CUMULUS NVUE: LAB GUIDE

Scope

This workbook covers configurations of network protocols and function using Nvidia Cumulus Linux as the Network Operating System. This workbook is based on the next generation CLI (NVUE). It is prepared for being used alongside the standard 3 session Cumulus Linux Boot Camp.

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 Nvidia Cumulus Air © platform, exercises in this workbook on a group of devices (four servers and four 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:

academy-support@nvidia.com

Release Date and Disclaimer

Revision 1.0 – April 2022 (Based on CL 5.0.1 Software release)

The lab was created by using Cumulus VX, the behavior/functionality of a physical environment might differ.

Good Luck,

NVIDIA Academy team

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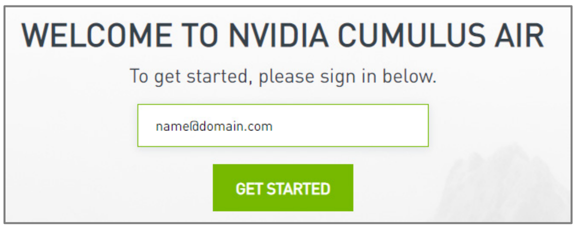
PRACTICE UNITS

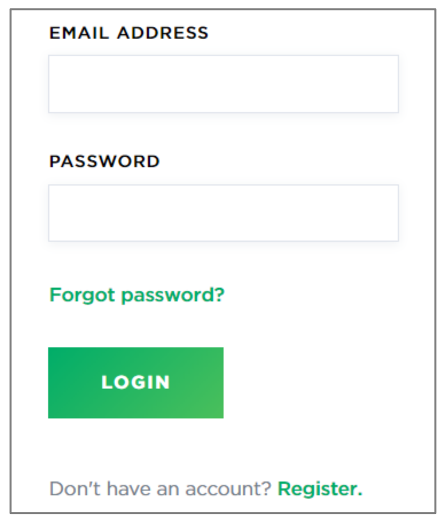
PREREQUISITES AND GUIDELINES

Please perform and review the following steps before you start:

1. Enter the Cumulus Air web page : https://air.nvidia.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.



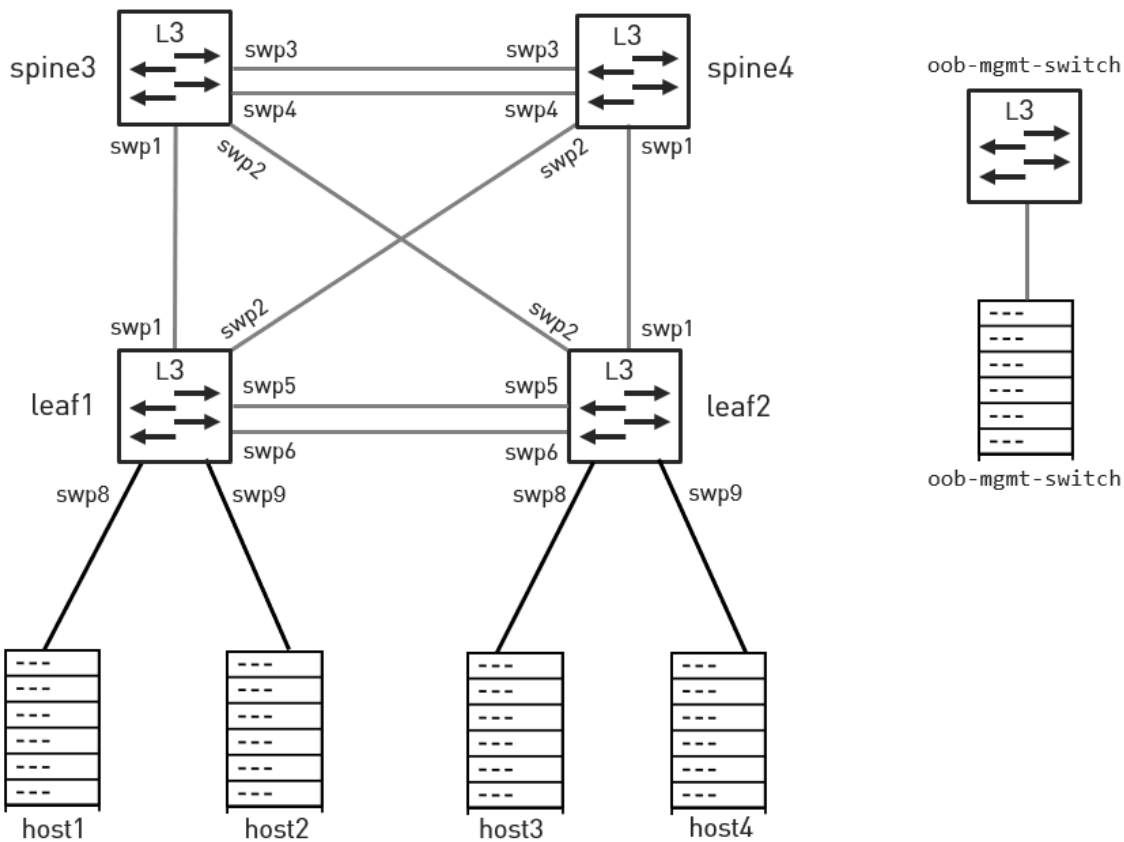
2. Once you are logged in, you will reach the **“Cumulus in The Cloud”** dashboard.
   Wait for the lab to be Loaded.

3. Click on the “Academy ILT CL5.0.1” label/name to access your lab.

ACADEMY LAB TOPOLOGY

Every student is using her/his own individual lab.

The training lab is organized in the following topology:



The lab layout resembles 100% the former NCLU based Cumulus Linux boot camp lab layout. For most exercises the links between the two leaf's are NOT used.

Four switches (leaf1, leaf2, spine3, and spine4) are running CL 5.0.1.

```
cumulus@leaf1:mgmt:~$ net show ver
NCLU_VERSION=1.0-cl5.0.0u11
DISTRIB_ID="Cumulus Linux"
DISTRIB_RELEASE=5.0.1
DISTRIB_DESCRIPTION="Cumulus Linux 5.0.1"
```

The four servers (host1, host2, host3, and host4) are running Ubuntu 20.04.

```
cumulus@host1:~$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 20.04.4 LTS
Release:        20.04
Codename:       focal
```

The out-of-band (OOB) infrastructure is provided via:

An oob-mgmt-switch, which is transparent during the entire labs, and is running CL 4.4.0.

The Jump-host (oob-mgmt-server) is running Ubuntu 18.04 and provides the services like DHCP and Orchestration (Ansible), next to others:

```
cumulus@oob-mgmt-server:/home/ubuntu$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 18.04.6 LTS
Release:        18.04
Codename:       bionic
```

SSH access:

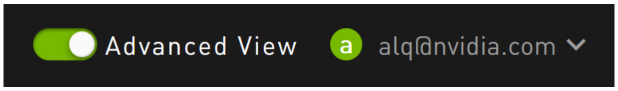
The user-account for the **`oob-mgmt-server`** when accessing via SSH might be “nvidia”. We will use the “cumulus” user, please change from user “nvidia” to user “cumulus” if needed.

ACADEMY LAB ACCESS

Views

The simulation environment offers two views: standard and advanced.

Via a button on the upper right corner:



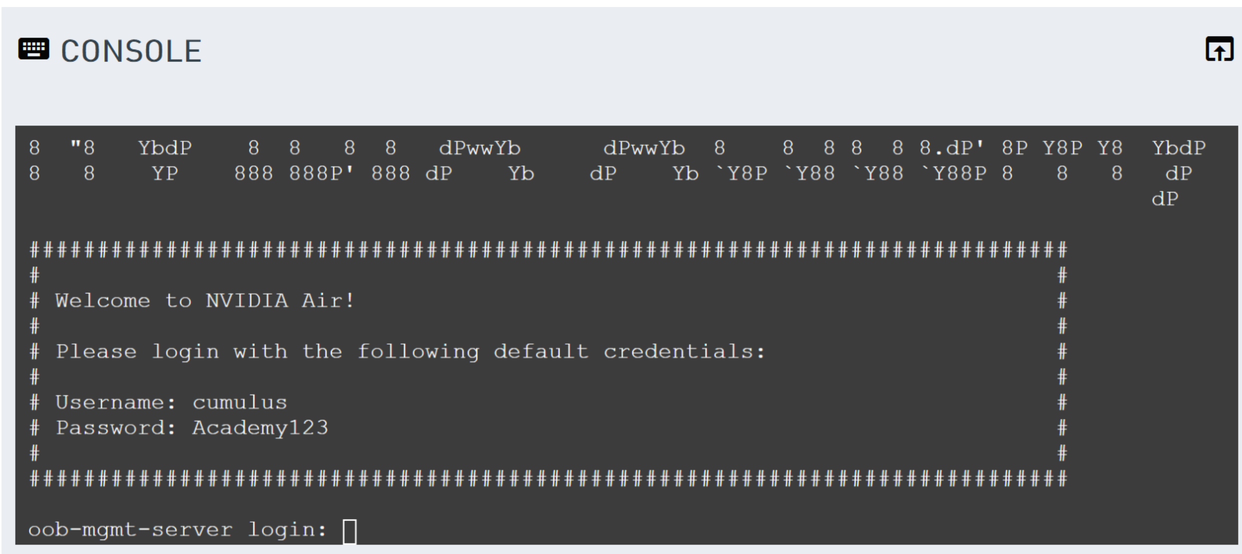
you can switch between the views. We recommend using the “Advanced View”.

Console-GUI

The console-GUI offers a connection to the oob-mgmt-server.

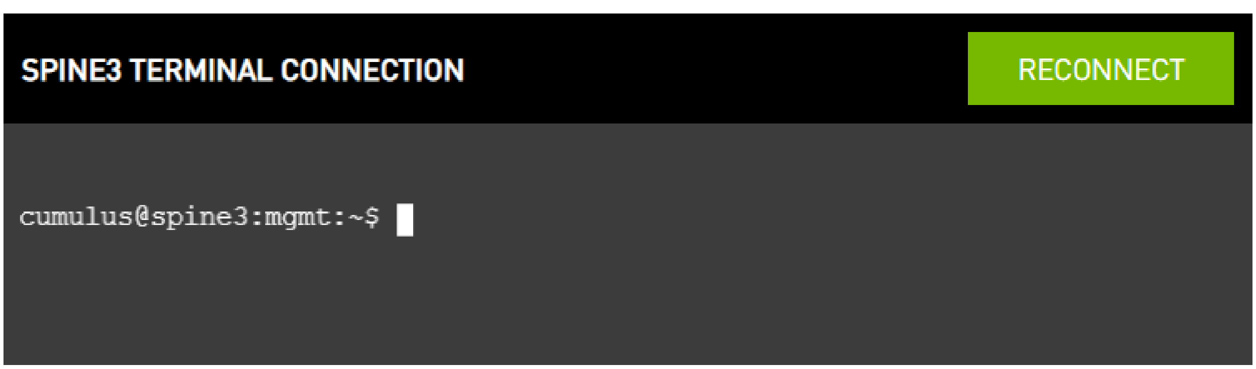
Using “cumulus” as the user and “Academy123” as the passwords allows access.

From here you can ssh directly to the nodes e.g., ssh leaf1



In the upper right corner you find the icon to pop-out the Console-GUI, which allows you to open multiple connections via the "plus icon" e.g. to the **oob-mgmt-server** and **leaf1**:

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: PREPARING THE LAB AND FIRST STEPS

netd and nvued - Daemons:

In this Lab we use CL 5.0 or newer for our "production" network (leaf1, leaf2, spine3, and spine4). Releases 4.3 and 4.4 used in former labs, could have enabled NVUE but had to have NCLU disabled. With CL 5.0 both daemons for NVUE and NCLU are active, the later one for providing a complete set of show commands, all starting with

```
$ net show …
```

General:

All tasks are executed with the user cumulus unless explicitly stated.

Practice Objectives:

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

- You will use '**`nv set`**' and '**`nv unset`**' commands to change the configuration.
- You will use '**`nv config apply`**' command to apply configuration changes.
- To save the configuration we will use use '**`nv config save`**'.
- You will use '**`nv config diff`**' commands to compare revisions.
- Lastly, you will use '**`nv config patch`**' and use '**`nv config replace`**' to modify the pending configurations.
- To view items, we use use '**`nv show`**'.

Task-01

Please ssh to at least one node and verify that both daemons are running.

```
cumulus@leaf1:mgmt:~$ sudo systemctl status netd
netd.service - Network Command Line Utility Daemon
   Loaded: loaded (/lib/systemd/system/netd.service; enabled; vendor preset: enabled)
   Active: active (running) since Mon 2022-03-07 08:48:57 UTC; 2 weeks 0 days ago
 Main PID: 975 (python)
   Memory: 52.9M
   CGroup: /system.slice/netd.service
           └─975 /usr/bin/python -O /usr/sbin/netd -d
```

```
cumulus@leaf1:mgmt:~$ sudo systemctl status nvued
nvued.service - NVIDIA User Experience Daemon
   Loaded: loaded (/lib/systemd/system/nvued.service; enabled; vendor preset:
enabled)
   Active: active (running) since Mon 2022-03-07 08:48:50 UTC; 2 weeks 0 days ago
 Main PID: 411 (python3)
   Memory: 222.8M
   CGroup: /system.slice/nvued.service
           └─411 /usr/bin/python3 /usr/sbin/nvued –daemon
```

Configuration tasks are not feasible via NCLU.

In other words, we use NCLU only for providing show commands.

Task-02

```
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: 192.168.200.2/24(DHCP)
UP     swp1  1G   9216   Default   spine3 (swp1)
UP     swp2  1G   9216   Default   spine4 (swp2)
UP     swp5  1G   9216   Default   leaf2 (swp5)
UP     swp6  1G   9216   Default   leaf2 (swp6)
UP     swp8  1G   9216   Default
UP     swp9  1G   9216   Default
UP     mgmt  N/A  65536  VRF                               IP: 127.0.0.1/8
       mgmt                                                IP: ::1/128
```

This output suggests that a non-default configuration is in place.
Interfaces **swp** are not configured or available with factory settings.

We will “clean-up” any legacy configurations before we start.

Task-03

SSH to all cumulus nodes and verify if the file **`/etc/nvue.d/startup.yaml`** is present.

By default, this file (as of CL 5.0) is not present. If present remove the file.

Apply the empty config to all nodes:

`$ nv config apply empty`

This also removes the hostname. Thus, apply the individual hostname via
`$ nv set system hostname <name>`

The syntax has changed between CL 4.4 and CL 5.0, so if you happen to have an older NVUE config file, please verify, and change the hostname configuration.

Apply your cleaned configuration via
`$ nv config apply`

Task-04

Host setup

The lab is using four hosts (host1, host2, host3, and host4) running Linux (Ubuntu 20.04). The Interface Manager by default is Netplan.

In case you are new to Linux and/or Netplan, please consider consulting external resources like:

https://netplan.io/examples/

or ask your instructor for a quick-live-demo/introduction.

Alternatively, to Netplan you can configure the hosts via:

- ifconfig
- ip(route2)

Both options create the same functionality for our use-cases but both are not persistent and might result in more time being consumed during the class.

However, ip(route2) provides the most configuration options compared to both **`ifconfig`** and **`netplan`**.

- Our order of preference:
  1) Netplan
  2) Ip(route2)
  3) ifconfig

Each hosts use two interfaces:

- Eth0 for OOB Management, this interface should NOT be changed
- Eth2 this interface connecting to the leaf switches and will be configured during class

Task-06

Enable all switch interfaces

Verify which interfaces are available on all four cumulus nodes:

```
cumulus@leaf1:mgmt:~$ net show int all
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:
192.168.200.2/24(DHCP)
ADMDN  swp1  N/A  9216   NotConfigured
ADMDN  swp2  N/A  9216   NotConfigured
ADMDN  swp5  N/A  9216   NotConfigured
ADMDN  swp6  N/A  9216   NotConfigured
ADMDN  swp8  N/A  9216   NotConfigured
ADMDN  swp9  N/A  9216   NotConfigured
UP     mgmt  N/A  65536  VRF                                     IP: 127.0.0.1/8
       mgmt                                                      IP: ::1/128
```

We can see for example on leaf1 that the interfaces swp1, swp2, swp5, swp6, swp8, and swp9 are “available” but in ADMINISTRATIVE DOWN state.

Enable all ADMDN interfaces (ADMDN == ADMIN DOWN):

```
cumulus@leaf1:mgmt:~$ nv set interface swp1,swp2,swp5,swp6,swp8,swp9
cumulus@leaf1:mgmt:~$ nv config diff
- set:
    interface:
      swp1-2,5-6,8-9:
        type: swp
```

Is your configuration active? … “activate” your configuration and verify.

Hosts

Configure your hosts with the following IPv4 addresses, we don't need a default gateway right now:

```
Host1(eth2):            172.16.1.1/24
Host2(eth2):            172.16.1.2/24
Host3(eth2):            172.16.1.3/24
Host4(eth2):            172.16.1.4/24
```

Task-07

Verify your link-layer neighbors (LLDP)

Verify that your switches are connected correctly according to the lab layout by using LLDP:

```
cumulus@leaf1:mgmt:~$ net show lldp

LocalPort  Speed  Mode     RemoteHost       RemotePort
---------  -----  -------  ---------------  -----------------
eth0       1G     Mgmt     oob-mgmt-switch  swp2
swp1       1G     Default  spine3           swp1
swp2       1G     Default  spine4           swp2
swp5       1G     Default  leaf2            swp5
swp6       1G     Default  leaf2            swp6
swp8       1G     Default  host1            44:38:39:00:00:11
swp9       1G     Default  host2            44:38:39:00:00:13
```

Task-08

Optional

It is beneficial to create maybe old-fashioned on a piece of paper a network documentation with the information about Layer 1 and Layer 2 to be used as a reference during class.

Task-09

Optional PTM

PTM is the abbreviation for Prescriptive Topology Manager, a service to verify if the intended layout correlates with the actual layout (both with a simulation or physical network).

Verify that your PTM daemon is running:

```
cumulus@leaf1:mgmt:/etc/ptm.d$ sudo systemctl status ptmd
 ptmd.service - Prescriptive Topology Manager (PTM) Daemon.
   Loaded: loaded (/lib/systemd/system/ptmd.service; enabled; vendor preset: enabled)
  Drop-In: /etc/systemd/system/ptmd.service.d
           └─ptmd.conf
   Active: active (running) since Mon 2022-03-07 08:48:58 UTC; 2 weeks 1 days ago
     Docs: man:ptmd(8)
           man:ptmctl(8)
 Main PID: 1093 (ptmd)
   Memory: 932.0K
   CGroup: /system.slice/ptmd.service
           └─1093 /usr/sbin/ptmd -l INFO
```

PTM is using a file called **`topology.dot`** which needs to be stored in the **`ptm.d`** directory:

```
cumulus@leaf1:mgmt:/etc/ptm.d$ ls
bfd-sess-down  bfd-sess-up  if-topo-fail  if-topo-pass
```

here in this example this file is missing.

Create a **`topology.dot`** file on one or multiple cumulus nodes.
You can use the following 3-line template as a starting point:

```
graph "<your name>" {
"spine3":"swp1" -- "leaf1":"swp1"
}
```

Once in place restart ptm and verify. For leaf1 the expected result is:

```
cumulus@leaf1:mgmt:~$ ptmctl
-----------------------------------------
port  cbl     BFD     BFD   BFD    BFD
      status  status  peer  local  type
-----------------------------------------
swp5  pass    N/A     N/A   N/A    N/A
swp6  pass    N/A     N/A   N/A    N/A
swp8  pass    N/A     N/A   N/A    N/A
swp9  pass    N/A     N/A   N/A    N/A
swp1  pass    N/A     N/A   N/A    N/A
swp2  pass    N/A     N/A   N/A    N/A

cumulus@leaf1:mgmt:~$ net show lldp

LocalPort  Speed  Mode     RemoteHost        RemotePort
---------  -----  -------  ---------------   -----------------
eth0       1G     Mgmt     oob-mgmt-switch   swp2
swp1       1G     Default  spine3            swp1
swp2       1G     Default  spine4            swp2
swp5       1G     Default  leaf2             swp5
swp6       1G     Default  leaf2             swp6
swp8       1G     Default  host1             44:38:39:00:00:11
swp9       1G     Default  host2             44:38:39:00:00:13
```

Task-10

Environment

Verify the FAN, LED, and SENSOR information, on a virtual switch dummy information is made available for the show commands:

```
cumulus@leaf1:mgmt:~$ net show system sensors
Fan1      (Fan Tray 1, Fan 1                      ):  OK
Fan2      (Fan Tray 1, Fan 2                      ):  OK
Fan3      (Fan Tray 2, Fan 1                      ):  OK
Fan4      (Fan Tray 2, Fan 2                      ):  OK
Fan5      (Fan Tray 3, Fan 1                      ):  OK
Fan6      (Fan Tray 3, Fan 2                      ):  OK
PSU1                                               :  OK
PSU2                                               :  OK
PSU1Fan1  (PSU1 Fan                               ):  OK
PSU1Temp1 (PSU1 Temp Sensor                       ):  OK
PSU2Fan1  (PSU2 Fan                               ):  OK
PSU2Temp1 (PSU2 Temp Sensor                       ):  OK
Temp1     (Board Sensor near CPU                  ):  OK
Temp2     (Board Sensor Near Virtual Switch       ):  OK
Temp3     (Board Sensor at Front Left Corner      ):  OK
Temp4     (Board Sensor at Front Right Corner     ):  OK
Temp5     (Board Sensor near Fan                  ):  OK
```

```
cumulus@leaf1:mgmt:~$ net show system leds
Power: green
            Fan: green
        System: green
```

```
cumulus@leaf1:mgmt:~$ nv show platform environment
          operational                         applied  description
--------  ----------------------------------  -------  --------------------------
[fan]     Fan1                                         The fans on the switch.
[fan]     Fan2
[fan]     Fan3
[fan]     Fan4
[fan]     Fan5
[fan]     Fan6
[fan]     PSU1Fan1
[fan]     PSU2Fan1
[led]     Fan                                          The LEDs on the switch.
[led]     Power
[led]     System
[psu]     PSU1                                         The PSUs on the switch.
[psu]     PSU2
[sensor]  Board Sensor Near Virtual Switch             The sensors on the switch.
[sensor]  Board Sensor at Front Left Corner
[sensor]  Board Sensor at Front Right Corner
[sensor]  Board Sensor near CPU
[sensor]  Board Sensor near Fan
[sensor]  PSU1 Temp Sensor
[sensor]  PSU2 Temp Sensor
```

```
cumulus@leaf1:mgmt:~$ nv show platform hardware
               operational        applied  description
-------------  -----------------  -------  ----------------------------------------
base-mac       44:38:39:00:00:1C           The base mac address provided by eeprom
manufacturer   Cumulus                     The platform's manufacturer
memory         1.88 GB                     Hardware RAM
model          VX                          The platform's model identifier
part-number    5.0.1                       System part number
product-name   VX                          Product Name
serial-number  44:38:39:00:00:1c           System serial number
system-mac     44:38:39:00:00:23           The MAC provided by eeprom for system-mac
cumulus@spine3:mgmt:~$ net show ver
NCLU_VERSION=1.0-cl5.0.0u11
DISTRIB_ID="Cumulus Linux"
DISTRIB_RELEASE=5.0.1
DISTRIB_DESCRIPTION="Cumulus Linux 5.0.1"
```

Task-11

Remove interfaces

Remove the direct interfaces between the leaf switches.

```
$ nv unset interface swp5-6
       $ nv config apply
```

Task-12

Verify the configuration history

```
$ nv config history
```

Example output:

```
cumulus@leaf1:mgmt:~$ nv config history
- apply-id: n/9
  apply-meta:
    method: CLI
    reason: Config update
    rev_id: changeset/cumulus/2022-03-22_12.12.01_AWD3
    state_controls: {}
    user: cumulus
  date: '2022-03-22T12:12:16+00:00'
  message: Config update by cumulus via CLI
  ref: apply/2022-03-22_12.12.13_AWD4/done
- apply-id: n/8
  apply-meta:
    method: CLI
    reason: Config update
    rev_id: startup
    state_controls: {}
    user: root
  date: '2022-03-22T10:52:36+00:00'
  message: Config update by root via CLI
  ref: apply/2022-03-22_10.52.34_AWD2/done
```

Identify the last two apply-id's, here n/9 and n/8.
n/9 includes the unsetting of swp5-6 and n/8 should include them as the state before unsetting.

Verify that the interfaces swp5-6 are not set on your leaf switches:

```
cumulus@leaf1:mgmt:~$ net show int
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: 192.168.200.2/24(DHCP)
UP     swp1  1G   9216   Default   spine3 (swp1)
UP     swp2  1G   9216   Default   spine4 (swp2)
UP     swp8  1G   9216   Default   host1 (44:38:39:00:00:11)
UP     swp9  1G   9216   Default   host2 (44:38:39:00:00:13)
UP     mgmt  N/A  65536  VRF                                  IP: 127.0.0.1/8
       mgmt                                                   IP: ::1/128
```

```
cumulus@leaf1:mgmt:~$ nv config apply n/8
applied

cumulus@leaf1:mgmt:~$ net show int
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:
192.168.200.2/24(DHCP)
UP     swp1  1G   9216   Default   spine3 (swp1)
UP     swp2  1G   9216   Default   spine4 (swp2)
UP     swp5  1G   9216   Default   leaf2 (swp5)
UP     swp6  1G   9216   Default   leaf2 (swp6)
UP     swp8  1G   9216   Default   host1 (44:38:39:00:00:11)
UP     swp9  1G   9216   Default   host2 (44:38:39:00:00:13)
UP     mgmt  N/A  65536  VRF                                  IP: 127.0.0.1/8
       mgmt                                                   IP: ::1/128
```

Task 13: Save the configuration

a. Make the applied configuration persistent (on all four switches):
   $ nv config save

```
cumulus@leaf1:mgmt:~$ nv config save
saved
```

Optional (more advanced) tasks:

Use a single line instruction (CLI) to make the config persistent on all four switches at once.

What would be your suggestions, please discuss in class during lab debriefing.

Task 14: Compare

b. Create on leaf1 a file in yaml syntax to add the interfaces swp5 and name it **/home/cumulus/replace.yaml** which includes the active configuration as a base:

`$ nv config show > /home/cumulus/replace.yaml`

Select an editor (e.g. nano or vi) and add Interface swp5

`$ nano replace.yaml`

```
- set:
    system:
      hostname: leaf1
    interface:
      swp1-2,5,8-9:
        type: swp
```

c. Replace the pending configuration

`$ nv config replace ./replace.yaml`

d. Verify the pending and the applied revisions

`$ nv config diff empty`
`$ nv config diff empty applied`

```
cumulus@leaf1:mgmt:~$ nv config diff
- set:
    interface:
      swp5:
        type: swp

cumulus@leaf1:mgmt:~$ nv config diff empty
- set:
    system:
      hostname: leaf1
    interface:
      swp1-2,5,8-9:
        type: swp
```

Apply the configuration and verify that swp5 is available.

```
cumulus@leaf1:mgmt:~$ net show int swp5
    Name  MAC                Speed  MTU   Mode
--  ----  -----------------  -----  ----  -------
UP  swp5  44:38:39:00:00:0d  1G     9216  Default
```

e. Copy the replace.yaml file, rename it to patch.yaml add the missing interface swp6. Within patch.yaml remove the hostname section.

   Add this set of information to the pending revision.
   Use **cl config diff** commands to compare and verify.
   Apply and save the new configuration.

```
    $ cp replace.yaml patch.yaml
    $ nano patch.yaml
    $ nv config patch patch.yaml

    $ nv config diff empty
    $ nv config diff startup
    $ nv config diff applied

    $ nv config apply
    $ nv config save
```

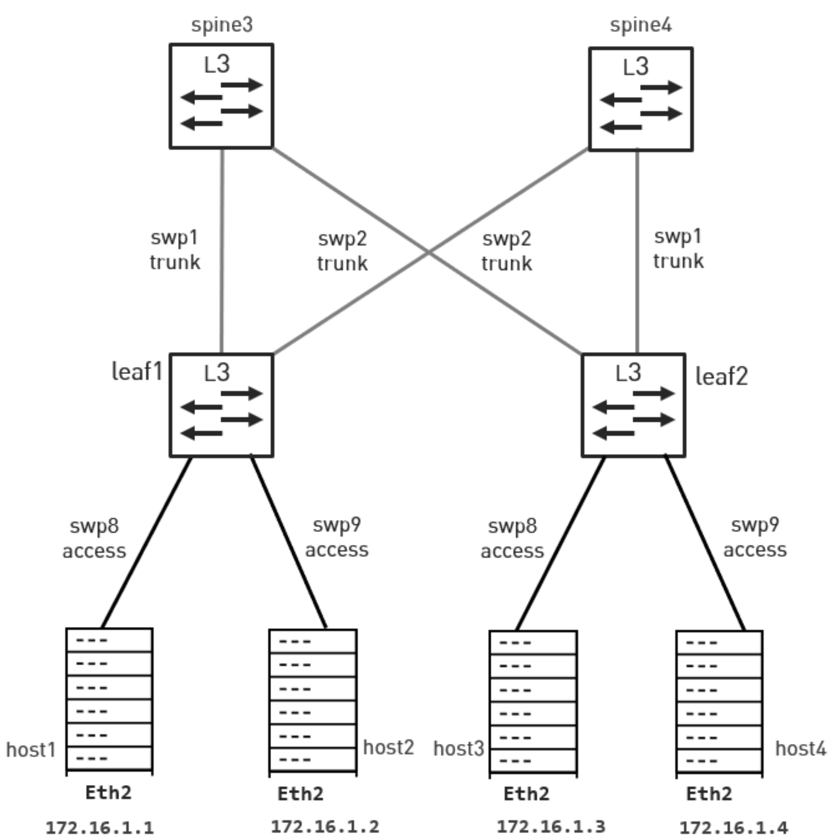
PRACTICE 2: BASIC SWITCH FUNCTIONS

Practice Objectives:

In this practice session you will create and 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'** MAC and IP settings:
   `$ ip address show dev eth2`

   or list all interfaces:

```
cumulus@host1:~$ ip -br a
lo               UNKNOWN        127.0.0.1/8 ::1/128
eth0             UP             192.168.200.6/24 fe80::4638:39ff:fe00:24/64
eth2             UP             172.16.1.1/24 fe80::4638:39ff:fe00:11/64
```

b. If they differ from the below table, correct them (/24 subnet):

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

Task 2

Clean up and configure a Bridge

a. Access the switches and reset configuration:

```
$ nv config apply empty -y
$ nv set system hostname [leaf1|leaf2|spine3|spine4]
$ nv config apply -y
$ nv config save
```

```
cumulus@leaf1:mgmt:~$ nv config save
saved
```

b. On all four switches – leaves and spines – create or enable a bridge named br_default, add VLAN10.
   Set the inter switch links (**swp1** and **swp2**) as trunk ports:

```
$ nv set bridge domain br_default vlan 10
$ nv set interface swp1-2 bridge domain br_default
```

   On the leaf switches only – leaf1 and leaf2 - set the host-facing ports, swp8 and swp9, as access ports in VLAN 10:

```
$ nv set interface swp8-9 bridge domain br_default access 10
```

Optional (more advanced) tasks:

Verify in the sys-file-system the resulting bridge type (traditional or vlan-aware-bridge (VAB).

Verify in the /e/n/i file the resulting bridge type.

Verify via ifquery the resulting bridge type.

c. Apply the pending revision:
   $ nv config apply

```
cumulus@leaf1:mgmt:~$ nv config apply
applied
```

Verification:

All hosts are configured with the same subnet 172.16.1.0/24. You should be able to reach from every host every other host. No default gateway is needed.

d. Verify configuration:
$ nv config diff startup applied
$ nv config show

```
cumulus@leaf1:mgmt:~$ nv config show
- set:
    bridge:
      domain:
        br_default:
          vlan:
            '10': {}
    system:
      hostname: leaf1
    interface:
      swp1-2:
        bridge:
          domain:
            br_default: {}
      swp1-2,8-9:
        type: swp
      swp8-9:
        bridge:
          domain:
            br_default:
              access: 10
```

e. Verify bridge mac-table:

$ nv show bridge domain br_default mac-table

$ net show bridge

```
cumulus@leaf1:mgmt:~$ nv show bridge domain br_default mac-table
      age  bridge-domain  entry-type  interface   last-update  mac                src-vni  vlan  vni  Summary
----  ---  -------------  ----------  ----------  -----------  -----------------  -------  ----  ---  -------
+ 0   27   br_default                 swp1        90           44:38:39:00:00:05           1
+ 1   93   br_default     permanent   swp1        93           44:38:39:00:00:06
+ 10  93   br_default     permanent   br_default  93           44:38:39:00:00:23
+ 2   30   br_default                 swp2        88           44:38:39:00:00:17           10
+ 3   28   br_default                 swp2        88           44:38:39:00:00:15           10
+ 4   28   br_default                 swp2        89           44:38:39:00:00:0b           1
+ 5   93   br_default     permanent   swp2        93           44:38:39:00:00:0c
+ 6   1    br_default                 swp8        88           44:38:39:00:00:11           10
+ 7   93   br_default     permanent   swp8        93           44:38:39:00:00:12
+ 8   1    br_default                 swp9        88           44:38:39:00:00:13           10
+ 9   93   br_default     permanent   swp9        93           44:38:39:00:00:14
```

```
cumulus@leaf1:mgmt:~$ net show bridge macs

VLAN      Master      Interface   MAC                TunnelDest  State      Flags  LastSeen
--------  ----------  ----------  -----------------  ----------  ---------  -----  --------
1         br_default  swp1        44:38:39:00:00:05                                00:00:29
1         br_default  swp2        44:38:39:00:00:0b                                00:00:29
10        br_default  swp2        44:38:39:00:00:15                                00:00:53
10        br_default  swp2        44:38:39:00:00:17                                00:01:02
10        br_default  swp8        44:38:39:00:00:11                                00:00:02
10        br_default  swp9        44:38:39:00:00:13                                00:00:02
untagged  br_default  br_default  44:38:39:00:00:23              permanent         00:03:05
untagged  br_default  swp1        44:38:39:00:00:06              permanent         00:03:05
untagged  br_default  swp2        44:38:39:00:00:0c              permanent         00:03:05
untagged  br_default  swp8        44:38:39:00:00:12              permanent         00:03:05
untagged  br_default  swp9        44:38:39:00:00:14              permanent         00:03:05
```

f. Verify the bridge via the native Linux commands:

$ bridge fdb
$ bridge link
$ bridge vlan

```
cumulus@leaf1:mgmt:~$ bridge fdb
44:38:39:00:00:05 dev swp1 vlan 1 master br_default
44:38:39:00:00:06 dev swp1 master br_default permanent
44:38:39:00:00:17 dev swp2 vlan 10 master br_default
44:38:39:00:00:15 dev swp2 vlan 10 master br_default
44:38:39:00:00:0b dev swp2 vlan 1 master br_default
44:38:39:00:00:0c dev swp2 master br_default permanent
44:38:39:00:00:11 dev swp8 vlan 10 master br_default
44:38:39:00:00:12 dev swp8 master br_default permanent
44:38:39:00:00:13 dev swp9 vlan 10 master br_default
44:38:39:00:00:14 dev swp9 master br_default permanent
44:38:39:00:00:23 dev br_default master br_default permanent
```

```
cumulus@leaf1:mgmt:~$ bridge link
3: swp1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9216 master br_default state forwarding
priority 8 cost 4
4: swp2: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9216 master br_default state forwarding
priority 8 cost 4
7: swp8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9216 master br_default state forwarding
priority 8 cost 4
8: swp9: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9216 master br_default state forwarding
priority 8 cost 4
```

```
cumulus@leaf1:mgmt:~$ bridge vlan
port    vlan ids
swp1     1 PVID Egress Untagged
         10

swp2     1 PVID Egress Untagged
         10

swp8     10 PVID Egress Untagged

swp9     10 PVID Egress Untagged

br_default      None
```

Task 3

Observe a Switch's Forwarding Database

a. Identify the MAC addresses of all four servers/hosts in your setup.

```
cumulus@host1:~$ ip -br l
lo                UNKNOWN        00:00:00:00:00:00 <LOOPBACK,UP,LOWER_UP>
eth0              UP             44:38:39:00:00:24 <BROADCAST,MULTICAST,UP,LOWER_UP>
eth2              UP             44:38:39:00:00:11 <BROADCAST,MULTICAST,UP,LOWER_UP>
```

verify that the eth2 MAC addresses is stored within the FDB/mac-address-tables of your switches

b. 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
```

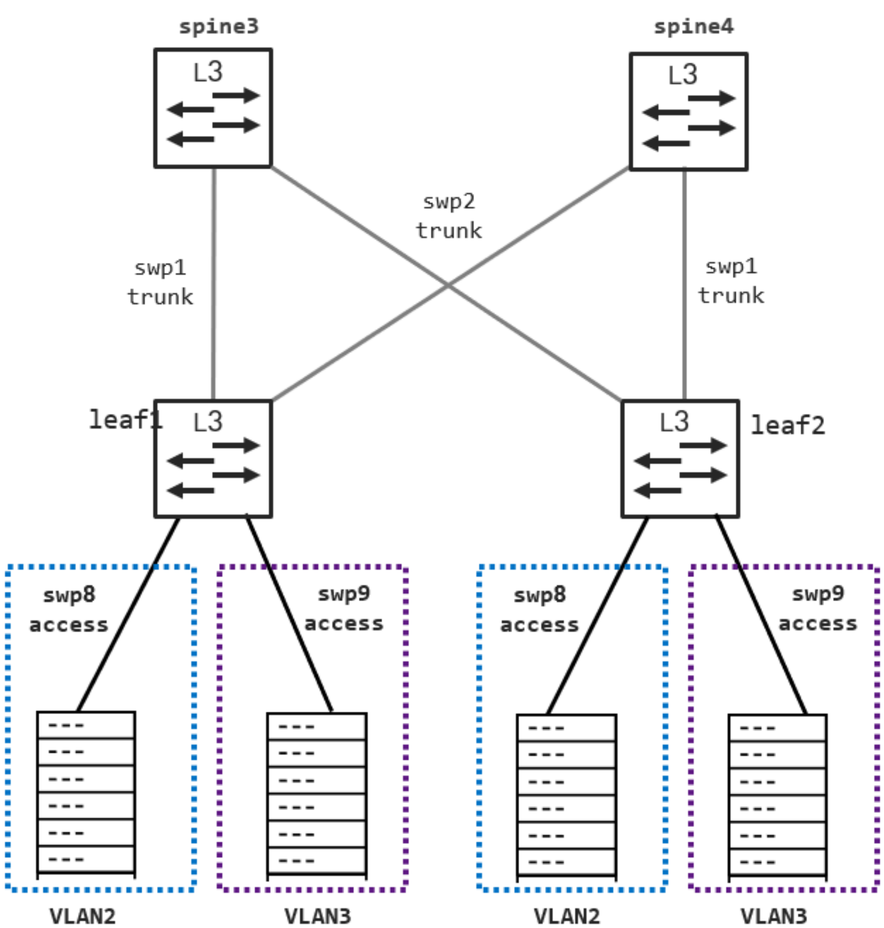
PRACTICE 3: VLANs AND TRUNKING

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 leaf and spine switches and reset configuration:

$ nv config apply empty

$ nv set system hostname [leaf1,leaf2,spine3,spine4]

$ nv config apply

b. On all four switches – spines and leaves - create a vlan-aware-bridge, two vlans (2 and 3) and set the inter switch links, **swp1** and **swp2**, as trunk ports:
$ nv set bridge domain br_default vlan 2-3
$ nv set interface swp1-2 bridge domain br_default

c. Verify if vlan 1, without explicitly configuration, is used by default and for which use case:

```
cumulus@leaf1:mgmt:~$ nv show bridge domain br_default vlan
     multicast.snooping.querier.source-ip  ptp.enable  Summary
---  ------------------------------------  ----------  -------
+ 2  0.0.0.0                               off
+ 3  0.0.0.0                               off
```

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

Interface  VLAN  Flags
---------  ----  ---------------------
swp1       1     PVID, Egress Untagged
           2-3   []
swp2       1     PVID, Egress Untagged
           2-3   []
```

Optionally, verify that LLDP is running between the switches. Following example shows spine3 view after configuring leaf1 but before configuring leaf2.

`$ sudo lldpcli`
`$ sudo lldpcli show neighbors`

```
[lldpcli] # show neighbors summary
-------------------------------------------------------------------------------
LLDP neighbors:
-------------------------------------------------------------------------------
Interface:    eth0, via: LLDP
  Chassis:
    ChassisID:    mac 44:38:39:00:00:19
    SysName:      oob-mgmt-switch
  Port:
    PortID:       ifname swp4
    PortDescr:    swp4
    TTL:          120
-------------------------------------------------------------------------------
Interface:    swp1, via: LLDP
  Chassis:
    ChassisID:    mac 44:38:39:00:00:1c
    SysName:      leaf1
  Port:
    PortID:       ifname swp1
    PortDescr:    swp1
    TTL:          120
-------------------------------------------------------------------------------
```

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**
`$ nv set interface swp9 bridge domain br_default access 3`

e. Commit changes and verify:

```
cumulus@leaf1:mgmt:~$ nv config apply
```

f. Verify VLANs configuration:

```
cumulus@leaf1:mgmt:~$ nv set interface swp8 bridge domain br_default access 2
cumulus@leaf1:mgmt:~$ nv set interface swp9 bridge domain br_default access 3
```

$ bridge vlan

```
cumulus@leaf1:mgmt:~$ bridge vlan
port    vlan ids
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 if needed the server's IP address and subnet mask according to the table above.

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

a non-persistent setting can be achieved via ip(route2) or you might consider to configure via netplan.

```
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
```

$ sudo ip route add *<NET_ADDRESS/MASK>* dev *<DEV>* via *<IP>*

Question: how would you remove a static route you might have set incorrectly before?

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

$ nv set interface vlan2 ip address 172.16.2.254/24

$ nv set interface vlan3 ip address 172.16.3.254/24

```
cumulus@spine3:mgmt:~$ nv set interface vlan2 ip address 172.16.2.254/24
cumulus@spine3:mgmt:~$ nv set interface vlan3 ip address 172.16.3.254/24
cumulus@spine3:mgmt:~$ nv config apply
```

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
```

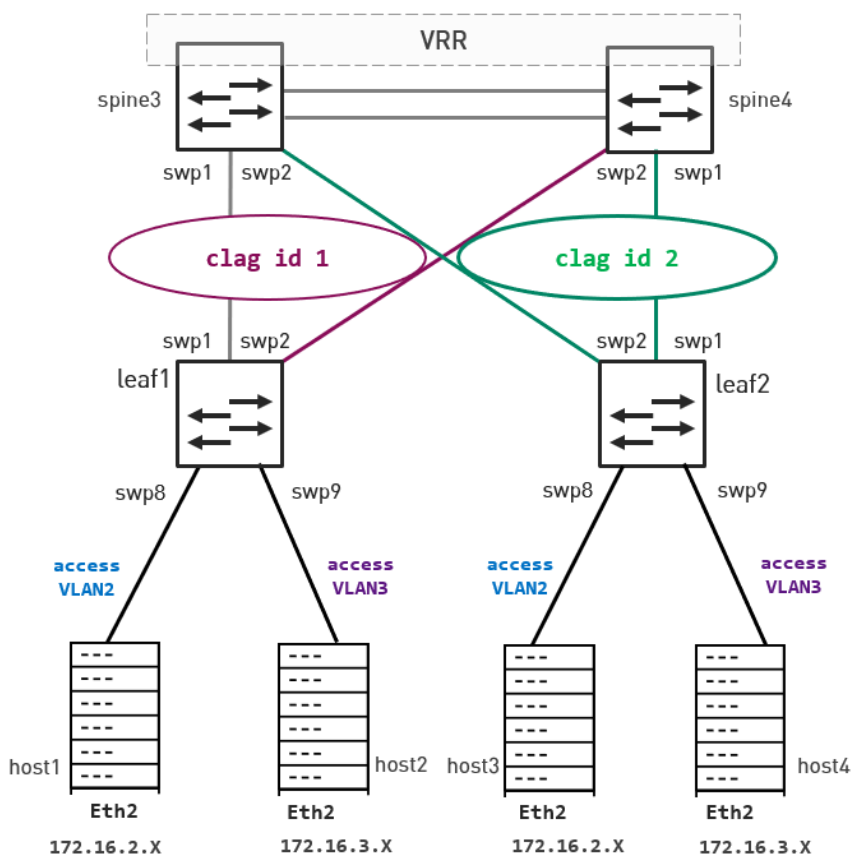
PRACTICE 4: CONFIGURING MLAG and VRR

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:

$ nv config apply empty

$ nv set system hostname [leaf1|leaf2]

b. Create a bridge
$ nv set bridge domain br_default

c. Create a bond named **'BOND_TO_SPINES'**, where bonds slaves are interfaces **swp1** and **swp2**.

$ nv set interface BOND_TO_SPINES type bond

$ nv set interface BOND_TO_SPINES bond member swp1-2

d. 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)

cumulus@leaf2:mgmt:~$ net show interface bondmems
    Name  Speed  MTU   Mode       Summary
--  ----  -----  ----  ---------  --------------------------
UP  swp1  1G     9216  LACP-UP    Master: BOND_TO_SPINES(DN)
UP  swp2  1G     9216  LACP-DOWN  Master: BOND_TO_SPINES(DN)
```

Please note:

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

e. Add the bond interface, **BOND-TO-SPINES**, and the host facing interfaces, **swp8** and **swp9**, to the bridge:

$ nv set interface BOND_TO_SPINES bridge domain br_default

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

g. **$ nv set interface swp8 bridge domain br_default access 2**

h. **$ nv set interface swp9 bridge domain br_default access 3**

Task 2: Configuring MLAG – spine switches

a. Access the spine switches and reset the configuration:

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

```
cumulus@spine3:mgmt:~$ ip -br a | grep eth0
eth0             UP             192.168.200.4/24 fe80::4638:39ff:fe00:20/64

cumulus@spine3:mgmt:~$ ip l | grep eth0
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast master mgmt state UP
mode DEFAULT group default qlen 1000
```

```
cumulus@spine4:mgmt:~$ ip -br a | grep eth0
eth0             UP             192.168.200.5/24 fe80::4638:39ff:fe00:22/64

cumulus@spine4:mgmt:~$ ip l | grep eth0
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast master mgmt state UP
mode DEFAULT group default qlen 1000
```

- Also verify if / which vrf is being used.
  Here: 192.168.200.4 and 192.168.200.5 (both **vrf mgmt**.)

b. Configure the spine switches, **spine3** (primary) and **spine4 (secondary)**, as MLAG peers.

```
$ nv set mlag mac-address 44:38:39:FF:00:01
$ nv set mlag backup 192.168.200.4 vrf mgmt.
$ nv set mlag init-delay 15
$ nv set mlag priority 2000
$ nv set interface peerlink bond member swp3-4
```

if you have selected your own IP address as the backup IP address, you will find the line:

Backup IP: 192.168.200.4 vrf mgmt (inactive: self)

indicating "inactive: self" as the reason.

A not yet reachable IP as the backup results in the following line:

`Backup IP: 172.168.200.5 vrf mgmt (inactive)`

Once you have configured both sides with a valid backup IP address, the **`show`** command will state "**`active`**", which is the desired outcome.

```
cumulus@spine3:mgmt:~$ net show clag
The peer is not alive
     Our Priority, ID, and Role: 1000 44:38:39:00:00:01 primary
          Peer Interface and IP: peerlink.4094 fe80::4638:39ff:fe00:2 (linklocal)
                      Backup IP: 192.168.200.5 vrf mgmt (active)
                     System MAC: 44:38:39:ff:00:01
```

Please note:

- The init-delay is being changed for lab use, not a production best practice.
  For production esp. for lagre scale deployments consult with your account team.
- 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.

c. Configure bridge settings – VLANs and STP priority: on both spines:

```
cumulus@spine3:mgmt:~$ nv set bridge domain br_default vlan 2-3
cumulus@spine3:mgmt:~$ nv set bridge domain br_default stp priority 4096
```

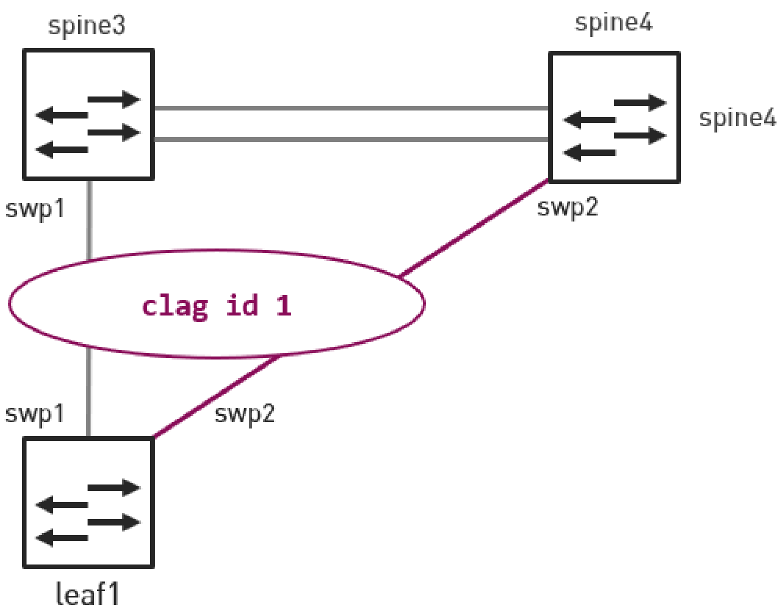
d. Apply the changes:

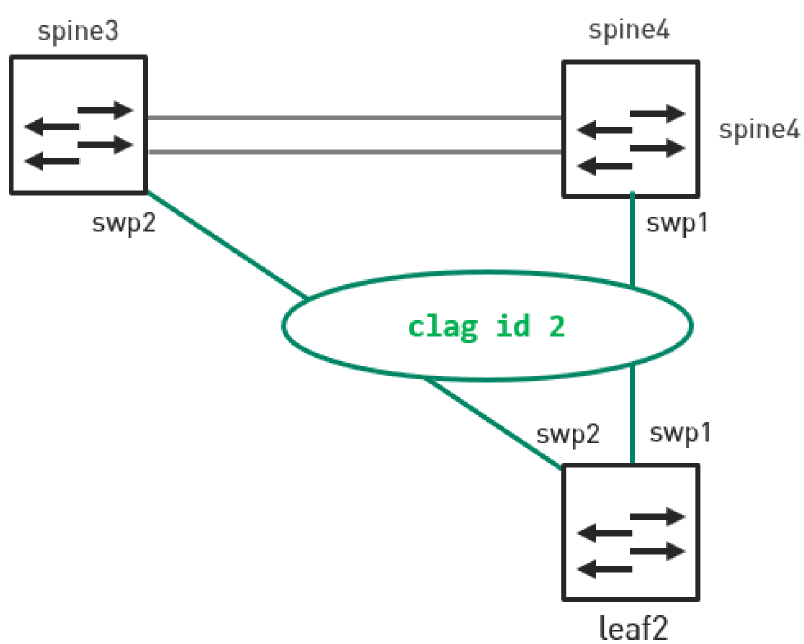
```
cumulus@spine3:mgmt:~$ nv config apply
```

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**





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

```
$ nv set interface LEAF1 bond member swp1
$ nv set interface LEAF2 bond member swp2
$ nv set interface LEAF1-2 type bond
$ nv set interface LEAF1 bond mlag id 1
$ nv set interface LEAF2 bond mlag id 2
$ nv set interface LEAF1-2 bridge domain br_default

$ nv config apply
```

Working output:

```
cumulus@spine3:mgmt:~$ net show clag
The peer is alive
     Our Priority, ID, and Role: 1000 44:38:39:00:00:01 primary
    Peer Priority, ID, and Role: 2000 44:38:39:00:00:02 secondary
          Peer Interface and IP: peerlink.4094 fe80::4638:39ff:fe00:2 (linklocal)
                      Backup IP: 192.168.200.5 vrf mgmt (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         -                      -
```

b. **Verify which interfaces have been added:**

```
cumulus@spine4:mgmt:~$ nv config apply
```

```
<SNIP>

auto peerlink
iface peerlink
        bond-slaves swp3 swp4
        bond-mode 802.3ad
        bond-lacp-bypass-allow no

auto peerlink.4094
iface peerlink.4094
        clagd-peer-ip linklocal
        clagd-priority 1000
        clagd-backup-ip 192.168.200.5 vrf mgmt
        clagd-sys-mac 44:38:39:FF:00:01
        clagd-args --initDelay 15

auto LEAF1
iface LEAF1
        bond-slaves swp1
        bond-mode 802.3ad
        bond-lacp-bypass-allow no
        clag-id 1

auto LEAF2
iface LEAF2
        bond-slaves swp2
        bond-mode 802.3ad
        bond-lacp-bypass-allow no
        clag-id 2

auto br_default
iface br_default
        bridge-ports peerlink LEAF1 LEAF2
        hwaddress 44:38:39:00:00:25
        bridge-vlan-aware yes
        bridge-vids 2 3
        bridge-pvid 1



<SNIP>
```

```
cumulus@spine3:mgmt:~$ nv config diff empty applied
- set:
    bridge:
      domain:
        br_default:
          stp:
            priority: 4096
          vlan:
            '2': {}
            '3': {}
    mlag:
      backup:
        192.168.200.5:
          vrf: mgmt
      enable: on
      init-delay: 15
      mac-address: 44:38:39:FF:00:01
      priority: 1000
    system:
      hostname: spine3
    interface:
      LEAF1:
        bond:
          member:
            swp1: {}
          mlag:
            id: 1
      LEAF1-2:
        bond:
          mlag:
            enable: on
        bridge:
          domain:
            br_default: {}
        type: bond
      LEAF2:
        bond:
          member:
            swp2: {}
          mlag:
            id: 2
      peerlink:
        bond:
          member:
            swp3: {}
            swp4: {}
        type: peerlink
      peerlink.4094:
        base-interface: peerlink
        type: sub
        vlan: 4094
      swp1-9:
        type: swp
```

c. View MLAG resulting configuration:
Verify which timers MLAG protocol is using by :
$ clagctl

Expected result:

"The peer is alive" and Spine3 is the primary, Spine4 the secondary with Priority values of 1000 and 2000 respectively.

An IPv6 LLA is used for the TCP connection between the peerlink.4094 sub-interfaces.

Both bonds (LEAF1 and LEAF2) are listed twice, once under "Our Interface" and once under the "Peer Interface" column.

The Backup IP is stated as (active)

```
cumulus@spine3:mgmt:~$ clagctl -v
The peer is alive
     Our Priority, ID, and Role: 1000 44:38:39:00:00:01 primary
    Peer Priority, ID, and Role: 2000 44:38:39:00:00:02 secondary
          Peer Interface and IP: peerlink.4094 fe80::4638:39ff:fe00:2 (linklocal)
                      Backup IP: 192.168.200.5 vrf mgmt (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         -                      -

<SNIP>
Timer Information
Timers             Value     Time remaining
----------------   -------   --------------
initDelay          15        00:00:00
peerTimeout        20        00:00:18
reloadTimer        300       00:00:00
sendTimeout        30

<SNIP>
```

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

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

$ sudo 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
```

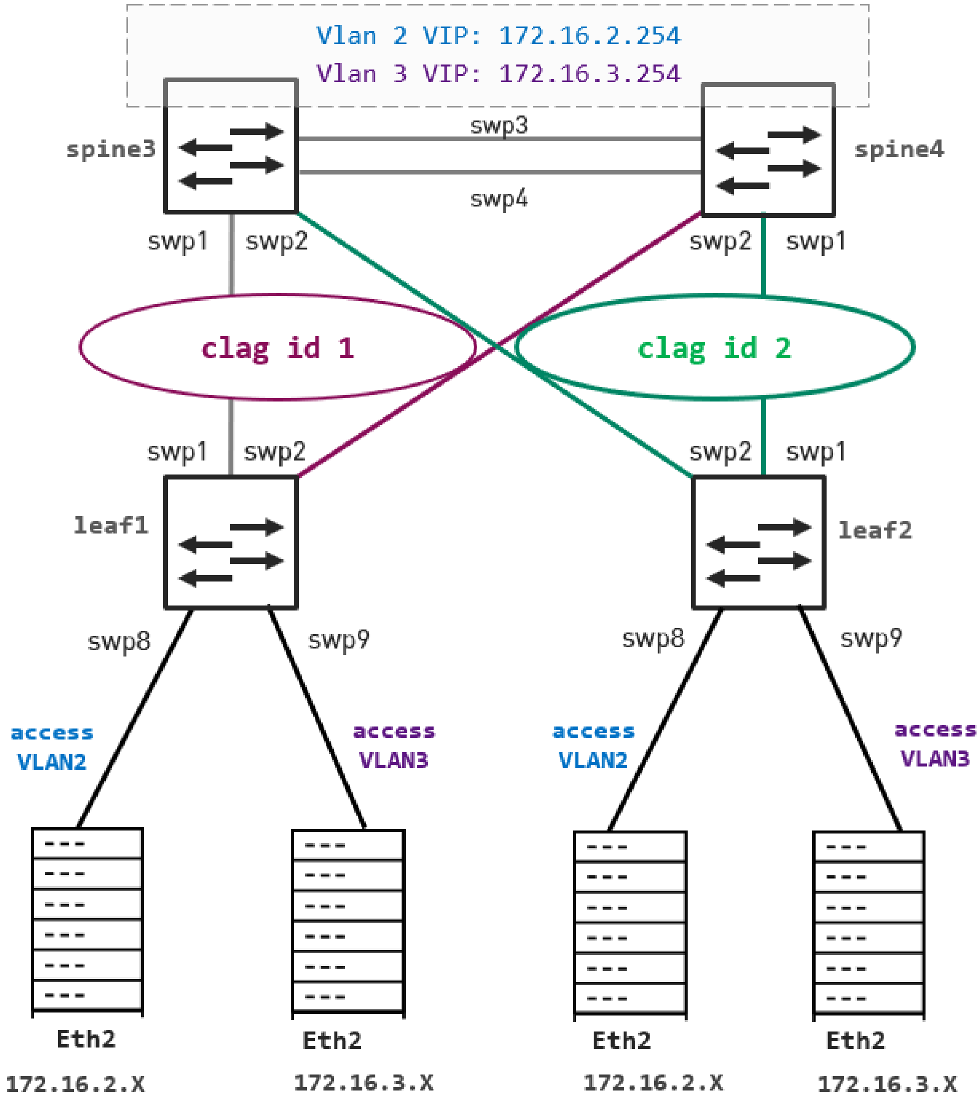
```
cumulus@spine4:mgmt:~$ net show bridge macs

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

`$ nv set interface vlan2 ip address 172.16.2.252/24`

`$ nv set interface vlan2 ip vrr address 172.16.2.254/24`

b. Verify VRR configuration:

```
$ ip l
<SNIP>
13: vlan2@br_default: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 9216 qdisc noqueue state UP
group default qlen 1000
    link/ether 44:38:39:00:00:01 brd ff:ff:ff:ff:ff:ff
    inet 172.16.2.252/24 scope global vlan2
       valid_lft forever preferred_lft forever
    inet6 fe80::4638:39ff:fe00:1/64 scope link
       valid_lft forever preferred_lft forever
```

The VRR interface is not listed because we are missing a parameter.

$ nv set interface vlan2 ip vrr state up

```
cumulus@spine3:mgmt:~$ nv set interface vlan2 ip vrr state up
cumulus@spine3:mgmt:~$ nv config apply
Invalid config
  'interface vlan2 ip vrr' requires one of the following to be configured:
        'system global anycast-id'
        'system global anycast-mac'
        'interface vlan2 ip vrr mac-id'
        'interface vlan2 ip vrr mac-address'
```

$ nv set interface vlan2 ip vrr mac-address 00:00:5e:00:01:02

Repeat for vlan3 as well as for spine4.

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 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:

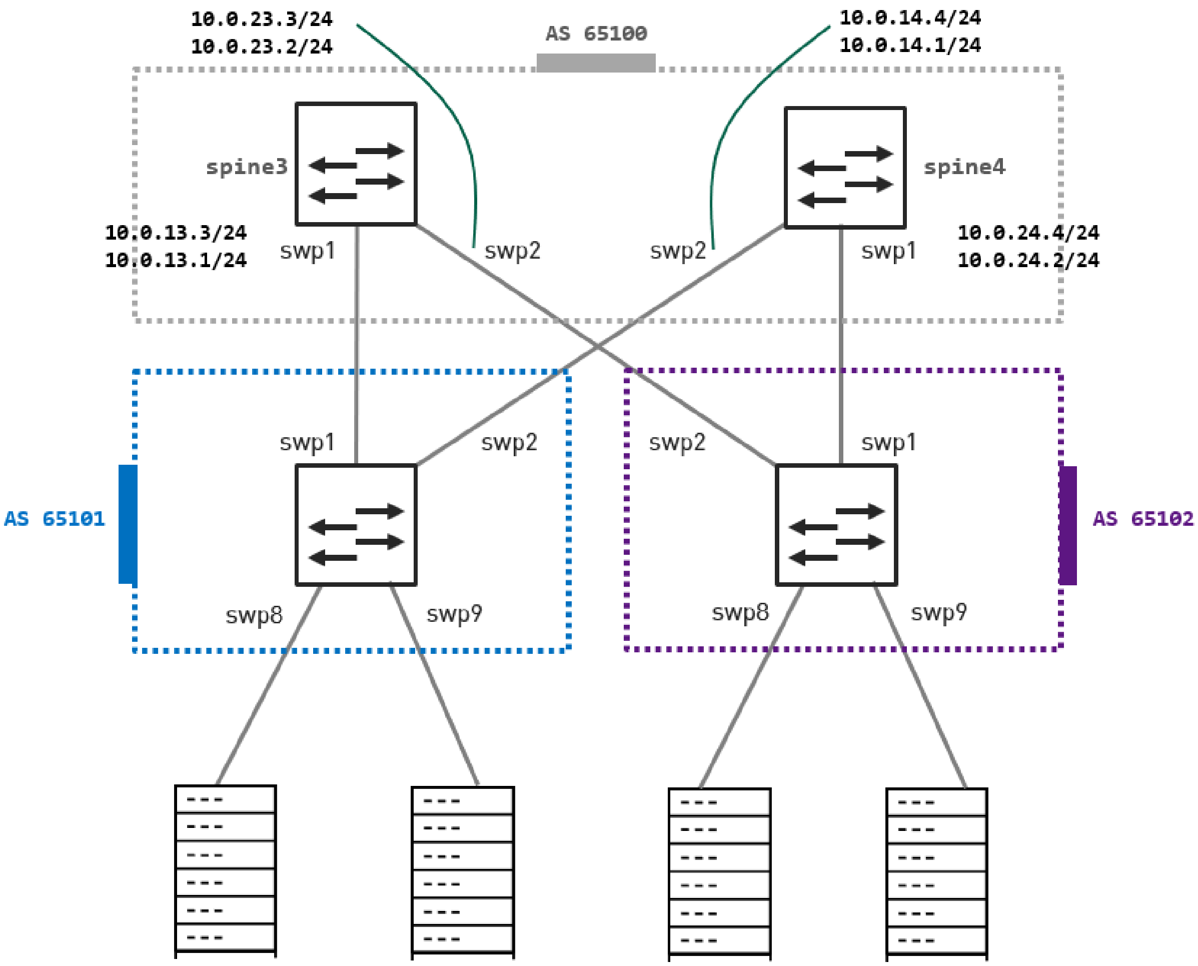
- Spine switches will be configured in the same AS and each of the leaf switches will be configured in its own AS.
- BGP unnumbered will be configured on all four switches.
- eBGP sessions will be established between the spine and leaf switches.
- Leaf switches will advertise their local IP prefixes.
- 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:

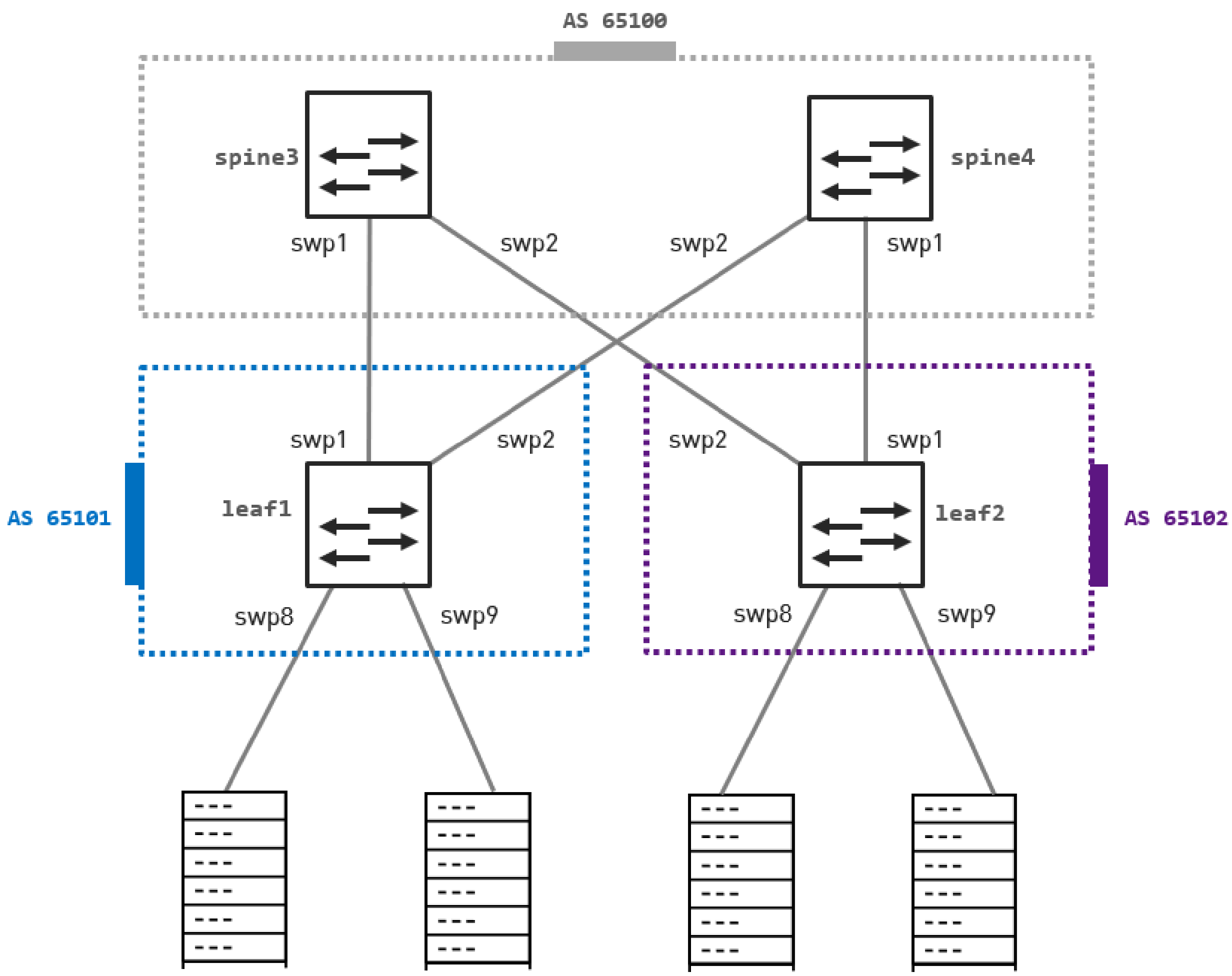
- Commands are demonstrated on switches **`selected switches`**. You should apply similar commands on the other two switches in your group.

Alternative lab:

You can configure BGP via the classical approach by using IPv4 Addresses on point-to-point links between the spines and leaf's. For teaching purposes we use a /24 network but in production a /30 or /31 is often preferred.



Topology used in this practice session covering BGP unnumbered:



Task 1: Starting FRR

a. Access the switches, reset the configuration, and set the host names:

```
# nv config apply empty
# nv set system hostname [leaf1|leaf2|spine3|spine4]
```

Task 2: Configuring loopback interfaces and enable interfaces between the spines and leafs:

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

```
$ nv set interface lo ip address 172.16.100.1/32
$ nv config apply
```

Enable the interfaces between the spines and leaf's as Layer 3 interfaces.

```
$ nv set interface swp1-2
$ nv config apply
```

Task 3: Configuring BGP Unnumbered

a. Configure BGP unnumbered (the three ASN used are 65100, 65101, and 65102):

```
cumulus@leaf1:mgmt:~$ nv set router bgp autonomous-system 65101
cumulus@leaf1:mgmt:~$ nv set router bgp router-id 172.16.100.1
cumulus@leaf1:mgmt:~$ nv set vrf default router bgp neighbor swp1 remote-as external
cumulus@leaf1:mgmt:~$ nv set vrf default router bgp neighbor swp2 remote-as external
```

b. Advertise the loopback addresses and apply the changes.

```
cumulus@leaf1:mgmt:~$ nv set vrf default router bgp address-family ipv4-unicast network
172.16.100.1/32
cumulus@leaf1:mgmt:~$ nv config apply
```

After you configured the first switch for bgp you can verify the state of the FSM and the number (zero) of prefixes exchanged:

```
cumulus@leaf1:mgmt:~$ net show bgp sum
show bgp ipv4 unicast summary
=============================
BGP router identifier 172.16.100.1, local AS number 65101 vrf-id 0
BGP table version 1
RIB entries 1, using 200 bytes of memory
Peers 2, using 46 KiB of memory

Neighbor         V         AS    MsgRcvd    MsgSent    TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt
swp1             4          0          0          0         0    0    0    never         Idle        0
swp2             4          0          0          0         0    0    0    never         Idle        0

Total number of neighbors 2
```

Please note:

Commands are demonstrated on one switche, all four switches should run and all loopback addresses should be known by all switches (one local and three remote).

c. Once you have configured all four devices you can verify configuration via net show commands or switch to the FRR provided CLI:

```
$ sudo vtysh
$ show run
$ show ip bgp sum
```

you should see two **neigbors** and a number **`!=0`** in the **`PfxSnt`** column

```
spine4# show ip bgp summary

IPv4 Unicast Summary:
BGP router identifier 172.16.100.4, local AS number 65100 vrf-id 0
BGP table version 3
RIB entries 5, using 1000 bytes of memory
Peers 2, using 46 KiB of memory

Neighbor        V         AS   MsgRcvd   MsgSent   TblVer  InQ OutQ  Up/Down State/PfxRcd   PfxSnt
leaf2(swp1)     4      65102         7         7        0    0    0 00:00:04            1        3
leaf1(swp2)     4      65101         9         8        0    0    0 00:00:07            1        3

Total number of neighbors 2


spine4# show ip bgp summary

IPv4 Unicast Summary:
```

You can also verify the RIB via "`show ip route`" within the FRR CLI

```
spine4# show ip route
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, r - rejected, b - backup
       t - trapped, o - offload failure
B>* 172.16.100.1/32 [20/0] via fe80::4638:39ff:fe00:c, swp2, weight 1, 00:01:52
B>* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:a, swp1, weight 1, 00:01:49
C>* 172.16.100.4/32 is directly connected, lo, 00:01:56
```

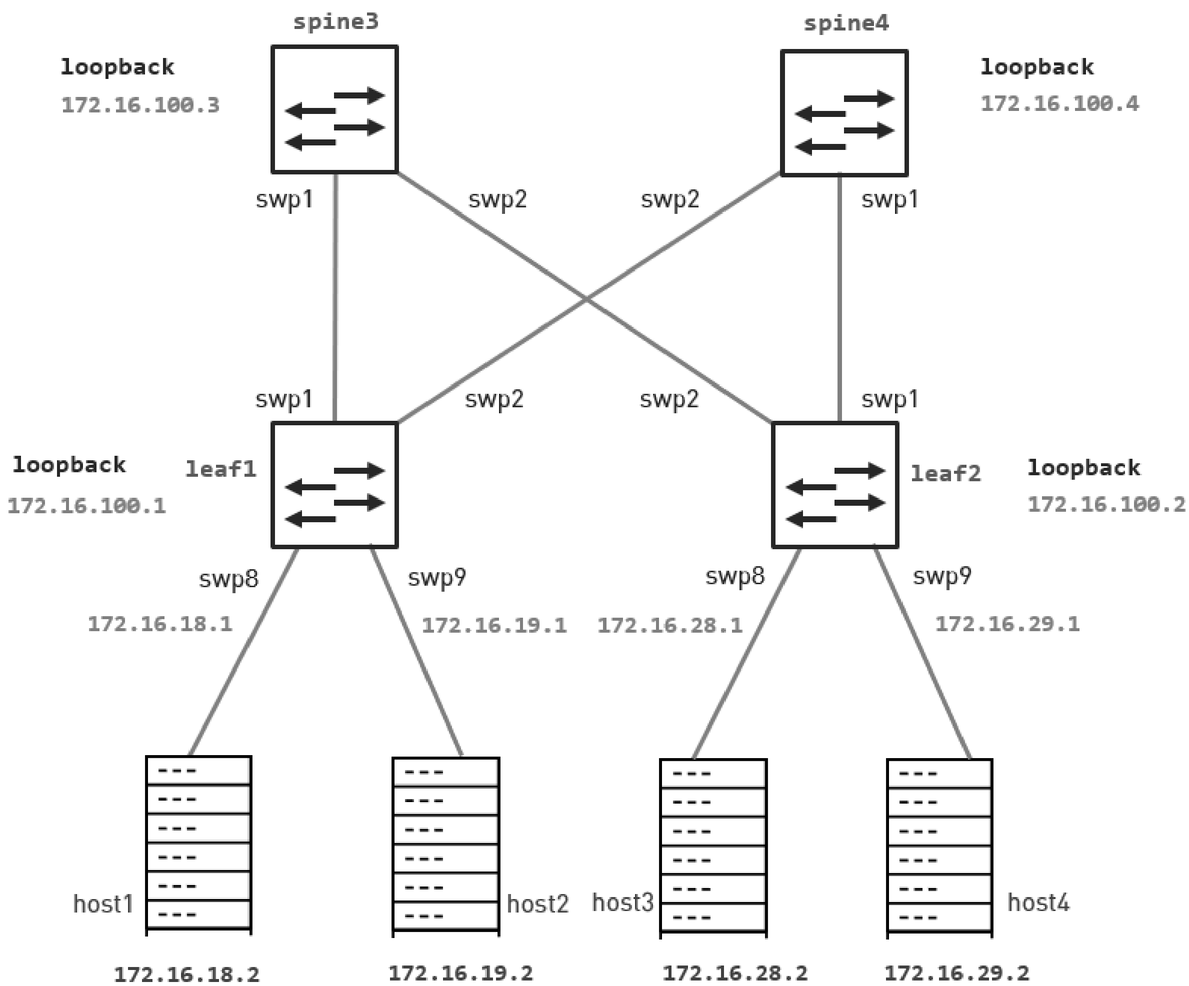
Verify loopback prefixes are reachable:

Please note:

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

Task 4: Advertise local IP prefixes

a. 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 bits for the subnet mask.



Example for leaf1:

```
$ nv set interface swp8 ip address 172.16.18.1/24

$ nv set interface swp9 ip address 172.16.19.1/24

$nv set vrf default router bgp address-family ipv4-unicast network 172.16.18.0/24
$nv set vrf default router bgp address-family ipv4-unicast network 172.16.19.0/24
$nv config apply
```

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**:
     - `172.16.28.0/24`
     - `172.16.29.0/24`

Intermediate state after configuring the first leaf, you see the local networks in the BGP Topology Table:

```
cumulus@leaf1:mgmt:~$ net show bgp
show bgp ipv4 unicast
=====================
BGP table version is 9, local router ID is 172.16.100.1, vrf id 0
Default local pref 100, local AS 65101
Status codes:  s suppressed, d damped, h history, * valid, > best, = multipath,
               i internal, r RIB-failure, S Stale, R Removed
Nexthop codes: @NNN nexthop's vrf id, < announce-nh-self
Origin codes:  i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*> 172.16.18.0/24   0.0.0.0                  0         32768 i
*> 172.16.19.0/24   0.0.0.0                  0         32768 i
*> 172.16.100.1/32  0.0.0.0                  0         32768 i

Displayed  3 routes and 3 total paths
```

Switch **leaf2** should have in its routing table the IP prefixes advertise by switch **leaf1**:

- 172.16.18.0/24
- 172.16.19.0/24

$ net show route bgp

```
leaf1# show ip route
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, r - rejected, b - backup
       t - trapped, o - offload failure
C>* 172.16.18.0/24 is directly connected, swp8, 00:06:06
C>* 172.16.19.0/24 is directly connected, swp9, 00:06:06
B>* 172.16.28.0/24 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:00:17
  *                       via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:00:17
B>* 172.16.29.0/24 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:00:17
  *                       via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:00:17
C>* 172.16.100.1/32 is directly connected, lo, 2d18h27m
B>* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:50:33
  *                        via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:50:33
B>* 172.16.100.3/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 2d18h12m
B>* 172.16.100.4/32 [20/0] via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:53:51
```

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

b. Add a route entry to 172.16.0.0/16 via interface **'eth2'**:

$ sudo 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
```

Or via netplan, for example:

```
<SNIP>
      routes:
      - to: 172.16.0.0/16
        via: 172.16.18.1
```

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.

$ nv config save

PRACTICE 6: CONFIGURING VXLAN WITH EVPN

Practice Objectives:

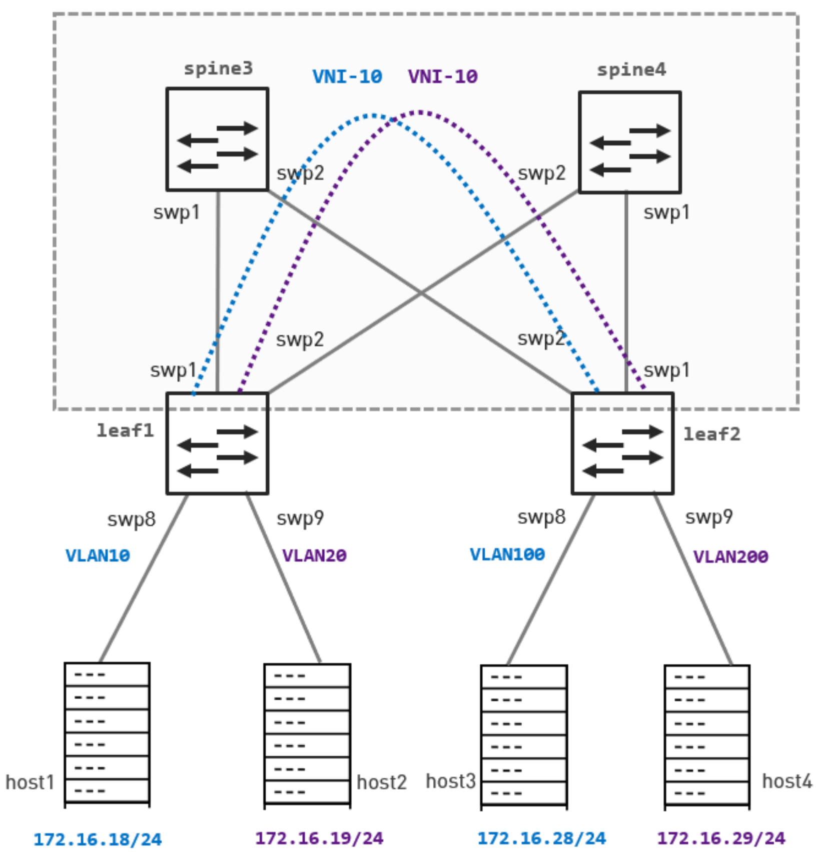
In this practice session you will configure VXLAN with EVPN:

- 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

a. 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:

  $ sudo ifconfig *<DEV>* 0.0.0.0

- Configure an IP address and a subnet mask:

  $ sudo ifconfig *<DEV>* *<IP/MASK>*

Alternatively consider to use Netplan to configure your Linux hosts[1-4].

Task 2: Configuring a Bridge with two VLANs and access-ports

a. 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

```
$ nv unset interface swp8
$ nv unset interface swp9
$ nv config apply
```

Interim state, interfaces swp8-9 are unconfigured:

```
cumulus@leaf1:mgmt:~$ net show int
State  Name  Spd  MTU    Mode          LLDP  Summary
-----  ----  ---  -----  ------------  ----  --------------------------
UP     lo    N/A  65536  Loopback            IP: 127.0.0.1/8
       lo                                    IP: 172.16.100.1/32
       lo                                    IP: ::1/128
UP     eth0  1G   1500   Mgmt                Master: mgmt(UP)
       eth0                                  IP: 192.168.200.2/24(DHCP)
UP     swp1  1G   9216   Default
UP     swp2  1G   9216   Default
UP     mgmt  N/A  65536  VRF                 IP: 127.0.0.1/8
       mgmt                                  IP: ::1/128
```

Leaf1:

```
$ nv set interface swp8 bridge domain br_default access 10
$ nv set interface swp9 bridge domain br_default access 20
$ nv set bridge domain br_default vlan 10,20
$ nv config apply
```

```
cumulus@leaf1:mgmt:~$ net show int
State  Name        Spd  MTU    Mode       LLDP                       Summary
-----  ----------  ---  -----  ---------  -------------------------  --------------------------
UP     lo          N/A  65536  Loopback                              IP: 127.0.0.1/8
       lo                                                            IP: 172.16.100.1/32
       lo                                                            IP: ::1/128
UP     eth0        1G   1500   Mgmt                                  Master: mgmt(UP)
       eth0                                                          IP: 192.168.200.2/24(DHCP)
UP     swp1        1G   9216   Default
UP     swp2        1G   9216   Default
UP     swp8        1G   9216   Access/L2  host1 (44:38:39:00:00:11)  Master: br_default(UP)
UP     swp9        1G   9216   Access/L2                             Master: br_default(UP)
UP     br_default  N/A  9216   Bridge/L2
UP     mgmt        N/A  65536  VRF                                   IP: 127.0.0.1/8
       mgmt                                                          IP: ::1/128
```

Leaf2:

```
$ nv set interface swp8 bridge domain br_default access 100
$ nv set interface swp9 bridge domain br_default access 200
$ nv set bridge domain br_default vlan 100,200
$ nv config apply
```

Verify the bridge configuration on both leafs:

```
$ bridge vlan
$ bridge link
```

Task 3: Configuring VNIs

a. Access the leaf switches and configure the VNIs:
   - Create a VXLAN interface (NVE) and use the leaf's loopback IP address as its source
   - Map the VXLAN to a VLAN
     Leaf1: VLAN 10 : VXLAN 10
     VLAN 20 : VXLAN 20
     Leaf2: VLAN 100 : VXLAN 10
     VLAN 200 : VXLAN 20

Leaf1:

```
$ nv set nve vxlan source address 172.16.100.1
$ nv set bridge domain br_default vlan 10 vni 10
$ nv set bridge domain br_default vlan 20 vni 20
$ nv config apply
```

Leaf2:

```
$ nv set nve vxlan source address 172.16.100.2
$ nv set bridge domain br_default vlan 100 vni 10
$ nv set bridge domain br_default vlan 200 vni 20
$ nv config apply
```

Task 4: Configuring EVPN

a. Access the switches and configure EVPN.

```
$ nv set evpn enable on
$ nv set vrf default router bgp address-family l2vpn-evpn enable on
$ nv set vrf default router bgp neighbor swp1 address-family l2vpn-evpn enable on
$ nv set vrf default router bgp neighbor swp2 address-family l2vpn-evpn enable on
$ nv config apply
```

b. Verify MAC VXLAN Information.

$ show evpn mac vni all

```
leaf1# show evpn mac vni all

VNI 10 #MACs (local and remote) 2

Flags: B=bypass N=sync-neighs, I=local-inactive, P=peer-active, X=peer-proxy
MAC               Type   Flags Intf/Remote ES/VTEP            VLAN  Seq #'s
44:38:39:00:00:11 local        swp8                           10    0/0
44:38:39:00:00:15 remote       172.16.100.2                         0/0

VNI 20 #MACs (local and remote) 2

Flags: B=bypass N=sync-neighs, I=local-inactive, P=peer-active, X=peer-proxy
MAC               Type   Flags Intf/Remote ES/VTEP            VLAN  Seq #'s
44:38:39:00:00:13 local        swp9                           20    0/0
44:38:39:00:00:17 remote       172.16.100.2                         0/0



leaf1# show evpn mac vni all
```

```
cumulus@leaf1:mgmt:~$ net show bridge macs

VLAN      Master      Interface   MAC                TunnelDest    State      Flags
LastSeen
--------  ----------  ----------  -----------------  ------------  ---------  ------------------  --
------
10        br_default  swp8        44:38:39:00:00:11
00:00:02
10        br_default  vxlan48     44:38:39:00:00:15                           extern_learn
00:13:52
20        br_default  swp9        44:38:39:00:00:13
00:00:20
20        br_default  vxlan48     44:38:39:00:00:17                           extern_learn
00:13:52
untagged              vxlan48     00:00:00:00:00:00  172.16.100.2  permanent  self
00:13:52
untagged              vxlan48     00:00:00:00:00:00  172.16.100.2  permanent  self
00:13:52
untagged              vxlan48     44:38:39:00:00:15  172.16.100.2             self, extern_learn
00:13:52
untagged              vxlan48     44:38:39:00:00:17  172.16.100.2             self, extern_learn
00:13:52
untagged  br_default  br_default  44:38:39:00:00:23                permanent
00:52:08
untagged  br_default  swp8        44:38:39:00:00:12                permanent
00:52:09
untagged  br_default  swp9        44:38:39:00:00:14                permanent
00:52:09
untagged  br_default  vxlan48     86:f4:84:2a:61:26                permanent
00:47:57
```

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 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.

As the FHRP we will use VRR under our SVI's.

```
- set:
    router:
      vrr:
        enable: on
    interface:
      vlan10:
        ip:
          address:
            172.16.10.252/24: {}
          vrr:
            address:
              172.16.10.254/24: {}
            enable: on
            mac-address: 00:00:00:00:00:0A
            state:
              up: {}
        type: svi
        vlan: 10

Adresses:
Leaf1:
SVI: VLAN10  172.16.10.252/24
VRR:                172.16.10.254/24
MAC                 00:00:00:00:00:0A
```

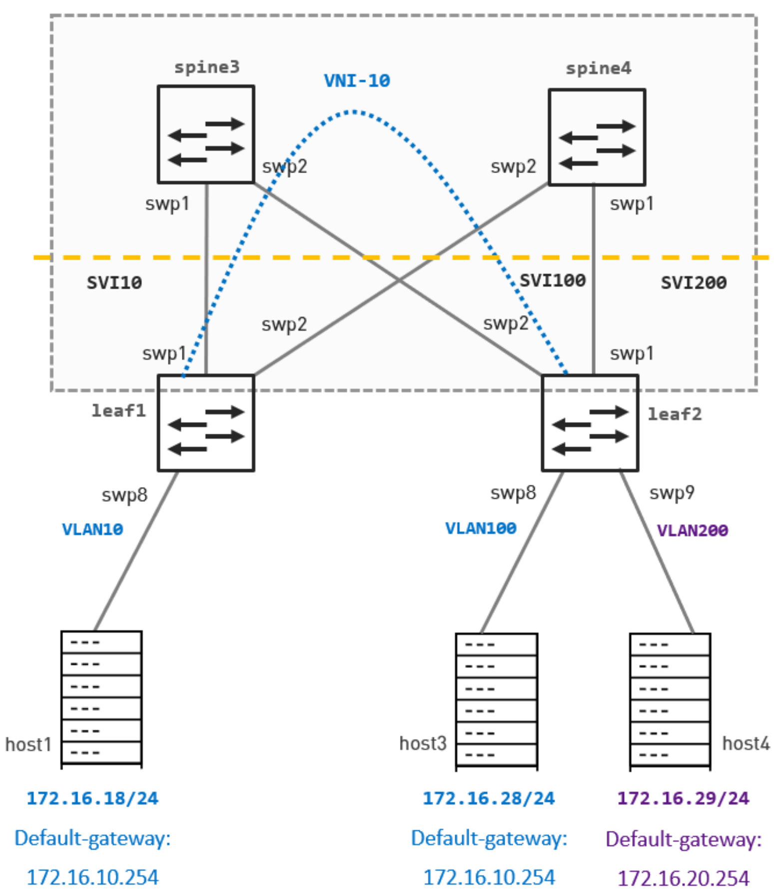
Leaf2:

```
SVI: VLAN100       172.16.10.253/24
VRF:               NVIDIA
VRR:               172.16.10.254/24
MAC                00:00:00:00:00:0A
SVI: VLAN200       172.16.20.253/24
VRF:               NVIDIA
VRR:               172.16.20.254/24
MAC                00:00:00:00:00:0B
```

The L3-VNI construct will use the VRF named NVIDIA along with the VXLAN ID of 4001 on both leaf's.

To verify L3 Distributed Symmetric the SVI on leaf1 for vlan 20 and the vlan 20 will need to be absent. Please remove them if they are present.

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.

```
$ nv set vrf NVIDIA evpn vni 4001
$ nv set interface vlan10 ip vrf NVIDIA
$ nv config apply
```

Question:

Why is the subnet 172.16.10.0/24 on leaf1 not shown in the routing table?

```
cumulus@leaf1:mgmt:~$ net show route
show ip route
=============
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, r - rejected, b - backup
       t - trapped, o - offload failure
C>* 172.16.100.1/32 is directly connected, lo, 06:48:17
B>* 172.16.100.2/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:01:40
  *                        via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:01:40
B>* 172.16.100.3/32 [20/0] via fe80::4638:39ff:fe00:5, swp1, weight 1, 00:01:43
B>* 172.16.100.4/32 [20/0] via fe80::4638:39ff:fe00:b, swp2, weight 1, 00:01:40
```

Please note:

Switch leaf2 should be configured similarly but for vlan 100 and 200.

Please verify the uniqueness of the system-mac addresses between leaf1 and leaf2:

```
cumulus@leaf1:mgmt:~$ cat /run/system_mac
44:38:39:00:00:23


cumulus@leaf2:mgmt:~$ cat /run/system_mac
44:38:39:00:00:25
```

In case the MACs are equal, please inform your instructor.

Task 3: Verify L3-VNI configuration

a. Verify that the L3-VNI is configured:

```
leaf1# show evpn vni
VNI        Type VxLAN IF              # MACs   # ARPs   # Remote VTEPs  Tenant VRF
10         L2   vxlan48               2        4        1               NVIDIA
4001       L3   vxlan99               1        1        n/a             NVIDIA

leaf2# sh evpn vni
VNI        Type VxLAN IF              # MACs   # ARPs   # Remote VTEPs  Tenant VRF
10         L2   vxlan48               2        4        1               NVIDIA
20         L2   vxlan48               1        3        0               NVIDIA
4001       L3   vxlan99               1        1        n/a             NVIDIA
```

```
leaf1# show evpn vni detail
VNI: 10
 Type: L2
 Vlan: 0
 Bridge: br_default
 Tenant VRF: NVIDIA
 VxLAN interface: vxlan48
 VxLAN ifIndex: 22
 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: 4
 Advertise-gw-macip: No
 Advertise-svi-macip: No

VNI: 4001
  Type: L3
  Tenant VRF: NVIDIA
  Vlan: 0
  Bridge: -
  Local Vtep Ip: 172.16.100.1
  Vxlan-Intf: vxlan99
  SVI-If: vlan444_l3
  State: Up
  VNI Filter: none
  System MAC: 44:38:39:00:00:23
  Router MAC: 44:38:39:00:00:23
  L2 VNIs: 10
```

```
leaf1# show ip route vrf NVIDIA
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, r - rejected, b - backup
       t - trapped, o - offload failure

VRF NVIDIA:
K>* 0.0.0.0/0 [255/8192] unreachable (ICMP unreachable), 01:45:23
C * 172.16.10.0/24 [0/1024] is directly connected, vlan10-v0, 01:45:23
C>* 172.16.10.0/24 is directly connected, vlan10, 01:45:23
B>* 172.16.10.28/32 [20/0] via 172.16.100.2, vlan444_l3 onlink, weight 1, 00:07:33
B>* 172.16.20.29/32 [20/0] via 172.16.100.2, vlan444_l3 onlink, weight 1, 00:07:33
```

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’ to ‘host3 and host4’
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
```