

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

Release Date

Revision 2.2 – January 2021

Good Luck,

NVIDIA Networking Academy team

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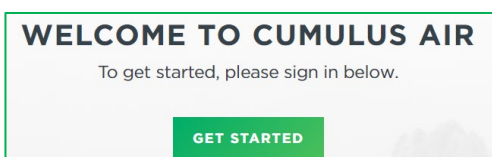
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PREREQUISITES AND GUIDELINES

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.



- If 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.

EMAIL ADDRESS

PASSWORD

[Forgot password?](#)

LOGIN

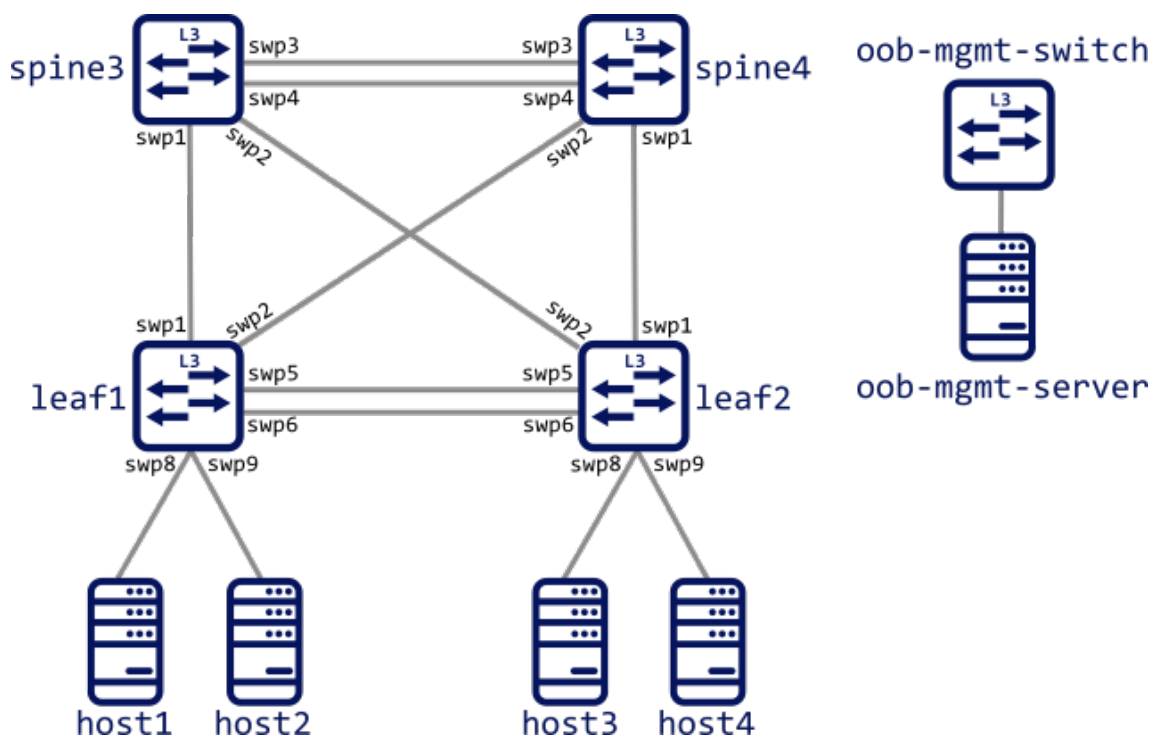
Don't have an account? [Register](#).

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



ACADEMY LAB TOPOLOGY

The training lab is organized in the following topology:



ACADEMY LAB ACCESS

Click 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**.

SPINE3 TERMINAL CONNECTION
RECONNECT

```

Debian GNU/Linux 8 spine3 ttyS0

spine3 login: cumulus
Password:
Last login: Sun Oct 11 09:20:57 UTC 2020 on ttyS0
Linux spine3 4.1.0-c1-7-amd64 #1 SMP Cumulus 4.1.33-1+c13u26 (2020-02-05)
x86_64

Welcome to Cumulus VX (TM)

Cumulus VX (TM) is a community supported virtual appliance designed for
experiencing, testing and prototyping Cumulus Networks' latest technology.
For any questions or technical support, visit our community site at:
http://community.cumulusnetworks.com

The registered trademark Linux (R) is used pursuant to a sublicense from L
MI,
the exclusive licensee of Linus Torvalds, owner of the mark on a world-wid
e
basis.
cumulus@spine3:~$

```

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

- 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

- 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

c. 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
UP	eth0	1G	1500	Mgmt	oob-mgmt-switch (swp3)	IP: ::1/128 Master: mgmt(UP) 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

- d. 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
```

- e. 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
```

- f. Commit the changes with a custom description:

net commit description <TEXT>

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

```
auto swp1
```

```
iface swp1
```

```
+ alias
```

```
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
```

```
auto swp1
```

```
iface swp1
```

```
+ 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

g. View the NCLU commit history:

net show commit history

Task 3: Rollback the Configuration

a. Rollback to the last commit:

net rollback last

```
cumulus@leaf1:mgmt:~$ net rollback last
```

b. 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.

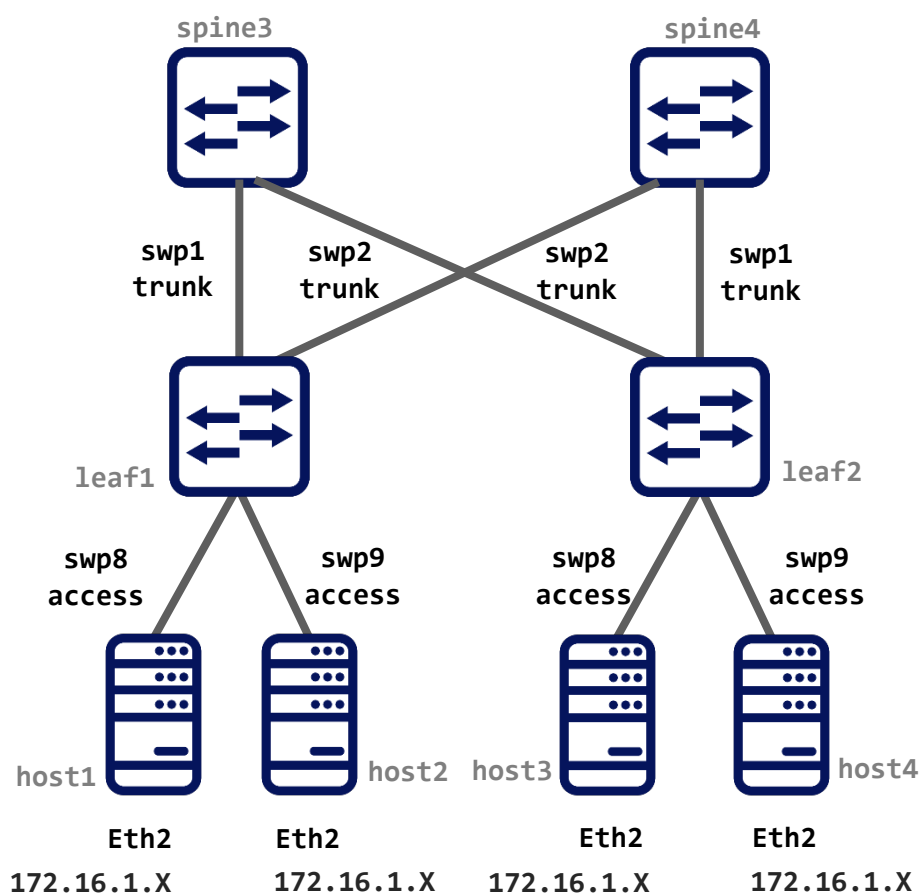
PRACTICE 2: BASIC SWITCH FUNCTIONS

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.

Topology Used in this Practice:



Task 1: Configure Servers IP Settings

- a. 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
```

- b. 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)
```

- c. 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

- a. Access the switches and reset configuration:

net del all

net commit

```
cumulus@leaf1:mgmt:~$ net del all
cumulus@leaf1:mgmt:~$ net commit
```

- b. 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
```

- c. 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
```

- d. Commit changes:

net commit

```
cumulus@leaf1:mgmt:~$ net commit
```

- e. 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
```

- f. 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

- 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'

- 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
```

- c. 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

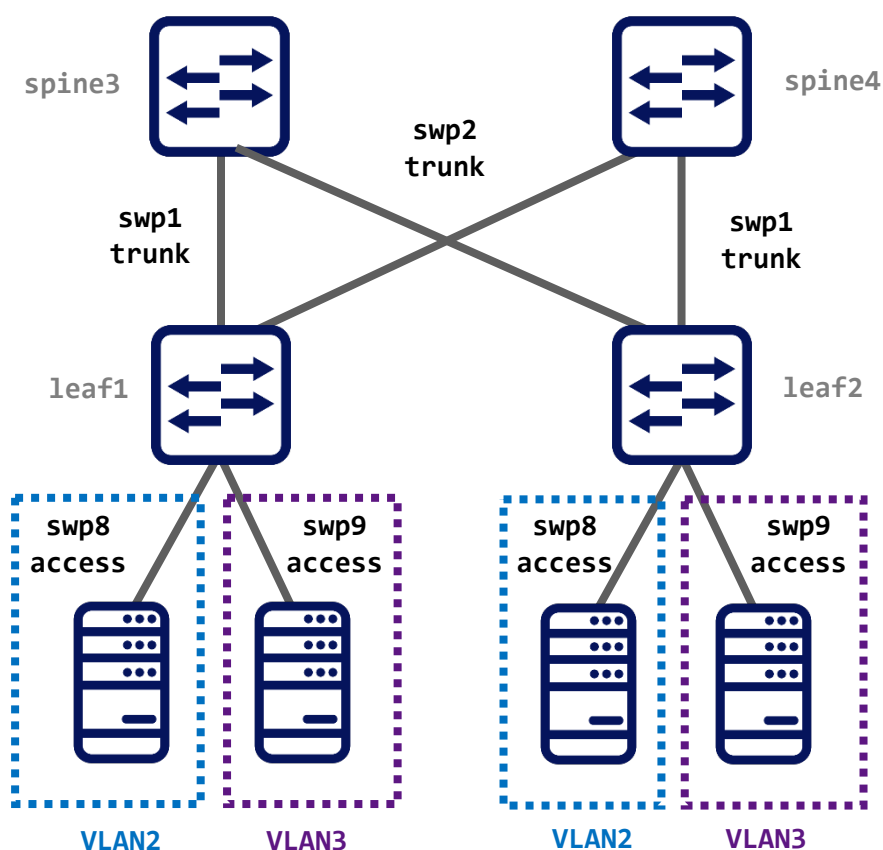
PRACTICE 3: VLANs AND TRUNKING

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:



Task 1: Configuring VLANs and Trunking

- a. 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
```

- b. 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
```

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

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

- d. 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
```

- e. Commit changes:

```
cumulus@leaf1:mgmt:~$ net commit
```

- f. 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
```

g. 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

a. 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
```

b. 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
```

- c. 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

- a. 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
```

- b. 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
```

```
[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
```

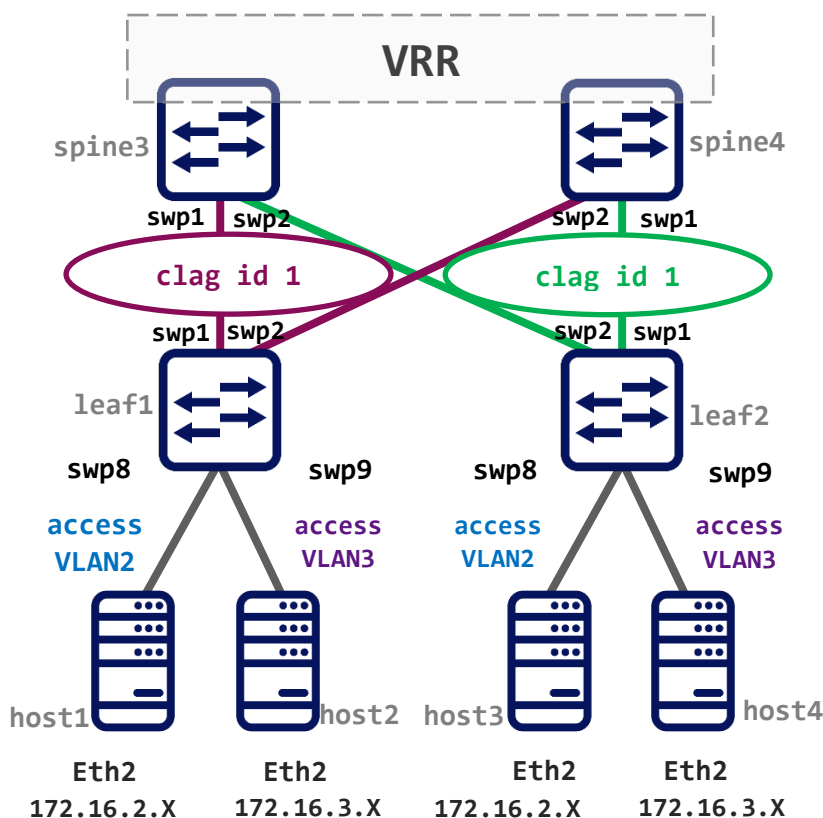
PRACTICE 4: CONFIGURING MLAG and VRR

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:



Task 1: LAG Configuration – Leaf Switches

- a. 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
```

- b. 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
```

- c. 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.

- d. 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-
```

- e. 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

- a. 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@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
```

```
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
```

- b. 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
```

- c. 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
```

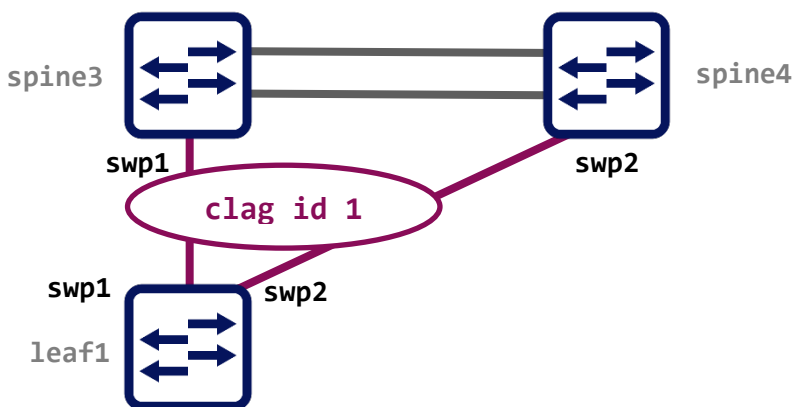
- d. Commit the changes:

```
cumulus@spine3:mgmt:~$ net commit
```

```
cumulus@spine4:mgmt:~$ net commit
```

Task 3: Configuring CLAG interfaces - spine switches

- a. 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**

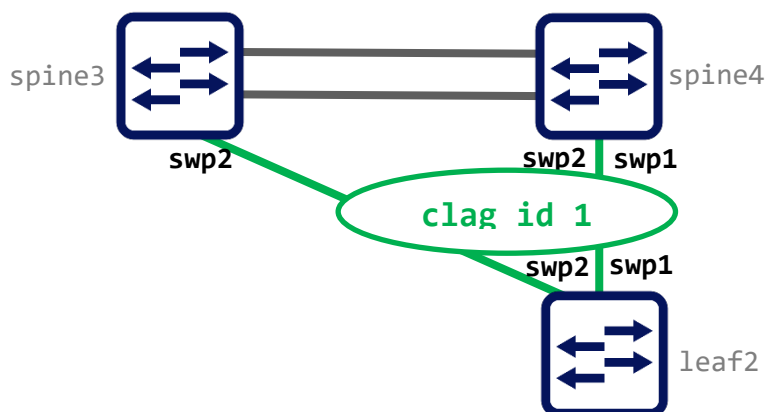


```
# net add clag port bond <BONDNAME> interface <PORTS> clag-id <ID>
```

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

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

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



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

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

b. Commit the changes:

```
cumulus@spine3:mgmt:~$ net commit
```

```
cumulus@spine4:mgmt:~$ net commit
```

c. 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
```

c. 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

- a. Access the servers and configure an IP address for interface **'eth2'** (see tables below).

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

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)
```

- b. 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

- c. 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
```

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

```
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

```
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

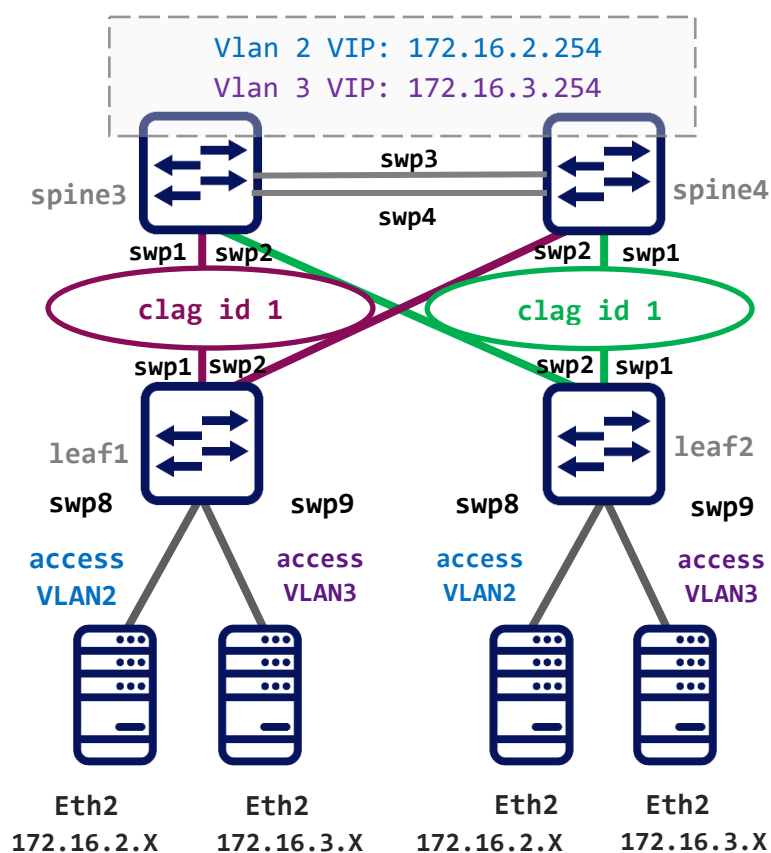
Please note:

- 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:



- a. 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@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
```

```
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
```

b. Verify VRR configuration:

```
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

```
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
-----	-----------------

c. 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 *
```

d. 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 disrupted now?

What are your conclusions regarding MLAG/VRR failover?

PRACTICE 5: CONFIGURING BGP UNNUMBERED

Practice Objectives:

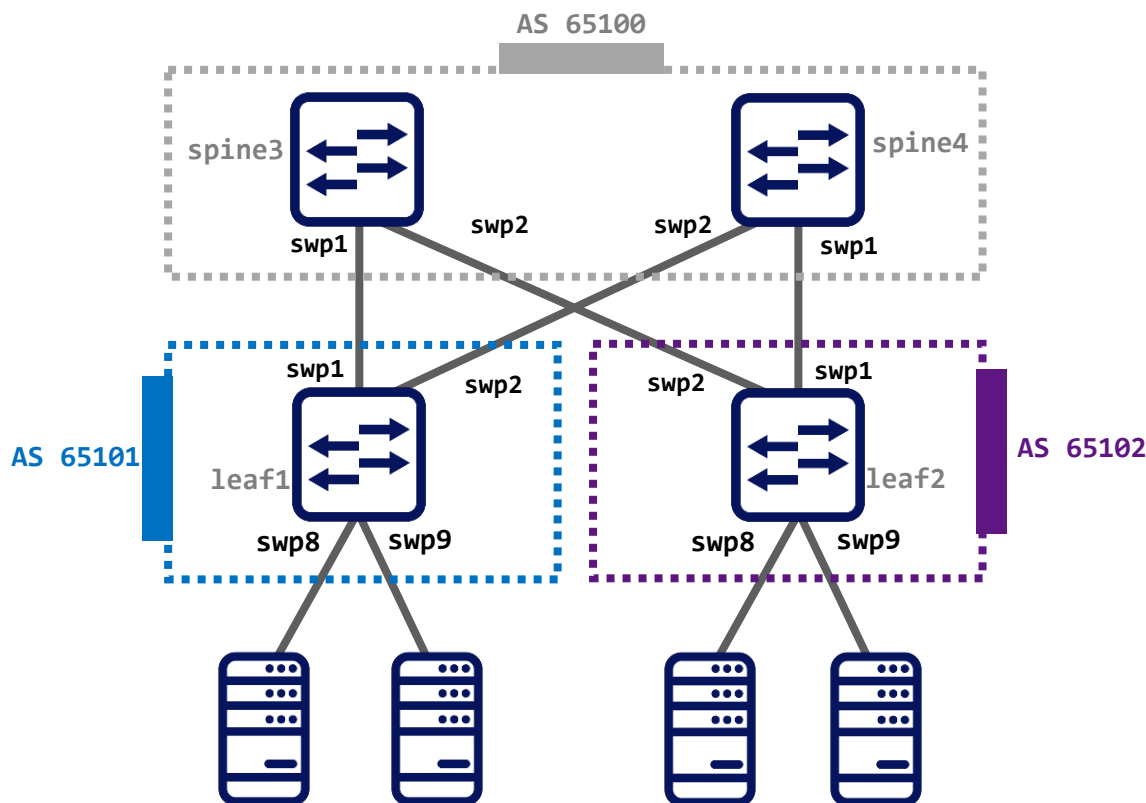
In this practice session you will configure BGP Unnumbered:

- 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:



Task 1: Starting FRR

- a. Access the switches and reset the configuration:

```
# net del all
# net commit
```

```
cumulus@leaf1:mgmt:~$ net del all
cumulus@leaf1:mgmt:~$ net commit
```

- b. 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
```

- c. Restart FRR Service.

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

Task 2: Configuring loopback interfaces

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

Use the following table for IP address assignment:

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

```
# 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

- a. Configure BGP unnumbered:

```
# net add bgp autonomous-system <LOCAL-AS>
# net add bgp neighbor <INTERFACE> 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
```

```
cumulus@spine3:mgmt:~$ net add bgp autonomous-system 65100
cumulus@spine3:mgmt:~$ net add bgp neighbor swp1-2 interface remote-as external
```

- b. Advertise the loopback addresses and commit the changes.

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

```
cumulus@leaf1:mgmt:~$ net add bgp network 172.16.100.1/24
cumulus@leaf1:mgmt:~$ net commit
```

```
cumulus@spine3:mgmt:~$ net add bgp network 172.16.100.3/24
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.

- c. 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
```

- d. 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
```

- b. 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

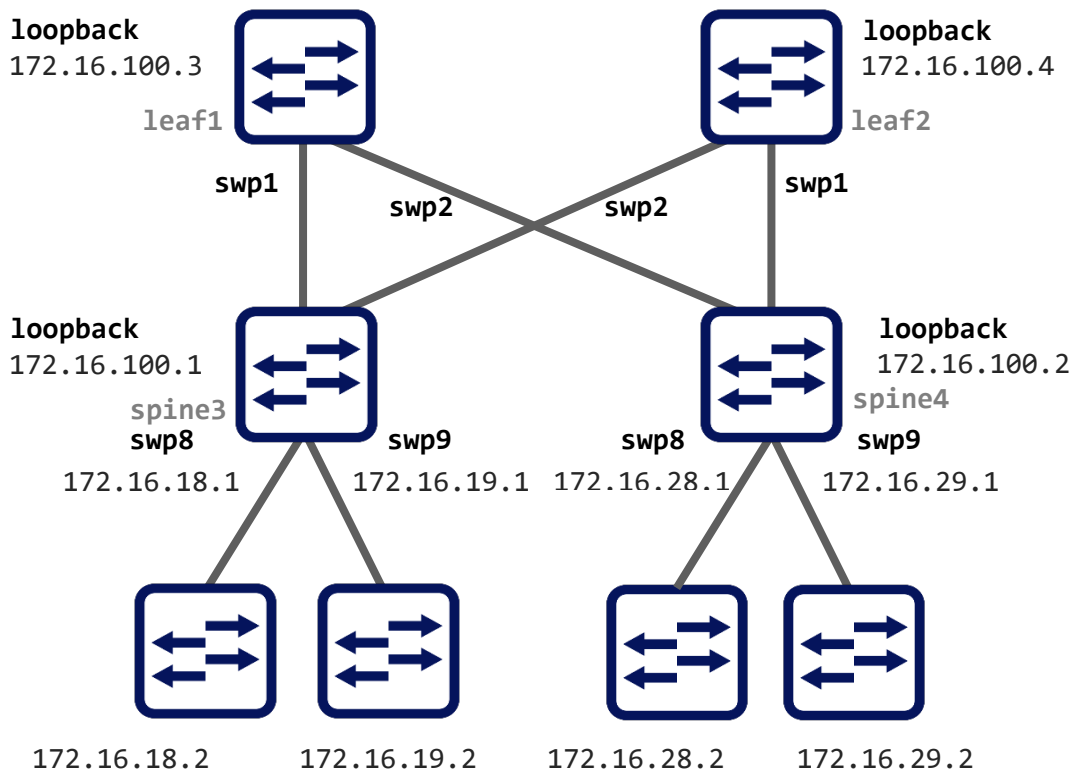
B>* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:06:41
   *                               via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:06:41
B>* 172.16.100.3/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:05:52
B>* 172.16.100.4/32 [20/0] via fe80::4638:39ff:fe00:b, 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

- 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.



```
# 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
```

- b. 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

- a. 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)
```

- b. 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:~$ sudo ip route add 172.16.0.0/16 dev eth2 via 172.16.18.1
```

```
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
```

- c. 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:

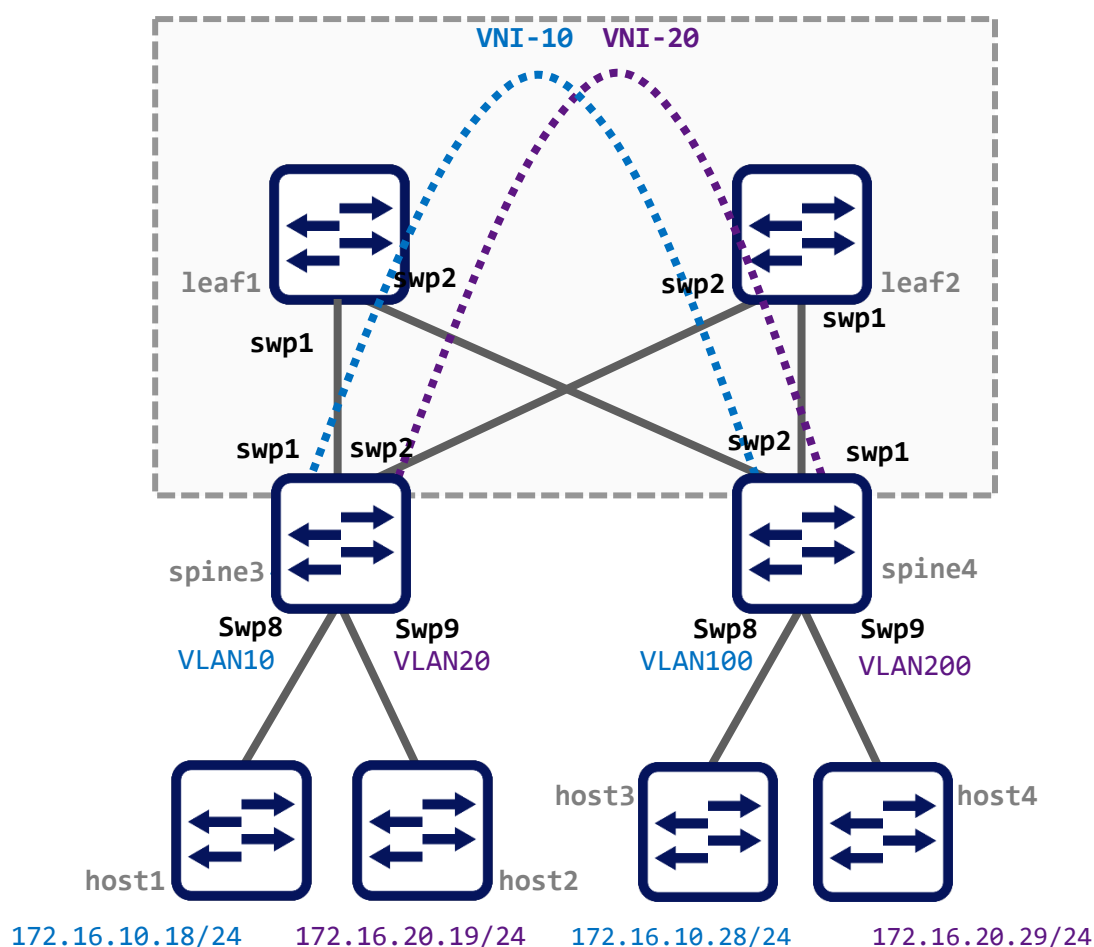
In this practice session you will configure VXLAN with EVPN:

- 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:



Task 1: Configuring 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
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

- 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

- 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@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
```

```
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
```

Task 4: Configuring EVPN

- 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
```

- b. 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
```

- c. 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
```

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:

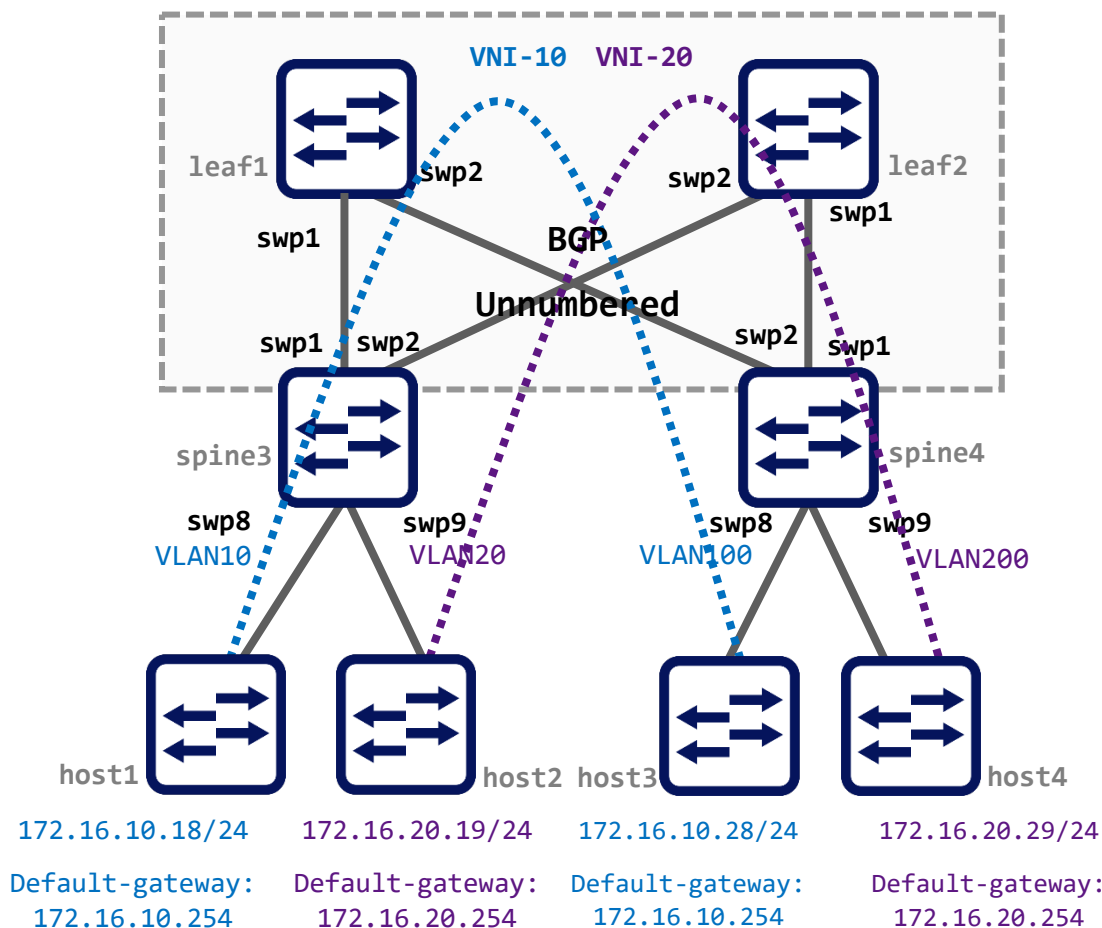
In this practice session you will configure distributed asymmetric VXLAN routing.

- 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:



Task 1: Configuring servers IP settings

- a. 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

- a. 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@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
```

```
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
```

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

- 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:

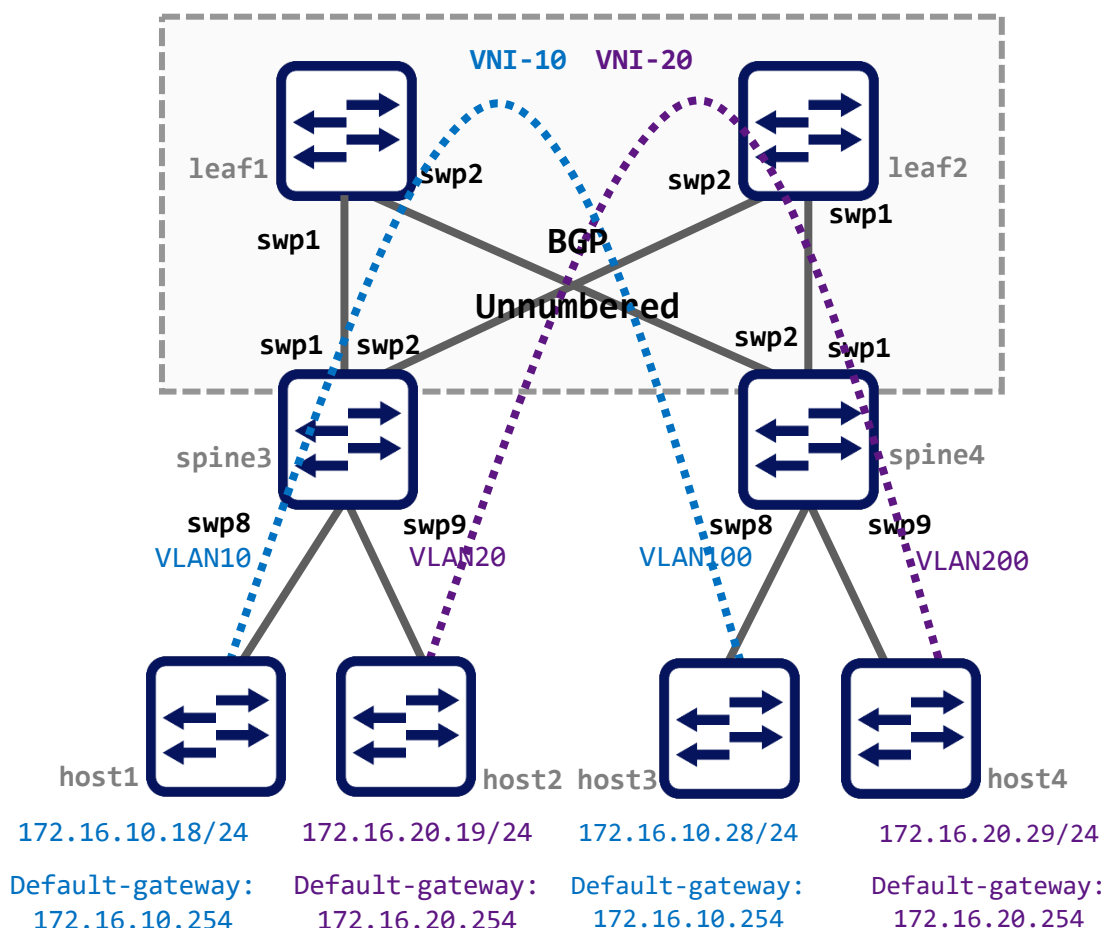
In this practice session you will configure distributed symmetric VXLAN routing.

- 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:



Task 1: Configuring the L3-VNI

- a. 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
```

- b. 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
```

- c. 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

- a. 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.

Switch leaf1:	SVI	IP
	VLAN 10	172.16.10.252
	VLAN 20	172.16.20.252

Switch leaf2:	SVI	IP
	VLAN 100	172.16.10.253
	VLAN 200	172.16.20.253

```
cumulus@leaf1:mgmt:~$ net add vlan 10 ip address 172.16.10.252/24
cumulus@leaf1:mgmt:~$ net add vlan 10 vrf VRFA
cumulus@leaf1:mgmt:~$ net add vlan 20 ip address 172.16.20.252/24
cumulus@leaf1:mgmt:~$ net add vlan 20 vrf VRFA
```

```
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
```

- b. Access the leaf switches and configure the anycast default gateway's VMAC and VIP.
Use the following tables:

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:	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

```
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
```

```
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
```

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

- a. 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

- b. 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
```