Red Hat OpenStack Platform 16.2

Spine Leaf Networking

Configuring routed spine-leaf networks using Red Hat OpenStack Platform director
Configuring routed spine-leaf networks using Red Hat OpenStack Platform director

OpenStack Team
rhos-docs@redhat.com
Abstract

This guide provides a basic scenario about how to configure a routed spine-leaf network on the overcloud. This includes configuring the undercloud, writing the main configuration files, and creating roles for your nodes.
# Table of Contents

**MAKING OPEN SOURCE MORE INCLUSIVE** .................................................. 3

**PROVIDING FEEDBACK ON RED HAT DOCUMENTATION** ............................................. 4

**CHAPTER 1. INTRODUCTION** ................................................................. 5

1.1. SPINE-LEAF NETWORKING .......................................................... 5
1.2. SPINE-LEAF NETWORK TOPOLOGY .................................................. 5
1.3. SPINE-LEAF REQUIREMENTS .......................................................... 7
1.4. SPINE-LEAF LIMITATIONS ............................................................. 7

**CHAPTER 2. CONFIGURING ROUTED SPINE-LEAF IN THE UNDERCLOUD** ........................................... 9

2.1. CONFIGURING THE SPINE LEAF PROVISIONING NETWORKS ........................................... 9
2.2. CONFIGURING A DHCP RELAY .......................................................... 10
2.3. CREATING FLAVORS AND TAGGING NODES FOR LEAF NETWORKS ........................................ 13
2.4. MAPPING BARE METAL NODE PORTS TO CONTROL PLANE NETWORK SEGMENTS .............. 14

**CHAPTER 3. ALTERNATIVE PROVISIONING NETWORK METHODS** ............................................. 16

3.1. VLAN PROVISIONING NETWORK ....................................................... 16
3.2. VXLAN PROVISIONING NETWORK ..................................................... 16

**CHAPTER 4. CONFIGURING THE OVERCLOUD** .............................................. 18

4.1. CREATING A NETWORK DATA FILE .................................................. 18
4.2. CREATING A ROLES DATA FILE ....................................................... 19
4.3. CREATING A CUSTOM NIC CONFIGURATION .......................................... 20
4.4. SETTING CONTROL PLANE PARAMETERS ............................................. 23
4.5. SETTING THE SUBNET FOR VIRTUAL IP ADDRESSES ......................................... 23
4.6. MAPPING SEPARATE NETWORKS ..................................................... 24
4.7. DEPLOYING A SPINE-LEAF ENABLED OVERCLOUD ........................................ 25
MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see our CTO Chris Wright’s message.
PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

We appreciate your input on our documentation. Tell us how we can make it better.

Using the Direct Documentation Feedback (DDF) function

Use the Add Feedback DDF function for direct comments on specific sentences, paragraphs, or code blocks.

1. View the documentation in the Multi-page HTML format.
2. Ensure that you see the Feedback button in the upper right corner of the document.
3. Highlight the part of text that you want to comment on.
4. Click Add Feedback.
5. Complete the Add Feedback field with your comments.
6. Optional: Add your email address so that the documentation team can contact you for clarification on your issue.
7. Click Submit.
CHAPTER 1. INTRODUCTION

This guide provides information about constructing a spine-leaf network topology for your Red Hat OpenStack Platform environment. This includes a full end-to-end scenario and example files to help replicate a more extensive network topology within your own environment.

1.1. SPINE-LEAF NETWORKING

Red Hat OpenStack Platform has a composable network architecture that you can use to adapt your networking to the routed spine-leaf data center topology. In a practical application of routed spine-leaf, a leaf is represented as a composable Compute or Storage role usually in a data center rack, as shown in Figure 1.1, “Routed spine-leaf example”. The Leaf 0 rack has an undercloud node, Controller nodes, and Compute nodes. The composable networks are presented to the nodes, which have been assigned to composable roles. The following diagram contains the following configuration:

- The StorageLeaf networks are presented to the Ceph storage and Compute nodes.
- The NetworkLeaf represents an example of any network you might want to compose.

Figure 1.1. Routed spine-leaf example

1.2. SPINE-LEAF NETWORK TOPOLOGY

The spine-leaf scenario takes advantage of OpenStack Networking (neutron) functionality to define multiple subnets within segments of a single network. Each network uses a base network which acts as Leaf 0. The director creates Leaf 1 and Leaf 2 subnets as segments of the main network.
This scenario uses the following networks:

**Table 1.1. Leaf 0 Networks (base networks)**

<table>
<thead>
<tr>
<th>Network</th>
<th>Roles attached</th>
<th>Subnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning / Ctlplane / Leaf0</td>
<td>Controller, ComputeLeaf0, CephStorageLeaf0</td>
<td>192.168.10.0/24</td>
</tr>
<tr>
<td>Storage</td>
<td>Controller, ComputeLeaf0, CephStorageLeaf0</td>
<td>172.16.0.0/24</td>
</tr>
<tr>
<td>StorageMgmt</td>
<td>Controller, CephStorageLeaf0</td>
<td>172.17.0.0/24</td>
</tr>
<tr>
<td>InternalApi</td>
<td>Controller, ComputeLeaf0</td>
<td>172.18.0.0/24</td>
</tr>
<tr>
<td>Tenant</td>
<td>Controller, ComputeLeaf0</td>
<td>172.19.0.0/24</td>
</tr>
<tr>
<td>External</td>
<td>Controller, ComputeLeaf0</td>
<td>10.1.1.0/24</td>
</tr>
</tbody>
</table>

**Table 1.2. Leaf 1 Networks**

<table>
<thead>
<tr>
<th>Network</th>
<th>Roles attached</th>
<th>Subnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning / Ctlplane / Leaf1</td>
<td>ComputeLeaf1, CephStorageLeaf1</td>
<td>192.168.11.0/24</td>
</tr>
<tr>
<td>StorageLeaf1</td>
<td>ComputeLeaf1, CephStorageLeaf1</td>
<td>172.16.1.0/24</td>
</tr>
<tr>
<td>StorageMgmtLeaf1</td>
<td>CephStorageLeaf1</td>
<td>172.17.1.0/24</td>
</tr>
<tr>
<td>InternalApiLeaf1</td>
<td>ComputeLeaf1</td>
<td>172.18.1.0/24</td>
</tr>
<tr>
<td>TenantLeaf1</td>
<td>ComputeLeaf1</td>
<td>172.19.1.0/24</td>
</tr>
</tbody>
</table>

**Table 1.3. Leaf 2 Networks**

<table>
<thead>
<tr>
<th>Network</th>
<th>Roles attached</th>
<th>Subnet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning / Ctlplane / Leaf2</td>
<td>ComputeLeaf2, CephStorageLeaf2</td>
<td>192.168.12.0/24</td>
</tr>
<tr>
<td>StorageLeaf2</td>
<td>ComputeLeaf2, CephStorageLeaf2</td>
<td>172.16.2.0/24</td>
</tr>
<tr>
<td>StorageMgmtLeaf2</td>
<td>CephStorageLeaf2</td>
<td>172.17.2.0/24</td>
</tr>
</tbody>
</table>
### 1.3. SPINE-LEAF REQUIREMENTS

To deploy the overcloud on a network with a L3 routed architecture, complete the following prerequisite steps:

**Layer-3 routing**

Configure the routing of the network infrastructure to enable traffic between the different L2 segments. You can configure this routing statically or dynamically.

**DHCP-Relay**

Each L2 segment not local to the undercloud must provide `dhcp-relay`. You must forward DHCP requests to the undercloud on the provisioning network segment where the undercloud is connected.

**NOTE**

The undercloud uses two DHCP servers. One for baremetal node introspection, and another for deploying overcloud nodes. Ensure that you read DHCP relay configuration to understand the requirements when you configure `dhcp-relay`.

### 1.4. SPINE-LEAF LIMITATIONS
• Some roles, such as the Controller role, use virtual IP addresses and clustering. The mechanism behind this functionality requires L2 network connectivity between these nodes. You must place these nodes within the same leaf.

• Similar restrictions apply to Networker nodes. The network service implements highly-available default paths in the network with Virtual Router Redundancy Protocol (VRRP). Because VRRP uses a virtual router IP address, you must connect master and backup nodes to the same L2 network segment.

• When you use tenant or provider networks with VLAN segmentation, you must share the particular VLANs between all Networker and Compute nodes.

**NOTE**

It is possible to configure the network service with multiple sets of Networker nodes. Each set of Networker nodes share routes for their networks, and VRRP provides highly-available default paths within each set of Networker nodes. In this type of configuration, all Networker nodes that share networks must be on the same L2 network segment.
CHAPTER 2. CONFIGURING ROUTED SPINE-LEAF IN THE UNDERCLOUD

This section describes a use case about how to configure the undercloud to accommodate routed spine-leaf with composable networks.

2.1. CONFIGURING THE SPINE LEAF PROVISIONING NETWORKS

To configure the provisioning networks for your spine leaf infrastructure, edit the `undercloud.conf` file and set the relevant parameters included in the following procedure.

**Procedure**

1. Log in to the undercloud as the `stack` user.

2. If you do not already have an `undercloud.conf` file, copy the sample template file:

   ```bash
   [stack@director ~]$ cp /usr/share/python-tripleclient/undercloud.conf.sample ~/undercloud.conf
   ```

3. Edit the `undercloud.conf` file.

4. Set the following values in the `[DEFAULT]` section:
   a. Set `local_ip` to the undercloud IP on `leaf0`:
      ```
      local_ip = 192.168.10.1/24
      ```
   b. Set `undercloud_public_host` to the externally facing IP address of the undercloud:
      ```
      undercloud_public_host = 10.1.1.1
      ```
   c. Set `undercloud_admin_host` to the administration IP address of the undercloud. This IP address is usually on `leaf0`:
      ```
      undercloud_admin_host = 192.168.10.2
      ```
   d. Set `local_interface` to the interface to bridge for the local network:
      ```
      local_interface = eth1
      ```
   e. Set `enable_routed_networks` to `true`:
      ```
      enable_routed_networks = true
      ```
   f. Define your list of subnets using the `subnets` parameter. Define one subnet for each L2 segment in the routed spine and leaf:
      ```
      subnets = leaf0,leaf1,leaf2
      ```
   g. Specify the subnet associated with the physical L2 segment local to the undercloud using the `local_subnet` parameter:
local_subnet = leaf0

h. Set the value of undercloud_nameservers.

undercloud_nameservers = 10.11.5.19, 10.11.5.20

**TIP**

You can find the current IP addresses of the DNS servers that are used for the undercloud nameserver by looking in /etc/resolv.conf.

5. Create a new section for each subnet that you define in the subnets parameter:

```plaintext
[leaf0]
cidr = 192.168.10.0/24
dhcp_start = 192.168.10.10
dhcp_end = 192.168.10.90
inspection_iprange = 192.168.10.100, 192.168.10.190
gateway = 192.168.10.1
masquerade = False

[leaf1]
cidr = 192.168.11.0/24
dhcp_start = 192.168.11.10
dhcp_end = 192.168.11.90
inspection_iprange = 192.168.11.100, 192.168.11.190
gateway = 192.168.11.1
masquerade = False

[leaf2]
cidr = 192.168.12.0/24
dhcp_start = 192.168.12.10
dhcp_end = 192.168.12.90
inspection_iprange = 192.168.12.100, 192.168.12.190
gateway = 192.168.12.1
masquerade = False
```

6. Save the undercloud.conf file.

7. Run the undercloud installation command:

```
[stack@director ~]$ openstack undercloud install
```

This configuration creates three subnets on the provisioning network or control plane. The overcloud uses each network to provision systems within each respective leaf.

To ensure proper relay of DHCP requests to the undercloud, you might need to configure a DHCP relay.

### 2.2. CONFIGURING A DHCP RELAY

You run the DHCP relay service on a switch, router, or server that is connected to the remote network segment you want to forward the requests from.
Do not run the DHCP relay service on the undercloud.

The undercloud uses two DHCP servers on the provisioning network:

- An introspection DHCP server.
- A provisioning DHCP server.

You must configure the DHCP relay to forward DHCP requests to both DHCP servers on the undercloud.

You can use UDP broadcast with devices that support it to relay DHCP requests to the L2 network segment where the undercloud provisioning network is connected. Alternatively, you can use UDP unicast, which relays DHCP requests to specific IP addresses.

Configuration of DHCP relay on specific device types is beyond the scope of this document. As a reference, this document provides a DHCP relay configuration example using the implementation in ISC DHCP software. For more information, see manual page dhcrelay(8).

Broadcast DHCP relay

This method relays DHCP requests using UDP broadcast traffic onto the L2 network segment where the DHCP server or servers reside. All devices on the network segment receive the broadcast traffic. When using UDP broadcast, both DHCP servers on the undercloud receive the relayed DHCP request. Depending on the implementation, you can configure this by specifying either the interface or IP network address:

**Interface**

Specify an interface that is connected to the L2 network segment where the DHCP requests are relayed.

**IP network address**

Specify the network address of the IP network where the DHCP requests are relayed.

Unicast DHCP relay

This method relays DHCP requests using UDP unicast traffic to specific DHCP servers. When you use UDP unicast, you must configure the device that provides the DHCP relay to relay DHCP requests to both the IP address that is assigned to the interface used for introspection on the undercloud and the IP address of the network namespace that the OpenStack Networking (neutron) service creates to host the DHCP service for the **ctlplane** network.

The interface used for introspection is the one defined as `inspection_interface` in the `undercloud.conf` file. If you have not set this parameter, the default interface for the undercloud is **br-ctlplane**.

It is common to use the **br-ctlplane** interface for introspection. The IP address that you define as the `local_ip` in the `undercloud.conf` file is on the **br-ctlplane** interface.
The IP address allocated to the Neutron DHCP namespace is the first address available in the IP range that you configure for the `local_subnet` in the `undercloud.conf` file. The first address in the IP range is the one that you define as `dhcp_start` in the configuration. For example, `192.168.10.10` is the IP address if you use the following configuration:

```conf
[DEFAULT]
local_subnet = leaf0
subnets = leaf0,leaf1,leaf2

[leaf0]
cidr = 192.168.10.0/24
dhcp_start = 192.168.10.10
dhcp_end = 192.168.10.90
inspection_iprange = 192.168.10.100,192.168.10.190
gateway = 192.168.10.1
masquerade = False
```

**WARNING**

The IP address for the DHCP namespace is automatically allocated. In most cases, this address is the first address in the IP range. To verify that this is the case, run the following commands on the undercloud:

```
$ openstack port list --device-owner network:dhcp -c "Fixed IP Addresses"
+----------------------------------------------------------------------------+
| Fixed IP Addresses                                                         |
+----------------------------------------------------------------------------+
| ip_address='192.168.10.10', subnet_id='7526fbe3-f52a-4b39-a828-ec59f4ed12b2' |
+----------------------------------------------------------------------------+

$ openstack subnet show 7526fbe3-f52a-4b39-a828-ec59f4ed12b2 -c name
+-------+--------+
| Field | Value  |
+-------+--------+
| name  | leaf0  |
+-------+--------+
```

**Example dhcrelay configuration**

In the following examples, the `dhcrelay` command in the `dhcp` package uses the following configuration:

- Interfaces to relay incoming DHCP request: `eth1`, `eth2`, and `eth3`.
- Interface the undercloud DHCP servers on the network segment are connected to: `eth0`.
- The DHCP server used for introspection is listening on IP address: `192.168.10.1`.
- The DHCP server used for provisioning is listening on IP address `192.168.10.10`.

This results in the following `dhcrelay` command:
**Example Cisco IOS routing switch configuration**

This example uses the following Cisco IOS configuration to perform the following tasks:

- Configure a VLAN to use for the provisioning network.
- Add the IP address of the leaf.
- Forward UDP and BOOTP requests to the introspection DHCP server that listens on IP address: `192.168.10.1`.
- Forward UDP and BOOTP requests to the provisioning DHCP server that listens on IP address `192.168.10.10`.

```plaintext
interface vlan 2
ip address 192.168.24.254 255.255.255.0
ip helper-address 192.168.10.1
ip helper-address 192.168.10.10
```

Now that you have configured the provisioning network, you can configure the remaining overcloud leaf networks.

### 2.3. CREATING FLAVORS AND TAGGING NODES FOR LEAF NETWORKS

Each role in each leaf network requires a flavor and role assignment so that you can tag nodes into their respective leaf. Complete the following steps to create and assign each flavor to a role.

**Procedure**

1. Source the `stackrc` file:

   ```
   $ source ~/stackrc
   ```

2. Create flavors for each custom role:

   ```
   $ ROLES="control compute_leaf0 compute_leaf1 compute_leaf2 ceph-storage_leaf0 ceph-storage_leaf1 ceph-storage_leaf2"
   $ for ROLE in $ROLES; do openstack flavor create --id auto --ram 4096 --disk 40 --vcpus 1 $ROLE ; done
   $ for ROLE in $ROLES; do openstack flavor set --property "cpu_arch"="x86_64" --property
"capabilities:boot_option"="local" --property "capabilities:profile"="$ROLE" --property resources:CUSTOM_BAREMETAL='1' --property resources:DISK_GB='0' --property resources:MEMORY_MB='0' --property resources:VCPU='0' $ROLE ; done

3. Tag nodes to their respective leaf networks. For example, run the following command to tag a node with UUID 58c3d07e-24f2-48a7-bbb6-6843f0e8ee13 to the Compute role on Leaf2:

   $ openstack baremetal node set --property capabilities='profile:compute_leaf2,boot_option:local' 58c3d07e-24f2-48a7-bbb6-6843f0e8ee13

4. Create an environment file (~/$templates/node-data.yaml) that contains the mapping of flavors to roles:

   parameter_defaults:
   OvercloudControllerFlavor: control
   OvercloudComputeLeaf0Flavor: compute_leaf0
   OvercloudComputeLeaf1Flavor: compute_leaf1
   OvercloudComputeLeaf2Flavor: compute_leaf2
   OvercloudCephStorageLeaf0Flavor: ceph-storage_leaf0
   OvercloudCephStorageLeaf1Flavor: ceph-storage_leaf1
   OvercloudCephStorageLeaf2Flavor: ceph-storage_leaf2
   ControllerLeaf0Count: 3
   ComputeLeaf0Count: 3
   ComputeLeaf1Count: 3
   ComputeLeaf2Count: 3
   CephStorageLeaf0Count: 3
   CephStorageLeaf1Count: 3
   CephStorageLeaf2Count: 3

   You can also set the number of nodes to deploy in the overcloud using each respective *Count parameter.

2.4. MAPPING BARE METAL NODE PORTS TO CONTROL PLANE NETWORK SEGMENTS

To enable deployment on a L3 routed network, you must configure the physical_network field on the bare metal ports. Each bare metal port is associated with a bare metal node in the OpenStack Bare Metal (ironic) service. The physical network names are the names that you include in the subnets option in the undercloud configuration.

   **NOTE**

   The physical network name of the subnet specified as local_subnet in the undercloud.conf file is always named ctlplane.

   **Procedure**

   1. Source the stackrc file:

      $ source ~/stackrc

   2. Check the bare metal nodes:
3. Ensure that the bare metal nodes are either in enroll or manageable state. If the bare metal node is not in one of these states, the command that sets the physical_network property on the baremetal port fails. To set all nodes to manageable state, run the following command:

   ```bash
   for node in $(openstack baremetal node list -f value -c Name); do openstack baremetal node manage $node --wait; done
   ```

4. Check which baremetal ports are associated with which baremetal node:

   ```bash
   openstack baremetal port list --node <node-uuid>
   ```

5. Set the physical_network parameter for the ports. In the example below, three subnets are defined in the configuration: leaf0, leaf1, and leaf2. The local_subnet is leaf0. Because the physical network for the local_subnet is always ctlplane, the baremetal port connected to leaf0 uses ctlplane. The remaining ports use the other leaf names:

   ```bash
   openstack baremetal port set --physical-network ctlplane <port-uuid>
   openstack baremetal port set --physical-network leaf1 <port-uuid>
   openstack baremetal port set --physical-network leaf2 <port-uuid>
   ```

6. Introspect the nodes before you deploy the overcloud. Include the --all-manageable and --provide options to set the nodes as available for deployment:

   ```bash
   openstack overcloud node introspect --all-manageable --provide
   ```
CHAPTER 3. ALTERNATIVE PROVISIONING NETWORK METHODS

This section contains information about other methods that you can use to configure the provisioning network to accommodate routed spine-leaf with composable networks.

3.1. VLAN PROVISIONING NETWORK

In this example, the director deploys new overcloud nodes through the provisioning network and uses a VLAN tunnel across the L3 topology. For more information, see Figure 3.1, “VLAN provisioning network topology”. If you use a VLAN provisioning network, the director DHCP servers can send DHCP OFFER broadcasts to any leaf. To establish this tunnel, trunk a VLAN between the Top-of-Rack (ToR) leaf switches. In the following diagram, the StorageLeaf networks are presented to the Ceph storage and Compute nodes; the NetworkLeaf represents an example of any network that you want to compose.

Figure 3.1. VLAN provisioning network topology

3.2. VXLAN PROVISIONING NETWORK

In this example, the director deploys new overcloud nodes through the provisioning network and uses a VXLAN tunnel to span across the layer 3 topology. For more information, see Figure 3.2, “VXLAN provisioning network topology”. If you use a VXLAN provisioning network, the director DHCP servers can send DHCP OFFER broadcasts to any leaf. To establish this tunnel, configure VXLAN endpoints on the Top-of-Rack (ToR) leaf switches.
CHAPTER 3. ALTERNATIVE PROVISIONING NETWORK METHODS

Figure 3.2. VXLAN provisioning network topology
CHAPTER 4. CONFIGURING THE OVERCLOUD

After you configure the undercloud, you can configure the remaining overcloud leaf networks with a series of configuration files. After you configure the remaining overcloud leaf networks and deploy the overcloud, the resulting deployment has multiple sets of networks with routing available.

4.1. CREATING A NETWORK DATA FILE

To define the leaf networks, create a network data file that contains a YAML formatted list of each composable network and its attributes. Use the subnets parameter to define the additional Leaf subnets with a base network.

Procedure

1. Create a new network_data_spine_leaf.yaml file in the home directory of the stack user. Use the default network_data_subnets_routed.yaml file as a basis:

   ```bash
   $ cp /usr/share/openstack-tripleo-heat-templates/network_data_subnets_routed.yaml /home/stack/network_data_spine_leaf.yaml
   ```

2. In the network_data_spine_leaf.yaml file, edit the YAML list to define each base network and respective leaf subnets as a composable network item. Use the following example syntax to define a base leaf and two leaf subnets:

   ```yaml
   - name: <base_name>
     name_lower: <lowercase_name>
     vip: <true/false>
     vlan: '<vlan_id>'
     ip_subnet: '<network_address>/<prefix>'
     allocation_pools: [{'start': '<start_address>', 'end': '<end_address>'}]
     gateway_ip: '<router_ip_address>'
     subnets:
       <leaf_subnet_name>:
         vlan: '<vlan_id>'
         ip_subnet: '<network_address>/<prefix>'
         allocation_pools: [{'start': '<start_address>', 'end': '<end_address>'}]
         gateway_ip: '<router_ip_address>'
       <leaf_subnet_name>:
         vlan: '<vlan_id>'
         ip_subnet: '<network_address>/<prefix>'
         allocation_pools: [{'start': '<start_address>', 'end': '<end_address>'}]
         gateway_ip: '<router_ip_address>'
   ```

The following example demonstrates how to define the Internal API network and its leaf networks:

```yaml
- name: InternalApi
  name_lower: internal_api
  vip: true
  vlan: 10
  ip_subnet: '172.18.0.0/24'
  allocation_pools: [{'start': '172.18.0.4', 'end': '172.18.0.250'}]
  gateway_ip: '172.18.0.1'
  subnets:
```
internal_api_leaf1:
  vlan: 11
  ip_subnet: '172.18.1.0/24'
  allocation_pools: [{'start': '172.18.1.4', 'end': '172.18.1.250'}]
  gateway_ip: '172.18.1.1'
internal_api_leaf2:
  vlan: 12
  ip_subnet: '172.18.2.0/24'
  allocation_pools: [{'start': '172.18.2.4', 'end': '172.18.2.250'}]
  gateway_ip: '172.18.2.1'

NOTE
You do not define the Control Plane networks in the network data file because the
undercloud has already created these networks. However, you must set the parameters
manually so that the overcloud can configure the NICs accordingly.

NOTE
Define vip: true for the networks that contain the Controller-based services. In this
example, InternalApiLeaf0 contains these services.

4.2. CREATING A ROLES DATA FILE

To define each composable role for each leaf and attach the composable networks to each respective
role, complete the following steps.

Procedure

1. Create a custom roles directory in the home directory of the stack user:

   $ mkdir ~/roles

2. Copy the default Controller, Compute, and Ceph Storage roles from the director core template
collection to the roles directory. Rename the files for Compute and Ceph Storage to suit Leaf 0:

   $ cp /usr/share/openstack-tripleo-heat-templates/roles/Controller.yaml ~/roles/Controller.yaml
   $ cp /usr/share/openstack-tripleo-heat-templates/roles/Compute.yaml ~/roles/Compute0.yaml
   $ cp /usr/share/openstack-tripleo-heat-templates/roles/CephStorage.yaml
      ~/roles/CephStorage0.yaml

3. Copy the Leaf 0 Compute and Ceph Storage files as a basis for your Leaf 1 and Leaf 2 files:

   $ cp ~/roles/Compute0.yaml ~/roles/Compute1.yaml
   $ cp ~/roles/Compute0.yaml ~/roles/Compute2.yaml
   $ cp ~/roles/CephStorage0.yaml ~/roles/CephStorage1.yaml
   $ cp ~/roles/CephStorage0.yaml ~/roles/CephStorage2.yaml

4. Edit the name, HostnameFormatDefault, and deprecated_nic_config_name parameters in
the Leaf 0, Leaf 1, and Leaf 2 files so that they align with the respective Leaf parameters. For
example, the parameters in the Leaf 0 Compute file have the following values:
The Leaf 0 Ceph Storage parameters have the following values:

- name: CephStorageLeaf0
  HostnameFormatDefault: '%stackname%-cephstorage-leaf0-%index%'
  deprecated_nic_config_name: 'ceph-storageleaf0.yaml'

5. Edit the `network` parameter in the Leaf 1 and Leaf 2 files so that they align with the respective Leaf network parameters. For example, the parameters in the Leaf 1 Compute file have the following values:

- name: ComputeLeaf1
  networks:
    InternalApi:
      subnet: internal_api_leaf1
    Tenant:
      subnet: tenant_leaf1
    Storage:
      subnet: storage_leaf1

The Leaf 1 Ceph Storage parameters have the following values:

- name: CephStorageLeaf1
  networks:
    Storage:
      subnet: storage_leaf1
    StorageMgmt:
      subnet: storage_mgmt_leaf1

NOTE

This applies only to Leaf 1 and Leaf 2. The `network` parameter for Leaf 0 retains the base subnet values, which are the lowercase names of each subnet combined with a `_subnet` suffix. For example, the Internal API for Leaf 0 is `internal_api_subnet`.

6. When your role configuration is complete, run the following command to generate the full roles data file:

```
$ openstack overcloud roles generate --roles-path ~/roles -o roles_data_spine_leaf.yaml
```

Controller Compute Compute1 Compute2 CephStorage CephStorage1 CephStorage2

This creates a full `roles_data_spine_leaf.yaml` file that includes all of the custom roles for each respective leaf network.

Each role has its own NIC configuration. Before you configure the spine-leaf configuration, you must create a base set of NIC templates to suit your current NIC configuration.

4.3. CREATING A CUSTOM NIC CONFIGURATION
Each role requires a unique NIC configuration. Complete the following steps to create a copy of the base set of NIC templates and map the new templates to the respective NIC configuration resources.

Procedure

1. Change to the core heat template directory:
   
   ```bash
   $ cd /usr/share/openstack-tripleo-heat-templates
   ```

2. Render the Jinja2 templates with the `tools/process-templates.py` script, your custom `network_data` file, and custom `roles_data` file:
   
   ```bash
   $ tools/process-templates.py \\
   -n /home/stack/network_data_spine_leaf.yaml \\
   -r /home/stack/roles_data_spine_leaf.yaml \\
   -o /home/stack/openstack-tripleo-heat-templates-spine-leaf
   ```

3. Change to the home directory:
   
   ```bash
   $ cd /home/stack
   ```

4. Copy the content from one of the default NIC templates to use as a basis for your spine-leaf templates. For example, copy the `single-nic-vlans` NIC template:
   
   ```bash
   ```

5. Edit each NIC configuration in `/home/stack/templates/spine-leaf-nics/` and change the location of the configuration script to an absolute location. Scroll to the network configuration section, which resembles the following snippet:

   ```yaml
   resources:
   OsNetConfigImpl:
     type: OS::Heat::SoftwareConfig
     properties:
       group: script
       config:
         str_replace:
           template:
             get_file: ../../scripts/run-os-net-config.sh
           params:
             $network_config:
               network_config:
   ```

   Change the location of the script to the absolute path:

   ```yaml
   resources:
   OsNetConfigImpl:
     type: OS::Heat::SoftwareConfig
     properties:
       group: script
       config:
         str_replace:
           template:
             $network_config:
               network_config:
   ```
params:
$network_config:

Make this change in each file for each Leaf and save the changes.

**NOTE**

For further NIC changes, see "Custom network interface templates" in the *Advanced Overcloud Customization* guide.

6. Create a file called *spine-leaf-nics.yaml* and edit the file.

7. Create a *resource_registry* section in the file and add a set of *::Net::SoftwareConfig* resources that map to the respective NIC templates:

```yaml
resource_registry:
  OS::TripleO::Controller::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/controller.yaml
  OS::TripleO::ComputeLeaf0::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/computeleaf0.yaml
  OS::TripleO::ComputeLeaf1::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/computeleaf1.yaml
  OS::TripleO::ComputeLeaf2::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/computeleaf2.yaml
  OS::TripleO::CephStorageLeaf0::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/ceph-storageleaf0.yaml
  OS::TripleO::CephStorageLeaf1::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/ceph-storageleaf1.yaml
  OS::TripleO::CephStorageLeaf2::Net::SoftwareConfig: /home/stack/templates/spine-leaf-nics/ceph-storageleaf2.yaml
```

These resources mappings override the default resource mappings during deployment.

8. Save the *spine-leaf-nics.yaml* file.

9. Remove the rendered template directory:

```
$ rm -rf openstack-tripleo-heat-templates-spine-leaf
```

As a result of this procedure, you now have a set of NIC templates and an environment file that maps the required *::Net::SoftwareConfig* resources to them. When you eventually run the `openstack overcloud deploy` command, ensure that you include the environment files in the following order:

1. `/usr/share/openstack-tripleo-heat-templates/environments/network-isolation.yaml`, which enables network isolation. Note that the director renders this file from the `network-isolation.j2.yaml` Jinja2 template.

2. `/usr/share/openstack-tripleo-heat-templates/environments/network-environment.yaml`, which is the default network environment file, including default NIC resource mappings. Note that the director renders this file from the `network-environment.j2.yaml` Jinja2 template.
3. `/home/stack/templates/spine-leaf-nics.yaml`, which contains your custom NIC resource mappings and overrides the default NIC resource mappings.

The following command snippet demonstrates the ordering:

```
$ openstack overcloud deploy --templates
... 
- e /usr/share/openstack-tripleo-heat-templates/environments/network-isolation.yaml \\n- e /usr/share/openstack-tripleo-heat-templates/environments/network-environment.yaml \\n- e /home/stack/templates/spine-leaf-nics.yaml \\n... 
```

**Resources**

- For more information about customizing your NIC templates, see “Custom network interface templates” in the Advanced Overcloud Customization guide.

Complete the procedures in the following sections to add details to your network environment file and define certain aspects of the spine leaf architecture. After you complete this configuration, include this file in the `openstack overcloud deploy` command.

### 4.4. SETTING CONTROL PLANE PARAMETERS

You usually define networking details for isolated spine-leaf networks using a `network_data` file. The exception is the control plane network, which the undercloud creates. However, the overcloud requires access to the control plane for each leaf. To enable this access, you must define additional parameters in your deployment.

In this example, define the IP, subnet, and default route for the respective Control Plane network on Leaf 0.

**Procedure**

1. Create a file called `spine-leaf-ctlplane.yaml` and edit the file.

2. Create a `parameter_defaults` section in the file and add the control plane subnet mapping for each spine-leaf network:

   ```yaml
   parameter_defaults:
   ... 
   ControllerControlPlaneSubnet: leaf0 
   Compute0ControlPlaneSubnet: leaf0 
   Compute1ControlPlaneSubnet: leaf1 
   Compute2ControlPlaneSubnet: leaf2 
   CephStorage0ControlPlaneSubnet: leaf0 
   CephStorage1ControlPlaneSubnet: leaf1 
   CephStorage2ControlPlaneSubnet: leaf2 
   ```

3. Save the `spine-leaf-ctlplane.yaml` file.

### 4.5. SETTING THE SUBNET FOR VIRTUAL IP ADDRESSES

The Controller role typically hosts virtual IP (VIP) addresses for each network. By default, the overcloud takes the VIPs from the base subnet of each network except for the control plane. The control plane
uses `ctlplane-subnet`, which is the default subnet name created during a standard undercloud installation.

In this spine leaf scenario, the default base provisioning network is `leaf0` instead of `ctlplane-subnet`. This means that you must add overriding values to the `VipSubnetMap` parameter to change the subnet that the control plane VIP uses.

Additionally, if the VIPs for each network do not use the base subnet of one or more networks, you must add additional overrides to the `VipSubnetMap` parameter to ensure that the director creates VIPs on the subnet associated with the L2 network segment that connects the Controller nodes.

Procedure:

1. Create a file called `spine-leaf-vips.yaml` and edit the file.

2. Create a `parameter_defaults` section in the file and add the `VipSubnetMap` parameter based on your requirements:
   - If you use `leaf0` for the provisioning / control plane network, set the `ctlplane` VIP remapping to `leaf0`:
     ```yaml
     parameter_defaults:
     VipSubnetMap:
     ctlplane: leaf0
     ```
   - If you use a different Leaf for multiple VIPs, set the VIP remapping to suit these requirements. For example, use the following snippet to configure the `VipSubnetMap` parameter to use `leaf1` for all VIPs:
     ```yaml
     parameter_defaults:
     VipSubnetMap:
     ctlplane: leaf1
     redis: internal_api_leaf1
     InternalApi: internal_api_leaf1
     Storage: storage_leaf1
     StorageMgmt: storage_mgmt_leaf1
     ```

3. Save the `spine-leaf-vips.yaml` file.

4.6. MAPPING SEPARATE NETWORKS

By default, OpenStack Platform uses Open Virtual Network (OVN), which requires that all Controller and Compute nodes connect to a single L2 network for external network access. This means that both Controller and Compute network configurations use a `br-ex` bridge, which director maps to the `datacentre` network in the overcloud by default. This mapping is usually either for a flat network mapping or a VLAN network mapping. In a spine leaf architecture, you can change these mappings so that each Leaf routes traffic through the specific bridge or VLAN on that Leaf, which is often the case with edge computing scenarios.

Procedure

1. Create a file called `spine-leaf-separate.yaml` and edit the file.

2. Create a `parameter_defaults` section in the `spine-leaf-separate.yaml` file and include the external network mapping for each spine-leaf network:
For flat network mappings, list each Leaf in the **NeutronFlatNetworks** parameter and set the **NeutronBridgeMappings** parameter for each Leaf:

```
parameter_defaults:
  NeutronFlatNetworks: leaf0, leaf1, leaf2
  Controller0Parameters:
    NeutronBridgeMappings: "leaf0:br-ex"
  Compute0Parameters:
    NeutronBridgeMappings: "leaf0:br-ex"
  Compute1Parameters:
    NeutronBridgeMappings: "leaf1:br-ex"
  Compute2Parameters:
    NeutronBridgeMappings: "leaf2:br-ex"
```

For VLAN network mappings, additionally set the **NeutronNetworkVLANRanges** to map VLANs for all three Leaf networks:

```
  NeutronNetworkType: 'geneve,vlan'
  NeutronNetworkVLANRanges: 'leaf0:1:1000, leaf1:1:1000, leaf2:1:1000'
```

3. Save the `spine-leaf-separate.yaml` file.

### 4.7. DEPLOYING A SPINE-LEAF ENABLED OVERCLOUD

When you have completed your spine-leaf overcloud configuration, complete the following steps to review each file and then run the deployment command:

**Procedure**

1. Review the `/home/stack/template/network_data_spine_leaf.yaml` file and ensure that it contains each network and subnet for each leaf.

   **NOTE**

   There is currently no automatic validation for the network subnet and `allocation_pools` values. Ensure that you define these values consistently and that there is no conflict with existing networks.

2. Review the `/home/stack/templates/roles_data_spine_leaf.yaml` values and ensure that you define a role for each leaf.

3. Review the NIC templates in the `~/templates/spine-leaf-nics/` directory and ensure that you define the interfaces for each role on each leaf correctly.

4. Review the custom `spine-leaf-nics.yaml` environment file and ensure that it contains a `resource_registry` section that references the custom NIC templates for each role.

5. Review the `/home/stack/templates/nodes_data.yaml` file and ensure that all roles have an assigned flavor and a node count. Also check that you have correctly tagged all nodes for each leaf.

6. Run the `openstack overcloud deploy` command to apply the spine leaf configuration. For example:
$ openstack overcloud deploy --templates \
  -n /home/stack/templates/network_data_spine_leaf.yaml \
  -r /home/stack/templates/roles_data_spine_leaf.yaml \
  -e /usr/share/openstack-tripleo-heat-templates/environments/network-isolation.yaml \
  -e /usr/share/openstack-tripleo-heat-templates/environments/network-environment.yaml \
  -e /home/stack/templates/spine-leaf-nics.yaml \
  -e /home/stack/templates/spine-leaf-ctlplane.yaml \
  -e /home/stack/templates/spine-leaf-vips.yaml \
  -e /home/stack/templates/spine-leaf-separate.yaml \
  -e /home/stack/templates/nodes_data.yaml \
  -e [OTHER ENVIRONMENT FILES]

- The **network-isolation.yaml** is the rendered name of the Jinja2 file in the same location (network-isolation.j2.yaml). Include this file in the deployment command to ensure that the director isolates each networks to the correct leaf. This ensures that the networks are created dynamically during the overcloud creation process.

- Include the **network-environment.yaml** file after the **network-isolation.yaml**. The **network-environment.yaml** file provides the default network configuration for composable network parameters.

- Include the **spine-leaf-nics.yaml** file after the **network-environment.yaml**. The **spine-leaf-nics.yaml** file overrides the default NIC template mappings from the **network-environment.yaml** file.

- If you created any other spine leaf network environment files, include these environment files after the **spine-leaf-nics.yaml** file.

- Add any additional environment files. For example, an environment file with your container image locations or Ceph cluster configuration.

7. Wait until the spine-leaf enabled overcloud deploys.