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Fundamentals of OpenStack® Technology

Student guide (2 of 2)

H6C68S E.01

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Fundamentals of OpenStack® Technology
Student guide (1 of 2)
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Fundamentals of OpenStack® Technology
Module 9—OpenStack® Object Storage (Swift)
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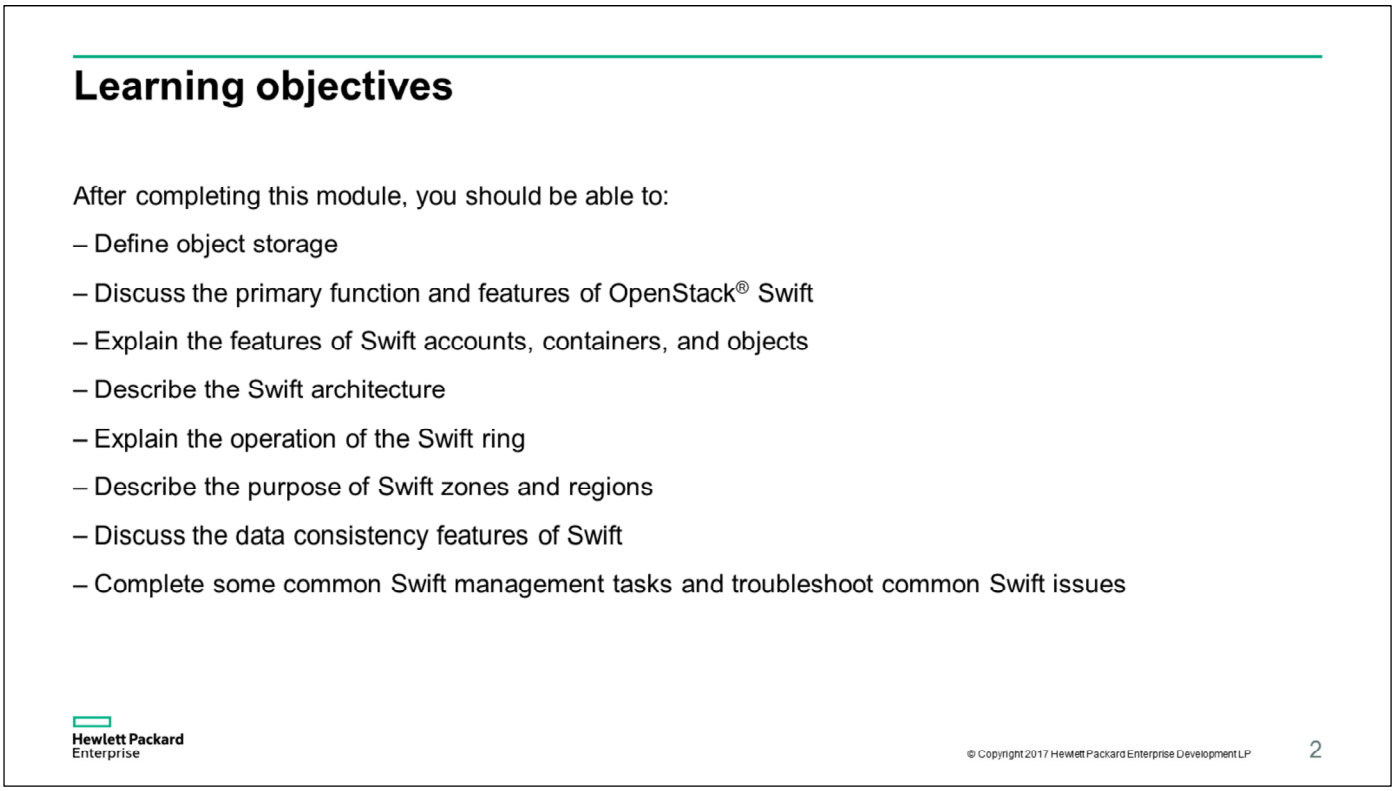

Learning objectives

After completing this module, you should be able to:

- Define object storage
- Discuss the primary function and features of OpenStack® Swift
- Explain the features of Swift accounts, containers, and objects
- Describe the Swift architecture
- Explain the operation of the Swift ring
- Describe the purpose of Swift zones and regions
- Discuss the data consistency features of Swift
- Complete the more common Swift management tasks and troubleshoot common Swift issues

Swift overview

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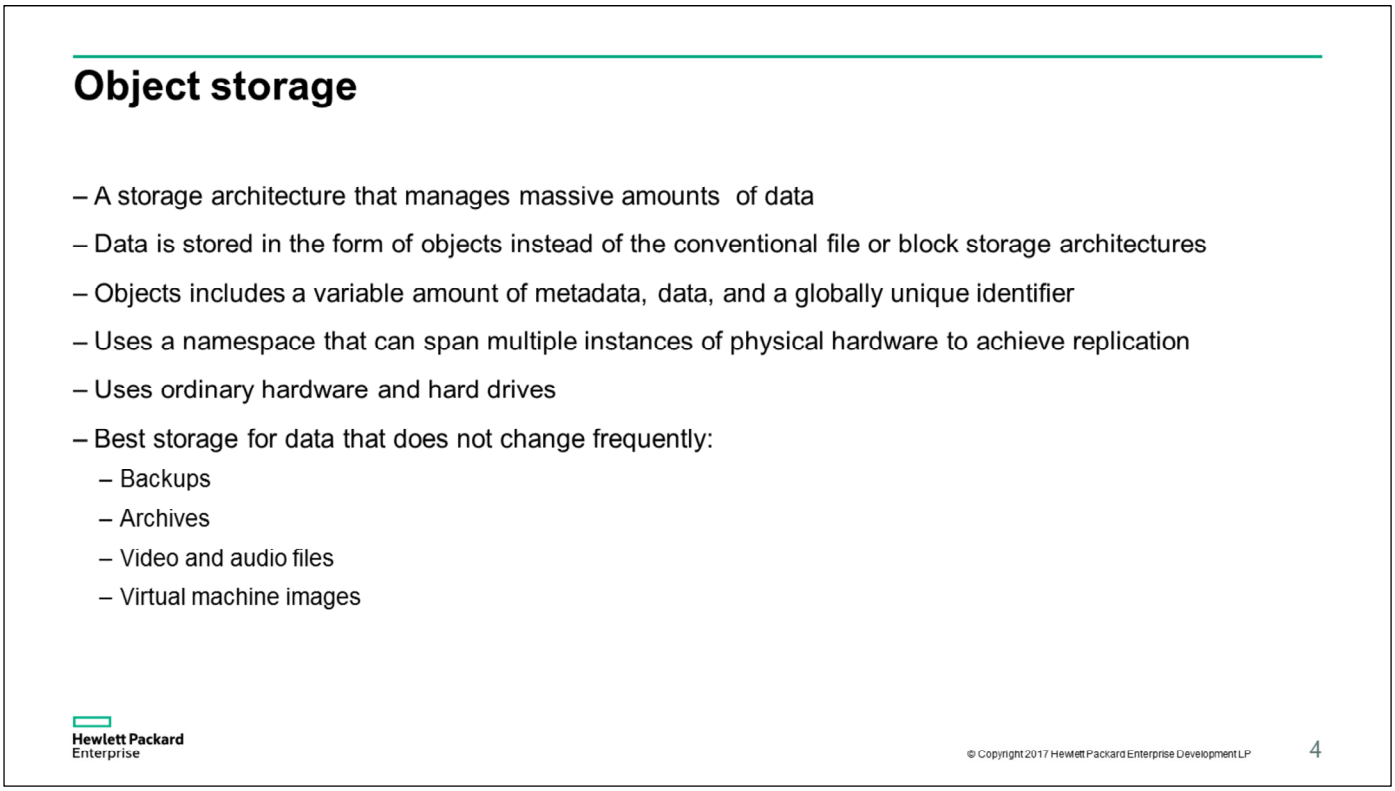


Object storage

Object storage is a storage architecture that manages massive amounts of data as objects instead of the conventional file or block storage architectures. Objects includes a variable amount of metadata, data, and a globally unique identifier.

Object storage uses a namespace that can span multiple instances of physical hardware, and data management functions like data replication and data distribution at object-level granularity. It provides relatively inexpensive, scalable, and self-healing retention of massive amounts of unstructured data.

Reliability is achieved on ordinary hardware and disk drives by replicating objects across multiple servers and locations. Object storage is unsuitable for data that changes frequently because data consistency is achieved only eventually, there may be a delay before a request returns the latest version of the data.

Object storage is the best storage for data that does not change much, like backups, archives, video and audio files, and virtual machine images.

Retrieving data from object storage takes more time than accessing a file from NAS. In addition to having significantly slower throughput than a traditional file system, the other big drawback of object storage is that data consistency is achieved only eventually. Whenever you update a file, you might have to wait until the change is propagated to all of the replicas before requests return the latest version. This makes object storage unsuitable for data that changes frequently.

“Unstructured data store” refers to a storage that stores bits. Object storage stores BLOBs (Binary Large Object) of data.

Swift functions and features

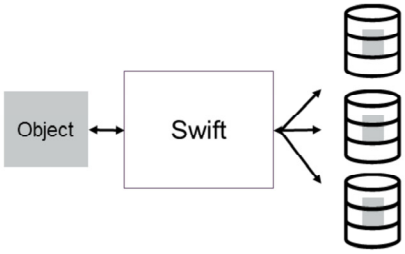
Reliably store billions of objects distributed across standard hardware

General features

- Allows you to store and retrieve data objects by URL over any IP network
- Does not use a conventional file system
- Data is distributed evenly throughout the system
- Account, container, and object structure
- No central database
- Accessed with a RESTful API
- Provides data redundancy (at least 3 replicas)
- Auditors to check staleness of data
- Eventual consistency

Hardware features

- Runs on commodity hardware
- Hardware-agnostic (no need for RAID)
- Supports multi-tenancy
- Augments SAN/NAS/DAS
- Optimized for scaling to zettabytes



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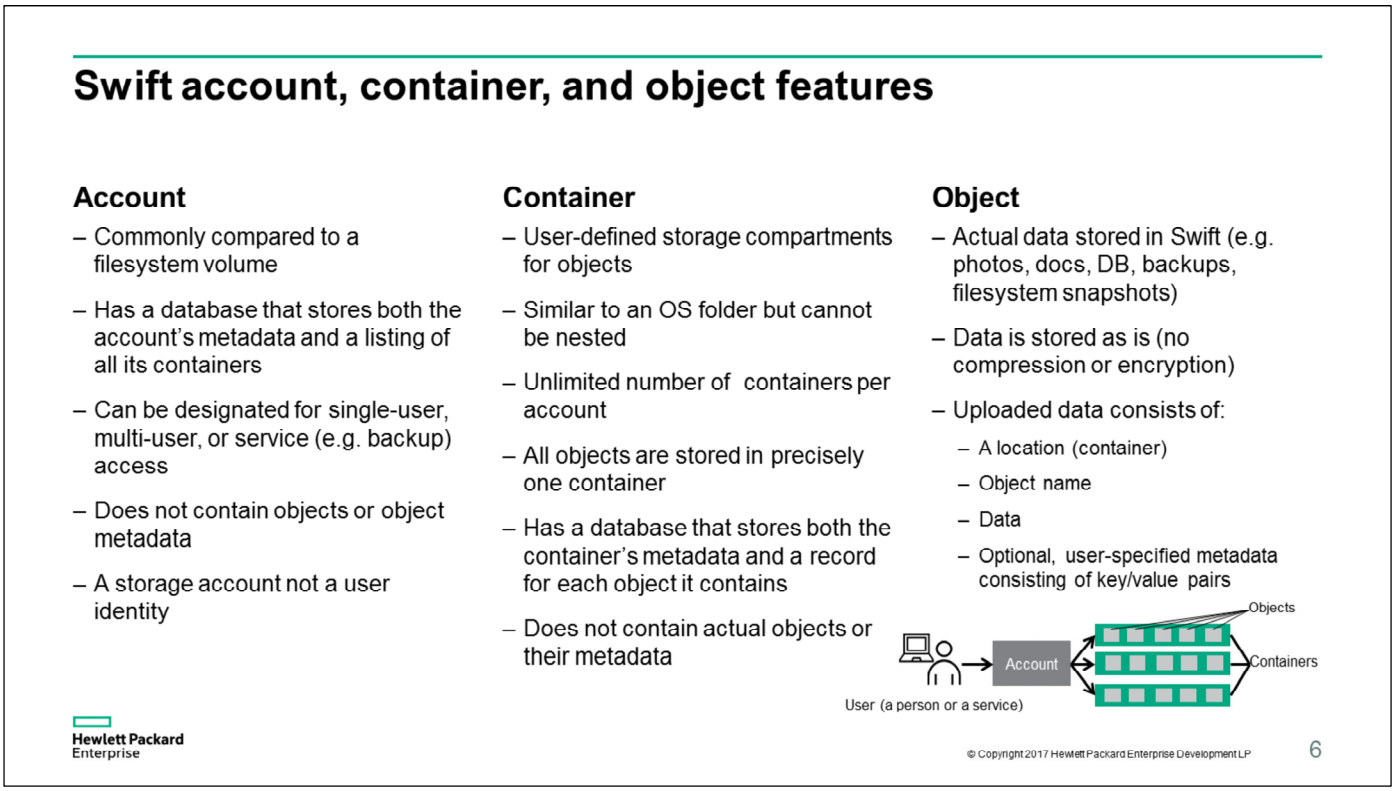
Swift functions and features—Reliably store billions of objects distributed across standard hardware

Swift is open source software used for managing scalable data storage using clusters of commodity hardware to store large amounts of data. Swift uses a distributed architecture to provide scalability and redundancy. Internally, Swift writes objects to multiple hardware devices (called “nodes”), and Swift ensures data replication and integrity across the cluster. Since Swift manages the replication and distribution of objects across different devices, inexpensive commodity hard drives and servers can be used.

Swift achieves high scalability by relaxing constraints on consistency. Listings and aggregate metadata (like usage information) might not be immediately accurate. Similarly, reading an object that has been overwritten with new data may return an older version of the object data. Swift provides the ability for the client to request the most up-to-date version at the cost of request latency.

Upgrades and cluster resizes can be easily performed on a production cluster with zero end-user downtime. Swift provides both forward and backwards compatibility of its API, so a Swift cluster can be running multiple versions of the Swift software at the same time, as is common while the software is being upgraded. During the process of resizing, the incongruent data about where data lives is simply seen as a failure and the replication process ensures that the data will be moved to its correct location.



Swift account, container, and object features

Swift manages mapping between the names of entities stored on disk and their physical location using entity called "the ring." There are separate rings for accounts, containers, and one object ring per storage policy. When other components need to perform any operation on an object, container, or account, they need to interact with the appropriate ring to determine its location in the cluster.

An account organizes and stores objects in object storage. It is similar to the concept of a Linux directory, but it cannot be nested.

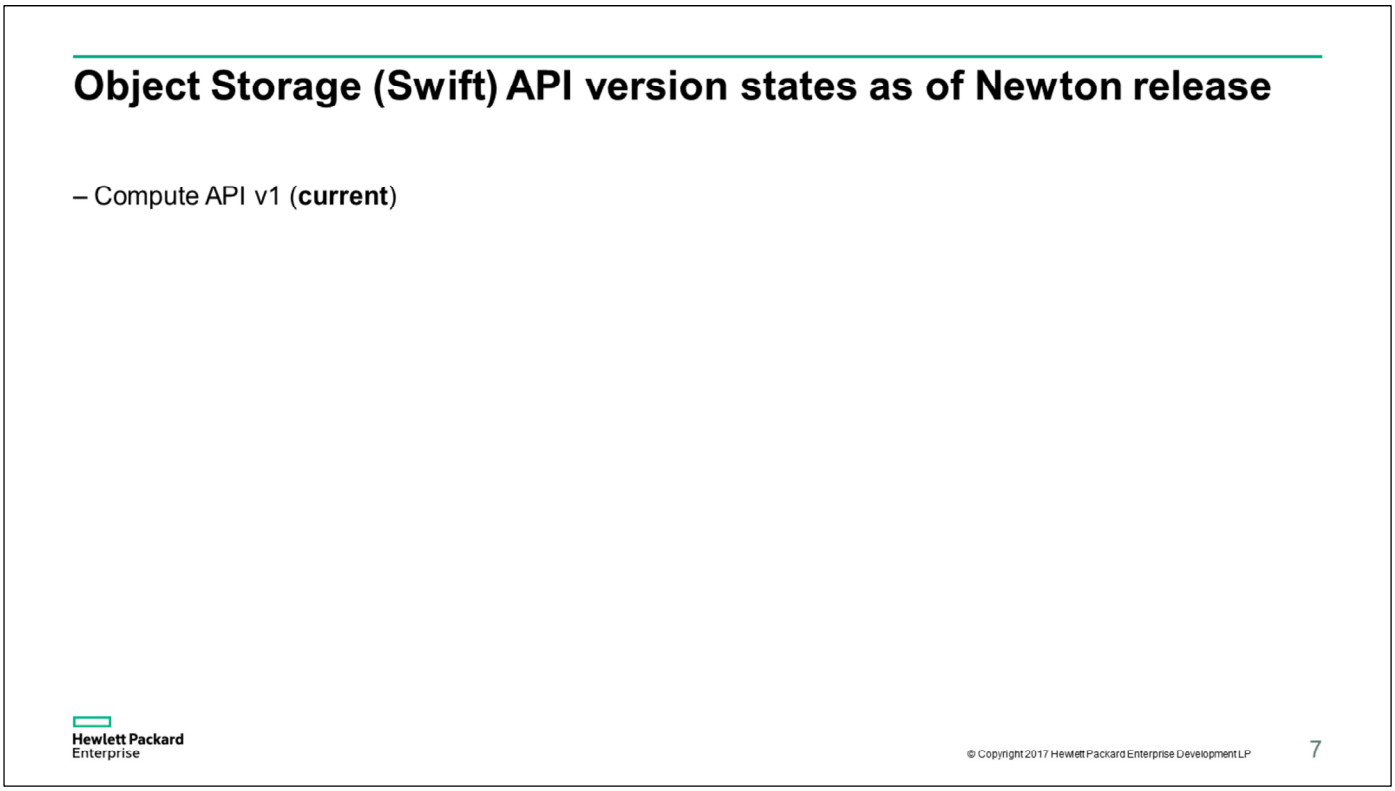
A container is a storage compartment for your objects and provides a way for you to organize your objects. Containers cannot be nested. You can, however, create an unlimited number of containers within your account. Data must be stored in a container, so you must have at least one container defined in your account prior to uploading data. When it comes to container names, the only restriction is that they cannot contain a forward slash (/) and must be less than 256 bytes in length. The length restriction applies to the name after it has been URL-encoded. For example, a container name of "Course Docs" would be URL-encoded as `Course%20Docs`. Therefore, it would be 13 bytes in length rather than the expected 11.

An object is the basic storage entity and any optional metadata that represents a file you store in Swift. When you upload data to OpenStack® Object Storage, that data is stored as is (no compression or encryption) and consists of a location (container), the object's name, and any metadata consisting of key/value pairs. For example, you can chose to store a backup of your favorite OpenStack® training course and organize it into folders. In this case, each object could be tagged with metadata such as ILT: OpenStack® Fundamentals, ILT: OpenStack® Networking.

The maximum allowable size for a storage object upon upload is 5 gigabytes (GB) and the minimum is zero bytes. You can use the built-in large object support and the Swift utility to retrieve objects larger than 5GB.

In summary:

- Each object is stored in a container.
- One or more containers can be owned by an account.
- Each object is identified by its account, container, and object ID.



Storage (Swift) API version states as of Newton release

OpenStack® Object Storage API v1 is in current state for the Newton release. There are no release notes available for object storage in Newton release.

Swift architecture

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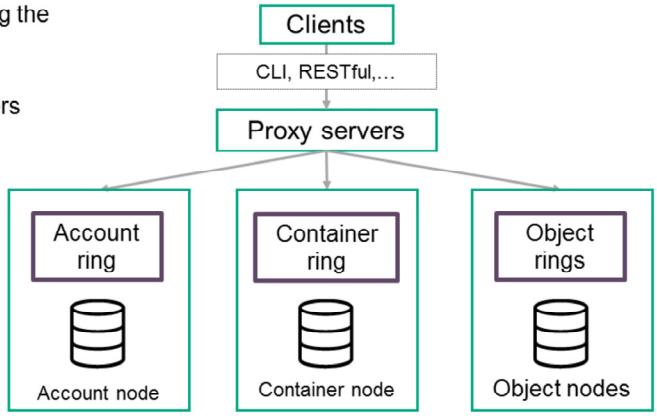
Swift architecture

- **A Swift cluster** is a group of nodes (systems) running the full set of processes and services need to act as a distributed storage system
- **An account ring** is responsible for listing of containers
- **A container ring**:
  - Is a directory of the containers the objects belong to
  - Tracks statistics on objects
- **Proxy servers**:
  - Coordinate the read-write requests from clients
  - Implement the read-write guarantees of the systems
  - Do not cache objects (proxy them directly)
  - Are CPU- and network I/O-intensive
- **An object ring** is a directory containing the list of storage drives that are used to store specific objects and their associated metadata



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Swift architecture

The Swift architecture is well-distributed to prevent any single point of failure as well as to scale horizontally. It includes the following components:

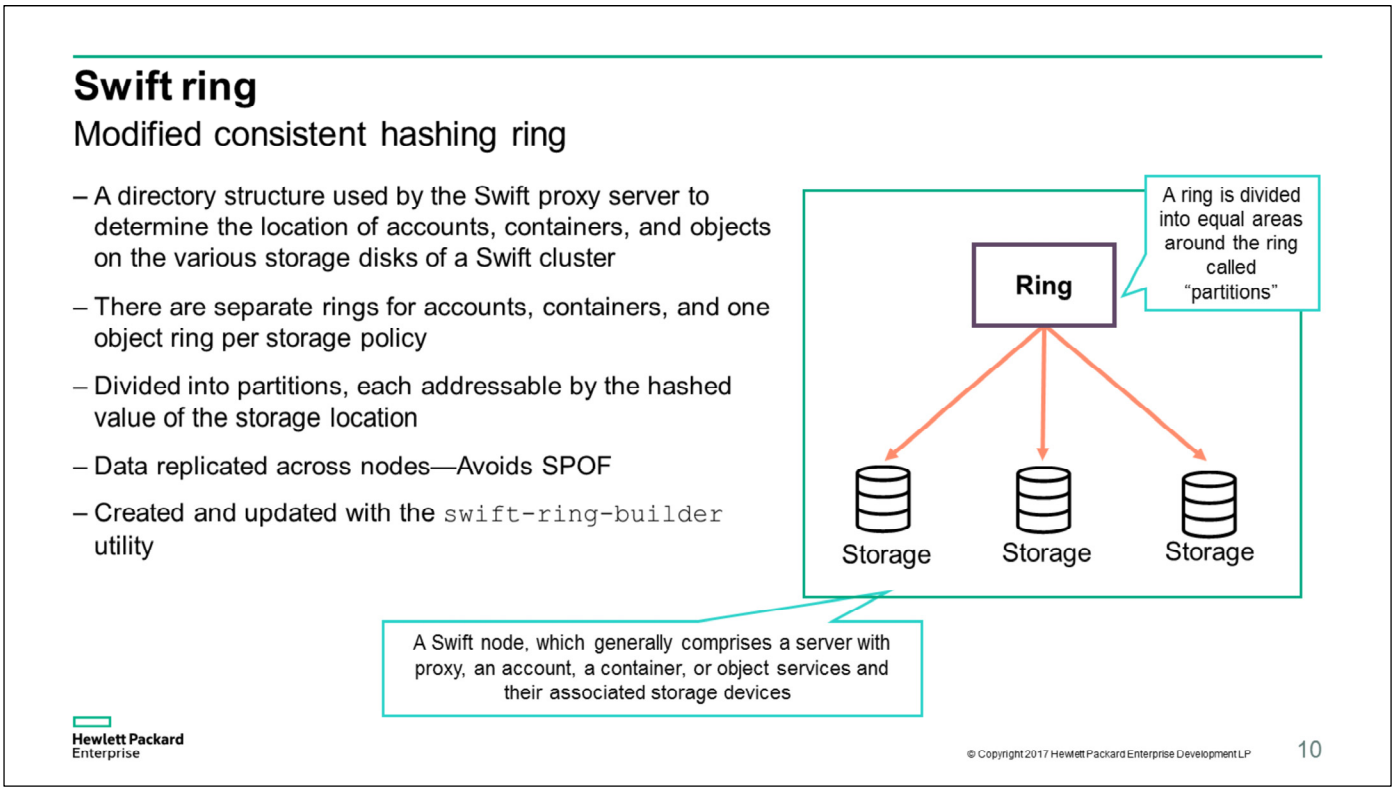
- **Proxy server** (`swift-proxy-server`) accepts incoming requests through the OpenStack® Object API or just raw HTTP. It accepts files to upload, modifications to metadata, or container creation. In addition, it serves files or container listing to web browsers. The proxy server can use an optional cache (usually deployed with memcache) to improve performance.
- **Account servers** manage accounts defined with the Object Storage service.
- **Container servers** manage a mapping of containers (folders) within the Object Storage service.
- **Object servers** manage actual objects (files) on the storage nodes.

Several periodic processes perform housekeeping tasks on the large data store. The most important of these are the replication services, which ensure consistency and availability through the cluster. Other periodic processes include auditors, updaters, and reapers.

Authentication is handled through configurable WSGI middleware (which is usually Keystone). The proxy server is responsible for tying together the rest of the OpenStack® Object Storage architecture. For each request, it looks up the location of the account, container, or object in the hash ring (see below) and routes the request accordingly. The public API is also exposed through the proxy server.

The object server is a very simple BLOB storage server that can store, retrieve, and delete objects stored on local devices. Objects are stored as binary files on the file system with metadata stored in the file's extended attributes (xattrs). This requires that the underlying file system choice for object servers support xattrs on files. Some file systems, like ext3, have xattrs turned off by default.

Each object is stored using a path derived from the object name's hash and the operation's timestamp. Last write always wins and ensures that the latest object version will be served. A deletion is also treated as a version of the file (a 0 byte file ending with ".ts," which stands for "tombstone"). This ensures that deleted files are replicated correctly and older versions do not reappear in failure scenarios.



Swift ring—Modified consistent hashing ring

A ring represents a mapping between the names of entities stored on disk and their physical location. A ring maintains this mapping using zones, devices, partitions, and replicas. Each partition in the ring is replicated, by default, 3 times across the cluster, and the locations for a partition are stored in the mapping maintained by the ring. The partitions of the ring are equally divided among all the devices in the Swift installation.

Swift ring determines where data should reside in the cluster. It maintains this mapping using zones, devices, partitions, and replicas. A copy of the ring should reside on every node of the cluster.

Rings are statically built and assigned as part of post installation tasks. They use a gzipped data structure. There are separate rings for account databases, container databases, and objects.

When it comes to ring management, remember that servers do not modify the rings—they are externally managed. Also, they are built and managed by the `ring-builder` utility.

Swift ring partition

- A Swift ring partition:
  - Is a segment of the Swift ring that indicates the storage systems storing the account, container, or object data
  - Maps to multiple storage drives, each of which are used to store the account, container, or object data written to it
  - Is a section of address space, not disk space
  - Is not related to the partitioning of a hard drive
- A ring is evenly divided into partitions during the ring creation process
- Number of partitions is determined by 2n, where n = partition power
  - For example, if n = 10, there would be 1024 partitions created on the ring
- Each partition has the following info for each replica's storage device:
  - Zone
  - Weight
  - IP address of the server containing the device
  - The TCP port the server listens on for device requests
  - Device ID
  - Metadata info

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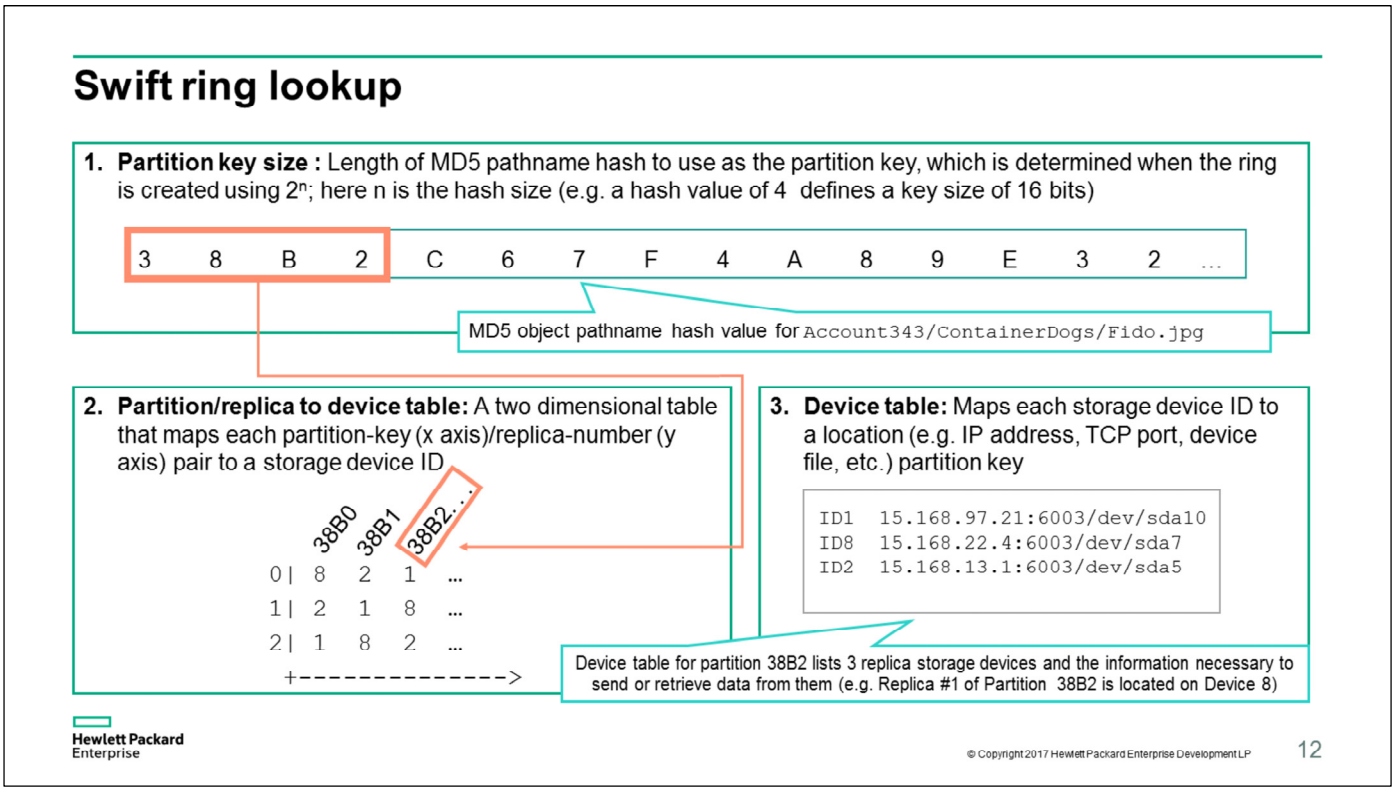
Swift ring partition

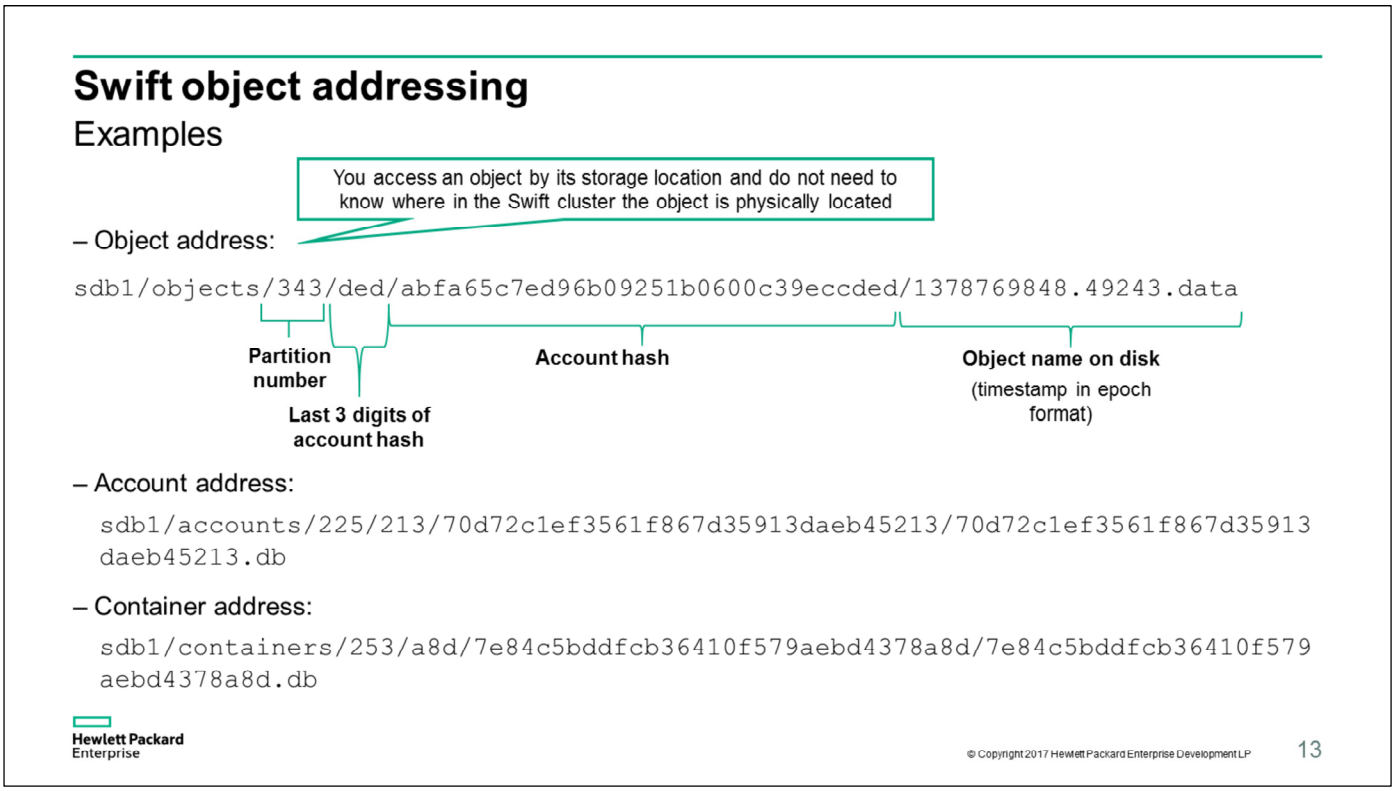
The partitions of the ring are equally divided among all the devices in the Swift installation. When you need to move partitions around (for example, if a device is added to the cluster), the ring ensures that a minimum number of partitions are moved at a time, and only one replica of a partition is moved at a time.

Weights can be used to balance the distribution of partitions on drives across the cluster. This can be useful, for example, when different-sized drives are used in a cluster.



Swift ring lookup

The ring uses a configurable number of bits from a path's MD5 hash as a partition key that designates a set of devices (based on the replication factor). The number of bits kept from the hash is the partition key length.



Swift object addressing

Swift uses the underlying file system to store data on disk. An administrator can use usual file system tools to find and inspect this data. Swift uses the following convention for storing objects:

`/path_to_mount_points/device/objects/partition/hash_suffix/hash/`

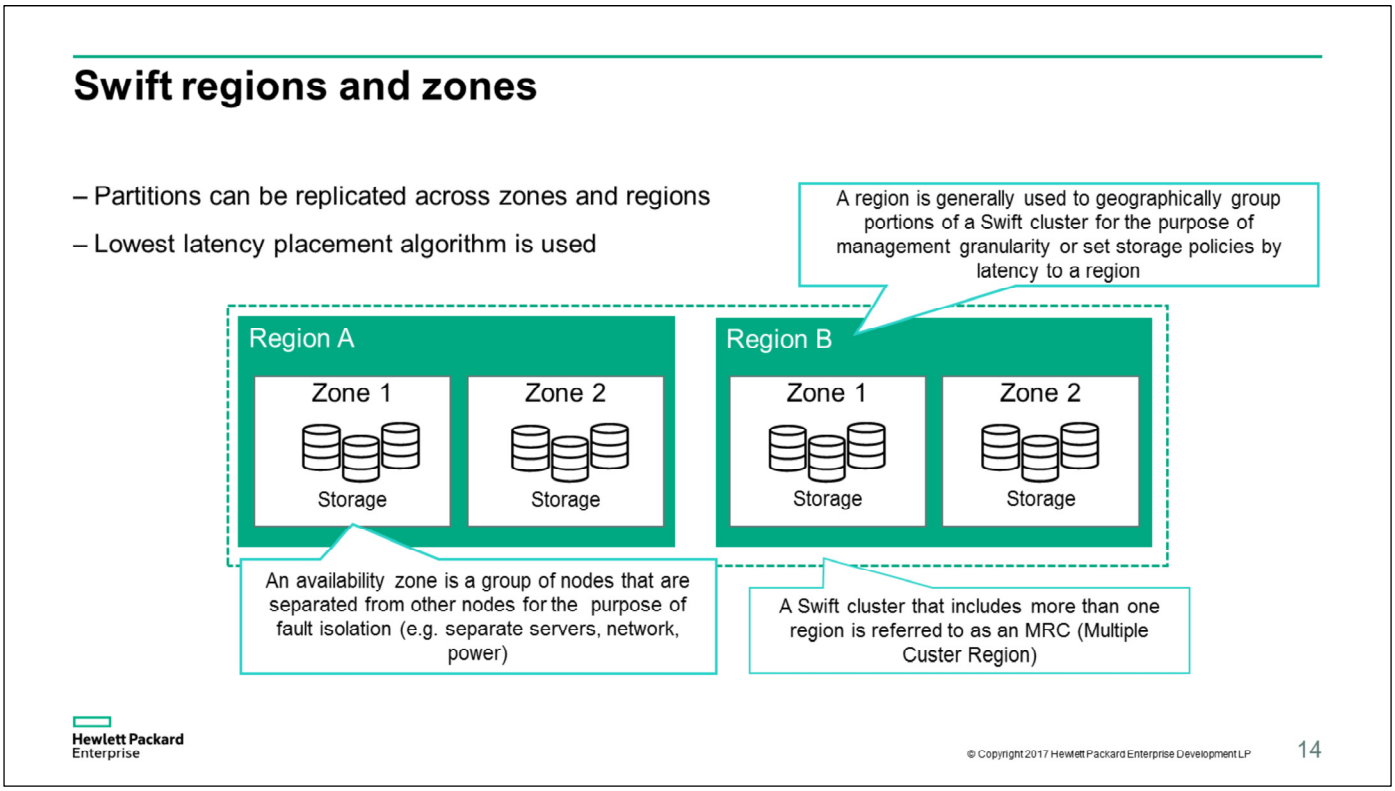
Accounts and containers are stored similarly, with the `objects` part of the path replaced with `accounts` or `containers`.

The directory is where all data for the object is stored. Inside the directory, there is usually just one file (named `<timestamp>.data`). The object data is stored in the file, and the object metadata is stored in the extended attributes (xattrs) of the file.

If you delete the object, the `.data` file is deleted and a `<timestamp>.ts` ("ts" stands for "tombstone") file is created as a zero-byte file. This is a delete marker that will be eventually reaped, but it exists to ensure that the delete properly propagates to all replicas in the cluster.

Swift uses this scheme of timestamps in the file name to implement conflict resolution. Each piece of data is assigned a timestamp by the proxy server when the request comes to the cluster, and that timestamp is used to name the file on disk on the object (or account or container) server. Usually, there will be a single file in the directory. If Swift receives multiple, concurrent requests to write to the same object, multiple `.data` files can be written to this directory. Swift uses a “last-write-wins” policy to resolve such conflicts, choosing the most recent file by timestamp.

Here is a full DevStack path example:
`/opt/stack/data/swift/1/sdb1/objects/343/ded/abfa65c7ed96b09251b0600c39eccded/1378769848.49243.data`



Swift regions and zones

A zone is a set of distinct storage hardware isolated from other zones. This provides fault isolation. A zone is a group of nodes that is as isolated as much as possible from other nodes (separate servers, network, power, and even geography). The ring guarantees that every replica is stored in a separate zone.

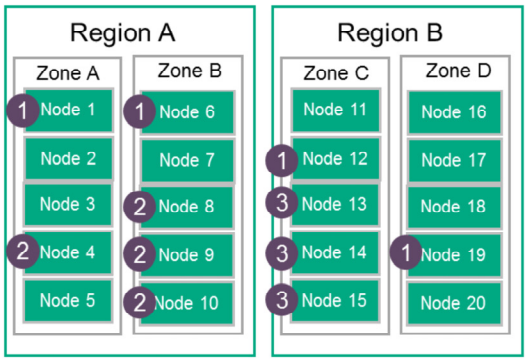
A region is a portion of the cluster that is typically located remotely from the data center. This allows for management of higher latency copies of partitions.

The combination of Swift pieces allows a Swift cluster to be highly fault-tolerant.

Availability zones within a single geographic region enable data to be written to hand-off nodes, if primary nodes in that zone are not available.

Swift is able to successfully survive hardware failures, including the loss of an entire availability zone with no impact to the end user.

Swift storage policies



1 Storage policy 1 (distributed across multiple regions)

2 Storage policy 2 (distributed across a single region)

3 Storage policy 3 (distributed across fast media (e.g. SSDs)

- Enable Swift operators to define storage space with a cluster-based, specific data storage requirements, such as:
  - Location
  - Replication
  - Hardware
- Set at the object level and implemented at the container level
- Use cases:
  - Distribute data across multiple regions
  - Distribute replicas across a lower latency region
  - Ensure that faster disk technology drive (e.g. SSD) is used for specific type of data

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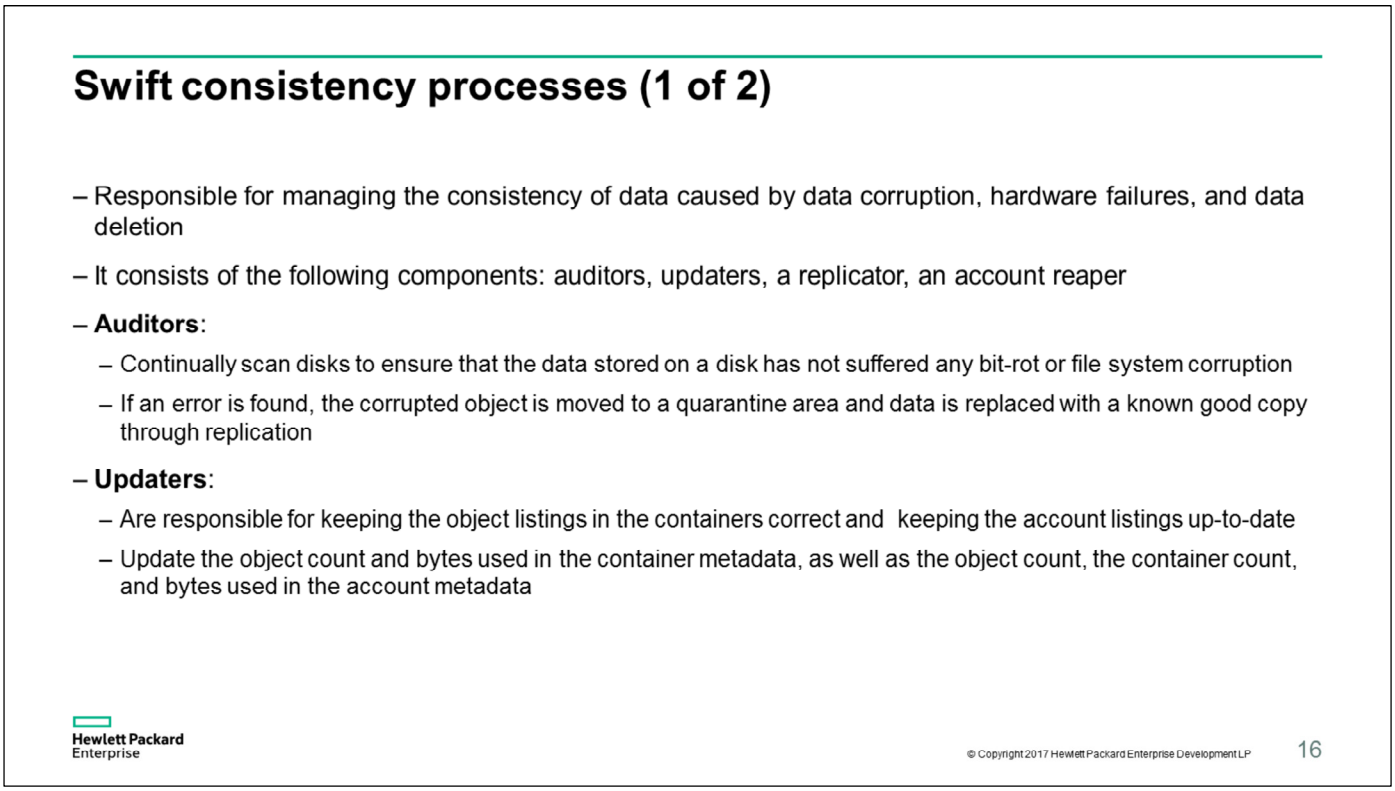
Swift storage policies

Storage policies let Swift operators define space within a cluster that can be customized in numerous ways, that is, by location, replication, hardware, and partitions, to meet specific data storage needs.

To implement storage polices, you must create them in the cluster and then apply them to containers. Creating user-defined storage policies is a two-step process:

1. The policies are declared in the `swift.conf` file with a name and an index number.
2. The policies' index number is used to create the corresponding builder files and rings.

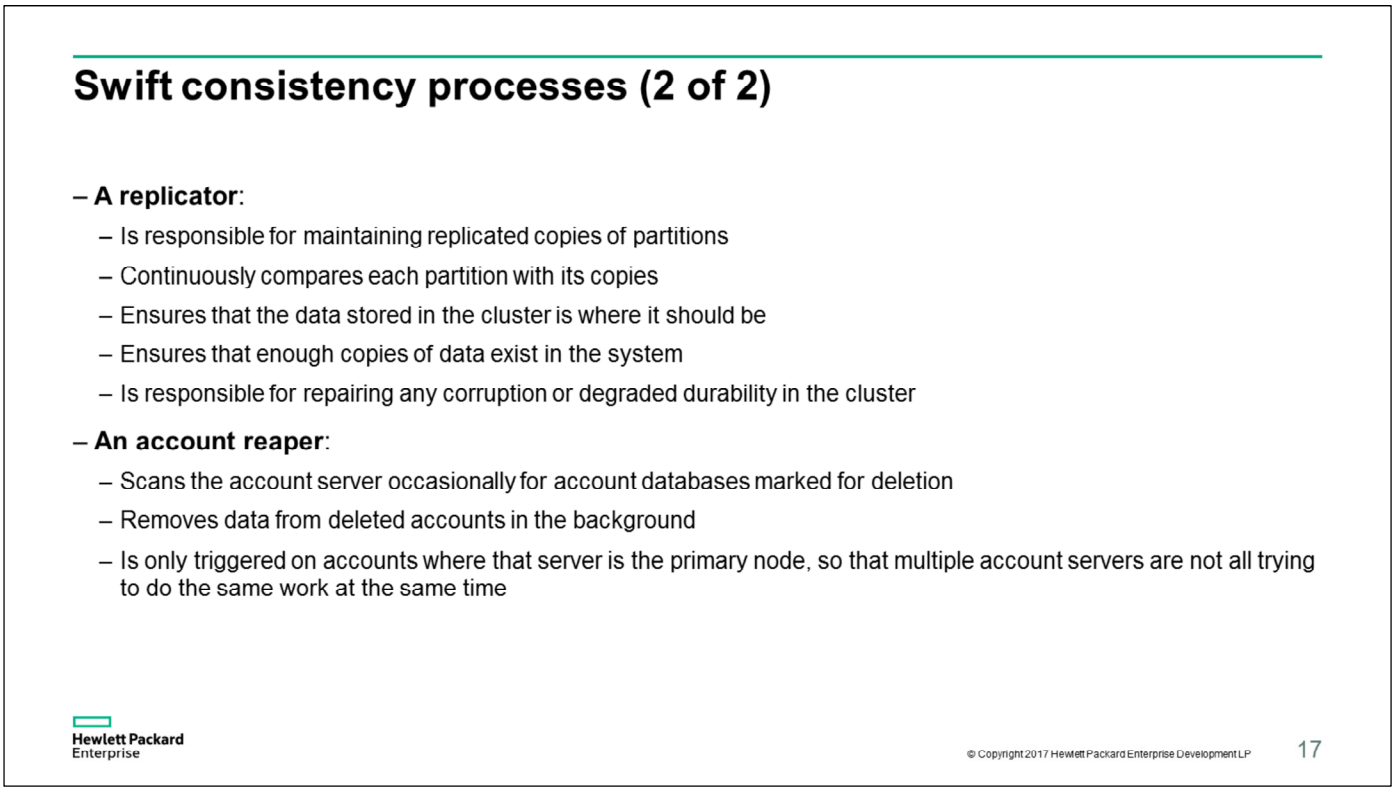
Swift defaults to an internally referenced storage policy 0, which is applied to all containers. There is always a minimum of one storage policy per cluster as a result. In addition to being the system default, this storage policy 0, named "Policy-0" allows for backward compatibility with clusters created before the storage policies feature was added to Swift.



Swift consistency processes (1 of 2)

Several periodic processes perform housekeeping tasks on a large data store:

- **Auditors** crawl the local server checking the integrity of the objects, containers, and accounts. If corruption is found, the file is quarantined, and replication replaces the bad file from another replica. If other errors are found, they are logged (for example, when an object's listing cannot be found on any container server).
- **Updaters** update container and account data. The storing of data and the creation of an object listing are two different things. There are times when such data cannot be immediately updated, such as during a failure or a period of high load (for example, if a container server is under load and a new object is put into the system). The object is immediately available for reads as soon as the proxy server responds to the client with success. However, the container server does not update the object listing, and so the update is queued for a later update. Container listings, therefore, might not immediately contain the object.



Swift consistency processes (2 of 2)

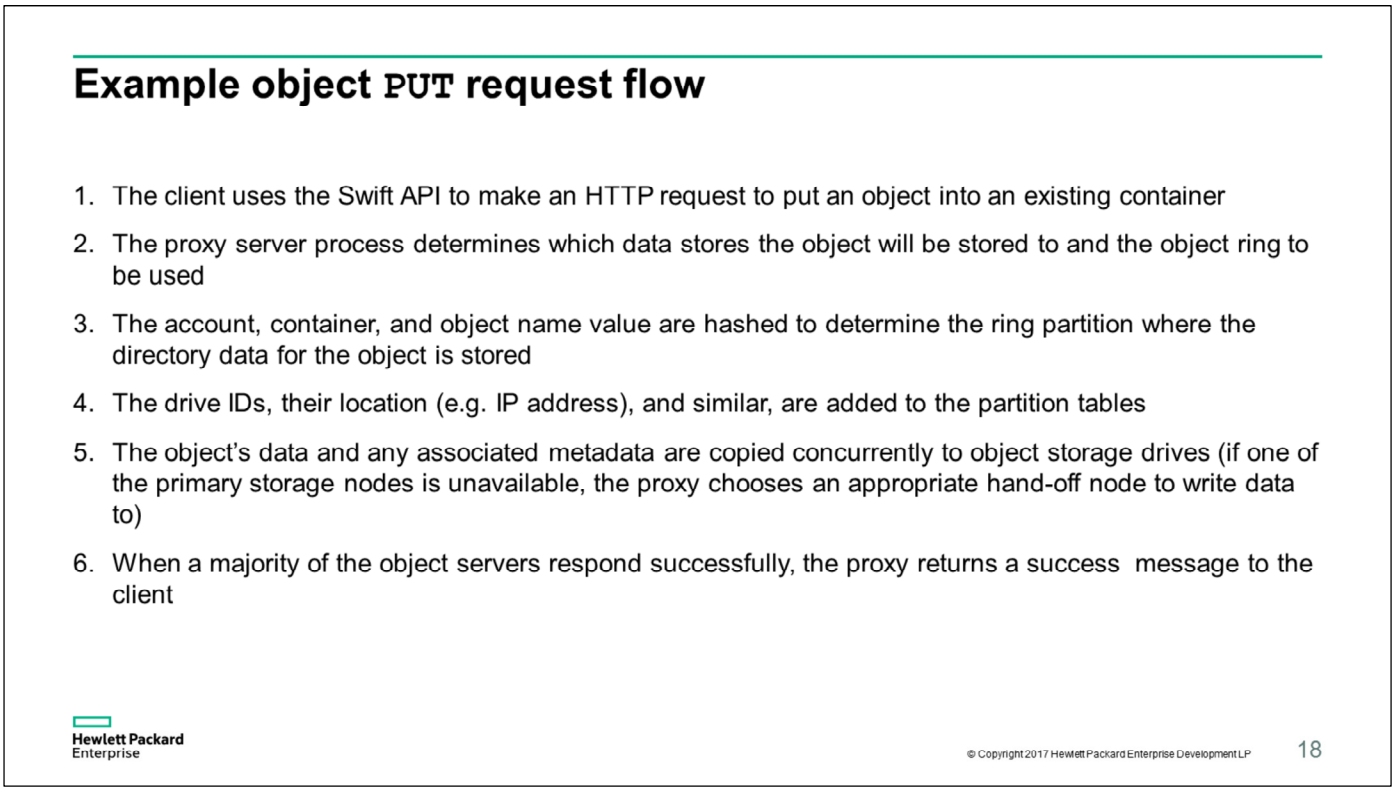
A replicator is designed to keep the system in a consistent state in the face of temporary error conditions like network outages or drive failures. The replication processes compare local data with each remote copy to ensure that they all contain the latest version. Object replication uses a hash list to quickly compare subsections of each partition, and container and account replication uses a combination of hashes and shared high water marks.

A replicator also ensures that data is removed from the system. When an item (an object, a container, or an account) is deleted, a tombstone is set as the latest version of the item. The replicator sees the tombstone and ensures that the item is removed from the entire system.

The account reaper removes data from deleted accounts in the background. The account reaper runs on each account server and occasionally scans the server for account databases marked for deletion. It only triggers on accounts that the server is the primary node for.

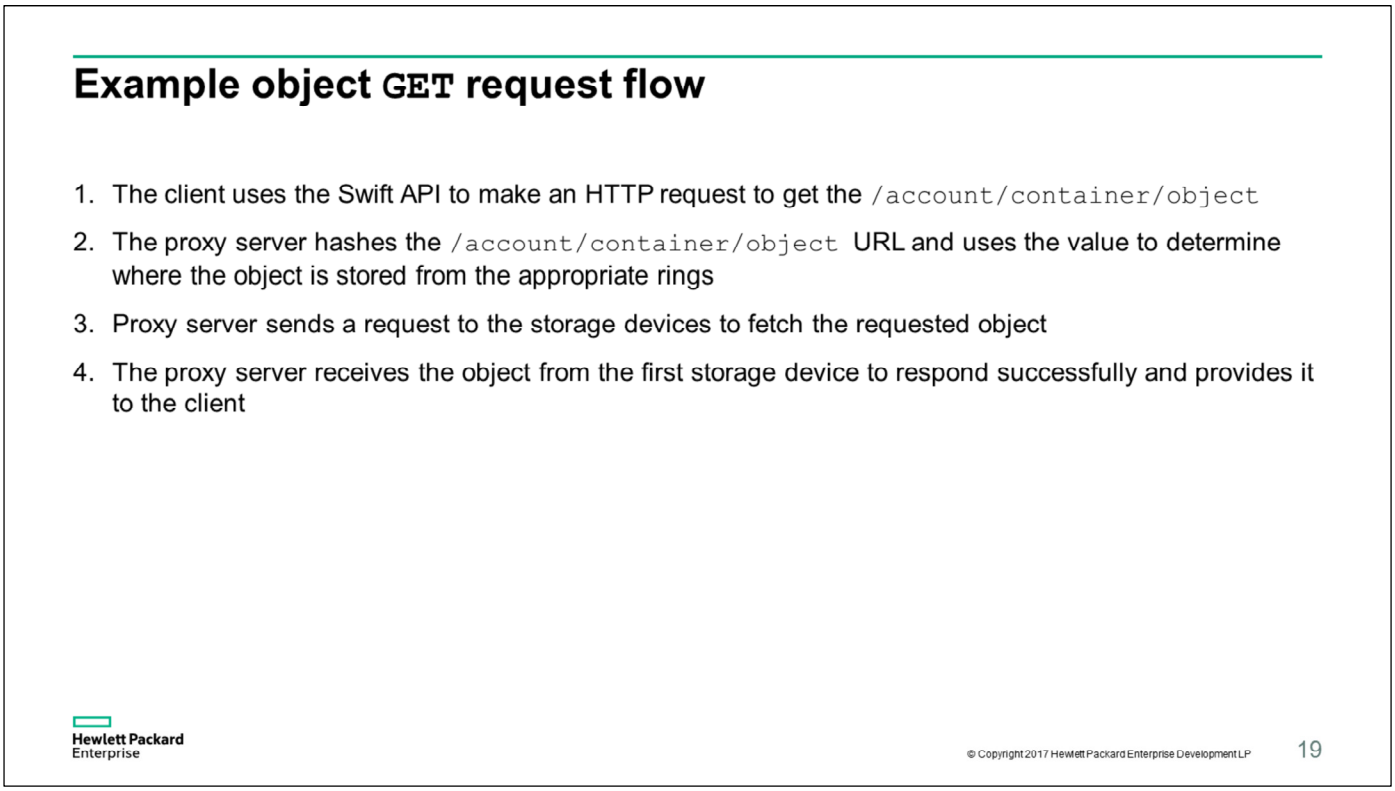
An account is marked for deletion by entering a `DELETE` request on the account's storage URL. This puts the value `DELETED` into the status column of the `account_stat` table in the account database (and replicas), indicating the data for the account should be deleted.

The deletion process for an account itself is straightforward. For each container in the account, first each object is deleted and then the container is deleted. Any deletion request that fails does not stop the overall process, but it causes the overall process to fail eventually (for example, if an object delete times out, the container is not able to be deleted later, and therefore, the account is not deleted either). The overall process continues even on a failure so that it doesn't get hung up reclaiming cluster space because of one troublesome spot. The account reaper repeatedly tries to delete an account, until it eventually becomes empty, at which point the database reclaim process within the `db_replicator` eventually removes the database files.



Example object `PUT` request flow

Six steps on the slide above describe the example object `PUT` request flow. `PUT` requests are used to store data in the Swift cluster.

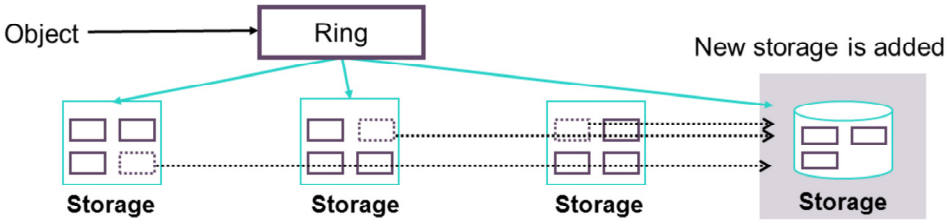


Example object `GET` request flow

Four steps on the slide above describe the example object `GET` request flow. `GET` requests are used to retrieve data from the Swift cluster.

Adding storage in a ring

- Swift Rings are manually constructed by administrators based on the Swift configuration desired
- When new storage is added, the ring tables must be updated and partitions must be redistributed across all available storage
  - `$ swift-ring-builder <builder_file> add z<zone>- <ip>:<port>/<device_name>_<meta> <weight>`
  - `$ swift-ring-builder <builder_file> rebalance`
- Once the administrator has installed new ring files, Swift carries out the partition redistribution



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Adding storage in a ring

Whenever you add additional hardware to Swift, it automatically redistributes partitions, so that the load is balanced across all arrays.

The OpenStack® administration documents recommend that there be a minimum of 100 partitions per drive to ensure even distribution across the drives. A good starting point might be to figure out the maximum number of drives the cluster will contain, multiply by 100, and then round up to the nearest power of two (partition key sizes are always a power of 2).

It is also recommended to keep the number of partitions small (relatively). The more partitions there are, the more work has to be done by the replicators and other backend jobs and the more memory the rings consume.

Configuring five zones and a replication factor of three are also well-tested recommendations.

In the example on the slide above, the `<builder_file>` is the name of the original ring builder file created, `<zone>` is the number of the zone this device is in, `<ip>` is the IP address of the server the device is in, `<port>` is the port number that the server is running on, `<device_name>` is the name of the device on the server (for example: `sdb1`), `<meta>` is a string of metadata for the device (optional), and `<weight>` is a float weight that determines how many partitions are put on the device relative to the rest of the devices in the cluster (for example, 100 times the number of TB on the drive).

Common Swift management tasks

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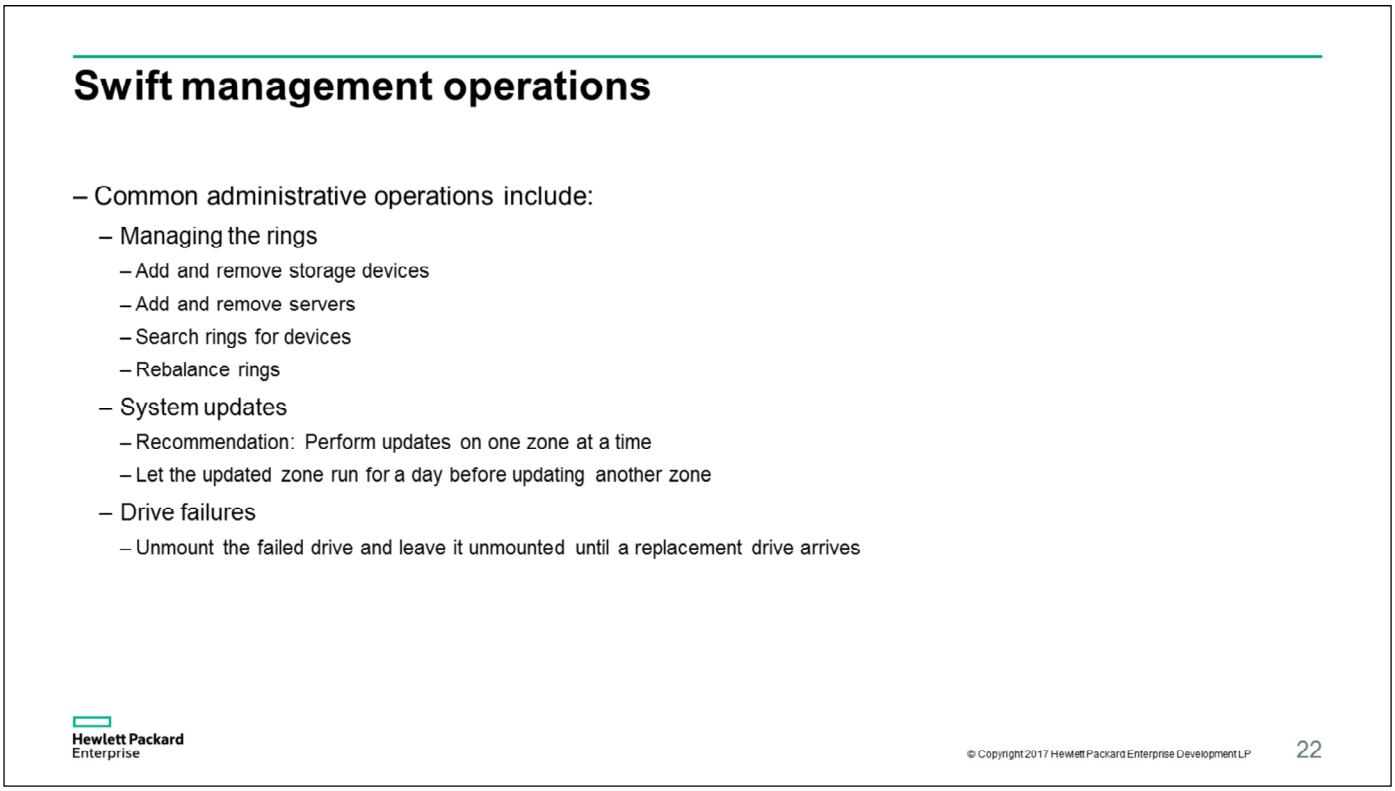

Swift management operations

You can build the storage rings on any server with the appropriate version of Swift installed. When storage rings are built or changed (rebalanced), you must distribute the rings to all the servers in the cluster. Storage rings contain information about all the Swift storage partitions and how they are distributed between the different nodes and disks.

System updates

It is recommended that system updates and reboots be performed on one zone at a time. This enables the Swift cluster to stay available and responsive to requests. After updating a zone, let it run for a while before updating another zone to ensure that it is operating properly.

Drive failures

In the event that a drive has failed, the first step is to make sure the drive is unmounted. This makes it easier for Swift to work around the failure until it has been resolved.

If the drive will be replaced immediately, then it is best to replace the drive, format it, remount it, and let replication fill it up.

If the drive cannot be replaced immediately, then it is best to leave it unmounted and remove the drive from the ring. This allows all the replicas that were on that drive to be replicated elsewhere until the drive is replaced. After the drive is replaced, it can be re-added to the ring.

CRUD (`create`, `read`, `update`, `delete`) operations

Four basic functions of persistent storage

Operation	Command
Post (create or update)	`swift post container1`
Upload	`swift upload container1 exercise.sh`
Download	`swift download container1 exercise.sh`
Delete	`swift delete container1 exercise.sh`
List	`swift list` `swift list container1`

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CRUD (`create`, `read`, `update`, `delete`) operations—Four basic functions of persistent storage

Use the Swift CLI client to perform common `create`, `read`, `update`, and `delete` (CRUD) operations:

- Use `swift post` to create a specified container. You must create a container before you can store objects.
- Use `swift upload` to upload an object in your file system and store it in a specified container.
- Use `swift download` to download a specific object from a specific container. To determine what containers exist and what objects are in a container:
  - Enter `swift list` to list all containers
  - Enter `swift list <container>` to list the contents of a container

Sample API PUT of an object

– Get a token (account was already created):

```
curl -i -X POST http://10.0.2.15:5000/v2.0/tokens \
-H "Content-Type: application/json" \
-d '{"auth": {"tenantName": "admin", \
"passwordCredentials": {"username": "admin", "password": "xxxxxx"}}}'
```

– Set the value of `myToken=<returned token>`

– Run `swift stat -v` to obtain the account ID (`AUTH_xxxx`)

– Create a container:

```
curl -i http://10.0.2.15:8080/v1/AUTH_d7cf0245512540b99fb2c917\
ec3ee3e6/container1 -X PUT -H "X-Auth-Token: $myToken"
```

– Put the object:

```
curl  -X PUT -H "x-auth-token: $myToken" -d  @test_file \
https://region-a.geo-1.objects.somecloudsvc.com/v1.0/48666127952678\
/test_container/object1
```

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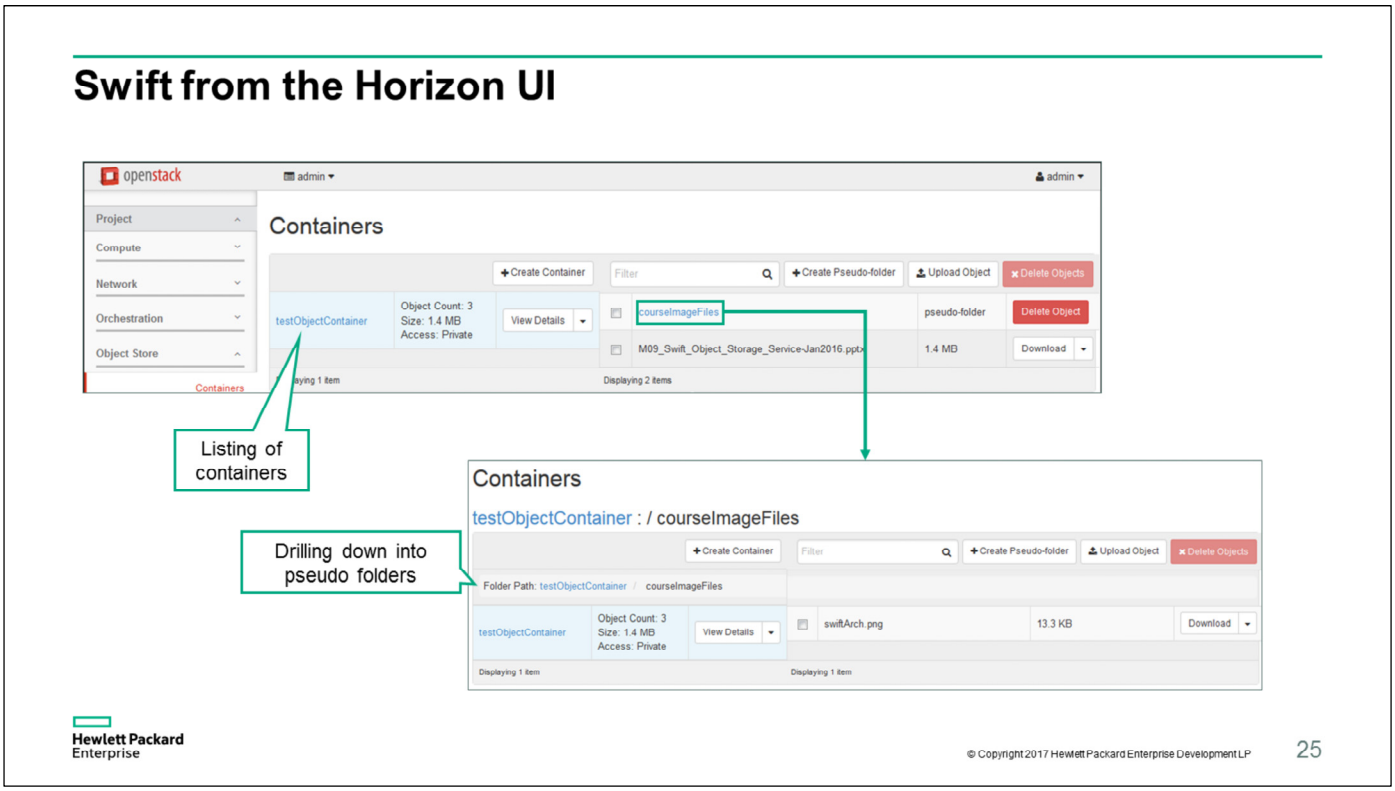
Sample API PUT of an object

The example content shows the formation of a set of API requests to create a container. Use the cURL commands when you need to see the actual responses returned by the service. If you are performing operations from the command line, you can normally use the Swift Python client, if it has been installed.

To create a container or upload an object, use the `PUT` operation. To update metadata, use a `POST` operation.

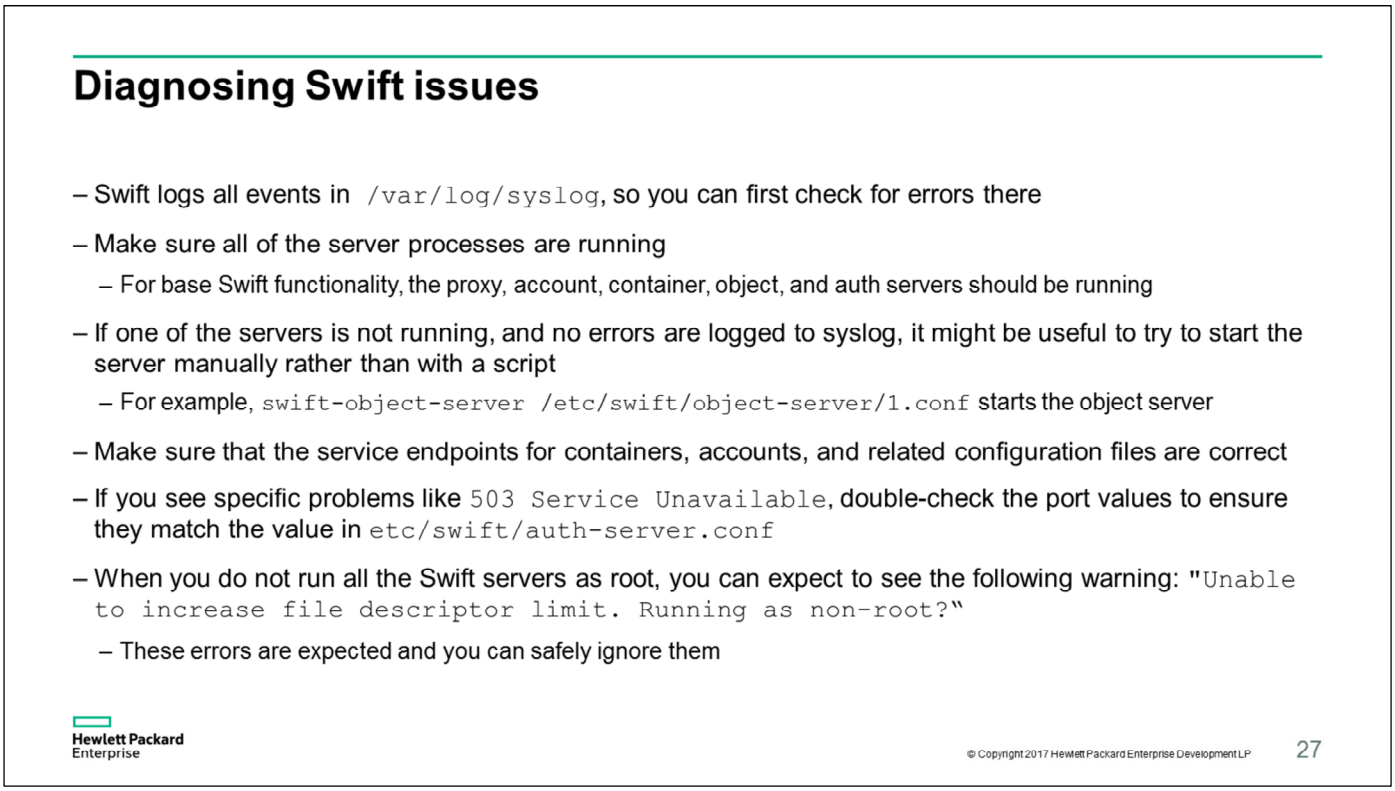
Note: The paths for your container and object are simply URLs. Those objects could, in fact, be web pages.



Swift from the Horizon UI

The Horizon UI provides the ability to create, modify, and add objects to containers, as well as pseudo folders.

Troubleshooting Swift



Diagnosing Swift issues

The slide above outlines some common checks to perform while diagnosing Swift issues. For example, get a listing of service endpoints using the Keystone catalog, and then verify your service endpoint.

If you see specific problems like `503 Service Unavailable`, double-check the port values to ensure they match the value in `etc/swift/auth-server.conf`.

When adding a new account or a user, the auth server calls out to the proxy server based on the `default_cluster_url` configuration file value and it should match the `bind_port` value. You also have to configure the port for the `proxy-server.conf` under the `[filter:auth]` section, which defaults to 11000.

Troubleshooting with Swift log files

- Swift logs to `/var/log/syslog`
  - Configured during installation
  - When a request is made to Swift, it is given a unique transaction ID that should be in every log line with the request

```
Oct 19 11:17:50 hpdevstack proxy-server Using identity: {'roles': [u'admin'], 'u
ser': u'admin', 'tenant': (u'd7cf0245512540b99fb2c917ec3ee3e6', u'admin')} (txn:
 txb7a2d0f12fba42b5bc7a6-005262cccd)
Oct 19 11:17:50 hpdevstack proxy-server allow user with role admin as account ad
min (txn: txb7a2d0f12fba42b5bc7a6-005262cccd) (client_ip: 10.0.2.15)
Oct 19 11:17:50 hpdevstack container-server 127.0.0.1 - - [19/Oct/2013:18:17:50
+0000] "HEAD /sdb1/427/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1" 204 - "
txb7a2d0f12fba42b5bc7a6-005262cccd" "HEAD http://10.0.2.15:8080/v1/AUTH_d7cf0245
512540b99fb2c917ec3ee3e6/container1" "proxy-server 31987" 0.0036
Oct 19 11:17:50 hpdevstack object-server 127.0.0.1 - - [19/Oct/2013:18:17:50 +00
00] "HEAD /sdb1/385/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1/localrc" 40
4 - "HEAD http://10.0.2.15:8080/v1/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/contain
er1/localrc" "txb7a2d0f12fba42b5bc7a6-005262cccd" "proxy-server 31987" 0.0007
```

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Troubleshooting with Swift log files

You can copy a transaction ID from the log file and then grep the log file for all lines containing that ID. For example:

```
$ grep  txb7a2d0f12fba42b5bc7a6-005262cccd /var/log/syslog

Oct 19 11:17:49 hpdevstack proxy-server STDOUT: 2013-10-19 18:17:49.430 31987 INFO
urllib3.connectionpool [-] Starting new HTTP connection (1): 10.0.2.15 (txn:
txb7a2d0f12fba42b5bc7a6-005262cccd)

Oct 19 11:17:50 hpdevstack proxy-server Using identity: {'roles': [u'admin'], 'user':
u'admin', 'tenant': (u'd7cf0245512540b99fb2c917ec3ee3e6', u'admin')} (txn:
txb7a2d0f12fba42b5bc7a6-005262cccd)

Oct 19 11:17:50 hpdevstack proxy-server allow user with role admin as account admin
(txn: txb7a2d0f12fba42b5bc7a6-005262cccd) (client_ip: 10.0.2.15)

Oct 19 11:17:50 hpdevstack container-server 127.0.0.1 - - [19/Oct/2013:18:17:50 +0000]
"HEAD /sdb1/427/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1" 204 -
"txb7a2d0f12fba42b5bc7a6-005262cccd" "HEAD
http://10.0.2.15:8080/v1/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1" "proxy-
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Oct 19 11:17:50 hpdevstack object-server 127.0.0.1 - - [19/Oct/2013:18:17:50 +0000]
"HEAD /sdb1/385/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1/localrc" 404 - "HEAD
http://10.0.2.15:8080/v1/AUTH_d7cf0245512540b99fb2c917ec3ee3e6/container1/localrc"
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```
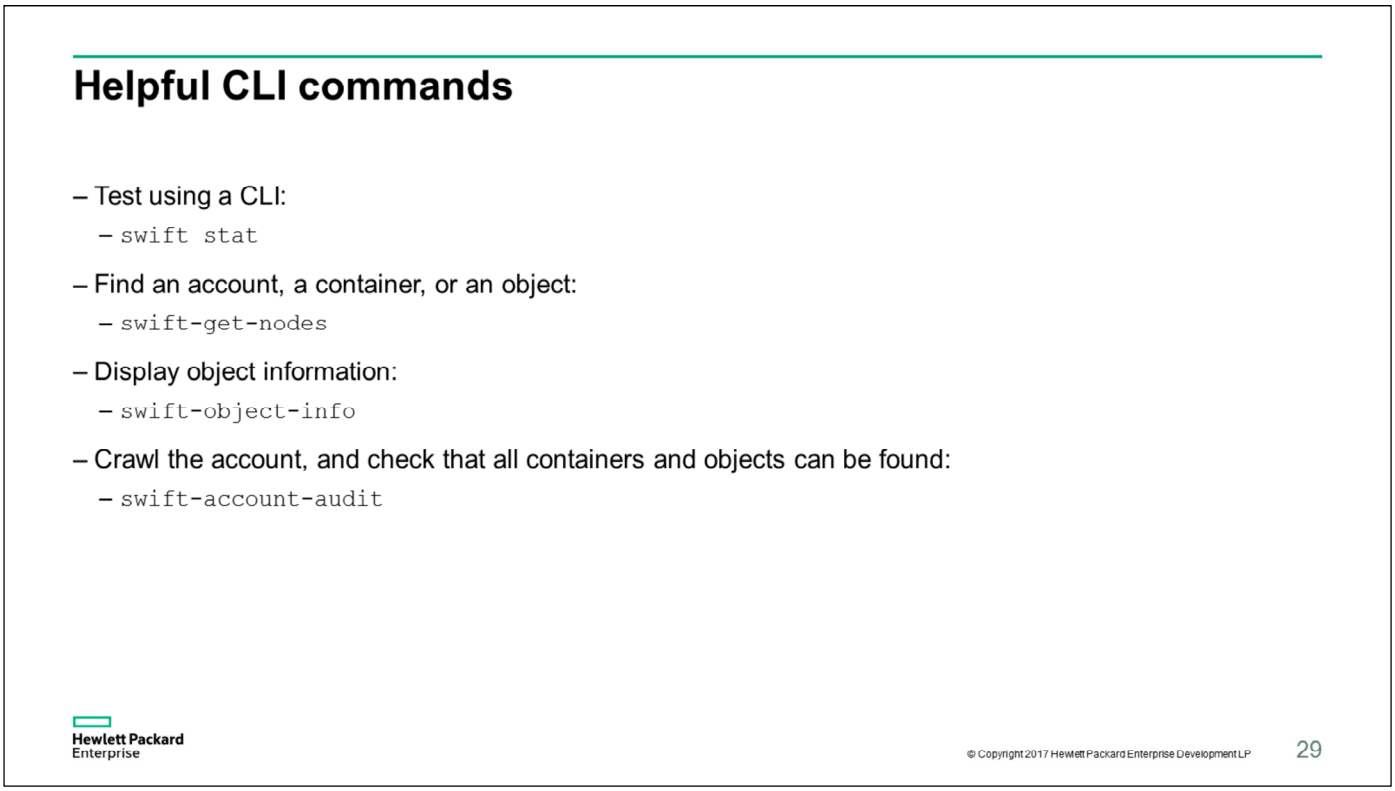



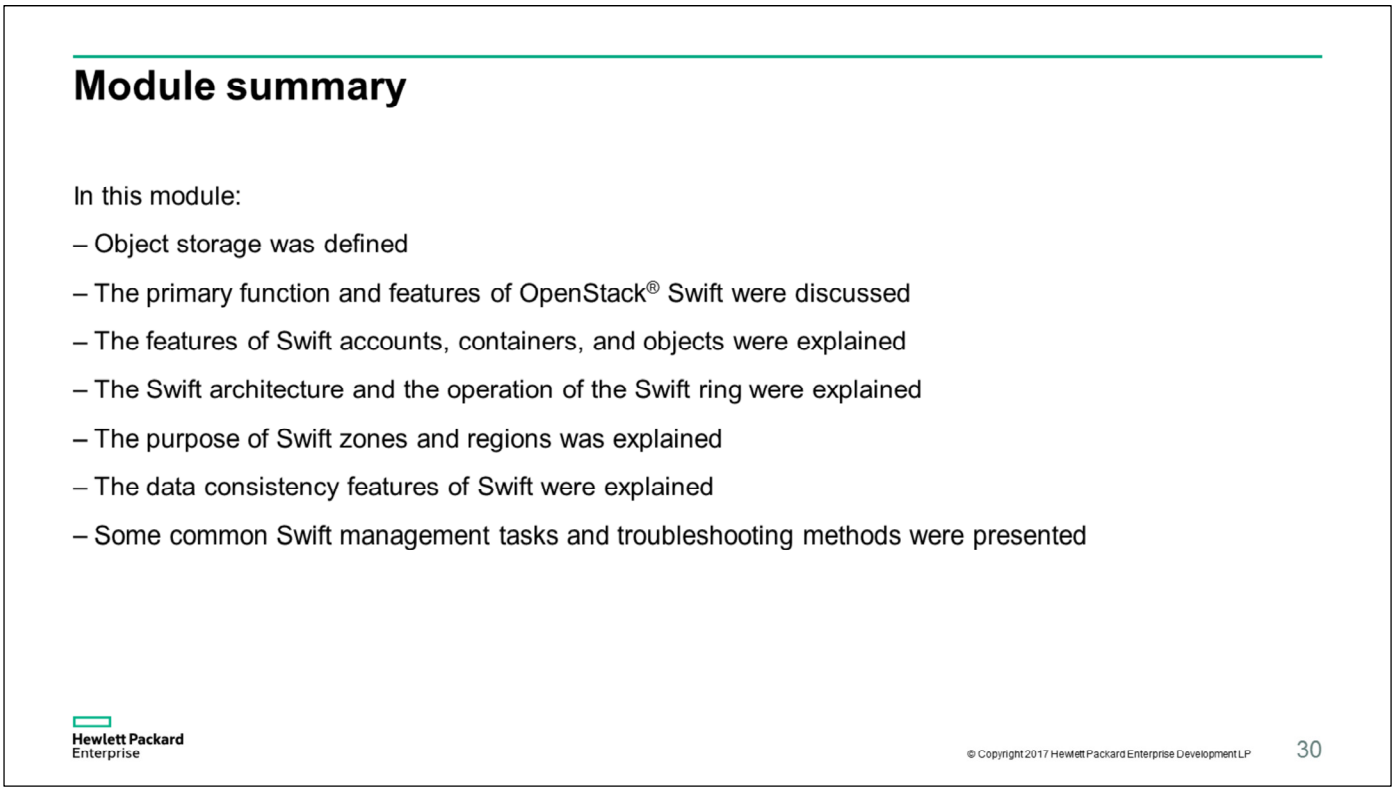
Helpful CLI commands

The following commands can be used to examine the status of the object storage:

- To test the object storage and show statistics, enter `swift-stat`
- To find an account, a container, or an object, enter `swift-get-nodes`
- To display object information, enter `swift-object-info`
- To check all containers and objects connected to a certain account, enter `swift-account-audit`

Example:

```
hp@hpdevstack:~/devstack$ swift stat
   Account: AUTH_d7cf0245512540b99fb2c917ec3ee3e6
Containers: 1
   Objects: 1
     Bytes: 3477
Accept-Ranges: bytes
X-Timestamp: 1382204001.10275
X-Trans-Id: tx239f96314ecd44979cdea-005262e23d
Content-Type: text/plain; charset=utf-8
```



Module summary

In this module:

- Object storage was defined
- The primary function and features of OpenStack® Swift were discussed
- The features of Swift accounts, containers, and objects were explained
- The Swift architecture and the operation of the Swift ring were explained
- The purpose of Swift zones and regions was explained
- The data consistency features of Swift were explained
- Some common Swift management tasks and troubleshooting methods were presented

Learning check

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Learning check

Object storage is not generally a good solution for which of the following types of data?

A. Massive amounts of unstructured data

B. Data that changes frequently, such as database entries

C. Storage backups

D. Video and audio files

E. Virtual machine images

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Learning check

Which of the following are the features of OpenStack® Swift? (select all the correct responses)

A. Does not use a conventional file system

B. Data is distributed evenly throughout the system

C. Uses a central database

D. Provides data redundancy (at least 3 replicas)

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Learning check answer

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Learning check

Which of the following Swift services has a database that stores both a container's metadata and a record for each object it contains?

A. Swift proxy server

B. Account

C. Container

D. Object

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Learning check answer

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Learning check

What is the purpose of a Swift ring?

A. Map between logical volumes and physical volumes

B. Map between external names of stored items and their physical location

C. Map containers to storage zones

D. Map an account, a container, or an object to a partition

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What is an attribute of Swift object storage? (Select two)

A. Scales to zettabytes

B. Supports multi-tenancy

C. Provides volumes for instances

D. Creates file systems for instances

E. Sizes chunks based on flavors

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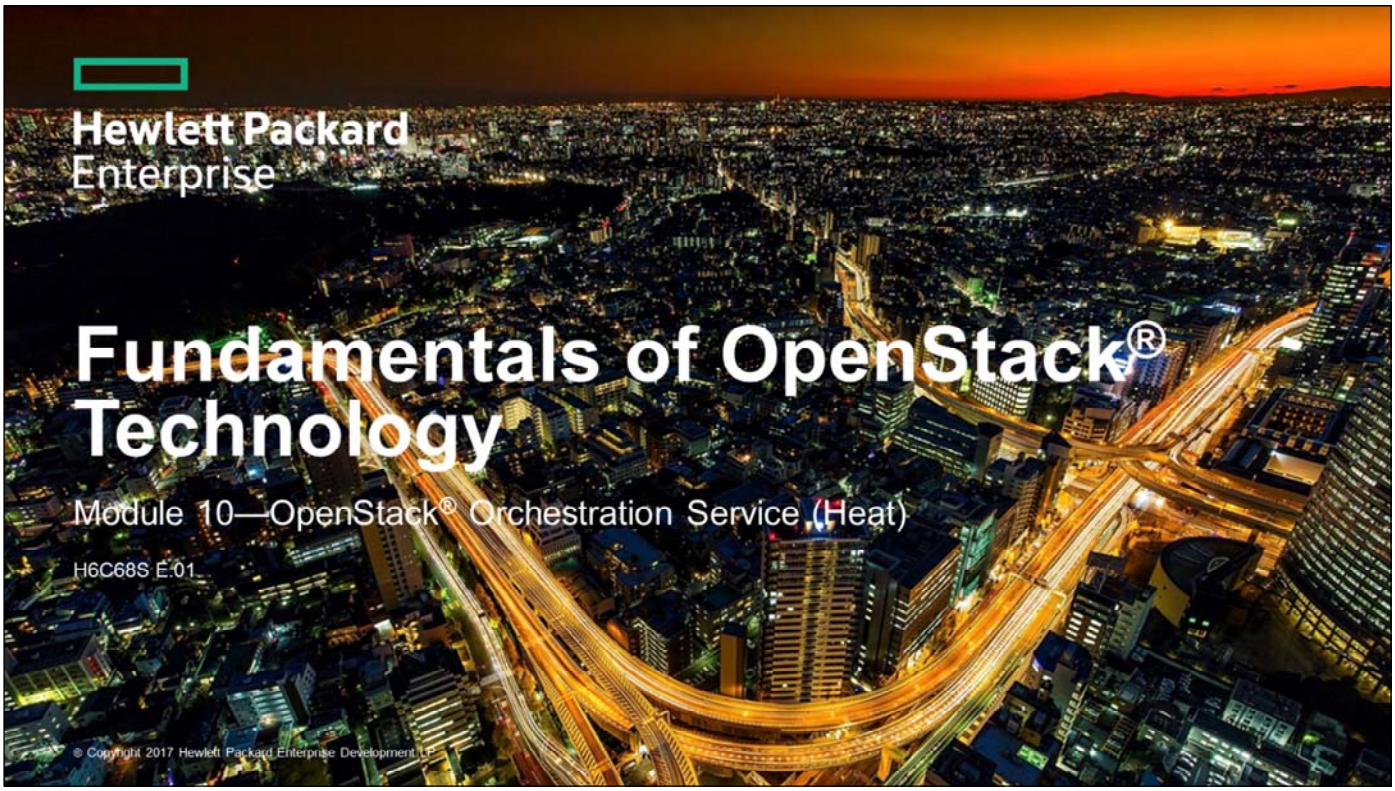
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Fundamentals of OpenStack® Technology
Module 10—OpenStack® Orchestration Service (Heat)
H6C68S E.01
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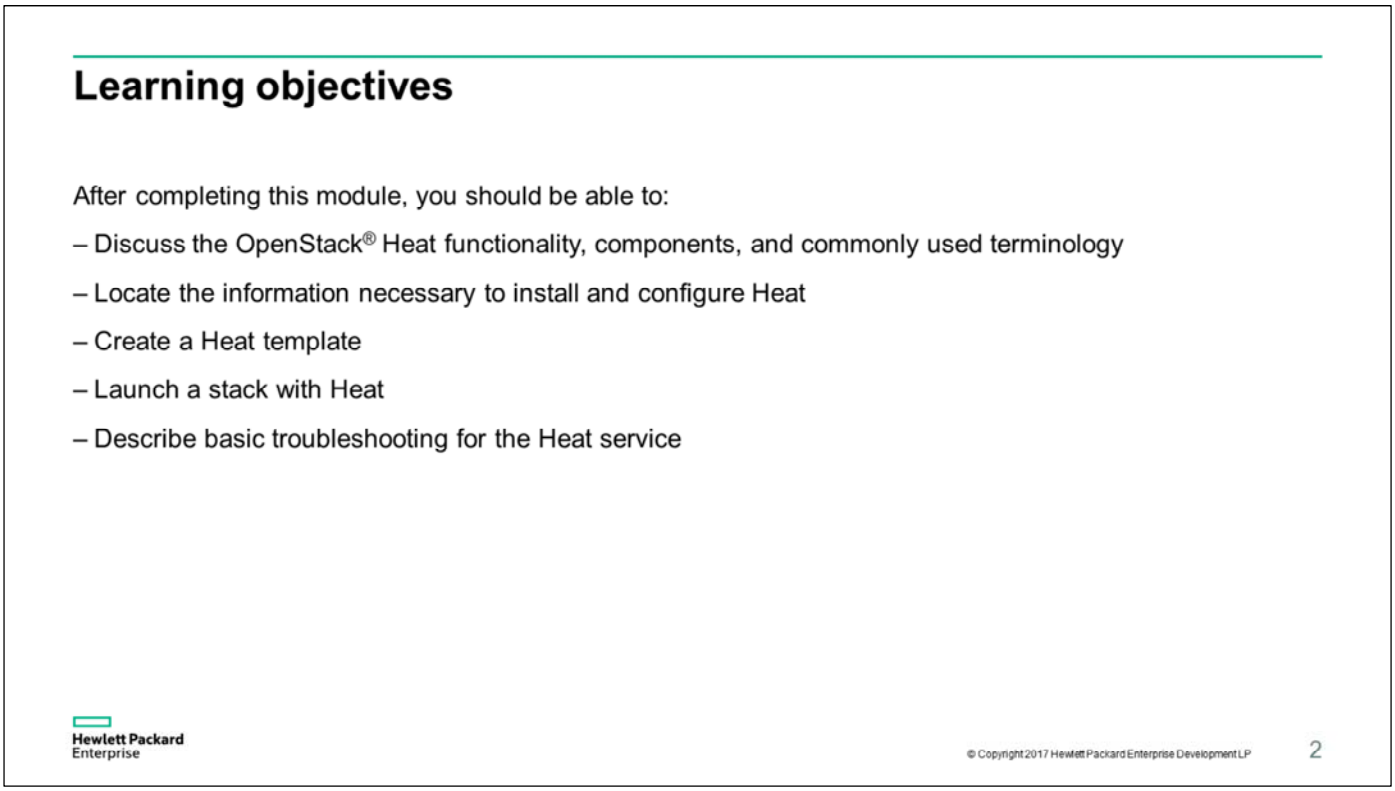

Learning objectives

After completing this module, you should be able to:

- Discuss the OpenStack® Heat functionality, components, and commonly used terminology
- Locate the information necessary to install and configure Heat
- Create a Heat template
- Launch a stack with Heat
- Describe basic troubleshooting for the Heat service

Heat overview

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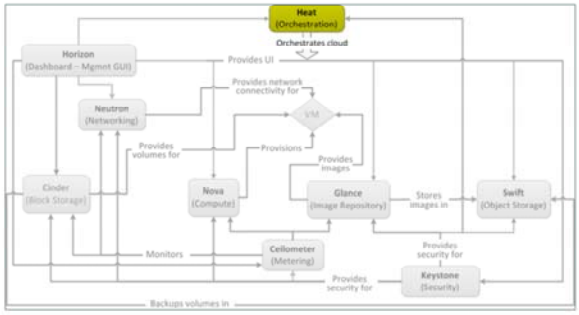
Heat functionality

- Heat:
  - Is a template-based service that executes OpenStack® API calls to generate running cloud applications
  - Provides for the creation of resource types:
    - Instances, Floating IP addresses, volumes, security groups, and so on
    - Advanced services such as high availability, auto-scaling, and nested stacks
  - Integrates with other core OpenStack® components
- All OpenStack® resources and related dependencies are specified in an AWS CloudFormation-compatible template called the Heat Orchestration Template (HOT)
- Management through both an OpenStack®-native REST API and a CloudFormation-compatible Query API



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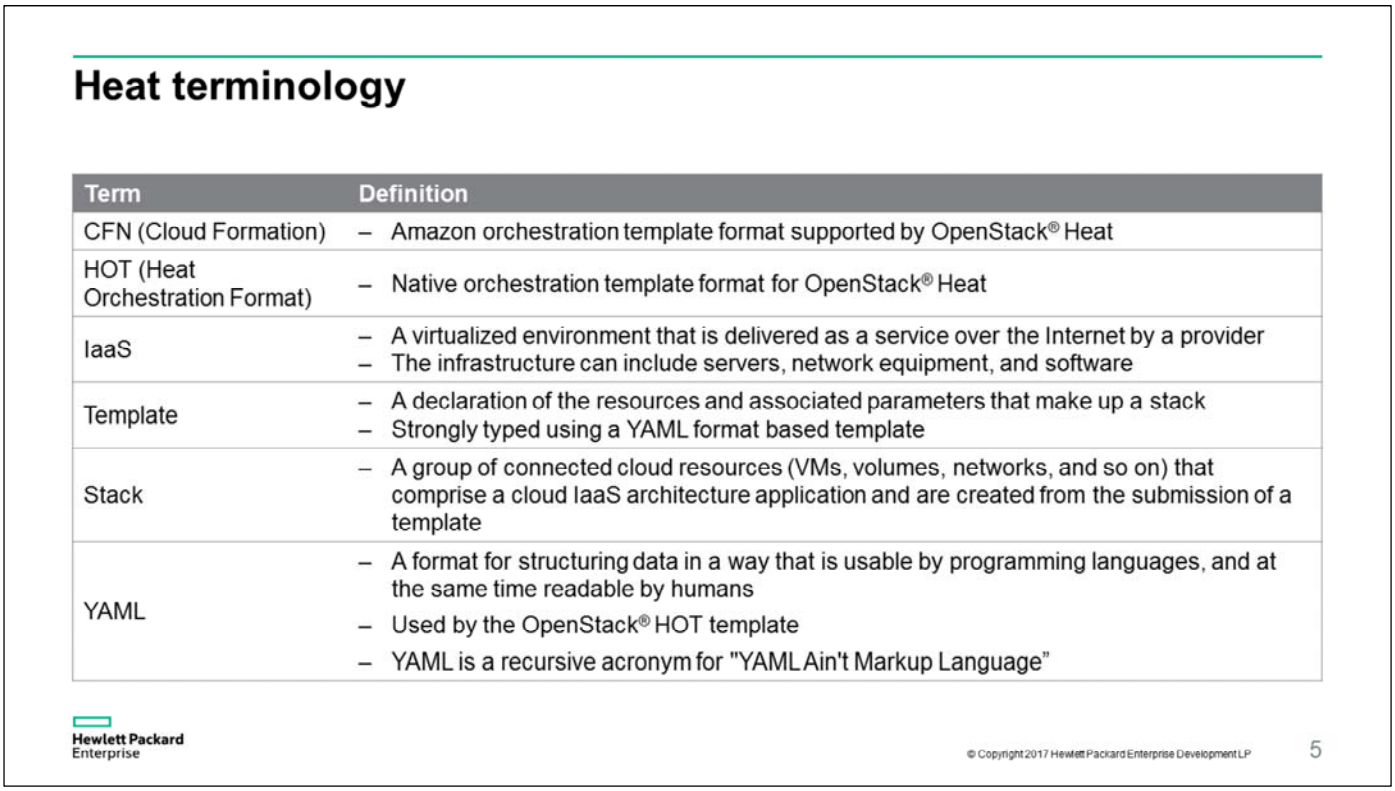
Heat functionality

Heat is the main project in the OpenStack® Orchestration program. It implements an orchestration engine to launch multiple composite cloud applications based on templates that are in the form of text files that can be treated like code. A native Heat template format is evolving, but Heat is also compatible with the Amazon Web Services (AWS) CloudFormation template format, so many existing CloudFormation templates can be launched on OpenStack®.

Heat provides both an OpenStack®-native Representational State Transfer (REST) API and a CloudFormation-compatible Query API.



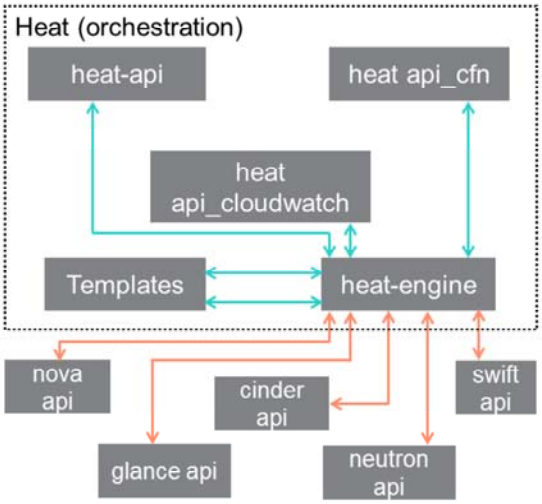
Heat terminology

The following terms are commonly used in Heat documentation:

- **Infrastructure as a Service (IaaS)**: A virtualized environment that is delivered as a service over the Internet by a provider. The infrastructure can include servers, network equipment, and software.
- **Template**: A declaration of the resources and associated parameters that make up a stack. A template can be stored as a text file with a format that complies with the JavaScript Object Notation (JSON) standard. As a plain text file, a template can be edited using any text editor and stored in any source control system.
- **Stack**: A group of connected cloud resources (virtual machines [VMs], volumes, networks, and so on) that comprise a cloud IaaS architecture application and are created from the submission of a template.

Heat components

- **heat-engine:** Does all the orchestration work and is the layer in which the resource integration is implemented
- **heat-api:** A service that exposes an external REST-based API to the heat-engine service
  - The communication between the heat-api and the heat-engine uses a message queue–based RPC
- **heat-api-cfn:** Provides an AWS Query API that is compatible with the AWS CloudFormation and that processes API requests by sending them to the heat-engine over RPC
- **heat–api-cloudwatch:** A CloudWatch-like API service available to the Heat project



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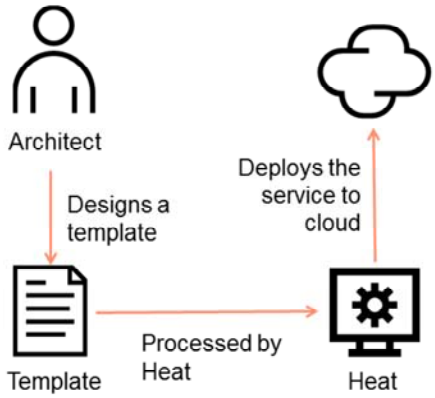
Heat components

The Heat service consists of four main components:

- **heat engine:** Does all the orchestration work and is the layer in which the resource integration is implemented.
- **heat-api:** A service that exposes an external REST-based API to the heat-engine service. The communication between the heat-api and the heat-engine uses a message queue–based Remote Procedure Call (RPC).
- **heat-api-cfn:** Provides an AWS Query API that is compatible with the AWS CloudFormation and that processes API requests by sending them to the heat-engine over RPC.
- **heat –api-cloudwatch:** A CloudWatch-like API service to the Heat project.

How a Heat template works

- Describes the infrastructure for a cloud application in a text file that can be committed to the version control repository
- Describes infrastructure resources such as servers, Floating IP addresses, volumes, security groups, and users
- Can be used to specify the relationships between resources
  - For example, which volume is connected to which server
- Specified in the command used to create a stack:
  `heat stack create <stack name> -- template-file =<template name>`
- Can be modified for updating an existing stack
- Integrates well with software configuration management tools such as Puppet and Chef



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How a Heat template works

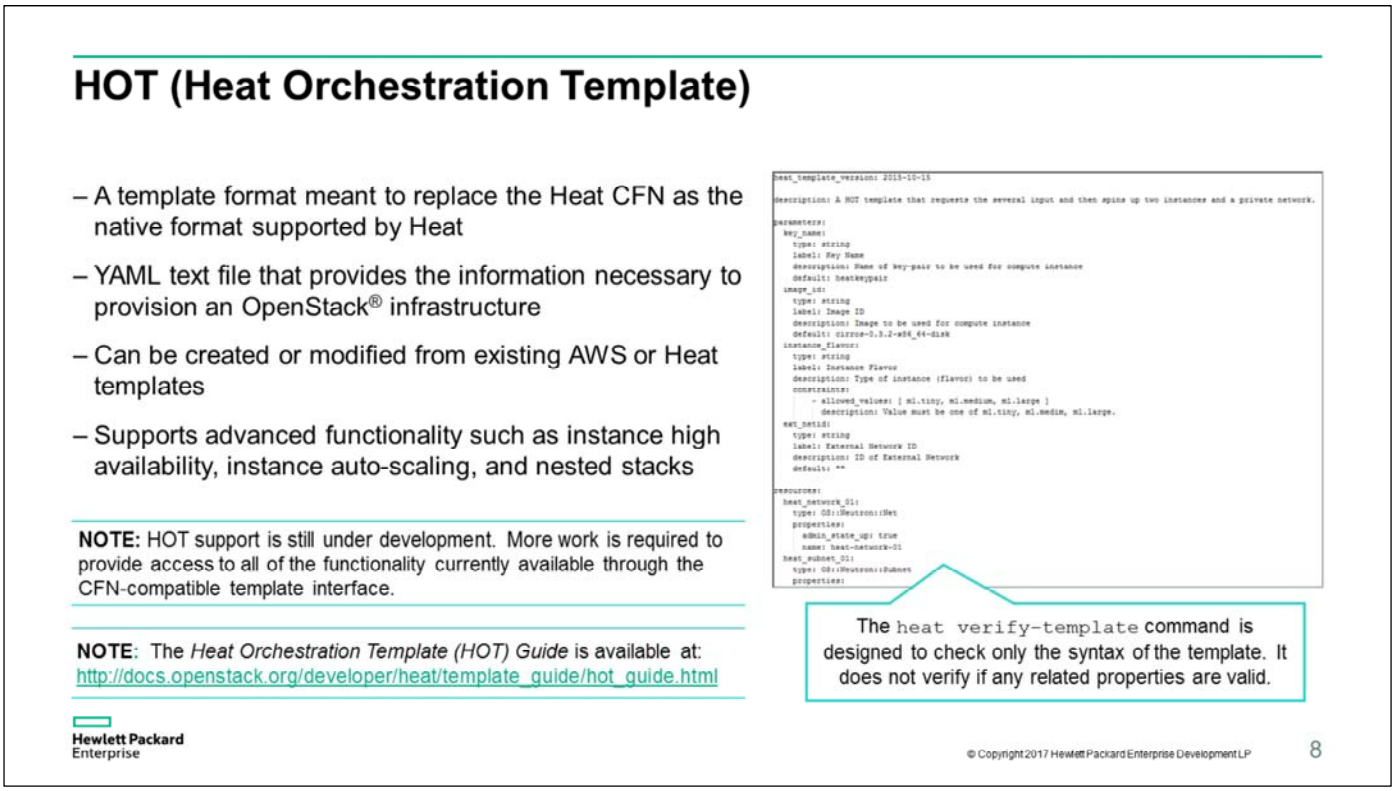
A Heat template describes the infrastructure for a cloud application in a text file that is readable and writable by humans, and can be checked into version control, diffed, and so on.

Infrastructure resources that can be described in the template include servers, Floating IPs, volumes, security groups, and users.

Templates can also specify the relationships between resources (for example, this volume is connected to this server). This enables Heat to call out to the OpenStack® APIs to create all of your infrastructure in the correct order to completely launch your application.

Heat manages the whole lifecycle of the application. When you need to change your infrastructure, simply modify the template and use it to update your existing stack. Heat knows how to make the necessary changes. It deletes all of the resources when you are finished with the application.

Heat primarily manages infrastructure, but the templates integrate well with software configuration management tools such as Puppet and Chef. For more information on these two tools, visit https://s3.amazonaws.com/cloudformation-examples/IntegratingAWSCloudFormationWithPuppet.pdf.

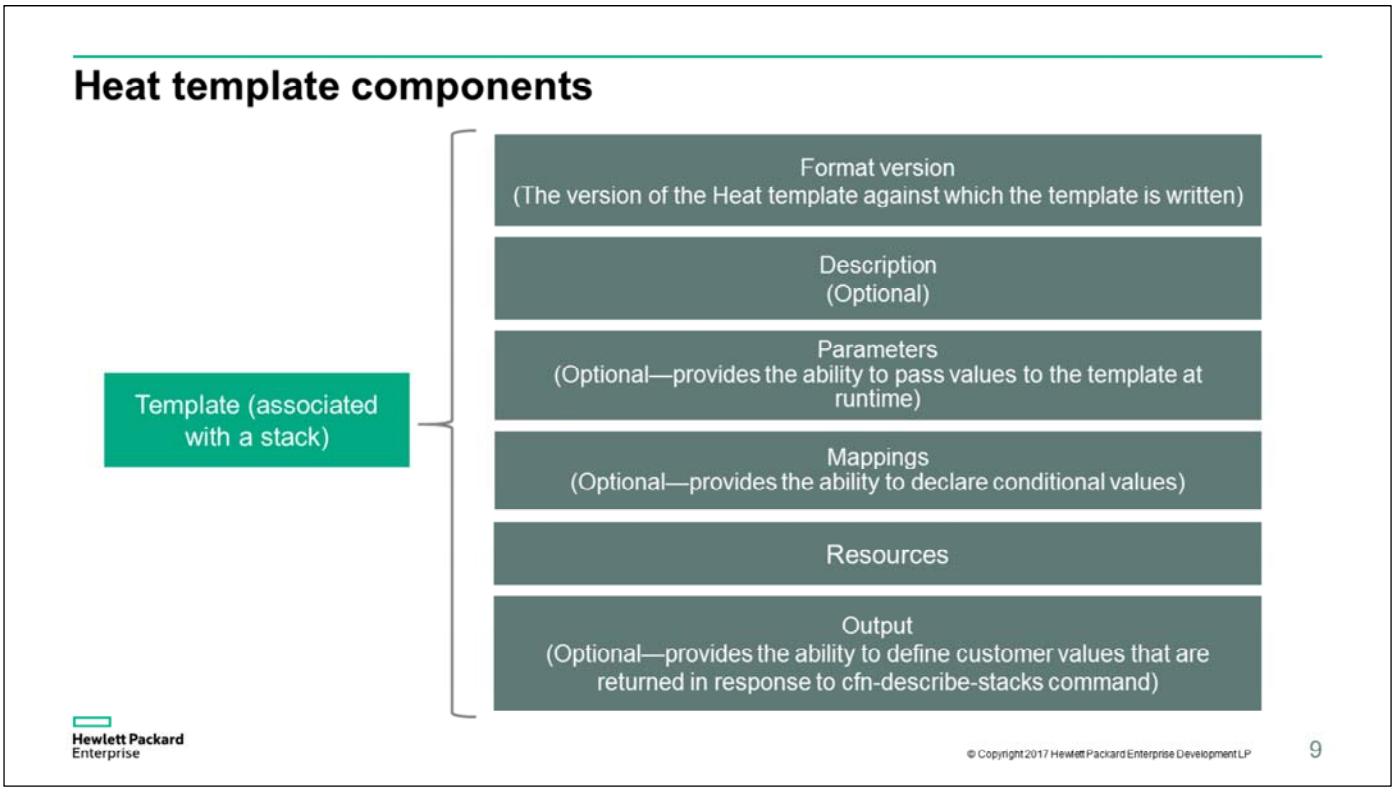


HOT (Heat Orchestration Template)

This specification explains in detail all elements of the HOT template format. An example-driven guide to writing HOT templates can be found in *Heat Orchestration Template (HOT) Guide*.

References:

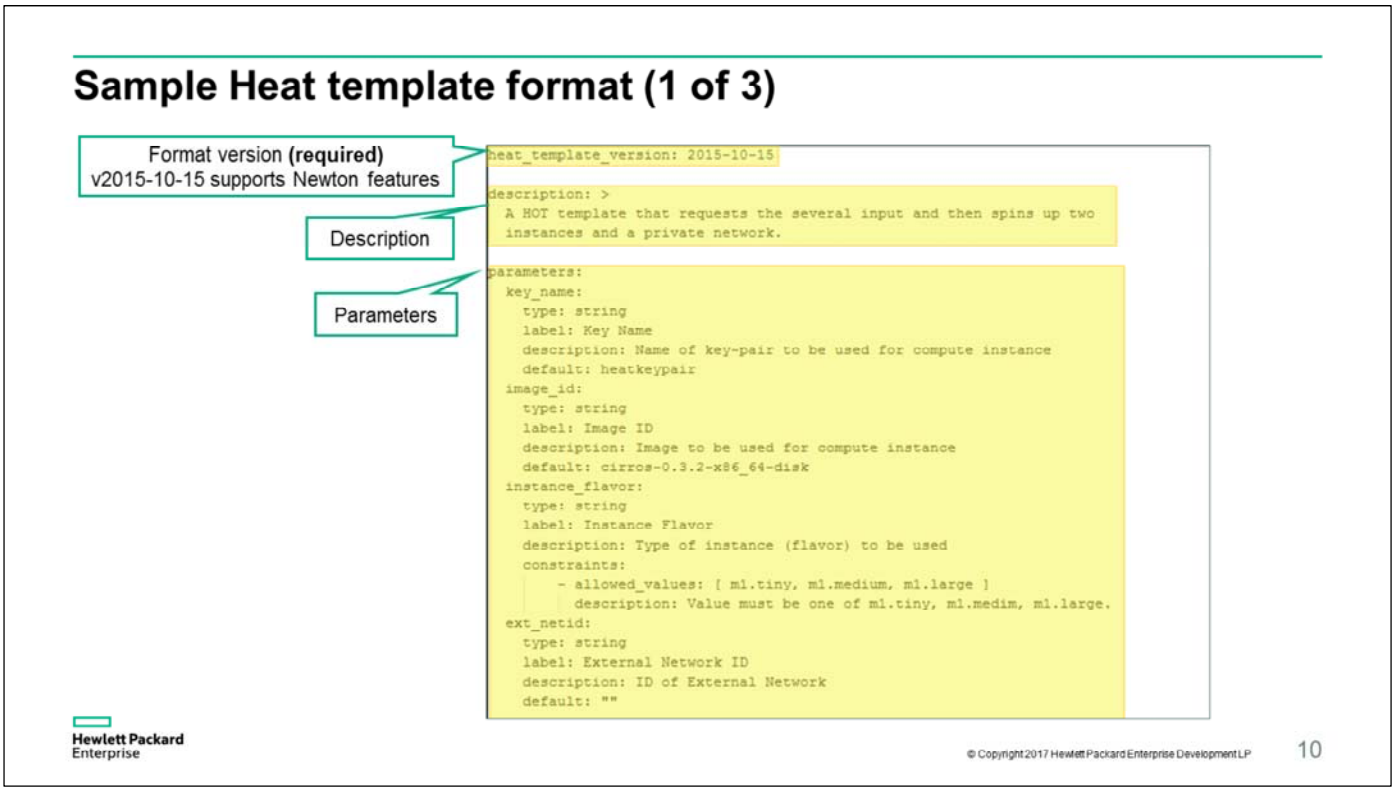
– http://docs.aws.amazon.com/AWSCloudFormation/latest/UserGuide/aws-template-resource-type-ref.html
– http://docs.openstack.org/developer/heat/template_guide/
– http://docs.openstack.org/developer/heat/template_guide/hot_guide.html



Heat template components

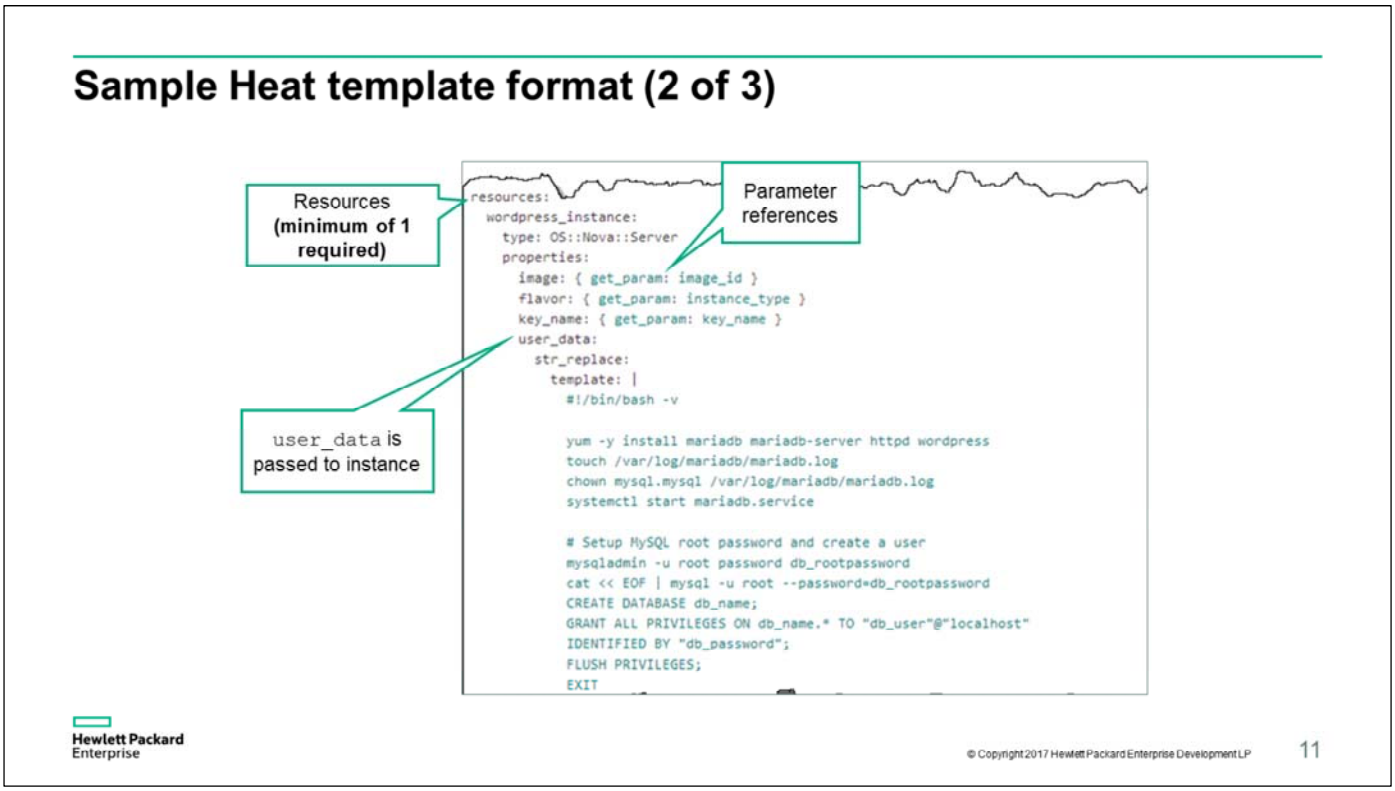
Heat Orchestration Templates (HOT) are defined in YAML:

- **heat_template_version**: This key with value 2013-05-23 (or a later date) indicates that the YAML document is a HOT template of the specified version. The version determines the features supported by the template.
- **Description**: Allows for giving a description of the template or the workload that can be deployed using the template.
- **parameter_groups**: Used to specify how the input parameters should be grouped and the order in which to provide the parameters. This section is optional and can be omitted when necessary.
- **Parameters**: Used to specify the input parameters that have to be provided when instantiating the template. This section is optional and can be omitted when no input is required.
- **Resources**: Used for the declaration of one or more resources to be used to create the stack from the template.
- **Outputs**: Used to specify the output parameters available to users once the template has been instantiated. This section is optional and can be omitted when no output values are required.



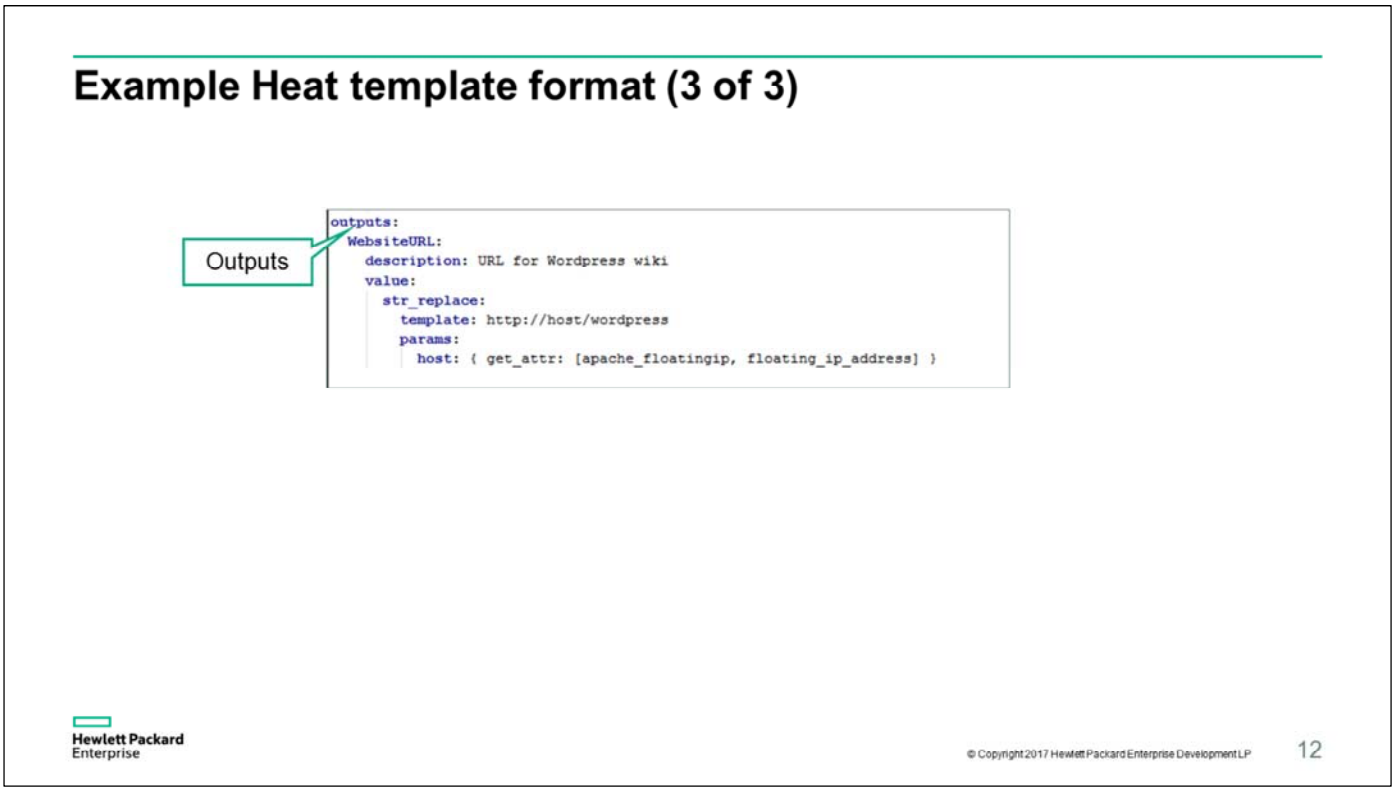
Sample Heat template format (1 of 3)

The sample above illustrates the Heat template starting with format version information, followed by `description` and `parameters` configuration sections.



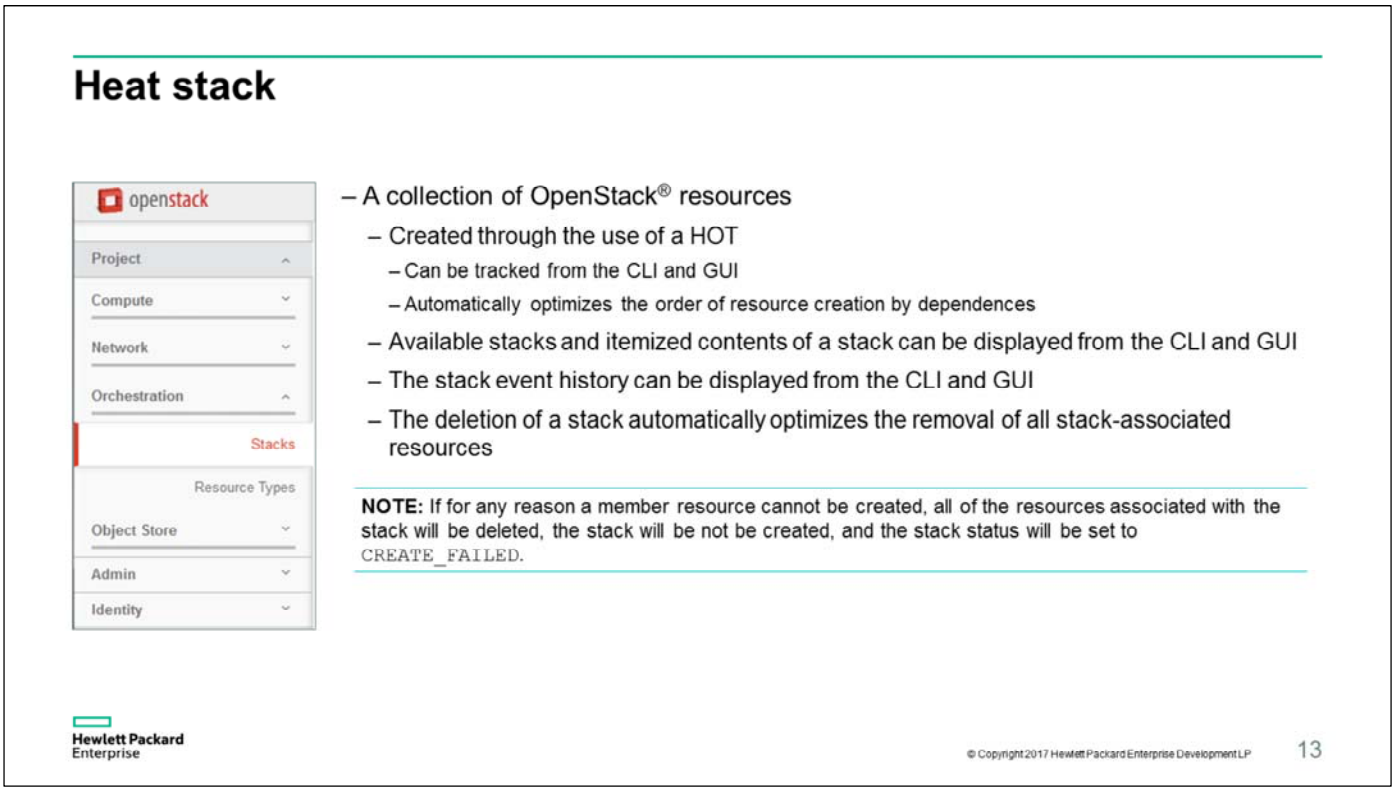
Sample Heat template format (2 of 3)

The sample above illustrates the `resources` section of the Heat template. The `resources` section allows you to define parameter references, as well user data to be passed to the instance.



Sample Heat template format (3 of 3)

The sample above illustrates the `outputs` section of the Heat template.

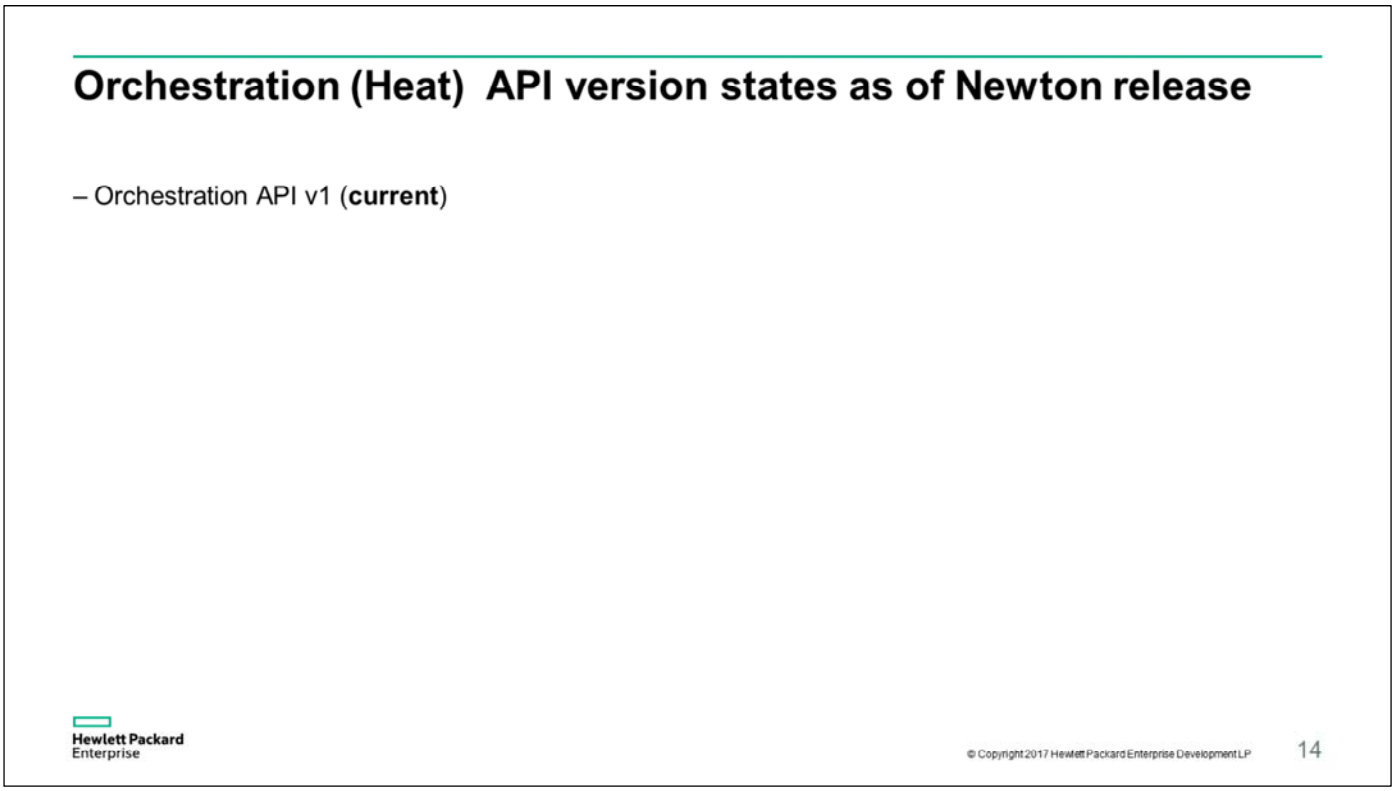


Heat stack

A Heat stack can be defined as a collection of OpenStack® resources. A stack is created through the use of a Heat Orchestration Template. The status of the stack can be tracked from the CLI and GUI.

Orchestration templates are used to start many VMs simultaneously, and Heat can automatically optimize the order of resource creation by dependencies. This is an important feature, considering that there could be dozens of virtual machine templates.

Similarly to the creation of a stack, the deletion of a stack automatically optimizes the removal of all stack-associated resources.



Orchestration (Heat) API version states as of Newton release

The orchestration API is at the version v1 (**current**).

Common Heat management tasks

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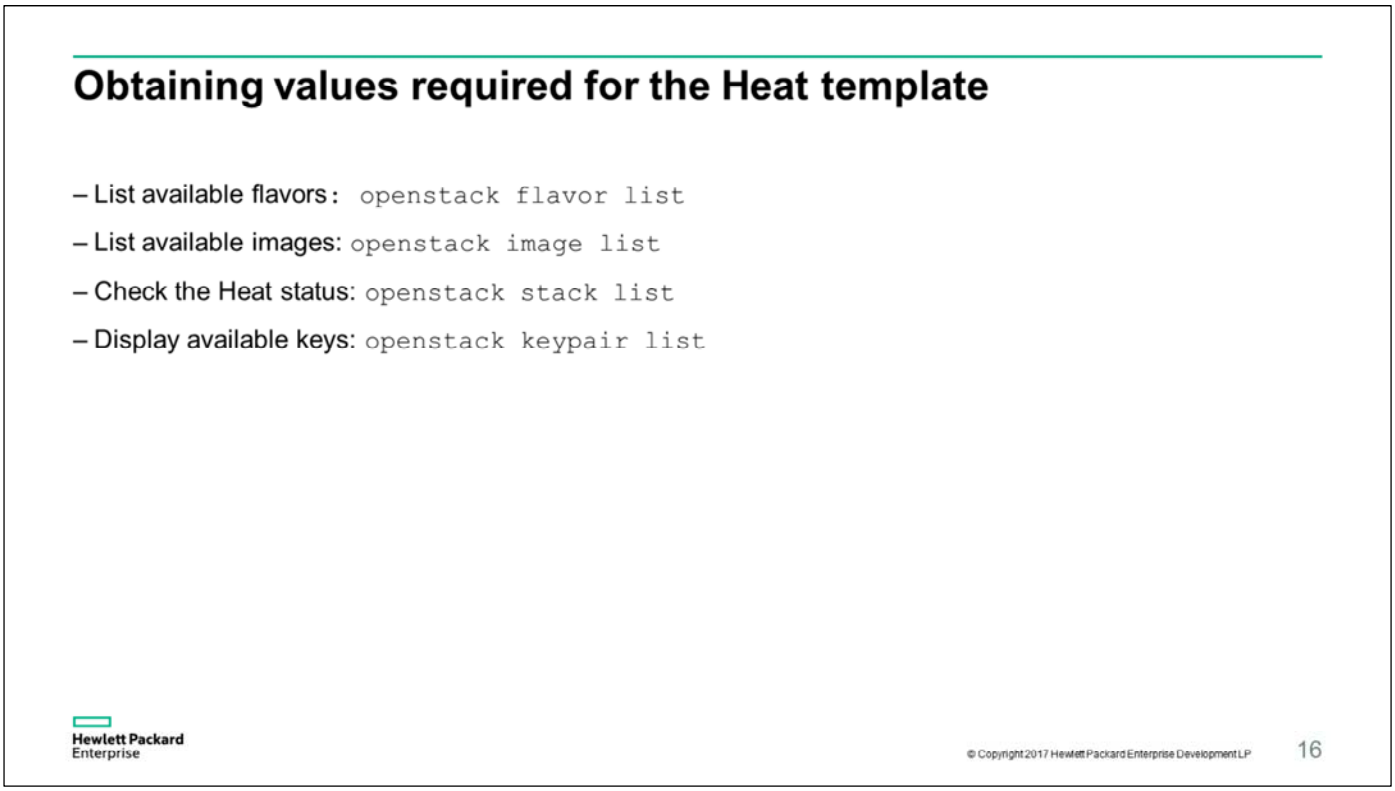
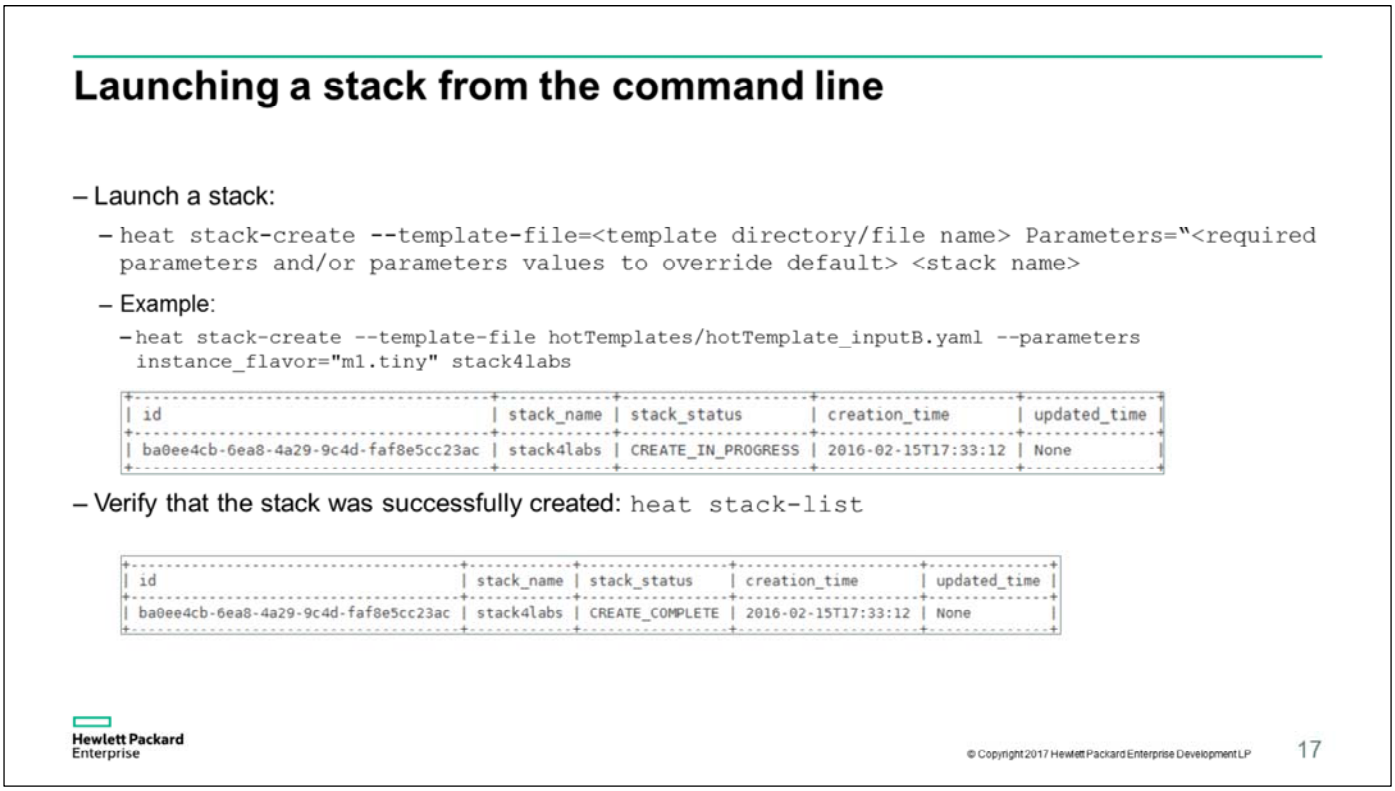


Obtaining values required for the Heat template

Values required for the HOT can be obtained using the CLI or GUI. Often, the CLI offers better visibility and structure of data. Depending on the information you want to extract, you can use some of the commands listed on the slide.

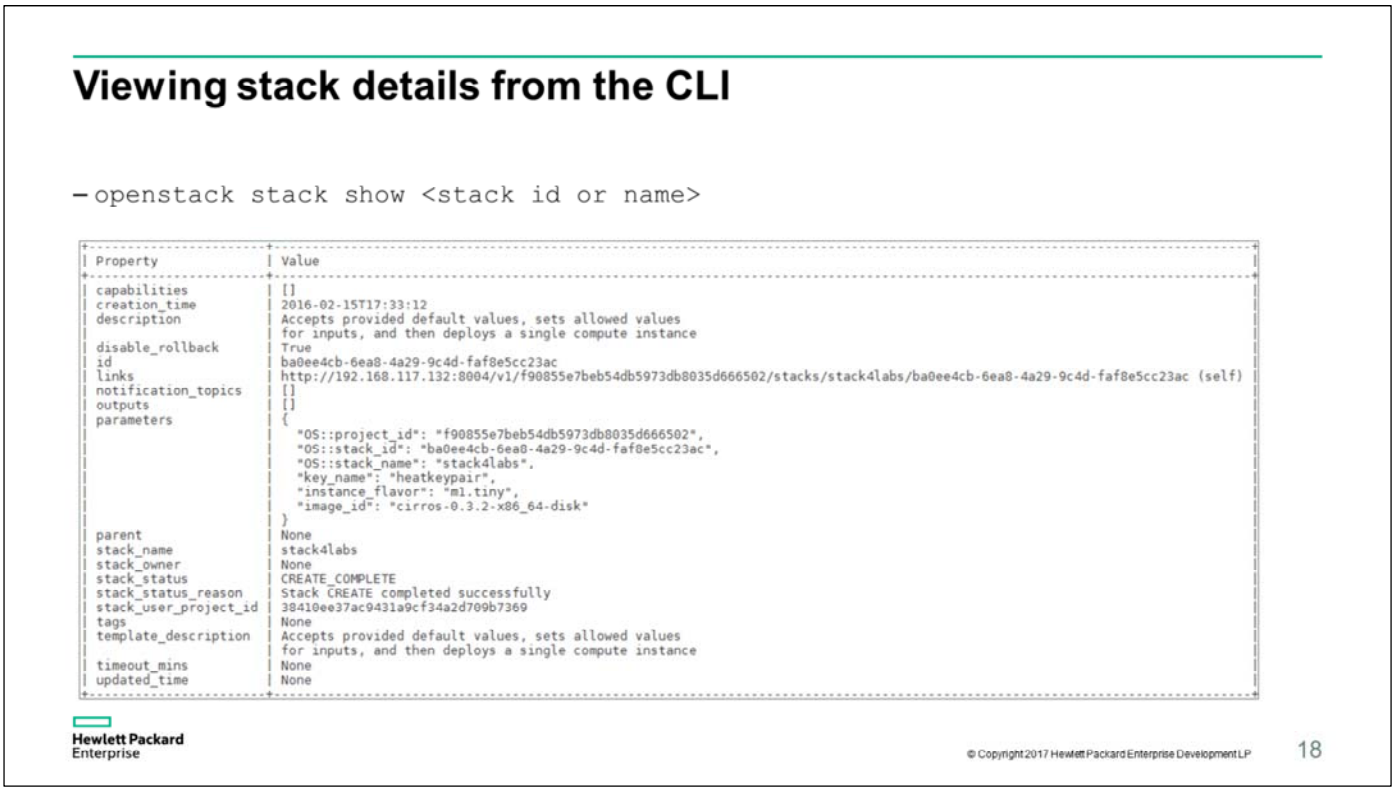


Launching a stack from the command line

All of the values specified by the parameters are either used to provide a value for a required parameter as specified by the template or override a value for a parameter specified by the template.

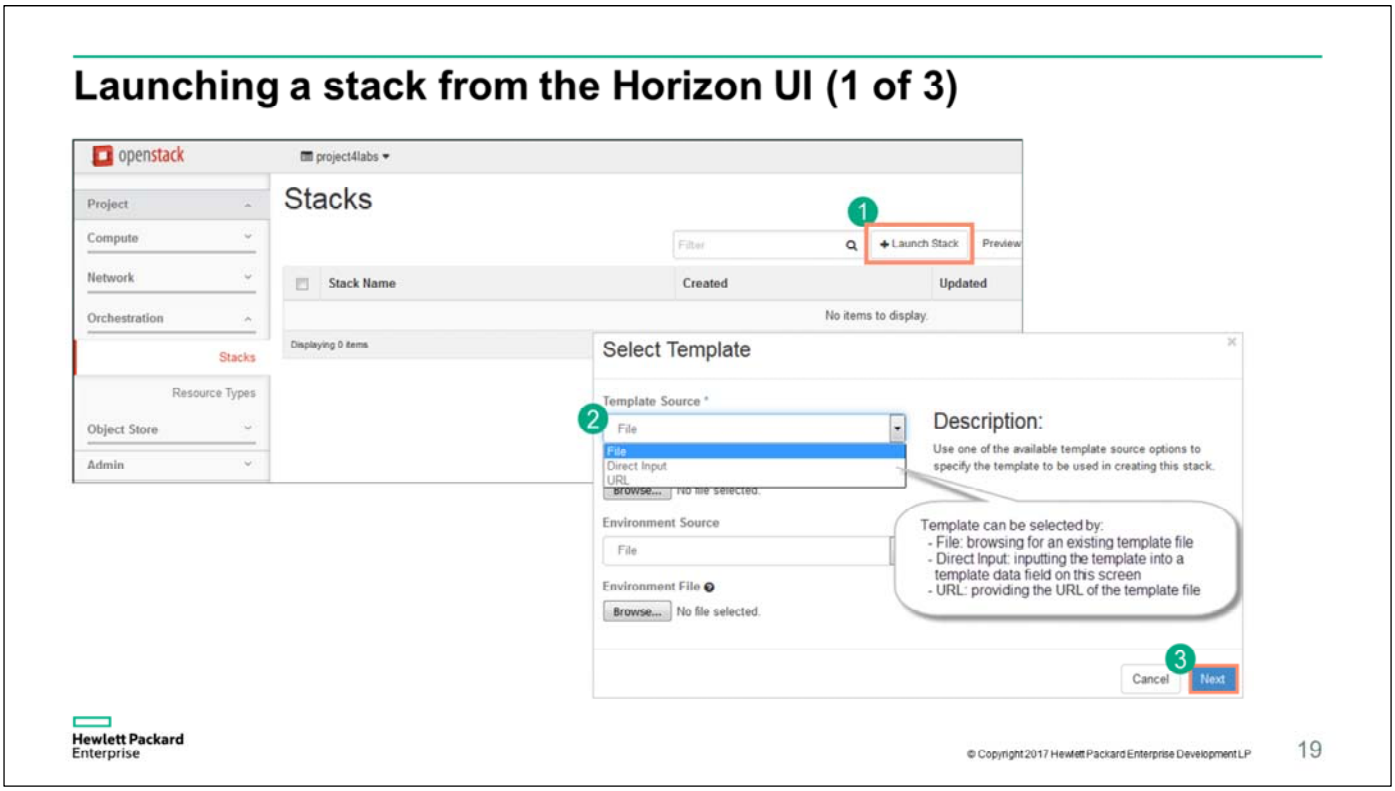
The `stack-list` command provides the ability to verify that the stack was successfully initialized.

If the deployment fails, refer to https://ask.openstack.org/en/question/9698/devstack-heat-dns-resolution-not-working-from-instance-cloud-init-fails/.



Viewing stack details from the CLI

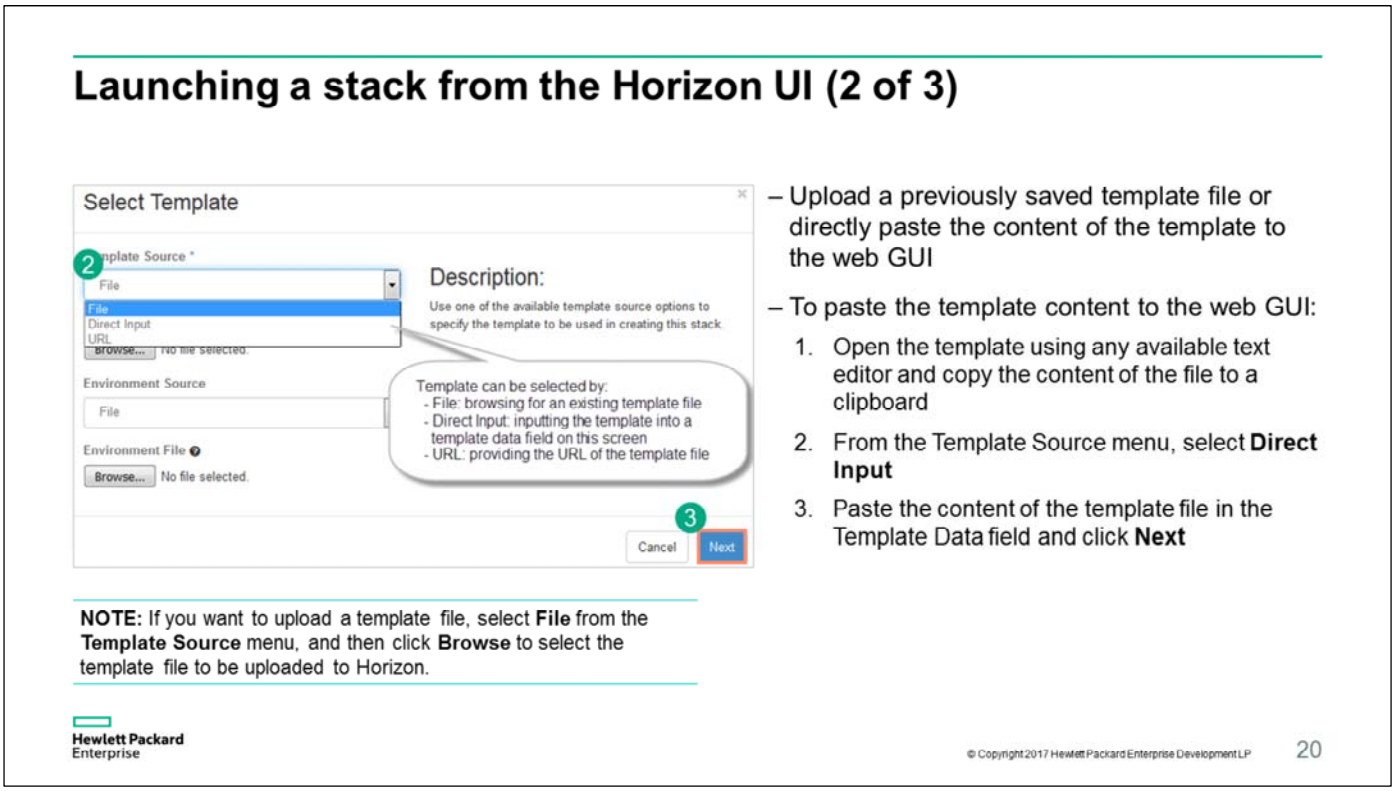
The stack details can be displayed using the `heat stack-show` command as well as using the new `openstack stack show` command as illustrated above.



Launching a stack from the Horizon UI (1 of 3)

To begin creating a new stack, log in to Horizon and then:

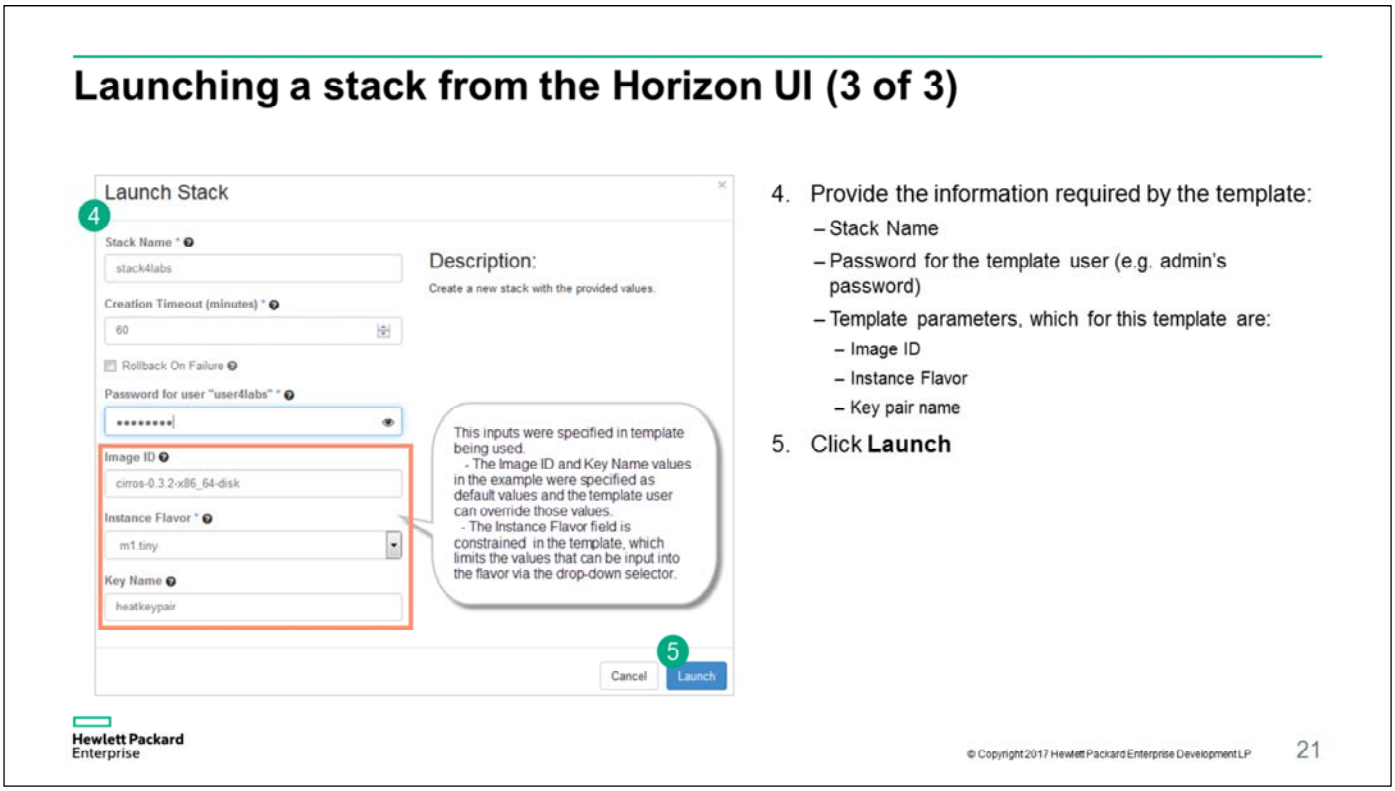
1. On the left side of the screen, expand the **Project** menu.
2. Click **Orchestration**.
3. Click **Stacks**.
4. On the right side of the screen, click the **Launch Stack** button.



Launching a stack from the Horizon UI (2 of 3)

To use a template through Horizon, you have to either upload a previously saved template file or directly paste the content of the template to the web GUI. To paste template content:

1. Open the template using any available text editor and copy the content of the file to a clipboard.
2. Select the **Direct Input from Template Source** drop-down list.
3. Paste the content of the template to the Template Data field and click **Next**.



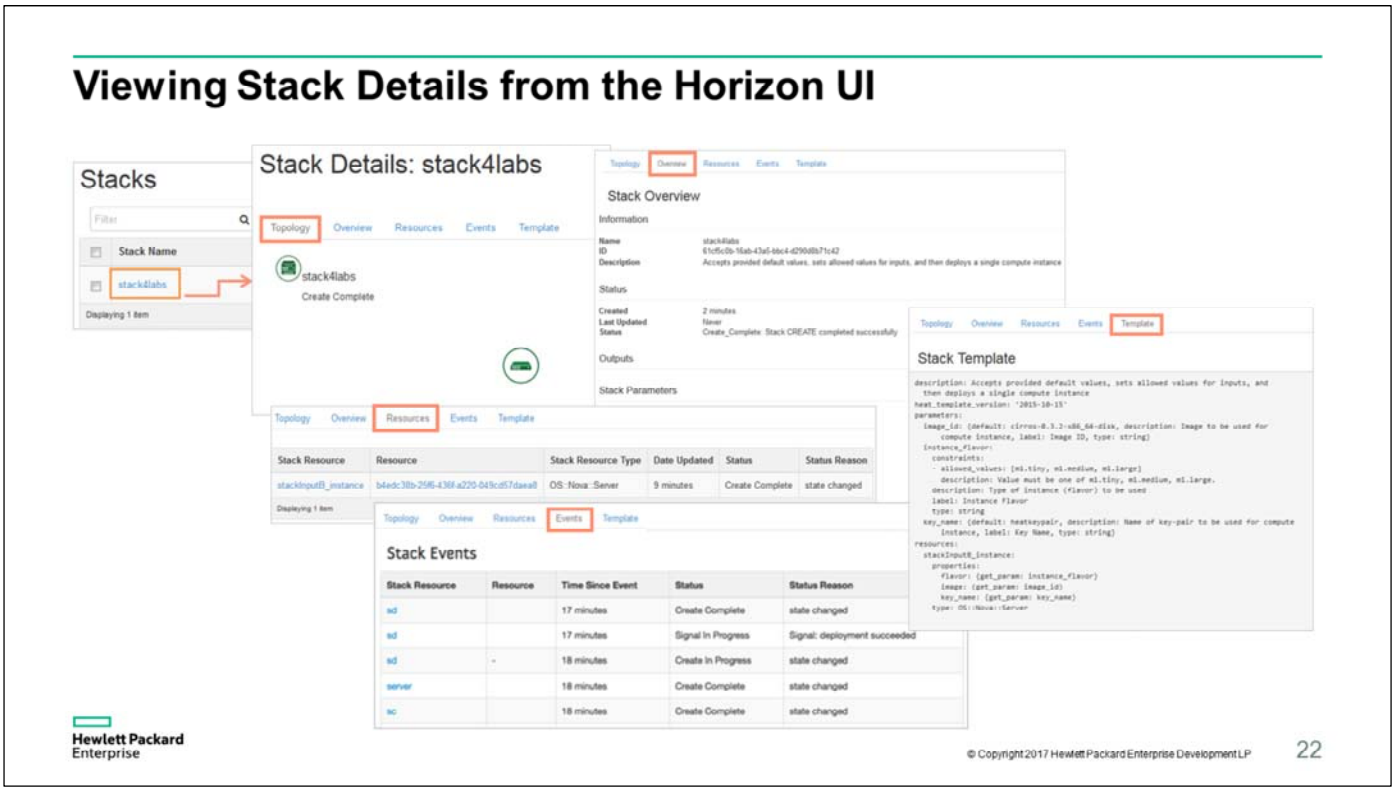
Launching a stack from the Horizon UI (3 of 3)

To launch a stack, you have to enter all of the required information in the launch stack dialog. The required information reflects the parameters defined in the `server:` section of the template you have provided. For example, the screenshot is based on a Heat template with a `server:` section that looks like this:

```
server:
    type: OS::Nova::Server
    properties:
      image: {get_param: image}
      flavor: {get_param: flavor}
      key_name: {get_param: key_name}
      user_data_format: SOFTWARE_CONFIG
```

This means that some of the required parameters have to be defined or created before you can launch a new stack. All of the required information, such as the Universal Unique Identifiers (UUIDs), key names, and so on, can be obtained using either a command line or the GUI.

After you have populated all of the required fields in the dialog, click **Launch** to initiate the new stack creation.



Viewing Stack Details from the Horizon UI

Depending on the level of complexity in the template and the speed of your hardware, the template creation might take some time. Using Horizon, you can monitor the instance creation initiated by Heat, and you can check the Stack Detail screen for a graphical representation of the template components. During the template creation process, the components that are already configured have a steady green color, and the components that are currently being configured flash in gray.

Troubleshooting Heat

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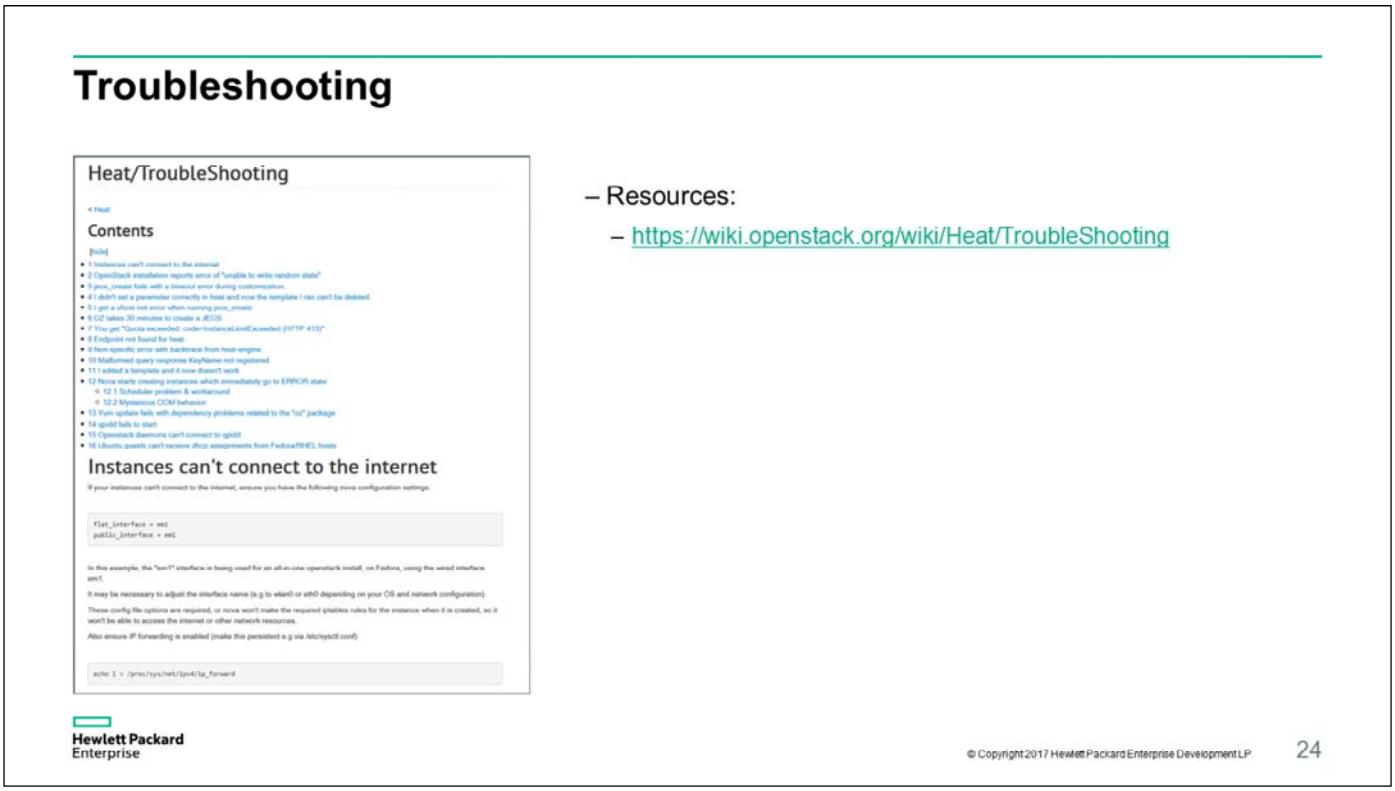


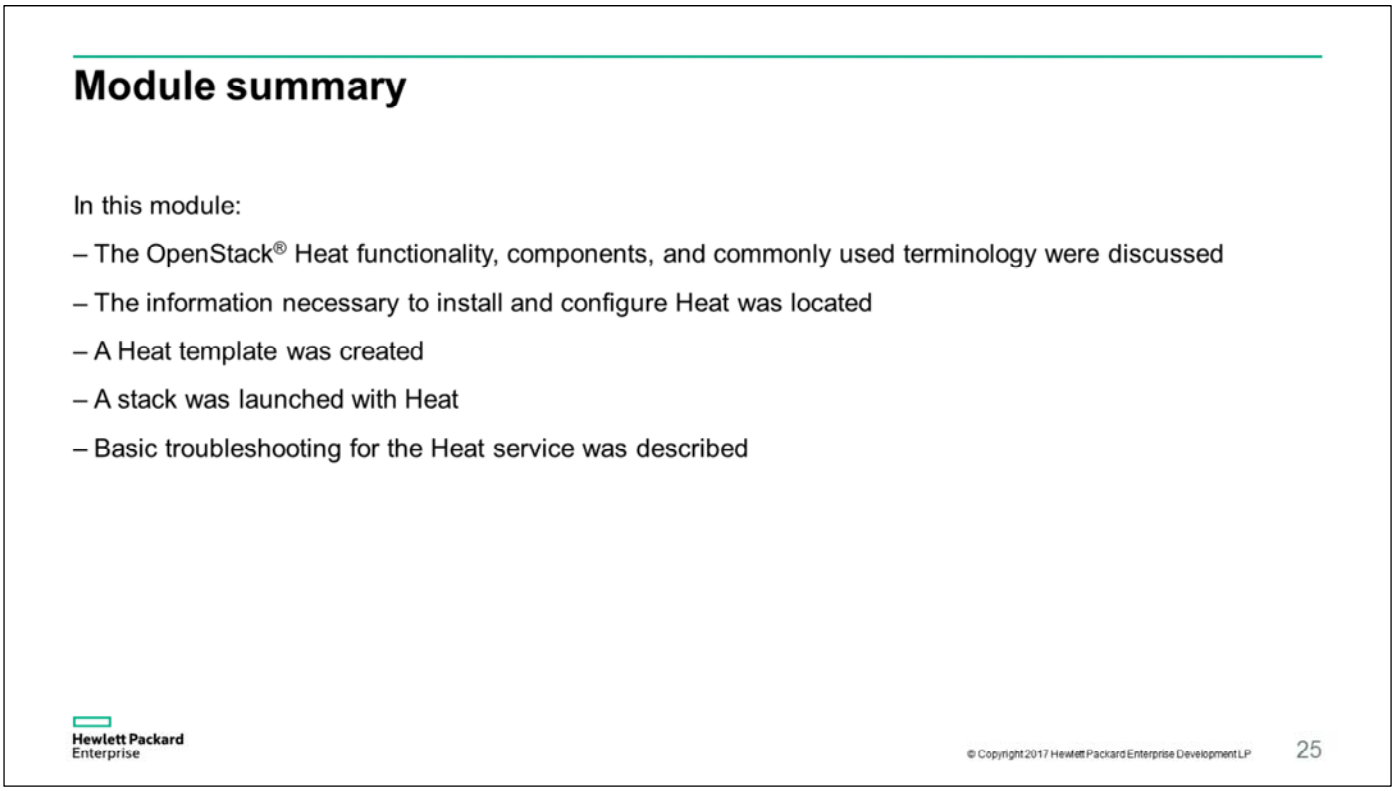
Troubleshooting

Troubleshooting problems with the Orchestration service is not an easy task, because Heat provides configuration for the whole stack in a single template file. Therefore, problems might occur at any level.

This section describes some of the common orchestration problems and their solutions:

- Instances cannot connect to the Internet
  - Check if you have enabled IP forwarding on your compute nodes by entering:
    `echo 1 > /etc/sys/net/ipv4/ip_forward`
  - Define the public and private interface names in `/etc/nova/nova.conf`. Adjust the name of your interface according to your local setup:
    ```
    flat_interface = eth0
    public_interface = eth0
    ```
- The OpenStack® installation reports an error of “unable to write random state”
  - If you are executing the `openstack` script as a non-root user, make sure that `~/.rnd` is owned by that user:
    ```
    stack@hpdevstack:~$ ls -l ~/.rnd
    -rw------- 1 stack stack 1024 Dec 23 17:09 /opt/stack/.rnd
    ```

For more information, see the Heat troubleshooting wiki at https://wiki.openstack.org/wiki/Heat/TroubleShooting.



Module summary

In this module:

- The OpenStack® Heat functionality, components, and commonly used terminology were discussed
- The information necessary to install and configure Heat was located
- A Heat template was created
- A stack was launched with Heat
- Basic troubleshooting for the Heat service was described

Learning check

Learning check

What two sections of a HOT template are required?

A. Resources

B. Parameters

C. Format version

D. Output

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Learning check

What two sections of a HOT template are required?

A. Resources

B. Parameters

C. Format version

D. Output

Learning check answer

What two sections of a HOT template are required?

A. Resources

B. Parameters

C. Format version

D. Output

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Learning check answer

What two sections of a HOT template are required?

A. Resources

B. Parameters

C. Format version

D. Output

Learning check

What is a Heat stack?

A. A collection of OpenStack® resources

B. The graphical representation of the orchestration template

C. The file describing bundled OpenStack® resources

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Learning check

What is a Heat stack?

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Learning check answer

What is a Heat stack?

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B. The graphical representation of the orchestration template

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Learning check answer

What is a Heat stack?

A. A collection of OpenStack® resources

B. The graphical representation of the orchestration template

C. The file describing bundled OpenStack® resources

Learning check

What service is provided by Heat?

A. SaaS

B. PaaS

C. IaaS

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Learning check

What service is provided by Heat?

A. SaaS

B. PaaS

C. IaaS

Learning check answer

What service is provided by Heat?

A. SaaS

B. PaaS

C. IaaS

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Learning check answer

What service is provided by Heat?

A. SaaS

B. PaaS

C. IaaS


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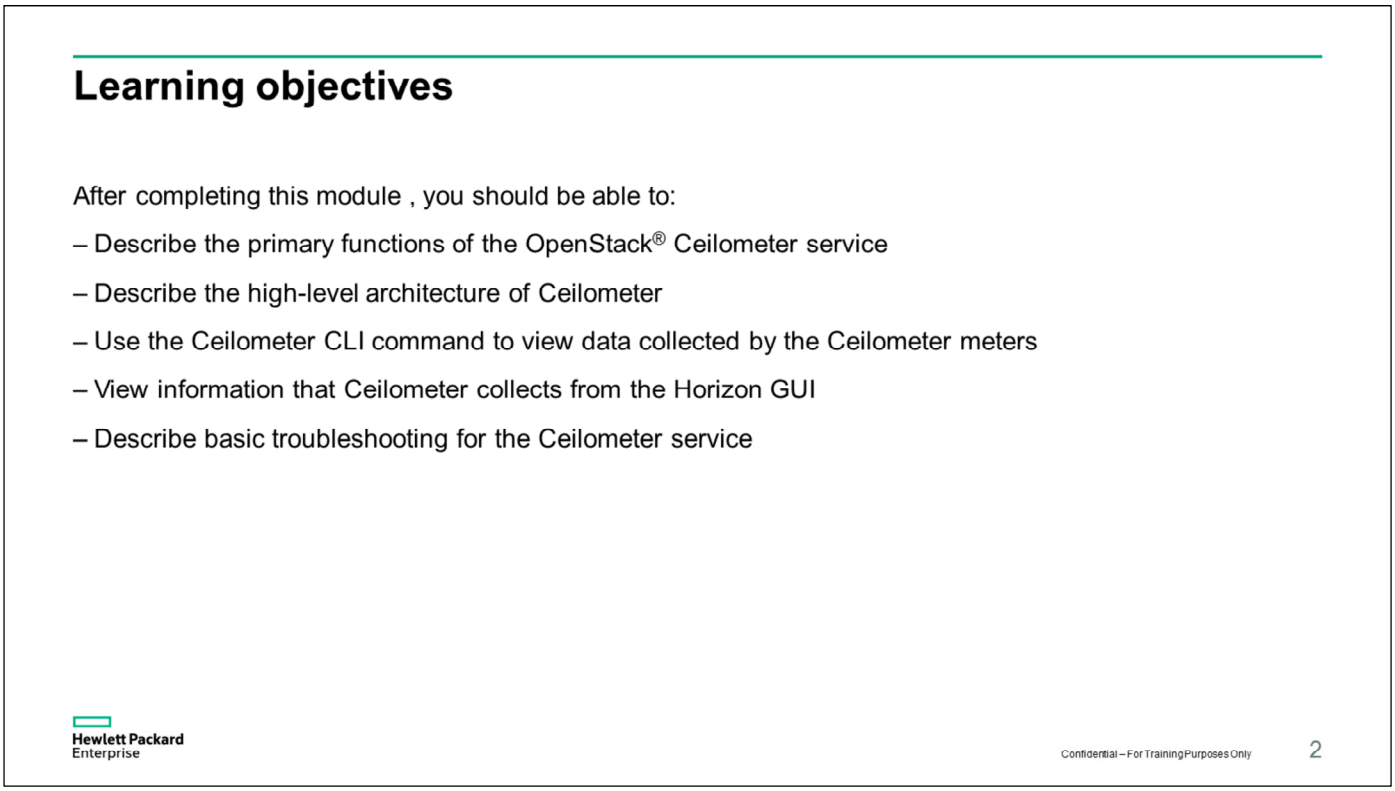
Fundamentals of
OpenStack® Technology
Module 11—OpenStack® Telemetry Service (Ceilometer)
H6C68S E.01



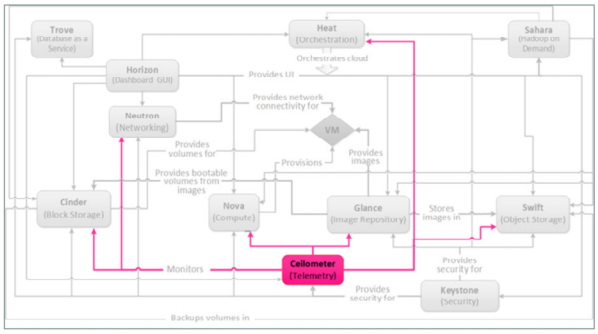
Learning objectives

After completing this lab, you should be able to:

- Describe the primary functions of the OpenStack® Ceilometer service
- Describe the high-level architecture of Ceilometer
- Use the Ceilometer CLI command to view data collected by the ceilometer meters
- View information that Ceilometer collects from the Horizon GUI
- Describe basic troubleshooting for the Ceilometer service

Ceilometer overview

Ceilometer functionality



- An OpenStack® project for providing metering information about cloud performance and utilization for billing, benchmarking, scalability, and statistics purposes
  - Provides efficient collection of metering data
  - Can be integrated with the metering system directly or by replacing components
  - Collects data through notifications and by polling the infrastructure
  - The type of data collected can be configured
  - Data is obtained through the REST API
  - Metering messages are signed and cannot be repudiated

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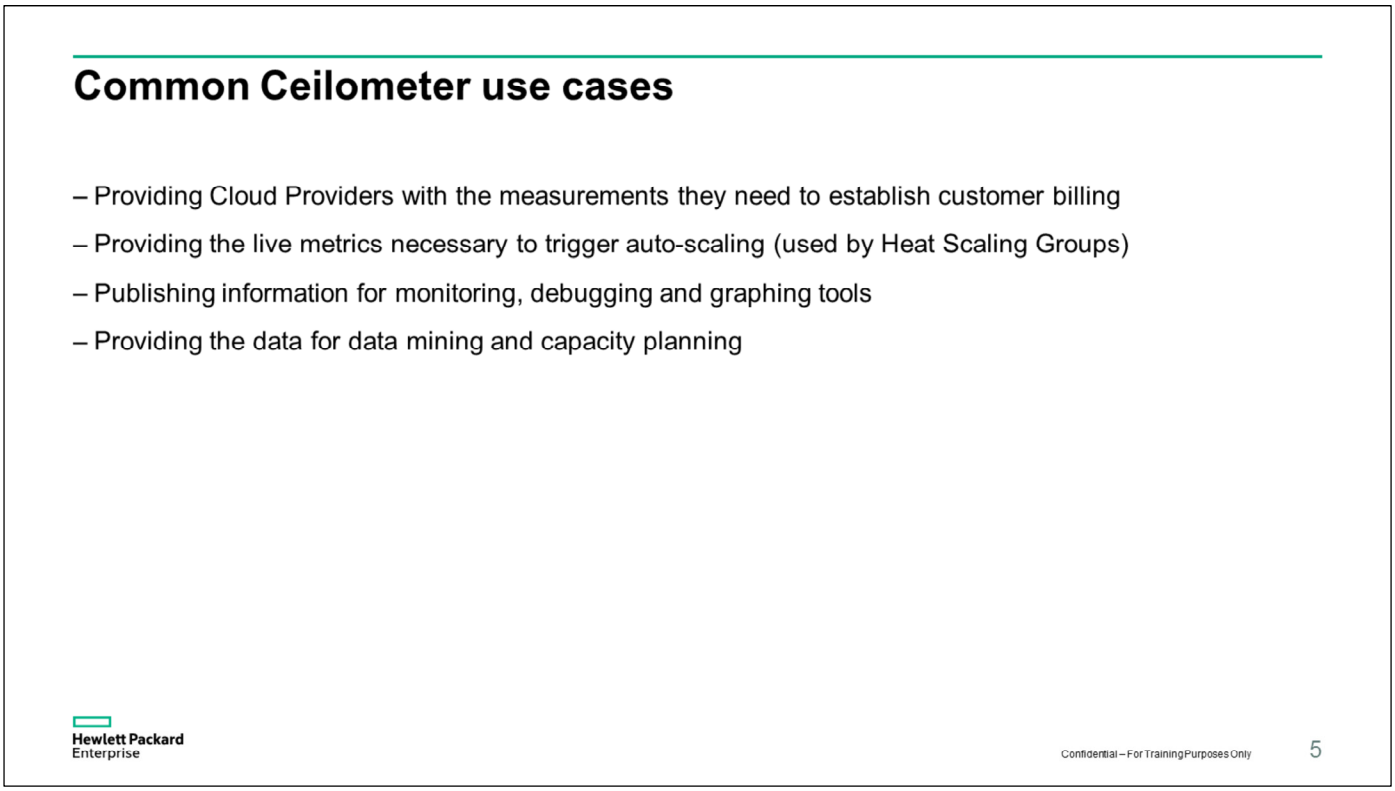
Ceilometer functionality

Because OpenStack® provides Infrastructure as a Service (IaaS), it is necessary to be able to meter its performance and utilization for billing, benchmarking, scalability, and statistics purposes. The Ceilometer project provides a single point of contact for billing systems to acquire the measurements needed to establish your billing. This service currently works across all OpenStack® core components.

Ceilometer provides efficient collection of metering data, in terms of processor (CPU) and network costs. It enables those who deploy it to integrate it with the metering system directly or by replacing components, and to configure the type of data collected to meet their operating requirements.

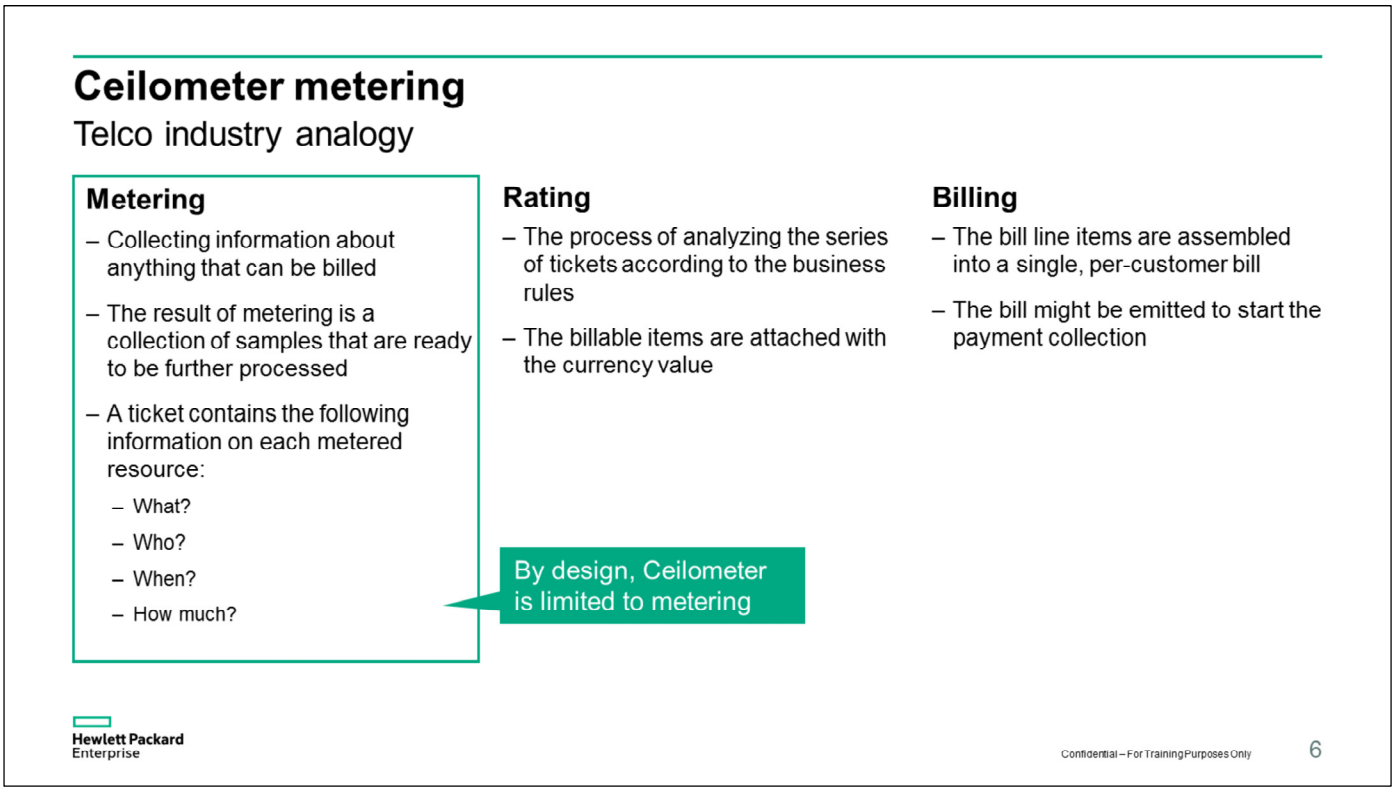
Data can be collected by monitoring the notifications sent from existing services or by polling the infrastructure. The data collected by the metering system is made visible to some users through a Representational State Transfer (REST) API. Metering messages are signed and cannot be repudiated.



Common Ceilometer use cases

Some of the common ceilometer cases are:

- Providing Cloud Providers with the measurements they need to establish customer billing
- Providing the live metrics necessary to trigger auto-scaling (used by Heat Scaling Groups)
- Publishing information for monitoring, debugging and graphing tools
- Providing the data for data mining and capacity planning



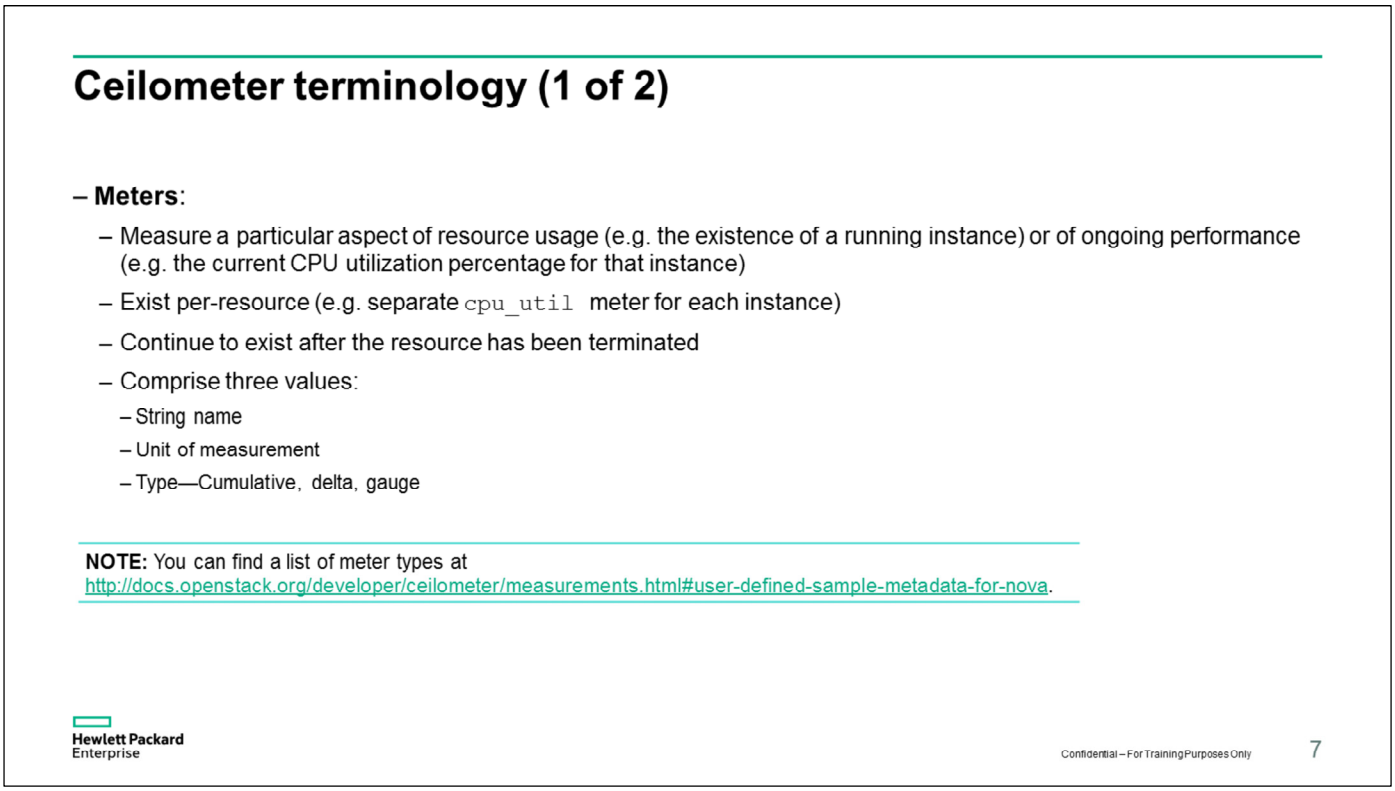
Ceilometer metering

Telco industry analogy

To better understand what can be done with the collected data and how the metering process works, this example divides a billing process into three steps that are commonly used in the Telco industry. The three steps are typically defined as follows:

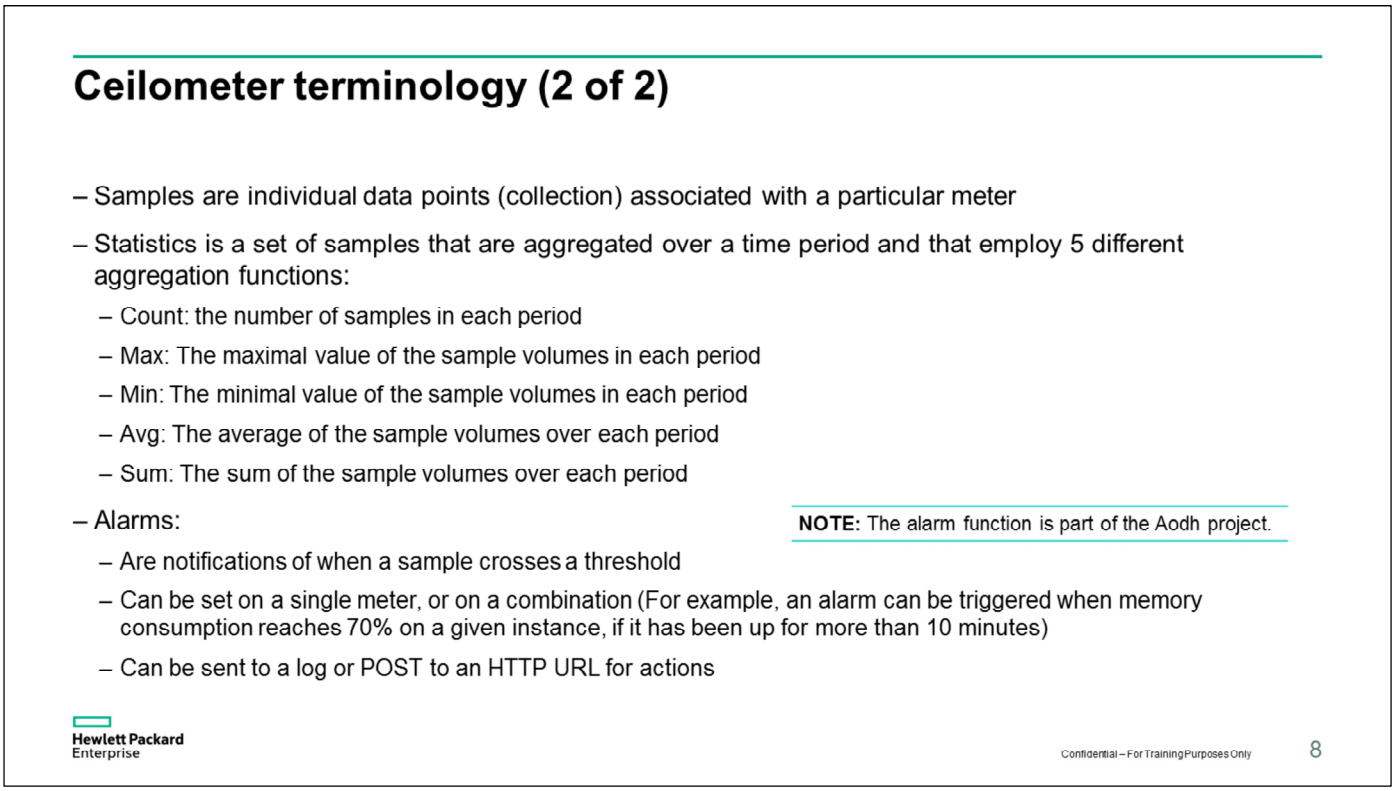
- **Metering:** Collecting information about anything that can be billed
- **Rating:** Analyzing the series of tickets according to the business rules
- **Billing:** Assembling the bill line items into a single, per-customer bill

Ceilometer is limited to the metering function. The decision not to go into rating or billing was made at the beginning, because the variety of private and public clouds seemed too broad for the project to ever deliver a solution that would meet all possibilities. However, you can use Ceilometer data and the Ceilometer API to build your own billing system that does more than metering.



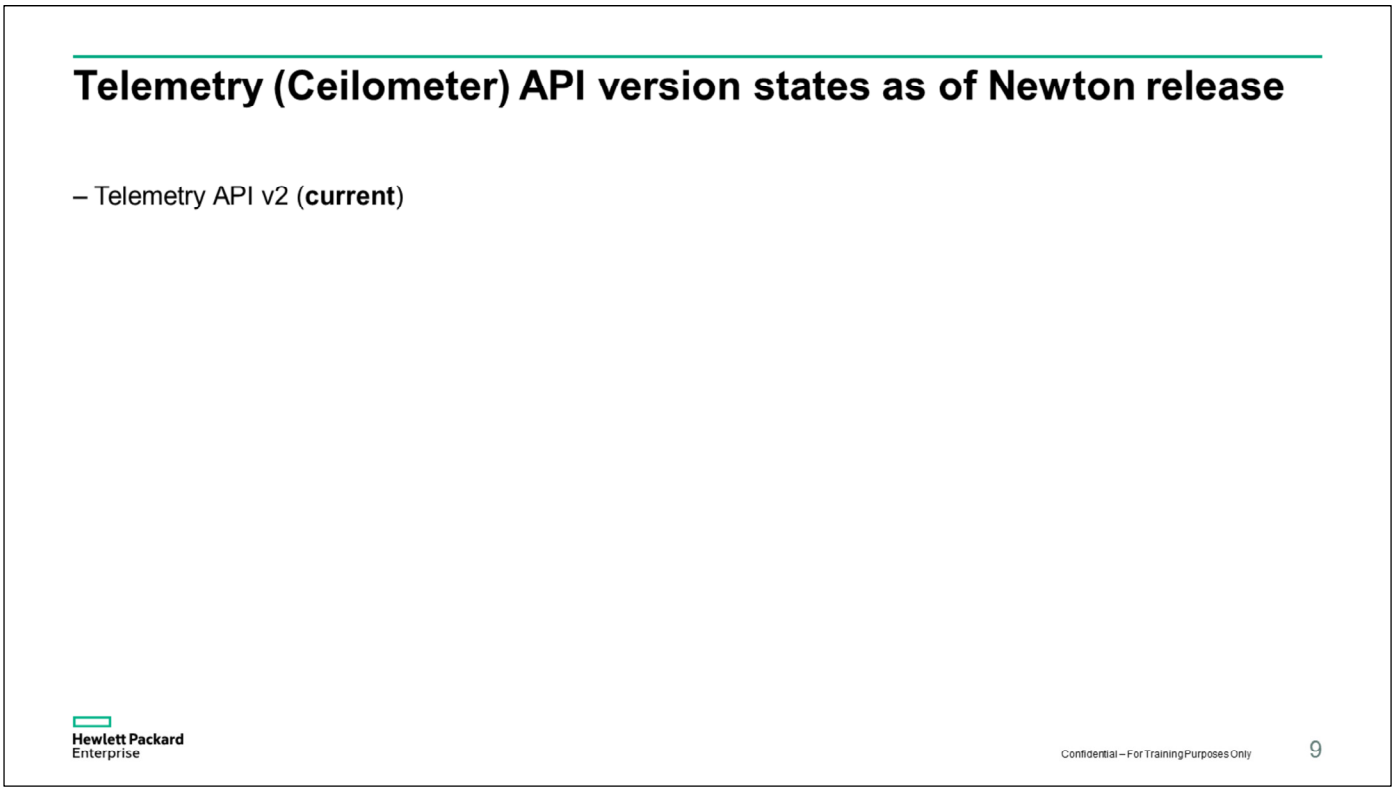
Ceilometer terminology (1 of 2)

Ceilometers meters measure a particular aspect of resource usage (for example, the existence of a running instance) or of ongoing performance (for example, current CPU utilization percentage for that instance). Meters exist per-resource and they continue to exist after the resource has been terminated.



Ceilometer terminology (2 of 2)

Ceilometer samples are individual data points (collection) associated with a particular meter. A set of samples aggregated over a certain period of time is called “statistics.” Statistical information is aggregated by the maximal and minimal values, count, averages, and sums. Ceilometer alarms are triggered when a sample crosses a threshold. As of Liberty release (and in Newton), the alarm function is part of the Aodh project.

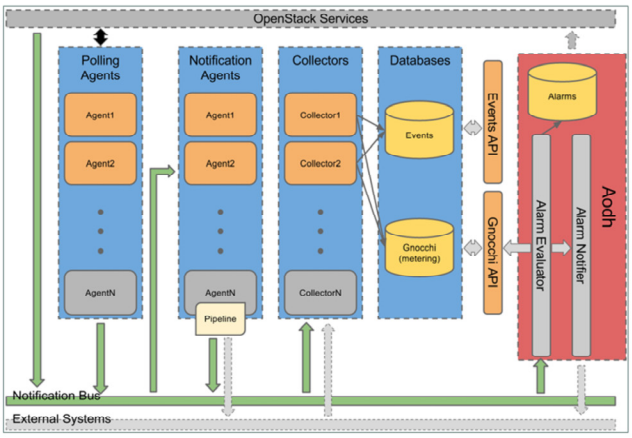


Telemetry (Ceilometer) API version states as of Newton release

In Newton release, Telemetry API is at the version 2.

Ceilometer architecture

Ceilometer architectural components



NOTE: The diagram above is taken from http://docs.openstack.org/developer/ceilometer/architecture.html

- Each Ceilometer service is designed to scale horizontally
  - **Polling agents** poll systems and publish metering messages
  - **Notification agents** is a daemon designed to listen to notifications on message queue, convert them to events and samples, and apply pipeline actions
  - **Collectors** read metering messages and send data through dispatchers
  - **Events API** queries and views data recorded by the collector service DBs
  - **Gnocchi** is an OpenStack® project developed to capture metering data in a time series database
  - **Aodh** is OpenStack® project designed to manage alarms and notifications

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Ceilometer architectural components

Ceilometer collects data from core OpenStack® projects to produce metering data (samples). Almost every part of Ceilometer is designed to support plug-in extension. The polling agent plug-ins poll services and generate metering data. The notification agent plug-ins receive notification messages and use the notifications to generate metering data.

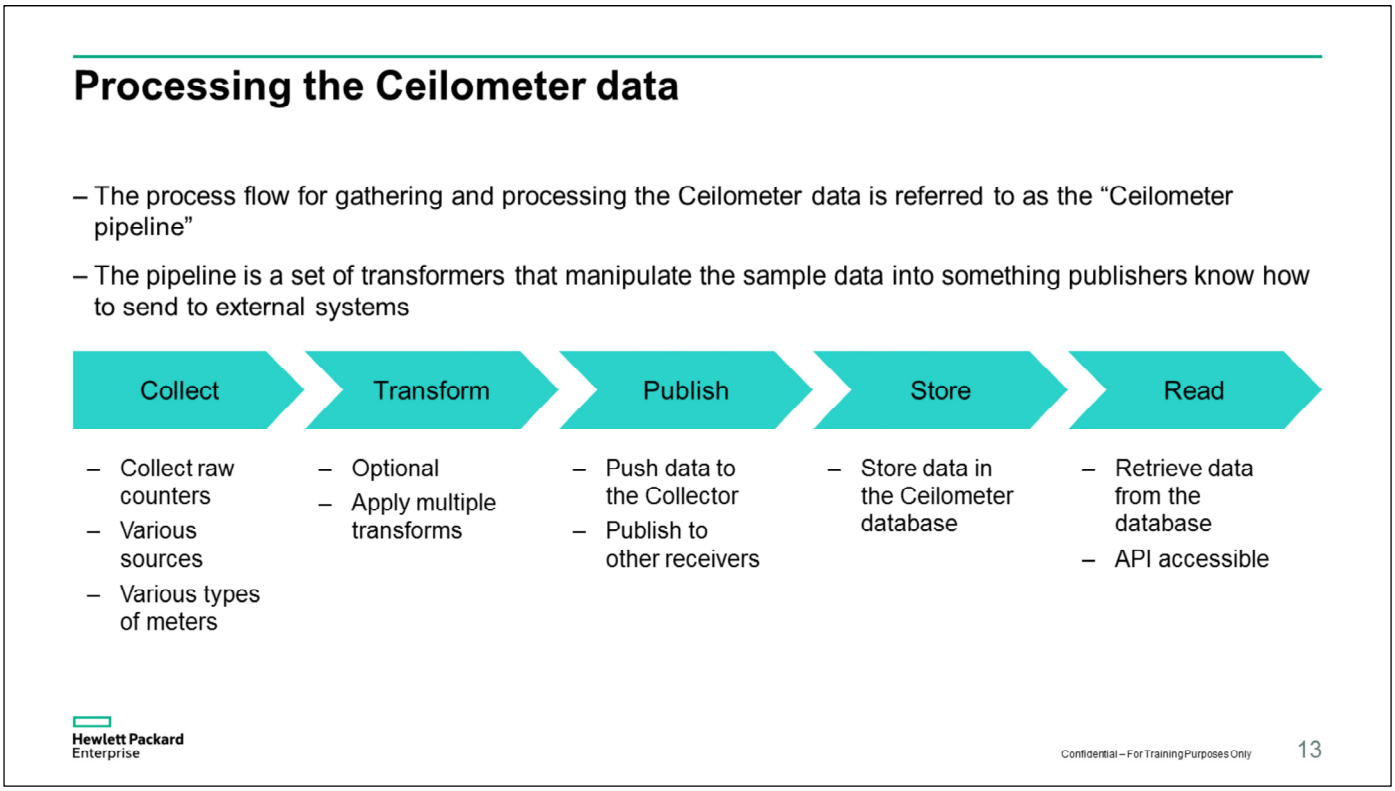
Metering data is emitted through queues and, optionally, to external services. The Collector supports the collector plug-ins which receive metering data and emit it to the collector dispatchers. The Collector supports multiple dispatchers of various types, including databases (at least one of which typically updates the main Ceilometer database), files in the filesystem, and HTTP endpoints. Plug-in polling agents, notification agents, collectors and dispatchers can be created easily and added to a running Ceilometer system.

Polling and notification pipelines allow transformer plug-ins to modify metering data. Multiple transformers can be connected in a pipeline. Pipelines end with dispatcher plug-ins which emit metering data at the end of the pipeline. Multiple dispatchers can be connected to send sample data to various locations (RabbitMQ, UDP Multicast, and so on).

Ceilometer consists of the following components:

- **ceilometer-acentral**: Runs on one or more central management servers and loads polling agent plug-ins to poll for resource utilization and emit metering data
- **ceilometer-acompute**: Polling agent that runs on each compute node and polls for compute instance resource utilization statistics
- **ceilometer-aipmi**: Intelligent Platform Management Interface, for board sensors and Intel node data
- **ceilometer-anotification**: Runs on one or more central management servers, loads notification agent plug-ins to read notifications and emit metering data

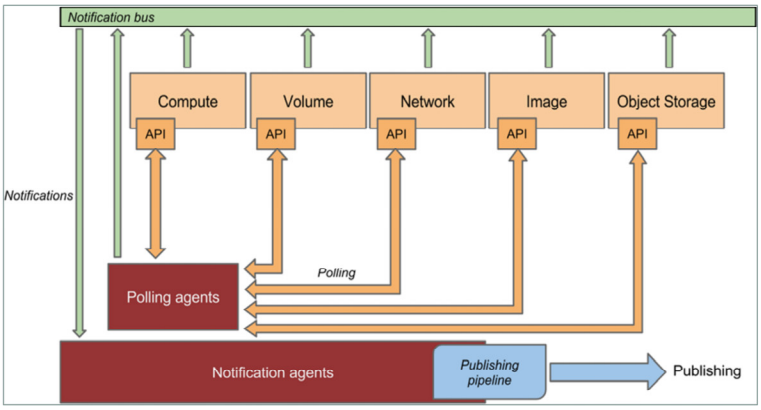
- **ceilometer-collector**: Runs on one or more central management servers, loads collector plug-ins to read metering data, and emits data to dispatcher plug-ins (database writers, file writers, HTTP writers, and so on)
- **ceilometer-api**: REST API server that runs on one or more central management servers to provide access to the data from the Ceilometer database
- **aodh**: Aodh alarm service (for Ceilometer)
- **aodh-api**: Aodh REST API (runs under Apache)
- **aodh-notifier**: Aodh/Ceilometer alarm notifier
- **aodh-evaluator**: Aodh/Ceilometer alarm evaluator
- **aodh-listener**: Aodh listener



Processing the Ceilometer data

Ceilometer employs a workflow that collects, transforms, publishes, and stores data in a database. The process flow for gathering and processing the Ceilometer data is referred to as the “Ceilometer pipeline.” The pipeline is a set of transformers that manipulate the sample data into something publishers know how to send to external systems.

Ceilometer data collection



- The Ceilometer project uses three methods to collect data:
  - **Notification agents** use the bus listener agent to take events generated on the notification bus and transform them into Ceilometer samples (**the preferred method** of data collection)
  - **Polling agents** poll some API or other tool to collect information at a regular interval (not the preferred option due to the load it can impose on the API services)
  - **Push agents** are added to each node to be monitored and used to push data to the collector (not shown in the diagram)

NOTE: The diagram above is taken from http://docs.openstack.org/developer/ceilometer/architecture.html

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Ceilometer data collection

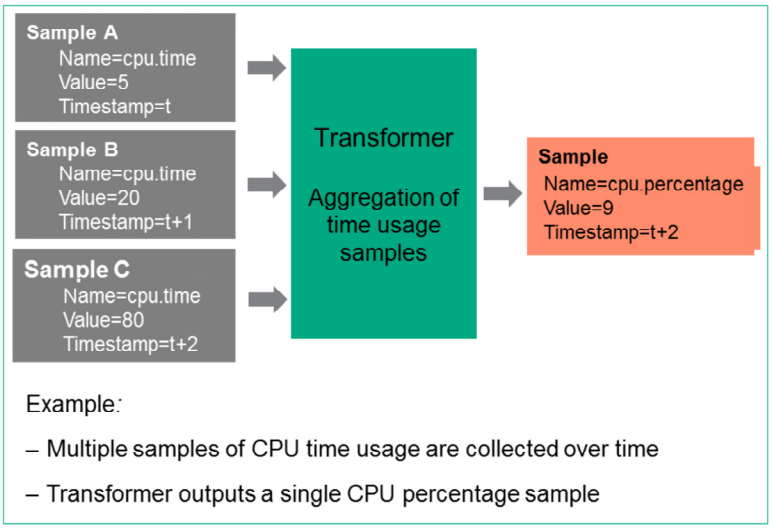
OpenStack® maintains a common notification bus (called Oslo). Each OpenStack® project can publish data on that bus. The Ceilometer Collector contains a listening agent that gathers data messages from the bus.

In theory, every project would send events on the Oslo bus about any metric of interest; however, not all projects have implemented this functionality, so you must instrument other tools that do not use the same bus. To overcome this, Ceilometer supports three independent data collection methods:

- **Bus listener agent**—Takes events generated on the Oslo notification bus and transforms them into Ceilometer samples. This is the preferred method of data collection.
- **Polling agents**—Poll an API or other tool to collect information at a regular intervals. The main drawback is that this method is not resilient.
- **Push agents**—Fetch data from projects that do not otherwise expose the required data in a remotely useable way. This process adds complexity by requiring a component to be added to each of the nodes to be monitored. This method is preferred to polling agents because it is more resilient.

The first method is supported by the ceilometer-collector agent, which monitors the message queues for notifications and for metering data coming from the push and polling agents. The second and third methods rely on a combination of the ceilometer-central-agent, the ceilometer-compute-agent, and the Collector.

Transforming the Ceilometer data (optional)



- Transformers are used to gather data samples, manipulate them, and output the results into a form useful for some downstream consumer
- Polling and notifications agents gather a rich set of data, which, if combined with historical or temporal context, can be used to derive even more data
- Ceilometer offers various transformers which can be used to manipulate data in the pipeline
- Output from a transformer can be fed into other transformers

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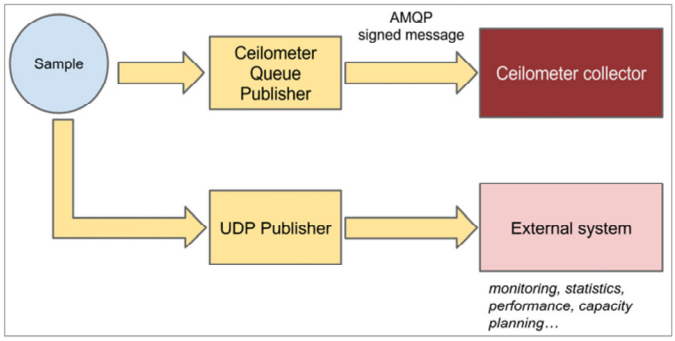
Transforming the Ceilometer data (optional)

Transformers are used to gather data samples, manipulate them, and output the results into a form useful for some downstream consumer. The polling and notifications agents gather a rich set of data which, if combined with historical or temporal context, can be used to derive even more data.

Ceilometer offers various transformers which can be used to manipulate data in the pipeline. The output from a transformer can be fed into other transformers.

Publishing the Ceilometer data



– The above example shows the processed Ceilometer data being published to multiple destinations

– Processed data can be published using several different transports:
  – **Notifier**, a notification-based publisher which pushes samples to a message queue which can be consumed by the collector or an external system
  – **UDP**, which publishes samples using UDP packets
  – **Kafka**, which publishes data to a Kafka message queue to be consumed by any system that supports Kafka

NOTE: The diagram above is taken from http://docs.openstack.org/developer/ceilometer/architecture.html

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Publishing the Ceilometer data

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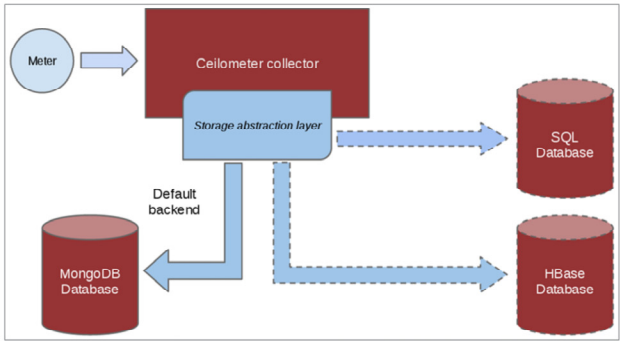
Storing the Ceilometer data



– The above example shows the processed Ceilometer data being published to multiple destinations

NOTE: The diagram above is taken from http://docs.openstack.org/developer/ceilometer/architecture.html

– Ceilometer uses a plug-in model to allow data to be stored to various types of database backends

– The Ceilometer database is divided into three separate connections:
  – Alarms
  – Events
  – Metering

– This allows a deployer to store all data within a single database or to divide the data into their own databases

– Ceilometer's storage service is designed to handle use cases where full fidelity of the data is required (e.g. auditing)

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Storing the Ceilometer data

Ceilometer uses a plug-in model to allow data to be stored to various types of database backends. The Ceilometer database is divided into three separate connections:

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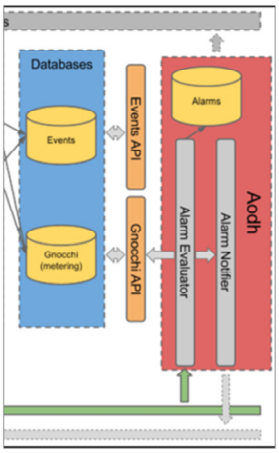
This allows a deployer to store all data within a single database or to divide data into their own databases. The Ceilometer storage service is designed to handle use cases where full fidelity of data is required (for example, auditing).

Ceilometer alarms (Aodh)



- Alarms enable Ceilometer to notify a receiver when a meter achieves a specified threshold value
- Setting alarms:
  - Set on a single meter or on a collection of meters
  - Set alarms from within instances (application alarms)
  - Use the CLI or API
- Notifications are triggered by reaching a sample value threshold
- Alarm actions:
  - Callback URL with parameters
  - Logging
- As of Liberty, alarming support (and subsequently its database) is handled by the OpenStack® Aodh project

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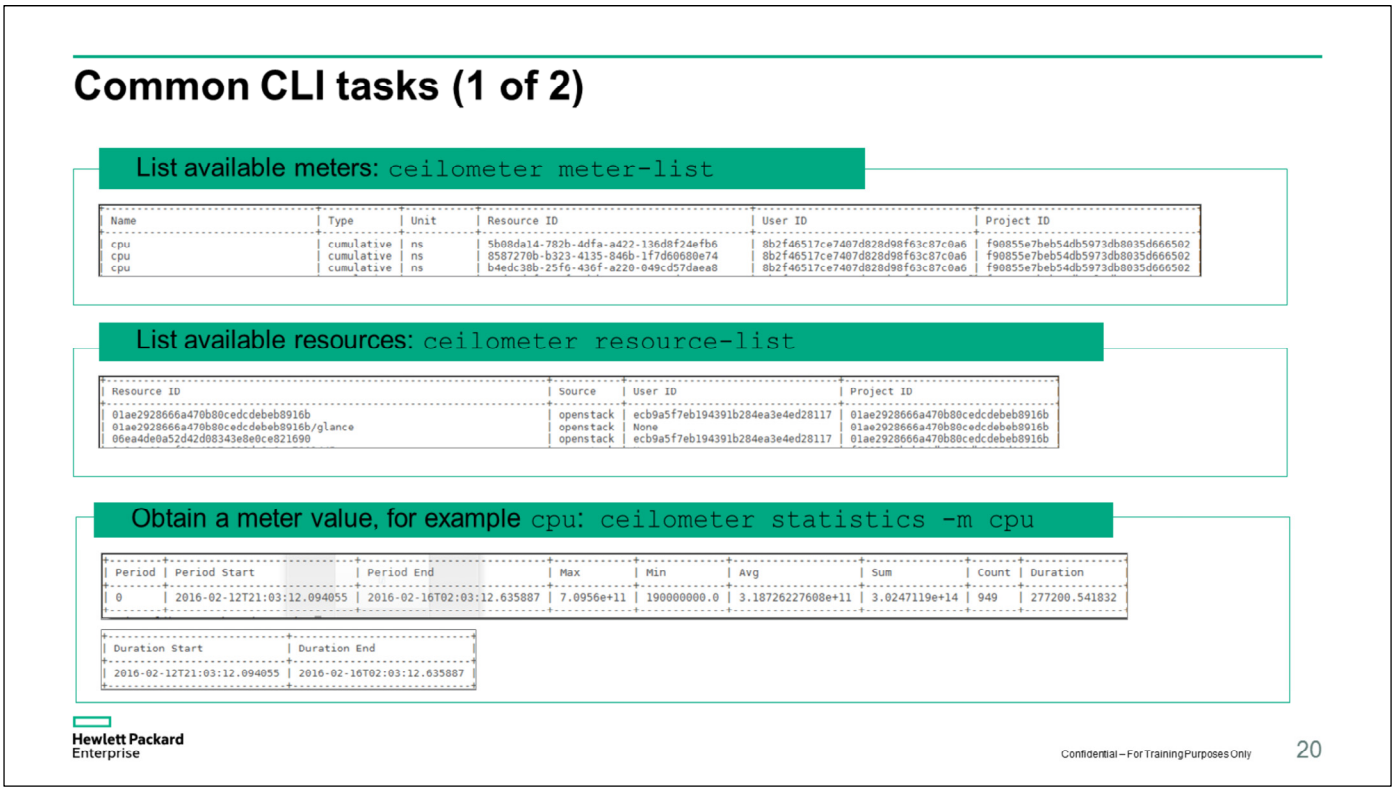
Ceilometer alarms (Aodh)

The alarm component of Ceilometer (first delivered in the Havana release) enables you to set alarms based on a threshold evaluation for a collection of samples. An alarm can be set on a single meter or on a combination of meters.

Example: You want an alarm to be triggered when the memory consumption reaches 70% on a given instance, if the instance has been up for more than 10 minutes. To set up this alarm, you would call the Ceilometer API server, specifying the alarm conditions and the action to take.

As of Liberty, alarming support, and subsequently its database, is handled by Aodh.

Common Ceilometer management tasks

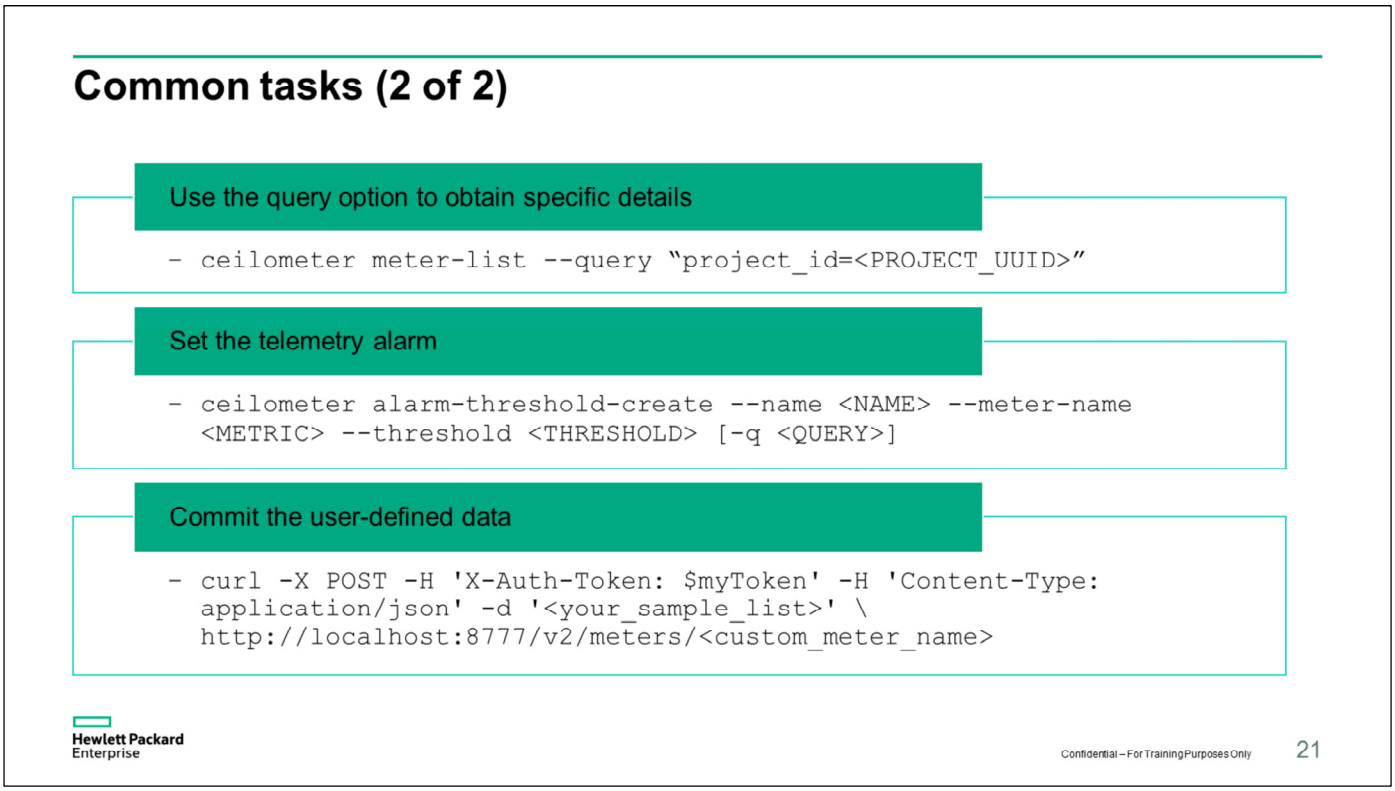


Common tasks (1 of 2)

To list available Telemetry meters, enter `ceilometer meter-list`.

To list available resources, enter `ceilometer resource-list`.

To obtain a meter value, enter `ceilometer statistics -m cpu`.



Common tasks (2 of 2)

To obtain details about a specific project, enter:

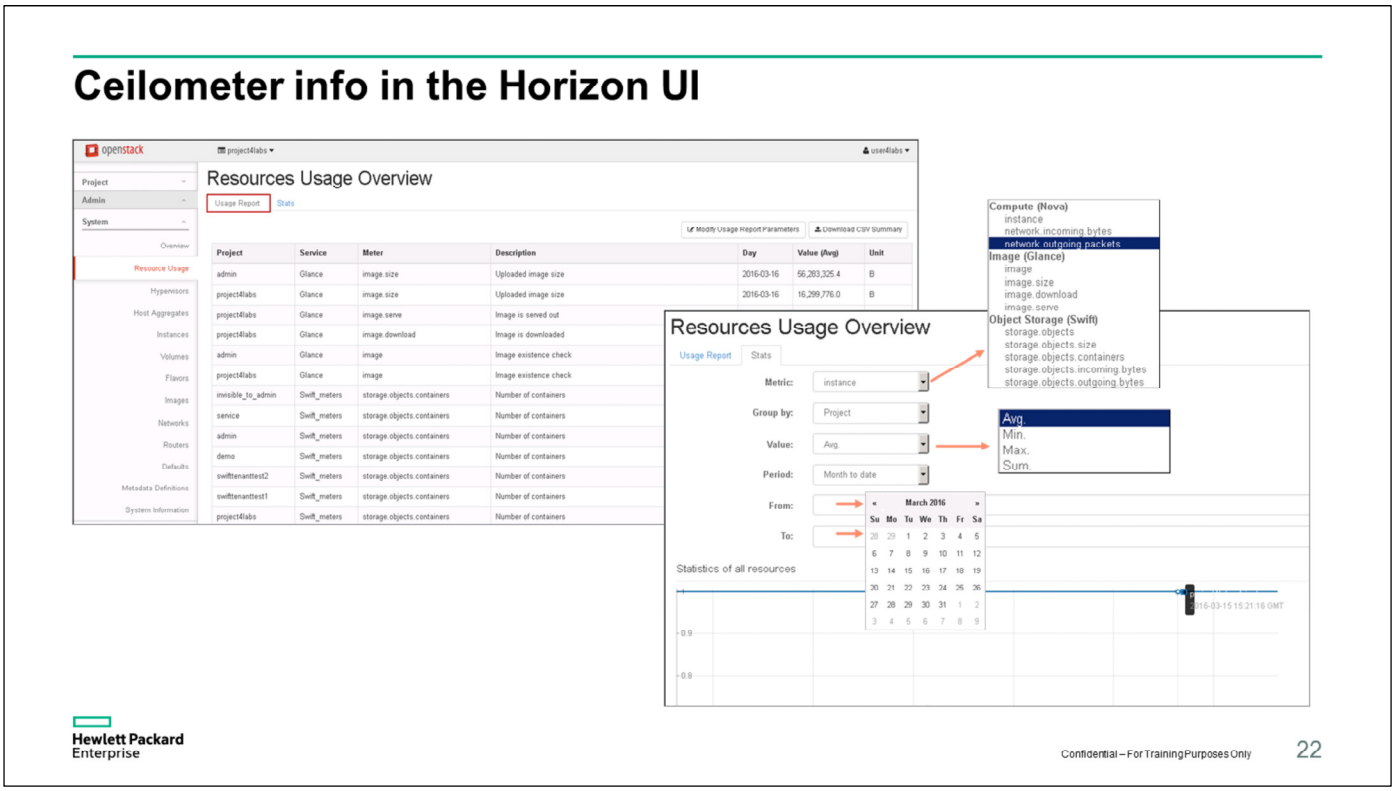
```
ceilometer meter-list --query "project_id=<PROJECT_UUID>"
```

To set the telemetry alarm, enter:

```
ceilometer alarm-threshold-create --name <NAME> --meter-name <METRIC> --threshold
<THRESHOLD> [-q <QUERY>]
```

To commit user-defined data, enter:

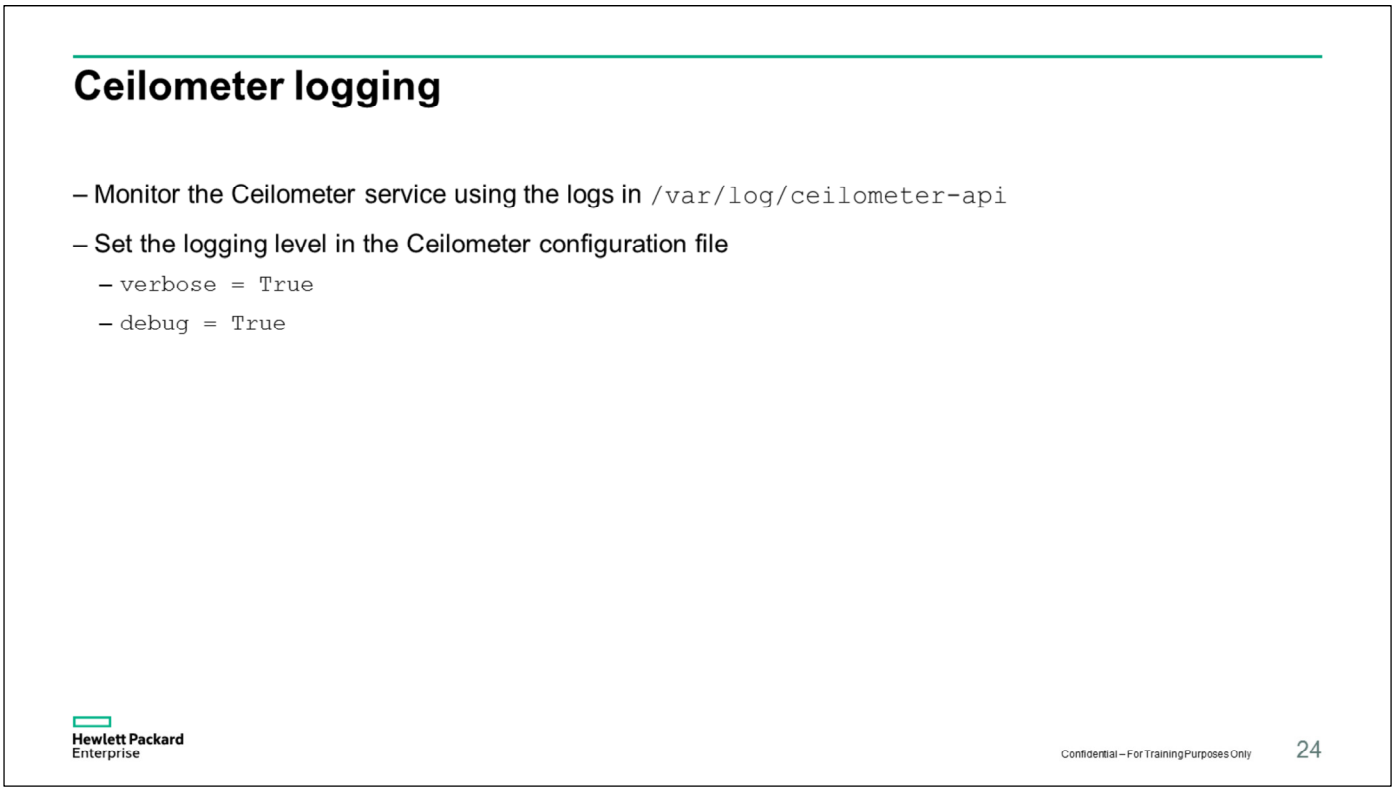
```
curl -X POST -H 'X-Auth-Token:$myToken' -H 'Content-Type: application/json'\ -d
'<your_sample_list>' http://localhost:8777/v2/meters/<custom_meter_name>
```



Ceilometer info in the Horizon UI

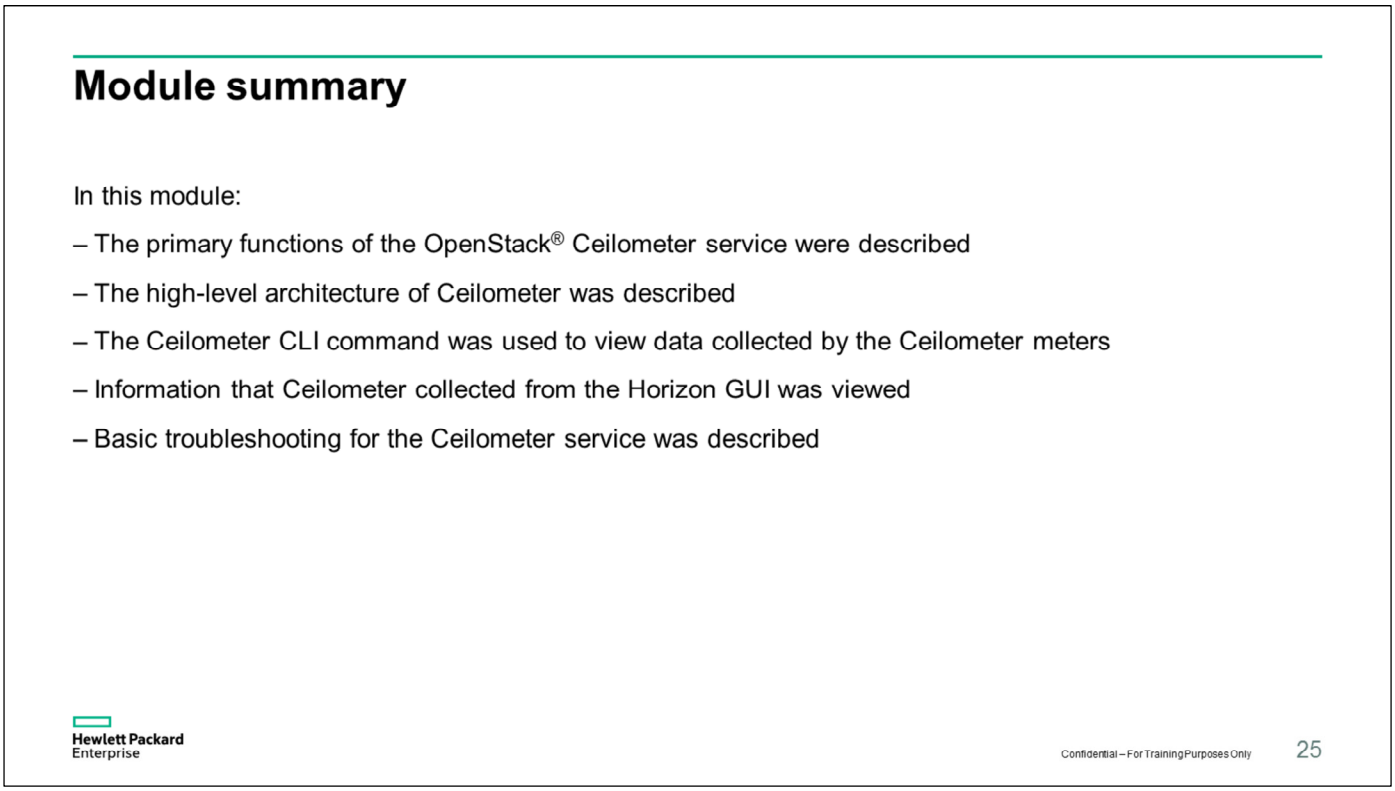
There are currently no Ceilometer settings that can be modified in the Horizon UI, but you can view information obtained by Ceilometer from the **Admin** → **System** → **Resource Usage** option. When clicked, the option displays the Resources Usage Overview screen that has two tabs to display the metered information, as shown in the above screenshot.

Ceilometer troubleshooting



Ceilometer logging

When the Ceilometer service is up and running, it can be monitored using the logs available at `/var/log/ceilometer-api`. The verbosity of the log output can be increased by using the `verbose` and `debug` options in Ceilometer configuration file.



Module summary

In this module:

- The primary functions of the OpenStack® Ceilometer service were described
- The high-level architecture of Ceilometer was described
- The Ceilometer CLI command was used to view data collected by the Ceilometer meters
- Information that Ceilometer collected from the Horizon GUI was viewed
- Basic troubleshooting for the Ceilometer service was described

Learning check

Learning check

To what category does the functionality of collecting samples (also known as “tickets”) belong?

A. Metering

B. Rating

C. Billing

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Learning check

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Learning check answer

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Learning check

What collection mode requires a component to be added to each node to be monitored?

A. Collection via notifications

B. Collection via pooling agents

C. Collection via push agents

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Learning check

Which new OpenStack® service now handles the alarm functions of Ceilometer?

A. Gnocci

B. Ironic

C. Aodh

D. Sahara

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Which new OpenStack® service now handles the time series database functions of Ceilometer?

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Hewlett Packard Enterprise

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Fundamentals of
OpenStack® Technology
Module 12—Other OpenStack® Projects
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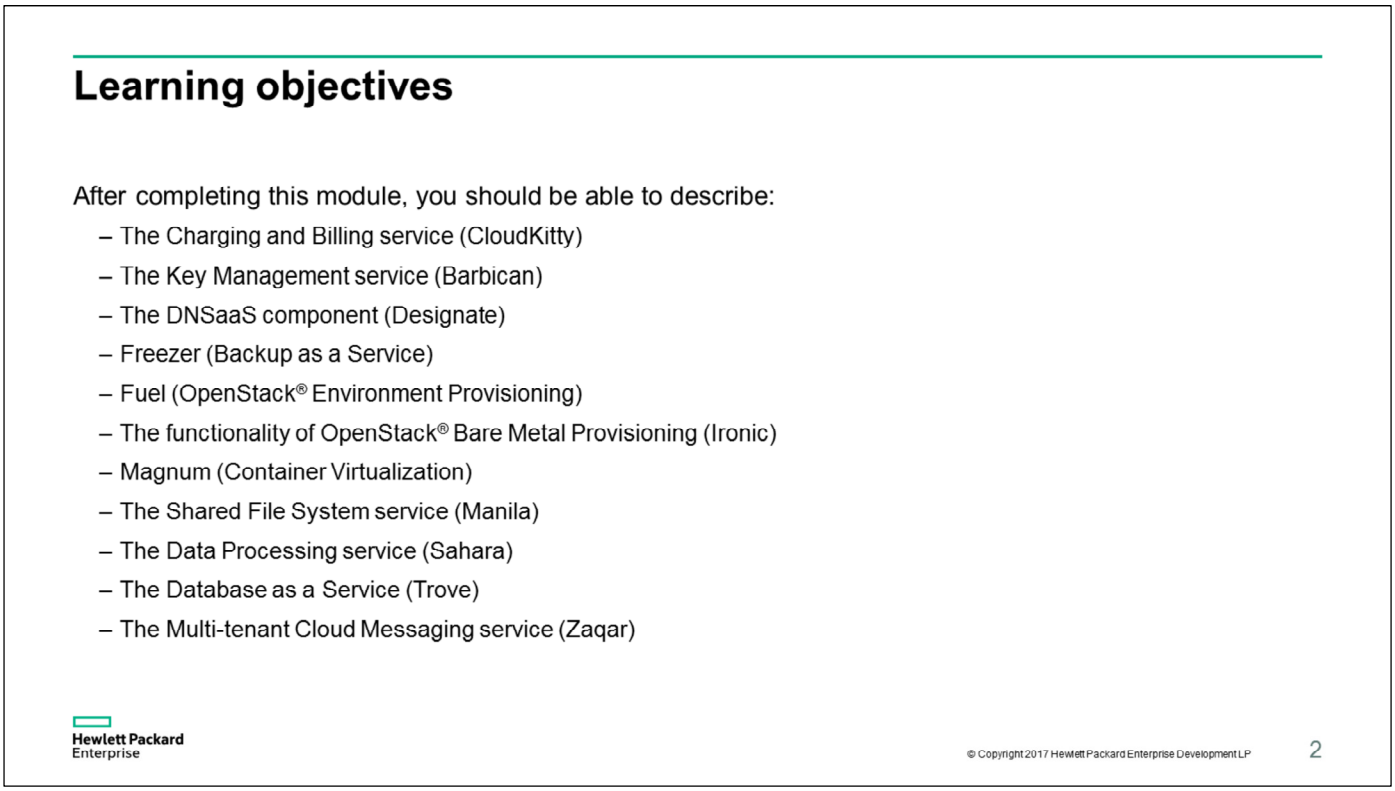

Learning objectives

After completing this module, you should be able to describe:

- The Charging and Billing service (CloudKitty)
- The Key Management service (Barbican)
- The DNSaaS component(Designate)
- Freezer (Backup as a Service)
- Fuel (OpenStack® Environment Provisioning)
- The functionality of OpenStack® Bare Metal Provisioning (Ironic)
- The Shared File System service (Manila)
- The Data Processing service (Sahara)
- The Database as a Service (Trove)
- The Multi-tenant Cloud Messaging service (Zaqar)

OpenStack® service course coverage

Core services covered in this course	Non-core services covered in this course	Non-core services covered in this module	Other services
– Cinder	– Ceilometer	– CloudKitty	– Chef
– Glance	– Heat	– Barbican	– Congress
– Keystone	– Horizon	– Designate	– Cue
– Neutron		– Freezer	– Fuel
– Nova		– Ironic	– Magnum
– Swift		– Manila	– Mistral
		– Sahara	– Monasca
		– Trove	– Ansible
		– Zaqar	– Puppet
			– Rally
			– Sanlin
			– Solum
			– Winstackers

NOTE: The most current list of OpenStack® projects and links to those projects are located at https://releases.openstack.org/newton/index.html#newton-cloudkitty.

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OpenStack® service course coverage

The table above lists some of the OpenStack® services. For the full list, please refer to https://releases.openstack.org/newton/index.html#newton-cloudkitty.

CloudKitty (Chargeback and Billing)

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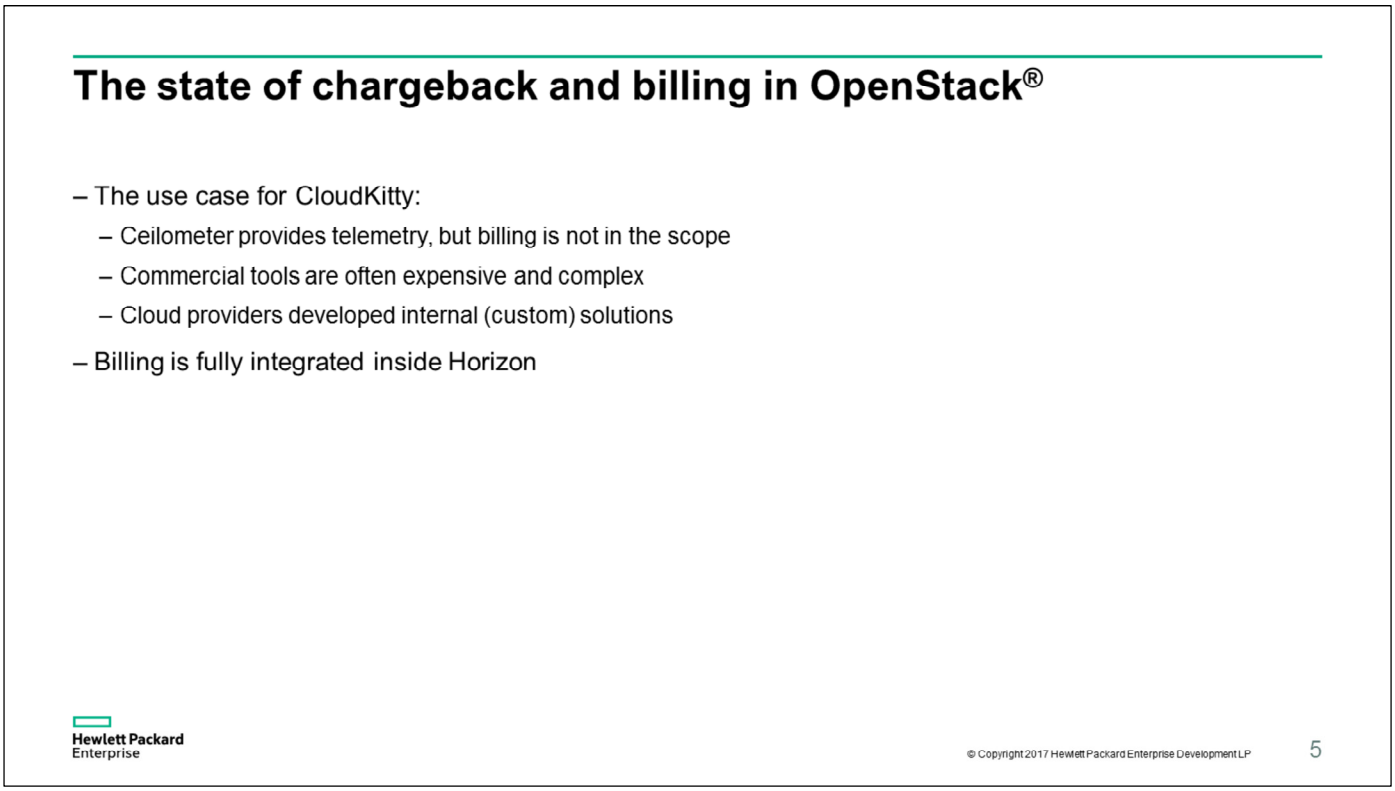

The state of chargeback and billing in OpenStack®

CloudKitty is an OpenStack® project that implements chargeback and billing based on the Ceilometer telemetry data. CloudKitty is built to address the following issues:

- Cloud providers have developed custom solutions for billing that are not applicable to OpenStack®.
- Commercial tools are often based on the complex infrastructure, and expensive to implement.

The user interface for chargeback and billing is fully integrated with Horizon.

Barbican (Key Management)

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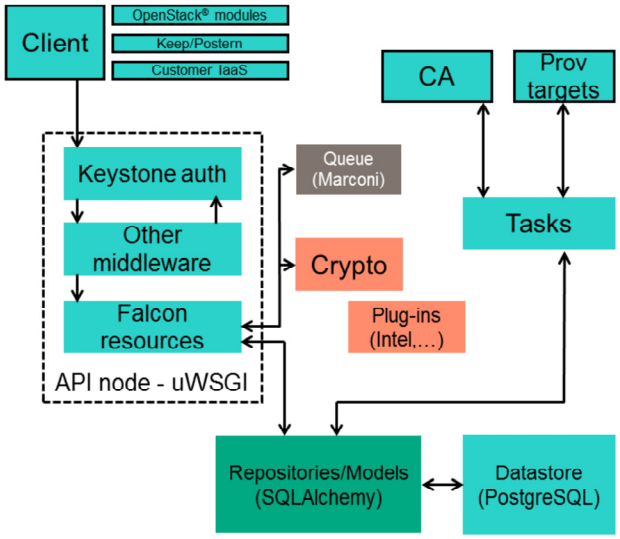
What is Barbican?

– A REST API designed for the secure storage, provisioning, and management of secrets
  – It is intended for use in all environments, including large ephemeral clouds

NOTE: See https://wiki.openstack.org/wiki/Barbican for links to the current project development status.



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What is Barbican?

Barbican is a REST API designed for the secure storage, provisioning, and management of secrets. It is aimed at being useful for all environments, including large ephemeral clouds.

Designate (DNS as a Service)

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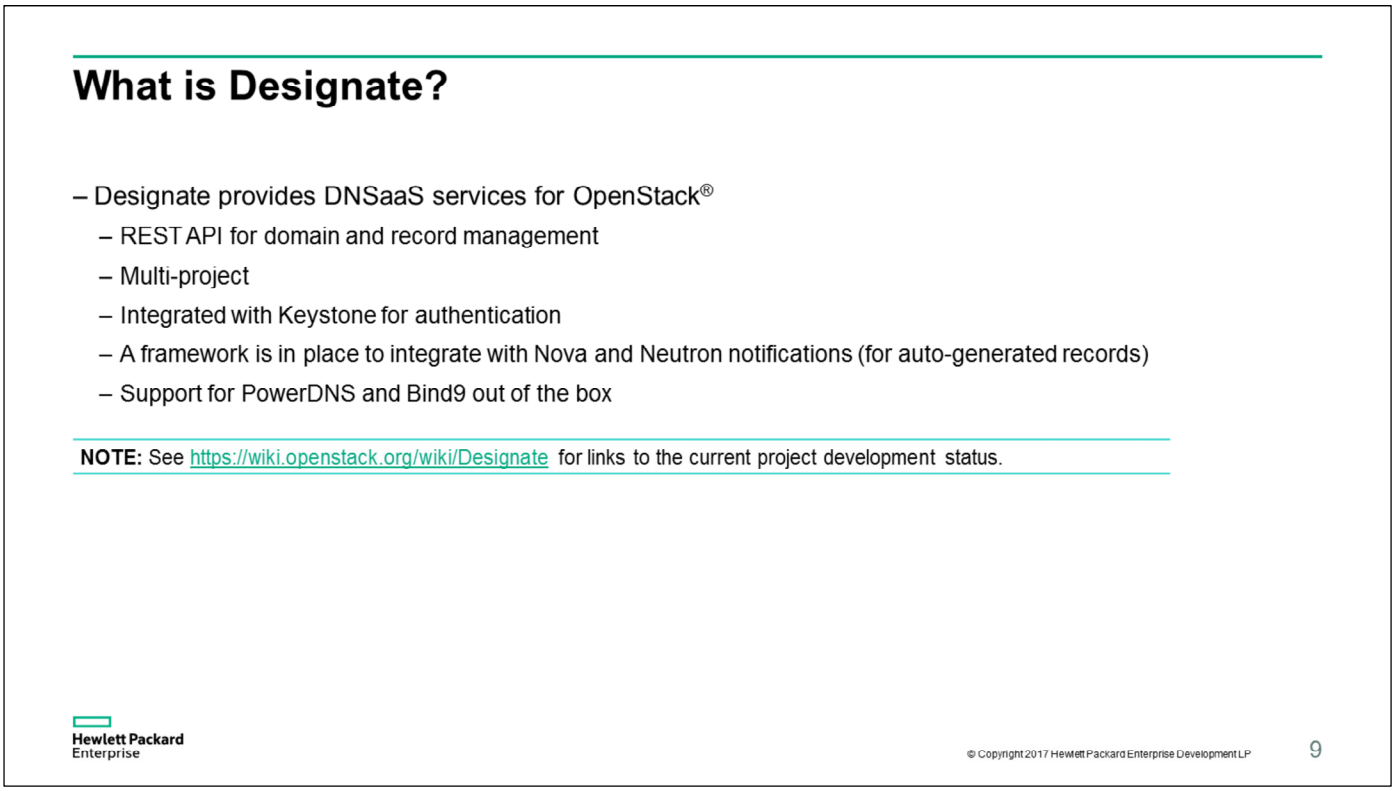

What is Designate?

Designate is a recently incubated OpenStack® project that is intended to solve the DNS needs of OpenStack® by providing a RESTful API for managing DNS data with a variety of databases on many different backends. Additionally, Designate provides a service for integrating with Nova and Neutron.

Designate is designed to provide several DNS-as-a-Service (DNSaaS) services for OpenStack®:

- REST API for domain and record management
- Multi-tenancy
- Integration with Keystone for authentication
- A framework to integrate with Nova and Neutron notifications (for auto-generated records)
- Support for PowerDNS and Bind9 out of the box

Freezer (Backup as a Service)

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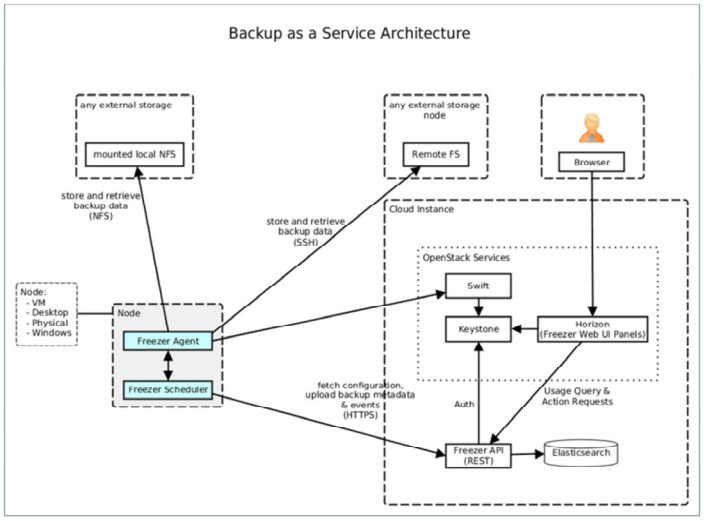
Backup as a Service architecture

- Freezer client components:
  - Freezer agent to perform the backup operation
  - Freezer scheduler to orchestrate a backup
- Freezer service components:
  - Freezer UI
  - Freezer API
- OpenStack® Swift for storage
- GNU Tar to execute backup and restore



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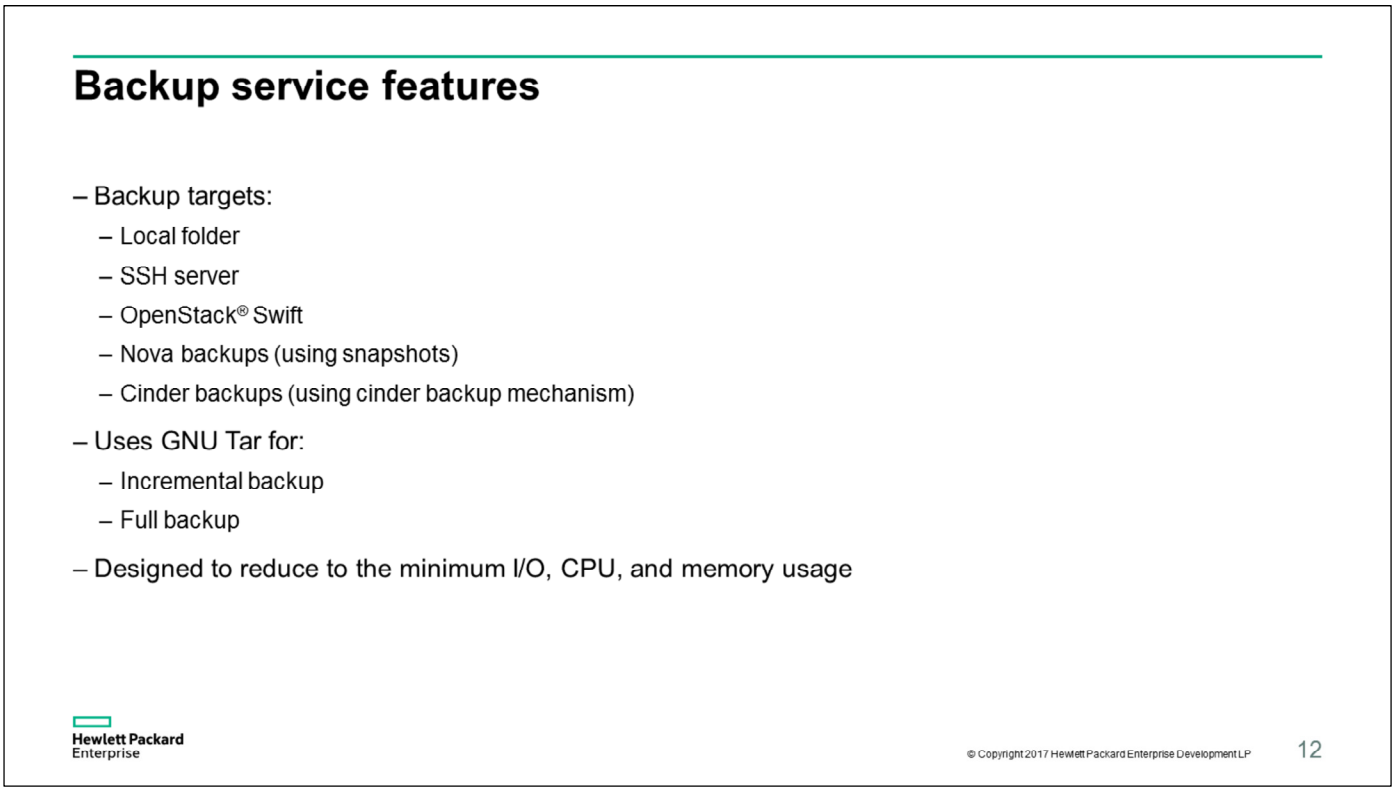
Backup as a Service architecture

Freezer has four different components: Freezer Web UI, Freezer scheduler, Freezer agent, and Freezer API. Freezer scheduler and Freezer agent are installed on the client side and Freezer web UI, Freezer API on OpenStack® controller server (The server where your Horizon and Keystone are installed).

Freezer agent is the CLI client that is used to commit jobs to the backup queue. The backup queue is managed by the backup scheduler. To offload the cloud controller server, both agent and scheduler processes are running on the compute node. The Freezer API component is running at the controller plane, to receive communication from agent and scheduler.

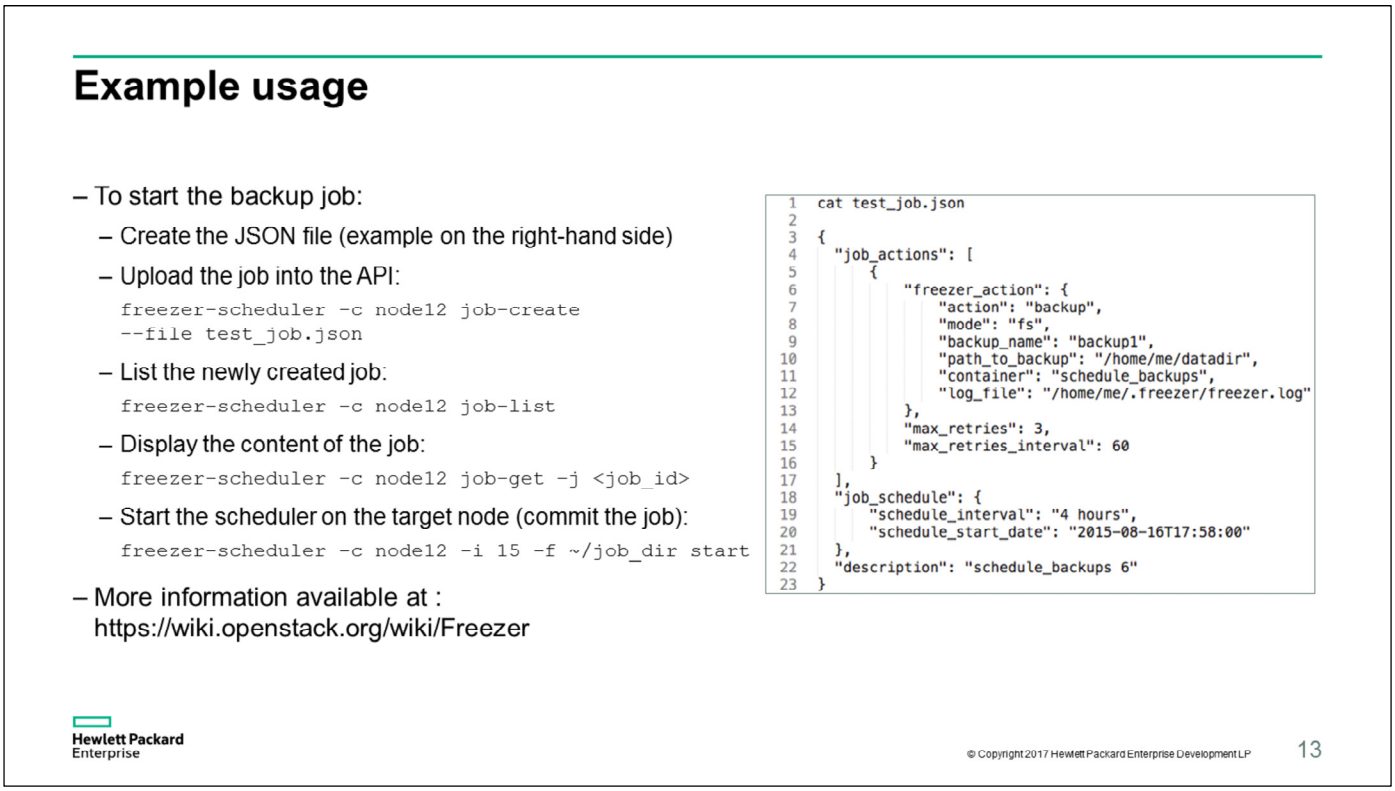


Backup service features

Freezer supports five types of backup targets (backup destinations to send data):

- Local folder—The directory on the local disk of the backup node
- SSH server—Remote SSH server which accepts data over the SSH protocol, and stores it on its local disk
- OpenStack® Swift storage—Freezer API sends the backup stream over the network to be stored as Swift object
- Nova—If you provide Nova arguments in the parameters, Freezer assumes that all necessary data is located on the instance disk and it can be successfully stored using Nova snapshot mechanism
- Cinder backups—Cinder has its own mechanism for backups, and Freezer supports it, but it also allows creating a Glance image from a volume and uploading to Swift

Freezer is designed to reduce to the minimum I/O, CPU, and memory usage. This is achieved by generating a data stream from tar (for archiving) and gzip (for compressing). Freezer segments the stream in a configurable chunk size (with the option `--max-seg-size`). The default segment size is 64MB, so it can be safely stored in memory, encrypted if the key is provided, and uploaded to Swift as a segment.



Example usage

To start the backup or restore job, you have to create the JSON backup description file. A sample backup job configuration file is shown on the right-hand side of the slide. Once the file is created, use the following command sequence to upload, list, display, and finally commit the backup job to the scheduler:

– Upload the job into the API:

```
freezer-scheduler -c node12 job-create
--file test_job.json
```

– List the newly created job:

```
freezer-scheduler -c node12 job-list
```

– Display the content of the job:

```
freezer-scheduler -c node12 job-get -j <job_id>
```

– Start the scheduler on the target node (commit the job):

```
freezer-scheduler -c node12 -i 15 -f ~/job_dir start
```

Fuel (OpenStack® Environment Provisioning)

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What is the OpenStack® Fuel project?

- A tool that enables you to:
  - Provision multiple OpenStack® environments
  - Manage environments after deployment
- The key features are:
  - Hardware discovery
  - Hardware configuration in UI (networks and disk partitioning)
  - Support for non-HA and HA OpenStack® deployment configurations
  - Pre-deployment checks and network validation
  - Post-deployment checks and running a set of tests for validating deployed OpenStack®
  - Logs can be viewed in real-time through UI
  - Support for multiple OpenStack® distributions
- More information available at: https://wiki.openstack.org/wiki/Fuel

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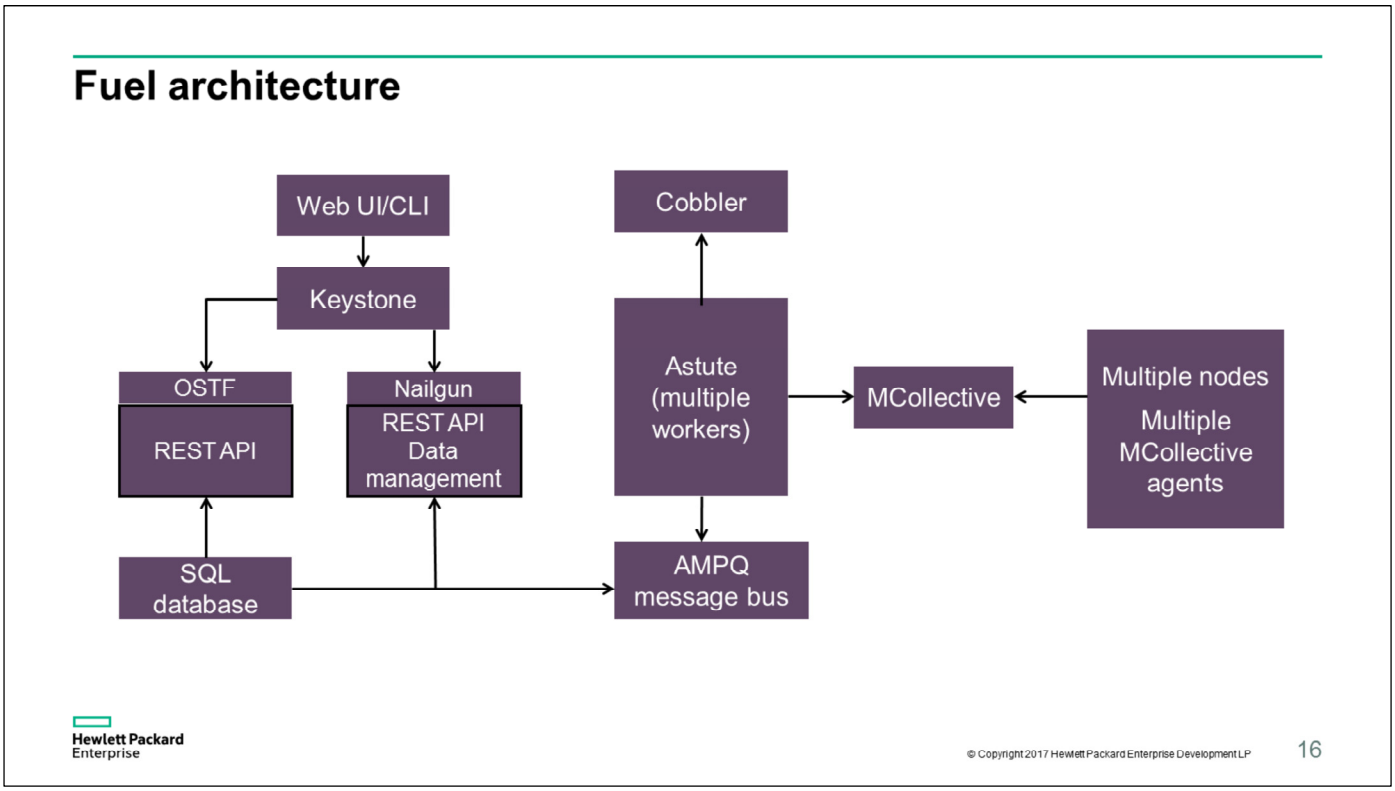
What is the OpenStack® Fuel project?

Fuel is an open-source tool that enables you to easily and quickly provision multiple OpenStack® environments, as well as manage your environments after deployment. You can install Fuel and deploy your OpenStack® environment on a virtual platform such as Oracle VirtualBox or VMware vSphere for testing purposes, as well as on bare-metal hardware for production.

Fuel brings consumer-grade simplicity to streamline and accelerate the otherwise time-consuming, often complex, and error-prone process of deploying, testing, and maintaining various configuration flavors of OpenStack® at scale. Unlike other platform-specific deployment or management utilities, Fuel is an upstream OpenStack® project that focuses on automating the deployment and testing of OpenStack® and a range of third-party options, so it’s not compromised by hard bundling or vendor lock-in.



Fuel architecture

Fuel is not monolithic. It consists of several independent components. Some of those components are Fuel-specific components, while others are third-party services like Cobbler, Puppet, MCollective, and so on. Some components can be reused separately from Fuel without any modifications and some require little tweaks.

UI is a single-page application, written in JavaScript. It uses bootstrap and backbone frameworks underneath.

Nailgun is the heart of the Fuel project. Nailgun is written in Python programming language. It implements REST API as well as deployment data management. It manages disk volumes configuration data, network configuration data, and any other environment-specific data that is necessary for successful deployment. It requires orchestration logic to build instructions for provisioning and deployment in a right order. Nailgun uses SQL database to store its data and AMQP service to interact with workers. The Fuel CLI provides even more functionality than UI.

Astute is another important component, which represents Nailgun's workers, and its function is to run certain actions according to the instructions provided from Nailgun. Astute is a layer which encapsulates all the details about interaction with a variety of services such as Cobbler, Puppet, shell scripts, and others, and provides universal asynchronous interface to those services. Depending on what you need to do, you can either manage a service directly via its native protocol (for example XML-RPC protocol is used for Cobbler) or you can use MCollective agents to perform specific tasks such as launching `puppet apply` on a remote node or running a script. Astute exchanges data with Nailgun via AMQP.

Cobbler is used as a provisioning service at the moment. There is a POC ready for move to Ironic, and production version is being implemented.

Puppet is the only deployment service at the moment. MCollective agent can be created to manage other configuration management frameworks, such as Chef, SaltStack, and so on.

MCollective agents allow you to perform specific tasks like hard drives clearing, network connectivity probing, and similar.

OSTF (OpenStack Testing Framework, or Health Check) is a separate component which can be easily removed and reused without Fuel. It implements post-deployment verification of OpenStack. Its main goal is to verify a maximum of functionality taking minimum of time.

Ironic (OpenStack® Bare Metal Provisioning)

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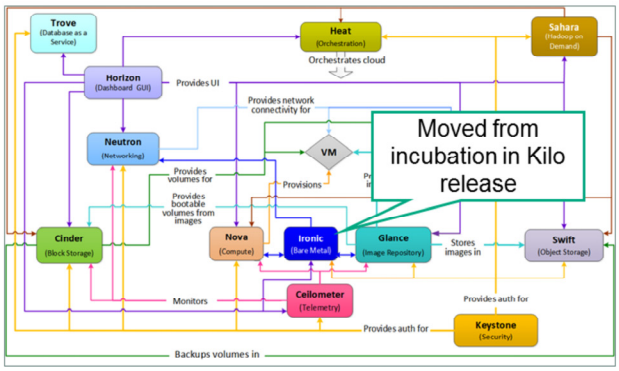
Ironic overview



- Is an OpenStack® service used to provision bare metal machines instead of virtual machines
- Is forked from the Nova baremetal driver
- Consists of metal hypervisor API and a set of plug-ins which interact with the baremetal hypervisors
- Uses PXE and IPMI in concert by default to provision and turn machines on or off
- Supports vendor-specific plug-ins which can implement additional functionality

NOTE: For a general overview, see http://docs.openstack.org/developer/ironic/deploy/user-guide.html.

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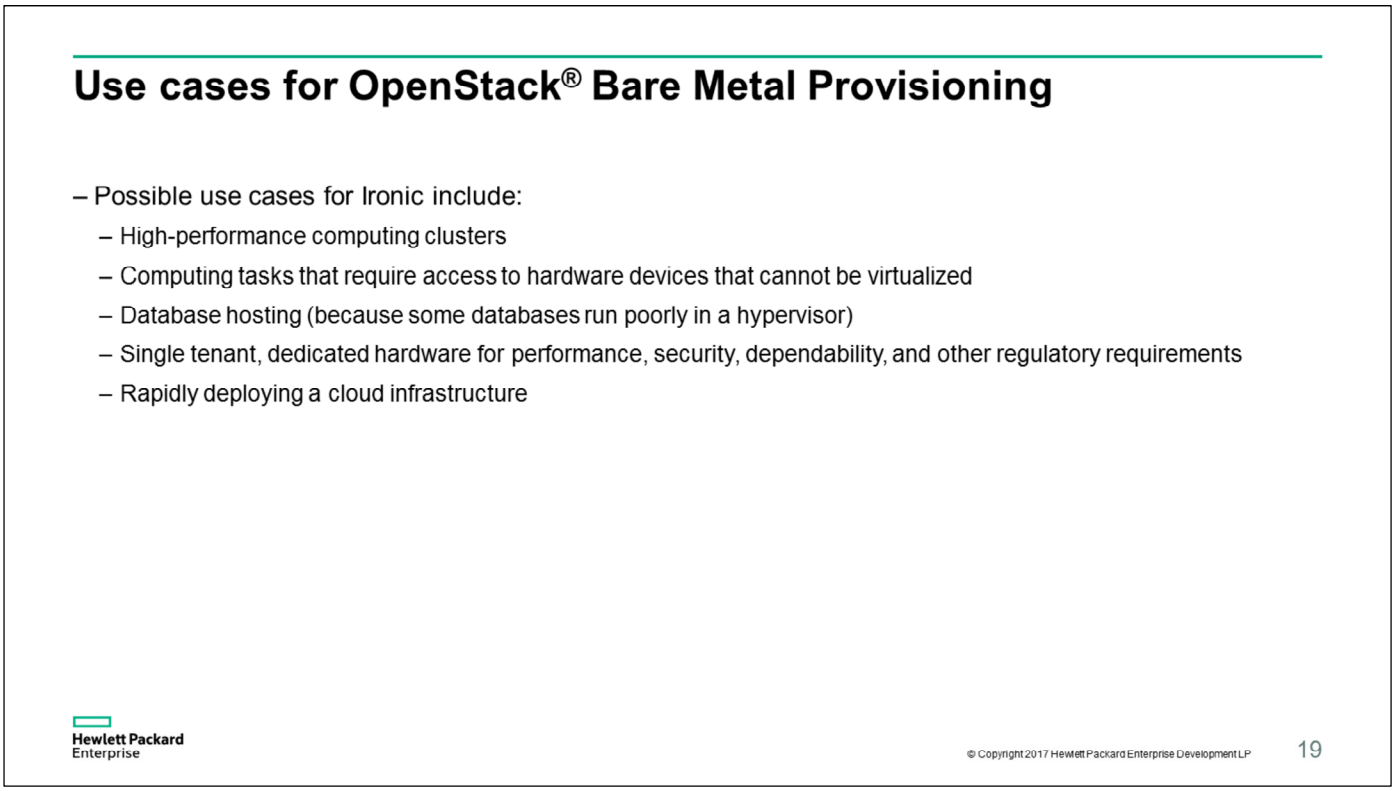
Ironic overview

Ironic is an OpenStack® project that provisions physical hardware rather than virtual machines (VMs). Ironic provides several reference drivers that leverage common technologies like the Preboot Execution Environment (PXE) and Intelligent Platform Management Interface (IPMI) to cover a wide range of hardware. The pluggable driver architecture of Ironic also enables you to add vendor-specific drivers for improved performance or for functionality that is not provided by the reference drivers.

If you think of traditional hypervisor functionality, such as creating a VM, enumerating virtual devices, managing the power state, loading an operating system (OS) on a VM, and so on, then you can think of Ironic as a hypervisor API gluing together multiple drivers, each of which implements some portion of that functionality with respect to physical hardware.

The OpenStack® Ironic project makes physical servers as easy to provision as VMs in cloud, which in turn opens up new avenues for enterprises and service providers.

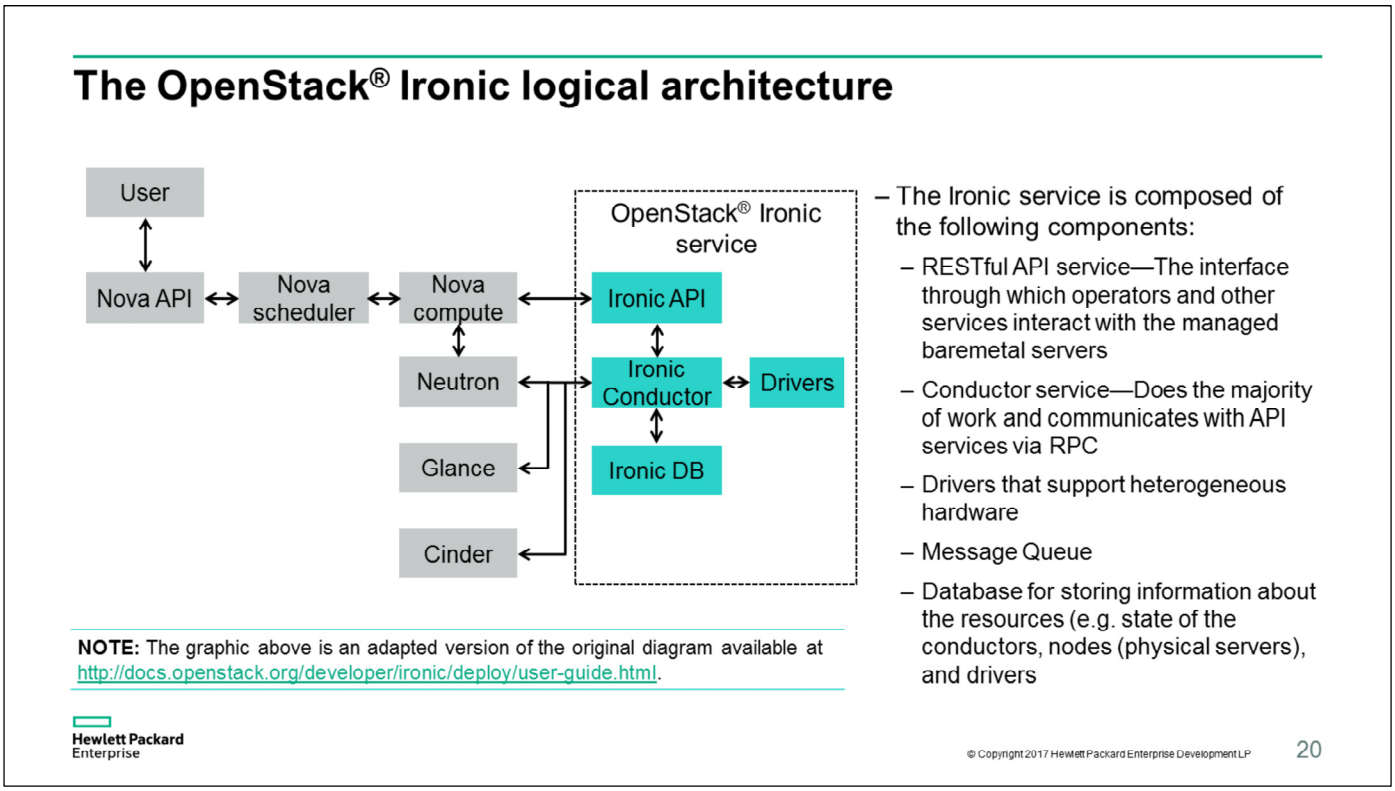
The Ironic driver replaces the Nova “baremetal” driver that was added in the Grizzly through Juno releases. Ironic is available for use and is supported by the Ironic developers starting with the Juno release.



Use cases for OpenStack® Bare Metal Provisioning

Here are a few use cases for baremetal (physical server) provisioning in cloud; there are doubtless many more:

- High-performance computing clusters
- Computing tasks that require access to hardware devices that cannot be virtualized
- Database hosting (because some databases run poorly in a hypervisor environment)
- Single-tenant, dedicated hardware for performance, security, dependability, and other regulatory requirements
- Rapidly deploying a cloud infrastructure



The OpenStack® Ironic logical architecture

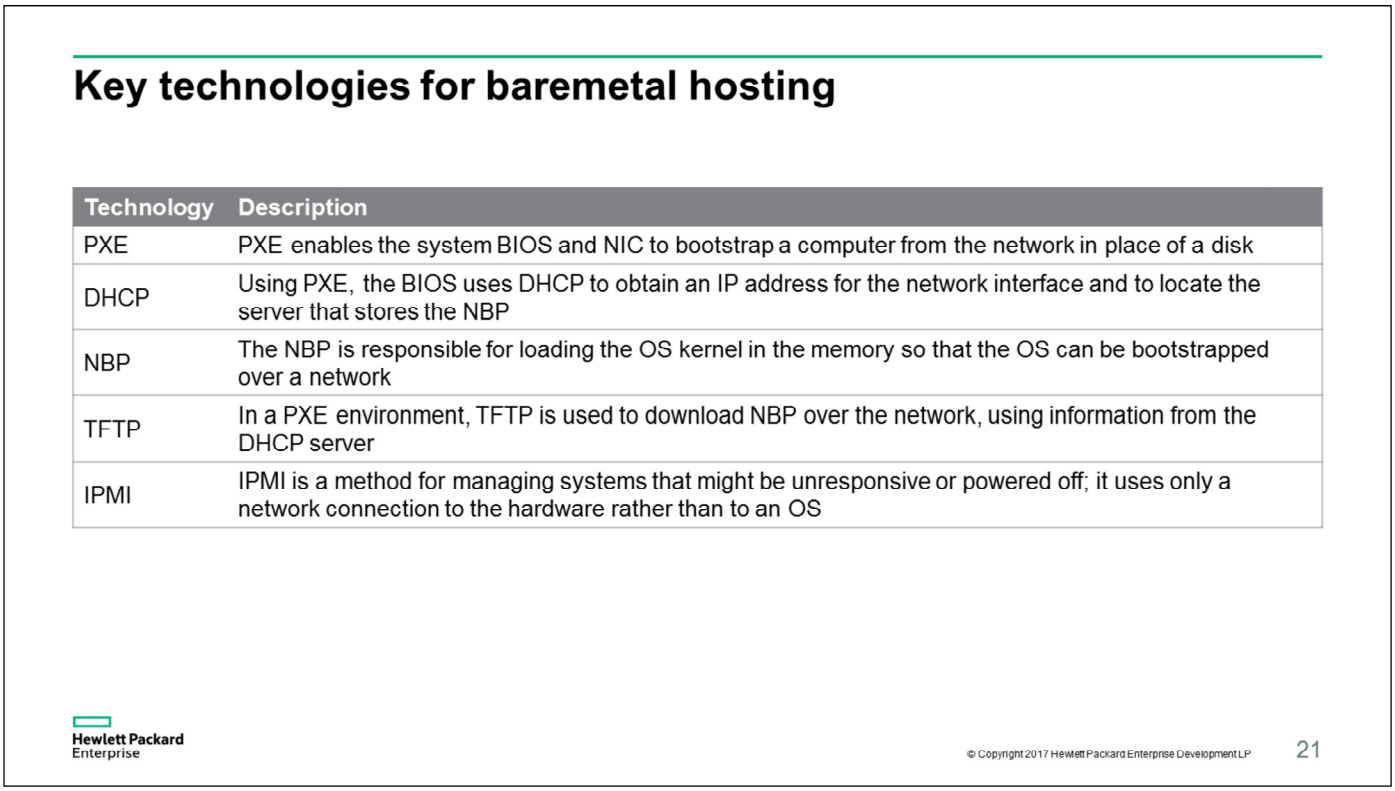
The Ironic service is composed of these components:

- A RESTful API service, through which operators and other services can interact with the managed bare-metal servers
- A Conductor service that does the majority of the work
- Various drivers that support heterogeneous hardware
- A message queue
- A database for storing information about the resources

Note: The Conductor functionality is exposed by the API service. The Conductor and API services communicate by means of Remote Procedure Call (RPC).

With this logical architecture, a user request for booting an instance is passed to the Nova Compute service by means of the Nova API and Nova scheduler. The Compute service hands this request to the Ironic service, where the request passes from the Ironic API to the Conductor and then to a driver to successfully provision a physical server for the user.

Just as the Nova Compute service communicates with various OpenStack® services like Glance, Neutron, and Swift to provision a VM instance, the Ironic service communicates with the same OpenStack® services for image, networking, and other resource needs to provision a bare-metal instance.



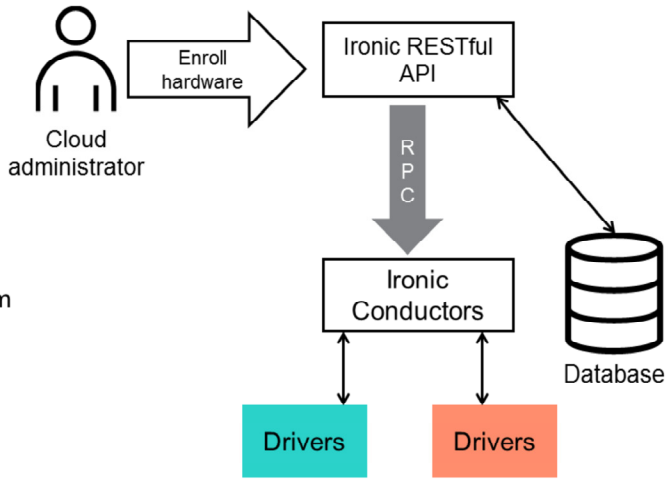
Key technologies for baremetal hosting

Several technologies are used to enable baremetal hosting:

- **PXE:** The Preboot Execution Environment (PXE) is part of the Wired for Management (WfM) specification developed by Intel and Microsoft. PXE enables the system BIOS and network interface card (NIC) to bootstrap a computer from the network in place of a disk. Bootstrapping is the process by which a system loads an OS to local memory so it can be executed by the processor. This capability of allowing a system to boot over a network simplifies server deployment and server management for administrators.
- **DHCP:** The Dynamic Host Configuration Protocol (DHCP) is a standardized networking protocol used on Internet Protocol (IP) networks for dynamically distributing network configuration parameters such as IP addresses for interfaces and services. Using PXE, the BIOS uses DHCP to obtain an IP address for the network interface and to locate the server that stores the Network Bootstrap Program (NBP).
- **NBP:** The NBP is equivalent to the Grand Unified Bootloader (GRUB) and Linux Loader (LILO) loaders, which are traditionally used in local booting. Like the boot program in a hard-drive environment, the NBP is responsible for loading the OS kernel in the memory so that the OS can be bootstrapped over a network.
- **TFTP:** The Trivial File Transfer Protocol (TFTP) is a simple file transfer protocol that is generally used for the automated transfer of configuration or boot files between machines in a local environment. In a PXE environment, TFTP is used to download NBP over the network, using information from the DHCP server.
- **IPMI:** Intelligent Platform Management Interface (IPMI) is a standardized computer system interface used by system administrators for out-of-band management of computer systems and monitoring of their operation. It is a method for managing systems that might be unresponsive or powered off, using only a network connection to the hardware rather than to an OS.

Ironic deployment architecture

- The Ironic RESTful API service is used to enroll the hardware that Ironic manages
- The Ironic Conductor does most of the work
- Multiple versions of the Conductor exist to support various classes of drivers and to manage failovers
- The API exposes a list of supported drivers and the names of the conductor hosts servicing them



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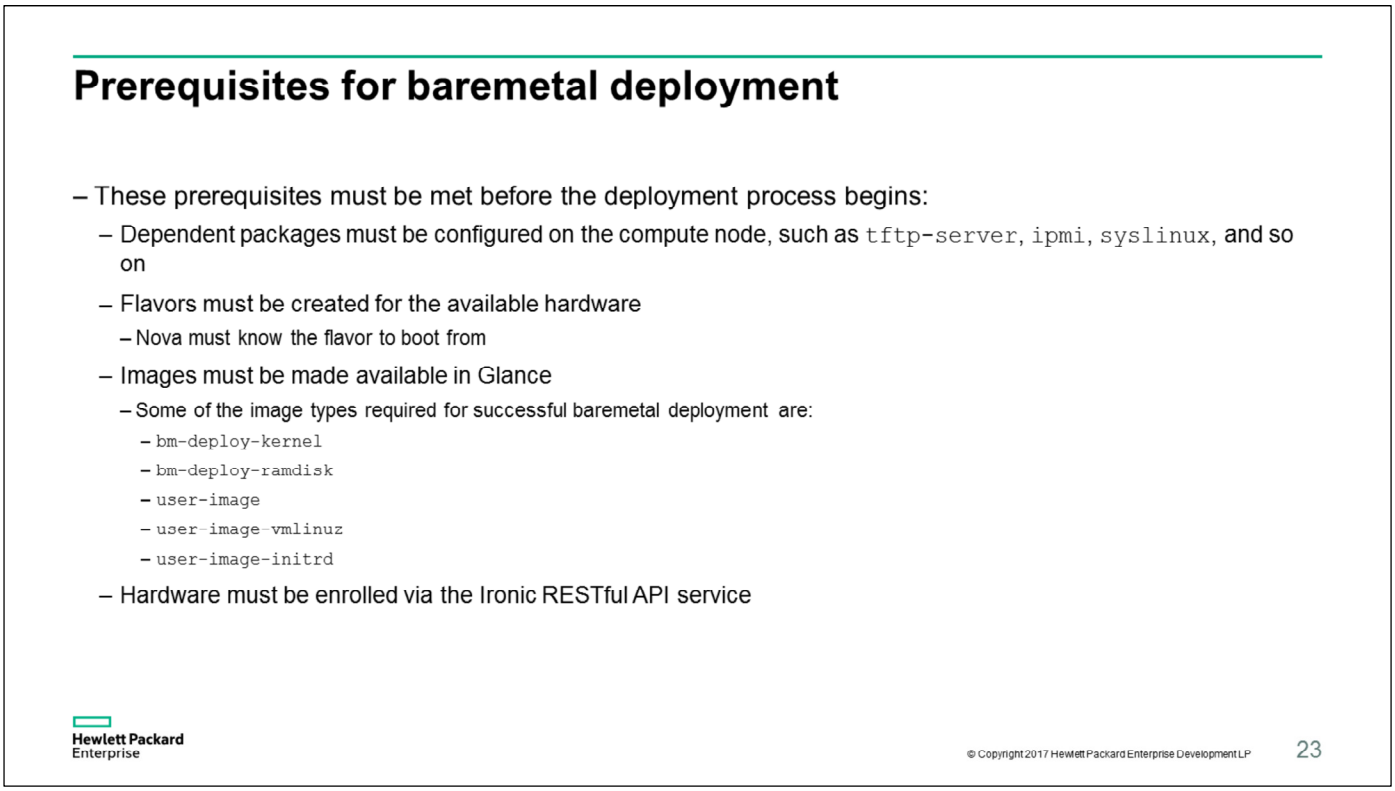
Ironic deployment architecture

The Ironic RESTful API service is used to enroll the hardware that Ironic manages. A cloud administrator usually registers the hardware, specifying attributes such as MAC addresses and IPMI credentials. The Ironic Conductor service does the majority of the work.

There can be multiple instances of the API service. Multiple instances of the Conductor service can be used to support various classes of drivers and to manage failovers. These instances of the Conductor service should be on separate nodes. Each conductor can run many drivers to operate heterogeneous hardware. The API exposes a list of supported drivers and the names of conductor hosts servicing them.

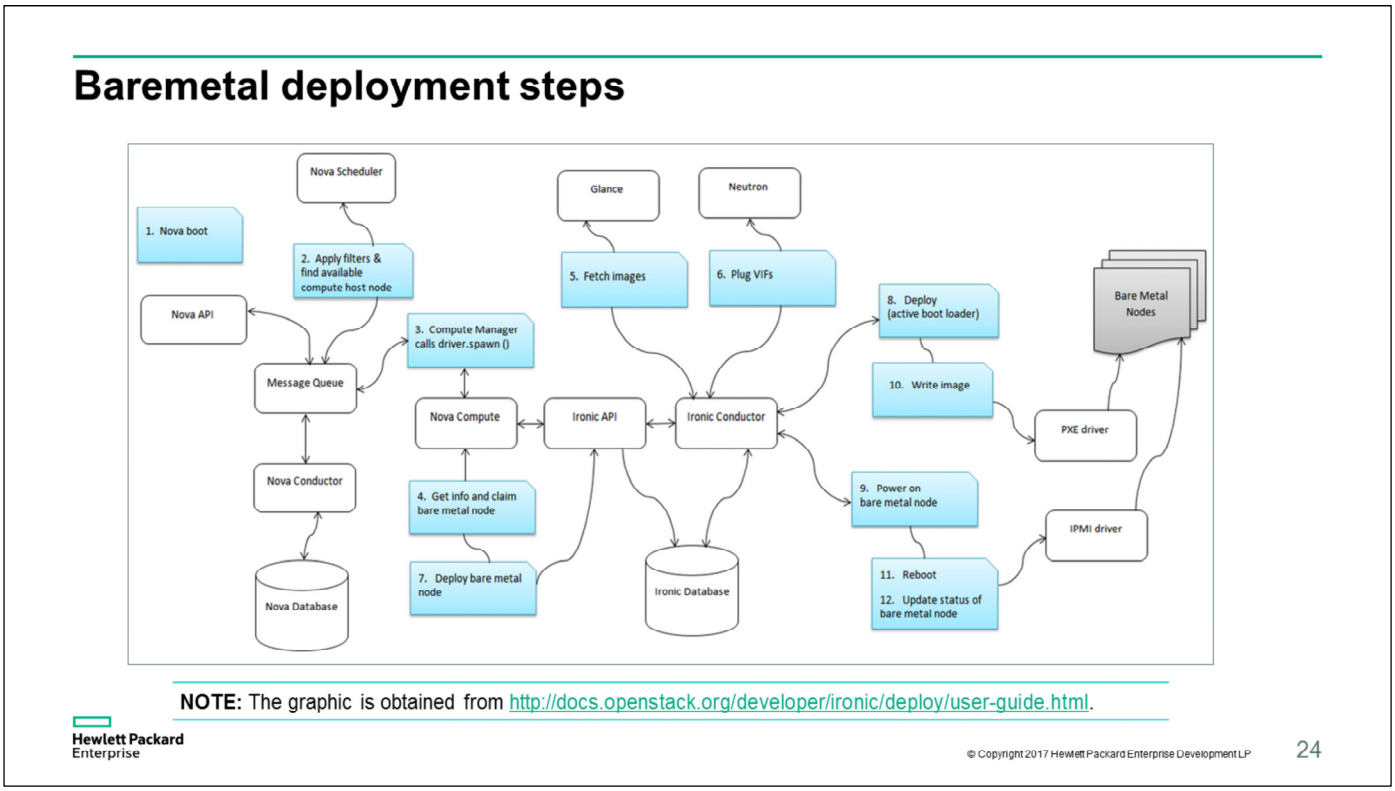
For security reasons, it is advisable to place the Conductor service on an isolated host, because it is the only service that requires access to both the data plane and the IPMI control plane.



Prerequisites for baremetal deployment

These prerequisites must be met before the deployment process begins:

- Dependent packages such as `tftp-server`, `ipmi`, `syslinux`, and so on, must be configured on the compute node for baremetal provisioning.
- Flavors must be created for the available hardware because Nova must know the flavor to boot from.
- Images must be made available in Glance; some of the image types required for successful baremetal deployment are:
  - `bm-deploy-kernel`
  - `bm-deploy-ramdisk`
  - `user-image`
  - `user-image-vmlinuz`
  - `user-image-initrd`
- Hardware must be enrolled by means of the Ironic RESTful API service.



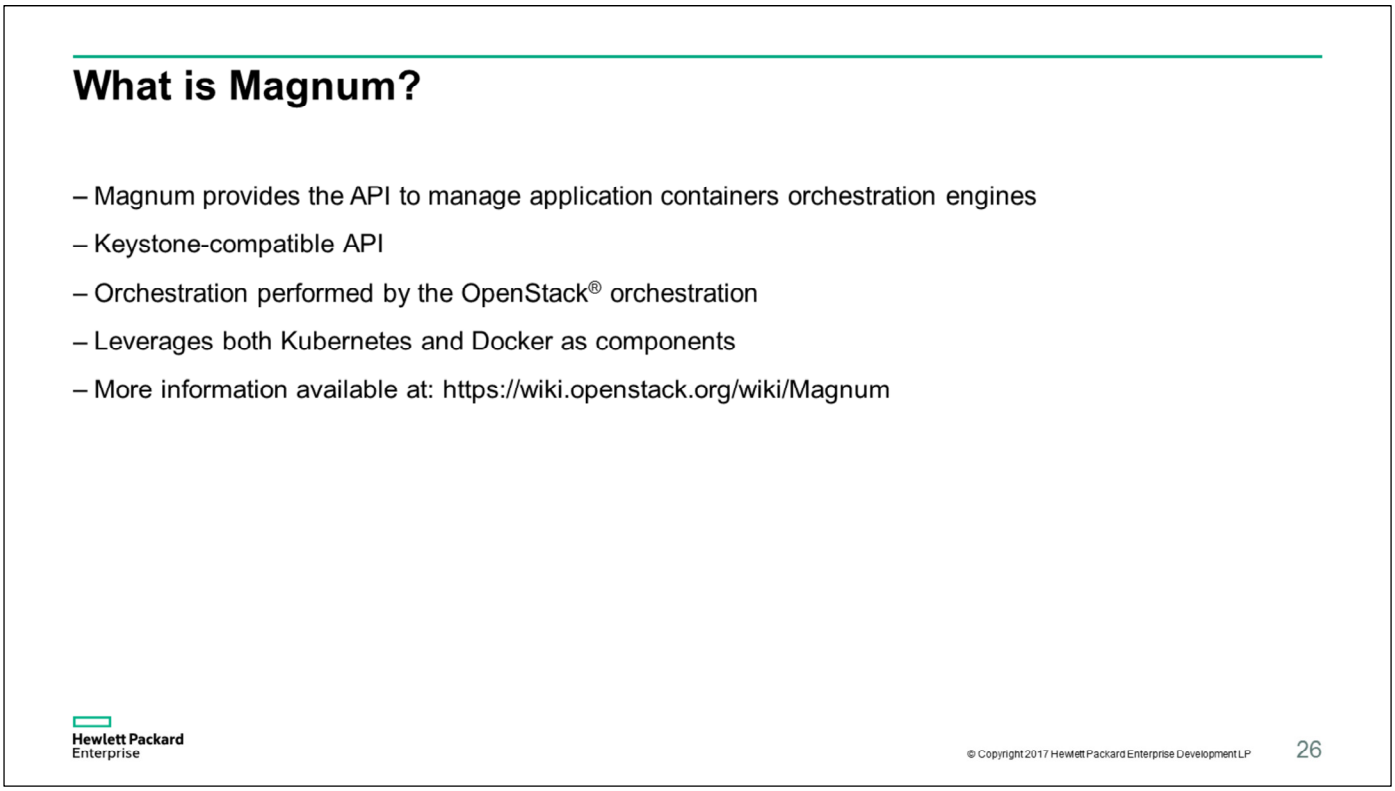
Baremetal deployment steps

1. A boot instance request comes in through the Nova API and through the message queue to the Nova scheduler.
2. The Nova scheduler applies the filter and finds the eligible compute node. The Nova scheduler uses flavor `extra_specs` detail such as `cpu_arch`, `baremetal:deploy_kernel_id`, and `baremetal:deploy_ramdisk_id` to match the target physical node.
3. The driver places a spawn task that contains all of the needed information, such as which image to boot from. It invokes the `driver.spawn` from the `virt` layer of Nova Compute.
4. Information about the baremetal node is retrieved from the bare-metal database and the node is reserved.
5. Images from Glance are pulled down to the local disk of the Ironic Conductor servicing the bare-metal node.
6. Virtual interfaces are plugged in, and the Neutron API updates the DHCP port to support the PXE and TFTP options.
7. The Nova Ironic driver issues a deploy request through the Ironic API to the Ironic Conductor that is servicing the bare-metal node.
8. The PXE driver prepares TFTP bootloader.
9. The IPMI driver issues a command to enable the network boot of a node and power it on.
10. The DHCP boots the deploy ramdisk. The PXE driver copies the image over iSCSI to the physical node. It connects to the iSCSI end point, partitions volume, “dd” the image, and closes the iSCSI connection. At this point, the deployment is done. The Ironic Conductor then switches `pxe config` to the service mode and notifies the ramdisk agent about the successful deployment.
11. The IPMI driver reboots the baremetal node.

Note: There are two power cycles during a baremetal deployment; the first is when the system is powered on and the images are deployed, as mentioned in step 9. The second time is after the images are deployed and the node is powered up.

12. The baremetal node status is updated and the node instance is made available.

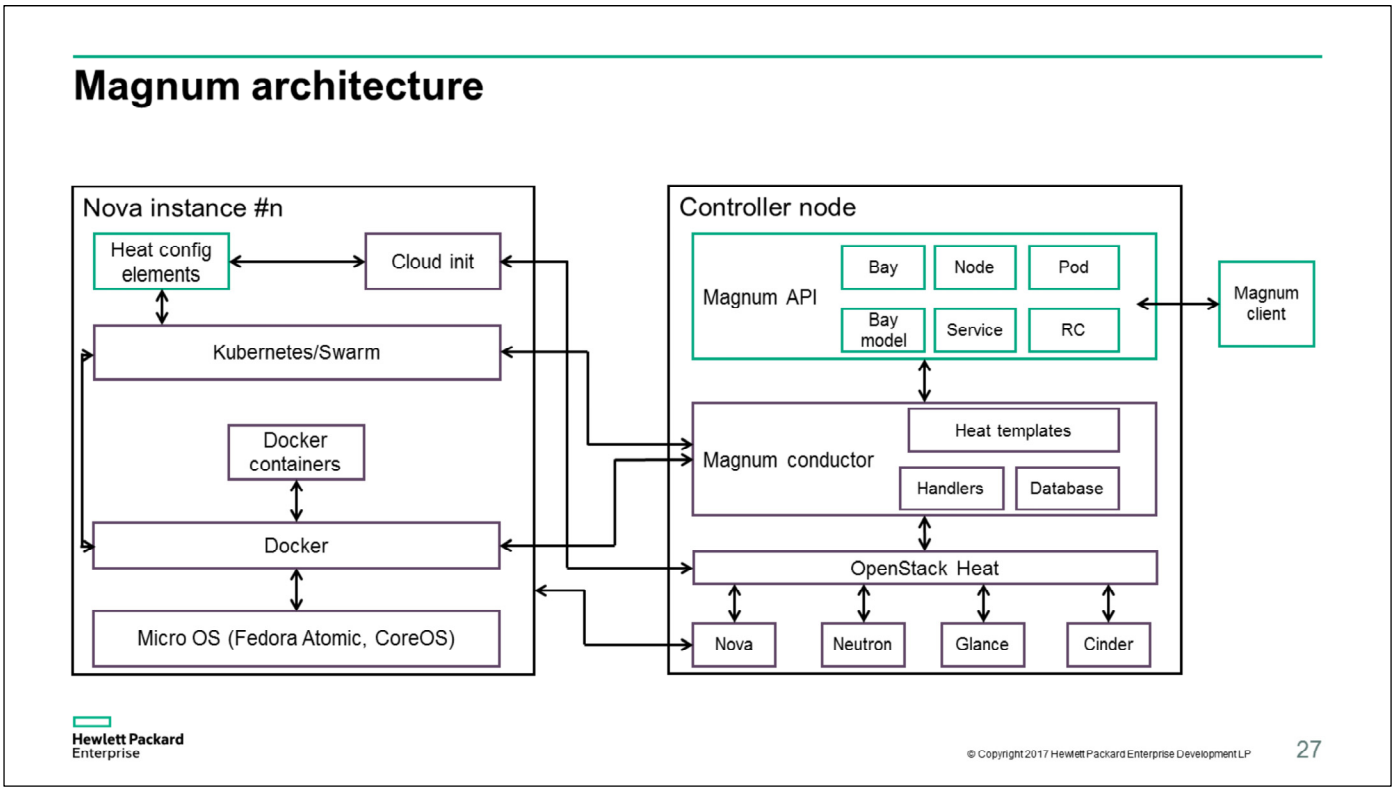
Magnum (Container Virtualization)



What is Magnum?

Magnum is for OpenStack® cloud operators (public or private) who want to offer a self-service solution to provide a hosted container service to their cloud users. Magnum simplifies the required integration with OpenStack®. It allows cloud users who can already launch cloud resources (such as Nova instances, Cinder volumes, Trove databases, and so on) to create container clusters (bays) to run applications in an environment that provides advanced features that are beyond the scope of existing cloud resources.

The OpenStack® Magnum project provides a purpose-built API to manage the application container orchestration engines. Magnum offers an asynchronous API that is compatible with Keystone and a complete multi-tenancy implementation. It does not perform orchestration internally, and instead relies on OpenStack® Orchestration. Magnum leverages both Kubernetes and Docker as components.



Magnum architecture

There are several different types of objects in the Magnum system:

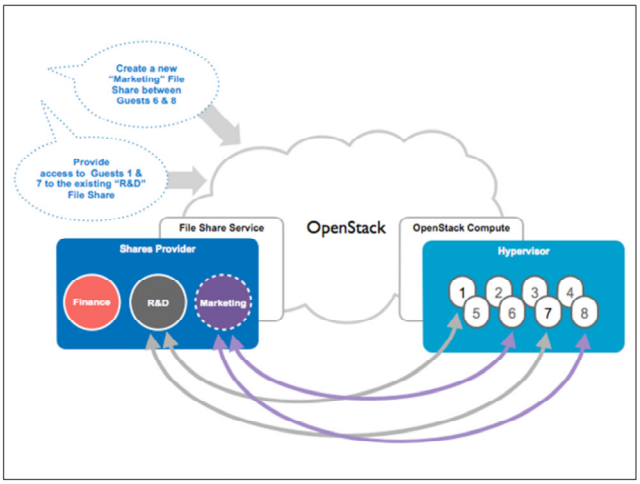
- **Cluster:** A collection of node objects where work is scheduled
- **Cluster template:** An object stores template information about the cluster which is used to create new clusters consistently

Two binaries work together to compose the Magnum system. The first binary (accessed by the `python-magnumclient` code) is the magnum-api REST server. The REST server may run as one process or multiple processes. When a REST request is sent to the client API, the request is sent via AMQP to the magnum-conductor process. The REST server is horizontally scalable. At this time, the Conductor is limited to one process.

Manila (Shared File System)

What is Manila?

- OpenStack® service, originally based on Cinder
  - Cinder currently functions as the canonical storage provisioning service for block storage
  - The file share service provides coordinated access to shared or distributed file systems



NOTE: See https://wiki.openstack.org/wiki/Manila for links to the current project development status.

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What is Manila?

Cinder currently functions as the canonical storage provisioning control plane in OpenStack® for block storage, and it delivers a persistence model for instance storage. Similarly, the OpenStack® File Share service prototype provides coordinated access to shared or distributed file systems.

Although the primary consumption of file shares is across OpenStack® Compute instances, the Manila service is also accessible as an independent capability because it has been designed with the same modularity as other OpenStack® services. The design and prototype implementation provide extensibility for multiple backends to support vendor-specific or file system-specific nuances and capabilities, but it is sufficiently abstract to accommodate a variety of shared or distributed file system types.

Sahara (Data Processing)

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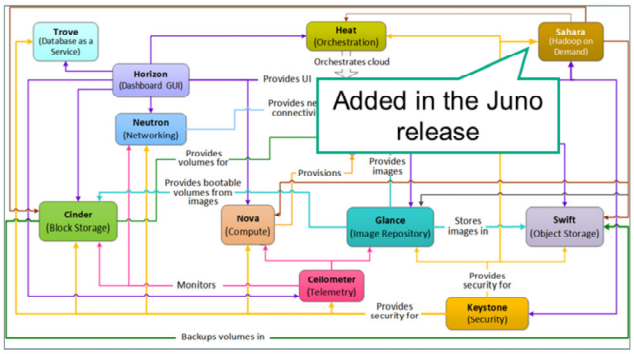
Sahara functionality



- Provides you with the ability to easily provision and manage Hadoop clusters on OpenStack®
- Managed through the REST API with a UI available as part of the OpenStack® Dashboard
- Support for different Hadoop distributions:
  - Pluggable system of Hadoop installation engines
  - Integration with vendor-specific management tools, such as Apache Ambari or Cloudera Management Console
- Provides predefined templates of Hadoop configurations with the ability to modify parameters

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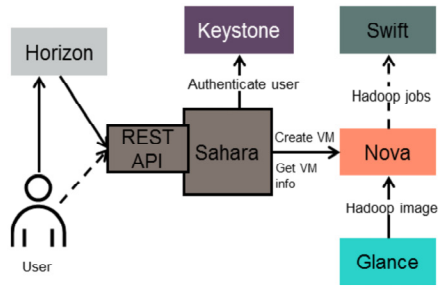
Sahara functionality

Sahara provides you with the ability to easily provision and manage Hadoop clusters on OpenStack. It is managed through the REST API with a UI available as part of the OpenStack Dashboard.

Sahara supports a pluggable system of Hadoop installation engines and integrates with vendor specific management tools. It also provides predefined templates of Hadoop configurations and the ability to modify parameters.

Sahara interactions with other OpenStack® projects



NOTE: The graphic above is an adapted version of the original diagram available at http://docs.openstack.org/developer/sahara/overview.html

– The Sahara project communicates with the following OpenStack® components:
  – **Horizon** provides a GUI with the ability to use all Sahara features
  – **Keystone** authenticates users and provides a security token that is used to work with OpenStack®
  – **Nova** is used to provision VMs for a Hadoop cluster
  – **Heat** orchestrates the required services for a Hadoop cluster
  – **Glance** is where Hadoop VM images are stored; each image contains an installed OS and Hadoop
  – **Swift** can be used as a storage for data that will be processed by Hadoop jobs
  – **Cinder** can be used as a block storage
  – **Neutron** provides the networking service
  – **Ceilometer** is used to collect measures of cluster usage for metering and monitoring purposes

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Sahara interactions with other OpenStack® projects

Sahara communicates with the following OpenStack® components:

– **Horizon**—Provides a GUI with the ability to use all Sahara features
– **Keystone**—Authenticates users and provides a security token that is used to work with OpenStack®
– **Nova**—Used to provision VMs for a Hadoop cluster
– **Heat**—Orchestrates the required services for a Hadoop cluster
– **Glance**—This is where Hadoop VM images are stored; each image contains an installed OS and Hadoop
– **Swift**—Can be used as a storage for data that will be processed by Hadoop jobs
– **Cinder**—Can be used as a block storage
– **Neutron**—Provides the networking service
– **Ceilometer**—Used to collect measures of cluster usage for metering and monitoring purposes

Trove (Database as a Service)

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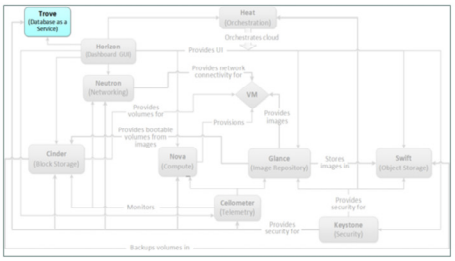
Trove functionality

- Provides scalable and reliable cloud Database as a Service provisioning functionality for both relational and non-relational database engines
- Interacts with other OpenStack® components purely through the API
- The Trove RESTful API allows for:
  - Spinning up and resizing instances
  - Creating replicas
  - Adding users and databases, and managing grants
  - Managing database backups
  - Changing database configurations
- VM instance deployed on demand with a fully functional database
- Cloud users and database administrators can provision and manage multiple database instances as needed



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Trove functionality

Database-as-a-Service (DBaaS) is generally of one of two different forms:

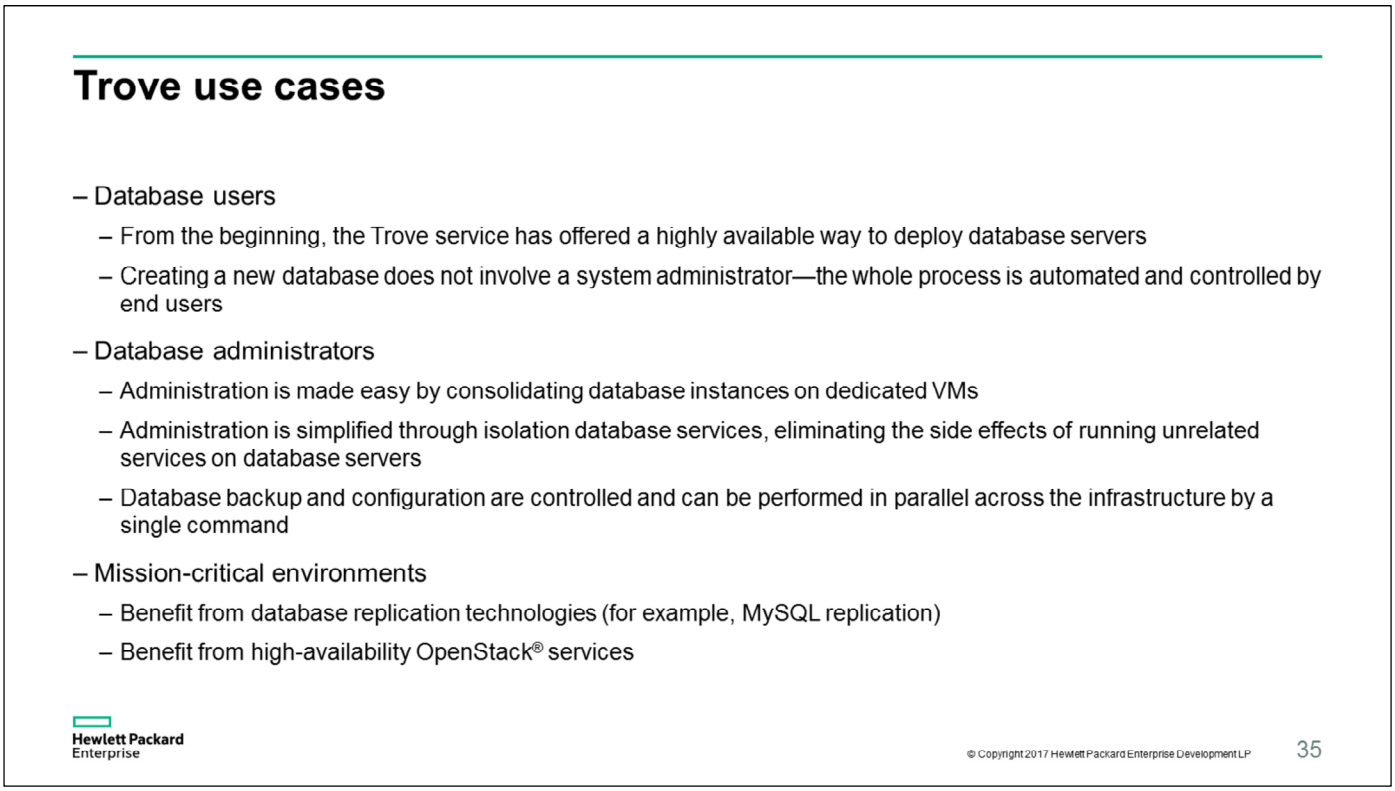
- A virtual machine image of a database installation, where you still need to configure the database for your needs.
- A vendor-supplied database service, which does not directly expose you to the physical or virtual instances behind the service itself. The vendor manages the service including security, elasticity, and multi-tenancy.

Each database server under management holds a portion of the complete data set, referred to as “a slice.” Each table in the application database is distributed (or sliced) among different database servers depending on its primary purpose in the setup. Tables containing supporting information (sometimes referred to as “dimension tables”) can "broadcast" across all MySQL servers to facilitate easy joining with other tables. Optionally, dimension tables may be sliced and distinct subsets can be stored on each database server.

Trove is the OpenStack® Database as a Service. It is designed to run entirely on OpenStack®, with the goal of allowing you to quickly and easily utilize the features of a relational database without the burden of handling complex administrative tasks. Cloud users and database administrators can provision and manage multiple database instances as needed. Initially, the service focuses on providing resource isolation at high performance while automating complex administrative tasks including deployment, configuration, patching, backups, restores, and monitoring.

Trove is designed to support a single-tenant database within a Nova instance. There are no restrictions on how Nova is configured, since Trove interacts with other OpenStack® components through the API.

Trove’s mission is to provide a scalable and reliable cloud Database as a Service provisioning functionality for both relational and non-relational database engines, and to continue improving its fully-featured and extensible open source framework.



Trove use cases

Trove currently enables you to provision a database within a single instance, manage users and databases, back up and restore data, resize instances, and check quota usage. Running entirely on OpenStack®, Trove can be used in a variety of scenarios and configurations.

Database users

From the beginning, the Trove service has offered a highly available way to deploy database servers. Creating a new database does not involve a system administrator—the whole process is automated and controlled by end users.

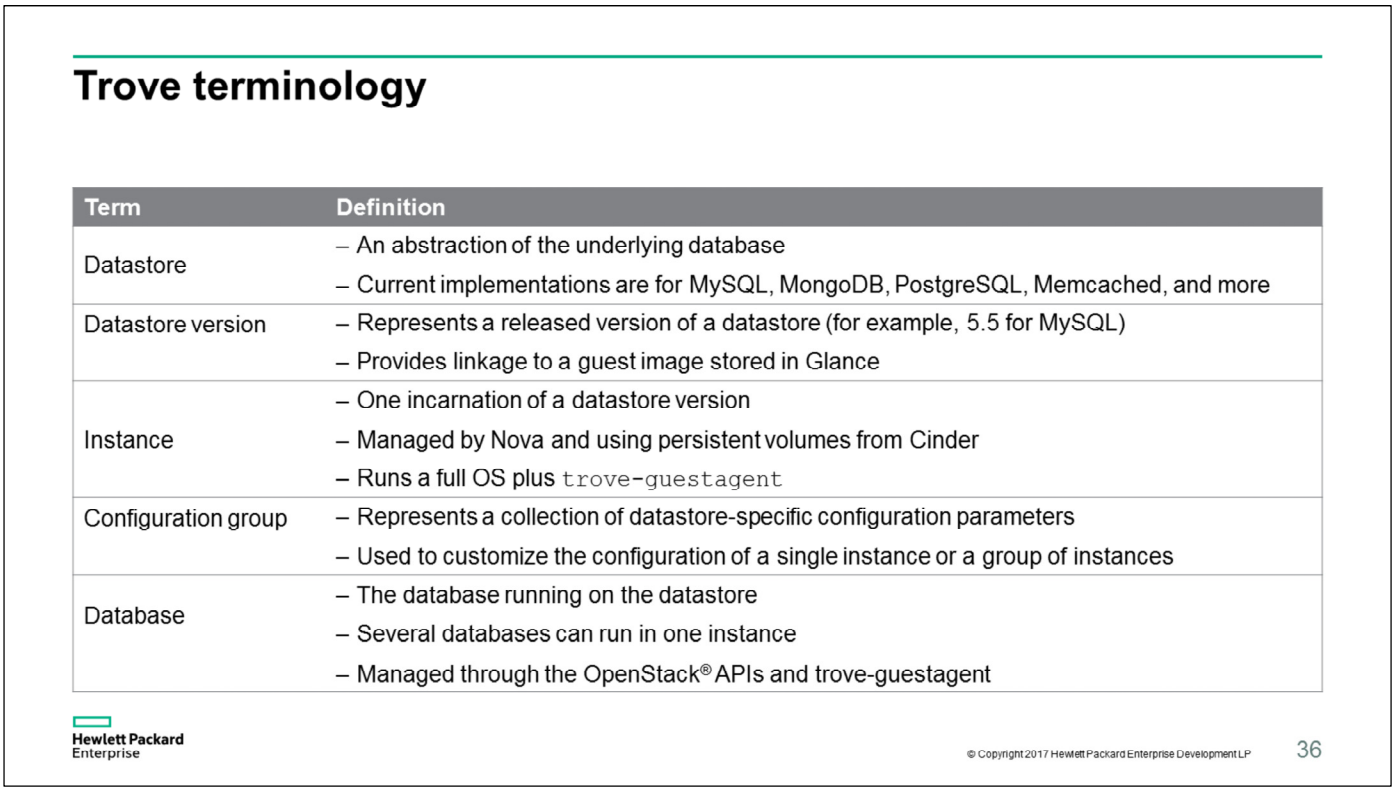
Database administrators

Administration has been made easy by consolidating database instances on dedicated virtual machines (VMs). Administration is simplified through isolation database services, which eliminated the side effects of running unrelated services on database servers.

Database backup and configuration are controlled and can be performed in parallel across the infrastructure through a single command.

Mission-critical environments

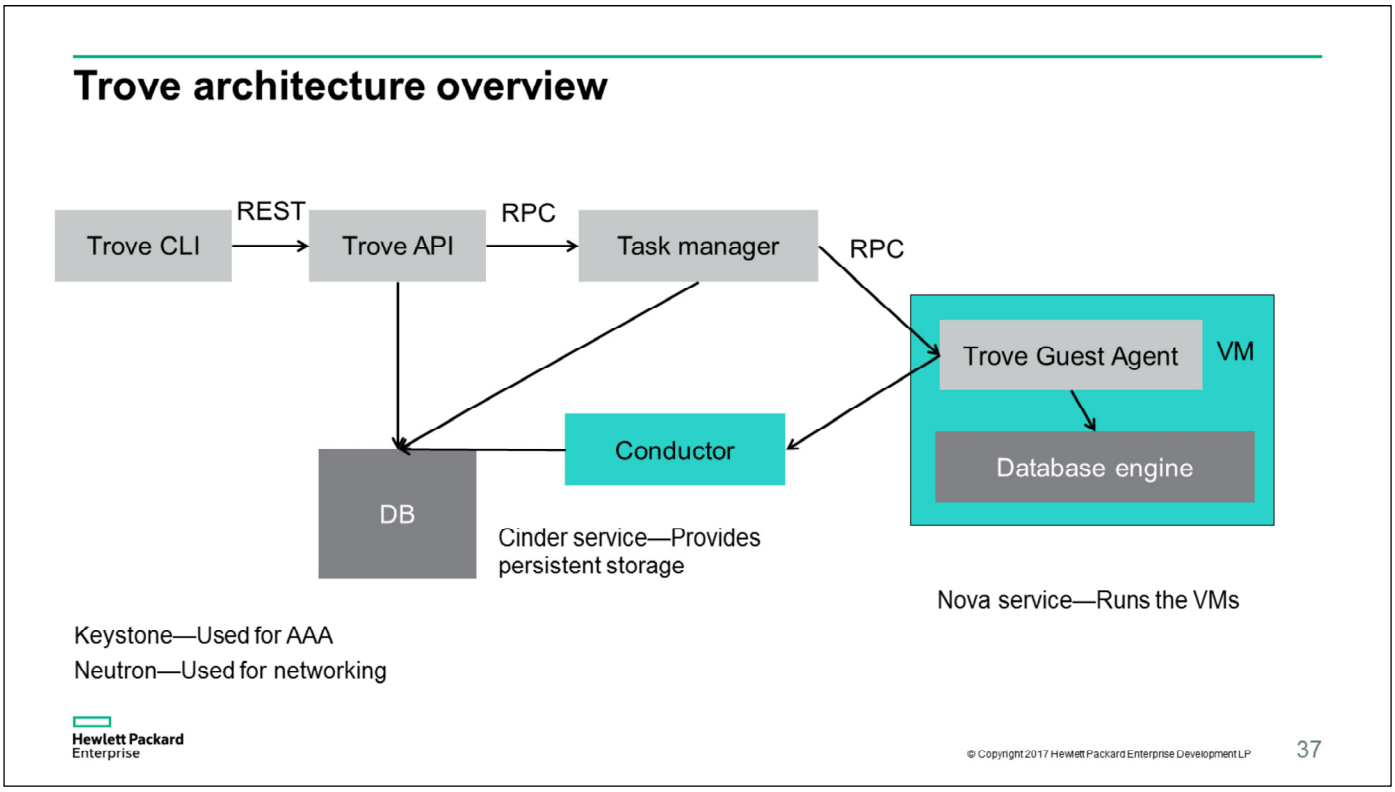
Mission-critical environments directly benefit from database replication technologies such as MySQL replication. Based completely on the OpenStack® platform, the Trove service leverages high-availability features, making disaster recovery and business continuity possible and easy to implement.



Trove terminology

To fully understand the function of the Trove service, you should be familiar with the following terminology:

- **Datastore**: An abstraction of the underlying database. The current implementations are for MySQL, MongoDB, PostgreSQL, Memcached, and others.
- **Datastore version**: Represents a released version of a datastore (such as 5.5 for MySQL), and provides linkage to a guest image stored in Glance.
- **Instance**: One incarnation of a datastore version. Instances are managed by Nova and use persistent volumes from Cinder. They run a full operating system (OS) plus trove-guestagent.
- **Configuration group**: Represents a collection of datastore-specific configuration parameters. They are used to customize the configuration of a single instance or a group of instances.
- **Database**: The database running on the datastore. Several databases can run in one instance. They are managed through the OpenStack® APIs and trove-guestagent.

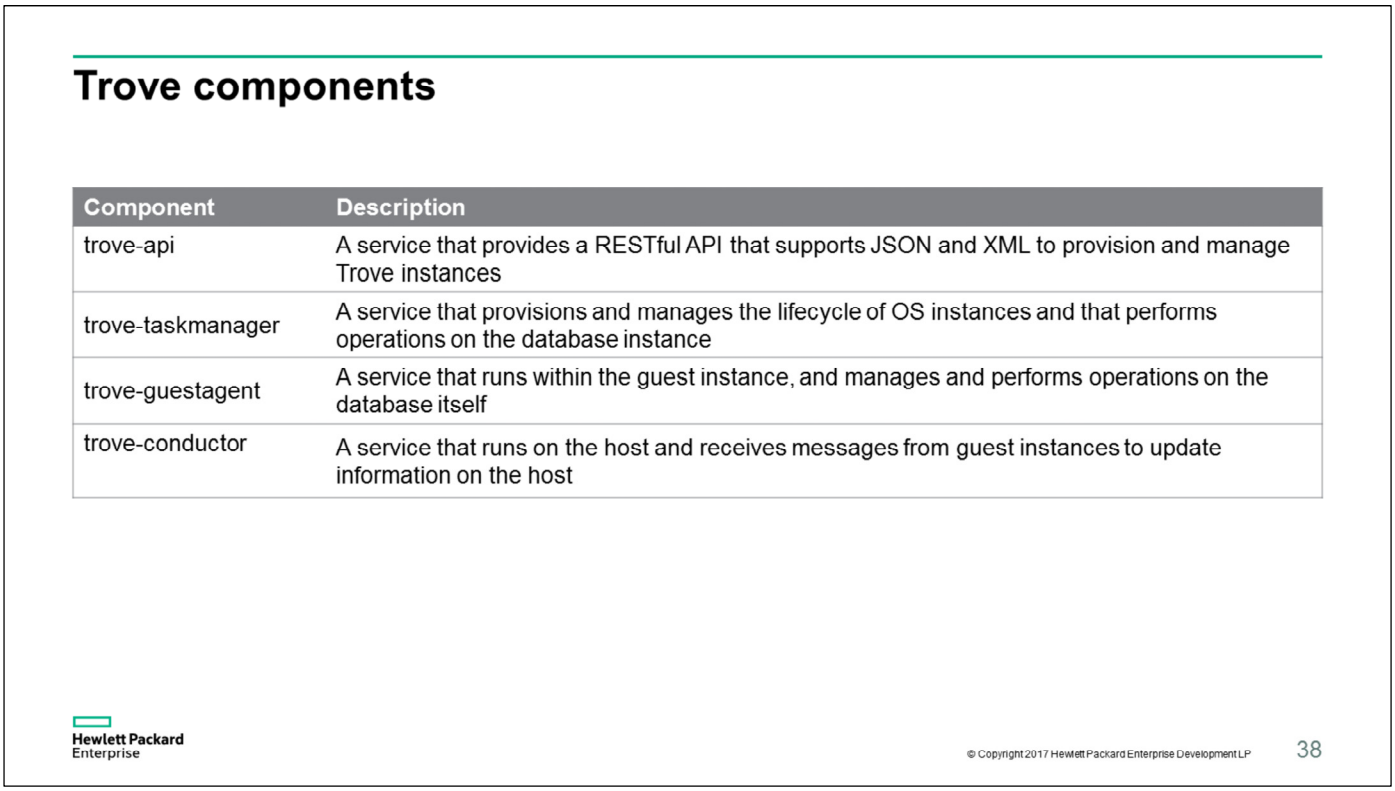


Trove architecture overview

Trove offers a Representational State Transfer (REST) API to provision instances and manage the service itself, leveraging the API to plug into OpenStack®. The Trove service is built on the following OpenStack® services:

- **Keystone:** Used to provide authorization, authentication, and access control (AAA)
- **Neutron:** Used to manage networking
- **Cinder:** Providing persistent storage service
- **Nova:** Compute service to support virtual machines

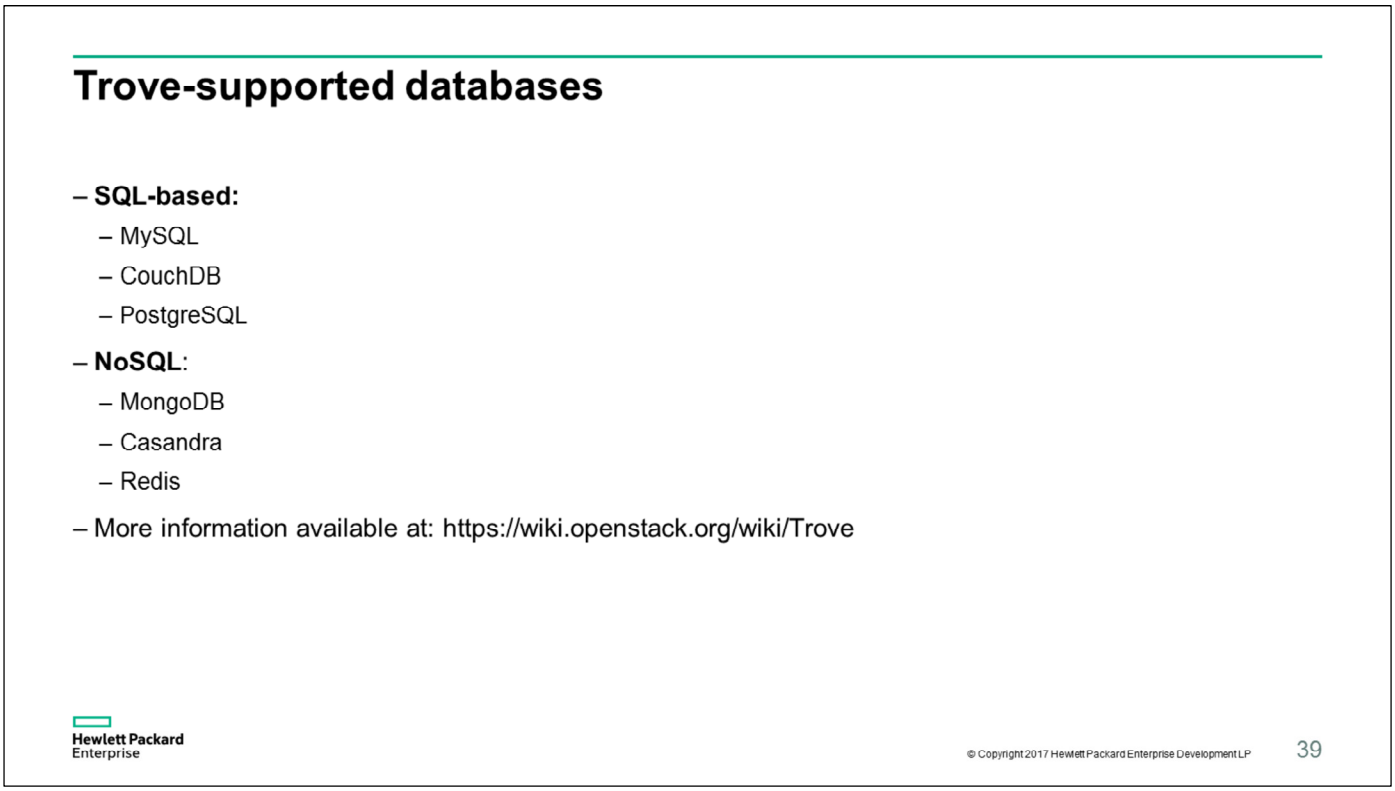
The Trove Conductor subservice oversees all of the individual guest DBaaS instances, managing the message bus communication and routing commands, maintaining the overall state of the distributed database service, and coordinating critical functions such as backups and restores.



Trove components

Trove relies on four primary components to provide DBaaS:

- **trove-api:** The trove-api service provides a RESTful API that supports JavaScript Object Notation (JSON) and XML to provision and manage Trove instances.
- **trove-taskmanager:** The trove-taskmanager service does the complex work regarding provisioning instances, managing the lifecycle of instances, and performing operations on the database instance.
- **trove-guestagent:** The trove-guestagent is a service that runs within the guest instance. It manages and performs operations on the database itself. The guest agent listens for Remote Procedure Call (RPC) messages through the message bus and performs the requested operation.
- **trove-conductor:** The Conductor service runs on the host. It receives messages from guest instances to update information on the host, such as instance statuses and the current status of a backup. With the Conductor service, guest instances do not need a direct connection to the host database. The Conductor service listens for RPC messages through the message bus and performs the relevant operation.



Trove-supported databases

The list of databases supported by Trove is given on the slide above.

Zaqar (Multi-Tenant Cloud Messaging)

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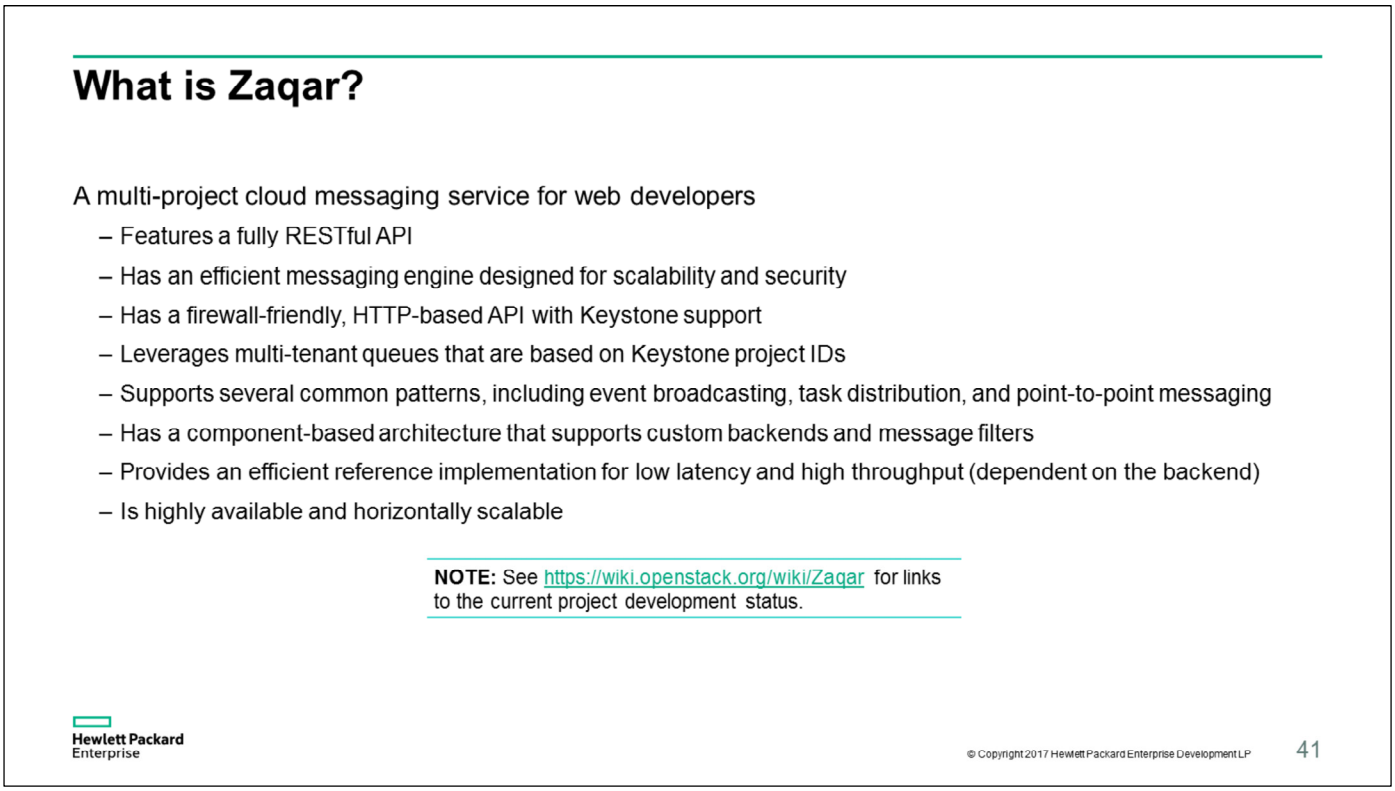
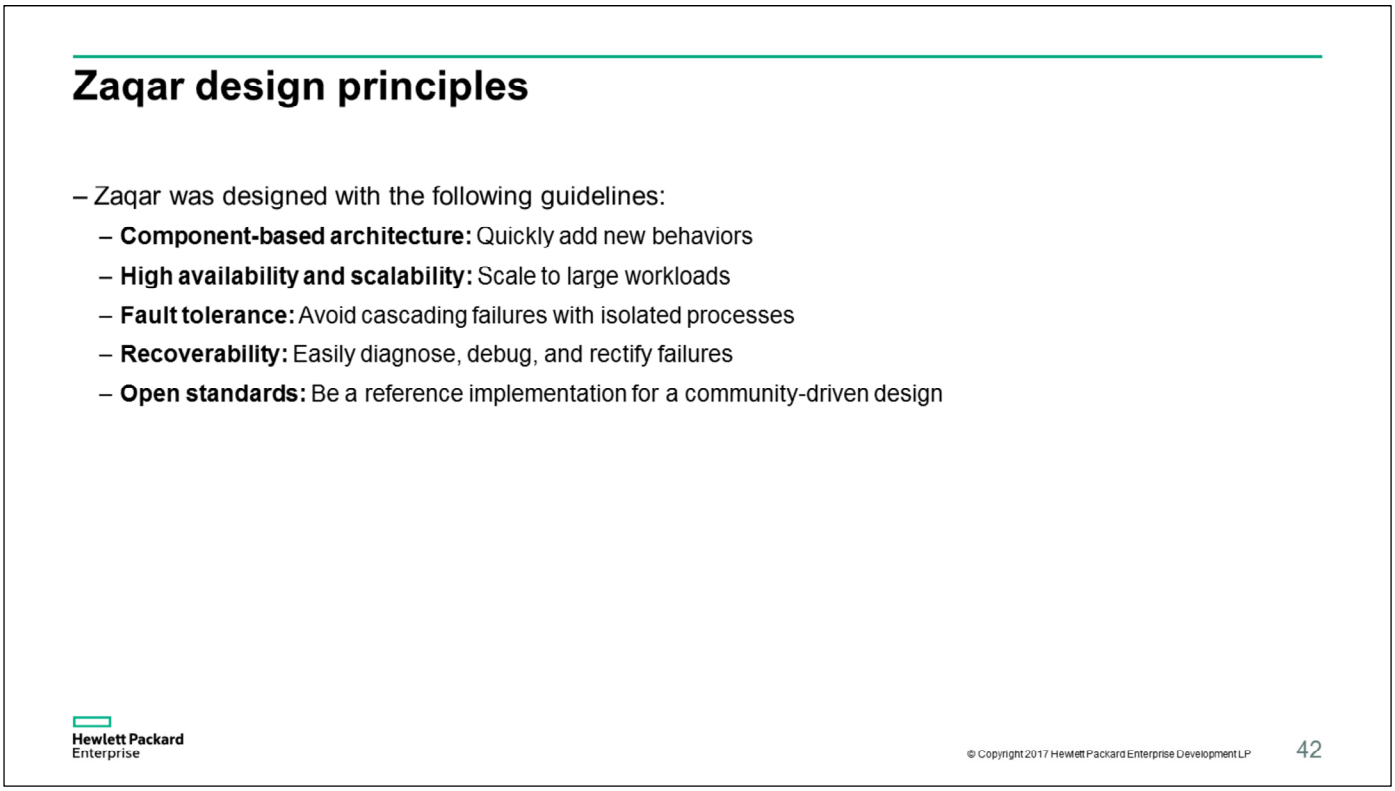


What is Zaqar?

Zaqar is a multi-tenant cloud messaging service for web developers. It combines the ideas pioneered by the Amazon SQS product with additional semantics to support event broadcasting.

The service features a fully RESTful API that developers can use to send messages between various components of their Software as a Service (SaaS) and mobile applications, by using a variety of communication patterns. Underlying this API is an efficient messaging engine that was designed for scalability and security.

Other OpenStack® components can integrate with Zaqar to bring events to users and to communicate with guest agents that run in the “over-cloud” layer. Cloud operators can leverage Zaqar to provide the equivalents of the Amazon Simple Queue Service (SQS) and Simple Notification Service (SNS) to their customers.



Zaqar design principles

Zaqar, like all OpenStack® projects, was designed with the following guidelines in mind:

- **Component-based architecture:** Quickly add new behaviors
- **High availability and scalability:** Scale to large workloads
- **Fault tolerance:** Avoid cascading failures with isolated processes
- **Recoverability:** Easily diagnose, debug, and rectify failures
- **Open standards:** Be a reference implementation for a community-driven design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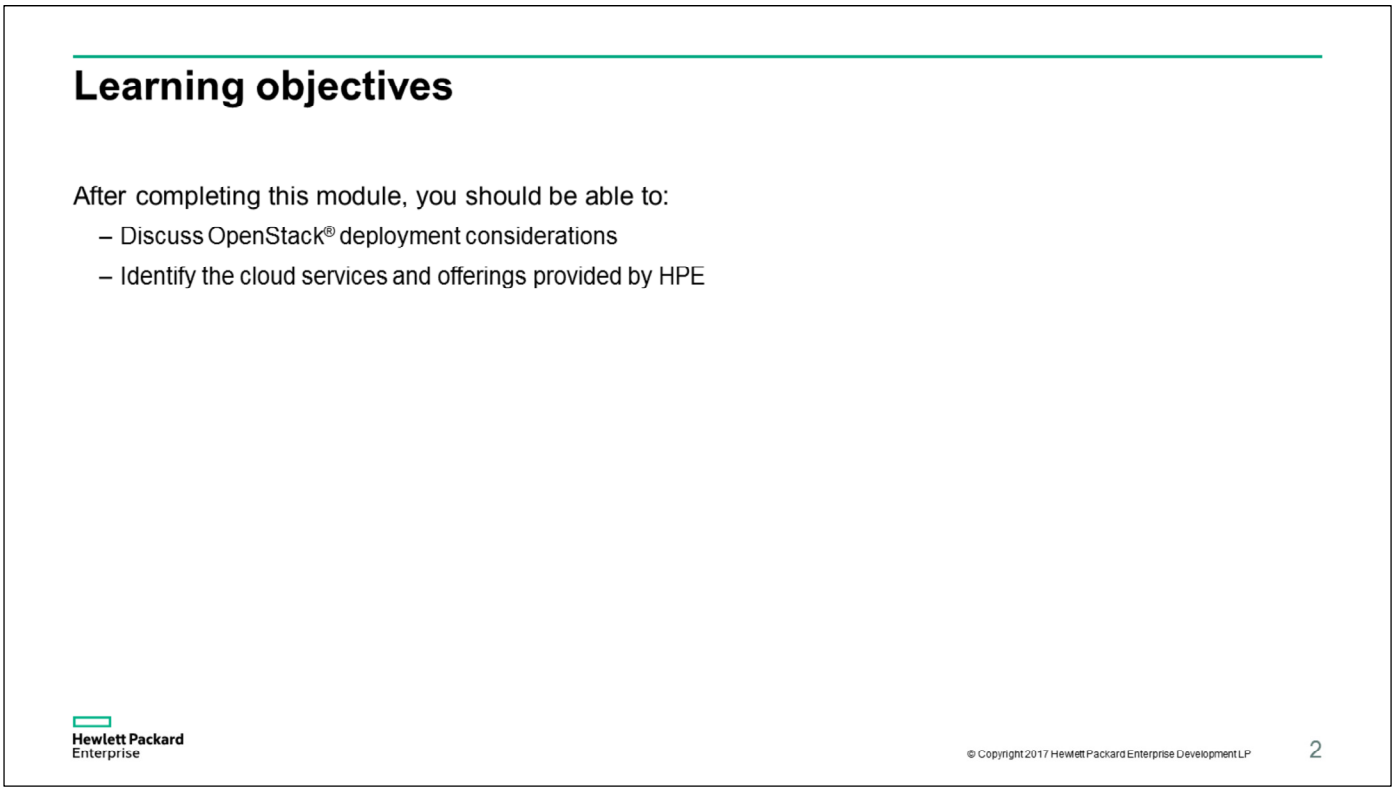

Learning objectives

After completing this module, you should be able to:

- Discuss OpenStack® deployment considerations
- Identify the cloud services and offerings provided by HPE

OpenStack® deployment considerations

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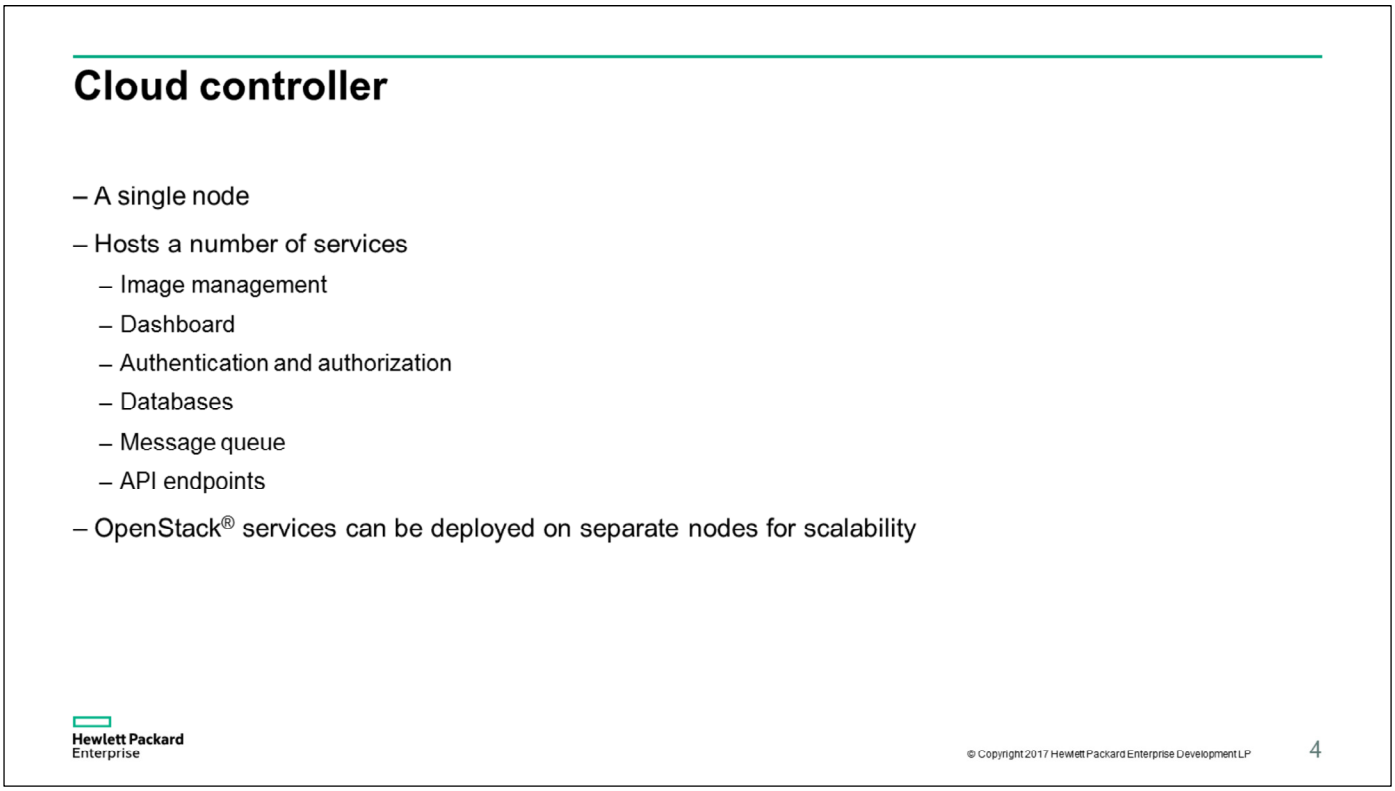


Cloud controller

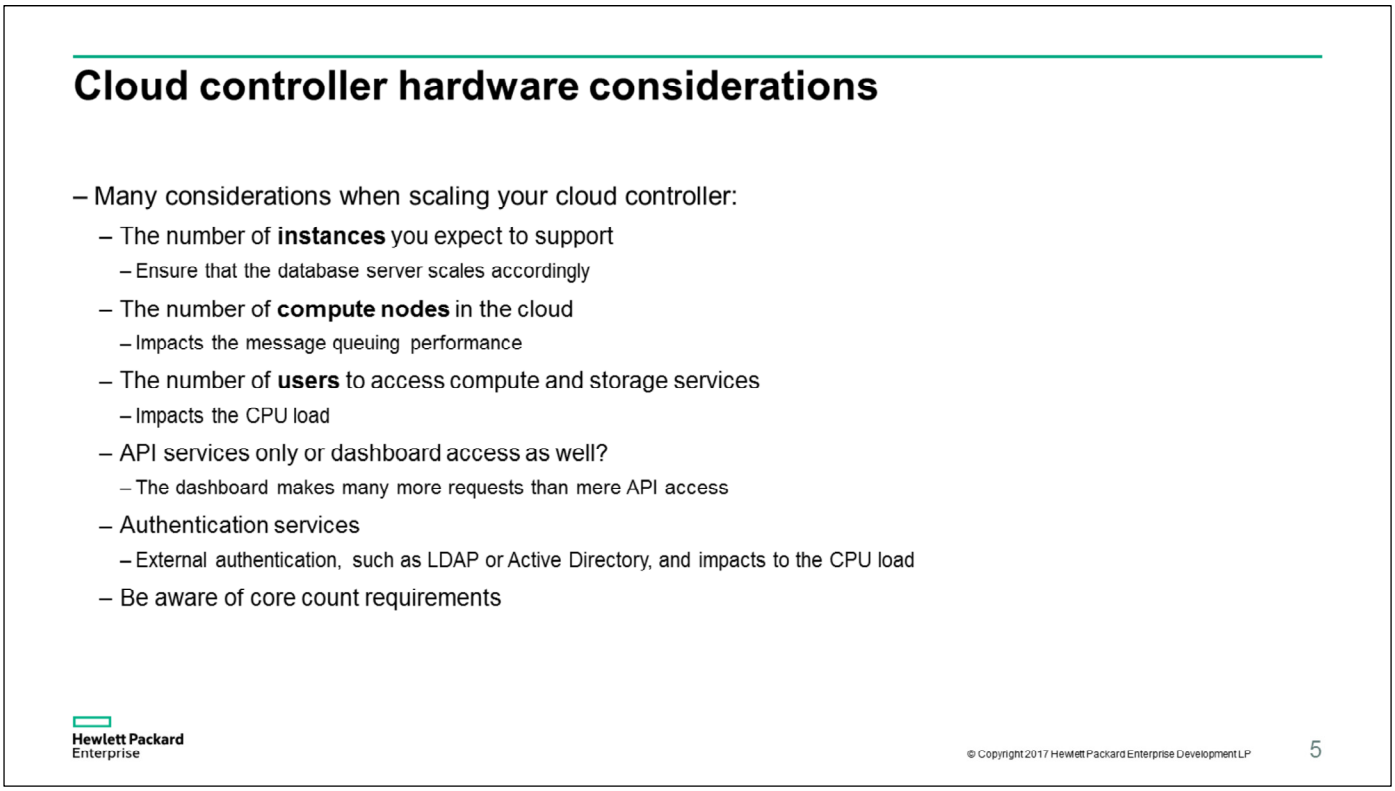
Each cloud is managed by a cloud controller. A cloud controller is a node that hosts the databases, message queue service, authentication and authorization service, image management service, user dashboard, and API endpoints.

The cloud controller provides centralized management for a multi-node OpenStack® deployment. Typically, the cloud controller manages authentication and sends messaging to all the OpenStack® services through a message queue.

The cloud controller has a collection of nova-* components that:

- Represent the global state of the cloud
- Communicate with the various OpenStack® services such as authentication
- Maintain information about the cloud in a database
- Communicate to all compute nodes and storage workers through a queue
- Provide API access

Each service running on a designated cloud controller can be broken out into separate nodes for scalability or availability.



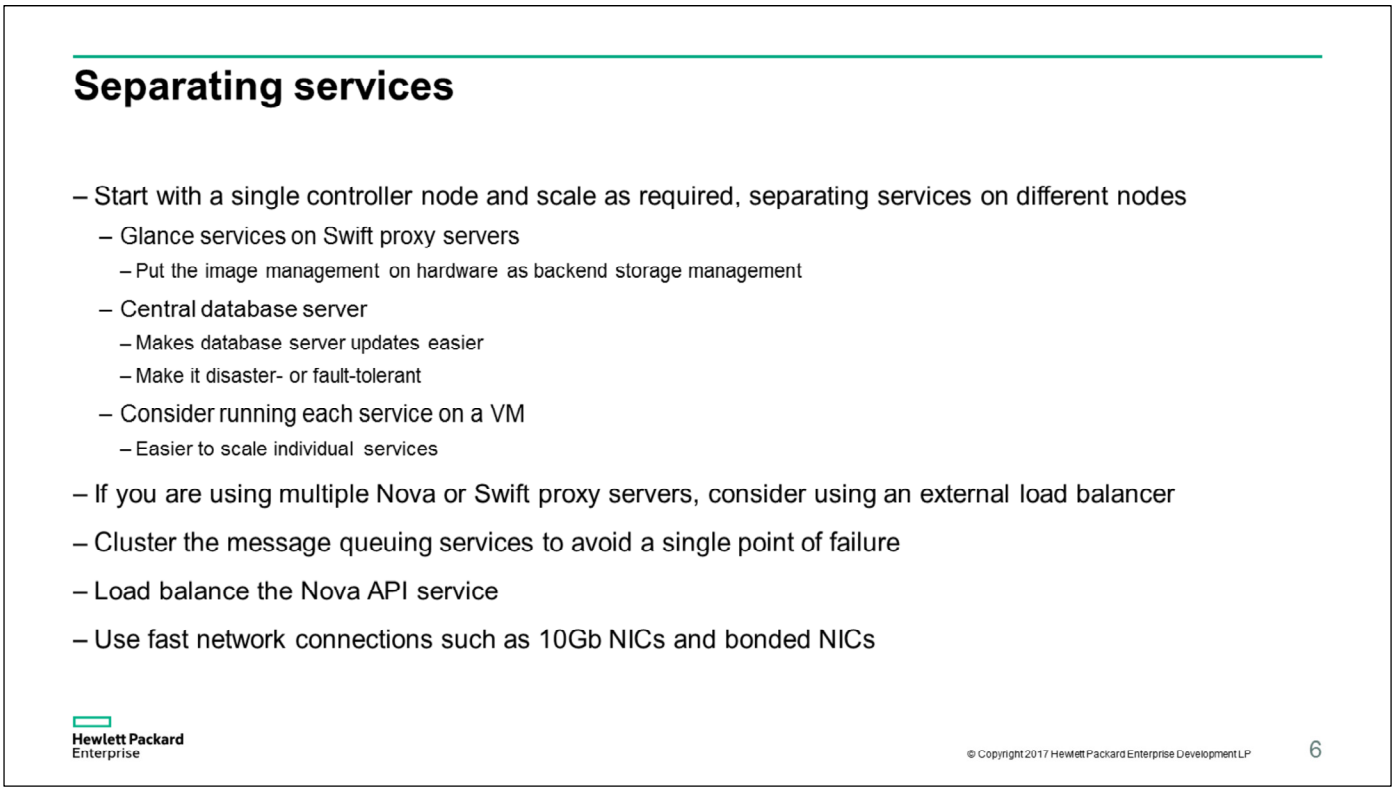
Cloud controller hardware considerations

When specifying cloud controller hardware, a good starting point is to consider the same type of hardware as you would use for a compute node. However, you have to consider the load on various services—not only the CPU load, but the network and memory load as well.

You can use virtual machines (VMs) for all or some of the services that the cloud controller manages, such as the message queuing.

To size the cloud controller correctly and determine whether to virtualize any part of it, you should estimate:

- The number of instances that you expect to run
- The number of compute nodes that you have
- The number of users who will access the compute or storage services
- Whether users interact with your cloud through the Representational State Transfer (REST) API or the dashboard
- Whether users authenticate against an external system such as the Lightweight Directory Access Protocol (LDAP) or Active Directory
- How long you expect single instances to run



Separating services

It is worth considering whether to run all of your cloud controller services on a single node or to spread them across several nodes. Start by estimating the expected load on the cloud controller and then scale out as required, based on your needs.

Glance can benefit from running on physical hardware and having good connectivity to the object storage backend.

Consider using a central dedicated server to provide the databases for all services. This model can simplify operations by isolating database server updates and allowing slave database servers for failover.

You can run various services on separate VMs. Then you can monitor and tune each VM to the service it hosts.

Consider placing services across several servers, using a load balancer to switch between them.

HPE cloud offerings

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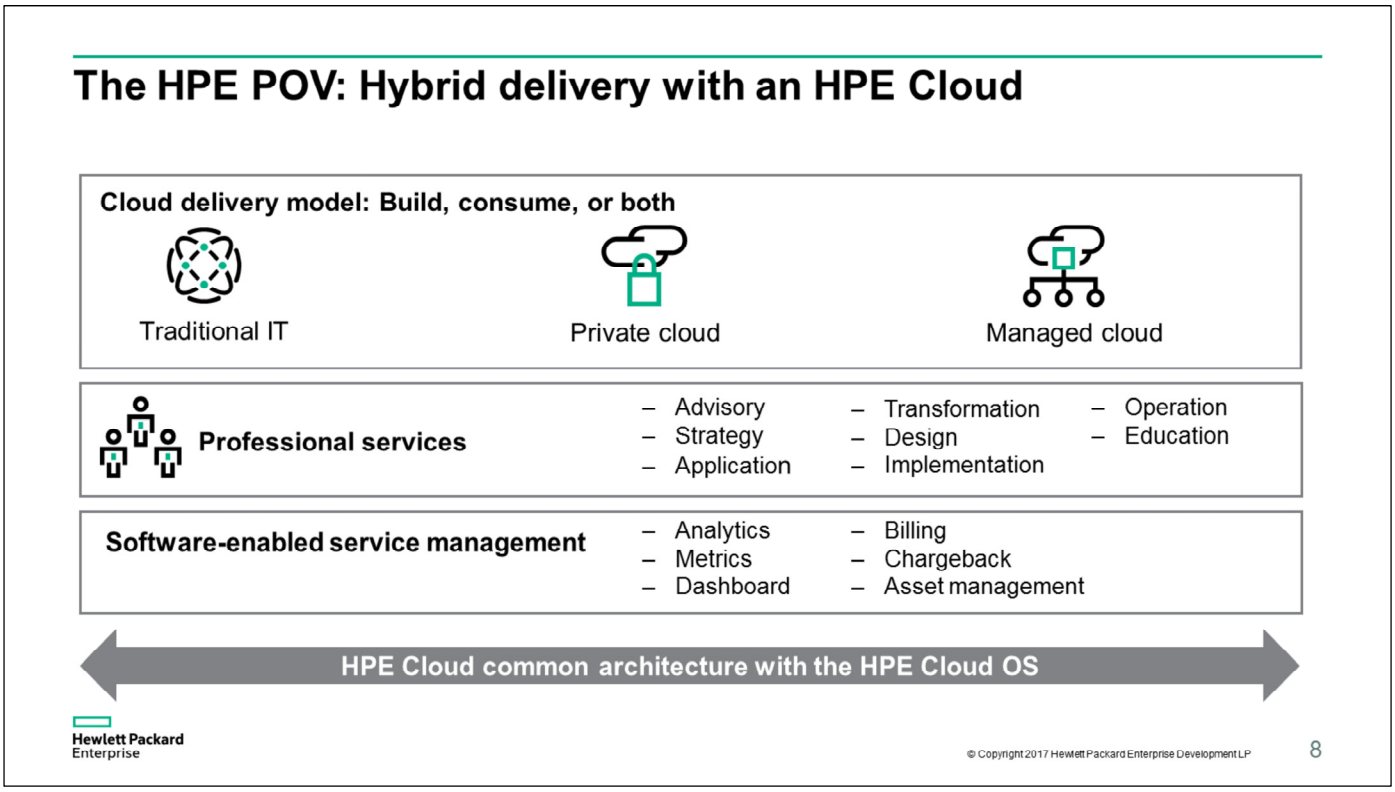


The HPE POV: Hybrid delivery with an HPE Cloud

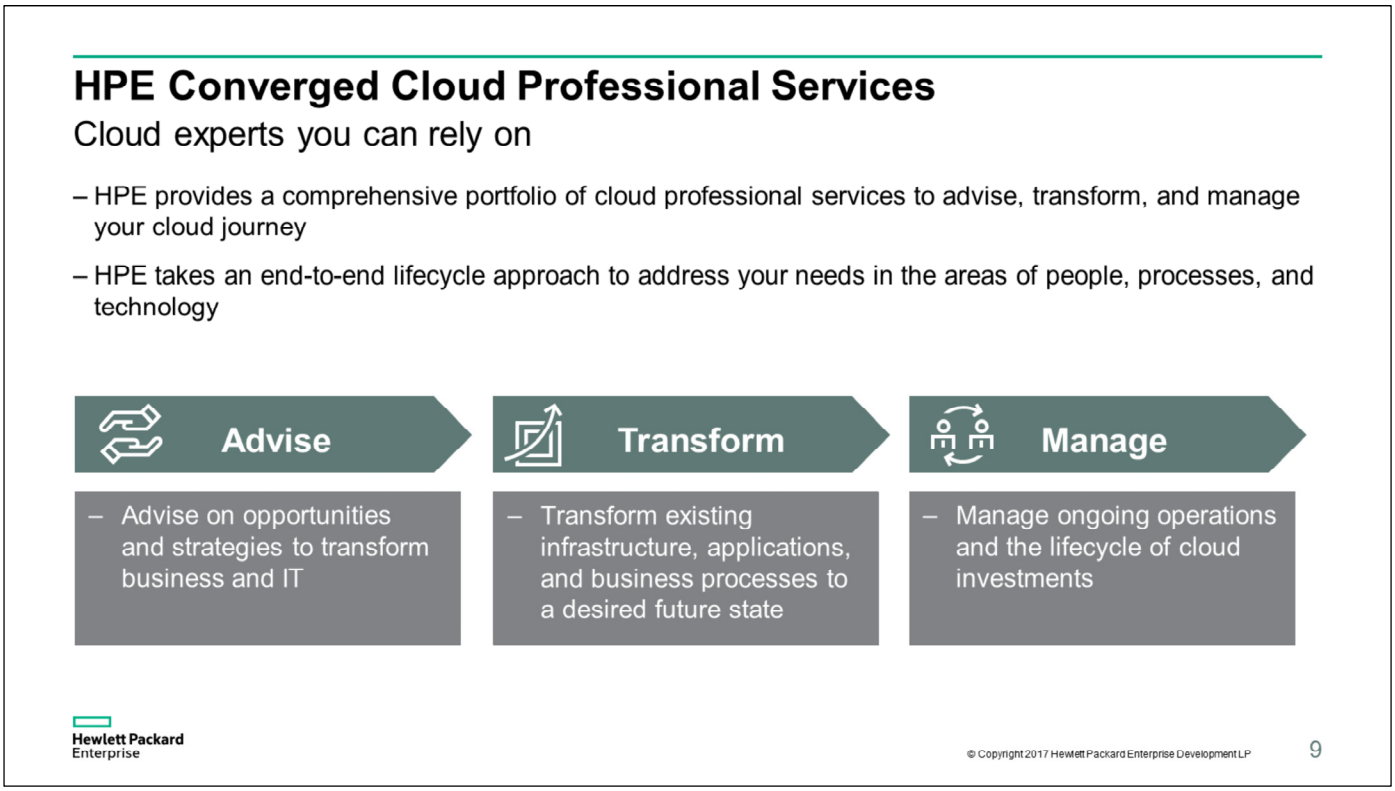
A hybrid cloud approach provides the means to address various IT service delivery challenges facing IT organizations today in the most efficient and cost effective way. This means taking advantage of the capabilities offered across the private cloud, managed cloud, and public cloud models and traditional IT, considering the various deployment models as a continuum of service level agreements (SLAs), and selecting an optimal mix of delivery models to achieve speed and agility.

Achieving a hybrid cloud models means looking at the portfolio of applications in your organization, segmenting them according to their respective SLA requirements, and then aligning the applications to the appropriate deployment model, thus creating the most optimal use of your internal and external resources.

In the hybrid world, the role of the chief information officer and IT organizations expands from the traditional builder of services to a build and broker of services, creating a seamless experience for users independent of the service source.

The hybrid cloud requires a broad portfolio of hardware, software, and services working together to drive outcomes.

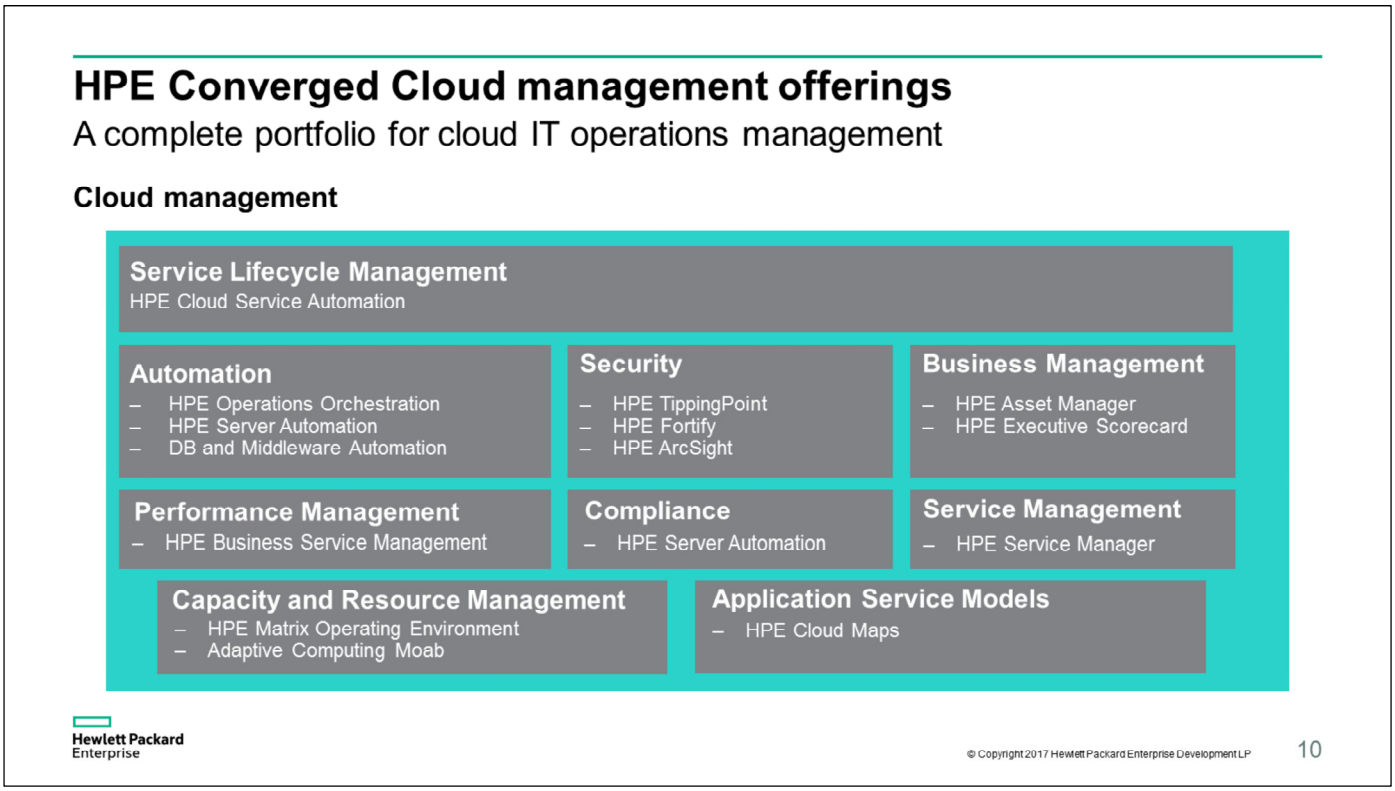
A narrow focus like that of some competitors locks you into their ecosystem, and also the outcomes that matter to them – not to you.



HPE Converged Cloud Professional Services—Cloud experts you can rely on

Many organizations are embracing hybrid delivery models to speed innovation, increase agility, and lower operating costs. However, disparate architectures, underperforming SLAs, and fragmented support can slow the adoption of a hybrid model that includes private, public, and managed clouds.

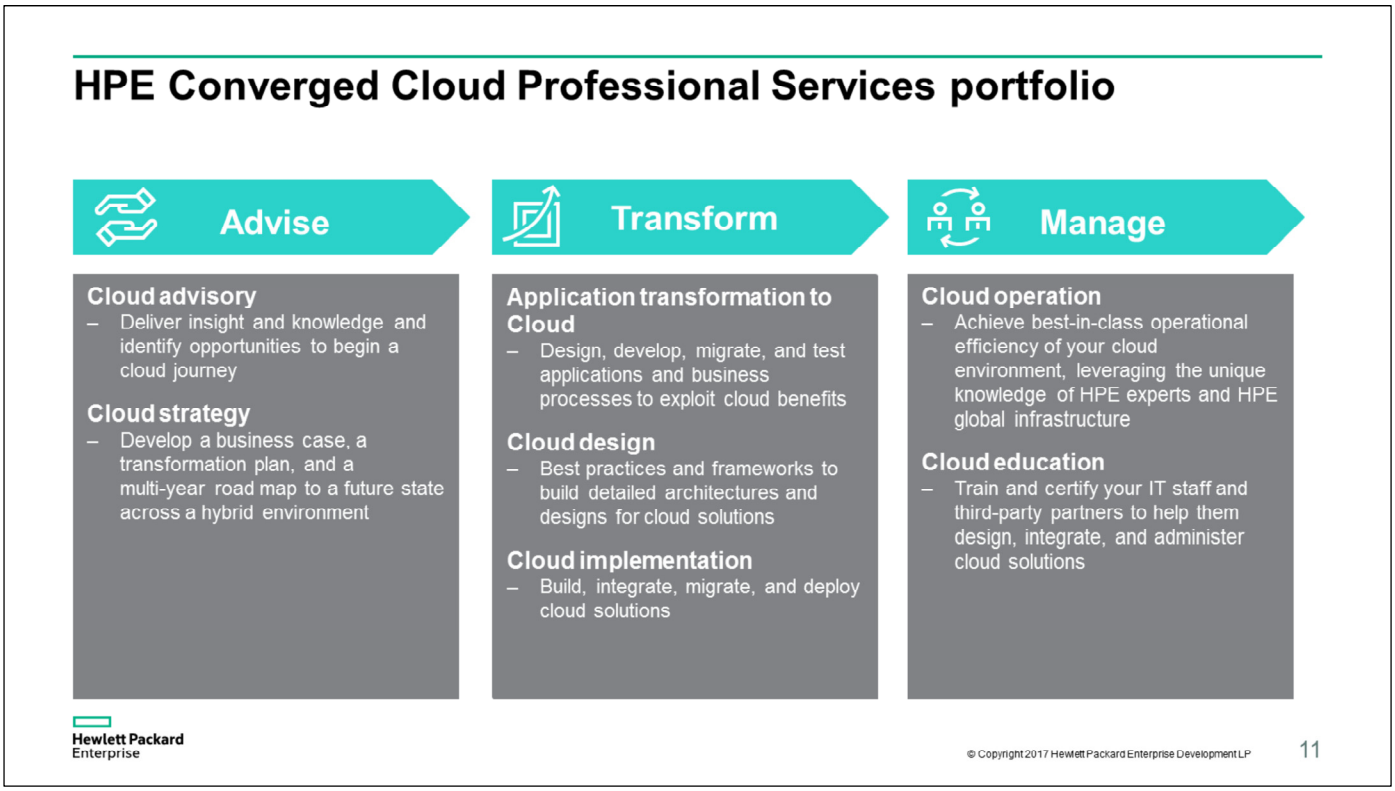
HPE Technology Services provides you with a single contact for your hybrid cloud design, implementation, and support that is personalized for your unique needs, delivering a proactive and cohesive cloud solution.



HPE Converged Cloud management offerings—A complete portfolio for cloud IT operations management

The HPE Converged Cloud offers a complete portfolio of solutions and services to meet your needs. Across private, managed, public, and hybrid clouds, HPE cloud solutions are built on a common foundation of HPE innovation and enterprise experience:

- **Choice**—Whether you are building onto existing infrastructure or from the ground up, the HPE multi-platform, multi-hypervisor cloud solutions are designed with open, standards-based technology with no vendor lock-in.
- **Confidence**—HPE provides a complete model with the right security and reliability levels across all delivery platforms. You can trust HPE to scale with you as your business evolves and transforms.
- **Consistency**—With the only common architecture across private, managed, and public clouds in the industry, rework is unnecessary. Your customers will appreciate the same application experience regardless of the backend.



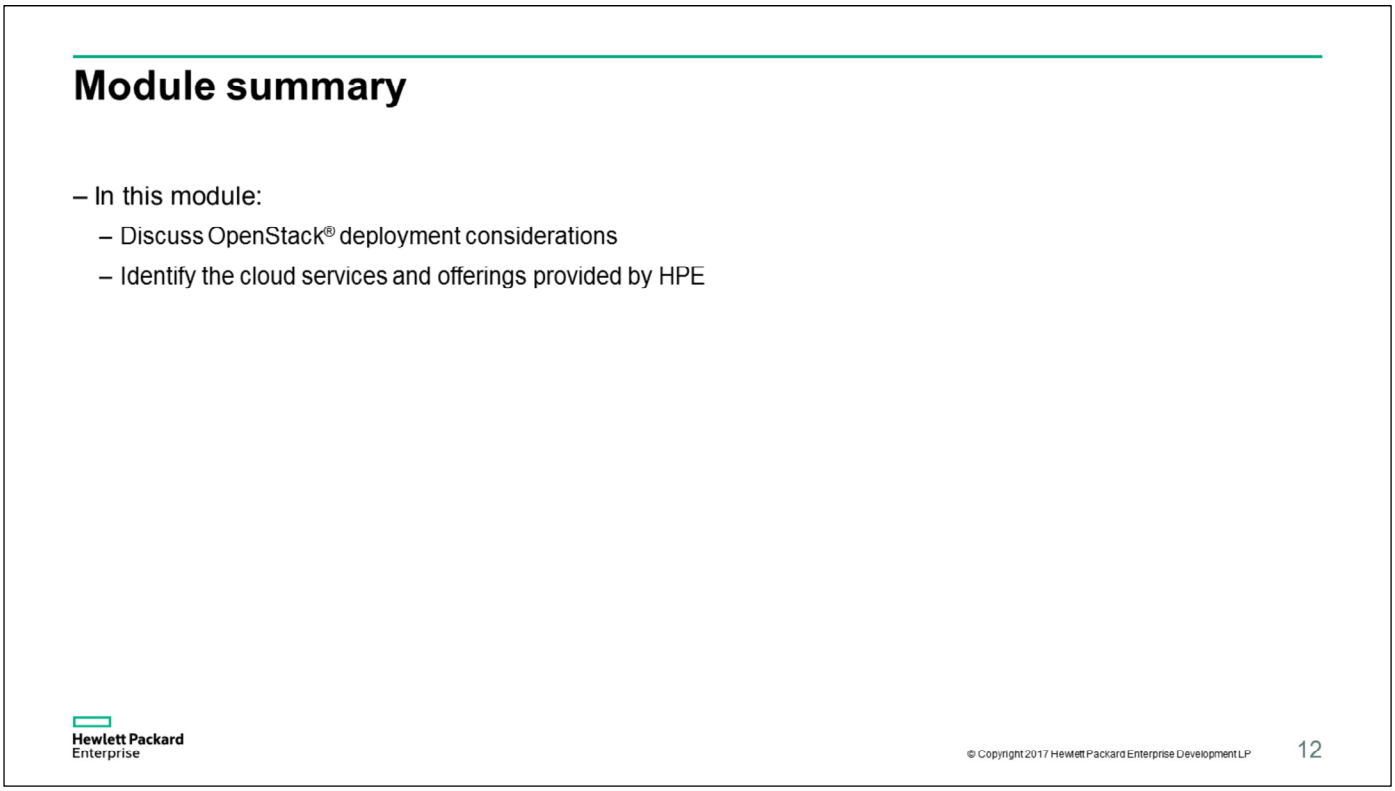
HPE Converged Cloud Professional Services portfolio

HPE offers a Cloud Services portfolio that matches the journey of each client and their unique requirements across the entire journey.

To provide you with insights and advice, HPE offers Cloud Advisory Services. These services identify opportunities to embrace the cloud based on business needs. With Cloud Strategy Services, HPE helps you develop a business case, a strategy, and a transformation plan to get you to the desired future state.

Based on that transformation plan, HPE helps you modernize and transform your applications, business processes, and infrastructure to take advantage of the cloud. Using the work from Cloud Design Services, HPE helps you build and deploy the appropriate solutions through Cloud Implementation Services.

As cloud services are deployed and updated over time, HPE Cloud Operation Services help you achieve best-in-class operational efficiency and support the services lifecycle end to end. With HPE Cloud Education Services, HPE can help to train and certify IT staff and partners to ensure they have the latest knowledge and skill set to continue to maintain and manage their cloud investments.



Module summary

In this module:

- Discuss OpenStack® deployment considerations
- Identify the cloud services and offerings provided by HPE

Learning check

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Learning check

How does the number of users impact the cloud controller?

A. It impacts the message queueing performance

B. It impacts the CPU load

C. It impacts the amount of available disk space

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Learning check answer

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Learning check

When planning for service separation, why would you consider running each service on a VM?

A. To make it easier to scale individual services

B. To make services disaster- or fault-tolerant

C. To make the database server updates easier

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Learning check

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