumulus@host1 ~]# ping 172.16.3.19

PING 172.16.3.19 (172.16.3.19) 56(84) bytes of data.

64 bytes from 172.16.3.19: icmp\_seq=1 ttl=63 time=3.83 ms

64 bytes from 172.16.3.19: icmp\_seq=2 ttl=63 time=1.90 ms

[cumulus@host1 ~]# traceroute 172.16.3.19

traceroute to 172.16.3.19 (172.16.3.19), 30 hops max, 60 byte packets

1 172.16.2.254 (172.16.2.254) 1.511 ms 1.423 ms 1.435 ms

2 172.16.3.19 (172.16.3.19) 2.182 ms 1.994 ms \*

1. Verify MLAG/VRR failover.  
   Use continuous ‘**ping’** between hosts in different VLANs.   
   For example, from server ‘**host1’** in **VLAN 2** to server ‘**host2’** in **VLAN 3**.

While **‘ping’** is running, reboot switch **spine3**. Was the traffic disrupted?

After switch **spine3**reboots, reboot switch **spine4**. Was the traffic disputed now?

What are your conclusions regarding MLAG/VRR failover?

## PRACTICE 5: CONFIGURING BGP UNNUMBERED

Practice Objectives:

In this practice session you will configure BGP Unnumbered:

* Spine switches will be configured in the same AS and each of the leaf switches will be configured in its own AS.
* BGP unnumbered will be configured on all four switches.
* eBGP sessions will be established between the spine and leaf switches.
* Leaf switches will advertise their local IP prefixes.
* By the end of this practice session you will achieve end-to-end connectivity between all servers in your group, over the BGP Autonomous Systems.

Please note:

* Commands are demonstrated on switches **leaf1** and **spine3**. You should apply similar commands on the other two switches in your group.

Topology used in this practice session:

**­­**



**swp2**

**swp2**

**swp8**

**swp9**

**swp1**

**swp2**



**swp2**

**swp1**

**swp8**

**swp9**

**swp1**



**swp1**

**AS 65101**

**AS 65102**

**AS 65100**

**spine4**

**spine3**

**leaf2**

**leaf1**

Task 1: Starting FRR

1. Access the switches and reset the configuration:

**# net del all**

**# net commit**

cumulus@leaf1:mgmt:~$ net del all

cumulus@leaf1:mgmt:~$ net commit

1. Start FRR routing daemons.   
   Edit the **/etc/frr/daemons** file. Set to ‘**yes**’ both **zebra** and **bgpd**.  
   Save and exit.

cumulus@leaf1:mgmt:~$ sudo vi /etc/frr/daemons

**zebra=yes**

**bgpd=yes**

1. Restart FRR Service.

cumulus@leaf1:mgmt:~$ sudo systemctl restart frr

Task 2: Configuring loopback interfaces

|  |  |
| --- | --- |
| Switch | Loopback IP address |
| leaf1 | 172.16.100.1/32 |
| leaf2 | 172.16.100.2/32 |
| spine3 | 172.16.100.3/32 |
| spine4 | 172.16.100.4/32 |

1. On each of the switches configure a loopback interface.

Use the following table for IP address assignment:

**# net add loopback lo ip address *<IP/MASK>***

cumulus@leaf1:mgmt:~$ net add loopback lo ip address 172.16.100.1/32

cumulus@spine3:mgmt:~$ net add loopback lo ip address 172.16.100.3/32

Task 3: Configuring BGP Unnumbered

1. Configure BGP unnumbered:

**# net add bgp autonomous-system *<LOCAL-AS>***

**# net add bgp neighbor *<INTERFACE>* interface remote-as external**

cumulus@spine3:mgmt:~$ net add bgp autonomous-system 65100

cumulus@spine3:mgmt:~$ net add bgp neighbor swp1-2 interface remote-as external

cumulus@leaf1:mgmt:~$ net add bgp autonomous-system 65101

cumulus@leaf1:mgmt:~$ net add bgp neighbor swp1-2 interface remote-as external

1. Advertise the loopback addresses and commit the changes.

**# net add bgp network *<IP/MASK>***

cumulus@leaf1:mgmt:~$ net add bgp network 172.16.100.1/32

cumulus@leaf1:mgmt:~$ net commit

cumulus@spine3:mgmt:~$ net add bgp network 172.16.100.3/32

cumulus@spine3:mgmt:~$ net commit

Please note:

Commands are demonstrated on switches **leaf1** and **spine3**. You should apply similar commands on the other two switches in your group.

1. Verify configuration:

cumulus@leaf1:mgmt:~$ net show configuration

router bgp 65101

bgp router-id 172.16.100.1

neighbor swp1 interface remote-as external

neighbor swp2 interface remote-as external

address-family ipv4 unicast

network 172.16.100.1/32

interface lo

address 172.13.100.1/32

1. Verify eBGP sessions were established:   
   Each switch should be able to see two eBGP neighbors, via interfaces **swp1** and **wp2**.

**# net show bgp summary**

cumulus@leaf1:mgmt:~$ net show bgp summary

show bgp ipv4 unicast summary

=============================

BGP router identifier 172.16.100.1, local AS number 65101 vrf-id 0

BGP table version 3

RIB entries 7, using 1344 bytes of memory

Peers 2, using 43 KiB of memory

Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd

spine3(swp1) 4 65100 1295 1294 0 0 0 00:58:16 2

spine4(swp2) 4 65100 349 420 0 0 0 00:15:22 2

Total number of neighbors 2

1. Verify loopback prefixes are reachable:

* Each switch should have in its routing table the prefixes of the other switch’s loopback interfaces.

**# net show route bgp**

cumulus@leaf1:mgmt:~$ net show route bgp

RIB entry for bgp

=================

Codes: K - kernel route, C - connected, S - static, R - RIP,

O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,

T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,

F - PBR, f - OpenFabric,

> - selected route, \* - FIB route, q - queued route, r - rejected route

B>\* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:06:41

\* via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:06:41

B>\* 172.16.100.3/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:05:52

B>\* 172.16.100.4/32 [20/0] via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:05:34

Please note:

* NEXT-HOP is the neighbor’s IPv6 Link Local Address
* BGP multipath is enabled

T­­ask 4: Advertise local IP prefixes

1. On the leaf switches, assign IP addresses to the host-facing interfaces,

**swp8** and **swp9**.  
Advertise the IP prefixes in the BGP process.  
Use the IP addresses listed in the below topology. Use /24 for the subnet mask.

**swp8**

**swp1**

**swp8**

**swp9**

**host1**

172.16.18.2

**host2**

172.16.19.2

**host3**

172.16.28.2

**host4**

172.16.29.2

172.16.18.1

172.16.19.1

**swp9**

172.16.28.1

172.16.29.1

**loopback**

172.16.100.1

172.16.100.2

**loopback**

172.16.100.4

**loopback**

**loopback**

172.16.100.3



**swp2**

**swp2**

**swp1**

**spine3**

**spine4**

**leaf2**

**leaf1**

A picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generatedA picture containing monitor, phone

Description automatically generated

**# net add interface *<INTERFACE>* ip add *<IP/MASK>***

**# net add bgp network *<IP/MASK>***

cumulus@leaf1:mgmt:~$ net add interface swp8 ip add 172.16.18.1/24

cumulus@leaf1:mgmt:~$ net add interface swp9 ip add 172.16.19.1/24

cumulus@leaf1:mgmt:~$ net add bgp network 172.16.18.0/24

cumulus@leaf1:mgmt:~$ net add bgp network 172.16.19.0/24

cumulus@leaf1:mgmt:~$ net commit

cumulus@leaf2:mgmt:~$ net add interface swp8 ip add 172.16.28.1/24

cumulus@leaf2:mgmt:~$ net add interface swp9 ip add 172.16.29.1/24

cumulus@leaf2:mgmt:~$ net add bgp network 172.16.28.0/24

cumulus@leaf2:mgmt:~$ net add bgp network 172.16.29.0/24

cumulus@leaf2:mgmt:~$ net commit

1. Verify that the remote leaf switch has learned the IP prefixes:

* Switch **leaf1** should have in its routing table the IP prefixes advertise by switch **leaf2**:
  + 172.16.28.1/24
  + 172.16.29.0/24
* Switch **leaf2** should have in its routing table the IP prefixes advertise by switch **leaf1**:
  + 172.16.18.1/24
  + 172.16.19.0/24

**# net show route bgp**

cumulus@leaf1:mgmt:~$ net show route bgp

RIB entry for bgp

=================

Codes: K - kernel route, C - connected, S - static, R - RIP,

O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,

T - Table, v - VNC, V - VNC-Direct, A - Babel, D - SHARP,

F - PBR, f - OpenFabric,

> - selected route, \* - FIB route, q - queued route, r - rejected route

B>\* 172.16.28.0/24 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:00:08

\* via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:00:08

B>\* 172.16.29.0/24 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:00:08

\* via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:00:08

B>\* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:21:36

\* via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:21:36

B>\* 172.16.100.3/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:20:47

B>\* 172.16.100.4/32 [20/0] via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:20:29

Task 5: Verify end-to-end connectivity

1. Configure the servers IP settings. Configure an IP address and a subnet mask for interface ’**eth2**’*.* Use the following tables for IP address assignment.   
   Use /24 as the subnet mask.

|  |  |  |
| --- | --- | --- |
| Server | ’eth2’ IP Address | Next Hop to 172.16.0.0/16 |
| host1 | 172.16.18.2 | 172.16.18.1 |
| host2 | 172.16.19.2 | 172.16.19.1 |
| host3 | 172.16.28.2 | 172.16.28.1 |
| host4 | 172.16.29.2 | 172.16.29.1 |

* Clear existing IP configuration:  
  **# ifconfig *<DEV>* 0.0.0.0**
* Configure an IP address and a subnet mask:  
  **# ifconfig *<DEV>* *<IP/MASK>***

cumulus@host1:~$ sudo ifconfig eth2 0.0.0.0

cumulus@host1:~$ sudo ifconfig eth2 172.16.18.2/24

cumulus@host1:~$ ifconfig eth2

eth2: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500

inet 172.16.18.2 netmask 255.255.255.0 broadcast 172.16.18.255

inet6 fe80::4638:39ff:fe00:11 prefixlen 64 scopeid 0x20<link>

ether 44:38:39:00:00:11 txqueuelen 1000 (Ethernet)

RX packets 3 bytes 180 (180.0 B)

RX errors 0 dropped 0 overruns 0 frame 0

TX packets 270015 bytes 51701450 (49.3 MiB)

TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

1. Add a route entry to 172.16.0.0/16 via interface **’eth2’**:  
   **# ip route add <ADDRESS/MASK> dev <DEV> via <IP\_ADDRESS>**

cumulus@host1:~$ route

Kernel IP routing table

Destination Gateway Genmask Flags Metric Ref Use Iface

default \_gateway 0.0.0.0 UG 0 0 0 eth0

172.16.0.0 172.16.18.1 255.255.0.0 UG 0 0 0 eth2

172.16.2.0 0.0.0.0 255.255.255.0 U 0 0 0 eth2

192.168.200.0 0.0.0.0 255.255.255.0 U 0 0 0 eth0

cumulus@host1:~$ sudo ip route add 172.16.0.0/16 dev eth2 via 172.16.18.1

1. Use ‘**ping’** and ‘**traceroute’** utilities to verify communication between servers in different Autonomous Systems.   
     
   For example, ping from server ‘**host1’** (AS 65101) to server ‘**host3’** (in AS 65102).

[cumulus@host1 ~]# ping 172.16.28.2

PING 172.16.28.2 (172.16.28.2) 56(84) bytes of data.

64 bytes from 172.16.28.2: icmp\_seq=1 ttl=61 time=4.04 ms

64 bytes from 172.16.28.2: icmp\_seq=2 ttl=61 time=2.56 ms

[cumulus@host1 ~]# traceroute 172.16.28.2

traceroute to 172.16.28.2 (172.16.28.2), 30 hops max, 60 byte packets

1 172.16.18.1 (172.16.18.1) 0.761 ms 0.927 ms 0.899 ms

2 172.16.100.3 (172.16.100.3) 1.433 ms 1.354 ms 1.372 ms

3 172.16.100.2 (172.16.100.2) 2.449 ms 2.058 ms 2.493 ms

4 172.16.28.2 (172.16.28.2) 3.215 ms 3.244 ms 3.348 ms

Please note:

The next practice relies on BGP Unnumbered configuration. Please make sure to save the configuration before exiting.

## PRACTICE 6: CONFIGURING VXLAN WITH EVPN

Practice Objectives:

In this practice session you will configure VXLAN with EVPN:

* The leaf switches will be configured as the VTEPs
* EVPN will be configured as the VXLAN control plane
* Two VXLAN Network IDs (VNIs) will be configured:
  + **VNI-10** will connect **VLAN 10** on switch **leaf1** and **VLAN 100** on switch **leaf2*.***
  + **VNI-20** will connect **VLAN 20** on switch **leaf1** and **VLAN 200** on switch **leaf2*.***
* Hosts in each VNI will be able to communicate in layer 2 over the underlay layer 3 network.

**Please note:**

The configuration in this practice session relies on the previous practice.   
Make sure that BGP Unnumbered is properly configured and fully operational.

Topology used in this practice session:



**swp1**

**swp8**

**swp9**

**swp8**

**swp9**

**swp2**

**swp1**



VLAN10

VLAN20

VLAN100

VLAN200

172.16.10.18/24

172.16.20.19/24

172.16.10.28/24

172.16.20.29/24

**swp2**

**swp2**

**swp1**

**swp2**

**swp1**

**VNI-10**

**VNI-20**

**­­**

**spine4**

**spine3**

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**leaf2**

**leaf1**

**host3**

**host4**

**host1**

**host2**

Task 1: Configuring servers IP settings

1. Configure an IP address and a subnet mask for interface ’**eth2**’*.*Use the following tables for IP address assignment. Use /24 as the subnet mask.

|  |  |
| --- | --- |
| Server | ETH2 IP Address |
| host1 | 172.16.10.18 |
| host2 | 172.16.20.19 |
| host3 | 172.16.10.28 |
| host4 | 172.16.20.29 |

* Clear existing IP configuration:  
  **# ifconfig *<DEV>* 0.0.0.0**
* Configure an IP address and a subnet mask:  
  **# ifconfig *<DEV*< *<IP/MASK>***

Task 2: Configuring VLANs

1. Access the leaf switches and configure the host-facing ports **swp8** and **swp9**.   
   First clear any existing configuration, then assign the ports to the appropriate VLAN:
   * Switch **leaf1**- assign swp8 to VLAN 10 and swp9 to VLAN 20
   * Switch **leaf2**- assign swp8 to VLAN 100 and swp9 to VLAN 200

**# net add interface *<INTERFACE>* bridge access *<VLAN>***

cumulus@leaf1:mgmt:~$ net del interface swp8-9

cumulus@leaf1:mgmt:~$ net add interface swp8 bridge access 10

cumulus@leaf1:mgmt:~$ net add interface swp9 bridge access 20

cumulus@leaf1:mgmt:~$ net commit

cumulus@leaf1:mgmt:~$ net del interface swp8-9

cumulus@leaf2:mgmt:~$ net add interface swp8 bridge access 100

cumulus@leaf2:mgmt:~$ net add interface swp9 bridge access 200

cumulus@leaf2:mgmt:~$ net commit

Task 3: Configuring VNIs

1. Access the leaf switches and configure the VNIs:
   * Create a VXLAN interface with a unique ID
   * Map the VXLAN to a VLAN
   * Configure the VXLAN’s local tunnel IP (use the VTEPs loopback)

**# net add vxlan *<VXLAN-NAME>* vxlan id *<VXLAN-ID>***

**# net add vxlan *<VXLAN-NAME>* bridge access *<VLAN-ID>***

**# net add vxlan *<VXLAN-NAME>* vxlan local-tunnelip *<IP-ADRESS>***

**# net commit**

* On switch **leaf1**:   
  VNI-10 will be mapped to VLAN 10 and VNI-20 will be mapped to VLAN 20***.***VXLAN’s local tunnel IP is 172.16.100.1
* On switch **leaf2**:   
  VNI-10 will be mapped to VLAN 100 and VNI-20 will be mapped to VLAN 200***.***VXLAN’s local tunnel IP is 172.16.100.2

cumulus@leaf2:mgmt:~$ net add vxlan VNI-10 vxlan id 10

cumulus@leaf2:mgmt:~$ net add vxlan VNI-10 bridge access 100

cumulus@leaf2:mgmt:~$ net add vxlan VNI-10 vxlan local-tunnelip 172.16.100.2

cumulus@leaf2:mgmt:~$ net add vxlan VNI-20 vxlan id 20

cumulus@leaf2:mgmt:~$ net add vxlan VNI-20 bridge access 200

cumulus@leaf2:mgmt:~$ net add vxlan VNI-20 vxlan local-tunnelip 172.16.100.2

cumulus@leaf2:mgmt:~$ net commit

cumulus@leaf1:mgmt:~$ net add vxlan VNI-10 vxlan id 10

cumulus@leaf1:mgmt:~$ net add vxlan VNI-10 bridge access 10

cumulus@leaf1:mgmt:~$ net add vxlan VNI-10 vxlan local-tunnelip 172.16.100.1

cumulus@leaf1:mgmt:~$ net add vxlan VNI-20 vxlan id 20

cumulus@leaf1:mgmt:~$ net add vxlan VNI-20 bridge access 20

cumulus@leaf1:mgmt:~$ net add vxlan VNI-20 vxlan local-tunnelip 172.16.100.1

cumulus@leaf1:mgmt:~$ net commit

Task 4: Configuring EVPN

1. Access the spine switches and configure EVPN.

Switch **spine4** should be configured similarly.

**# net add bgp evpn neighbor *<INTERFACE>* activate**

cumulus@spine3:mgmt:~$ net add bgp evpn neighbor swp1-2 activate

cumulus@spine3:mgmt:~$ net commit

1. Access the leaf switches and configure EVPN to advertise all VNIs (EVPN allows VTEPs to exchange VNI membership information).  
   Switch **leaf2** should be configured similarly.

**# net add bgp evpn neighbor *<INTERFACE>* activate**

**# net add bgp evpn advertise-all-vni**

cumulus@leaf1:mgmt:~$ net add bgp evpn neighbor swp1-2 activate

cumulus@leaf1:mgmt:~$ net add bgp evpn advertise-all-vni

cumulus@leaf1:mgmt:~$ net commit

cumulus@leaf1:~$ net commit

1. Verify VXLAN Information.

**# net show evpn vni *<VNI>***

cumulus@leaf1:mgmt:~$ net show evpn vni 10

VNI: 10

Type: L2

Tenant VRF: default

VxLAN interface: VNI-10

VxLAN ifIndex: 12

Local VTEP IP: 172.16.100.1

Mcast group: 0.0.0.0

Remote VTEPs for this VNI:

172.16.100.2 flood: HER

Number of MACs (local and remote) known for this VNI: 2

Number of ARPs (IPv4 and IPv6, local and remote) known for this VNI: 0

Advertise-gw-macip: No

Task 5: Verify end-to-end communication

* Each VNI is a logical layer 2 network over the underlay layer 3 network.  
  Logically there are no layer 3 hops between hosts in the same VNI.
* Use ‘**ping**’ and ‘**traceroute**’ utilities to verify end-to-end communication between hosts in a VNI. For example, from host ‘**host1**’ to ‘**host3**’ that are configured in VNI-10.

[cumulus@host1 ~]# ping 172.16.10.28

PING 172.16.10.28 (172.16.10.28) 56(84) bytes of data.

64 bytes from 172.16.10.28: icmp\_seq=1 ttl=64 time=7.19 ms

[cumulus@host1 ~]# traceroute 172.16.10.28

traceroute to 172.16.10.28 (172.16.10.28), 30 hops max, 60 byte packets

1 172.16.10.28 (172.16.10.28) 4.887 ms 4.817 ms 4.788 ms

Please note:   
The next practice relies on VXLAN with EVPN configuration. Please make sure to save the configuration before exiting.

## PRACTICE 7: DISTRIBUTED ASYMMETRIC VXLAN ROUTING

Practice Objectives:

In this practice session you will configure distributed asymmetric VXLAN routing.

* VTEPs (leaf switches) will be configured as the distributed anycast default gateway, i.e., each VTEP will be configured with a VIP and VMAC for each of the subnets.  
  Each VTEP will serve as the default gateway for its locally connected hosts.
* In asymmetric VXLAN routing only the ingress VTEP perform the routing, while the egress VTEP perform VXLAN bridging only.

Please note:

The configuration in this practice session relies on the previous practice. Make sure that BGP Unnumbered and VXLAN with EVPN are properly configured and fully operational.

Topology used in this practice session:

**­­**

**spine4**

**spine3**



**swp1**

**swp8**

**swp9**

**swp8**

**swp9**

**swp2**

**swp1**



VLAN10

VLAN20

VLAN100

VLAN200

**swp2**

**swp2**

**swp1**

**swp2**

**swp1**

**VNI-10**

**VNI-20**

172.16.10.18/24

Default-gateway:  
172.16.10.254

172.16.20.19/24

Default-gateway:  
172.16.20.254

172.16.10.28/24

Default-gateway:  
172.16.10.254

172.16.20.29/24

Default-gateway:  
172.16.20.254

**BGP Unnumbered**

**leaf1**

**leaf2**

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**host4**

**host3**

**host2**

**host1**

Task 1: Configuring servers IP settings

1. Add a static route entry to network 172.16.0.0/16 via the default gateway’s IP:

* Servers ‘host1’ and ‘host3’ are in VNI-10, their default gateway is 172.16.10.254
* Servers ‘host2’ and ‘host4’ are in VNI-20, their default gateway is 172.16.20.254

|  |  |
| --- | --- |
| **Server** | **Default gateway** |
| host1 | 172.16.10.254 |
| host2 | 172.16.20.254 |
| host3 | 172.16.10.254 |
| host4 | 172.16.20.254 |

**# ip route add *<NET\_ADD/MASK>* dev *<DEV>* via *<IP>***

[cumulus@host1 ~]# sudo ip route add 172.16.0.0/16 dev eth2 via 172.16.10.254

Task 2: Configuring SVIs on the VTEPs

1. Access the leaf switch and configure the SVIs and the anycast default gateway’s VMAC and VIP.   
   Assign IP addresses according the following tables. Use /24 as the subnet mask.

Switch leaf1:

|  |  |  |  |
| --- | --- | --- | --- |
| SVI | IP | Default gateway’s VIP | Default gateway’s VMAC |
| VLAN 10 | 172.16.10.252 | 172.16.10.254 | 00:00:5e:00:01:01 |
| VLAN 20 | 172.16.20.252 | 172.16.20.254 | 00:00:5e:00:01:02 |

Switch leaf2:

|  |  |  |  |
| --- | --- | --- | --- |
| SVI | IP | Default gateway’s VIP | Default gateway’s VMAC |
| VLAN 100 | 172.16.10.253 | 172.16.10.254 | 00:00:5e:00:01:01 |
| VLAN 200 | 172.16.20.253 | 172.16.20.254 | 00:00:5e:00:01:02 |

**# net add vlan *<VLAN>* ip address *<IP>***

**# net add vlan *<VLAN>* ip address-virtual *<VMAC> <VIP/MASK>***

cumulus@leaf2:mgmt:~$ net add vlan 100 ip address 172.16.10.253/24

cumulus@leaf2:mgmt:~$ net add vlan 100 ip address-virtual 00:00:5e:00:01:01 172.16.10.254/24

cumulus@leaf2:mgmt:~$ net add vlan 200 ip address 172.16.20.253/24

cumulus@leaf2:mgmt:~$ net add vlan 200 ip address-virtual 00:00:5e:00:01:02 172.16.20.254/24

cumulus@leaf2:mgmt:~$ net commit

cumulus@leaf1:mgmt:~$ net add vlan 10 ip address 172.16.10.252/24

cumulus@leaf1:mgmt:~$ net add vlan 10 ip address-virtual 00:00:5e:00:01:01 172.16.10.254/24

cumulus@leaf1:mgmt:~$ net add vlan 20 ip address 172.16.20.252/24

cumulus@leaf1:mgmt:~$ net add vlan 20 ip address-virtual 00:00:5e:00:01:02 172.16.20.254/24

cumulus@leaf1:mgmt:~$ net commit

Please note:

The VMAC and VIP must be identical on both VTEPs in order to implement anycast default gateway and to allow proper inter-VXLAN routing.

Task 3: Test inter-VXLAN communication

1. Use ‘**ping**’ and ‘**traceroute**’ utilities to verify end-to-end communication between hosts in different VNIs.   
   For example, ping from host ‘host1’ in VNI-10 to ‘host2’ in VNI-20.   
   In this case the egress switch **leaf1** will perform VXLAN routing between the source and destination VNIs, while the egress switch **leaf2**will bridge between destination VNI and the destination VLAN.

[cumulus@host1 ~]# ping 172.16.20.19

PING 172.16.20.19 (172.16.20.19) 56(84) bytes of data.

64 bytes from 172.16.20.19: icmp\_seq=1 ttl=63 time=3.48 ms

64 bytes from 172.16.20.19: icmp\_seq=2 ttl=63 time=1.15 ms

[cumulus@host1 ~]# traceroute 172.16.20.19

traceroute to 172.16.20.19 (172.16.20.19), 30 hops max, 60 byte packets

1 172.16.10.254 (172.16.10.254) 1.271 ms 1.431 ms 1.412 ms

2 172.16.20.19 (172.16.20.19) 1.564 ms 1.593 ms 1.595 ms

## PRACTICE 8: DISTRIBUTED SYMMETRIC VXLAN ROUTING

Practice Objectives:

In this practice session you will configure distributed symmetric VXLAN routing.

* VTEPs (leaf switches) will be configured as the distributed anycast default gateway, i.e., each VTEP will be configured with a VIP and VMAC for each of the subnets.  
  Each VTEP will serve as the default gateway for its locally connected hosts.
* In symmetric VXLAN routing both the ingress and egress VTEPs perform the routing.
* A new special transit VNI is used for all routed VXLAN traffic, called the L3-VNI.

Please note:

The configuration in this practice session relies on the previous practice. Make sure that BGP Unnumbered and VXLAN with EVPN are properly configured and fully operational. Test and verify that hosts in the same VNI can communicate with each other.

Topology used in this practice session:

**­­**

**spine4**

**spine3**



**swp1**

**swp8**

**swp9**

**swp8**

**swp9**

**swp2**

**swp1**



VLAN10

VLAN20

VLAN100

VLAN200

**swp2**

**swp2**

**swp1**

**swp2**

**swp1**

**VNI-10**

**VNI-20**

**BGP Unnumbered**

**leaf1**

**leaf2**

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Description automatically generated

172.16.20.29/24

Default-gateway:  
172.16.20.254

**host4**

172.16.10.28/24

Default-gateway:  
172.16.10.254

**host3**

172.16.20.19/24

Default-gateway:  
172.16.20.254

**host2**

**host1**

172.16.10.18/24

Default-gateway:  
172.16.10.254

Task 1: Configuring the L3-VNI

1. Access both leaf switches and configure a per-tenant VXLAN interface.  
   Use VNI 4001.

cumulus@leaf1:mgmt:~$ net add vlan 4001

cumulus@leaf1:mgmt:~$ net add vxlan VNI-4001 vxlan id 4001

cumulus@leaf1:mgmt:~$ net add vxlan VNI-4001 bridge access 4001

cumulus@leaf1:mgmt:~$ net add vxlan VNI-4001 vxlan local-tunnelip 172.16.100.1

1. Access both leaf switches and configure an SVI for the L3-VNI.

cumulus@leaf1:mgmt:~$ net add vrf VRFA

cumulus@leaf1:mgmt:~$ net add vlan 4001 vrf VRFA

1. Access both leaf switches and configure the VRF to L3-VNI mapping.

cumulus@leaf1:mgmt:~$ net add vrf VRFA vni 4001

cumulus@leaf1:mgmt:~$ net commit

Please note:

Switch leaf2 should be configured similarly.

Task 2: Configuring Anycast Gateways

1. Access the leaf switches and configure the SVIs and associate them to the L3-VNI Configure the anycast default gateway’s VMAC and VIP.   
   Assign IP addresses according the following tables. Use /24 as the subnet mask.

|  |  |
| --- | --- |
| SVI | IP |
| VLAN 10 | 172.16.10.252 |
| VLAN 20 | 172.16.20.252 |

Switch leaf1:

|  |  |
| --- | --- |
| SVI | IP |
| VLAN 100 | 172.16.10.253 |
| VLAN 200 | 172.16.20.253 |

Switch leaf2:

cumulus@leaf2:mgmt:~$ net add vlan 100 ip address 172.16.10.253/24

cumulus@leaf2:mgmt:~$ net add vlan 200 vrf VRFA

cumulus@leaf2:mgmt:~$ net add vlan 200 ip address 172.16.20.253/24

cumulus@leaf2:mgmt:~$ net add vlan 200 vrf VRFA

cumulus@leaf1:mgmt:~$ net add vlan 10 ip address 172.16.10.252/24

cumulus@leaf1:mgmt:~$ net add vlan 10vrf VRFA

cumulus@leaf1:mgmt:~$ net add vlan 20 ip address 172.16.20.252/24

cumulus@leaf1:mgmt:~$ net add vlan 20vrf VRFA

1. Access the leaf switches and configure the anycast default gateway’s VMAC and VIP.   
   Use the following tables:

|  |  |
| --- | --- |
| Default gateway’s VIP | Default gateway’s VMAC |
| 172.16.10.254 | 00:00:5e:00:01:01 |
| 172.16.20.254 | 00:00:5e:00:01:02 |

Switch leaf1:

|  |  |
| --- | --- |
| Default gateway’s VIP | Default gateway’s VMAC |
| 172.16.10.254 | 00:00:5e:00:01:01 |
| 172.16.20.254 | 00:00:5e:00:01:02 |

Switch leaf2:

cumulus@leaf2:mgmt:~$ net add vlan 100 ip address-virtual 00:00:5e:00:01:01 172.16.10.254/24

cumulus@leaf2:mgmt:~$ net add vlan 200 ip address-virtual 00:00:5e:00:01:02 172.16.20.254/24

cumulus@leaf2:mgmt:~$ net commit

cumulus@leaf1:mgmt:~$ net add vlan 10 ip address-virtual 00:00:5e:00:01:01 172.16.10.254/24

cumulus@leaf1:mgmt:~$ net add vlan 20 ip address-virtual 00:00:5e:00:01:02 172.16.20.254/24

cumulus@leaf1:mgmt:~$ net commit

Please note:

The VMAC and VIP must be identical on both VTEPs for each VLAN in order to implement anycast default gateway and to allow proper inter-VXLAN routing.  
  
Task 3: Verify L3-VNI configuration

1. Verify that the L3-VNI is up:

cumulus@leaf1:mgmt:~$ net show evpn vni 4001

VNI: 4001

Type: L3

Tenant VRF: VRFA

Local Vtep Ip: 172.16.100.1

Vxlan-Intf: VNI-4001

SVI-If: vlan4001

State: Up

VNI Filter: none

System MAC: 44:38:39:00:00:12

Router MAC: 44:38:39:00:00:12

L2 VNIs: 10 20

cumulus@leaf1:mgmt:~$ net show vrf vni

VRF VNI VxLAN IF L3-SVI State Rmac

VRFA 4001 VNI-4001 vlan4001 Up 44:38:39:00:00:12

Task 4: Test inter-VXLAN communication

1. Use ‘**ping**’ and ‘**traceroute**’ utilities to verify end-to-end communication between hosts in different VNIs.   
   For example, ping from host ‘host1’ in VNI-10 to ‘host2’ in VNI-20.   
   In this case the egress switch **leaf1** will perform routing between the source VNI and the L3-VNI, while the egress switch **leaf2**will perform routing between L3-VNI and the destination VNI.

cumulus@host1:~$ ping 172.16.20.29

PING 172.16.20.29 (172.16.20.29) 56(84) bytes of data.

64 bytes from 172.16.20.29: icmp\_seq=7 ttl=62 time=2.91 ms

64 bytes from 172.16.20.29: icmp\_seq=8 ttl=62 time=3.44 ms

cumulus@host1:~$ traceroute 172.16.20.29

traceroute to 172.16.20.29 (172.16.20.29), 30 hops max, 60 byte packets

1 172.16.10.252 (172.16.10.252) 0.588 ms 0.546 ms 0.546 ms

2 172.16.20.253 (172.16.20.253) 2.656 ms 2.653 ms 2.652 ms

3 172.16.20.29 (172.16.20.29) 3.431 ms 3.415 ms 3.416 ms