Red Hat OpenStack Platform 14

Deploying an Overcloud with Containerized Red Hat Ceph

Configuring the Director to Deploy and Use a Containerized Red Hat Ceph Cluster

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Abstract

This guide provides information on using the Red Hat OpenStack Platform director to create an Overcloud with a containerized Red Hat Ceph Storage cluster. This includes instructions for customizing your Ceph cluster through the director.

Table of Contents

CHAPTER 1. INTRODUCTION

Red Hat OpenStack Platform director creates a cloud environment called the *overcloud*. The director provides the ability to configure extra features for an Overcloud. One of these extra features includes integration with Red Hat Ceph Storage. This includes both Ceph Storage clusters created with the director or existing Ceph Storage clusters.

The Red Hat Ceph cluster described in this guide features *containerized Ceph Storage*. For more information about containerized services in OpenStack, see "Configuring a Basic Overcloud with the CLI Tools" in the Director *Installation and Usage Guide*.

1.1. DEFINING CEPH STORAGE

Red Hat Ceph Storage is a distributed data object store designed to provide excellent performance, reliability, and scalability. Distributed object stores are the future of storage, because they accommodate unstructured data, and because clients can use modern object interfaces and legacy interfaces simultaneously. At the heart of every Ceph deployment is the **Ceph Storage Cluster**, which consists of two types of daemons:

Ceph OSD (Object Storage Daemon)

Ceph OSDs store data on behalf of Ceph clients. Additionally, Ceph OSDs utilize the CPU and memory of Ceph nodes to perform data replication, rebalancing, recovery, monitoring and reporting functions.

Ceph Monitor

A Ceph monitor maintains a master copy of the Ceph storage cluster map with the current state of the storage cluster.

For more information about Red Hat Ceph Storage, see the Red Hat Ceph Storage Architecture Guide .

IMPORTANT

This guide only integrates Ceph Block storage and the Ceph Object Gateway (RGW). It does not include Ceph File (CephFS) storage.

1.2. DEFINING THE SCENARIO

This guide provides instructions for deploying a *containerized* Red Hat Ceph cluster with your overcloud. To do this, the director uses Ansible playbooks provided through the **ceph-ansible** package. The director also manages the configuration and scaling operations of the cluster.

1.3. SETTING REQUIREMENTS

This guide acts as supplementary information for the Director Installation and Usage guide. This means the Requirements section also applies to this guide. Implement these requirements as necessary.

If using the Red Hat OpenStack Platform director to create Ceph Storage nodes, note the following requirements for these nodes:

CHAPTER 2. CEPH STORAGE NODE REQUIREMENTS

Ceph Storage nodes are responsible for providing object storage in a Red Hat OpenStack Platform environment.

Placement Groups

Ceph uses Placement Groups to facilitate dynamic and efficient object tracking at scale. In the case of OSD failure or cluster re-balancing, Ceph can move or replicate a placement group and its contents, which means a Ceph cluster can re-balance and recover efficiently. The default Placement Group count that Director creates is not always optimal so it is important to calculate the correct Placement Group count according to your requirements. You can use the Placement Group calculator to calculate the correct count: Placement Groups (PGs) per Pool Calculator

Processor

64-bit x86 processor with support for the Intel 64 or AMD64 CPU extensions.

Memory

Red Hat typically recommends a baseline of 16GB of RAM per OSD host, with an additional 2 GB of RAM per OSD daemon.

Disk Layout

Sizing is dependant on your storage need. The recommended Red Hat Ceph Storage node configuration requires at least three or more disks in a layout similar to the following example:

- **/dev/sda** - The root disk. The director copies the main Overcloud image to the disk. This should be at minimum 40 GB of available disk space.
- **/dev/sdb** - The journal disk. This disk divides into partitions for Ceph OSD journals. For example, **/dev/sdb1**, **/dev/sdb2**, **/dev/sdb3**, and onward. The journal disk is usually a solid state drive (SSD) to aid with system performance.
- **/dev/sdc** and onward - The OSD disks. Use as many disks as necessary for your storage requirements.

> **NOTE**
>
> Red Hat OpenStack Platform director uses **ceph-ansible**, which does not support installing the OSD on the root disk of Ceph Storage nodes. This means you need at least two or more disks for a supported Ceph Storage node.

Network Interface Cards

A minimum of one 1 Gbps Network Interface Cards, although it is recommended to use at least two NICs in a production environment. Use additional network interface cards for bonded interfaces or to delegate tagged VLAN traffic. It is recommended to use a 10 Gbps interface for storage node, especially if creating an OpenStack Platform environment that serves a high volume of traffic.

Power Management

Each Controller node requires a supported power management interface, such as an Intelligent Platform Management Interface (IPMI) functionality, on the server's motherboard.

This guide also requires the following:

- An Undercloud host with the Red Hat OpenStack Platform director installed. See Installing the Undercloud.

- Any additional hardware recommendation for Red Hat Ceph Storage. See the Red Hat Ceph Storage Hardware Selection Guide for these recommendations.

IMPORTANT

The Ceph Monitor service is installed on the Overcloud's Controller nodes. This means you must provide adequate resources to alleviate performance issues. Ensure the Controller nodes in your environment use at least 16 GB of RAM for memory and solid-state drive (SSD) storage for the Ceph monitor data. For a medium to large Ceph installation, provide at least 500 GB of Ceph monitor data. This space is necessary to avoid levelDB growth if the cluster becomes unstable.

2.1. ADDITIONAL RESOURCES

The **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml** environment file instructs the director to use playbooks derived from the ceph-ansible project. These playbooks are installed in **/usr/share/ceph-ansible/** of the undercloud. In particular, the following file lists all the default settings applied by the playbooks:

- **/usr/share/ceph-ansible/group_vars/all.yml.sample**

WARNING

While **ceph-ansible** uses playbooks to deploy containerized Ceph Storage, do not edit these files to customize your deployment. Doing this will result in a failed deployment. Rather, use Heat environment files to override the defaults set by these playbooks.

You can also consult the documentation of this project (http://docs.ceph.com/ceph-ansible/master/) to learn more about the playbook collection.

Alternatively, you can also consult the Heat templates in **/usr/share/openstack-tripleo-heat-templates/docker/services/ceph-ansible/** for information about the default settings applied by director for containerized Ceph Storage.

NOTE

Reading these templates requires a deeper understanding of how environment files and Heat templates work in director. See Understanding Heat Templates and Environment Files for reference.

Lastly, for more information about containerized services in OpenStack, see "Configuring a Basic Overcloud with the CLI Tools" in the Director *Installation and Usage Guide*.

CHAPTER 3. PREPARING OVERCLOUD NODES

All nodes in this scenario are bare metal systems using IPMI for power management. These nodes do not require an operating system because the director copies a Red Hat Enterprise Linux 7 image to each node; in addition, the Ceph Storage services on the nodes described here are containerized. The director communicates to each node through the Provisioning network during the introspection and provisioning processes. All nodes connect to this network through the native VLAN.

3.1. CLEANING CEPH STORAGE NODE DISKS

The Ceph Storage OSDs and journal partitions require GPT disk labels. This means the additional disks on Ceph Storage require conversion to GPT before installing the Ceph OSD services. For this to happen, all metadata must be deleted from the disks; this will allow the director to set GPT labels on them.

You can set the director to delete all disk metadata by default by adding the following setting to your **/home/stack/undercloud.conf** file:

```
clean_nodes=true
```

With this option, the Bare Metal Provisioning service will run an additional step to boot the nodes and *clean* the disks each time the node is set to **available**. This adds an additional power cycle after the first introspection and before each deployment. The Bare Metal Provisioning service uses **wipefs --force --all** to perform the clean.

After setting this option, run the **openstack undercloud install** command to execute this configuration change.

> **WARNING**
>
> The **wipefs --force --all** will delete all data and metadata on the disk, but does not perform a *secure erase*. A secure erase takes much longer.

3.2. REGISTERING NODES

A node definition template (**instackenv.json**) is a JSON format file and contains the hardware and power management details for registering nodes. For example:

```
{
  "nodes":[
    {
      "mac":[
        "b1:b1:b1:b1:b1:b1"
      ],
      "cpu":"4",
      "memory":"6144",
      "disk":"40",
      "arch":"x86_64",
      "pm_type":"ipmi",
```

```
        "pm_user":"admin",
        "pm_password":"p@55w0rd!",
        "pm_addr":"192.0.2.205"
    },
    {
        "mac":[
            "b2:b2:b2:b2:b2:b2"
        ],
        "cpu":"4",
        "memory":"6144",
        "disk":"40",
        "arch":"x86_64",
        "pm_type":"ipmi",
        "pm_user":"admin",
        "pm_password":"p@55w0rd!",
        "pm_addr":"192.0.2.206"
    },
    {
        "mac":[
            "b3:b3:b3:b3:b3:b3"
        ],
        "cpu":"4",
        "memory":"6144",
        "disk":"40",
        "arch":"x86_64",
        "pm_type":"ipmi",
        "pm_user":"admin",
        "pm_password":"p@55w0rd!",
        "pm_addr":"192.0.2.207"
    },
    {
        "mac":[
            "c1:c1:c1:c1:c1:c1"
        ],
        "cpu":"4",
        "memory":"6144",
        "disk":"40",
        "arch":"x86_64",
        "pm_type":"ipmi",
        "pm_user":"admin",
        "pm_password":"p@55w0rd!",
        "pm_addr":"192.0.2.208"
    },
    {
        "mac":[
            "c2:c2:c2:c2:c2:c2"
        ],
        "cpu":"4",
        "memory":"6144",
        "disk":"40",
        "arch":"x86_64",
        "pm_type":"ipmi",
        "pm_user":"admin",
        "pm_password":"p@55w0rd!",
        "pm_addr":"192.0.2.209"
    },
```

```
        {
            "mac":[
                "c3:c3:c3:c3:c3:c3"
            ],
            "cpu":"4",
            "memory":"6144",
            "disk":"40",
            "arch":"x86_64",
            "pm_type":"ipmi",
            "pm_user":"admin",
            "pm_password":"p@55w0rd!",
            "pm_addr":"192.0.2.210"
        },
        {
            "mac":[
                "d1:d1:d1:d1:d1:d1"
            ],
            "cpu":"4",
            "memory":"6144",
            "disk":"40",
            "arch":"x86_64",
            "pm_type":"ipmi",
            "pm_user":"admin",
            "pm_password":"p@55w0rd!",
            "pm_addr":"192.0.2.211"
        },
        {
            "mac":[
                "d2:d2:d2:d2:d2:d2"
            ],
            "cpu":"4",
            "memory":"6144",
            "disk":"40",
            "arch":"x86_64",
            "pm_type":"ipmi",
            "pm_user":"admin",
            "pm_password":"p@55w0rd!",
            "pm_addr":"192.0.2.212"
        },
        {
            "mac":[
                "d3:d3:d3:d3:d3:d3"
            ],
            "cpu":"4",
            "memory":"6144",
            "disk":"40",
            "arch":"x86_64",
            "pm_type":"ipmi",
            "pm_user":"admin",
            "pm_password":"p@55w0rd!",
            "pm_addr":"192.0.2.213"
        }
    ]
}
```

After creating the template, save the file to the stack user's home directory (**/home/stack/instackenv.json**). Initialize the stack user, then import **instackenv.json** into the director:

```
$ source ~/stackrc
$ openstack overcloud node import ~/instackenv.json
```

This imports the template and registers each node from the template into the director.

Assign the kernel and ramdisk images to each node:

```
$ openstack overcloud node configure <node>
```

The nodes are now registered and configured in the director.

3.3. MANUALLY TAGGING THE NODES

After registering each node, you will need to inspect the hardware and tag the node into a specific profile. Profile tags match your nodes to flavors, and in turn the flavors are assigned to a deployment role.

To inspect and tag new nodes, follow these steps:

1. Trigger hardware introspection to retrieve the hardware attributes of each node:

    ```
    $ openstack overcloud node introspect --all-manageable --provide
    ```

    - The **--all-manageable** option introspects only nodes in a managed state. In this example, it is all of them.
    - The **--provide** option resets all nodes to an **active** state after introspection.

    > **IMPORTANT**
    >
    > Make sure this process runs to completion. This process usually takes 15 minutes for bare metal nodes.

2. Retrieve a list of your nodes to identify their UUIDs:

    ```
    $ openstack baremetal node list
    ```

3. Add a **profile** option to the **properties/capabilities** parameter for each node to manually tag a node to a specific profile.
    For example, a typical deployment will use three profiles: **control**, **compute**, and **ceph-storage**. The following commands tag three nodes for each profile:

    ```
    $ ironic node-update 1a4e30da-b6dc-499d-ba87-0bd8a3819bc0 add
    properties/capabilities='profile:control,boot_option:local'
    $ ironic node-update 6faba1a9-e2d8-4b7c-95a2-c7fbdc12129a add
    properties/capabilities='profile:control,boot_option:local'
    $ ironic node-update 5e3b2f50-fcd9-4404-b0a2-59d79924b38e add
    properties/capabilities='profile:control,boot_option:local'
    $ ironic node-update 484587b2-b3b3-40d5-925b-a26a2fa3036f add
    properties/capabilities='profile:compute,boot_option:local'
    ```

```
$ ironic node-update d010460b-38f2-4800-9cc4-d69f0d067efe add properties/capabilities='profile:compute,boot_option:local'
$ ironic node-update d930e613-3e14-44b9-8240-4f3559801ea6 add properties/capabilities='profile:compute,boot_option:local'
$ ironic node-update da0cc61b-4882-45e0-9f43-fab65cf4e52b add properties/capabilities='profile:ceph-storage,boot_option:local'
$ ironic node-update b9f70722-e124-4650-a9b1-aade8121b5ed add properties/capabilities='profile:ceph-storage,boot_option:local'
$ ironic node-update 68bf8f29-7731-4148-ba16-efb31ab8d34f add properties/capabilities='profile:ceph-storage,boot_option:local'
```

TIP

You can also configure a new custom profile that will allow you to tag a node for the Ceph MON and Ceph MDS services. See Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* for details.

The addition of the **profile** option tags the nodes into each respective profiles.

NOTE

As an alternative to manual tagging, use the Automated Health Check (AHC) Tools to automatically tag larger numbers of nodes based on benchmarking data.

3.4. DEFINING THE ROOT DISK

Director must identify the root disk during provisioning in the case of nodes with multiple disks. For example, most Ceph Storage nodes use multiple disks. By default, the director writes the overcloud image to the root disk during the provisioning process.

There are several properties that you can define to help the director identify the root disk:

- **model** (String): Device identifier.
- **vendor** (String): Device vendor.
- **serial** (String): Disk serial number.
- **hctl** (String): Host:Channel:Target:Lun for SCSI.
- **size** (Integer): Size of the device in GB.
- **wwn** (String): Unique storage identifier.
- **wwn_with_extension** (String): Unique storage identifier with the vendor extension appended.
- **wwn_vendor_extension** (String): Unique vendor storage identifier.
- **rotational** (Boolean): True for a rotational device (HDD), otherwise false (SSD).
- **name** (String): The name of the device, for example: /dev/sdb1.
- **by_path** (String): The unique PCI path of the device. Use this property if you do not want to use the UUID of the device.

IMPORTANT

Use the **name** property only for devices with persistent names. Do not use **name** to set the root disk for any other device because this value can change when the node boots.

Complete the following steps to specify the root device using its serial number.

Procedure

1. Check the disk information from the hardware introspection of each node. Run the following command to display the disk information of a node:

```
(undercloud) $ openstack baremetal introspection data save 1a4e30da-b6dc-499d-ba87-
0bd8a3819bc0 | jq ".inventory.disks"
```

For example, the data for one node might show three disks:


```
[
  {
    "size": 299439751168,
    "rotational": true,
    "vendor": "DELL",
    "name": "/dev/sda",
    "wwn_vendor_extension": "0x1ea4dcc412a9632b",
    "wwn_with_extension": "0x61866da04f3807001ea4dcc412a9632b",
    "model": "PERC H330 Mini",
    "wwn": "0x61866da04f380700",
    "serial": "61866da04f3807001ea4dcc412a9632b"
  }
  {
    "size": 299439751168,
    "rotational": true,
    "vendor": "DELL",
    "name": "/dev/sdb",
    "wwn_vendor_extension": "0x1ea4e13c12e36ad6",
    "wwn_with_extension": "0x61866da04f380d001ea4e13c12e36ad6",
    "model": "PERC H330 Mini",
    "wwn": "0x61866da04f380d00",
    "serial": "61866da04f380d001ea4e13c12e36ad6"
  }
  {
    "size": 299439751168,
    "rotational": true,
    "vendor": "DELL",
    "name": "/dev/sdc",
    "wwn_vendor_extension": "0x1ea4e31e121cfb45",
    "wwn_with_extension": "0x61866da04f37fc001ea4e31e121cfb45",
    "model": "PERC H330 Mini",
    "wwn": "0x61866da04f37fc00",
    "serial": "61866da04f37fc001ea4e31e121cfb45"
  }
]
```

2. Change to the **root_device** parameter for the node definition. The following example shows how to set the root device to disk 2, which has **61866da04f380d001ea4e13c12e36ad6** as the serial number:

```
(undercloud) $ openstack baremetal node set --property root_device='{"serial":
"61866da04f380d001ea4e13c12e36ad6"}' 1a4e30da-b6dc-499d-ba87-0bd8a3819bc0
```

> **NOTE**
>
> Ensure that you configure the BIOS of each node to include booting from the root disk that you choose. Configure the boot order to boot from the network first, then to boot from the root disk.

The director identifies the specific disk to use as the root disk. When you run the **openstack overcloud deploy** command, the director provisions and writes the Overcloud image to the root disk.

3.5. USING THE OVERCLOUD-MINIMAL IMAGE TO AVOID USING A RED HAT SUBSCRIPTION ENTITLEMENT

By default, the director writes the QCOW2 **overcloud-full** image to the root disk during the provisioning process. The **overcloud-full** image uses a valid Red Hat subscription. However, you can also use the **overcloud-minimal** image if you do not require any other OpenStack services on your node and you do not want to use one of your Red Hat OpenStack Platform subscription entitlements. Use the **overcloud-minimal** image option to avoid reaching the limit of your paid Red Hat subscriptions.

Procedure

1. To configure director to use the **overcloud-minimal** image, create an environment file that contains the following image definition:

```
parameter_defaults:
  <roleName>Image: overcloud-minimal
```

2. Replace **<roleName>** with the name of the role and append **Image** to the name of the role. The following example shows an **overcloud-minimal** image for Ceph storage nodes:

```
parameter_defaults:
  CephStorageImage: overcloud-minimal
```

3. Pass the environment file to the **openstack overcloud deploy** command.

> **NOTE**
>
> The **overcloud-minimal** image supports only standard Linux bridges and not OVS because OVS is an OpenStack service that requires an OpenStack subscription entitlement.

CHAPTER 4. DEPLOYING OTHER CEPH SERVICES ON DEDICATED NODES

By default, the director deploys the Ceph MON and Ceph MDS services on the Controller nodes. This is suitable for small deployments. However, with larger deployments we advise that you deploy the Ceph MON and Ceph MDS services on dedicated nodes to improve the performance of your Ceph cluster. You can do this by creating a *custom role* for either one.

> **NOTE**
>
> For detailed information about custom roles, see Creating a New Role from the Advanced Overcloud Customization guide.

The director uses the following file as a default reference for all overcloud roles:

- **/usr/share/openstack-tripleo-heat-templates/roles_data.yaml**

Copy this file to **/home/stack/templates/** so you can add custom roles to it:

```
$ cp /usr/share/openstack-tripleo-heat-templates/roles_data.yaml
/home/stack/templates/roles_data_custom.yaml
```

You invoke the **/home/stack/templates/roles_data_custom.yaml** file later during overcloud creation (Section 8.2, “Initiating Overcloud Deployment”). The following sub-sections describe how to configure custom roles for either Ceph MON and Ceph MDS services.

4.1. CREATING A CUSTOM ROLE AND FLAVOR FOR THE CEPH MON SERVICE

This section describes how to create a custom role (named **CephMon**) and flavor (named **ceph-mon**) for the Ceph MON role. You should already have a copy of the default roles data file as described in Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* .

1. Open the **/home/stack/templates/roles_data_custom.yaml** file.
2. Remove the service entry for the Ceph MON service (namely, **OS::TripleO::Services::CephMon**) from under the Controller role.
3. Add the **OS::TripleO::Services::CephClient** service to the Controller role:

```
[...]
- name: Controller # the 'primary' role goes first
  CountDefault: 1
  ServicesDefault:
    - OS::TripleO::Services::CACerts
    - OS::TripleO::Services::CephMds
    - OS::TripleO::Services::CephClient
    - OS::TripleO::Services::CephExternal
    - OS::TripleO::Services::CephRbdMirror
    - OS::TripleO::Services::CephRgw
    - OS::TripleO::Services::CinderApi
[...]
```

4. At the end of **roles_data_custom.yaml**, add a custom **CephMon** role containing the Ceph MON service and all the other required node services. For example:

```
- name: CephMon
  ServicesDefault:
   # Common Services
   - OS::TripleO::Services::AuditD
   - OS::TripleO::Services::CACerts
   - OS::TripleO::Services::CertmongerUser
   - OS::TripleO::Services::Collectd
   - OS::TripleO::Services::Docker
   - OS::TripleO::Services::FluentdClient
   - OS::TripleO::Services::Kernel
   - OS::TripleO::Services::Ntp
   - OS::TripleO::Services::ContainersLogrotateCrond
   - OS::TripleO::Services::SensuClient
   - OS::TripleO::Services::Snmp
   - OS::TripleO::Services::Timezone
   - OS::TripleO::Services::TripleoFirewall
   - OS::TripleO::Services::TripleoPackages
   - OS::TripleO::Services::Tuned
   # Role-Specific Services
   - OS::TripleO::Services::CephMon
```

5. Using the **openstack flavor create** command, define a new flavor named **ceph-mon** for this role:

```
$ openstack flavor create --id auto --ram 6144 --disk 40 --vcpus 4 ceph-mon
```

NOTE

For more details about this command, run **openstack flavor create --help**.

6. Map this flavor to a new profile, also named **ceph-mon**:

```
$ openstack flavor set --property "cpu_arch"="x86_64" --property
"capabilities:boot_option"="local" --property "capabilities:profile"="ceph-mon" ceph-mon
```

NOTE

For more details about this command, run **openstack flavor set --help**.

7. Tag nodes into the new **ceph-mon** profile:

```
$ ironic node-update UUID add properties/capabilities='profile:ceph-mon,boot_option:local'
```

See Section 3.3, “Manually Tagging the Nodes” for more details about tagging nodes. See also Tagging Nodes Into Profiles for related information on custom role profiles.

4.2. CREATING A CUSTOM ROLE AND FLAVOR FOR THE CEPH MDS SERVICE

This section describes how to create a custom role (named **CephMDS**) and flavor (named **ceph-mds**) for the Ceph MDS role. You should already have a copy of the default roles data file as described in Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* .

1. Open the **/home/stack/templates/roles_data_custom.yaml** file.

2. Remove the service entry for the Ceph MDS service (namely, **OS::TripleO::Services::CephMds**) from under the Controller role:

```
[...]
- name: Controller # the 'primary' role goes first
  CountDefault: 1
  ServicesDefault:
    - OS::TripleO::Services::CACerts
    # - OS::TripleO::Services::CephMds (1)
    - OS::TripleO::Services::CephMon
    - OS::TripleO::Services::CephExternal
    - OS::TripleO::Services::CephRbdMirror
    - OS::TripleO::Services::CephRgw
    - OS::TripleO::Services::CinderApi
[...]
```

(1) Comment out this line. This same service will be added to a custom role in the next step.

3. At the end of **roles_data_custom.yaml**, add a custom **CephMDS** role containing the Ceph MDS service and all the other required node services. For example:

```
- name: CephMDS
  ServicesDefault:
    # Common Services
    - OS::TripleO::Services::AuditD
    - OS::TripleO::Services::CACerts
    - OS::TripleO::Services::CertmongerUser
    - OS::TripleO::Services::Collectd
    - OS::TripleO::Services::Docker
    - OS::TripleO::Services::FluentdClient
    - OS::TripleO::Services::Kernel
    - OS::TripleO::Services::Ntp
    - OS::TripleO::Services::ContainersLogrotateCrond
    - OS::TripleO::Services::SensuClient
    - OS::TripleO::Services::Snmp
    - OS::TripleO::Services::Timezone
    - OS::TripleO::Services::TripleoFirewall
    - OS::TripleO::Services::TripleoPackages
    - OS::TripleO::Services::Tuned
    # Role-Specific Services
    - OS::TripleO::Services::CephMds
    - OS::TripleO::Services::CephClient (1)
```

(1) The Ceph MDS service requires the admin keyring, which can be set by either Ceph MON or Ceph Client service. As we are deploying Ceph MDS on a dedicated node (without the Ceph MON service), include the Ceph Client service on the role as well.

4. Using the **openstack flavor create** command, define a new flavor named **ceph-mds** for this role:

```
$ openstack flavor create --id auto --ram 6144 --disk 40 --vcpus 4 ceph-mds
```

> **NOTE**
>
> For more details about this command, run **openstack flavor create --help**.

5. Map this flavor to a new profile, also named **ceph-mds**:

```
$ openstack flavor set --property "cpu_arch"="x86_64" --property
"capabilities:boot_option"="local" --property "capabilities:profile"="ceph-mds" ceph-mds
```

> **NOTE**
>
> For more details about this command, run **openstack flavor set --help**.

Tag nodes into the new **ceph-mds** profile:

```
$ ironic node-update UUID add properties/capabilities='profile:ceph-mds,boot_option:local'
```

See Section 3.3, “Manually Tagging the Nodes” for more details about tagging nodes. See also Tagging Nodes Into Profiles for related information on custom role profiles.

CHAPTER 5. CUSTOMIZING THE STORAGE SERVICE

The Heat template collection provided by the director already contains the necessary templates and environment files to enable a basic Ceph Storage configuration.

The **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml** environment file will create a Ceph cluster and integrate it with your overcloud upon deployment. This cluster will feature *containerized* Ceph Storage nodes. For more information about containerized services in OpenStack, see "Configuring a Basic Overcloud with the CLI Tools" in the Director *Installation and Usage Guide*.

The Red Hat OpenStack director will also apply basic, default settings to the deployed Ceph cluster. You need a *custom environment file* to pass custom settings to your Ceph cluster. To create one:

1. Create the file **storage-config.yaml** in **/home/stack/templates/**. For the purposes of this document, **~/templates/storage-config.yaml** will contain most of the overcloud-related custom settings for your environment. It will override all the default settings applied by the director to your overcloud.

2. Add a **parameter_defaults** section to **~/templates/storage-config.yaml**. This section will contain custom settings for your overcloud. For example, to set **vxlan** as the network type of the networking service (**neutron**):

```
parameter_defaults:
  NeutronNetworkType: vxlan
```

3. If needed, set the following options under **parameter_defaults** as you see fit:

Option	Description	Default value
CinderEnableIscsiBackend	Enables the iSCSI backend	false
CinderEnableRbdBackend	Enables the Ceph Storage back end	true
CinderBackupBackend	Sets ceph or swift as the back end for volume backups; see Section 5.3, "Configuring the Backup Service to Use Ceph" for related details	ceph
NovaEnableRbdBackend	Enables Ceph Storage for Nova ephemeral storage	true
GlanceBackend	Defines which back end the Image service should use: **rbd** (Ceph), **swift**, or **file**	rbd
GnocchiBackend	Defines which back end the Telemetry service should use: **rbd** (Ceph), **swift**, or **file**	rbd

NOTE

You can omit an option from **~/templates/storage-config.yaml** if you intend to use the default setting.

The contents of your environment file will change depending on the settings you apply in the sections that follow. See Appendix A, *Sample Environment File: Creating a Ceph Cluster* for a finished example.

The following subsections explain how to override common default storage service settings applied by the director.

5.1. ENABLING THE CEPH METADATA SERVER

The *Ceph Metadata Server* (MDS) runs the **ceph-mds** daemon, which manages metadata related to files stored on CephFS. CephFS can be consumed via NFS. For related information about using CephFS via NFS, see Ceph File System Guide and CephFS via NFS Back End Guide for the Shared File System Service.

NOTE

Red Hat only supports deploying Ceph MDS with the CephFS via NFS back end for the Shared File System service.

To enable the Ceph Metadata Server, invoke the following environment file when creating your overcloud:

- **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-mds.yaml**

See Section 8.2, "Initiating Overcloud Deployment" for more details. For more information about the Ceph Metadata Server, see Configuring Metadata Server Daemons.

NOTE

By default, the Ceph Metadata Server will be deployed on the Controller node. You can deploy the Ceph Metadata Server on its own dedicated node; for instructions, see Section 4.2, "Creating a Custom Role and Flavor for the Ceph MDS Service" .

5.2. ENABLING THE CEPH OBJECT GATEWAY

The *Ceph Object Gateway* provides applications with an interface to object storage capabilities within a Ceph storage cluster. Upon deploying the Ceph Object Gateway, you can then replace the default Object Storage service (**swift**) with Ceph. For more information, see Object Gateway Guide for Red Hat Enterprise Linux.

To enable a Ceph Object Gateway in your deployment, invoke the following environment file when creating your overcloud:

- **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-rgw.yaml**

See Section 8.2, "Initiating Overcloud Deployment" for details.

The Ceph Object Gateway acts as a drop-in replacement for the default Object Storage service. As such, all other services that normally use **swift** can seamlessly start using the Ceph Object Gateway instead without further configuration. Refer to the Block Storage Backup Guide for instructions.

5.3. CONFIGURING THE BACKUP SERVICE TO USE CEPH

The Block Storage Backup service (**cinder-backup**) is disabled by default. To enable it, invoke the following environment file when creating your overcloud:

- **/usr/share/openstack-tripleo-heat-templates/environments/cinder-backup.yaml**

Refer to the Block Storage Backup Guide for instructions.

5.4. CONFIGURING MULTIPLE BONDED INTERFACES PER CEPH NODE

Using a *bonded interface* allows you to combine multiple NICs to add redundancy to a network connection. If you have enough NICs on your Ceph nodes, you can take this a step further by creating *multiple bonded interfaces* per node.

With this, you can then use a bonded interface for *each* network connection required by the node. This provides both redundancy and a dedicated connection for each network.

The simplest implementation of this involves the use of two bonds, one for each storage network used by the Ceph nodes. These networks are the following:

Front-end storage network (StorageNet)

The Ceph client uses this network to interact with its Ceph cluster.

Back-end storage network (StorageMgmtNet)

The Ceph cluster uses this network to balance data in accordance with the *placement group* policy of the cluster. For more information, see Placement Groups (PG) (from the Red Hat Ceph Architecture Guide).

Configuring this involves customizing a network interface template, as the director does not provide any sample templates that deploy multiple bonded NICs. However, the director does provide a template that deploys a single bonded interface – namely, **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml**. You can add a bonded interface for your additional NICs by defining it there.

NOTE

For more detailed instructions on how to do this, see Creating Custom Interface Templates (from the Advanced Overcloud Customization guide). That section also explains the different components of a bridge and bonding definition.

The following snippet contains the default definition for the single bonded interface defined by **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml**:

```
type: ovs_bridge // 1
name: br-bond
members:
  -
    type: ovs_bond // 2
    name: bond1 // 3
    ovs_options: {get_param: BondInterfaceOvsOptions} 4
    members: // 5
      -
```

```
        type: interface
        name: nic2
        primary: true
      -
        type: interface
        name: nic3
  -
    type: vlan // 6
    device: bond1 // 7
    vlan_id: {get_param: StorageNetworkVlanID}
    addresses:
      -
        ip_netmask: {get_param: StorageIpSubnet}
  -
    type: vlan
    device: bond1
    vlan_id: {get_param: StorageMgmtNetworkVlanID}
    addresses:
      -
        ip_netmask: {get_param: StorageMgmtIpSubnet}
```

1. A single bridge named **br-bond** holds the bond defined by this template. This line defines the bridge type, namely OVS.

2. The first member of the **br-bond** bridge is the bonded interface itself, named **bond1**. This line defines the bond type of **bond1**, which is also OVS.

3. The default bond is named **bond1**, as defined in this line.

4. The **ovs_options** entry instructs director to use a specific set of *bonding module directives*. Those directives are passed through the **BondInterfaceOvsOptions**, which you can also configure in this same file. For instructions on how to configure this, see Section 5.4.1, “Configuring Bonding Module Directives”.

5. The **members** section of the bond defines which network interfaces are bonded by **bond1**. In this case, the bonded interface uses **nic2** (set as the primary interface) and **nic3**.

6. The **br-bond** bridge has two other members: namely, a VLAN for both front-end (**StorageNetwork**) and back-end (**StorageMgmtNetwork**) storage networks.

7. The **device** parameter defines what device a VLAN should use. In this case, both VLANs will use the bonded interface **bond1**.

With at least two more NICs, you can define an additional bridge and bonded interface. Then, you can move one of the VLANs to the new bonded interface. This results in added throughput and reliability for both storage network connections.

When customizing **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml** for this purpose, it is advisable to also use Linux bonds (**type: linux_bond**) instead of the default OVS (**type: ovs_bond**). This bond type is more suitable for enterprise production deployments.

The following edited snippet defines an additional OVS bridge (**br-bond2**) which houses a new Linux bond named **bond2**. The **bond2** interface uses two additional NICs (namely, **nic4** and **nic5**) and will be used solely for back-end storage network traffic:

```
    type: ovs_bridge
    name: br-bond
    members:
     -
       type: linux_bond
       name: bond1
       bonding_options: {get_param: BondInterfaceOvsOptions} // (1)
       members:
        -
          type: interface
          name: nic2
          primary: true
        -
          type: interface
          name: nic3
     -
       type: vlan
       device: bond1
       vlan_id: {get_param: StorageNetworkVlanID}
       addresses:
        -
          ip_netmask: {get_param: StorageIpSubnet}
  -
    type: ovs_bridge
    name: br-bond2
    members:
     -
       type: linux_bond
       name: bond2
       bonding_options: {get_param: BondInterfaceOvsOptions}
       members:
        -
          type: interface
          name: nic4
          primary: true
        -
          type: interface
          name: nic5
     -
       type: vlan
       device: bond1
       vlan_id: {get_param: StorageMgmtNetworkVlanID}
       addresses:
        -
          ip_netmask: {get_param: StorageMgmtIpSubnet}
```

1. As **bond1** and **bond2** are both Linux bonds (instead of OVS), they use **bonding_options** instead of **ovs_options** to set bonding directives. For related information, see Section 5.4.1, "Configuring Bonding Module Directives".

For the full contents of this customized template, see Appendix B, *Sample Custom Interface Template: Multiple Bonded Interfaces*.

5.4.1. Configuring Bonding Module Directives

After adding and configuring the bonded interfaces, use the **BondInterfaceOvsOptions** parameter to set what directives each should use. You can find this in the **parameters:** section of **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml**. The following snippet shows the default definition of this parameter (namely, empty):

```
BondInterfaceOvsOptions:
  default: ''
  description: The ovs_options string for the bond interface. Set
         things like lacp=active and/or bond_mode=balance-slb
         using this option.
  type: string
```

Define the options you need in the **default:** line. For example, to use 802.3ad (mode 4) and a LACP rate of 1 (fast), use **'mode=4 lacp_rate=1'**, as in:

```
BondInterfaceOvsOptions:
  default: 'mode=4 lacp_rate=1'
  description: The bonding_options string for the bond interface. Set
         things like lacp=active and/or bond_mode=balance-slb
         using this option.
  type: string
```

See Appendix C. Open vSwitch Bonding Options (from the Advanced Overcloud Optimization guide) for other supported bonding options. For the full contents of the customized **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml** template, see Appendix B, *Sample Custom Interface Template: Multiple Bonded Interfaces* .

CHAPTER 6. CUSTOMIZING THE CEPH STORAGE CLUSTER

Deploying containerized Ceph Storage involves the use of **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml** during overcloud deployment (as described in Chapter 5, *Customizing the Storage Service*). This environment file also defines the following resources:

CephAnsibleDisksConfig

This resource maps the Ceph Storage node disk layout. See Section 6.1, "Mapping the Ceph Storage Node Disk Layout" for more details.

CephConfigOverrides

This resource applies all other custom settings to your Ceph cluster.

Use these resources to override any defaults set by the director for containerized Ceph Storage.

The **/usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml** environment file uses playbooks provided by the **ceph-ansible** package. As such, you need to install this package on your undercloud first:

```
$ sudo yum install ceph-ansible
```

To customize your Ceph cluster, define your custom parameters in a new environment file, namely **/home/stack/templates/ceph-config.yaml**. You can arbitrarily apply global Ceph cluster settings using the following syntax in the **parameter_defaults** section of your environment file:

```
parameter_defaults:
  CephConfigOverrides:
    KEY:VALUE
```

Replace **KEY** and **VALUE** with the Ceph cluster settings you want to apply. For example, consider the following snippet:

```
parameter_defaults:
  CephConfigOverrides:
    max_open_files: 131072
```

This will result in the following settings defined in the configuration file of your Ceph cluster:

```
[global]
max_open_files: 131072
```

See the Red Hat Ceph Storage Configuration Guide for information about supported parameters.

NOTE

The **CephConfigOverrides** parameter applies only to the **[global]** section of the **ceph.conf** file. You cannot make changes to other sections, for example the **[osd]** section, with the CephConfigOverrides parameter.

The ceph-ansible tool has a **group_vars** directory that you can use to set many different Ceph parameters. For more information, see 3.2. Installing a Red Hat Ceph Storage Cluster in the *Installation Guide for Red Hat Enterprise Linux*.

To change the variable defaults in director, you can use the **CephAnsibleExtraConfig** parameter to pass the new values in heat environment files. For example, to set the ceph-ansible group variable **journal_size** to 40960, create an environment file with the following **journal_size** definition:

```
parameter_defaults:
  CephAnsibleExtraConfig:
    journal_size: 40960
```

> **IMPORTANT**
>
> Change ceph-ansible group variables with the override parameters; do not edit group variables directly in the **/usr/share/ceph-ansible** directory on the undercloud.

6.1. MAPPING THE CEPH STORAGE NODE DISK LAYOUT

When you deploy containerized Ceph Storage, you need to map the disk layout and specify dedicated block devices for the Ceph OSD service. You can do this in the environment file you created earlier to define your custom Ceph parameters – namely, **/home/stack/templates/ceph-config.yaml**.

Use the **CephAnsibleDisksConfig** resource in **parameter_defaults** to map your disk layout. This resource uses the following variables:

Variable	Required?	Default value (if unset)	Description
osd_scenario	Yes	lvm NOTE: For new deployments using Ceph 3.2 and later, **lvm** is the default. For Ceph 3.1 and earlier, the default is **collocated**	With Ceph 3.2, **lvm** allows ceph-ansible to use **ceph-volume** to configure OSDs and BlueStore WAL devices. With Ceph 3.1, the values set the journaling scenario, such as whether OSDs should be created with journals that are either: - co-located on the same device for **filestore** (**collocated**), or - stored on dedicated devices for **filestore** (**non-collocated**).
devices	Yes	*NONE. Variable must be set.*	A list of block devices to be used on the node for OSDs.

Variable	Required?	Default value (if unset)	Description
dedicated_devices	Yes (only if **osd_scenario** is **non-collocated**)	devices	A list of block devices that maps each entry under devices to a dedicated journaling block device. This variable is only usable when **osd_scenario=non-collocated**.
dmcrypt	No	false	Sets whether data stored on OSDs are encrypted (**true**) or not (**false**).
osd_objectstore	No	bluestore NOTE: For new deployments using Ceph 3.2 and later, **bluestore** is the default. For Ceph 3.1 and earlier, the default is **filestore**.	Sets the storage back end used by Ceph.

IMPORTANT

If you deployed your Ceph cluster with a version of **ceph-ansible** older than 3.3 and 'osd_scenario` is set to `collocated' or 'non-collocated', OSD reboot failure can occur due to a device naming discrepancy. For more information about this fault, see https://bugzilla.redhat.com/show_bug.cgi?id=1670734. For information about a workaround, see https://access.redhat.com/solutions/3702681.

6.1.1. Using BlueStore in Ceph 3.2 and later

NOTE

New deployments of OpenStack Platform 13 should use **bluestore**. Current deployments that use **filestore** should continue using **filestore**, as described in Using FileStore in Ceph 3.1 and earlier. Migrations from **filestore** to **bluestore** are not supported by default in RHCS 3.x.

To specify the block devices to be used as Ceph OSDs, use a variation of the following:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
```

```
      - /dev/nvme0n1
    osd_scenario: lvm
    osd_objectstore: bluestore
```

Because **/dev/nvme0n1** is in a higher performing device class—it is an SSD and the other devices are HDDs—the example parameter defaults produce three OSDs that run on **/dev/sdb**, **/dev/sdc**, and **/dev/sdd**. The three OSDs use **/dev/nvme0n1** as a BlueStore WAL device. The ceph-volume tool does this by using the **batch** subcommand. The same setup is duplicated per Ceph storage node and assumes uniform hardware. If the BlueStore WAL data resides on the same disks as the OSDs, then the parameter defaults could be changed to the following:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
    osd_scenario: lvm
    osd_objectstore: bluestore
```

6.1.2. Using FileStore in Ceph 3.1 and earlier

IMPORTANT

The default journaling scenario is set to **osd_scenario=collocated**, which has lower hardware requirements consistent with most testing environments. In a typical production environment, however, journals are stored on dedicated devices (**osd_scenario=non-collocated**) to accommodate heavier I/O workloads. For related information, see Identifying a Performance Use Case.

List each block device to be used by the OSDs as a simple list under the **devices** variable. For example:

```
devices:
  - /dev/sda
  - /dev/sdb
  - /dev/sdc
  - /dev/sdd
```

If **osd_scenario=non-collocated**, you must also map each entry in **devices** to a corresponding entry in **dedicated_devices**. For example, notice the following snippet in **/home/stack/templates/ceph-config.yaml**:

```
osd_scenario: non-collocated
devices:
  - /dev/sda
  - /dev/sdb
  - /dev/sdc
  - /dev/sdd

dedicated_devices:
  - /dev/sdf
```

```
  - /dev/sdf
  - /dev/sdg
  - /dev/sdg
```

Each Ceph Storage node in the resulting Ceph cluster has the following characteristics:

- **/dev/sda** has **/dev/sdf1** as its journal
- **/dev/sdb** has **/dev/sdf2** as its journal
- **/dev/sdc** has **/dev/sdg1** as its journal
- **/dev/sdd** has **/dev/sdg2** as its journal

6.1.3. Referring to devices with persistent names

In some nodes, disk paths, such as **/dev/sdb** and **/dev/sdc**, may not point to the same block device during reboots. If this is the case with your **CephStorage** nodes, specify each disk through its **/dev/disk/by-path/** symlink.

For example:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:

      - /dev/disk/by-path/pci-0000:03:00.0-scsi-0:0:10:0
      - /dev/disk/by-path/pci-0000:03:00.0-scsi-0:0:11:0


    dedicated_devices
      - /dev/nvme0n1
      - /dev/nvme0n1
```

This ensures that the block device mapping is consistent throughout deployments.

Because the list of OSD devices must be set prior to overcloud deployment, it may not be possible to identify and set the PCI path of disk devices. In this case, gather the **/dev/disk/by-path/symlink** data for block devices during introspection.

In the following example, the first command downloads the introspection data from the undercloud Object Storage service (swift) for the server **b08-h03-r620-hci** and saves the data in a file called **b08-h03-r620-hci.json**. The second command greps for “by-path” and the results show the required data.

```
(undercloud) [stack@b08-h02-r620 ironic]$ openstack baremetal introspection data save b08-h03-
r620-hci | jq . > b08-h03-r620-hci.json
(undercloud) [stack@b08-h02-r620 ironic]$ grep by-path b08-h03-r620-hci.json
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:0:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:1:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:3:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:4:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:5:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:6:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:7:0",
        "by_path": "/dev/disk/by-path/pci-0000:02:00.0-scsi-0:2:0:0",
```

For more information about naming conventions for storage devices, see Persistent Naming.

For details about each journaling scenario and disk mapping for containerized Ceph Storage, see the OSD Scenarios section of the project documentation for ceph-ansible.

> **WARNING**
>
> **osd_scenario: lvm** is used in the example to default new deployments to **bluestore** as configured by **ceph-volume**; this is only available with ceph-ansible 3.2 or later and Ceph Luminous or later. The parameters to support **filestore** with ceph-ansible 3.2 are backwards compatible. Therefore, in existing FileStore deployments, do not simply change the **osd_objectstore** or **osd_scenario** parameters.

6.2. ASSIGNING CUSTOM ATTRIBUTES TO DIFFERENT CEPH POOLS

By default, Ceph pools created through the director have the same placement group (**pg_num** and **pgp_num**) and sizes. You can use either method in Chapter 6, *Customizing the Ceph Storage Cluster* to override these settings globally; that is, doing so will apply the same values for all pools.

You can also apply different attributes to each Ceph pool. To do so, use the **CephPools** parameter, as in:

```
parameter_defaults:
  CephPools:
    - name: POOL
      pg_num: 128
      application: rbd
```

Replace **POOL** with the name of the pool you want to configure along with the **pg_num** setting to indicate number of placement groups. This overrides the default **pg_num** for the specified pool.

If you use the **CephPools** parameter, you must also specify the application type. The application type for Compute, Block Storage, and Image Storage should be **rbd**, as shown in the examples, but depending on what the pool will be used for, you may need to specify a different application type. For example, the application type for the gnocchi metrics pool is **openstack_gnocchi**. See Enable Application in the *Storage Strategies Guide* for more information.

If you do not use the **CephPools** parameter, director sets the appropriate application type automatically, but only for the default pool list.

You can also create new custom pools through the **CephPools** parameter. For example, to add a pool called **custompool**:

```
parameter_defaults:
  CephPools:
    - name: custompool
      pg_num: 128
      application: rbd
```

This creates a new custom pool in addition to the default pools.

TIP

For typical pool configurations of common Ceph use cases, see the Ceph Placement Groups (PGs) per Pool Calculator. This calculator is normally used to generate the commands for manually configuring your Ceph pools. In this deployment, the director will configure the pools based on your specifications.

> **WARNING**
>
> Red Hat Ceph Storage 3 (Luminous) introduces a hard limit on the maximum number of PGs an OSD can have, which is 200 by default. Do not override this parameter beyond 200. If there is a problem because the Ceph PG number exceeds the maximum, adjust the **pg_num** per pool to address the problem, not the **mon_max_pg_per_osd**.

6.3. MAPPING THE DISK LAYOUT TO NON-HOMOGENEOUS CEPH STORAGE NODES

By default, all nodes of a role which will host Ceph OSDs (indicated by the **OS::TripleO::Services::CephOSD** service in **roles_data.yaml**), for example **CephStorage** or **ComputeHCI** nodes, will use the global **devices** and **dedicated_devices** lists set in Section 6.1, "Mapping the Ceph Storage Node Disk Layout". This assumes that all of these servers have homogeneous hardware. If a subset of these servers do not have homogeneous hardware, then director needs to be aware that each of these servers has different **devices** and **dedicated_devices** lists. This is known as a *node-specific disk configuration*.

To pass director a node-specific disk configuration, a Heat environment file, such as **node-spec-overrides.yaml**, must be passed to the **openstack overcloud deploy** command and the file's content must identify each server by a machine unique UUID and a list of local variables which override the global variables.

The machine unique UUID may be extracted for each individual server or from the Ironic database.

To locate the UUID for an individual server, log in to the server and run:

```
dmidecode -s system-uuid
```

To extract the UUID from the Ironic database, run the following command on the undercloud:

```
openstack baremetal introspection data save NODE-ID | jq .extra.system.product.uuid
```

> **WARNING**
>
> If the **undercloud.conf** does not have **inspection_extras = true** prior to undercloud installation or upgrade and introspection, then the machine unique UUID will not be in the Ironic database.

> **IMPORTANT**
>
> The machine unique UUID is not the Ironic UUID.

A valid **node-spec-overrides.yaml** file may look like the following:

```
parameter_defaults:
  NodeDataLookup: {"32E87B4C-C4A7-418E-865B-191684A6883B": {"devices": ["/dev/sdc"]}}
```

All lines after the first two lines must be valid JSON. An easy way to verify that the JSON is valid is to use the **jq** command. For example:

1. Remove the first two lines (**parameter_defaults:** and **NodeDataLookup:**) from the file temporarily.
2. Run **cat node-spec-overrides.yaml | jq .**

As the **node-spec-overrides.yaml** file grows, **jq** may also be used to ensure that the embedded JSON is valid. For example, because the **devices** and **dedicated_devices** list should be the same length, use the following to verify that they are the same length before starting the deployment.

```
(undercloud) [stack@b08-h02-r620 tht]$ cat node-spec-c05-h17-h21-h25-6048r.yaml | jq '.[] | .devices | length'
33
30
33
(undercloud) [stack@b08-h02-r620 tht]$ cat node-spec-c05-h17-h21-h25-6048r.yaml | jq '.[] | .dedicated_devices | length'
33
30
33
(undercloud) [stack@b08-h02-r620 tht]$
```

In the above example, the **node-spec-c05-h17-h21-h25-6048r.yaml** has three servers in rack c05 in which slots h17, h21, and h25 are missing disks. A more complicated example is included at the end of this section.

After the JSON has been validated add back the two lines which makes it a valid environment YAML file (**parameter_defaults:** and **NodeDataLookup:**) and include it with a **-e** in the deployment.

In the example below, the updated Heat Environment File uses NodeDataLookup for Ceph deployment. All of the servers had a devices list with 35 disks except one of them had a disk missing. This environment file overrides the default devices list for only that single node and gives it the list of 34 disks it should use instead of the global list.

–

```
parameter_defaults:
  # c05-h01-6048r is missing scsi-0:2:35:0 (00000000-0000-0000-0000-0CC47A6EFD0C)
  NodeDataLookup: {
    "00000000-0000-0000-0000-0CC47A6EFD0C": {
      "devices": [
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:1:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:32:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:2:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:3:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:4:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:5:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:6:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:33:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:7:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:8:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:34:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:9:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:10:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:11:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:12:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:13:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:14:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:15:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:16:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:17:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:18:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:19:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:20:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:21:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:22:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:23:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:24:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:25:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:26:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:27:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:28:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:29:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:30:0",
    "/dev/disk/by-path/pci-0000:03:00.0-scsi-0:2:31:0"
        ],
      "dedicated_devices": [
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
    "/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
```

```
"/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:81:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1",
"/dev/disk/by-path/pci-0000:84:00.0-nvme-1"
    ]
  }
}
```

CHAPTER 7. DEPLOYING SECOND-TIER CEPH STORAGE ON OPENSTACK

Using OpenStack director, you can deploy different Red Hat Ceph Storage performance tiers by adding new Ceph nodes dedicated to a specific tier in a Ceph cluster.

For example, you can add new object storage daemon (OSD) nodes with SSD drives to an existing Ceph cluster to create a Block Storage (cinder) backend exclusively for storing data on these nodes. A user creating a new Block Storage volume can then choose the desired performance tier: either HDDs or the new SSDs.

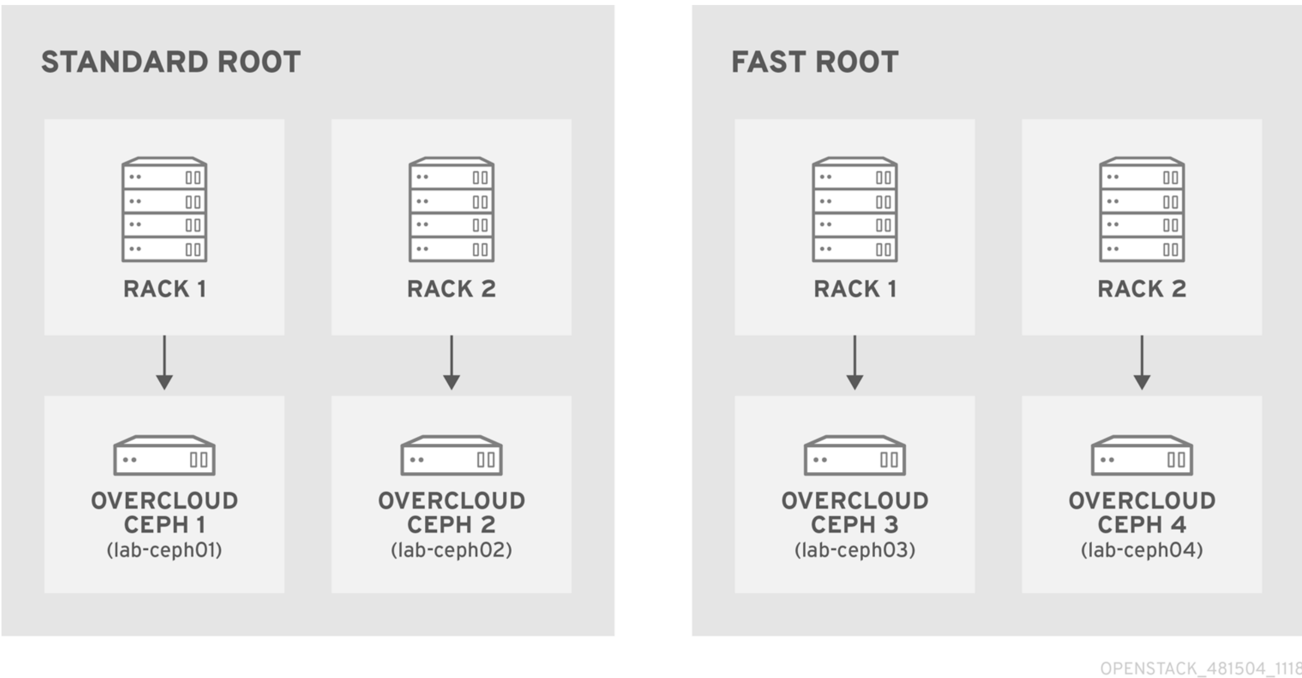
This type of deployment requires Red Hat OpenStack Platform director to pass a customized CRUSH map to ceph-ansible. The CRUSH map allows you to split OSD nodes based on disk performance, but you can also use this feature for mapping physical infrastructure layout.

The following sections demonstrate how to deploy four nodes where two of the nodes use SSDs and the other two use HDDs. The example is kept simple to communicate a repeatable pattern. However, a production deployment should use more nodes and more OSDs to be supported as per the Red Hat Ceph Storage hardware selection guide.

7.1. CREATE A CRUSH MAP

The CRUSH map allows you to put OSD nodes into a CRUSH root. By default, a “default” root is created and all OSD nodes are included in it.

Inside a given root, you define the physical topology, rack, rooms, and so forth, and then place the OSD nodes in the desired hierarchy (or bucket). By default, no physical topology is defined; a flat design is assumed as if all nodes are in the same rack.



See Crush Administration in the *Storage Strategies Guide* for details about creating a custom CRUSH map.

7.2. MAPPING THE OSDS

Complete the following step to map the OSDs.

Procedure

1. Declare the OSDs/journal mapping:

```
parameter_defaults:
  CephAnsibleDisksConfig:
   devices:
   - /dev/sda
   - /dev/sdb
   dedicated_devices:
   - /dev/sdc
   - /dev/sdc
   osd_scenario: non-collocated
   journal_size: 8192
```

7.3. SETTING THE REPLICATION FACTOR

Complete the following step to set the replication factor.

> **NOTE**
>
> This is normally supported only for full SSD deployment. See Red Hat Ceph Storage: Supported configurations.

Procedure

1. Set the default replication factor to two. This example splits four nodes into two different roots.

```
parameter_defaults:
  CephPoolDefaultSize: 2
```

> **NOTE**
>
> If you upgrade a deployment that uses gnocchi as the backend, you might encounter deployment timeout. To prevent this timeout, use the following **CephPool** definition to customize the gnocchi pool:
>
> ```
> parameter_defaults
>     CephPools:  {"name": metrics, "pg_num": 128, "pgp_num": 128, "size": 1}
> ```

7.4. DEFINING THE CRUSH HIERARCHY

Director provides the data for the CRUSH hierarchy, but ceph-ansible actually passes that data by getting the CRUSH mapping through the Ansible inventory file. Unless you keep the default root, you must specify the location of the root for each node.

For example if node lab-ceph01 (provisioning IP 172.16.0.26) is placed in **rack1** inside the **fast_root**, the Ansible inventory should resemble the following:

```
172.16.0.26:
osd_crush_location: {host: lab-ceph01, rack: rack1, root: fast_root}
```

When you use director to deploy Ceph, you don't actually write the Ansible inventory; it is generated for you. Therefore, you must use **NodeDataLookup** to append the data.

NodeDataLookup works by specifying the system product UUID stored on the motherboard of the systems. The Bare Metal service (ironic) also stores this information after the introspection phase.

To create a CRUSH map that supports second-tier storage, complete the following steps:

Procedure

1. Run the following commands to retrieve the UUIDs of the four nodes:

```
for ((x=1; x<=4; x++)); \
{ echo "Node overcloud-ceph0${x}"; \
openstack baremetal introspection data save overcloud-ceph0${x} | jq
.extra.system.product.uuid; }
Node overcloud-ceph01
"32C2BC31-F6BB-49AA-971A-377EFDFDB111"
Node overcloud-ceph02
"76B4C69C-6915-4D30-AFFD-D16DB74F64ED"
Node overcloud-ceph03
"FECF7B20-5984-469F-872C-732E3FEF99BF"
Node overcloud-ceph04
"5FFEFA5F-69E4-4A88-B9EA-62811C61C8B3"
```

NOTE

In the example, overcloud-ceph0[1-4] are the Ironic nodes names; they will be deployed as **lab-ceph0[1–4]** (via HostnameMap.yaml).

2. Specify the node placement as follows:

Root	Rack	Node
standard_root	rack1_std	overcloud-ceph01 (lab-ceph01)
	rack2_std	overcloud-ceph02 (lab-ceph02)
fast_root	rack1_fast	overcloud-ceph03 (lab-ceph03)
	rack2_fast	overcloud-ceph04 (lab-ceph04)

NOTE

You cannot have two buckets with the same name. Even if **lab-ceph01** and **lab-ceph03** are in the same physical rack, you cannot have two buckets called **rack1**. Therefore, we named them **rack1_std** and **rack1_fast**.

NOTE

This example demonstrates how to create a specific route called “standard_root” to illustrate multiple custom roots. However, you could have kept the HDDs OSD nodes in the default root.

3. Use the following **NodeDataLookup** syntax:

```
NodeDataLookup: {"SYSTEM_UUID": {"osd_crush_location": {"root": "$MY_ROOT", "rack":
"$MY_RACK", "host": "$OVERCLOUD_NODE_HOSTNAME"}}}
```

NOTE

You must specify the system UUID and then the CRUSH hierarchy from top to bottom. Also, the **host** parameter must point to the node’s overcloud host name, not the Bare Metal service (ironic) node name. To match the example configuration, enter the following:

```
parameter_defaults:
  NodeDataLookup: {"32C2BC31-F6BB-49AA-971A-377EFDFDB111":
{"osd_crush_location": {"root": "standard_root", "rack": "rack1_std", "host": "lab-ceph01"}},
     "76B4C69C-6915-4D30-AFFD-D16DB74F64ED": {"osd_crush_location": {"root":
"standard_root", "rack": "rack2_std", "host": "lab-ceph02"}},
     "FECF7B20-5984-469F-872C-732E3FEF99BF": {"osd_crush_location": {"root":
"fast_root", "rack": "rack1_fast", "host": "lab-ceph03"}},
     "5FFEFA5F-69E4-4A88-B9EA-62811C61C8B3": {"osd_crush_location": {"root":
"fast_root", "rack": "rack2_fast", "host": "lab-ceph04"}}}
```

4. Enable CRUSH map management at the ceph-ansible level:

```
parameter_defaults:
  CephAnsibleExtraConfig:
    create_crush_tree: true
```

5. Use scheduler hints to ensure the Bare Metal service node UUIDs correctly map to the hostnames:

```
parameter_defaults:
  CephStorageCount: 4
  OvercloudCephStorageFlavor: ceph-storage
  CephStorageSchedulerHints:
    'capabilities:node': 'ceph-%index%'
```

6. Tag the Bare Metal service nodes with the corresponding hint:

```
openstack baremetal node set --property capabilities='profile:ceph-storage,node:ceph-
0,boot_option:local' overcloud-ceph01
```

```
openstack baremetal node set --property capabilities=profile:ceph-storage,'node:ceph-1,boot_option:local' overcloud-ceph02

openstack baremetal node set --property capabilities='profile:ceph-storage,node:ceph-2,boot_option:local' overcloud-ceph03

openstack baremetal node set --property capabilities='profile:ceph-storage,node:ceph-3,boot_option:local' overcloud-ceph04
```

> **NOTE**
>
> For more information about predictive placement, see Assigning Specific Node IDs in the *Advanced Overcloud Customization* guide.

7.5. DEFINING CRUSH MAP RULES

Rules define how the data is written on a cluster. After the CRUSH map node placement is complete, define the CRUSH rules.

Procedure

1. Use the following syntax to define the CRUSH rules:

```
parameter_defaults:
  CephAnsibleExtraConfig:
    crush_rules:
      - name: $RULE_NAME
        root: $ROOT_NAME
        type: $REPLICAT_DOMAIN
        default: true/false
```

> **NOTE**
>
> Setting the default parameter to **true** means that this rule will be used when you create a new pool without specifying any rule. There may only be one default rule.

In the following example, rule **standard** points to the OSD nodes hosted on the **standard_root** with one replicate per rack. Rule **fast** points to the OSD nodes hosted on the **standard_root** with one replicate per rack:

```
parameter_defaults:
  CephAnsibleExtraConfig:
    crush_rule_config: true
    crush_rules:
      - name: standard
        root: standard_root
        type: rack
        default: true
      - name: fast
        root: fast_root
        type: rack
        default: false
```

NOTE

You must set **crush_rule_config** to **true**.

7.6. CONFIGURING OSP POOLS

Ceph pools are configured with a CRUSH rules that define how to store data. This example features all built-in OSP pools using the **standard_root** (the standard rule) and a new pool using **fast_root** (the fast rule).

Procedure

1. Use the following syntax to define or change a pool property:

```
- name: $POOL_NAME
    pg_num: $PG_COUNT
    rule_name: $RULE_NAME
    application: rbd
```

2. List all OSP pools and set the appropriate rule (standard, in this case), and create a new pool called **tier2** that uses the **fast** rule. This pool will be used by Block Storage (cinder).

```
parameter_defaults:
  CephPools:
    - name: tier2
      pg_num: 64
      rule_name: fast
      application: rbd

    - name: volumes
      pg_num: 64
      rule_name: standard
      application: rbd

    - name: vms
      pg_num: 64
      rule_name: standard
      application: rbd

    - name: backups
      pg_num: 64
      rule_name: standard
      application: rbd

    - name: images
      pg_num: 64
      rule_name: standard
      application: rbd

    - name: metrics
      pg_num: 64
      rule_name: standard
      application: openstack_gnocchi
```

7.7. CONFIGURING BLOCK STORAGE TO USE THE NEW POOL

Add the Ceph pool to the **cinder.conf** file to enable Block Storage (cinder) to consume it:

Procedure

1. Update **cinder.conf** as follows:

```
parameter_defaults:
  CinderRbdExtraPools:
    - tier2
```

7.8. VERIFYING CUSTOMIZED CRUSH MAP

After the **openstack overcloud deploy** command creates or updates the overcloud, complete the following step to verify that the customized CRUSH map was correctly applied.

> **NOTE**
>
> Be careful if you move a host from one route to another.

Procedure

1. Connect to a Ceph monitor node and run the following command:

```
# ceph osd tree
ID WEIGHT  TYPE NAME             UP/DOWN REWEIGHT PRIMARY-AFFINITY
-7 0.39996 root standard_root
-6 0.19998     rack rack1_std
-5 0.19998         host lab-ceph02
 1 0.09999             osd.1          up  1.00000          1.00000
 4 0.09999             osd.4          up  1.00000          1.00000
-9 0.19998     rack rack2_std
-8 0.19998         host lab-ceph03
 0 0.09999             osd.0          up  1.00000          1.00000
 3 0.09999             osd.3          up  1.00000          1.00000
-4 0.19998 root fast_root
-3 0.19998     rack rack1_fast
-2 0.19998         host lab-ceph01
 2 0.09999             osd.2          up  1.00000          1.00000
 5 0.09999             osd.5          up  1.00000          1.00000
```

CHAPTER 8. CREATING THE OVERCLOUD

Once your custom environment files are ready, you can specify which flavors and nodes each role should use and then execute the deployment. The following subsections explain both steps in greater detail.

8.1. ASSIGNING NODES AND FLAVORS TO ROLES

Planning an overcloud deployment involves specifying how many nodes and which flavors to assign to each role. Like all Heat template parameters, these role specifications are declared in the **parameter_defaults** section of your environment file (in this case, **~/templates/storage-config.yaml**).

For this purpose, use the following parameters:

Table 8.1. Roles and Flavors for Overcloud Nodes

Heat Template Parameter	Description
ControllerCount	The number of Controller nodes to scale out
OvercloudControlFlavor	The flavor to use for Controller nodes (**control**)
ComputeCount	The number of Compute nodes to scale out
OvercloudComputeFlavor	The flavor to use for Compute nodes (**compute**)
CephStorageCount	The number of Ceph storage (OSD) nodes to scale out
OvercloudCephStorageFlavor	The flavor to use for Ceph Storage (OSD) nodes (**ceph-storage**)
CephMonCount	The number of dedicated Ceph MON nodes to scale out
OvercloudCephMonFlavor	The flavor to use for dedicated Ceph MON nodes (**ceph-mon**)
CephMdsCount	The number of dedicated Ceph MDS nodes to scale out
OvercloudCephMdsFlavor	The flavor to use for dedicated Ceph MDS nodes (**ceph-mds**)

IMPORTANT

The **CephMonCount**, **CephMdsCount**, **OvercloudCephMonFlavor**, and **OvercloudCephMdsFlavor** parameters (along with the **ceph-mon** and **ceph-mds** flavors) will only be valid if you created a custom **CephMON** and **CephMds** role, as described in Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* .

For example, to configure the overcloud to deploy three nodes for each role (Controller, Compute, Ceph-Storage, and CephMon), add the following to your **parameter_defaults**:

```
parameter_defaults:
  ControllerCount: 3
  OvercloudControlFlavor: control
  ComputeCount: 3
  OvercloudComputeFlavor: compute
  CephStorageCount: 3
  OvercloudCephStorageFlavor: ceph-storage
  CephMonCount: 3
  OvercloudCephMonFlavor: ceph-mon
  CephMdsCount: 3
  OvercloudCephMdsFlavor: ceph-mds
```

NOTE

See Creating the Overcloud with the CLI Tools from the Director Installation and Usage guide for a more complete list of Heat template parameters.

8.2. INITIATING OVERCLOUD DEPLOYMENT

NOTE

During undercloud installation, set **generate_service_certificate=false** in the **undercloud.conf** file. Otherwise, you must inject a trust anchor when you deploy the overcloud, as described in Enabling SSL/TLS on Overcloud Public Endpoints in the *Advanced Overcloud Customization* guide.

The creation of the overcloud requires additional arguments for the **openstack overcloud deploy** command. For example:

```
$ openstack overcloud deploy --templates -r /home/stack/templates/roles_data_custom.yaml \
  -e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml \
  -e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-rgw.yaml \
  -e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-mds.yaml
  -e /usr/share/openstack-tripleo-heat-templates/environments/cinder-backup.yaml \
  -e /home/stack/templates/storage-config.yaml \
  -e /home/stack/templates/ceph-config.yaml \
  --ntp-server pool.ntp.org
```

The above command uses the following options:

- **--templates** - Creates the Overcloud from the default Heat template collection (namely, **/usr/share/openstack-tripleo-heat-templates/**).
- **-r /home/stack/templates/roles_data_custom.yaml** - Specifies the customized roles definition file from Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* , which adds custom roles for either Ceph MON or Ceph MDS services. These roles allow either service to be installed on dedicated nodes.

- **-e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml** - Sets the director to create a Ceph cluster. In particular, this environment file will deploy a Ceph cluster with *containerized* Ceph Storage nodes.

- **-e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-rgw.yaml** - Enables the Ceph Object Gateway, as described in Section 5.2, “Enabling the Ceph Object Gateway”.

- **-e /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-mds.yaml** - Enables the Ceph Metadata Server, as described in Section 5.1, “Enabling the Ceph Metadata Server”.

- **-e /usr/share/openstack-tripleo-heat-templates/environments/cinder-backup.yaml** - Enables the Block Storage Backup service (**cinder-backup**), as described in Section 5.3, “Configuring the Backup Service to Use Ceph”.

- **-e /home/stack/templates/storage-config.yaml** - Adds the environment file containing your custom Ceph Storage configuration.

- **-e /home/stack/templates/ceph-config.yaml** - Adds the environment file containing your custom Ceph cluster settings, as described in Chapter 6, *Customizing the Ceph Storage Cluster*.

- **--ntp-server pool.ntp.org** - Sets our NTP server.

TIP

You can also use an *answers file* to invoke all your templates and environment files. For example, you can use the following command to deploy an identical overcloud:

```
$ openstack overcloud deploy -r /home/stack/templates/roles_data_custom.yaml \
  --answers-file /home/stack/templates/answers.yaml --ntp-server pool.ntp.org
```

In this case, the answers file **/home/stack/templates/answers.yaml** contains:

```
templates: /usr/share/openstack-tripleo-heat-templates/
environments:
  - /usr/share/openstack-tripleo-heat-templates/environments/ceph-ansible/ceph-ansible.yaml
  - /usr/share/openstack-tripleo-heat-templates/environments/ceph-rgw.yaml
  - /usr/share/openstack-tripleo-heat-templates/environments/ceph-mds.yaml
  - /usr/share/openstack-tripleo-heat-templates/environments/cinder-backup.yaml
  - /home/stack/templates/storage-config.yaml
  - /home/stack/templates/ceph-config.yaml
```

See Including Environment Files in Overcloud Creation for more details.

For a full list of options, run:

```
$ openstack help overcloud deploy
```

For more information, see Creating the Overcloud with the CLI Tools in the Director Installation and Usage guide.

The Overcloud creation process begins and the director provisions your nodes. This process takes some time to complete. To view the status of the Overcloud creation, open a separate terminal as the **stack** user and run:

```
$ source ~/stackrc
$ openstack stack list --nested
```

CHAPTER 9. POST-DEPLOYMENT

The following subsections describe several post-deployment operations for managing the Ceph cluster.

9.1. ACCESSING THE OVERCLOUD

The director generates a script to configure and help authenticate interactions with your overcloud from the director host. The director saves this file (**overcloudrc**) in your **stack** user's home directory. Run the following command to use this file:

```
$ source ~/overcloudrc
```

This loads the necessary environment variables to interact with your overcloud from the director host's CLI. To return to interacting with the director's host, run the following command:

```
$ source ~/stackrc
```

9.2. MONITORING CEPH STORAGE NODES

After you create the overcloud, check the status of the Ceph Storage cluster to ensure that it works correctly.

Procedure

1. Log in to a Controller node as the **heat-admin** user:

   ```
   $ nova list
   $ ssh heat-admin@192.168.0.25
   ```

2. Check the health of the cluster:

   ```
   $ sudo docker exec ceph-mon-$HOSTNAME ceph health
   ```

   If the cluster has no issues, the command reports back **HEALTH_OK**. This means the cluster is safe to use.

3. Log in to an overcloud node that runs the Ceph monitor service and check the status of all OSDs in the cluster:

   ```
   sudo docker exec ceph-mon-$HOSTNAME ceph osd tree
   ```

4. Check the status of the Ceph Monitor quorum:

   ```
   $ sudo ceph quorum_status
   ```

   This shows the monitors participating in the quorum and which one is the leader.

5. Verify that all Ceph OSDs are running:

   ```
   $ ceph osd stat
   ```

For more information on monitoring Ceph Storage clusters, see Monitoring in the *Red Hat Ceph Storage Administration Guide*.

CHAPTER 10. REBOOTING THE ENVIRONMENT

A situation might occur where you need to reboot the environment. For example, when you might need to modify the physical servers, or you might need to recover from a power outage. In this situation, it is important to make sure your Ceph Storage nodes boot correctly.

Make sure to boot the nodes in the following order:

- **Boot all Ceph Monitor nodes first**- This ensures the Ceph Monitor service is active in your high availability cluster. By default, the Ceph Monitor service is installed on the Controller node. If the Ceph Monitor is separate from the Controller in a custom role, make sure this custom Ceph Monitor role is active.
- **Boot all Ceph Storage nodes**- This ensures the Ceph OSD cluster can connect to the active Ceph Monitor cluster on the Controller nodes.

10.1. REBOOTING A CEPH STORAGE (OSD) CLUSTER

Complete the following steps to reboot a cluster of Ceph Storage (OSD) nodes.

Procedure

1. Log into a Ceph MON or Controller node and disable Ceph Storage cluster rebalancing temporarily:

```
$ sudo ceph osd set noout
$ sudo ceph osd set norebalance
```

2. Select the first Ceph Storage node to reboot and log into the node.
3. Reboot the node:

```
$ sudo reboot
```

4. Wait until the node boots.
5. Log into the node and check the cluster status:

```
$ sudo ceph -s
```

Check the **pgmap** reports all **pgs** as normal (**active+clean**).

6. Log out of the node, reboot the next node, and check its status. Repeat this process until you have rebooted all Ceph storage nodes.
7. When complete, log into a Ceph MON or Controller node and enable cluster rebalancing again:

```
$ sudo ceph osd unset noout
$ sudo ceph osd unset norebalance
```

8. Perform a final status check to verify the cluster reports **HEALTH_OK**:

```
$ sudo ceph status
```

If a situation occurs where all Overcloud nodes boot at the same time, the Ceph OSD services might not start correctly on the Ceph Storage nodes. In this situation, reboot the Ceph Storage OSDs so they can connect to the Ceph Monitor service.

Verify a **HEALTH_OK** status of the Ceph Storage node cluster with the following command:

```
$ sudo ceph status
```

CHAPTER 11. SCALING THE CEPH CLUSTER

11.1. SCALING UP THE CEPH CLUSTER

You can scale up the number of Ceph Storage nodes in your overcloud by re-running the deployment with the number of Ceph Storage nodes you need.

Before doing so, ensure that you have enough nodes for the updated deployment. These nodes must be registered with the director and tagged accordingly.

Registering New Ceph Storage Nodes

To register new Ceph storage nodes with the director, follow these steps:

1. Log into the director host as the **stack** user and initialize your director configuration:

```
$ source ~/stackrc
```

2. Define the hardware and power management details for the new nodes in a new node definition template; for example, **instackenv-scale.json**.

3. Import this file to the OpenStack director:

```
$ openstack overcloud node import ~/instackenv-scale.json
```

Importing the node definition template registers each node defined there to the director.

4. Assign the kernel and ramdisk images to all nodes:

```
$ openstack overcloud node configure
```

NOTE

For more information about registering new nodes, see Section 3.2, “Registering Nodes”.

Manually Tagging New Nodes

After registering each node, you will need to inspect the hardware and tag the node into a specific profile. Profile tags match your nodes to flavors, and in turn the flavors are assigned to a deployment role.

To inspect and tag new nodes, follow these steps:

1. Trigger hardware introspection to retrieve the hardware attributes of each node:

```
$ openstack overcloud node introspect --all-manageable --provide
```

- The **--all-manageable** option introspects only nodes in a managed state. In this example, it is all of them.

- The **--provide** option resets all nodes to an **active** state after introspection.

> **IMPORTANT**
>
> Make sure this process runs to completion. This process usually takes 15 minutes for bare metal nodes.

2. Retrieve a list of your nodes to identify their UUIDs:

```
$ openstack baremetal node list
```

3. Add a **profile** option to the **properties/capabilities** parameter for each node to manually tag a node to a specific profile.
For example, the following commands tag three additional nodes with the **ceph-storage** profile:

```
$ ironic node-update 551d81f5-4df2-4e0f-93da-6c5de0b868f7 add
properties/capabilities='profile:ceph-storage,boot_option:local'
$ ironic node-update 5e735154-bd6b-42dd-9cc2-b6195c4196d7 add
properties/capabilities='profile:ceph-storage,boot_option:local'
$ ironic node-update 1a2b090c-299d-4c20-a25d-57dd21a7085b add
properties/capabilities='profile:ceph-storage,boot_option:local'
```

TIP

If the nodes you just tagged and registered use multiple disks, you can set the director to use a specific root disk on each node. See Section 3.4, “Defining the root disk” for instructions on how to do so.

Re-deploying the Overcloud with Additional Ceph Storage Nodes

After registering and tagging the new nodes, you can now scale up the number of Ceph Storage nodes by re-deploying the overcloud. When you do, set the **CephStorageCount** parameter in the **parameter_defaults** of your environment file (in this case, **~/templates/storage-config.yaml**). In Section 8.1, “Assigning Nodes and Flavors to Roles”, the overcloud is configured to deploy with 3 Ceph Storage nodes. To scale it up to 6 nodes instead, use:

```
parameter_defaults:
  ControllerCount: 3
  OvercloudControlFlavor: control
  ComputeCount: 3
  OvercloudComputeFlavor: compute
  CephStorageCount: 6
  OvercloudCephStorageFlavor: ceph-storage
  CephMonCount: 3
  OvercloudCephMonFlavor: ceph-mon
```

Upon re-deployment with this setting, the overcloud should now have 6 Ceph Storage nodes instead of 3.

11.2. SCALING DOWN AND REPLACING CEPH STORAGE NODES

In some cases, you may need to scale down your Ceph cluster, or even replace a Ceph Storage node (for example, if a Ceph Storage node is faulty). In either situation, you need to disable and rebalance any Ceph Storage node you are removing from the Overcloud to ensure no data loss. This procedure explains the process for replacing a Ceph Storage node.

> **NOTE**
>
> This procedure uses steps from the *Red Hat Ceph Storage Administration Guide* to manually remove Ceph Storage nodes. For more in-depth information about manual removal of Ceph Storage nodes, see Administering Ceph clusters that run in Containers and Removing a Ceph OSD using the command-line interface .

1. Log in to a Controller node as the **heat-admin** user. The director's **stack** user has an SSH key to access the **heat-admin** user.

2. List the OSD tree and find the OSDs for your node. For example, the node you want to remove might contain the following OSDs:

```
-2 0.09998     host overcloud-cephstorage-0
0 0.04999         osd.0                     up  1.00000          1.00000
1 0.04999         osd.1                     up  1.00000          1.00000
```

3. Disable the OSDs on the Ceph Storage node. In this case, the OSD IDs are 0 and 1.

```
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd out 0
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd out 1
```

4. The Ceph Storage cluster begins rebalancing. Wait for this process to complete. Follow the status using the following command:

```
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph -w
```

5. After the Ceph cluster completes rebalancing, log in to the Ceph Storage node you are removing (in this case, **overcloud-cephstorage-0**) as the **heat-admin** user and stop the node.

```
[heat-admin@overcloud-cephstorage-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME
systemctl disable ceph-osd@0
[heat-admin@overcloud-cephstorage-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME
systemctl disable ceph-osd@1
```

6. Stop the OSDs.

```
[heat-admin@overcloud-cephstorage-0 ~]$ sudo systemctl stop ceph-osd@0
[heat-admin@overcloud-cephstorage-0 ~]$ sudo systemctl stop ceph-osd@1
```

7. While logged in to the Controller node, remove the OSDs from the CRUSH map so that they no longer receive data.

```
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd crush remove osd.0
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd crush remove osd.1
```

8. Remove the OSD authentication key.

```
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
```

```
auth del osd.0
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
auth del osd.1
```

9. Remove the OSD from the cluster.

```
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd rm 0
[heat-admin@overcloud-controller-0 ~]$ sudo docker exec ceph-mon-$HOSTNAME ceph
osd rm 1
```

10. Leave the node and return to the director host as the **stack** user.

```
[heat-admin@overcloud-controller-0 ~]$ exit
[stack@director ~]$
```

11. Disable the Ceph Storage node so the director does not reprovision it.

```
[stack@director ~]$ openstack baremetal node list
[stack@director ~]$ openstack baremetal node maintenance set UUID
```

12. Removing a Ceph Storage node requires an update to the **overcloud** stack in the director using the local template files. First identify the UUID of the Overcloud stack:

```
$ openstack stack list
```

13. Identify the UUIDs of the Ceph Storage node you want to delete:

```
$ openstack server list
```

14. Run the following command to delete the node from the stack and update the plan accordingly:

```
$ openstack overcloud node delete --stack overcloud NODE_UUID
```

IMPORTANT

If you passed any extra environment files when you created the overcloud, pass them again here using the **-e** option to avoid making undesired changes to the overcloud. For more information, see Modifying the Overcloud Environment (from Director Installation and Usage).

15. Wait until the stack completes its update. Monitor the stack update using the **heat stack-list --show-nested** command.

16. Add new nodes to the director's node pool and deploy them as Ceph Storage nodes. Use the **CephStorageCount** parameter in the **parameter_defaults** of your environment file (in this case, **~/templates/storage-config.yaml**) to define the total number of Ceph Storage nodes in the Overcloud. For example:

```
parameter_defaults:
  ControllerCount: 3
  OvercloudControlFlavor: control
```

```
ComputeCount: 3
OvercloudComputeFlavor: compute
CephStorageCount: 3
OvercloudCephStorageFlavor: ceph-storage
CephMonCount: 3
OvercloudCephMonFlavor: ceph-mon
```

> **NOTE**
>
> See Section 8.1, "Assigning Nodes and Flavors to Roles" for details on how to define the number of nodes per role.

17. After you update your environment file, re-deploy the overcloud as normal:

```
$ openstack overcloud deploy --templates -e ENVIRONMENT_FILES
```

The director provisions the new node and updates the entire stack with the new node's details.

18. Log in to a Controller node as the **heat-admin** user and check the status of the Ceph Storage node. For example:

```
[heat-admin@overcloud-controller-0 ~]$ sudo ceph status
```

19. Confirm that the value in the **osdmap** section matches the number of desired nodes in your cluster. The Ceph Storage node you removed has now been replaced with a new node.

11.3. ADDING AN OSD TO A CEPH STORAGE NODE

This procedure demonstrates how to add an OSD to a node.

Procedure

1. Notice the following heat template deploys Ceph Storage with three OSD devices:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
    osd_scenario: lvm
    osd_objectstore: bluestore
```

2. To add an OSD, update the node disk layout as described in Section 6.1, "Mapping the Ceph Storage Node Disk Layout". In this example, add **/dev/sde** to the template:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
```

```
  - /dev/sde
osd_scenario: lvm
osd_objectstore: bluestore
```

3. Run **openstack overcloud deploy** to update the overcloud.

> **NOTE**
>
> This example assumes that all hosts with OSDs have a new device called **/dev/sde**. If you do not want all nodes to have the new device, update the heat template as shown and see Section 6.3, “Mapping the Disk Layout to Non-Homogeneous Ceph Storage Nodes” for information about how to define hosts with a differing **devices** list.

11.4. REMOVING AN OSD FROM A CEPH STORAGE NODE

This procedure demonstrates how to remove an OSD from a node. It assumes the following about the environment:

- A server (**ceph-storage0**) has an OSD (**ceph-osd@4**) running on **/dev/sde**.
- The Ceph monitor service (**ceph-mon**) is running on **controller0**.
- There are enough available OSDs to ensure the storage cluster is not at its near-full ratio.

Procedure

1. SSH into **ceph-storage0** and log in as **root**.
2. Disable and stop the OSD service:

```
[root@ceph-storage0 ~]# systemctl disable ceph-osd@4
[root@ceph-stoarge0 ~]# systemctl stop ceph-osd@4
```

3. Disconnect from **ceph-storage0**.
4. SSH into **controller0** and log in as **root**.
5. Identify the name of the Ceph monitor container:

```
[root@controller0 ~]# docker ps | grep ceph-mon
ceph-mon-controller0
[root@controller0 ~]#
```

6. Enable the Ceph monitor container to mark the undesired OSD as **out**:

```
[root@controller0 ~]# docker exec ceph-mon-controller0 ceph osd out 4
```

> **NOTE**
>
> This command causes Ceph to rebalance the storage cluster and copy data to other OSDs in the cluster. The cluster temporarily leaves the **active+clean** state until rebalancing is complete.

7. Run the following command and wait for the storage cluster state to become **active+clean**:

```
[root@controller0 ~]# docker exec ceph-mon-controller0 ceph -w
```

8. Remove the OSD from the CRUSH map so that it no longer receives data:

```
[root@controller0 ~]# docker exec ceph-mon-controller0 ceph osd crush remove osd.4
```

9. Remove the OSD authentication key:

```
[root@controller0 ~]# docker exec ceph-mon-controller0 ceph auth del osd.4
```

10. Remove the OSD:

```
[root@controller0 ~]# docker exec ceph-mon-controller0 ceph osd rm 4
```

11. Disconnect from **controller0**.

12. SSH into the undercloud as the **stack** user and locate the heat environment file in which you defined the **CephAnsibleDisksConfig** parameter.

13. Notice the heat template contains four OSDs:

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
      - /dev/sde
    osd_scenario: lvm
    osd_objectstore: bluestore
```

14. Modify the template to remove **/dev/sde**.

```
parameter_defaults:
  CephAnsibleDisksConfig:
    devices:
      - /dev/sdb
      - /dev/sdc
      - /dev/sdd
    osd_scenario: lvm
    osd_objectstore: bluestore
```

15. Run **openstack overcloud deploy** to update the overcloud.

> **NOTE**
>
> This example assumes that you removed the **/dev/sde** device from all hosts with OSDs. If you do not remove the same device from all nodes, update the heat template as shown and see Section 6.3, “Mapping the Disk Layout to Non-Homogeneous Ceph Storage Nodes” for information about how to define hosts with a differing **devices** list.

11.5. HANDLING DISK FAILURE

If a disk fails, see Handling a Disk Failure in the Red Hat Ceph Storage *Operations Guide*.

APPENDIX A. SAMPLE ENVIRONMENT FILE: CREATING A CEPH CLUSTER

The following custom environment file uses many of the options described throughout Chapter 3, *Preparing Overcloud Nodes*. This sample does not include any commented-out options. For an overview on environment files, see Environment Files (from the Advanced Overcloud Customization guide).

/home/stack/templates/storage-config.yaml

```
parameter_defaults: (1)
  CinderBackupBackend: ceph (2)
  CephAnsibleDisksConfig: (3)
    osd_scenario: lvm
    osd_objectstore: bluestore
    dmcrypt: true
    devices:
      - /dev/disk/by-path/pci-0000:03:00.0-scsi-0:0:10:0
      - /dev/disk/by-path/pci-0000:03:00.0-scsi-0:0:11:0
      - /dev/nvme0n1
  ControllerCount: 3 (4)
  OvercloudControlFlavor: control
  ComputeCount: 3
  OvercloudComputeFlavor: compute
  CephStorageCount: 3
  OvercloudCephStorageFlavor: ceph-storage
  CephMonCount: 3
  OvercloudCephMonFlavor: ceph-mon
  CephMdsCount: 3
  OvercloudCephMdsFlavor: ceph-mds
  NeutronNetworkType: vxlan (5)
```

1. The **parameter_defaults** section modifies the default values for parameters in all templates. Most of the entries listed here are described in Chapter 5, *Customizing the Storage Service* .

2. If you are deploying the Ceph Object Gateway, you can use Ceph Object Storage (**ceph-rgw**) as a backup target. To configure this, set **CinderBackupBackend** to **swift**. See Section 5.2, "Enabling the Ceph Object Gateway" for details.

3. The **CephAnsibleDisksConfig** section defines a custom disk layout for deployments using BlueStore and Ceph 3.2 or later. For deployments using FileStore and Ceph 3.1 or earlier, modify **CephAnsibleDisksConfig** using the examples in described in Section 6.1, "Mapping the Ceph Storage Node Disk Layout".

> **WARNING**
>
> **osd_scenario: lvm** is used in the example to default new deployments to **bluestore** as configured by **ceph-volume**; this is only available with ceph-ansible 3.2 or later and Ceph Luminous or later. The parameters to support **filestore** with ceph-ansible 3.2 are backwards compatible. Therefore, in existing FileStore deployments, do not simply change the **osd_objectstore** or **osd_scenario** parameters.

4 For each role, the ***Count** parameters assign a number of nodes while the **Overcloud*Flavor** parameters assign a flavor. For example, **ControllerCount: 3** assigns 3 nodes to the Controller role, and **OvercloudControlFlavor: control** sets each of those roles to use the **control** flavor. See Section 8.1, "Assigning Nodes and Flavors to Roles" for details.

> **NOTE**
>
> The **CephMonCount**, **CephMdsCount**, **OvercloudCephMonFlavor**, and **OvercloudCephMdsFlavor** parameters (along with the **ceph-mon** and **ceph-mds** flavors) will only be valid if you created a custom **CephMON** and **CephMds** role, as described in Chapter 4, *Deploying Other Ceph Services on Dedicated Nodes* .

5 **NeutronNetworkType:** sets the network type that the **neutron** service should use (in this case, **vxlan**).

APPENDIX B. SAMPLE CUSTOM INTERFACE TEMPLATE: MULTIPLE BONDED INTERFACES

The following template is a customized version of **/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml**. It features multiple bonded interfaces to isolate back-end and front-end storage network traffic, along with redundancy for both connections (as described in]). It also uses custom bonding options (namely, **'mode=4 lacp_rate=1'**, as described in xref:multibonded-nics-ovs-opts[).

/usr/share/openstack-tripleo-heat-templates/network/config/bond-with-vlans/ceph-storage.yaml (custom)

```
heat_template_version: 2015-04-30

description: >
  Software Config to drive os-net-config with 2 bonded nics on a bridge
  with VLANs attached for the ceph storage role.

parameters:
  ControlPlaneIp:
    default: ''
    description: IP address/subnet on the ctlplane network
    type: string
  ExternalIpSubnet:
    default: ''
    description: IP address/subnet on the external network
    type: string
  InternalApiIpSubnet:
    default: ''
    description: IP address/subnet on the internal API network
    type: string
  StorageIpSubnet:
    default: ''
    description: IP address/subnet on the storage network
    type: string
  StorageMgmtIpSubnet:
    default: ''
    description: IP address/subnet on the storage mgmt network
    type: string
  TenantIpSubnet:
    default: ''
    description: IP address/subnet on the tenant network
    type: string
  ManagementIpSubnet: # Only populated when including environments/network-management.yaml
    default: ''
    description: IP address/subnet on the management network
    type: string
  BondInterfaceOvsOptions:
    default: 'mode=4 lacp_rate=1'
    description: The bonding_options string for the bond interface. Set
                 things like lacp=active and/or bond_mode=balance-slb
                 using this option.
    type: string
    constraints:
      - allowed_pattern: "^((?!balance.tcp).)*$"
```

```
      description: |
        The balance-tcp bond mode is known to cause packet loss and
        should not be used in BondInterfaceOvsOptions.
  ExternalNetworkVlanID:
    default: 10
    description: Vlan ID for the external network traffic.
    type: number
  InternalApiNetworkVlanID:
    default: 20
    description: Vlan ID for the internal_api network traffic.
    type: number
  StorageNetworkVlanID:
    default: 30
    description: Vlan ID for the storage network traffic.
    type: number
  StorageMgmtNetworkVlanID:
    default: 40
    description: Vlan ID for the storage mgmt network traffic.
    type: number
  TenantNetworkVlanID:
    default: 50
    description: Vlan ID for the tenant network traffic.
    type: number
  ManagementNetworkVlanID:
    default: 60
    description: Vlan ID for the management network traffic.
    type: number
  ControlPlaneSubnetCidr: # Override this via parameter_defaults
    default: '24'
    description: The subnet CIDR of the control plane network.
    type: string
  ControlPlaneDefaultRoute: # Override this via parameter_defaults
    description: The default route of the control plane network.
    type: string
  ExternalInterfaceDefaultRoute: # Not used by default in this template
    default: '10.0.0.1'
    description: The default route of the external network.
    type: string
  ManagementInterfaceDefaultRoute: # Commented out by default in this template
    default: unset
    description: The default route of the management network.
    type: string
  DnsServers: # Override this via parameter_defaults
    default: []
    description: A list of DNS servers (2 max for some implementations) that will be added to
resolv.conf.
    type: comma_delimited_list
  EC2MetadataIp: # Override this via parameter_defaults
    description: The IP address of the EC2 metadata server.
    type: string

resources:
  OsNetConfigImpl:
    type: OS::Heat::StructuredConfig
    properties:
      group: os-apply-config
```

```
config:
  os_net_config:
    network_config:
      -
        type: interface
        name: nic1
        use_dhcp: false
        dns_servers: {get_param: DnsServers}
        addresses:
          -
            ip_netmask:
              list_join:
                - '/'
                - - {get_param: ControlPlaneIp}
                  - {get_param: ControlPlaneSubnetCidr}
        routes:
          -
            ip_netmask: 169.254.169.254/32
            next_hop: {get_param: EC2MetadataIp}
          -
            default: true
            next_hop: {get_param: ControlPlaneDefaultRoute}
      -
        type: ovs_bridge
        name: br-bond
        members:
          -
            type: linux_bond
            name: bond1
            bonding_options: {get_param: BondInterfaceOvsOptions}
            members:
              -
                type: interface
                name: nic2
                primary: true
              -
                type: interface
                name: nic3
          -
            type: vlan
            device: bond1
            vlan_id: {get_param: StorageNetworkVlanID}
            addresses:
              -
                ip_netmask: {get_param: StorageIpSubnet}
      -
        type: ovs_bridge
        name: br-bond2
        members:
          -
            type: linux_bond
            name: bond2
            bonding_options: {get_param: BondInterfaceOvsOptions}
            members:
              -
                type: interface
```

```
                name: nic4
                primary: true
              -
                type: interface
                name: nic5
            -
              type: vlan
              device: bond1
              vlan_id: {get_param: StorageMgmtNetworkVlanID}
              addresses:
              -
                ip_netmask: {get_param: StorageMgmtIpSubnet}
outputs:
  OS::stack_id:
    description: The OsNetConfigImpl resource.
    value: {get_resource: OsNetConfigImpl}
```