Operations Guide

Release Version: 15.0.0

OpenStack contributors

Jun 12, 2017

CONTENTS

ABSTRACT

This guide provides information about operating OpenStack clouds.

We recommend that you turn to the Installation Tutorials and Guides, which contains a step-by-step guide on how to manually install the OpenStack packages and dependencies on your cloud.

While it is important for an operator to be familiar with the steps involved in deploying OpenStack, we also strongly encourage you to evaluate OpenStack deployment tools and configuration-management tools, such as *Puppet* or *Chef*, which can help automate this deployment process.

In this guide, we assume that you have successfully deployed an OpenStack cloud and are able to perform basic operations such as adding images, booting instances, and attaching volumes.

As your focus turns to stable operations, we recommend that you do skim this guide to get a sense of the content. Some of this content is useful to read in advance so that you can put best practices into effect to simplify your life in the long run. Other content is more useful as a reference that you might turn to when an unexpected event occurs (such as a power failure), or to troubleshoot a particular problem.

Acknowledgements

The OpenStack Foundation supported the creation of this book with plane tickets to Austin, lodging (including one adventurous evening without power after a windstorm), and delicious food. For about USD $10,000, we could collaborate intensively for a week in the same room at the Rackspace Austin office. The authors are all members of the OpenStack Foundation, which you can join. Go to the Foundation web site.

We want to acknowledge our excellent host Rackers at Rackspace in Austin:

- Emma Richards of Rackspace Guest Relations took excellent care of our lunch orders and even set aside a pile of sticky notes that had fallen off the walls.
- Betsy Hagemeier, a Fanatical Executive Assistant, took care of a room reshuffle and helped us settle in for the week.
- The Real Estate team at Rackspace in Austin, also known as "The Victors," were super responsive.
- Adam Powell in Racker IT supplied us with bandwidth each day and second monitors for those of us needing more screens.
- On Wednesday night we had a fun happy hour with the Austin OpenStack Meetup group and Racker Katie Schmidt took great care of our group.

We also had some excellent input from outside of the room:

- Tim Bell from CERN gave us feedback on the outline before we started and reviewed it mid-week.
- Sébastien Han has written excellent blogs and generously gave his permission for re-use.
- Oisin Feeley read it, made some edits, and provided emailed feedback right when we asked.

Inside the book sprint room with us each day was our book sprint facilitator Adam Hyde. Without his tireless support and encouragement, we would have thought a book of this scope was impossible in five days. Adam has proven the book sprint method effectively again and again. He creates both tools and faith in collaborative authoring at www.booksprints.net.

We couldn't have pulled it off without so much supportive help and encouragement.

Preface

OpenStack is an open source platform that lets you build an *Infrastructure-as-a-Service (IaaS)* cloud that runs on commodity hardware.

Introduction to OpenStack

OpenStack believes in open source, open design, and open development, all in an open community that encourages participation by anyone. The long-term vision for OpenStack is to produce a ubiquitous open source cloud computing platform that meets the needs of public and private cloud providers regardless of size. OpenStack services control large pools of compute, storage, and networking resources throughout a data center.

The technology behind OpenStack consists of a series of interrelated projects delivering various components for a cloud infrastructure solution. Each service provides an open API so that all of these resources can be managed through a dashboard that gives administrators control while empowering users to provision resources through a web interface, a command-line client, or software development kits that support the API. Many OpenStack APIs are extensible, meaning you can keep compatibility with a core set of calls while providing access to more resources and innovating through API extensions. The OpenStack project is a global collaboration of developers and cloud computing technologists. The project produces an open standard cloud computing platform for both public and private clouds. By focusing on ease of implementation, massive scalability, a variety of rich features, and tremendous extensibility, the project aims to deliver a practical and reliable cloud solution for all types of organizations.

Getting Started with OpenStack

As an open source project, one of the unique aspects of OpenStack is that it has many different levels at which you can begin to engage with it—you don't have to do everything yourself.

Using OpenStack

You could ask, "Do I even need to build a cloud?" If you want to start using a compute or storage service by just swiping your credit card, you can go to eNovance, HP, Rackspace, or other organizations to start using their public OpenStack clouds. Using their OpenStack cloud resources is similar to accessing the publicly available Amazon Web Services Elastic Compute Cloud (EC2) or Simple Storage Solution (S3).

Plug and Play OpenStack

However, the enticing part of OpenStack might be to build your own private cloud, and there are several ways to accomplish this goal. Perhaps the simplest of all is an appliance-style solution. You purchase an appliance, unpack it, plug in the power and the network, and watch it transform into an OpenStack cloud with minimal additional configuration.

However, hardware choice is important for many applications, so if that applies to you, consider that there are several software distributions available that you can run on servers, storage, and network products of your choosing. Canonical (where OpenStack replaced Eucalyptus as the default cloud option in 2011), Red Hat, and SUSE offer enterprise OpenStack solutions and support. You may also want to take a look at some of the specialized distributions, such as those from Rackspace, Piston, SwiftStack, or Cloudscaling.

Alternatively, if you want someone to help guide you through the decisions about the underlying hardware or your applications, perhaps adding in a few features or integrating components along the way, consider contacting one of the system integrators with OpenStack experience, such as Mirantis or Metacloud.

If your preference is to build your own OpenStack expertise internally, a good way to kick-start that might be to attend or arrange a training session. The OpenStack Foundation has a Training Marketplace where you can look for nearby events. Also, the OpenStack community is working to produce open source training materials.

Roll Your Own OpenStack

However, this guide has a different audience—those seeking flexibility from the OpenStack framework by deploying do-it-yourself solutions.

OpenStack is designed for horizontal scalability, so you can easily add new compute, network, and storage resources to grow your cloud over time. In addition to the pervasiveness of massive OpenStack public clouds, many organizations, such as PayPal, Intel, and Comcast, build large-scale private clouds. OpenStack offers much more than a typical software package because it lets you integrate a number of different technologies to construct a cloud. This approach provides great flexibility, but the number of options might be daunting at first.

Who This Book Is For

This book is for those of you starting to run OpenStack clouds as well as those of you who were handed an operational one and want to keep it running well. Perhaps you're on a DevOps team, perhaps you are a system administrator starting to dabble in the cloud, or maybe you want to get on the OpenStack cloud team at your company. This book is for all of you.

This guide assumes that you are familiar with a Linux distribution that supports OpenStack, SQL databases, and virtualization. You must be comfortable administering and configuring multiple Linux machines for networking. You must install and maintain an SQL database and occasionally run queries against it.

One of the most complex aspects of an OpenStack cloud is the networking configuration. You should be familiar with concepts such as DHCP, Linux bridges, VLANs, and iptables. You must also have access to a network hardware expert who can configure the switches and routers required in your OpenStack cloud.

Note: Cloud computing is quite an advanced topic, and this book requires a lot of background knowledge. However, if you are fairly new to cloud computing, we recommend that you make use of the *Glossary* at the back of the book, as well as the online documentation for OpenStack and additional resources mentioned in this book in *Resources*.

Further Reading

There are other books on the OpenStack documentation website that can help you get the job done.

Installation Tutorials and Guides Describes a manual installation process, as in, by hand, without automation, for multiple distributions based on a packaging system:

- OpenStack Installation Tutorial for openSUSE and SUSE Linux Enterprise
- OpenStack Installation Tutorial for Red Hat Enterprise Linux and CentOS
- OpenStack Installation Tutorial for Ubuntu

OpenStack Configuration Reference Contains a reference listing of all configuration options for core and integrated OpenStack services by release version

OpenStack Architecture Design Guide Contains guidelines for designing an OpenStack cloud

OpenStack Administrator Guide Contains how-to information for managing an OpenStack cloud as needed for your use cases, such as storage, computing, or software-defined-networking

OpenStack High Availability Guide Describes potential strategies for making your OpenStack services and related controllers and data stores highly available

OpenStack Security Guide Provides best practices and conceptual information about securing an OpenStack cloud

Virtual Machine Image Guide Shows you how to obtain, create, and modify virtual machine images that are compatible with OpenStack

OpenStack End User Guide Shows OpenStack end users how to create and manage resources in an OpenStack cloud with the OpenStack dashboard and OpenStack client commands

OpenStack Networking Guide This guide targets OpenStack administrators seeking to deploy and manage OpenStack Networking (neutron).

OpenStack API Guide A brief overview of how to send REST API requests to endpoints for OpenStack services

How This Book Is Organized

This book contains several parts to show best practices and tips for the repeated operations for running OpenStack clouds.

Lay of the Land This chapter is written to let you get your hands wrapped around your OpenStack cloud through command-line tools and understanding what is already set up in your cloud.

Managing Projects and Users This chapter walks through user-enabling processes that all admins must face to manage users, give them quotas to parcel out resources, and so on.

User-Facing Operations This chapter shows you how to use OpenStack cloud resources and how to train your users.

Maintenance, Failures, and Debugging This chapter goes into the common failures that the authors have seen while running clouds in production, including troubleshooting.

Network Troubleshooting Because network troubleshooting is especially difficult with virtual resources, this chapter is chock-full of helpful tips and tricks for tracing network traffic, finding the root cause of networking failures, and debugging related services, such as DHCP and DNS.

Logging and Monitoring This chapter shows you where OpenStack places logs and how to best read and manage logs for monitoring purposes.

Backup and Recovery This chapter describes what you need to back up within OpenStack as well as best practices for recovering backups.

Customization For readers who need to get a specialized feature into OpenStack, this chapter describes how to use DevStack to write custom middleware or a custom scheduler to rebalance your resources.

Advanced Configuration Much of OpenStack is driver-oriented, so you can plug in different solutions to the base set of services. This chapter describes some advanced configuration topics.

Upgrades This chapter provides upgrade information based on the architectures used in this book.

Back matter:

Use Cases You can read a small selection of use cases from the OpenStack community with some technical details and further resources.

Tales From the Cryp^H^H^H^H Cloud These are shared legendary tales of image disappearances, VM massacres, and crazy troubleshooting techniques that result in hard-learned lessons and wisdom.

Working with Roadmaps Read about how to track the OpenStack roadmap through the open and transparent development processes.

Resources So many OpenStack resources are available online because of the fast-moving nature of the project, but there are also resources listed here that the authors found helpful while learning themselves.

Glossary A list of terms used in this book is included, which is a subset of the larger OpenStack glossary available online.

Why and How We Wrote This Book

We wrote this book because we have deployed and maintained OpenStack clouds for at least a year and we wanted to share this knowledge with others. After months of being the point people for an OpenStack cloud, we also wanted to have a document to hand to our system administrators so that they'd know how to operate the cloud on a daily basis—both reactively and pro-actively. We wanted to provide more detailed technical information about the decisions that deployers make along the way.

We wrote this book to help you:

- Design and create an architecture for your first nontrivial OpenStack cloud. After you read this guide, you'll know which questions to ask and how to organize your compute, networking, and storage resources and the associated software packages.
- Perform the day-to-day tasks required to administer a cloud.

We wrote this book in a book sprint, which is a facilitated, rapid development production method for books. For more information, see the BookSprints site. Your authors cobbled this book together in five days during February 2013, fueled by caffeine and the best takeout food that Austin, Texas, could offer.

On the first day, we filled white boards with colorful sticky notes to start to shape this nebulous book about how to architect and operate clouds:

We wrote furiously from our own experiences and bounced ideas between each other. At regular intervals we reviewed the shape and organization of the book and further molded it, leading to what you see today.

The team includes:

Tom Fifield After learning about scalability in computing from particle physics experiments, such as ATLAS at the Large Hadron Collider (LHC) at CERN, Tom worked on OpenStack clouds in production to support the Australian public research sector. Tom currently serves as an OpenStack community manager and works on OpenStack documentation in his spare time.

Diane Fleming Diane works on the OpenStack API documentation tirelessly. She helped out wherever she could on this project.

Anne Gentle Anne is the documentation coordinator for OpenStack and also served as an individual contributor to the Google Documentation Summit in 2011, working with the Open Street Maps team. She has worked on book sprints in the past, with FLOSS Manuals' Adam Hyde facilitating. Anne lives in Austin, Texas.

Lorin Hochstein An academic turned software-developer-slash-operator, Lorin worked as the lead architect for Cloud Services at Nimbis Services, where he deploys OpenStack for technical computing applications. He has been working with OpenStack since the Cactus release. Previously, he worked on high-performance computing extensions for OpenStack at University of Southern California's Information Sciences Institute (USC-ISI).

Adam Hyde Adam facilitated this book sprint. He also founded the book sprint methodology and is the most experienced book-sprint facilitator around. See BookSprints for more information. Adam founded FLOSS Manuals—a community of some 3,000 individuals developing Free Manuals about Free Software. He is also the founder and project manager for Booktype, an open source project for writing, editing, and publishing books online and in print.

Jonathan Proulx Jon has been piloting an OpenStack cloud as a senior technical architect at the MIT Computer Science and Artificial Intelligence Lab for his researchers to have as much computing power as they need. He started contributing to OpenStack documentation and reviewing the documentation so that he could accelerate his learning.

Everett Toews Everett is a developer advocate at Rackspace making OpenStack and the Rackspace Cloud easy to use. Sometimes developer, sometimes advocate, and sometimes operator, he's built web applications, taught workshops, given presentations around the world, and deployed OpenStack for production use by academia and business.

Joe Topjian Joe has designed and deployed several clouds at Cybera, a nonprofit where they are building e-infrastructure to support entrepreneurs and local researchers in Alberta, Canada. He also actively maintains and operates these clouds as a systems architect, and his experiences have generated a wealth of troubleshooting skills for cloud environments.

OpenStack community members Many individual efforts keep a community book alive. Our community members updated content for this book year-round. Also, a year after the first sprint, Jon Proulx hosted a second two-day mini-sprint at MIT with the goal of updating the book for the latest release. Since the book's inception, more than 30 contributors have supported this book. We have a tool chain for reviews, continuous builds, and translations. Writers and developers continuously review patches, enter doc bugs, edit content, and fix doc bugs. We want to recognize their efforts!

The following people have contributed to this book: Akihiro Motoki, Alejandro Avella, Alexandra Settle, Andreas Jaeger, Andy McCallum, Benjamin Stassart, Chandan Kumar, Chris Ricker, David Cramer, David Wittman, Denny Zhang, Emilien Macchi, Gauvain Pocentek, Ignacio Barrio, James E. Blair, Jay Clark, Jeff White, Jeremy Stanley, K Jonathan Harker, KATO Tomoyuki, Lana Brindley, Laura Alves, Lee Li, Lukasz Jernas, Mario B. Codeniera, Matthew Kassawara, Michael Still, Monty Taylor, Nermina Miller, Nigel Williams, Phil Hopkins, Russell Bryant, Sahid Orentino Ferdjaoui, Sandy Walsh, Sascha Peilicke, Sean M. Collins, Sergey Lukjanov, Shilla Saebi, Stephen Gordon, Summer Long, Uwe Stuehler, Vaibhav Bhatkar, Veronica Musso, Ying Chun "Daisy" Guo, Zhengguang Ou, and ZhiQiang Fan.

How to Contribute to This Book

The genesis of this book was an in-person event, but now that the book is in your hands, we want you to contribute to it. OpenStack documentation follows the coding principles of iterative work, with bug logging, investigating, and fixing. We also store the source content on GitHub and invite collaborators through the OpenStack Gerrit installation, which offers reviews. For the O'Reilly edition of this book, we are using the company's Atlas system, which also stores source content on GitHub and enables collaboration among contributors.

Learn more about how to contribute to the OpenStack docs at OpenStack Documentation Contributor Guide.

If you find a bug and can't fix it or aren't sure it's really a doc bug, log a bug at OpenStack Manuals. Tag the bug under Extra options with the `ops-guide` tag to indicate that the bug is in this guide. You can assign the bug to yourself if you know how to fix it. Also, a member of the OpenStack doc-core team can triage the doc bug.

Conventions

The OpenStack documentation uses several typesetting conventions.

Notices

Notices take these forms:

Note: A comment with additional information that explains a part of the text.

Important: Something you must be aware of before proceeding.

Tip: An extra but helpful piece of practical advice.

Caution: Helpful information that prevents the user from making mistakes.

Warning: Critical information about the risk of data loss or security issues.

Command prompts

```
$ command
```

Any user, including the `root` user, can run commands that are prefixed with the `$` prompt.

```
# command
```

The `root` user must run commands that are prefixed with the `#` prompt. You can also prefix these commands with the **sudo** command, if available, to run them.

Factors affecting OpenStack deployment

Security requirements

When deploying OpenStack in an enterprise as a private cloud, it is usually behind the firewall and within the trusted network alongside existing systems. Users are employees that are bound by the company security requirements. This tends to drive most of the security domains towards a more trusted model. However, when deploying OpenStack in a public facing role, no assumptions can be made and the attack vectors significantly increase.

Consider the following security implications and requirements:

- Managing the users for both public and private clouds. The Identity service allows for LDAP to be part of the authentication process. This may ease user management if integrating into existing systems.
- User authentication requests include sensitive information including usernames, passwords, and authentication tokens. It is strongly recommended to place API services behind hardware that performs SSL termination.
- Negative or hostile users who would attack or compromise the security of your deployment regardless of firewalls or security agreements.
- Attack vectors increase further in a public facing OpenStack deployment. For example, the API endpoints and the software behind it become vulnerable to hostile entities attempting to gain unauthorized access or prevent access to services. You should provide appropriate filtering and periodic security auditing.

> **Warning:** Be mindful of consistency when utilizing third party clouds to explore authentication options.

For more information OpenStack Security, see the OpenStack Security Guide.

Security domains

A security domain comprises of users, applications, servers or networks that share common trust requirements and expectations within a system. Typically they have the same authentication and authorization requirements and users.

Security domains include:

Public security domains The public security domain can refer to the internet as a whole or networks over which you have no authority. This domain is considered untrusted. For example, in a hybrid cloud deployment, any information traversing between and beyond the clouds is in the public domain and untrustworthy.

Guest security domains The guest security domain handles compute data generated by instances on the cloud, but not services that support the operation of the cloud, such as API calls. Public cloud providers and private cloud providers who do not have stringent controls on instance use or who allow unrestricted internet access to instances should consider this domain to be untrusted. Private cloud providers may want to consider this network as internal and therefore trusted only if they have controls in place to assert that they trust instances and all their tenants.

Management security domains The management security domain is where services interact. Sometimes referred to as the control plane, the networks in this domain transport confidential data such as configuration parameters, user names, and passwords. In most deployments this domain is considered trusted when it is behind an organization's firewall.

Data security domains The data security domain is primarily concerned with information pertaining to the storage services within OpenStack. The data that crosses this network has high integrity and confidentiality requirements and, depending on the type of deployment, may also have strong availability requirements. The trust level of this network is heavily dependent on other deployment decisions.

These security domains can be individually or collectively mapped to an OpenStack deployment. The cloud operator should be aware of the appropriate security concerns. Security domains should be mapped out against your specific OpenStack deployment topology. The domains and their trust requirements depend upon whether the cloud instance is public, private, or hybrid.

Hypervisor security

The hypervisor also requires a security assessment. In a public cloud, organizations typically do not have control over the choice of hypervisor. Properly securing your hypervisor is important. Attacks made upon the unsecured hypervisor are called a **hypervisor breakout**. Hypervisor breakout describes the event of a compromised or malicious instance breaking out of the resource controls of the hypervisor and gaining access to the bare metal operating system and hardware resources.

Hypervisor security is not an issue if the security of instances is not important. However, enterprises can minimize vulnerability by avoiding hardware sharing with others in a public cloud.

Baremetal security

There are other services worth considering that provide a bare metal instance instead of a cloud. In other cases, it is possible to replicate a second private cloud by integrating with a private Cloud-as-a-Service deployment. The organization does not buy the hardware, but also does not share with other tenants. It is also possible to use a provider that hosts a bare-metal public cloud instance for which the hardware is dedicated only to one customer, or a provider that offers private Cloud-as-a-Service.

Important: Each cloud implements services differently. Understand the security requirements of every cloud that handles the organization's data or workloads.

Networking security

Consider security implications and requirements before designing the physical and logical network topologies. Make sure that the networks are properly segregated and traffic flows are going to the correct destinations without crossing through locations that are undesirable. Consider the following factors:

- Firewalls
- Overlay interconnects for joining separated tenant networks
- Routing through or avoiding specific networks

How networks attach to hypervisors can expose security vulnerabilities. To mitigate hypervisor breakouts, separate networks from other systems and schedule instances for the network onto dedicated Compute nodes. This prevents attackers from having access to the networks from a compromised instance.

Multi-site security

Securing a multi-site OpenStack installation brings several challenges. Tenants may expect a tenant-created network to be secure. In a multi-site installation the use of a non-private connection between sites may be required. This may mean that traffic would be visible to third parties and, in cases where an application requires security, this issue requires mitigation. In these instances, install a VPN or encrypted connection between sites to conceal sensitive traffic.

Identity is another security consideration. Authentication centralization provides a single authentication point for users across the deployment, and a single administration point for traditional create, read, update, and delete operations. Centralized authentication is also useful for auditing purposes because all authentication tokens originate from the same source.

Tenants in multi-site installations need isolation from each other. The main challenge is ensuring tenant networks function across regions which is not currently supported in OpenStack Networking (neutron). Therefore an external system may be required to manage mapping. Tenant networks may contain sensitive information requiring accurate and consistent mapping to ensure that a tenant in one site does not connect to a different tenant in another site.

Legal requirements

Using remote resources for collection, processing, storage, and retrieval provides potential benefits to businesses. With the rapid growth of data within organizations, businesses need to be proactive about their data storage strategies from a compliance point of view.

Most countries have legislative and regulatory requirements governing the storage and management of data in cloud environments. This is particularly relevant for public, community and hybrid cloud models, to ensure data privacy and protection for organizations using a third party cloud provider.

Common areas of regulation include:

- Data retention policies ensuring storage of persistent data and records management to meet data archival requirements.
- Data ownership policies governing the possession and responsibility for data.
- Data sovereignty policies governing the storage of data in foreign countries or otherwise separate jurisdictions.
- Data compliance policies governing certain types of information needing to reside in certain locations due to regulatory issues - and more importantly, cannot reside in other locations for the same reason.
- Data location policies ensuring that the services deployed to the cloud are used according to laws and regulations in place for the employees, foreign subsidiaries, or third parties.
- Disaster recovery policies ensuring regular data backups and relocation of cloud applications to another supplier in scenarios where a provider may go out of business, or their data center could become inoperable.
- Security breach policies governing the ways to notify individuals through cloud provider's systems or other means if their personal data gets compromised in any way.
- Industry standards policy governing additional requirements on what type of cardholder data may or may not be stored and how it is to be protected.

This is an example of such legal frameworks:

Data storage regulations in Europe are currently driven by provisions of the Data protection framework. Financial Industry Regulatory Authority works on this in the United States.

Privacy and security are spread over different industry-specific laws and regulations:

- Health Insurance Portability and Accountability Act (HIPAA)
- Gramm-Leach-Bliley Act (GLBA)
- Payment Card Industry Data Security Standard (PCI DSS)
- Family Educational Rights and Privacy Act (FERPA)

Cloud security architecture

Cloud security architecture should recognize the issues that arise with security management, which addresses these issues with security controls. Cloud security controls are put in place to safeguard any weaknesses in the system, and reduce the effect of an attack.

The following security controls are described below.

Deterrent controls: Typically reduce the threat level by informing potential attackers that there will be adverse consequences for them if they proceed.

Preventive controls: Strengthen the system against incidents, generally by reducing if not actually eliminating vulnerabilities.

Detective controls: Intended to detect and react appropriately to any incidents that occur. System and network security monitoring, including intrusion detection and prevention arrangements, are typically employed to detect attacks on cloud systems and the supporting communications infrastructure.

Corrective controls: Reduce the consequences of an incident, normally by limiting the damage. They come into effect during or after an incident. Restoring system backups in order to rebuild a compromised system is an example of a corrective control.

For more information, see See also NIST Special Publication 800-53.

Software licensing

The many different forms of license agreements for software are often written with the use of dedicated hardware in mind. This model is relevant for the cloud platform itself, including the hypervisor operating system, supporting software for items such as database, RPC, backup, and so on. Consideration must be made when offering Compute service instances and applications to end users of the cloud, since the license terms for that software may need some adjustment to be able to operate economically in the cloud.

Multi-site OpenStack deployments present additional licensing considerations over and above regular OpenStack clouds, particularly where site licenses are in use to provide cost efficient access to software licenses. The licensing for host operating systems, guest operating systems, OpenStack distributions (if applicable), software-defined infrastructure including network controllers and storage systems, and even individual applications need to be evaluated.

Topics to consider include:

- The definition of what constitutes a site in the relevant licenses, as the term does not necessarily denote a geographic or otherwise physically isolated location.

- Differentiations between "hot" (active) and "cold" (inactive) sites, where significant savings may be made in situations where one site is a cold standby for disaster recovery purposes only.
- Certain locations might require local vendors to provide support and services for each site which may vary with the licensing agreement in place.

Planning for deploying and provisioning OpenStack

The decisions you make with respect to provisioning and deployment will affect your maintenance of the cloud. Your configuration management will be able to evolve over time. However, more thought and design need to be done for upfront choices about deployment, disk partitioning, and network configuration.

A critical part of a cloud's scalability is the amount of effort that it takes to run your cloud. To minimize the operational cost of running your cloud, set up and use an automated deployment and configuration infrastructure with a configuration management system, such as *Puppet* or *Chef*. Combined, these systems greatly reduce manual effort and the chance for operator error.

This infrastructure includes systems to automatically install the operating system's initial configuration and later coordinate the configuration of all services automatically and centrally, which reduces both manual effort and the chance for error. Examples include Ansible, CFEngine, Chef, Puppet, and Salt. You can even use OpenStack to deploy OpenStack, named TripleO (OpenStack On OpenStack).

Automated deployment

An automated deployment system installs and configures operating systems on new servers, without intervention, after the absolute minimum amount of manual work, including physical racking, MAC-to-IP assignment, and power configuration. Typically, solutions rely on wrappers around PXE boot and TFTP servers for the basic operating system install and then hand off to an automated configuration management system.

Both Ubuntu and Red Hat Enterprise Linux include mechanisms for configuring the operating system, including preseed and kickstart, that you can use after a network boot. Typically, these are used to bootstrap an automated configuration system. Alternatively, you can use an image-based approach for deploying the operating system, such as systemimager. You can use both approaches with a virtualized infrastructure, such as when you run VMs to separate your control services and physical infrastructure.

When you create a deployment plan, focus on a few vital areas because they are very hard to modify post deployment. The next two sections talk about configurations for:

- Disk partitioning and disk array setup for scalability
- Networking configuration just for PXE booting

Disk partitioning and RAID

At the very base of any operating system are the hard drives on which the operating system (OS) is installed.

You must complete the following configurations on the server's hard drives:

- Partitioning, which provides greater flexibility for layout of operating system and swap space, as described below.
- Adding to a RAID array (RAID stands for redundant array of independent disks), based on the number of disks you have available, so that you can add capacity as your cloud grows. Some options are described in more detail below.

The simplest option to get started is to use one hard drive with two partitions:

- File system to store files and directories, where all the data lives, including the root partition that starts and runs the system.
- Swap space to free up memory for processes, as an independent area of the physical disk used only for swapping and nothing else.

RAID is not used in this simplistic one-drive setup because generally for production clouds, you want to ensure that if one disk fails, another can take its place. Instead, for production, use more than one disk. The number of disks determine what types of RAID arrays to build.

We recommend that you choose one of the following multiple disk options:

Option 1 Partition all drives in the same way in a horizontal fashion, as shown in *Partition setup of drives*.

With this option, you can assign different partitions to different RAID arrays. You can allocate partition 1 of disk one and two to the `/boot` partition mirror. You can make partition 2 of all disks the root partition mirror. You can use partition 3 of all disks for a `cinder-volumes` LVM partition running on a RAID 10 array.

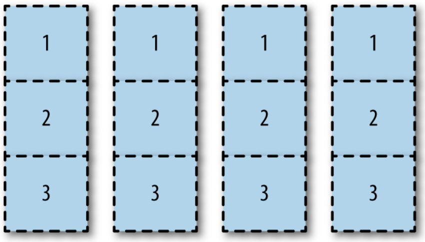


Fig. 1: Partition setup of drives

While you might end up with unused partitions, such as partition 1 in disk three and four of this example, this option allows for maximum utilization of disk space. I/O performance might be an issue as a result of all disks being used for all tasks.

Option 2 Add all raw disks to one large RAID array, either hardware or software based. You can partition this large array with the boot, root, swap, and LVM areas. This option is simple to implement and uses all partitions. However, disk I/O might suffer.

Option 3 Dedicate entire disks to certain partitions. For example, you could allocate disk one and two entirely to the boot, root, and swap partitions under a RAID 1 mirror. Then, allocate disk three and four entirely to the LVM partition, also under a RAID 1 mirror. Disk I/O should be better because I/O is focused on dedicated tasks. However, the LVM partition is much smaller.

Tip: You may find that you can automate the partitioning itself. For example, MIT uses Fully Automatic Installation (FAI) to do the initial PXE-based partition and then install using a combination of min/max and percentage-based partitioning.

As with most architecture choices, the right answer depends on your environment. If you are using existing hardware, you know the disk density of your servers and can determine some decisions based on the options above. If you are going through a procurement process, your user's requirements also help you determine hardware purchases. Here are some examples from a private cloud providing web developers custom environments at AT&T. This example is from a specific deployment, so your existing hardware or procurement opportunity may vary from this. AT&T uses three types of hardware in its deployment:

- Hardware for controller nodes, used for all stateless OpenStack API services. About 32–64 GB memory, small attached disk, one processor, varied number of cores, such as 6–12.
- Hardware for compute nodes. Typically 256 or 144 GB memory, two processors, 24 cores. 4–6 TB direct attached storage, typically in a RAID 5 configuration.
- Hardware for storage nodes. Typically for these, the disk space is optimized for the lowest cost per GB of storage while maintaining rack-space efficiency.

Again, the right answer depends on your environment. You have to make your decision based on the trade-offs between space utilization, simplicity, and I/O performance.

Network configuration

Network configuration is a very large topic that spans multiple areas of this book. For now, make sure that your servers can PXE boot and successfully communicate with the deployment server.

For example, you usually cannot configure NICs for VLANs when PXE booting. Additionally, you usually cannot PXE boot with bonded NICs. If you run into this scenario, consider using a simple 1 GB switch in a private network on which only your cloud communicates.

Automated configuration

The purpose of automatic configuration management is to establish and maintain the consistency of a system without using human intervention. You want to maintain consistency in your deployments so that you can have the same cloud every time, repeatably. Proper use of automatic configuration-management tools ensures that components of the cloud systems are in particular states, in addition to simplifying deployment, and configuration change propagation.

These tools also make it possible to test and roll back changes, as they are fully repeatable. Conveniently, a large body of work has been done by the OpenStack community in this space. Puppet, a configuration management tool, even provides official modules for OpenStack projects in an OpenStack infrastructure system known as Puppet OpenStack. Chef configuration management is provided within https://git.openstack.org/cgit/openstack/openstack-chef-repo. Additional configuration management systems include Juju, Ansible, and Salt. Also, PackStack is a command-line utility for Red Hat Enterprise Linux and derivatives that uses Puppet modules to support rapid deployment of OpenStack on existing servers over an SSH connection.

An integral part of a configuration-management system is the item that it controls. You should carefully consider all of the items that you want, or do not want, to be automatically managed. For example, you may not want to automatically format hard drives with user data.

Remote management

In our experience, most operators don't sit right next to the servers running the cloud, and many don't necessarily enjoy visiting the data center. OpenStack should be entirely remotely configurable, but sometimes not everything goes according to plan.

In this instance, having an out-of-band access into nodes running OpenStack components is a boon. The IPMI protocol is the de facto standard here, and acquiring hardware that supports it is highly recommended to achieve that lights-out data center aim.

In addition, consider remote power control as well. While IPMI usually controls the server's power state, having remote access to the PDU that the server is plugged into can really be useful for situations when everything seems wedged.

Other considerations

You can save time by understanding the use cases for the cloud you want to create. Use cases for OpenStack are varied. Some include object storage only; others require preconfigured compute resources to speed development-environment set up; and others need fast provisioning of compute resources that are already secured per tenant with private networks. Your users may have need for highly redundant servers to make sure their legacy applications continue to run. Perhaps a goal would be to architect these legacy applications so that they run on multiple instances in a cloudy, fault-tolerant way, but not make it a goal to add to those clusters over time. Your users may indicate that they need scaling considerations because of heavy Windows server use.

You can save resources by looking at the best fit for the hardware you have in place already. You might have some high-density storage hardware available. You could format and repurpose those servers for OpenStack Object Storage. All of these considerations and input from users help you build your use case and your deployment plan.

Tip: For further research about OpenStack deployment, investigate the supported and documented preconfigured, prepackaged installers for OpenStack from companies such as Canonical, Cisco, Cloudscaling, IBM, Metacloud, Mirantis, Rackspace, Red Hat, SUSE, and SwiftStack.

Capacity planning and scaling

Cloud-based applications typically request more discrete hardware (horizontal scaling) as opposed to traditional applications, which require larger hardware to scale (vertical scaling).

OpenStack is designed to be horizontally scalable. Rather than switching to larger servers, you procure more servers and simply install identically configured services. Ideally, you scale out and load balance among groups of functionally identical services (for example, compute nodes or `nova-api` nodes), that communicate on a message bus.

Determining cloud scalability

Determining the scalability of your cloud and how to improve it requires balancing many variables. No one solution meets everyone's scalability goals. However, it is helpful to track a number of metrics. You can define virtual hardware templates called "flavors" in OpenStack, which will impact your cloud scaling decisions. These templates define sizes for memory in RAM, root disk size, amount of ephemeral data disk space available, and the number of CPU cores.

The default OpenStack flavors are shown in *Table. OpenStack default flavors*.

Table 1: Table. OpenStack default flavors

Name	Virtual cores	Memory	Disk	Ephemeral
m1.tiny	1	512 MB	1 GB	0 GB
m1.small	1	2 GB	10 GB	20 GB
m1.medium	2	4 GB	10 GB	40 GB
m1.large	4	8 GB	10 GB	80 GB
m1.xlarge	8	16 GB	10 GB	160 GB

The starting point is the core count of your cloud. By applying some ratios, you can gather information about:

- The number of virtual machines (VMs) you expect to run, `((overcommit fraction × cores) / virtual cores per instance)`
- How much storage is required `(flavor disk size × number of instances)`

You can use these ratios to determine how much additional infrastructure you need to support your cloud.

Here is an example using the ratios for gathering scalability information for the number of VMs expected as well as the storage needed. The following numbers support (200 / 2) × 16 = 1600 VM instances and require 80 TB of storage for `/var/lib/nova/instances`:

- 200 physical cores.
- Most instances are size m1.medium (two virtual cores, 50 GB of storage).
- Default CPU overcommit ratio (`cpu_allocation_ratio` in the `nova.conf` file) of 16:1.

Note: Regardless of the overcommit ratio, an instance can not be placed on any physical node with fewer raw (pre-overcommit) resources than instance flavor requires.

However, you need more than the core count alone to estimate the load that the API services, database servers, and queue servers are likely to encounter. You must also consider the usage patterns of your cloud.

As a specific example, compare a cloud that supports a managed web-hosting platform with one running integration tests for a development project that creates one VM per code commit. In the former, the heavy work of creating a VM happens only every few months, whereas the latter puts constant heavy load on the cloud controller. You must consider your average VM lifetime, as a larger number generally means less load on the cloud controller.

Aside from the creation and termination of VMs, you must consider the impact of users accessing the service particularly on `nova-api` and its associated database. Listing instances garners a great deal of information and, given the frequency with which users run this operation, a cloud with a large number of users can increase the load significantly. This can occur even without their knowledge. For example, leaving the OpenStack dashboard instances tab open in the browser refreshes the list of VMs every 30 seconds.

After you consider these factors, you can determine how many cloud controller cores you require. A typical eight core, 8 GB of RAM server is sufficient for up to a rack of compute nodes — given the above caveats.

You must also consider key hardware specifications for the performance of user VMs, as well as budget and performance needs, including storage performance (spindles/core), memory availability (RAM/core), network bandwidth hardware specifications and (Gbps/core), and overall CPU performance (CPU/core).

Tip: For a discussion of metric tracking, including how to extract metrics from your cloud, see the OpenStack

Operations Guide.

Adding cloud controller nodes

You can facilitate the horizontal expansion of your cloud by adding nodes. Adding compute nodes is straightforward since they are easily picked up by the existing installation. However, you must consider some important points when you design your cluster to be highly available.

A cloud controller node runs several different services. You can install services that communicate only using the message queue internally— `nova-scheduler` and `nova-console` on a new server for expansion. However, other integral parts require more care.

You should load balance user-facing services such as dashboard, `nova-api`, or the Object Storage proxy. Use any standard HTTP load-balancing method (DNS round robin, hardware load balancer, or software such as Pound or HAProxy). One caveat with dashboard is the VNC proxy, which uses the WebSocket protocol—something that an L7 load balancer might struggle with. See also Horizon session storage.

You can configure some services, such as `nova-api` and `glance-api`, to use multiple processes by changing a flag in their configuration file allowing them to share work between multiple cores on the one machine.

Tip: Several options are available for MySQL load balancing, and the supported AMQP brokers have built-in clustering support. Information on how to configure these and many of the other services can be found in the Operations Guide.

Segregating your cloud

Segregating your cloud is needed when users require different regions for legal considerations for data storage, redundancy across earthquake fault lines, or for low-latency API calls. It can be segregated by *cells*, *regions*, *availability zones*, or *host aggregates*.

Each method provides different functionality and can be best divided into two groups:

- Cells and regions, which segregate an entire cloud and result in running separate Compute deployments.
- *Availability zones* and host aggregates, which merely divide a single Compute deployment.

Table. OpenStack segregation methods provides a comparison view of each segregation method currently provided by OpenStack Compute.

Table 2: Table. OpenStack segregation methods

	Cells	Regions	Availability zones	Host aggregates
Use	A single *API endpoint* for compute, or you require a second level of scheduling.	Discrete regions with separate API endpoints and no coordination between regions.	Logical separation within your nova deployment for physical isolation or redundancy.	To schedule a group of hosts with common features.
Example	A cloud with multiple sites where you can schedule VMs "anywhere" or on a particular site.	A cloud with multiple sites, where you schedule VMs to a particular site and you want a shared infrastructure.	A single-site cloud with equipment fed by separate power supplies.	Scheduling to hosts with trusted hardware support.
Overhead	Considered experimental. A new service, nova-cells. Each cell has a full nova installation except nova-api.	A different API endpoint for every region. Each region has a full nova installation.	Configuration changes to `nova.conf`.	Configuration changes to `nova.conf`.
Shared services	Keystone, `nova-api`	Keystone	Keystone, All nova services	Keystone, All nova services

Cells and regions

OpenStack Compute cells are designed to allow running the cloud in a distributed fashion without having to use more complicated technologies, or be invasive to existing nova installations. Hosts in a cloud are partitioned into groups called *cells*. Cells are configured in a tree. The top-level cell ("API cell") has a host that runs the `nova-api` service, but no `nova-compute` services. Each child cell runs all of the other typical `nova-*` services found in a regular installation, except for the `nova-api` service. Each cell has its own message queue and database service and also runs `nova-cells`, which manages the communication between the API cell and child cells.

This allows for a single API server being used to control access to multiple cloud installations. Introducing a second level of scheduling (the cell selection), in addition to the regular `nova-scheduler` selection of hosts, provides greater flexibility to control where virtual machines are run.

Unlike having a single API endpoint, regions have a separate API endpoint per installation, allowing for a more discrete separation. Users wanting to run instances across sites have to explicitly select a region. However, the additional complexity of a running a new service is not required.

The OpenStack dashboard (horizon) can be configured to use multiple regions. This can be configured through the `AVAILABLE_REGIONS` parameter.

Availability zones and host aggregates

You can use availability zones, host aggregates, or both to partition a nova deployment. Both methods are configured and implemented in a similar way.

Availability zone

This enables you to arrange OpenStack compute hosts into logical groups and provides a form of physical isolation and redundancy from other availability zones, such as by using a separate power supply or network equipment.

You define the availability zone in which a specified compute host resides locally on each server. An availability zone is commonly used to identify a set of servers that have a common attribute. For instance, if some of the racks in your data center are on a separate power source, you can put servers in those racks in their own availability zone. Availability zones can also help separate different classes of hardware.

When users provision resources, they can specify from which availability zone they want their instance to be built. This allows cloud consumers to ensure that their application resources are spread across disparate machines to achieve high availability in the event of hardware failure.

Host aggregates zone

This enables you to partition OpenStack Compute deployments into logical groups for load balancing and instance distribution. You can use host aggregates to further partition an availability zone. For example, you might use host aggregates to partition an availability zone into groups of hosts that either share common resources, such as storage and network, or have a special property, such as trusted computing hardware.

A common use of host aggregates is to provide information for use with the `nova-scheduler`. For example, you might use a host aggregate to group a set of hosts that share specific flavors or images.

The general case for this is setting key-value pairs in the aggregate metadata and matching key-value pairs in flavor's `extra_specs` metadata. The `AggregateInstanceExtraSpecsFilter` in the filter scheduler will enforce that instances be scheduled only on hosts in aggregates that define the same key to the same value.

An advanced use of this general concept allows different flavor types to run with different CPU and RAM allocation ratios so that high-intensity computing loads and low-intensity development and testing systems can share the same cloud without either starving the high-use systems or wasting resources on low-utilization systems. This works by setting `metadata` in your host aggregates and matching `extra_specs` in your flavor types.

The first step is setting the aggregate metadata keys `cpu_allocation_ratio` and `ram_allocation_ratio` to a floating-point value. The filter schedulers `AggregateCoreFilter` and `AggregateRamFilter` will use those values rather than the global defaults in `nova.conf` when scheduling to hosts in the aggregate. Be cautious when using this feature, since each host can be in multiple aggregates, but should have only one allocation ratio for each resources. It is up to you to avoid putting a host in multiple aggregates that define different values for the same resource.

This is the first half of the equation. To get flavor types that are guaranteed a particular ratio, you must set the `extra_specs` in the flavor type to the key-value pair you want to match in the aggregate. For example, if you define `extra_specs` `cpu_allocation_ratio` to "1.0", then instances of that type will run in aggregates only where the metadata key `cpu_allocation_ratio` is also defined as "1.0." In practice, it is better to define an additional key-value pair in the aggregate metadata to match on rather than match directly on `cpu_allocation_ratio` or `core_allocation_ratio`. This allows better abstraction. For example, by defining a key `overcommit` and setting a value of "high," "medium," or "low," you could then tune the numeric allocation ratios in the aggregates without also needing to change all flavor types relating to them.

Note: Previously, all services had an availability zone. Currently, only the `nova-compute` service has its own availability zone. Services such as `nova-scheduler`, `nova-network`, and `nova-conductor` have always spanned all availability zones.

When you run any of the following operations, the services appear in their own internal availability zone (CONF.internal_service_availability_zone):

- **openstack host list** (os-hosts)
- **euca-describe-availability-zones verbose**
- **openstack compute service list**

The internal availability zone is hidden in euca-describe-availability_zones (nonverbose).

CONF.node_availability_zone has been renamed to CONF.default_availability_zone and is used only by the `nova-api` and `nova-scheduler` services.

CONF.node_availability_zone still works but is deprecated.

Scalable Hardware

While several resources already exist to help with deploying and installing OpenStack, it's very important to make sure that you have your deployment planned out ahead of time. This guide presumes that you have set aside a rack for the OpenStack cloud but also offers suggestions for when and what to scale.

Hardware Procurement

"The Cloud" has been described as a volatile environment where servers can be created and terminated at will. While this may be true, it does not mean that your servers must be volatile. Ensuring that your cloud's hardware is stable and configured correctly means that your cloud environment remains up and running.

OpenStack can be deployed on any hardware supported by an OpenStack compatible Linux distribution.

Hardware does not have to be consistent, but it should at least have the same type of CPU to support instance migration.

The typical hardware recommended for use with OpenStack is the standard value-for-money offerings that most hardware vendors stock. It should be straightforward to divide your procurement into building blocks such as "compute," "object storage," and "cloud controller," and request as many of these as you need. Alternatively, any existing servers you have that meet performance requirements and virtualization technology are likely to support OpenStack.

Capacity Planning

OpenStack is designed to increase in size in a straightforward manner. Taking into account the considerations previous mentioned, particularly on the sizing of the cloud controller, it should be possible to procure additional compute or object storage nodes as needed. New nodes do not need to be the same specification or vendor as existing nodes.

For compute nodes, `nova-scheduler` will manage differences in sizing with core count and RAM. However, you should consider that the user experience changes with differing CPU speeds. When adding object storage nodes, a *weight* should be specified that reflects the *capability* of the node.

Monitoring the resource usage and user growth will enable you to know when to procure. The Logging and Monitoring chapte in the Operations Guide details some useful metrics.

Burn-in Testing

The chances of failure for the server's hardware are high at the start and the end of its life. As a result, dealing with hardware failures while in production can be avoided by appropriate burn-in testing to attempt to trigger the early-stage failures. The general principle is to stress the hardware to its limits. Examples of burn-in tests include running a CPU or disk benchmark for several days.

Lay of the Land

This chapter helps you set up your working environment and use it to take a look around your cloud.

Using the OpenStack Dashboard for Administration

As a cloud administrative user, you can use the OpenStack dashboard to create and manage projects, users, images, and flavors. Users are allowed to create and manage images within specified projects and to share images, depending on the Image service configuration. Typically, the policy configuration allows admin users only to set quotas and create and manage services. The dashboard provides an *Admin* tab with a *System Panel* and an *Identity* tab. These interfaces give you access to system information and usage as well as to settings for configuring what end users can do. Refer to the OpenStack Administrator Guide for detailed how-to information about using the dashboard as an admin user.

Command-Line Tools

We recommend using a combination of the OpenStack command-line interface (CLI) tools and the OpenStack dashboard for administration. Some users with a background in other cloud technologies may be using the EC2 Compatibility API, which uses naming conventions somewhat different from the native API.

The pip utility is used to manage package installation from the PyPI archive and is available in the python-pip package in most Linux distributions. While each OpenStack project has its own client, they are being deprecated in favour of a common OpenStack client. It is generally recommended to install the OpenStack client.

Tip: To perform testing and orchestration, it is usually easier to install the OpenStack CLI tools in a dedicated VM in the cloud. We recommend that you keep the VM installation simple. All the tools should be installed from a single OpenStack release version. If you need to run tools from multiple OpenStack releases, then we recommend that you run with multiple VMs that are each running a dedicated version.

Install OpenStack command-line clients

For instructions on installing, upgrading, or removing command-line clients, see the Install the OpenStack command-line clients section in OpenStack End User Guide.

Note: If you support the EC2 API on your cloud, you should also install the euca2ools package or some other EC2 API tool so that you can get the same view your users have. Using EC2 API-based tools is mostly out of the scope of this guide, though we discuss getting credentials for use with it.

Administrative Command-Line Tools

There are also several **`*-manage`** command-line tools. These are installed with the project's services on the cloud controller and do not need to be installed separately:

- **`nova-manage`**
- **`glance-manage`**
- **`keystone-manage`**
- **`cinder-manage`**

Unlike the CLI tools mentioned above, the **`*-manage`** tools must be run from the cloud controller, as root, because they need read access to the config files such as `/etc/nova/nova.conf` and to make queries directly against the database rather than against the OpenStack *API endpoints*.

> **Warning:** The existence of the `*-manage` tools is a legacy issue. It is a goal of the OpenStack project to eventually migrate all of the remaining functionality in the `*-manage` tools into the API-based tools. Until that day, you need to SSH into the *cloud controller node* to perform some maintenance operations that require one of the `*-manage` tools.

Getting Credentials

You must have the appropriate credentials if you want to use the command-line tools to make queries against your OpenStack cloud. By far, the easiest way to obtain *authentication* credentials to use with command-line clients is to use the OpenStack dashboard. Select *Project*, click the *Project* tab, and click *Access & Security* on the *Compute* category. On the *Access & Security* page, click the *API Access* tab to display two buttons, *Download OpenStack RC File* and *Download EC2 Credentials*, which let you generate files that you can source in your shell to populate the environment variables the command-line tools require to know where your service endpoints and your authentication information are. The user you logged in to the dashboard dictates the filename for the openrc file, such as `demo-openrc.sh`. When logged in as admin, the file is named `admin-openrc.sh`.

The generated file looks something like this:

```
#!/usr/bin/env bash

# To use an OpenStack cloud you need to authenticate against the Identity
# service named keystone, which returns a **Token** and **Service Catalog**.
# The catalog contains the endpoints for all services the user/tenant has
# access to - such as Compute, Image Service, Identity, Object Storage, Block
# Storage, and Networking (code-named nova, glance, keystone, swift,
# cinder, and neutron).
#
# *NOTE*: Using the 3 *Identity API* does not necessarily mean any other
# OpenStack API is version 3. For example, your cloud provider may implement
# Image API v1.1, Block Storage API v2, and Compute API v2.0. OS_AUTH_URL is
# only for the Identity API served through keystone.
export OS_AUTH_URL=http://203.0.113.10:5000/v3

# With the addition of Keystone we have standardized on the term **project**
# as the entity that owns the resources.
export OS_PROJECT_ID=98333aba48e756fa8f629c83a818ad57
export OS_PROJECT_NAME="test-project"
export OS_USER_DOMAIN_NAME="default"
```

```
if [ -z "$OS_USER_DOMAIN_NAME" ]; then unset OS_USER_DOMAIN_NAME; fi

# In addition to the owning entity (tenant), OpenStack stores the entity
# performing the action as the **user**.
export OS_USERNAME="demo"

# With Keystone you pass the keystone password.
echo "Please enter your OpenStack Password for project $OS_PROJECT_NAME as user $OS_
↪USERNAME: "
read -sr OS_PASSWORD_INPUT
export OS_PASSWORD=$OS_PASSWORD_INPUT

# If your configuration has multiple regions, we set that information here.
# OS_REGION_NAME is optional and only valid in certain environments.
export OS_REGION_NAME="RegionOne"
# Don't leave a blank variable, unset it if it was empty
if [ -z "$OS_REGION_NAME" ]; then unset OS_REGION_NAME; fi

export OS_INTERFACE=public
export OS_IDENTITY_API_VERSION=3
```

Warning: This does not save your password in plain text, which is a good thing. But when you source or run the script, it prompts you for your password and then stores your response in the environment variable `OS_PASSWORD`. It is important to note that this does require interactivity. It is possible to store a value directly in the script if you require a noninteractive operation, but you then need to be extremely cautious with the security and permissions of this file.

EC2 compatibility credentials can be downloaded by selecting *Project*, then *Compute*, then *Access & Security*, then *API Access* to display the *Download EC2 Credentials* button. Click the button to generate a ZIP file with server x509 certificates and a shell script fragment. Create a new directory in a secure location because these are live credentials containing all the authentication information required to access your cloud identity, unlike the default `user-openrc`. Extract the ZIP file here. You should have `cacert.pem`, `cert.pem`, `ec2rc.sh`, and `pk.pem`. The `ec2rc.sh` is similar to this:

```
#!/bin/bash

NOVARC=$(readlink -f "${BASH_SOURCE:-${0}}" 2>/dev/null) ||\
NOVARC=$(python -c 'import os,sys; \
print os.path.abspath(os.path.realpath(sys.argv[1]))' "${BASH_SOURCE:-${0}}")
NOVA_KEY_DIR=${NOVARC%/*}
export EC2_ACCESS_KEY=df7f93ec47e84ef8a347bbb3d598449a
export EC2_SECRET_KEY=ead2fff9f8a344e489956deacd47e818
export EC2_URL=http://203.0.113.10:8773/services/Cloud
export EC2_USER_ID=42 # nova does not use user id, but bundling requires it
export EC2_PRIVATE_KEY=${NOVA_KEY_DIR}/pk.pem
export EC2_CERT=${NOVA_KEY_DIR}/cert.pem
export NOVA_CERT=${NOVA_KEY_DIR}/cacert.pem
export EUCALYPTUS_CERT=${NOVA_CERT} # euca-bundle-image seems to require this

alias ec2-bundle-image="ec2-bundle-image --cert $EC2_CERT --privatekey \
$EC2_PRIVATE_KEY --user 42 --ec2cert $NOVA_CERT"
alias ec2-upload-bundle="ec2-upload-bundle -a $EC2_ACCESS_KEY -s \
$EC2_SECRET_KEY --url $S3_URL --ec2cert $NOVA_CERT"
```

To put the EC2 credentials into your environment, source the `ec2rc.sh` file.

Inspecting API Calls

The command-line tools can be made to show the OpenStack API calls they make by passing the `--debug` flag to them. For example:

```
# openstack --debug server list
```

This example shows the HTTP requests from the client and the responses from the endpoints, which can be helpful in creating custom tools written to the OpenStack API.

Using cURL for further inspection

Underlying the use of the command-line tools is the OpenStack API, which is a RESTful API that runs over HTTP. There may be cases where you want to interact with the API directly or need to use it because of a suspected bug in one of the CLI tools. The best way to do this is to use a combination of cURL and another tool, such as jq, to parse the JSON from the responses.

The first thing you must do is authenticate with the cloud using your credentials to get an *authentication token*.

Your credentials are a combination of username, password, and tenant (project). You can extract these values from the `openrc.sh` discussed above. The token allows you to interact with your other service endpoints without needing to reauthenticate for every request. Tokens are typically good for 24 hours, and when the token expires, you are alerted with a 401 (Unauthorized) response and you can request another token.

1. Look at your OpenStack service *catalog*:

```
$ curl -s -X POST http://203.0.113.10:35357/v2.0/tokens \
  -d '{"auth": {"passwordCredentials": {"username":"test-user", "password":"test-
↪password"}, "tenantName":"test-project"}}' \
  -H "Content-type: application/json" | jq .
```

2. Read through the JSON response to get a feel for how the catalog is laid out.

   To make working with subsequent requests easier, store the token in an environment variable:

```
$ TOKEN=`curl -s -X POST http://203.0.113.10:35357/v2.0/tokens \
  -d '{"auth": {"passwordCredentials": {"username":"test-user", "password":"test-
↪password"}, "tenantName":"test-project"}}' \
  -H "Content-type: application/json" |  jq -r .access.token.id`
```

   Now you can refer to your token on the command line as `$TOKEN`.

3. Pick a service endpoint from your service catalog, such as compute. Try a request, for example, listing instances (servers):

```
$ curl -s \
  -H "X-Auth-Token: $TOKEN" \
  http://203.0.113.10:8774/v2.0/98333aba48e756fa8f629c83a818ad57/servers | jq .
```

To discover how API requests should be structured, read the OpenStack API Reference. To chew through the responses using jq, see the jq Manual.

The `-s flag` used in the cURL commands above are used to prevent the progress meter from being shown. If you are having trouble running cURL commands, you'll want to remove it. Likewise, to help you troubleshoot cURL commands, you can include the `-v` flag to show you the verbose output. There are many more extremely useful features in cURL; refer to the man page for all the options.

Servers and Services

As an administrator, you have a few ways to discover what your OpenStack cloud looks like simply by using the OpenStack tools available. This section gives you an idea of how to get an overview of your cloud, its shape, size, and current state.

First, you can discover what servers belong to your OpenStack cloud by running:

```
# openstack compute service list --long
```

The output looks like the following:

```
+----+------------------+-------------------+------+---------+-------+----------------------
↪------+-----------------+
| Id | Binary           | Host              | Zone | Status  | State | Updated_at          
↪      | Disabled Reason |
+----+------------------+-------------------+------+---------+-------+----------------------
↪------+-----------------+
| 1  | nova-cert        | cloud.example.com | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 2  | nova-compute     | c01.example.com   | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 3  | nova-compute     | c01.example.com.  | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 4  | nova-compute     | c01.example.com   | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 5  | nova-compute     | c01.example.com   | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 6  | nova-compute     | c01.example.com   | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 7  | nova-conductor   | cloud.example.com | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 8  | nova-cert        | cloud.example.com | nova | enabled | up    | 2016-01-05T17:20:42.
↪000000 | -               |
| 9  | nova-scheduler   | cloud.example.com | nova | enabled | up    | 2016-01-05T17:20:38.
↪000000 | -               |
| 10 | nova-consoleauth | cloud.example.com | nova | enabled | up    | 2016-01-05T17:20:35.
↪000000 | -               |
+----+------------------+-------------------+------+---------+-------+----------------------
↪------+-----------------+
```

The output shows that there are five compute nodes and one cloud controller. You see all the services in the up state, which indicates that the services are up and running. If a service is in a down state, it is no longer available. This is an indication that you should troubleshoot why the service is down.

If you are using cinder, run the following command to see a similar listing:

```
# cinder-manage host list | sort
host                  zone
c01.example.com   nova
c02.example.com   nova
```

```
c03.example.com   nova
c04.example.com   nova
c05.example.com   nova
cloud.example.com nova
```

With these two tables, you now have a good overview of what servers and services make up your cloud.

You can also use the Identity service (keystone) to see what services are available in your cloud as well as what endpoints have been configured for the services.

The following command requires you to have your shell environment configured with the proper administrative variables:

```
$ openstack catalog list
+----------+------------+--------------------------------------------------------------------
↪--------------+
| Name     | Type       | Endpoints
↪               |
+----------+------------+--------------------------------------------------------------------
↪--------------+
| nova     | compute    | RegionOne
↪               |
|          |            |   public: http://192.168.122.10:8774/v2/
↪9faa845768224258808fc17a1bb27e5e         |
|          |            | RegionOne
↪               |
|          |            |   internal: http://192.168.122.10:8774/v2/
↪9faa845768224258808fc17a1bb27e5e       |
|          |            | RegionOne
↪               |
|          |            |   admin: http://192.168.122.10:8774/v2/
↪9faa845768224258808fc17a1bb27e5e          |
|          |            |
↪               |
| cinderv2 | volumev2   | RegionOne
↪               |
|          |            |   public: http://192.168.122.10:8776/v2/
↪9faa845768224258808fc17a1bb27e5e         |
|          |            | RegionOne
↪               |
|          |            |   internal: http://192.168.122.10:8776/v2/
↪9faa845768224258808fc17a1bb27e5e       |
|          |            | RegionOne
↪               |
|          |            |   admin: http://192.168.122.10:8776/v2/
↪9faa845768224258808fc17a1bb27e5e          |
|          |            |
↪               |
```

The preceding output has been truncated to show only two services. You will see one service entry for each service that your cloud provides. Note how the endpoint domain can be different depending on the endpoint type. Different endpoint domains per type are not required, but this can be done for different reasons, such as endpoint privacy or network traffic segregation.

You can find the version of the Compute installation by using the OpenStack command-line client:

```
# openstack --version
```

Diagnose Your Compute Nodes

You can obtain extra information about virtual machines that are running—their CPU usage, the memory, the disk I/O or network I/O—per instance, by running the **nova diagnostics** command with a server ID:

```
$ nova diagnostics <serverID>
```

The output of this command varies depending on the hypervisor because hypervisors support different attributes. The following demonstrates the difference between the two most popular hypervisors. Here is example output when the hypervisor is Xen:

```
+----------------+-----------------+
|    Property    |      Value      |
+----------------+-----------------+
| cpu0           | 4.3627          |
| memory         | 1171088064.0000 |
| memory_target  | 1171088064.0000 |
| vbd_xvda_read  | 0.0             |
| vbd_xvda_write | 0.0             |
| vif_0_rx       | 3223.6870       |
| vif_0_tx       | 0.0             |
| vif_1_rx       | 104.4955        |
| vif_1_tx       | 0.0             |
+----------------+-----------------+
```

While the command should work with any hypervisor that is controlled through libvirt (KVM, QEMU, or LXC), it has been tested only with KVM. Here is the example output when the hypervisor is KVM:

```
+------------------+------------+
| Property         | Value      |
+------------------+------------+
| cpu0_time        | 2870000000 |
| memory           | 524288     |
| vda_errors       | -1         |
| vda_read         | 262144     |
| vda_read_req     | 112        |
| vda_write        | 5606400    |
| vda_write_req    | 376        |
| vnet0_rx         | 63343      |
| vnet0_rx_drop    | 0          |
| vnet0_rx_errors  | 0          |
| vnet0_rx_packets | 431        |
| vnet0_tx         | 4905       |
| vnet0_tx_drop    | 0          |
| vnet0_tx_errors  | 0          |
| vnet0_tx_packets | 45         |
+------------------+------------+
```

Network Inspection

To see which fixed IP networks are configured in your cloud, you can use the **openstack** command-line client to get the IP ranges:

```
$ openstack subnet list
+--------------------------------------+----------------+-----------------------------------
↪---+-----------------+
| ID                                   | Name           | Network                           
↪   | Subnet          |
+--------------------------------------+----------------+-----------------------------------
↪---+-----------------+
| 346806ee-a53e-44fd-968a-ddb2bcd2ba96 | public_subnet  | 0bf90de6-fc0f-4dba-b80d-
↪96670dfb331a | 172.24.4.224/28 |
| f939a1e4-3dc3-4540-a9f6-053e6f04918f | private_subnet | 1f7f429e-c38e-47ba-8acf-
↪c44e3f5e8d71 | 10.0.0.0/24     |
+--------------------------------------+----------------+-----------------------------------
↪---+-----------------+
```

The OpenStack command-line client can provide some additional details:

```
# openstack compute service list
+----+------------------+------------+----------+---------+-------+------------------------
↪---+
| Id | Binary           | Host       | Zone     | Status  | State | Updated At             
↪   |
+----+------------------+------------+----------+---------+-------+------------------------
↪---+
|  1 | nova-consoleauth | controller | internal | enabled | up    | 2016-08-18T12:16:53.
↪000000 |
|  2 | nova-scheduler   | controller | internal | enabled | up    | 2016-08-18T12:16:59.
↪000000 |
|  3 | nova-conductor   | controller | internal | enabled | up    | 2016-08-18T12:16:52.
↪000000 |
|  7 | nova-compute     | controller | nova     | enabled | up    | 2016-08-18T12:16:58.
↪000000 |
+----+------------------+------------+----------+---------+-------+------------------------
↪---+
```

This output shows that two networks are configured, each network containing 255 IPs (a /24 subnet). The first network has been assigned to a certain project, while the second network is still open for assignment. You can assign this network manually; otherwise, it is automatically assigned when a project launches its first instance.

To find out whether any floating IPs are available in your cloud, run:

```
# openstack floating ip list
+--------------------------------------+---------------------+------------------+----------
↪--------------------------+
| ID                                   | Floating IP Address | Fixed IP Address | Port     
↪                          |
+--------------------------------------+---------------------+------------------+----------
↪--------------------------+
| 340cb36d-6a52-4091-b256-97b6e61cbb20 | 172.24.4.227        | 10.2.1.8         | 1fec8fb8-
↪7a8c-44c2-acd8-f10e2e6cd326 |
| 8b1bfc0c-7a91-4da0-b3cc-4acae26cbdec | 172.24.4.228        | None             | None     
↪                          |
+--------------------------------------+---------------------+------------------+----------
↪--------------------------+
```

Here, two floating IPs are available. The first has been allocated to a project, while the other is unallocated.

Users and Projects

To see a list of projects that have been added to the cloud, run:

```
$ openstack project list
+----------------------------------+--------------------+
| ID                               | Name               |
+----------------------------------+--------------------+
| 422c17c0b26f4fbe9449f37a5621a5e6 | alt_demo           |
| 5dc65773519248f3a580cfe28ba7fa3f | demo               |
| 9faa845768224258808fc17a1bb27e5e | admin              |
| a733070a420c4b509784d7ea8f6884f7 | invisible_to_admin |
| aeb3e976e7794f3f89e4a7965db46c1e | service            |
+----------------------------------+--------------------+
```

To see a list of users, run:

```
$ openstack user list
+----------------------------------+----------+
| ID                               | Name     |
+----------------------------------+----------+
| 5837063598694771aedd66aa4cddf0b8 | demo     |
| 58efd9d852b74b87acc6efafaf31b30e | cinder   |
| 6845d995a57a441f890abc8f55da8dfb | glance   |
| ac2d15a1205f46d4837d5336cd4c5f5a | alt_demo |
| d8f593c3ae2b47289221f17a776a218b | admin    |
| d959ec0a99e24df0b7cb106ff940df20 | nova     |
+----------------------------------+----------+
```

Note: Sometimes a user and a group have a one-to-one mapping. This happens for standard system accounts, such as cinder, glance, nova, and swift, or when only one user is part of a group.

Running Instances

To see a list of running instances, run:

```
$ openstack server list --all-projects
+--------------------------------------+------+--------+---------------------+------------+
| ID                                   | Name | Status | Networks            | Image Name |
+--------------------------------------+------+--------+---------------------+------------+
| 495b4f5e-0b12-4c5a-b4e0-4326dee17a5a | vm1  | ACTIVE | public=172.24.4.232 | cirros     |
| e83686f9-16e8-45e6-911d-48f75cb8c0fb | vm2  | ACTIVE | private=10.0.0.7    | cirros     |
+--------------------------------------+------+--------+---------------------+------------+
```

Unfortunately, this command does not tell you various details about the running instances, such as what compute node the instance is running on, what flavor the instance is, and so on. You can use the following command to view details about individual instances:

```
$ openstack server show <uuid>
```

For example:

```
# openstack server show 81db556b-8aa5-427d-a95c-2a9a6972f630
+-------------------------------------+----------------------------------------------------
↪------+
| Field                               | Value                                              
↪      |
+-------------------------------------+----------------------------------------------------
↪------+
| OS-DCF:diskConfig                   | AUTO                                               
↪      |
| OS-EXT-AZ:availability_zone         | nova                                               
↪      |
| OS-EXT-SRV-ATTR:host                | c02.example.com                                    
↪      |
| OS-EXT-SRV-ATTR:hypervisor_hostname | c02.example.com                                    
↪      |
| OS-EXT-SRV-ATTR:instance_name       | instance-00000001                                  
↪      |
| OS-EXT-STS:power_state              | Running                                            
↪      |
| OS-EXT-STS:task_state               | None                                               
↪      |
| OS-EXT-STS:vm_state                 | active                                             
↪      |
| OS-SRV-USG:launched_at              | 2016-10-19T15:18:09.000000                         
↪      |
| OS-SRV-USG:terminated_at            | None                                               
↪      |
| accessIPv4                          |                                                    
↪      |
| accessIPv6                          |                                                    
↪      |
| addresses                           | private=10.0.0.7                                   
↪      |
| config_drive                        |                                                    
↪      |
| created                             | 2016-10-19T15:17:46Z                               
↪      |
| flavor                              | m1.tiny (1)                                        
↪      |
| hostId                              |
↪2b57e2b7a839508337fb55695b8f6e65aa881460a20449a76352040b |
| id                                  | e83686f9-16e8-45e6-911d-48f75cb8c0fb               
↪      |
| image                               | cirros (9fef3b2d-c35d-4b61-bea8-09cc6dc41829)      
↪      |
| key_name                            | None                                               
↪      |
| name                                | test                                               
↪      |
| os-extended-volumes:volumes_attached | []                                                
↪      |
| progress                            | 0                                                  
↪      |
```

```
| project_id                          | 1eaaf6ede7a24e78859591444abf314a                      
↪       |
| properties                          |                                                       
↪       |
| security_groups                     | [{u'name': u'default'}]                               
↪       |
| status                              | ACTIVE                                                
↪       |
| updated                             | 2016-10-19T15:18:58Z                                  
↪       |
| user_id                             | 7aaa9b5573ce441b98dae857a82ecc68                      
↪       |
+-----------------------------------+-----------------------------------------------------
↪------+
```

This output shows that an instance named `devstack` was created from an Ubuntu 12.04 image using a flavor of `m1.small` and is hosted on the compute node `c02.example.com`.

Summary

We hope you have enjoyed this quick tour of your working environment, including how to interact with your cloud and extract useful information. From here, you can use the OpenStack Administrator Guide as your reference for all of the command-line functionality in your cloud.

Managing Projects and Users

Managing Projects

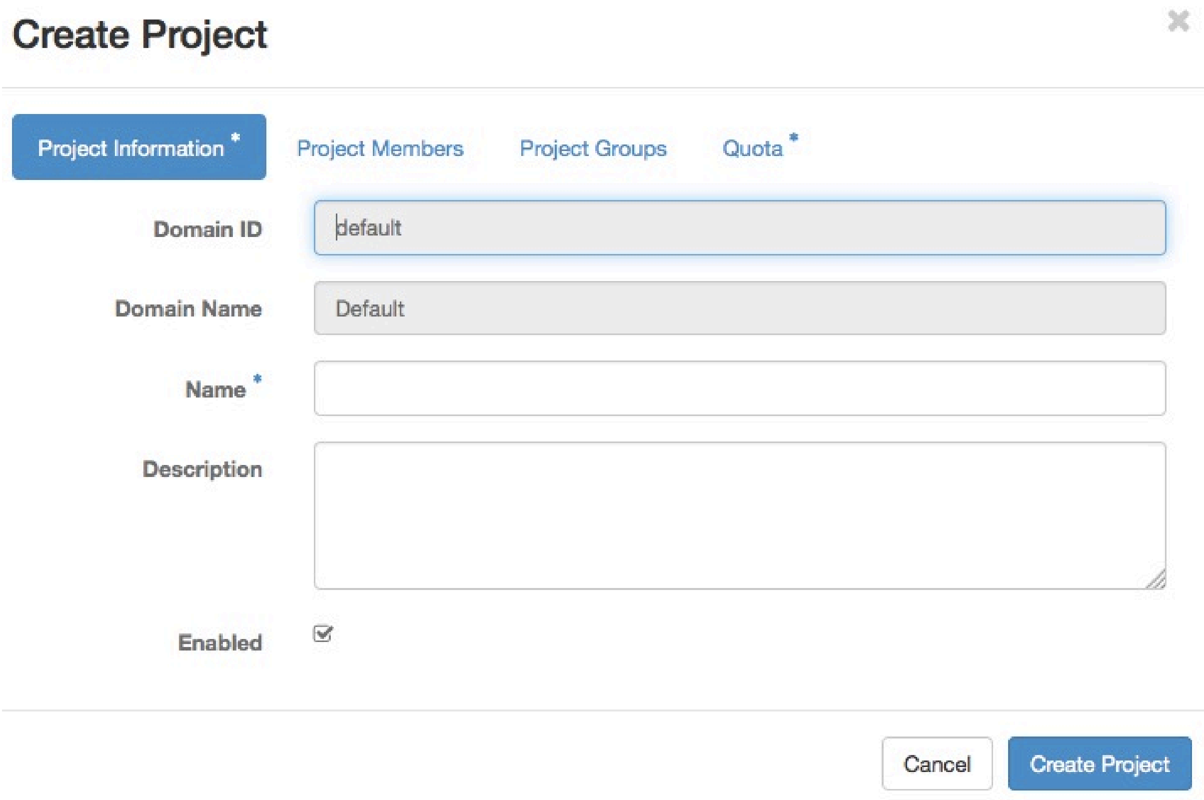
Users must be associated with at least one project, though they may belong to many. Therefore, you should add at least one project before adding users.

Adding Projects

To create a project through the OpenStack dashboard:

1. Log in as an administrative user.
2. Select the *Identity* tab in the left navigation bar.
3. Under Identity tab, click *Projects*.
4. Click the *Create Project* button.

You are prompted for a project name and an optional, but recommended, description. Select the check box at the bottom of the form to enable this project. By default, it is enabled, as shown below:



It is also possible to add project members and adjust the project quotas. We'll discuss those actions later, but in practice, it can be quite convenient to deal with all these operations at one time.

To add a project through the command line, you must use the OpenStack command line client.

```
# openstack project create demo --domain default
```

This command creates a project named `demo`. Optionally, you can add a description string by appending `--description PROJECT_DESCRIPTION`, which can be very useful. You can also create a project in a disabled state by appending `--disable` to the command. By default, projects are created in an enabled state.

Quotas

To prevent system capacities from being exhausted without notification, you can set up *quotas*. Quotas are operational limits. For example, the number of gigabytes allowed per tenant can be controlled to ensure that a single tenant cannot consume all of the disk space. Quotas are currently enforced at the tenant (or project) level, rather than the user level.

> **Warning:** Because without sensible quotas a single tenant could use up all the available resources, default quotas are shipped with OpenStack. You should pay attention to which quota settings make sense for your hardware capabilities.

Using the command-line interface, you can manage quotas for the OpenStack Compute service and the Block Storage service.

Typically, default values are changed because a tenant requires more than the OpenStack default of 10 volumes per tenant, or more than the OpenStack default of 1 TB of disk space on a compute node.

Note: To view all tenants, run:

```
$ openstack project list
+---------------------------------+----------+
| ID                              | Name     |
+---------------------------------+----------+
| a981642d22c94e159a4a6540f70f9f8 | admin    |
| 934b662357674c7b9f5e4ec6ded4d0e | tenant01 |
| 7bc1dbfd7d284ec4a856ea1eb82dca8 | tenant02 |
| 9c554aaef7804ba49e1b21cbd97d218 | services |
+---------------------------------+----------+
```

Set Image Quotas

You can restrict a project's image storage by total number of bytes. Currently, this quota is applied cloud-wide, so if you were to set an Image quota limit of 5 GB, then all projects in your cloud will be able to store only 5 GB of images and snapshots.

To enable this feature, edit the `/etc/glance/glance-api.conf` file, and under the `[DEFAULT]` section, add:

```
user_storage_quota = <bytes>
```

For example, to restrict a project's image storage to 5 GB, do this:

```
user_storage_quota = 5368709120
```

Note: There is a configuration option in `/etc/glance/glance-api.conf` that limits the number of members allowed per image, called `image_member_quota`, set to 128 by default. That setting is a different quota from the storage quota.

Set Compute Service Quotas

As an administrative user, you can update the Compute service quotas for an existing tenant, as well as update the quota defaults for a new tenant. See *Compute quota descriptions*.

Table 3: Compute quota descriptions

Quota	Description	Property name
Fixed IPs	Number of fixed IP addresses allowed per project. This number must be equal to or greater than the number of allowed instances.	`fixed-ips`
Floating IPs	Number of floating IP addresses allowed per project.	`floating-ips`
Injected file content bytes	Number of content bytes allowed per injected file.	`injected-file-content-bytes`
Injected file path bytes	Number of bytes allowed per injected file path.	`injected-file-path-bytes`
Injected files	Number of injected files allowed per project.	`injected-files`
Instances	Number of instances allowed per project.	`instances`
Key pairs	Number of key pairs allowed per user.	`key-pairs`
Metadata items	Number of metadata items allowed per instance.	`metadata-items`
RAM	Megabytes of instance RAM allowed per project.	`ram`
Security group rules	Number of security group rules per project.	`security-group-rules`
Security groups	Number of security groups per project.	`security-groups`
VCPUs	Number of instance cores allowed per project.	`cores`
Server Groups	Number of server groups per project.	`server_groups`
Server Group Members	Number of servers per server group.	`server_group_members`

View and update compute quotas for a tenant (project)

As an administrative user, you can use the **`nova quota-*`** commands, which are provided by the `python-novaclient` package, to view and update tenant quotas.

To view and update default quota values

1. List all default quotas for all tenants, as follows:

```
$ nova quota-defaults
```

For example:

```
$ nova quota-defaults
+-----------------------------+-------+
| Quota                       | Limit |
+-----------------------------+-------+
| instances                   | 10    |
| cores                       | 20    |
| ram                         | 51200 |
| floating_ips                | 10    |
| fixed_ips                   | -1    |
| metadata_items              | 128   |
| injected_files              | 5     |
| injected_file_content_bytes | 10240 |
| injected_file_path_bytes    | 255   |
```

```
| key_pairs                   | 100   |
| security_groups             | 10    |
| security_group_rules        | 20    |
| server_groups               | 10    |
| server_group_members        | 10    |
+-----------------------------+-------+
```

2. Update a default value for a new tenant, as follows:

```
$ nova quota-class-update default key value
```

For example:

```
$ nova quota-class-update default --instances 15
```

To view quota values for a tenant (project)

1. Place the tenant ID in a variable:

```
$ tenant=$(openstack project list | awk '/tenantName/ {print $2}')
```

2. List the currently set quota values for a tenant, as follows:

```
$ nova quota-show --tenant $tenant
```

For example:

```
$ nova quota-show --tenant $tenant
+-----------------------------+-------+
| Quota                       | Limit |
+-----------------------------+-------+
| instances                   | 10    |
| cores                       | 20    |
| ram                         | 51200 |
| floating_ips                | 10    |
| fixed_ips                   | -1    |
| metadata_items              | 128   |
| injected_files              | 5     |
| injected_file_content_bytes | 10240 |
| injected_file_path_bytes    | 255   |
| key_pairs                   | 100   |
| security_groups             | 10    |
| security_group_rules        | 20    |
| server_groups               | 10    |
| server_group_members        | 10    |
+-----------------------------+-------+
```

To update quota values for a tenant (project)

1. Obtain the tenant ID, as follows:

```
$ tenant=$(openstack project list | awk '/tenantName/ {print $2}')
```

2. Update a particular quota value, as follows:

```
# nova quota-update --quotaName quotaValue tenantID
```

For example:

```
# nova quota-update --floating-ips 20 $tenant
# nova quota-show --tenant $tenant
+-----------------------------+-------+
| Quota                       | Limit |
+-----------------------------+-------+
| instances                   | 10    |
| cores                       | 20    |
| ram                         | 51200 |
| floating_ips                | 20    |
| fixed_ips                   | -1    |
| metadata_items              | 128   |
| injected_files              | 5     |
| injected_file_content_bytes | 10240 |
| injected_file_path_bytes    | 255   |
| key_pairs                   | 100   |
| security_groups             | 10    |
| security_group_rules        | 20    |
| server_groups               | 10    |
| server_group_members        | 10    |
+-----------------------------+-------+
```

Note: To view a list of options for the `nova quota-update` command, run:

```
$ nova help quota-update
```

Set Object Storage Quotas

There are currently two categories of quotas for Object Storage:

Container quotas Limit the total size (in bytes) or number of objects that can be stored in a single container.

Account quotas Limit the total size (in bytes) that a user has available in the Object Storage service.

To take advantage of either container quotas or account quotas, your Object Storage proxy server must have `container_quotas` or `account_quotas` (or both) added to the `[pipeline:main]` pipeline. Each quota type also requires its own section in the `proxy-server.conf` file:

```
[pipeline:main]
pipeline = catch_errors [...] slo dlo account_quotas proxy-server

[filter:account_quotas]
use = egg:swift#account_quotas

[filter:container_quotas]
use = egg:swift#container_quotas
```

To view and update Object Storage quotas, use the **`swift`** command provided by the `python-swiftclient` package. Any user included in the project can view the quotas placed on their project. To update Object Storage quotas on a project, you must have the role of ResellerAdmin in the project that the quota is being applied to.

To view account quotas placed on a project:

```
$ swift stat
   Account: AUTH_b36ed2d326034beba0a9dd1fb19b70f9
Containers: 0
   Objects: 0
     Bytes: 0
Meta Quota-Bytes: 214748364800
X-Timestamp: 1351050521.29419
Content-Type: text/plain; charset=utf-8
Accept-Ranges: bytes
```

To apply or update account quotas on a project:

```
$ swift post -m quota-bytes:
     <bytes>
```

For example, to place a 5 GB quota on an account:

```
$ swift post -m quota-bytes:
     5368709120
```

To verify the quota, run the **swift stat** command again:

```
$ swift stat
   Account: AUTH_b36ed2d326034beba0a9dd1fb19b70f9
Containers: 0
   Objects: 0
     Bytes: 0
Meta Quota-Bytes: 5368709120
X-Timestamp: 1351541410.38328
Content-Type: text/plain; charset=utf-8
Accept-Ranges: bytes
```

Set Block Storage Quotas

As an administrative user, you can update the Block Storage service quotas for a tenant, as well as update the quota defaults for a new tenant. See *Table: Block Storage quota descriptions*.

Table 4: Table: Block Storage quota descriptions

Property name	Description
gigabytes	Number of volume gigabytes allowed per tenant
snapshots	Number of Block Storage snapshots allowed per tenant.
volumes	Number of Block Storage volumes allowed per tenant

View and update Block Storage quotas for a tenant (project)

As an administrative user, you can use the **cinder quota-*** commands, which are provided by the `python-cinderclient` package, to view and update tenant quotas.

To view and update default Block Storage quota values

1. List all default quotas for all tenants, as follows:

```
$ cinder quota-defaults tenantID
```

2. Obtain the tenant ID, as follows:

```
$ tenant=$(openstack project list | awk '/tenantName/ {print $2}')
```

For example:

```
$ cinder quota-defaults $tenant
+-----------+-------+
|  Property | Value |
+-----------+-------+
| gigabytes |  1000 |
| snapshots |   10  |
|  volumes  |   10  |
+-----------+-------+
```

3. To update a default value for a new tenant, update the property in the `/etc/cinder/cinder.conf` file.

To view Block Storage quotas for a tenant (project)

1. View quotas for the tenant, as follows:

```
# cinder quota-show  tenantID
```

For example:

```
# cinder quota-show $tenant
+-----------+-------+
|  Property | Value |
+-----------+-------+
| gigabytes |  1000 |
| snapshots |   10  |
|  volumes  |   10  |
+-----------+-------+
```

To update Block Storage quotas for a tenant (project)

1. Place the tenant ID in a variable:

```
$ tenant=$(openstack project list | awk '/tenantName/ {print $2}')
```

2. Update a particular quota value, as follows:

```
# cinder quota-update --quotaName NewValue tenantID
```

For example:

```
# cinder quota-update --volumes 15 $tenant
# cinder quota-show $tenant
+-----------+-------+
|  Property | Value |
+-----------+-------+
| gigabytes |  1000 |
| snapshots |   10  |
|  volumes  |   15  |
+-----------+-------+
```

User Management

The OpenStack Dashboard provides a graphical interface to manage users. This section describes user management with the Dashboard.

You can also manage projects, users, and roles from the command-line clients.

In addition, many sites write custom tools for local needs to enforce local policies and provide levels of self-service to users that are not currently available with packaged tools.

Creating New Users

To create a user, you need the following information:

- Username
- Description
- Email address
- Password
- Primary project
- Role
- Enabled

Username and email address are self-explanatory, though your site may have local conventions you should observe. The primary project is simply the first project the user is associated with and must exist prior to creating the user. Role is almost always going to be "member." Out of the box, OpenStack comes with two roles defined:

member A typical user

admin An administrative super user, which has full permissions across all projects and should be used with great care

It is possible to define other roles, but doing so is uncommon.

Once you've gathered this information, creating the user in the dashboard is just another web form similar to what we've seen before and can be found by clicking the *Users* link in the *Identity* navigation bar and then clicking the *Create User* button at the top right.

Modifying users is also done from this *Users* page. If you have a large number of users, this page can get quite crowded. The *Filter* search box at the top of the page can be used to limit the users listing. A form very similar to the user creation dialog can be pulled up by selecting *Edit* from the actions drop-down menu at the end of the line for the user you are modifying.

Associating Users with Projects

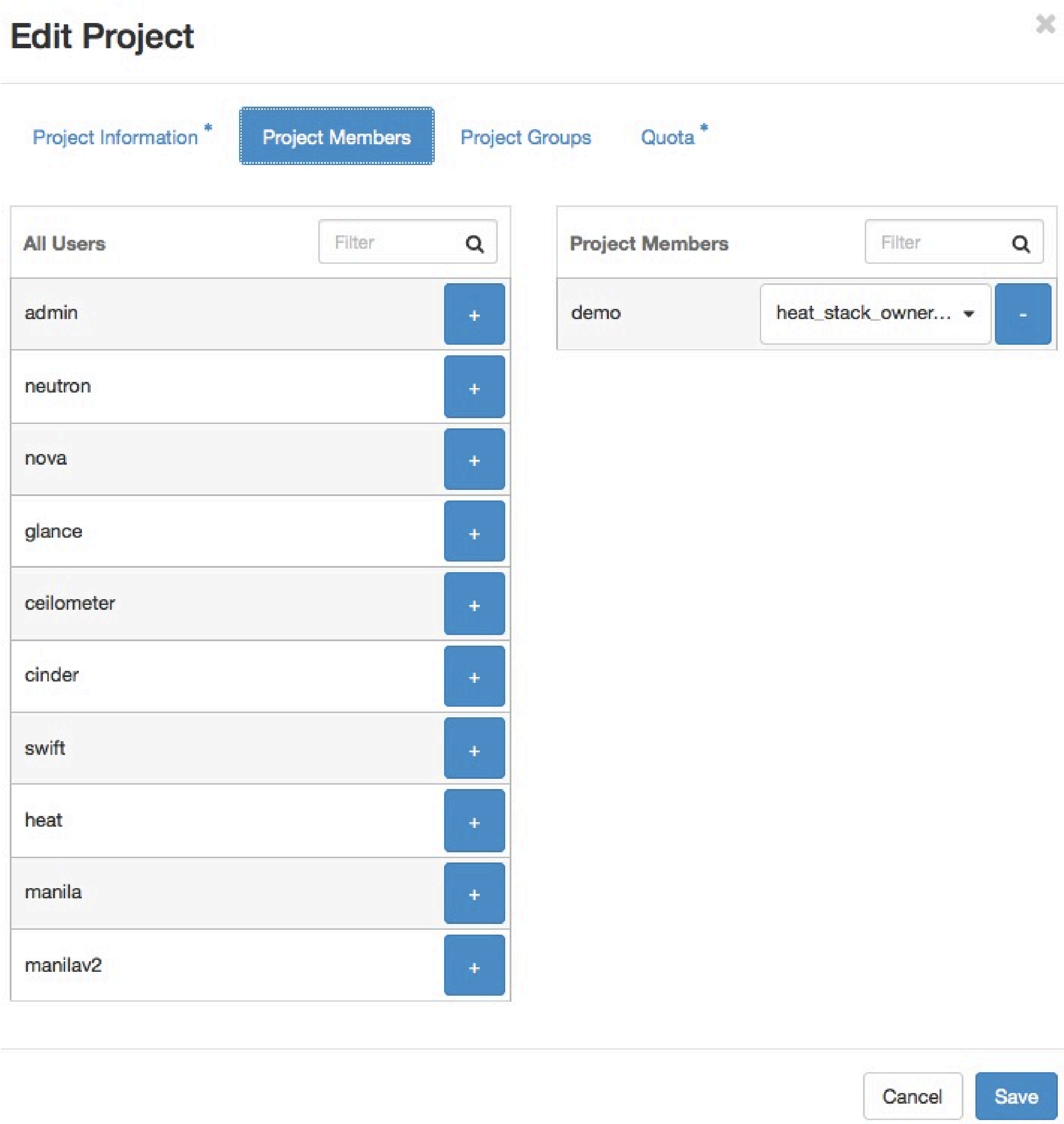
Many sites run with users being associated with only one project. This is a more conservative and simpler choice both for administration and for users. Administratively, if a user reports a problem with an instance or quota, it is obvious which project this relates to. Users needn't worry about what project they are acting in if they are only in one project. However, note that, by default, any user can affect the resources of any other user within their project. It is also possible to associate users with multiple projects if that makes sense for your organization.

Associating existing users with an additional project or removing them from an older project is done from the *Projects* page of the dashboard by selecting *Manage Members* from the *Actions* column, as shown in the screenshot below.

From this view, you can do a number of useful things, as well as a few dangerous ones.

The first column of this form, named *All Users*, includes a list of all the users in your cloud who are not already associated with this project. The second column shows all the users who are. These lists can be quite long, but they can be limited by typing a substring of the username you are looking for in the filter field at the top of the column.

From here, click the + icon to add users to the project. Click the - to remove them.



The dangerous possibility comes with the ability to change member roles. This is the dropdown list below the username in the *Project Members* list. In virtually all cases, this value should be set to *Member*. This example purposefully shows an administrative user where this value is `admin`.

> **Warning:** The admin is global, not per project, so granting a user the `admin` role in any project gives the user administrative rights across the whole cloud.

Typical use is to only create administrative users in a single project, by convention the admin project, which is created by default during cloud setup. If your administrative users also use the cloud to launch and manage instances, it is strongly recommended that you use separate user accounts for administrative access and normal operations and that they be in distinct projects.

Customizing Authorization

The default *authorization* settings allow administrative users only to create resources on behalf of a different project. OpenStack handles two kinds of authorization policies:

Operation based Policies specify access criteria for specific operations, possibly with fine-grained control over specific attributes.

Resource based Whether access to a specific resource might be granted or not according to the permissions configured for the resource (currently available only for the network resource). The actual authorization policies enforced in an OpenStack service vary from deployment to deployment.

The policy engine reads entries from the `policy.json` file. The actual location of this file might vary from distribution to distribution: for nova, it is typically in `/etc/nova/policy.json`. You can update entries while the system is running, and you do not have to restart services. Currently, the only way to update such policies is to edit the policy file.

The OpenStack service's policy engine matches a policy directly. A rule indicates evaluation of the elements of such policies. For instance, in a `compute:create: "rule:admin_or_owner"` statement, the policy is `compute:create`, and the rule is `admin_or_owner`.

Policies are triggered by an OpenStack policy engine whenever one of them matches an OpenStack API operation or a specific attribute being used in a given operation. For instance, the engine tests the `create:compute` policy every time a user sends a `POST /v2/{tenant_id}/servers` request to the OpenStack Compute API server. Policies can be also related to specific *API extensions*. For instance, if a user needs an extension like `compute_extension:rescue`, the attributes defined by the provider extensions trigger the rule test for that operation.

An authorization policy can be composed by one or more rules. If more rules are specified, evaluation policy is successful if any of the rules evaluates successfully; if an API operation matches multiple policies, then all the policies must evaluate successfully. Also, authorization rules are recursive. Once a rule is matched, the rule(s) can be resolved to another rule, until a terminal rule is reached. These are the rules defined:

Role-based rules Evaluate successfully if the user submitting the request has the specified role. For instance, `"role:admin"` is successful if the user submitting the request is an administrator.

Field-based rules Evaluate successfully if a field of the resource specified in the current request matches a specific value. For instance, `"field:networks:shared=True"` is successful if the attribute shared of the network resource is set to `true`.

Generic rules Compare an attribute in the resource with an attribute extracted from the user's security credentials and evaluates successfully if the comparison is successful. For instance, `"tenant_id:%(tenant_id)s"` is successful if the tenant identifier in the resource is equal to the tenant identifier of the user submitting the request.

Here are snippets of the default nova `policy.json` file:

```
{
        "context_is_admin":  "role:admin",
        "admin_or_owner":  "is_admin:True", "project_id:%(project_id)s", ~~~~(1)~~~~
        "default": "rule:admin_or_owner", ~~~~(2)~~~~
        "compute:create": "",
        "compute:create:attach_network": "",
        "compute:create:attach_volume": "",
        "compute:get_all": "",
        "admin_api": "is_admin:True",
        "compute_extension:accounts": "rule:admin_api",
        "compute_extension:admin_actions": "rule:admin_api",
        "compute_extension:admin_actions:pause": "rule:admin_or_owner",
        "compute_extension:admin_actions:unpause": "rule:admin_or_owner",
        ...
        "compute_extension:admin_actions:migrate": "rule:admin_api",
        "compute_extension:aggregates": "rule:admin_api",
        "compute_extension:certificates": "",
        ...
        "compute_extension:flavorextraspecs": "",
        "compute_extension:flavormanage": "rule:admin_api", ~~~~(3)~~~~
}
```

1. Shows a rule that evaluates successfully if the current user is an administrator or the owner of the resource specified in the request (tenant identifier is equal).
2. Shows the default policy, which is always evaluated if an API operation does not match any of the policies in `policy.json`.
3. Shows a policy restricting the ability to manipulate flavors to administrators using the Admin API only.

In some cases, some operations should be restricted to administrators only. Therefore, as a further example, let us consider how this sample policy file could be modified in a scenario where we enable users to create their own flavors:

```
"compute_extension:flavormanage": "",
```

Users Who Disrupt Other Users

Users on your cloud can disrupt other users, sometimes intentionally and maliciously and other times by accident. Understanding the situation allows you to make a better decision on how to handle the disruption.

For example, a group of users have instances that are utilizing a large amount of compute resources for very compute-intensive tasks. This is driving the load up on compute nodes and affecting other users. In this situation, review your user use cases. You may find that high compute scenarios are common, and should then plan for proper segregation in your cloud, such as host aggregation or regions.

Another example is a user consuming a very large amount of bandwidth. Again, the key is to understand what the user is doing. If she naturally needs a high amount of bandwidth, you might have to limit her transmission rate as to not affect other users or move her to an area with more bandwidth available. On the other hand, maybe her instance has been hacked and is part of a botnet launching DDOS attacks. Resolution of this issue is the same as though any other server on your network has been hacked. Contact the user and give her time to respond. If she doesn't respond, shut down the instance.

A final example is if a user is hammering cloud resources repeatedly. Contact the user and learn what he is trying to do. Maybe he doesn't understand that what he's doing is inappropriate, or maybe there is an issue with the resource he is trying to access that is causing his requests to queue or lag.

Summary

One key element of systems administration that is often overlooked is that end users are the reason systems administrators exist. Don't go the BOFH route and terminate every user who causes an alert to go off. Work with users to understand what they're trying to accomplish and see how your environment can better assist them in achieving their goals. Meet your users needs by organizing your users into projects, applying policies, managing quotas, and working with them.

An OpenStack cloud does not have much value without users. This chapter covers topics that relate to managing users, projects, and quotas. This chapter describes users and projects as described by version 2 of the OpenStack Identity API.

Projects or Tenants?

In OpenStack user interfaces and documentation, a group of users is referred to as a *project* or *tenant*. These terms are interchangeable.

The initial implementation of OpenStack Compute had its own authentication system and used the term `project`. When authentication moved into the OpenStack Identity (keystone) project, it used the term `tenant` to refer to a group of users. Because of this legacy, some of the OpenStack tools refer to projects and some refer to tenants.

Tip: This guide uses the term `project`, unless an example shows interaction with a tool that uses the term `tenant`.

User-Facing Operations

This guide is for OpenStack operators and does not seek to be an exhaustive reference for users, but as an operator, you should have a basic understanding of how to use the cloud facilities. This chapter looks at OpenStack from a basic user perspective, which helps you understand your users' needs and determine, when you get a trouble ticket, whether it is a user issue or a service issue. The main concepts covered are images, flavors, security groups, block storage, shared file system storage, and instances.

Images

OpenStack images can often be thought of as "virtual machine templates." Images can also be standard installation media such as ISO images. Essentially, they contain bootable file systems that are used to launch instances.

Adding Images

Several pre-made images exist and can easily be imported into the Image service. A common image to add is the CirrOS image, which is very small and used for testing purposes. To add this image, simply do:

```
$ wget http://download.cirros-cloud.net/0.3.5/cirros-0.3.5-x86_64-disk.img
$ openstack image create --file cirros-0.3.5-x86_64-disk.img \
  --public --container-format bare \
  --disk-format qcow2 "cirros image"
```

The **openstack image create** command provides a large set of options for working with your image. For example, the `--min-disk` option is useful for images that require root disks of a certain size (for example, large Windows images). To view these options, run:

```
$ openstack help image create
```

Run the following command to view the properties of existing images:

```
$ openstack image show IMAGE_NAME_OR_UUID
```

Adding Signed Images

To provide a chain of trust from an end user to the Image service, and the Image service to Compute, an end user can import signed images that can be initially verified in the Image service, and later verified in the Compute service. Appropriate Image service properties need to be set to enable this signature feature.

Note: Prior to the steps below, an asymmetric keypair and certificate must be generated. In this example, these are called private_key.pem and new_cert.crt, respectively, and both reside in the current directory. Also note that the image in this example is cirros-0.3.5-x86_64-disk.img, but any image can be used.

The following are steps needed to create the signature used for the signed images:

1. Retrieve image for upload

   ```
   $ wget http://download.cirros-cloud.net/0.3.5/cirros-0.3.5-x86_64-disk.img
   ```

2. Use private key to create a signature of the image

   Note: The following implicit values are being used to create the signature in this example:

   - Signature hash method = SHA-256
   - Signature key type = RSA-PSS

   Note: The following options are currently supported:

   - Signature hash methods: SHA-224, SHA-256, SHA-384, and SHA-512
   - Signature key types: DSA, ECC_SECT571K1, ECC_SECT409K1, ECC_SECT571R1, ECC_SECT409R1, ECC_SECP521R1, ECC_SECP384R1, and RSA-PSS

   Generate signature of image and convert it to a base64 representation:

   ```
   $ openssl dgst -sha256 -sign private_key.pem -sigopt rsa_padding_mode:pss \
     -out image-file.signature cirros-0.3.5-x86_64-disk.img
   ```

```
$ base64 -w 0 image-file.signature > signature_64
$ cat signature_64
'c4br5f3FYQV6Nu20cRUSnx75R/
↪VcW3diQdsUN2nhPw+UcQRDoGx92hwMgRxzFYeUyydRTWCcUS2ZLudPR9X7rM
THFInA54Zj1TwEIbJTkHwlqbWBMU4+k5IUIjXxHO6RuH3Z5f/SlSt7ajsNVXaIclWqIw5YvEkgXTIEuDPE+C4=
↪'
```

Note:

- Using Image API v1 requires '-w 0' above, since multiline image properties are not supported.
- Image API v2 supports multiline properties, so this option is not required for v2 but it can still be used.

3. Create context

```
$ python
>>> from keystoneclient.v3 import client
>>> keystone_client = client.Client(username='demo',
                                    user_domain_name='Default',
                                    password='password',
                                    project_name='demo',
                                    auth_url='http://localhost:5000/v3')

>>> from oslo_context import context
>>> context = context.RequestContext(auth_token=keystone_client.auth_token,
                                     tenant=keystone_client.project_id)
```

4. Encode certificate in DER format

```
>>> from cryptography import x509 as cryptography_x509
>>> from cryptography.hazmat import backends
>>> from cryptography.hazmat.primitives import serialization
>>> with open("new_cert.crt", "rb") as cert_file:
>>>     cert = cryptography_x509.load_pem_x509_certificate(
              cert_file.read(),
              backend=backends.default_backend()
              )
>>> certificate_der = cert.public_bytes(encoding=serialization.Encoding.DER)
```

5. Upload Certificate in DER format to Castellan

```
>>> from castellan.common.objects import x_509
>>> from castellan import key_manager
>>> castellan_cert = x_509.X509(certificate_der)
>>> key_API = key_manager.API()
>>> cert_uuid = key_API.store(context, castellan_cert)
>>> cert_uuid
u'62a33f41-f061-44ba-9a69-4fc247d3bfce'
```

6. Upload Image to Image service, with Signature Metadata

Note: The following signature properties are used:

- img_signature uses the signature called signature_64

- img_signature_certificate_uuid uses the value from cert_uuid in section 5 above
- img_signature_hash_method matches 'SHA-256' in section 2 above
- img_signature_key_type matches 'RSA-PSS' in section 2 above

```
$ . openrc demo
$ export OS_IMAGE_API_VERSION=2
$ openstack image create --property name=cirrosSignedImage_goodSignature \
  --property is-public=true --container-format bare --disk-format qcow2 \
  --property img_signature='c4br5f3FYQV6Nu20cRUSnx75R/
↪VcW3diQdsUN2nhPw+UcQRDoGx92hwMgRxzFYeUyydRTWCcUS2ZLudPR9X7rMTHFInA54Zj1TwEIbJTkHwlqbWBMU4+k5IUIjXxHO
↪' \
  --property img_signature_certificate_uuid='62a33f41-f061-44ba-9a69-4fc247d3bfce' \
  --property img_signature_hash_method='SHA-256' \
  --property img_signature_key_type='RSA-PSS' < ~/cirros-0.3.5-x86_64-disk.img
```

Note: The maximum image signature character limit is 255.

7. Verify the Keystone URL

Note: The default Keystone configuration assumes that Keystone is in the local host, and it uses `http://localhost:5000/v3` as the endpoint URL, which is specified in `glance-api.conf` and `nova-api.conf` files:

```
[barbican]
auth_endpoint = http://localhost:5000/v3
```

Note: If Keystone is located remotely instead, edit the `glance-api.conf` and `nova.conf` files. In the `[barbican]` section, configre the `auth_endpoint` option:

```
[barbican]
auth_endpoint = https://192.168.245.9:5000/v3
```

8. Signature verification will occur when Compute boots the signed image

Note: nova-compute servers first need to be updated by the following steps:

- Ensure that cryptsetup is installed, and ensure that `pythin-barbicanclient` Python package is installed
- Set up the Key Manager service by editing /etc/nova/nova.conf and adding the entries in the code-block below
- The flag verify_glance_signatures enables Compute to automatically validate signed instances prior to its launch. This validation feature is enabled when the value is set to TRUE

```
[key_manager]
api_class = castellan.key_manager.barbican_key_manager.BarbicanKeyManager
```

```
[glance]
verify_glance_signatures = TRUE
```

Note: The api_class [keymgr] is deprecated as of Newton, so it should not be included in this release or beyond.

Sharing Images Between Projects

In a multi-tenant cloud environment, users sometimes want to share their personal images or snapshots with other projects. This can be done on the command line with the `glance` tool by the owner of the image.

To share an image or snapshot with another project, do the following:

1. Obtain the UUID of the image:

```
$ openstack image list
```

2. Obtain the UUID of the project with which you want to share your image, let's call it target project. Unfortunately, non-admin users are unable to use the **openstack** command to do this. The easiest solution is to obtain the UUID either from an administrator of the cloud or from a user located in the target project.

3. Once you have both pieces of information, run the **openstack image add project** command:

```
$ openstack image add project IMAGE_NAME_OR_UUID PROJECT_NAME_OR_UUID
```

For example:

```
$ openstack image add project 733d1c44-a2ea-414b-aca7-69decf20d810 \
  771ed149ef7e4b2b88665cc1c98f77ca
```

4. You now need to act in the target project scope.

Note: You will not see the shared image yet. Therefore the sharing needs to be accepted.

To accept the sharing, you need to update the member status:

```
$ glance member-update IMAGE_UUID PROJECT_UUID accepted
```

For example:

```
$ glance member-update 733d1c44-a2ea-414b-aca7-69decf20d810 \
  771ed149ef7e4b2b88665cc1c98f77ca accepted
```

Project `771ed149ef7e4b2b88665cc1c98f77ca` will now have access to image `733d1c44-a2ea-414b-aca7-69decf20d810`.

Tip: You can explicitly ask for pending member status to view shared images not yet accepted:

```
$ glance image-list --member-status pending
```

Deleting Images

To delete an image, just execute:

```
$ openstack image delete IMAGE_NAME_OR_UUID
```

> **Caution:** Generally, deleting an image does not affect instances or snapshots that were based on the image. However, some drivers may require the original image to be present to perform a migration. For example, XenAPI live-migrate will work fine if the image is deleted, but libvirt will fail.

Other CLI Options

A full set of options can be found using:

```
$ glance help
```

or the Command-Line Interface Reference.

The Image service and the Database

The only thing the Image service does not store in a database is the image itself. The Image service database has two main tables:

- `images`
- `image_properties`

Working directly with the database and SQL queries can provide you with custom lists and reports of images. Technically, you can update properties about images through the database, although this is not generally recommended.

Example Image service Database Queries

One interesting example is modifying the table of images and the owner of that image. This can be easily done if you simply display the unique ID of the owner. This example goes one step further and displays the readable name of the owner:

```
mysql> select glance.images.id,
              glance.images.name, keystone.tenant.name, is_public from
              glance.images inner join keystone.tenant on
              glance.images.owner=keystone.tenant.id;
```

Another example is displaying all properties for a certain image:

```
mysql> select name, value from
              image_properties where id = <image_id>
```

Flavors

Virtual hardware templates are called "flavors" in OpenStack, defining sizes for RAM, disk, number of cores, and so on. The default install provides five flavors.

These are configurable by admin users (the rights may also be delegated to other users by redefining the access controls for `compute_extension:flavormanage` in `/etc/nova/policy.json` on the `nova-api` server). To get the list of available flavors on your system, run:

```
$ openstack flavor list
+----+-----------+-------+------+-----------+-------+-----------+
| ID | Name      |   RAM | Disk | Ephemeral | VCPUs | Is Public |
+----+-----------+-------+------+-----------+-------+-----------+
| 1  | m1.tiny   |   512 |    1 |         0 |     1 | True      |
| 2  | m1.small  |  2048 |   20 |         0 |     1 | True      |
| 3  | m1.medium |  4096 |   40 |         0 |     2 | True      |
| 4  | m1.large  |  8192 |   80 |         0 |     4 | True      |
| 5  | m1.xlarge | 16384 |  160 |         0 |     8 | True      |
+----+-----------+-------+------+-----------+-------+-----------+
```

The **`openstack flavor create`** command allows authorized users to create new flavors. Additional flavor manipulation commands can be shown with the following command:

```
$ openstack help | grep flavor
```

Flavors define a number of parameters, resulting in the user having a choice of what type of virtual machine to run—just like they would have if they were purchasing a physical server. *Table. Flavor parameters* lists the elements that can be set. Note in particular `extra_specs`, which can be used to define free-form characteristics, giving a lot of flexibility beyond just the size of RAM, CPU, and Disk.

Table 5: Table. Flavor parameters

Column	Description
ID	Unique ID (integer or UUID) for the flavor.
Name	A descriptive name, such as xx.size_name, is conventional but not required, though some third-party tools may rely on it.
Memory_MB	Virtual machine memory in megabytes.
Disk	Virtual root disk size in gigabytes. This is an ephemeral disk the base image is copied into. You don't use it when you boot from a persistent volume. The "0" size is a special case that uses the native base image size as the size of the ephemeral root volume.
Ephemeral	Specifies the size of a secondary ephemeral data disk. This is an empty, unformatted disk and exists only for the life of the instance.
Swap	Optional swap space allocation for the instance.
VCPUs	Number of virtual CPUs presented to the instance.
RXTX_Factor	Optional property that allows created servers to have a different bandwidth cap from that defined in the network they are attached to. This factor is multiplied by the rxtx_base property of the network. Default value is 1.0 (that is, the same as the attached network).
Is_Public	Boolean value that indicates whether the flavor is available to all users or private. Private flavors do not get the current tenant assigned to them. Defaults to `True`.
extra_specs	Additional optional restrictions on which compute nodes the flavor can run on. This is implemented as key-value pairs that must match against the corresponding key-value pairs on compute nodes. Can be used to implement things like special resources (such as flavors that can run only on compute nodes with GPU hardware).

Private Flavors

A user might need a custom flavor that is uniquely tuned for a project she is working on. For example, the user might require 128 GB of memory. If you create a new flavor as described above, the user would have access to the custom flavor, but so would all other tenants in your cloud. Sometimes this sharing isn't desirable. In this scenario, allowing all users to have access to a flavor with 128 GB of memory might cause your cloud to reach full capacity very quickly. To prevent this, you can restrict access to the custom flavor using the **`nova flavor-access-add`** command:

```
$ nova flavor-access-add FLAVOR_ID PROJECT_ID
```

To view a flavor's access list, do the following:

```
$ nova flavor-access-list [--flavor FLAVOR_ID]
```

Tip: Once access to a flavor has been restricted, no other projects besides the ones granted explicit access will be able to see the flavor. This includes the admin project. Make sure to add the admin project in addition to the original project.

It's also helpful to allocate a specific numeric range for custom and private flavors. On UNIX-based systems, nonsystem accounts usually have a UID starting at 500. A similar approach can be taken with custom flavors. This helps you easily identify which flavors are custom, private, and public for the entire cloud.

How Do I Modify an Existing Flavor?

The OpenStack dashboard simulates the ability to modify a flavor by deleting an existing flavor and creating a new one with the same name.

Security Groups

A common new-user issue with OpenStack is failing to set an appropriate security group when launching an instance. As a result, the user is unable to contact the instance on the network.

Security groups are sets of IP filter rules that are applied to an instance's networking. They are project specific, and project members can edit the default rules for their group and add new rules sets. All projects have a "default" security group, which is applied to instances that have no other security group defined. Unless changed, this security group denies all incoming traffic.

Tip: As noted in the previous chapter, the number of rules per security group is controlled by the `quota_security_group_rules`, and the number of allowed security groups per project is controlled by the `quota_security_groups` quota.

End-User Configuration of Security Groups

Security groups for the current project can be found on the OpenStack dashboard under *Access & Security*. To see details of an existing group, select the *Edit Security Group* action for that security group. Obviously, modifying existing groups can be done from this edit interface. There is a *Create Security Group* button on the main *Access & Security* page for creating new groups. We discuss the terms used in these fields when we explain the command-line equivalents.

Setting with openstack command

If your environment is using Neutron, you can configure security groups settings using the **`openstack`** command. Get a list of security groups for the project you are acting in, by using following command:

```
$ openstack security group list
+------------------------+---------+------------------------+-------------------------+
| ID                     | Name    | Description            | Project                 |
+------------------------+---------+------------------------+-------------------------+
| 3bef30ed-442d-4cf1     | default | Default security group | 35e3820f7490493ca9e3a5e |
| -b84d-2ba50a395599     |         |                        | 685393298               |
| aaf1d0b7-98a0-41a3-ae1 | default | Default security group | 32e9707393c34364923edf8 |
| 6-a58b94503289         |         |                        | f5029cbfe               |
+------------------------+---------+------------------------+-------------------------+
```

To view the details of a security group:

```
$ openstack security group show 3bef30ed-442d-4cf1-b84d-2ba50a395599
+-----------------+-------------------------------------------------------------------------
↪-----------------------------------------------------------------------------------------
↪---------------------+
| Field           | Value
↪
↪                     |
+-----------------+-------------------------------------------------------------------------
↪-----------------------------------------------------------------------------------------
↪---------------------+
```

```
| created_at      | 2016-11-08T21:55:19Z                                                   
↪                                                                                          
↪                      |
| description     | Default security group                                                 
↪                                                                                          
↪                      |
| id              | 3bef30ed-442d-4cf1-b84d-2ba50a395599                                   
↪                                                                                          
↪                      |
| name            | default                                                                
↪                                                                                          
↪                      |
| project_id      | 35e3820f7490493ca9e3a5e685393298                                       
↪                                                                                          
↪                      |
| project_id      | 35e3820f7490493ca9e3a5e685393298                                       
↪                                                                                          
↪                      |
| revision_number | 1                                                                      
↪                                                                                          
↪                      |
| rules           | created_at='2016-11-08T21:55:19Z', direction='egress', ethertype='IPv6',
↪ id='1dca4cac-d4f2-46f5-b757-d53c01a87bdf', project_id='35e3820f7490493ca9e3a5e685393298',
↪                      |
|                 | revision_number='1', updated_at='2016-11-08T21:55:19Z'                 
↪                                                                                          
↪                      |
|                 | created_at='2016-11-08T21:55:19Z', direction='egress', ethertype='IPv4',
↪ id='2d83d6f2-424e-4b7c-b9c4-1ede89c00aab', project_id='35e3820f7490493ca9e3a5e685393298',
↪                      |
|                 | revision_number='1', updated_at='2016-11-08T21:55:19Z'                 
↪                                                                                          
↪                      |
|                 | created_at='2016-11-08T21:55:19Z', direction='ingress', ethertype='IPv4
↪', id='62b7d1eb-b98d-4707-a29f-6df379afdbaa', project_id='35e3820f7490493ca9e3a5e685393298
↪', remote_group_id     |
|                 | ='3bef30ed-442d-4cf1-b84d-2ba50a395599', revision_number='1', updated_
↪at='2016-11-08T21:55:19Z'                                                                 
↪                        |
|                 | created_at='2016-11-08T21:55:19Z', direction='ingress', ethertype='IPv6
↪', id='f0d4b8d6-32d4-4f93-813d-3ede9d698fbb', project_id='35e3820f7490493ca9e3a5e685393298
↪', remote_group_id     |
|                 | ='3bef30ed-442d-4cf1-b84d-2ba50a395599', revision_number='1', updated_
↪at='2016-11-08T21:55:19Z'                                                                 
↪                        |
| updated_at      | 2016-11-08T21:55:19Z                                                   
↪                                                                                          
↪                      |
+-----------------+------------------------------------------------------------------------
↪------------------------------------------------------------------------------------------
↪--------------------+
```

These rules are all "allow" type rules, as the default is deny. This example shows the full port range for all protocols allowed from all IPs. This section describes the most common security group rule parameters:

direction The direction in which the security group rule is applied. Valid values are `ingress` or `egress`.

remote_ip_prefix This attribute value matches the specified IP prefix as the source IP address of the IP packet.

protocol The protocol that is matched by the security group rule. Valid values are `null`, `tcp`, `udp`, `icmp`, and `icmpv6`.

port_range_min The minimum port number in the range that is matched by the security group rule. If the protocol is TCP or UDP, this value must be less than or equal to the `port_range_max` attribute value. If the protocol is ICMP or ICMPv6, this value must be an ICMP or ICMPv6 type, respectively.

port_range_max The maximum port number in the range that is matched by the security group rule. The `port_range_min` attribute constrains the `port_range_max` attribute. If the protocol is ICMP or ICMPv6, this value must be an ICMP or ICMPv6 type, respectively.

ethertype Must be `IPv4` or `IPv6`, and addresses represented in CIDR must match the ingress or egress rules.

When adding a new security group, you should pick a descriptive but brief name. This name shows up in brief descriptions of the instances that use it where the longer description field often does not. Seeing that an instance is using security group `http` is much easier to understand than `bobs_group` or `secgrp1`.

This example creates a security group that allows web traffic anywhere on the Internet. We'll call this group `global_http`, which is clear and reasonably concise, encapsulating what is allowed and from where. From the command line, do:

```
$ openstack security group create global_http --description "allow web traffic from the
↪Internet"
Created a new security_group:
+-----------------+------------------------------------------------------------------
↪-----------------------------------------------------------------------------------
↪---------------------+
| Field           | Value
↪
↪                         |
+-----------------+------------------------------------------------------------------
↪-----------------------------------------------------------------------------------
↪---------------------+
| created_at      | 2016-11-10T16:09:18Z
↪
↪                         |
| description     | allow web traffic from the Internet
↪
↪                         |
| headers         |
↪
↪                         |
| id              | 70675447-1b92-4102-a7ea-6a3ca99d2290
↪
↪                         |
| name            | global_http
↪
↪                         |
| project_id      | 32e9707393c34364923edf8f5029cbfe
↪
↪                         |
| project_id      | 32e9707393c34364923edf8f5029cbfe
↪
↪                         |
| revision_number | 1
↪
↪                         |
| rules           | created_at='2016-11-10T16:09:18Z', direction='egress', ethertype='IPv4',
↪ id='e440b13a-e74f-4700-a36f-9ecc0de76612', project_id='32e9707393c34364923edf8f5029cbfe',
↪                         |
```

```
|                 | revision_number='1', updated_at='2016-11-10T16:09:18Z'
↪
↪                      |
|                 | created_at='2016-11-10T16:09:18Z', direction='egress', ethertype='IPv6',
↪ id='0debf8cb-9f1d-45e5-98db-ee169c0715fe', project_id='32e9707393c34364923edf8f5029cbfe',
↪                      |
|                 | revision_number='1', updated_at='2016-11-10T16:09:18Z'
↪
↪                      |
| updated_at      | 2016-11-10T16:09:18Z
↪
↪                      |
+-----------------+---------------------------------------------------------------------
↪-------------------------------------------------------------------------------------
↪--------------------+
```

Immediately after create, the security group has only an allow egress rule. To make it do what we want, we need to add some rules:

```
$ openstack security group rule create --help
usage: openstack security group rule create [-h]
                                            [-f {json,shell,table,value,yaml}]
                                            [-c COLUMN]
                                            [--max-width <integer>]
                                            [--noindent] [--prefix PREFIX]
                                            [--remote-ip <ip-address> | --remote-group
↪<group>]
                                            [--dst-port <port-range>]
                                            [--icmp-type <icmp-type>]
                                            [--icmp-code <icmp-code>]
                                            [--protocol <protocol>]
                                            [--ingress | --egress]
                                            [--ethertype <ethertype>]
                                            [--project <project>]
                                            [--project-domain <project-domain>]
                                            <group>

$ openstack security group rule create --ingress --ethertype IPv4 \
  --protocol tcp --remote-ip 0.0.0.0/0 global_http

Created a new security group rule:
+-------------------+--------------------------------------+
| Field             | Value                                |
+-------------------+--------------------------------------+
| created_at        | 2016-11-10T16:12:27Z                 |
| description       |                                      |
| direction         | ingress                              |
| ethertype         | IPv4                                 |
| headers           |                                      |
| id                | 694d30b1-1c4d-4bb8-acbe-7f1b3de2b20f |
| port_range_max    | None                                 |
| port_range_min    | None                                 |
| project_id        | 32e9707393c34364923edf8f5029cbfe     |
| project_id        | 32e9707393c34364923edf8f5029cbfe     |
| protocol          | tcp                                  |
| remote_group_id   | None                                 |
| remote_ip_prefix  | 0.0.0.0/0                            |
```

```
| revision_number   | 1                                    |
| security_group_id | 70675447-1b92-4102-a7ea-6a3ca99d2290 |
| updated_at        | 2016-11-10T16:12:27Z                 |
+-------------------+--------------------------------------+
```

Despite only outputting the newly added rule, this operation is additive:

```
$ openstack security group show global_http
+-----------------+-------------------------------------------------------------------
↪-------------------------------------------------------------------------------------
↪--------------------+
| Field           | Value
↪
↪                    |
+-----------------+-------------------------------------------------------------------
↪-------------------------------------------------------------------------------------
↪--------------------+
| created_at      | 2016-11-10T16:09:18Z
↪
↪                    |
| description     | allow web traffic from the Internet
↪
↪                    |
| id              | 70675447-1b92-4102-a7ea-6a3ca99d2290
↪
↪                    |
| name            | global_http
↪
↪                    |
| project_id      | 32e9707393c34364923edf8f5029cbfe
↪
↪                    |
| project_id      | 32e9707393c34364923edf8f5029cbfe
↪
↪                    |
| revision_number | 2
↪
↪                    |
| rules           | created_at='2016-11-10T16:09:18Z', direction='egress', ethertype='IPv6',
↪ id='0debf8cb-9f1d-45e5-98db-ee169c0715fe', project_id='32e9707393c34364923edf8f5029cbfe',
↪                    |
|                 | revision_number='1', updated_at='2016-11-10T16:09:18Z'
↪
↪                    |
|                 | created_at='2016-11-10T16:12:27Z', direction='ingress', ethertype='IPv4
↪', id='694d30b1-1c4d-4bb8-acbe-7f1b3de2b20f', project_id='32e9707393c34364923edf8f5029cbfe
↪', protocol='tcp',     |
|                 | remote_ip_prefix='0.0.0.0/0', revision_number='1', updated_at='2016-11-
↪10T16:12:27Z'
↪                     |
|                 | created_at='2016-11-10T16:09:18Z', direction='egress', ethertype='IPv4',
↪ id='e440b13a-e74f-4700-a36f-9ecc0de76612', project_id='32e9707393c34364923edf8f5029cbfe',
↪                    |
|                 | revision_number='1', updated_at='2016-11-10T16:09:18Z'
↪
↪                    |
| updated_at      | 2016-11-10T16:12:27Z
↪
↪                    |
```

```
+-----------------+-------------------------------------------------------------------
↪---------------------------------------------------------------------------------------
↪---------------------+
```

The inverse operation is called **openstack security group rule delete**, specifying security-group-rule ID. Whole security groups can be removed with **openstack security group delete**.

To create security group rules for a cluster of instances, use RemoteGroups.

RemoteGroups are a dynamic way of defining the CIDR of allowed sources. The user specifies a RemoteGroup (security group name) and then all the users' other instances using the specified RemoteGroup are selected dynamically. This dynamic selection alleviates the need for individual rules to allow each new member of the cluster.

The code is similar to the above example of **openstack security group rule create**. To use RemoteGroup, specify `--remote-group` instead of `--remote-ip`. For example:

```
$ openstack security group rule create --ingress \
  --ethertype IPv4 --protocol tcp \
  --remote-group global_http cluster
```

The "cluster" rule allows SSH access from any other instance that uses the `global-http` group.

Block Storage

OpenStack volumes are persistent block-storage devices that may be attached and detached from instances, but they can be attached to only one instance at a time. Similar to an external hard drive, they do not provide shared storage in the way a network file system or object store does. It is left to the operating system in the instance to put a file system on the block device and mount it, or not.

As with other removable disk technology, it is important that the operating system is not trying to make use of the disk before removing it. On Linux instances, this typically involves unmounting any file systems mounted from the volume. The OpenStack volume service cannot tell whether it is safe to remove volumes from an instance, so it does what it is told. If a user tells the volume service to detach a volume from an instance while it is being written to, you can expect some level of file system corruption as well as faults from whatever process within the instance was using the device.

There is nothing OpenStack-specific in being aware of the steps needed to access block devices from within the instance operating system, potentially formatting them for first use and being cautious when removing them. What is specific is how to create new volumes and attach and detach them from instances. These operations can all be done from the *Volumes* page of the dashboard or by using the `openstack` command-line client.

To add new volumes, you need only a volume size in gigabytes. Either put these into the *Create Volume* web form or use the command line:

```
$ openstack volume create volume1 --size 10
```

This creates a 10 GB volume. To list existing volumes and the instances they are connected to, if any:

```
$ openstack volume list
+--------------------------------------+--------------+--------+------+-------------+
| ID                                   | Display Name | Status | Size | Attached to |
+--------------------------------------+--------------+--------+------+-------------+
| 6cf4114a-56b2-476b-acf7-7359d8334aa2 | volume1      | error  |   10 |             |
+--------------------------------------+--------------+--------+------+-------------+
```

OpenStack Block Storage also allows creating snapshots of volumes. Remember that this is a block-level snapshot that is crash consistent, so it is best if the volume is not connected to an instance when the snapshot is taken and second best if the volume is not in use on the instance it is attached to. If the volume is under heavy use, the snapshot may have an inconsistent file system. In fact, by default, the volume service does not take a snapshot of a volume that is attached to an image, though it can be forced to. To take a volume snapshot, either select *Create Snapshot* from the actions column next to the volume name on the dashboard *Volumes* page, or run this from the command line:

```
$ openstack help snapshot create
usage: openstack snapshot create [-h] [-f {json,shell,table,value,yaml}]
                                 [-c COLUMN] [--max-width <integer>]
                                 [--noindent] [--prefix PREFIX]
                                 [--name <name>] [--description <description>]
                                 [--force] [--property <key=value>]
                                 <volume>

Create new snapshot

positional arguments:
  <volume>              Volume to snapshot (name or ID)

optional arguments:
  -h, --help            show this help message and exit
  --name <name>         Name of the snapshot
  --description <description>
                        Description of the snapshot
  --force               Create a snapshot attached to an instance. Default is
                        False
  --property <key=value>
                        Set a property to this snapshot (repeat option to set
                        multiple properties)

output formatters:
  output formatter options

  -f {json,shell,table,value,yaml}, --format {json,shell,table,value,yaml}
                        the output format, defaults to table
  -c COLUMN, --column COLUMN
                        specify the column(s) to include, can be repeated

table formatter:
  --max-width <integer>
                        Maximum display width, <1 to disable. You can also use
                        the CLIFF_MAX_TERM_WIDTH environment variable, but the
                        parameter takes precedence.

json formatter:
  --noindent            whether to disable indenting the JSON

shell formatter:
  a format a UNIX shell can parse (variable="value")

  --prefix PREFIX       add a prefix to all variable names
```

Note: For more information about updating Block Storage volumes (for example, resizing or transferring), see the OpenStack End User Guide.

Block Storage Creation Failures

If a user tries to create a volume and the volume immediately goes into an error state, the best way to troubleshoot is to grep the cinder log files for the volume's UUID. First try the log files on the cloud controller, and then try the storage node where the volume was attempted to be created:

```
# grep 903b85d0-bacc-4855-a261-10843fc2d65b /var/log/cinder/*.log
```

Shared File Systems Service

Similar to Block Storage, the Shared File System is a persistent storage, called share, that can be used in multi-tenant environments. Users create and mount a share as a remote file system on any machine that allows mounting shares, and has network access to share exporter. This share can then be used for storing, sharing, and exchanging files. The default configuration of the Shared File Systems service depends on the back-end driver the admin chooses when starting the Shared File Systems service. For more information about existing back-end drivers, see Share Backends of Shared File Systems service Developer Guide. For example, in case of OpenStack Block Storage based back-end is used, the Shared File Systems service cares about everything, including VMs, networking, keypairs, and security groups. Other configurations require more detailed knowledge of shares functionality to set up and tune specific parameters and modes of shares functioning.

Shares are a remote mountable file system, so users can mount a share to multiple hosts, and have it accessed from multiple hosts by multiple users at a time. With the Shared File Systems service, you can perform a large number of operations with shares:

- Create, update, delete, and force-delete shares
- Change access rules for shares, reset share state
- Specify quotas for existing users or tenants
- Create share networks
- Define new share types
- Perform operations with share snapshots: create, change name, create a share from a snapshot, delete
- Operate with consistency groups
- Use security services

For more information on share management see Share management of chapter "Shared File Systems" in OpenStack Administrator Guide. As to Security services, you should remember that different drivers support different authentication methods, while generic driver does not support Security Services at all (see section Security services of chapter "Shared File Systems" in OpenStack Administrator Guide).

You can create a share in a network, list shares, and show information for, update, and delete a specified share. You can also create snapshots of shares (see Share snapshots of chapter "Shared File Systems" in OpenStack Administrator Guide).

There are default and specific share types that allow you to filter or choose back-ends before you create a share. Functions and behaviour of share type is similar to Block Storage volume type (see Share types of chapter "Shared File Systems" in OpenStack Administrator Guide).

To help users keep and restore their data, Shared File Systems service provides a mechanism to create and operate snapshots (see Share snapshots of chapter "Shared File Systems" in OpenStack Administrator Guide).

A security service stores configuration information for clients for authentication and authorization. Inside Manila a share network can be associated with up to three security types (for detailed information see Security services of chapter "Shared File Systems" in OpenStack Administrator Guide):

- LDAP
- Kerberos
- Microsoft Active Directory

Shared File Systems service differs from the principles implemented in Block Storage. Shared File Systems service can work in two modes:

- Without interaction with share networks, in so called "no share servers" mode.
- Interacting with share networks.

Networking service is used by the Shared File Systems service to directly operate with share servers. For switching interaction with Networking service on, create a share specifying a share network. To use "share servers" mode even being out of OpenStack, a network plugin called StandaloneNetworkPlugin is used. In this case, provide network information in the configuration: IP range, network type, and segmentation ID. Also you can add security services to a share network (see section "Networking" of chapter "Shared File Systems" in OpenStack Administrator Guide).

The main idea of consistency groups is to enable you to create snapshots at the exact same point in time from multiple file system shares. Those snapshots can be then used for restoring all shares that were associated with the consistency group (see section "Consistency groups" of chapter "Shared File Systems" in OpenStack Administrator Guide).

Shared File System storage allows administrators to set limits and quotas for specific tenants and users. Limits are the resource limitations that are allowed for each tenant or user. Limits consist of:

- Rate limits
- Absolute limits

Rate limits control the frequency at which users can issue specific API requests. Rate limits are configured by administrators in a config file. Also, administrator can specify quotas also known as max values of absolute limits per tenant. Whereas users can see only the amount of their consumed resources. Administrator can specify rate limits or quotas for the following resources:

- Max amount of space available for all shares
- Max number of shares
- Max number of shared networks
- Max number of share snapshots
- Max total amount of all snapshots
- Type and number of API calls that can be made in a specific time interval

User can see his rate limits and absolute limits by running commands **`manila rate-limits`** and **`manila absolute-limits`** respectively. For more details on limits and quotas see Quotas and limits of "Share management" section of OpenStack Administrator Guide document.

This section lists several of the most important Use Cases that demonstrate the main functions and abilities of Shared File Systems service:

- Create share
- Operating with a share
- Manage access to shares
- Create snapshots
- Create a share network
- Manage a share network

Note: Shared File Systems service cannot warn you beforehand if it is safe to write a specific large amount of data onto a certain share or to remove a consistency group if it has a number of shares assigned to it. In such a potentially erroneous situations, if a mistake happens, you can expect some error message or even failing of shares or consistency groups into an incorrect status. You can also expect some level of system corruption if a user tries to unmount an unmanaged share while a process is using it for data transfer.

Create Share

In this section, we examine the process of creating a simple share. It consists of several steps:

- Check if there is an appropriate share type defined in the Shared File Systems service
- If such a share type does not exist, an Admin should create it using **`manila type-create`** command before other users are able to use it
- Using a share network is optional. However if you need one, check if there is an appropriate network defined in Shared File Systems service by using **`manila share-network-list`** command. For the information on creating a share network, see *Create a Share Network* below in this chapter.
- Create a public share using **`manila create`**.
- Make sure that the share has been created successfully and is ready to use (check the share status and see the share export location)

Below is the same whole procedure described step by step and in more detail.

Note: Before you start, make sure that Shared File Systems service is installed on your OpenStack cluster and is ready to use.

By default, there are no share types defined in Shared File Systems service, so you can check if a required one has been already created:

```
$ manila type-list
+------+--------+-----------+-----------+----------------------------------+----------------
↪------+
| ID   | Name   | Visibility| is_default| required_extra_specs             | optional_extra_
↪specs |
+------+--------+-----------+-----------+----------------------------------+----------------
↪------+
| c0...| default| public    | YES       | driver_handles_share_servers:True| snapshot_
↪support:True|
+------+--------+-----------+-----------+----------------------------------+----------------
↪------+
```

If the share types list is empty or does not contain a type you need, create the required share type using this command:

```
$ manila type-create netapp1 False --is_public True
```

This command will create a public share with the following parameters: `name = netapp1`, `spec_driver_handles_share_servers = False`

You can now create a public share with my_share_net network, default share type, NFS shared file systems protocol, and 1 GB size:

```
$ manila create nfs 1 --name "Share1" --description "My first share" \
  --share-type default --share-network my_share_net --metadata aim=testing --public
+-----------------------------+--------------------------------------+
| Property                    | Value                                |
+-----------------------------+--------------------------------------+
| status                      | creating                             |
| share_type_name             | default                              |
| description                 | My first share                       |
| availability_zone           | None                                 |
| share_network_id            | 9c187d23-7e1d-4d91-92d0-77ea4b9b9496 |
| share_server_id             | None                                 |
| host                        |                                      |
| access_rules_status         | active                               |
| snapshot_id                 | None                                 |
| is_public                   | True                                 |
| task_state                  | None                                 |
| snapshot_support            | True                                 |
| id                          | edd82179-587e-4a87-9601-f34b2ca47e5b |
| size                        | 1                                    |
| name                        | Share1                               |
| share_type                  | e031d5e9-f113-491a-843f-607128a5c649 |
| has_replicas                | False                                |
| replication_type            | None                                 |
| created_at                  | 2016-03-20T00:00:00.000000           |
| share_proto                 | NFS                                  |
| consistency_group_id        | None                                 |
| source_cgsnapshot_member_id | None                                 |
| project_id                  | e81908b1bfe8468abb4791eae0ef6dd9     |
| metadata                    | {u'aim': u'testing'}                 |
+-----------------------------+--------------------------------------+
```

To confirm that creation has been successful, see the share in the share list:

```
$ manila list
+----+-------+-----+------------+-----------+-------------------------------+---------------
↪-------+
| ID | Name  | Size| Share Proto| Share Type| Export location               | Host          
↪       |
+----+-------+-----+------------+-----------+-------------------------------+---------------
↪-------+
| a..| Share1| 1   | NFS        | c0086...  | 10.254.0.3:/shares/share-2d5..|
↪manila@generic1#GEN..|
+----+-------+-----+------------+-----------+-------------------------------+---------------
↪-------+
```

Check the share status and see the share export location. After creation, the share status should become `available`:

```
$ manila show Share1
+-----------------------------+-----------------------------------------------------------
↪---------+
| Property                    | Value                                                     
↪         |
+-----------------------------+-----------------------------------------------------------
↪---------+
| status                      | available                                                 
↪         |
| share_type_name             | default                                                   
↪         |
| description                 | My first share                                            
↪         |
| availability_zone           | nova                                                      
↪         |
| share_network_id            | 9c187d23-7e1d-4d91-92d0-77ea4b9b9496                      
↪         |
| export_locations            |                                                           
↪         |
|                             | path = 10.254.0.3:/shares/share-18cb05be-eb69-4cb2-810f-
↪91c75ef30f90 |
|                             | preferred = False                                         
↪         |
|                             | is_admin_only = False                                     
↪         |
|                             | id = d6a82c0d-36b0-438b-bf34-63f3932ddf4e                 
↪         |
|                             | share_instance_id = 18cb05be-eb69-4cb2-810f-91c75ef30f90  
↪         |
|                             | path = 10.0.0.3:/shares/share-18cb05be-eb69-4cb2-810f-
↪91c75ef30f90   |
|                             | preferred = False                                         
↪         |
|                             | is_admin_only = True                                      
↪         |
|                             | id = 51672666-06b8-4741-99ea-64f2286f52e2                 
↪         |
|                             | share_instance_id = 18cb05be-eb69-4cb2-810f-91c75ef30f90  
↪         |
| share_server_id             | ea8b3a93-ab41-475e-9df1-0f7d49b8fa54                      
↪         |
| host                        | manila@generic1#GENERIC1                                  
↪         |
| access_rules_status         | active                                                    
↪         |
| snapshot_id                 | None                                                      
↪         |
| is_public                   | True                                                      
↪         |
| task_state                  | None                                                      
↪         |
| snapshot_support            | True                                                      
↪         |
| id                          | e7364bcc-3821-49bf-82d6-0c9f0276d4ce                      
↪         |
| size                        | 1                                                         
↪         |
```

```
| name                        | Share1                                                    
↪         |
| share_type                  | e031d5e9-f113-491a-843f-607128a5c649                      
↪         |
| has_replicas                | False                                                     
↪         |
| replication_type            | None                                                      
↪         |
| created_at                  | 2016-03-20T00:00:00.000000                                
↪         |
| share_proto                 | NFS                                                       
↪         |
| consistency_group_id        | None                                                      
↪         |
| source_cgsnapshot_member_id | None                                                      
↪         |
| project_id                  | e81908b1bfe8468abb4791eae0ef6dd9                          
↪         |
| metadata                    | {u'aim': u'testing'}                                      
↪         |
+-----------------------------+-----------------------------------------------------------
↪---------+
```

The value `is_public` defines the level of visibility for the share: whether other tenants can or cannot see the share. By default, the share is private. Now you can mount the created share like a remote file system and use it for your purposes.

Note: See Share Management of "Shared File Systems" section of OpenStack Administrator Guide document for the details on share management operations.

Manage Access To Shares

Currently, you have a share and would like to control access to this share for other users. For this, you have to perform a number of steps and operations. Before getting to manage access to the share, pay attention to the following important parameters. To grant or deny access to a share, specify one of these supported share access levels:

- `rw`: read and write (RW) access. This is the default value.
- `ro:` read-only (RO) access.

Additionally, you should also specify one of these supported authentication methods:

- `ip`: authenticates an instance through its IP address. A valid format is XX.XX.XX.XX orXX.XX.XX.XX/XX. For example 0.0.0.0/0.
- `cert`: authenticates an instance through a TLS certificate. Specify the TLS identity as the IDENTKEY. A valid value is any string up to 64 characters long in the common name (CN) of the certificate. The meaning of a string depends on its interpretation.
- `user`: authenticates by a specified user or group name. A valid value is an alphanumeric string that can contain some special characters and is from 4 to 32 characters long.

Note: Do not mount a share without an access rule! This can lead to an exception.

Allow access to the share with IP access type and 10.254.0.4 IP address:

```
$ manila access-allow Share1 ip 10.254.0.4 --access-level rw
+--------------+--------------------------------------+
| Property     | Value                                |
+--------------+--------------------------------------+
| share_id     | 7bcd888b-681b-4836-ac9c-c3add4e62537 |
| access_type  | ip                                   |
| access_to    | 10.254.0.4                           |
| access_level | rw                                   |
| state        | new                                  |
| id           | de715226-da00-4cfc-b1ab-c11f3393745e |
+--------------+--------------------------------------+
```

Mount the Share:

```
$ sudo mount -v -t nfs 10.254.0.5:/shares/share-5789ddcf-35c9-4b64-a28a-7f6a4a574b6a /mnt/
```

Then check if the share mounted successfully and according to the specified access rules:

```
$ manila access-list Share1
+--------------------------------------+-------------+------------+--------------+--------+
| id                                   | access type | access to  | access level | state  |
+--------------------------------------+-------------+------------+--------------+--------+
| 4f391c6b-fb4f-47f5-8b4b-88c5ec9d568a | user        | demo       | rw           | error  |
| de715226-da00-4cfc-b1ab-c11f3393745e | ip          | 10.254.0.4 | rw           | active |
+--------------------------------------+-------------+------------+--------------+--------+
```

Note: Different share features are supported by different share drivers. In these examples there was used generic (Cinder as a back-end) driver that does not support `user` and `cert` authentication methods.

Tip: For the details of features supported by different drivers see Manila share features support mapping of Manila Developer Guide document.

Manage Shares

There are several other useful operations you would perform when working with shares.

Update Share

To change the name of a share, or update its description, or level of visibility for other tenants, use this command:

```
$ manila update Share1 --description "My first share. Updated" --is-public False
```

Check the attributes of the updated Share1:

```
$ manila show Share1
+-----------------------------+-----------------------------------------------------------
↪---------+
| Property                    | Value                                                     
↪         |
+-----------------------------+-----------------------------------------------------------
↪---------+
| status                      | available                                                 
↪         |
| share_type_name             | default                                                   
↪         |
| description                 | My first share. Updated                                   
↪         |
| availability_zone           | nova                                                      
↪         |
| share_network_id            | 9c187d23-7e1d-4d91-92d0-77ea4b9b9496                      
↪         |
| export_locations            |                                                           
↪         |
|                             | path = 10.254.0.3:/shares/share-18cb05be-eb69-4cb2-810f-
↪91c75ef30f90 |
|                             | preferred = False                                         
↪         |
|                             | is_admin_only = False                                     
↪         |
|                             | id = d6a82c0d-36b0-438b-bf34-63f3932ddf4e                 
↪         |
|                             | share_instance_id = 18cb05be-eb69-4cb2-810f-91c75ef30f90  
↪         |
|                             | path = 10.0.0.3:/shares/share-18cb05be-eb69-4cb2-810f-
↪91c75ef30f90   |
|                             | preferred = False                                         
↪         |
|                             | is_admin_only = True                                      
↪         |
|                             | id = 51672666-06b8-4741-99ea-64f2286f52e2                 
↪         |
|                             | share_instance_id = 18cb05be-eb69-4cb2-810f-91c75ef30f90  
↪         |
| share_server_id             | ea8b3a93-ab41-475e-9df1-0f7d49b8fa54                      
↪         |
| host                        | manila@generic1#GENERIC1                                  
↪         |
| access_rules_status         | active                                                    
↪         |
| snapshot_id                 | None                                                      
↪         |
| is_public                   | False                                                     
↪         |
| task_state                  | None                                                      
↪         |
| snapshot_support            | True                                                      
↪         |
| id                          | e7364bcc-3821-49bf-82d6-0c9f0276d4ce                      
↪         |
| size                        | 1                                                         
↪         |
```

```
| name                         | Share1                                          
↪           |
| share_type                   | e031d5e9-f113-491a-843f-607128a5c649            
↪           |
| has_replicas                 | False                                           
↪           |
| replication_type             | None                                            
↪           |
| created_at                   | 2016-03-20T00:00:00.000000                      
↪           |
| share_proto                  | NFS                                             
↪           |
| consistency_group_id         | None                                            
↪           |
| source_cgsnapshot_member_id  | None                                            
↪           |
| project_id                   | e81908b1bfe8468abb4791eae0ef6dd9                
↪           |
| metadata                     | {u'aim': u'testing'}                            
↪           |
+------------------------------+-------------------------------------------------------------
↪---------+
```

Reset Share State

Sometimes a share may appear and then hang in an erroneous or a transitional state. Unprivileged users do not have the appropriate access rights to correct this situation. However, having cloud administrator's permissions, you can reset the share's state by using

```
$ manila reset-state [-state state] share_name
```

command to reset share state, where state indicates which state to assign the share to. Options include: `available, error, creating, deleting, error_deleting` states.

After running

```
$ manila reset-state Share2 --state deleting
```

check the share's status:

```
$ manila show Share2
+------------------------------+-------------------------------------------+
| Property                     | Value                                     |
+------------------------------+-------------------------------------------+
| status                       | deleting                                  |
| share_type_name              | default                                   |
| description                  | share from a snapshot.                    |
| availability_zone            | nova                                      |
| share_network_id             | 5c3cbabb-f4da-465f-bc7f-fadbe047b85a      |
| export_locations             | []                                        |
| share_server_id              | 41b7829d-7f6b-4c96-aea5-d106c2959961      |
| host                         | manila@generic1#GENERIC1                  |
| snapshot_id                  | 962e8126-35c3-47bb-8c00-f0ee37f42ddd      |
| is_public                    | False                                     |
| task_state                   | None                                      |
```

```
| snapshot_support            | True                                     |
| id                          | b6b0617c-ea51-4450-848e-e7cff69238c7     |
| size                        | 1                                        |
| name                        | Share2                                   |
| share_type                  | c0086582-30a6-4060-b096-a42ec9d66b86     |
| created_at                  | 2015-09-25T06:25:50.000000               |
| export_location             | 10.254.0.3:/shares/share-1dc2a471-3d47-...|
| share_proto                 | NFS                                      |
| consistency_group_id        | None                                     |
| source_cgsnapshot_member_id | None                                     |
| project_id                  | 20787a7ba11946adad976463b57d8a2f         |
| metadata                    | {u'source': u'snapshot'}                 |
+-----------------------------+------------------------------------------+
```

Delete Share

If you do not need a share any more, you can delete it using **manila delete share_name_or_ID** command like:

```
$ manila delete Share2
```

Note: If you specified the consistency group while creating a share, you should provide the –consistency-group parameter to delete the share:

```
$ manila delete ba52454e-2ea3-47fa-a683-3176a01295e6 --consistency-group \
  ffee08d9-c86c-45e5-861e-175c731daca2
```

Sometimes it appears that a share hangs in one of transitional states (i.e. `creating, deleting, managing, unmanaging, extending, and shrinking`). In that case, to delete it, you need **manila force-delete share_name_or_ID** command and administrative permissions to run it:

```
$ manila force-delete b6b0617c-ea51-4450-848e-e7cff69238c7
```

Tip: For more details and additional information about other cases, features, API commands etc, see Share Management of "Shared File Systems" section of OpenStack Administrator Guide document.

Create Snapshots

The Shared File Systems service provides a mechanism of snapshots to help users to restore their own data. To create a snapshot, use **manila snapshot-create** command like:

```
$ manila snapshot-create Share1 --name Snapshot1 --description "Snapshot of Share1"
+-------------------+--------------------------------------+
| Property          | Value                                |
+-------------------+--------------------------------------+
| status            | creating                             |
| share_id          | e7364bcc-3821-49bf-82d6-0c9f0276d4ce |
| description       | Snapshot of Share1                   |
| created_at        | 2016-03-20T00:00:00.000000           |
```

```
| share_proto       | NFS                                  |
| provider_location | None                                 |
| id                | a96cf025-92d1-4012-abdd-bb0f29e5aa8f |
| size              | 1                                    |
| share_size        | 1                                    |
| name              | Snapshot1                            |
+-------------------+--------------------------------------+
```

Then, if needed, update the name and description of the created snapshot:

```
$ manila snapshot-rename Snapshot1 Snapshot_1 --description "Snapshot of Share1. Updated."
```

To make sure that the snapshot is available, run:

```
$ manila snapshot-show Snapshot1
+-------------------+--------------------------------------+
| Property          | Value                                |
+-------------------+--------------------------------------+
| status            | available                            |
| share_id          | e7364bcc-3821-49bf-82d6-0c9f0276d4ce |
| description       | Snapshot of Share1                   |
| created_at        | 2016-03-30T10:53:19.000000           |
| share_proto       | NFS                                  |
| provider_location | 3ca7a3b2-9f9f-46af-906f-6a565bf8ee37 |
| id                | a96cf025-92d1-4012-abdd-bb0f29e5aa8f |
| size              | 1                                    |
| share_size        | 1                                    |
| name              | Snapshot1                            |
+-------------------+--------------------------------------+
```

Tip: For more details and additional information on snapshots, see Share Snapshots of "Shared File Systems" section of "OpenStack Administrator Guide" document.

Create a Share Network

To control a share network, Shared File Systems service requires interaction with Networking service to manage share servers on its own. If the selected driver runs in a mode that requires such kind of interaction, you need to specify the share network when a share is created. For the information on share creation, see *Create Share* earlier in this chapter. Initially, check the existing share networks type list by:

```
$ manila share-network-list
+--------------------------------------+--------------+
| id                                   | name         |
+--------------------------------------+--------------+
+--------------------------------------+--------------+
```

If share network list is empty or does not contain a required network, just create, for example, a share network with a private network and subnetwork.

```
$ manila share-network-create --neutron-net-id 5ed5a854-21dc-4ed3-870a-117b7064eb21 \
  --neutron-subnet-id 74dcfb5a-b4d7-4855-86f5-a669729428dc --name my_share_net \
  --description "My first share network"
+-------------------+--------------------------------------+
```

```
| Property          | Value                                |
+-------------------+--------------------------------------+
| name              | my_share_net                         |
| segmentation_id   | None                                 |
| created_at        | 2015-09-24T12:06:32.602174           |
| neutron_subnet_id | 74dcfb5a-b4d7-4855-86f5-a669729428dc |
| updated_at        | None                                 |
| network_type      | None                                 |
| neutron_net_id    | 5ed5a854-21dc-4ed3-870a-117b7064eb21 |
| ip_version        | None                                 |
| nova_net_id       | None                                 |
| cidr              | None                                 |
| project_id        | 20787a7ba11946adad976463b57d8a2f     |
| id                | 5c3cbabb-f4da-465f-bc7f-fadbe047b85a |
| description       | My first share network               |
+-------------------+--------------------------------------+
```

The `segmentation_id`, `cidr`, `ip_version`, and `network_type` share network attributes are automatically set to the values determined by the network provider.

Then check if the network became created by requesting the networks list once again:

```
$ manila share-network-list
+--------------------------------------+--------------+
| id                                   | name         |
+--------------------------------------+--------------+
| 5c3cbabb-f4da-465f-bc7f-fadbe047b85a | my_share_net |
+--------------------------------------+--------------+
```

Finally, to create a share that uses this share network, get to Create Share use case described earlier in this chapter.

Tip: See Share Networks of "Shared File Systems" section of OpenStack Administrator Guide document for more details.

Manage a Share Network

There is a pair of useful commands that help manipulate share networks. To start, check the network list:

```
$ manila share-network-list
+--------------------------------------+--------------+
| id                                   | name         |
+--------------------------------------+--------------+
| 5c3cbabb-f4da-465f-bc7f-fadbe047b85a | my_share_net |
+--------------------------------------+--------------+
```

If you configured the back-end with `driver_handles_share_servers = True` (with the share servers) and had already some operations in the Shared File Systems service, you can see `manila_service_network` in the neutron list of networks. This network was created by the share driver for internal usage.

```
$ openstack network list
+--------------+------------------------+------------------------------------+
| ID           | Name                   | Subnets                            |
```

```
+--------------+-----------------------+----------------------------------+
| 3b5a629a-e...| manila_service_network | 4f366100-50... 10.254.0.0/28      |
| bee7411d-d...| public                 | 884a6564-01... 2001:db8::/64      |
|              |                        | e6da81fa-55... 172.24.4.0/24      |
| 5ed5a854-2...| private                | 74dcfb5a-bd... 10.0.0.0/24        |
|              |                        | cc297be2-51... fd7d:177d:a48b::/64 |
+--------------+-----------------------+----------------------------------+
```

You also can see detailed information about the share network including `network_type, segmentation_id` fields:

```
$ openstack network show manila_service_network
+---------------------------+--------------------------------------+
| Field                     | Value                                |
+---------------------------+--------------------------------------+
| admin_state_up            | True                                 |
| availability_zone_hints   |                                      |
| availability_zones        | nova                                 |
| created_at                | 2016-03-20T00:00:00                  |
| description               |                                      |
| id                        | ef5282ab-dbf9-4d47-91d4-b0cc9b164567 |
| ipv4_address_scope        |                                      |
| ipv6_address_scope        |                                      |
| mtu                       | 1450                                 |
| name                      | manila_service_network               |
| port_security_enabled     | True                                 |
| provider:network_type     | vxlan                                |
| provider:physical_network |                                      |
| provider:segmentation_id  | 1047                                 |
| router:external           | False                                |
| shared                    | False                                |
| status                    | ACTIVE                               |
| subnets                   | aba49c7d-c7eb-44b9-9c8f-f6112b05a2e0 |
| tags                      |                                      |
| tenant_id                 | f121b3ee03804266af2959e56671b24a     |
| updated_at                | 2016-03-20T00:00:00                  |
+---------------------------+--------------------------------------+
```

You also can add and remove the security services to the share network.

Tip: For details, see subsection Security Services of "Shared File Systems" section of OpenStack Administrator Guide document.

Instances

Instances are the running virtual machines within an OpenStack cloud. This section deals with how to work with them and their underlying images, their network properties, and how they are represented in the database.

Starting Instances

To launch an instance, you need to select an image, a flavor, and a name. The name needn't be unique, but your life will be simpler if it is because many tools will use the name in place of the UUID so long as the name is unique. You can start an instance from the dashboard from the *Launch Instance* button on the *Instances* page or by selecting the *Launch* action next to an image or a snapshot on the *Images* page.

On the command line, do this:

```
$ openstack server create --flavor FLAVOR --image IMAGE_NAME_OR_ID
```

There are a number of optional items that can be specified. You should read the rest of this section before trying to start an instance, but this is the base command that later details are layered upon.

To delete instances from the dashboard, select the *Delete Instance* action next to the instance on the *Instances* page.

Note: In releases prior to Mitaka, select the equivalent *Terminate instance* action.

From the command line, do this:

```
$ openstack server delete INSTANCE_ID
```

It is important to note that powering off an instance does not terminate it in the OpenStack sense.

Instance Boot Failures

If an instance fails to start and immediately moves to an error state, there are a few different ways to track down what has gone wrong. Some of these can be done with normal user access, while others require access to your log server or compute nodes.

The simplest reasons for nodes to fail to launch are quota violations or the scheduler being unable to find a suitable compute node on which to run the instance. In these cases, the error is apparent when you run a **`openstack server show`** on the faulted instance:

```
$ openstack server show test-instance
+--------------------------------------+----------------------------------------------
↪--------------------------------------------------------------------------------------+
| Field                                | Value
↪                                                                                      |
+--------------------------------------+----------------------------------------------
↪--------------------------------------------------------------------------------------+
| OS-DCF:diskConfig                    | AUTO
↪                                                                                      |
| OS-EXT-AZ:availability_zone          | nova
↪                                                                                      |
| OS-EXT-SRV-ATTR:host                 | None
↪                                                                                      |
| OS-EXT-SRV-ATTR:hypervisor_hostname  | None
↪                                                                                      |
| OS-EXT-SRV-ATTR:instance_name        | instance-0000000a
↪                                                                                      |
| OS-EXT-STS:power_state               | NOSTATE
↪                                                                                      |
| OS-EXT-STS:task_state                | None
↪                                                                                      |
| OS-EXT-STS:vm_state                  | error
↪                                                                                      |
| OS-SRV-USG:launched_at               | None
↪                                                                                      |
```

```
| OS-SRV-USG:terminated_at             | None                                          
↪                                                                                    |
| accessIPv4                           |                                               
↪                                                                                    |
| accessIPv6                           |                                               
↪                                                                                    |
| addresses                            |                                               
↪                                                                                    |
| config_drive                         |                                               
↪                                                                                    |
| created                              | 2016-11-23T07:51:53Z                          
↪                                                                                    |
| fault                                | {u'message': u'Build of instance 6ec42311-a121-
↪4887-aece-48fb93a4a098 aborted: Failed to allocate the network(s), not rescheduling.', |
|                                      | u'code': 500, u'details': u'  File "/usr/lib/
↪python2.7/site-packages/nova/compute/manager.py", line 1779, in                       |
|                                      | _do_build_and_run_instance\n    filter_
↪properties)\n  File "/usr/lib/python2.7/site-packages/nova/compute/manager.py", line 1960,
↪ in  |
|                                      | _build_and_run_instance\n    reason=msg)\n', u
↪'created': u'2016-11-23T07:57:04Z'}                                                     |
| flavor                               | m1.tiny (1)                                   
↪                                                                                    |
| hostId                               |                                               
↪                                                                                    |
| id                                   | 6ec42311-a121-4887-aece-48fb93a4a098          
↪                                                                                    |
| image                                | cirros (9fef3b2d-c35d-4b61-bea8-09cc6dc41829) 
↪                                                                                    |
| key_name                             | None                                          
↪                                                                                    |
| name                                 | test-instance                                 
↪                                                                                    |
| os-extended-volumes:volumes_attached | []                                            
↪                                                                                    |
| project_id                           | 5669caad86a04256994cdf755df4d3c1              
↪                                                                                    |
| properties                           |                                               
↪                                                                                    |
| status                               | ERROR                                         
↪                                                                                    |
| updated                              | 2016-11-23T07:57:04Z                          
↪                                                                                    |
| user_id                              | c36cec73b0e44876a4478b1e6cd749bb              
↪                                                                                    |
+--------------------------------------+-----------------------------------------------
↪------------------------------------------------------------------------------------+
```

In this case, looking at the `fault` message shows `NoValidHost`, indicating that the scheduler was unable to match the instance requirements.

If **`openstack server show`** does not sufficiently explain the failure, searching for the instance UUID in the `nova-compute.log` on the compute node it was scheduled on or the `nova-scheduler.log` on your scheduler hosts is a good place to start looking for lower-level problems.

Using **`openstack server show`** as an admin user will show the compute node the instance was scheduled on as `hostId`. If the instance failed during scheduling, this field is blank.

Using Instance-Specific Data

There are two main types of instance-specific data: metadata and user data.

Instance metadata

For Compute, instance metadata is a collection of key-value pairs associated with an instance. Compute reads and writes to these key-value pairs any time during the instance lifetime, from inside and outside the instance, when the end user uses the Compute API to do so. However, you cannot query the instance-associated key-value pairs with the metadata service that is compatible with the Amazon EC2 metadata service.

For an example of instance metadata, users can generate and register SSH keys using the **openstack keypair create** command:

```
$ openstack keypair create mykey > mykey.pem
```

This creates a key named `mykey`, which you can associate with instances. The file `mykey.pem` is the private key, which should be saved to a secure location because it allows root access to instances the `mykey` key is associated with.

Use this command to register an existing key with OpenStack:

```
$ openstack keypair create --public-key mykey.pub mykey
```

Note: You must have the matching private key to access instances associated with this key.

To associate a key with an instance on boot, add `--key-name mykey` to your command line. For example:

```
$ openstack server create --image ubuntu-cloudimage --flavor 2 \
  --key-name mykey myimage
```

When booting a server, you can also add arbitrary metadata so that you can more easily identify it among other running instances. Use the `--property` option with a key-value pair, where you can make up the string for both the key and the value. For example, you could add a description and also the creator of the server:

```
$ openstack server create --image=test-image --flavor=1 \
  --property description='Small test image' smallimage
```

When viewing the server information, you can see the metadata included on the metadata line:

```
$ openstack server show smallimage

+--------------------------------------+-------------------------------------------------
↪------+
| Field                                | Value                                           
↪      |
+--------------------------------------+-------------------------------------------------
↪------+
| OS-DCF:diskConfig                    | MANUAL                                          
↪      |
| OS-EXT-AZ:availability_zone          | nova                                            
↪      |
| OS-EXT-SRV-ATTR:host                 | rdo-newton.novalocal                            
↪      |
```

```
| OS-EXT-SRV-ATTR:hypervisor_hostname  | rdo-newton.novalocal                            
↪       |
| OS-EXT-SRV-ATTR:instance_name        | instance-00000002                               
↪       |
| OS-EXT-STS:power_state               | Running                                         
↪       |
| OS-EXT-STS:task_state                | None                                            
↪       |
| OS-EXT-STS:vm_state                  | active                                          
↪       |
| OS-SRV-USG:launched_at               | 2016-12-07T11:20:08.000000                      
↪       |
| OS-SRV-USG:terminated_at             | None                                            
↪       |
| accessIPv4                           |                                                 
↪       |
| accessIPv6                           |                                                 
↪       |
| addresses                            | public=172.24.4.227                             
↪       |
| config_drive                         |                                                 
↪       |
| created                              | 2016-12-07T11:17:44Z                            
↪       |
| flavor                               | m1.tiny (1)                                     
↪       |
| hostId                               |
↪aca973d5b7981faaf8c713a0130713bbc1e64151be65c8dfb53039f7 |
| id                                   | 4f7c6b2c-f27e-4ccd-a606-6bfc9d7c0d91            
↪       |
| image                                | cirros (01bcb649-45d7-4e3d-8a58-1fcc87816907)   
↪       |
| key_name                             | None                                            
↪       |
| name                                 | smallimage                                      
↪       |
| os-extended-volumes:volumes_attached | []                                              
↪       |
| progress                             | 0                                               
↪       |
| project_id                           | 2daf82a578e9437cab396c888ff0ca57                
↪       |
| properties                           | description='Small test image'                  
↪       |
| security_groups                      | [{u'name': u'default'}]                         
↪       |
| status                               | ACTIVE                                          
↪       |
| updated                              | 2016-12-07T11:20:08Z                            
↪       |
| user_id                              | 8cbea24666ae49bbb8c1641f9b12d2d2                
↪       |
+--------------------------------------+-------------------------------------------------
↪------+
```

Instance user data

The `user-data` key is a special key in the metadata service that holds a file that cloud-aware applications within the guest instance can access. For example, cloudinit is an open source package from Ubuntu, but available in most distributions, that handles early initialization of a cloud instance that makes use of this user data.

This user data can be put in a file on your local system and then passed in at instance creation with the flag `--user-data <user-data-file>`.

For example

```
$ openstack server create --image ubuntu-cloudimage --flavor 1 \
  --user-data mydata.file mydatainstance
```

To understand the difference between user data and metadata, realize that user data is created before an instance is started. User data is accessible from within the instance when it is running. User data can be used to store configuration, a script, or anything the tenant wants.

File injection

Arbitrary local files can also be placed into the instance file system at creation time by using the `--file <dst-path=src-path>` option. You may store up to five files.

For example, let's say you have a special `authorized_keys` file named special_authorized_keysfile that for some reason you want to put on the instance instead of using the regular SSH key injection. In this case, you can use the following command:

```
$ openstack server create --image ubuntu-cloudimage --flavor 1  \
  --file /root/.ssh/authorized_keys=special_authorized_keysfile \
  authkeyinstance
```

Associating Security Groups

Security groups, as discussed earlier, are typically required to allow network traffic to an instance, unless the default security group for a project has been modified to be more permissive.

Adding security groups is typically done on instance boot. When launching from the dashboard, you do this on the *Access & Security* tab of the *Launch Instance* dialog. When launching from the command line, append `--security-groups` with a comma-separated list of security groups.

It is also possible to add and remove security groups when an instance is running. Currently this is only available through the command-line tools. Here is an example:

```
$ openstack server add security group SERVER SECURITY_GROUP_NAME_OR_ID
```

```
$ openstack server remove security group SERVER SECURITY_GROUP_NAME_OR_ID
```

Floating IPs

Where floating IPs are configured in a deployment, each project will have a limited number of floating IPs controlled by a quota. However, these need to be allocated to the project from the central pool prior to their use—usually by the administrator of the project. To allocate a floating IP to a project, use the *Allocate IP To*

Project button on the *Floating IPs* tab of the *Access & Security* page of the dashboard. The command line can also be used:

```
$ openstack floating ip create NETWORK_NAME_OR_ID
```

Once allocated, a floating IP can be assigned to running instances from the dashboard either by selecting *Associate* from the actions drop-down next to the IP on the *Floating IPs* tab of the *Access & Security* page or by making this selection next to the instance you want to associate it with on the Instances page. The inverse action, Dissociate Floating IP, is available from the *Floating IPs* tab of the *Access & Security* page and from the *Instances* page.

To associate or disassociate a floating IP with a server from the command line, use the following commands:

```
$ openstack server add floating ip SERVER IP_ADDRESS
```

```
$ openstack server remove floating ip SERVER IP_ADDRESS
```

Attaching Block Storage

You can attach block storage to instances from the dashboard on the *Volumes* page. Click the *Manage Attachments* action next to the volume you want to attach.

To perform this action from command line, run the following command:

```
$ openstack server add volume SERVER VOLUME_NAME_OR_ID --device DEVICE
```

You can also specify block deviceblock device mapping at instance boot time through the nova command-line client with this option set:

```
--block-device-mapping <dev-name=mapping>
```

The block device mapping format is `<dev-name>=<id>:<type>:<size(GB)>:<delete-on-terminate>`, where:

dev-name A device name where the volume is attached in the system at `/dev/dev_name`

id The ID of the volume to boot from, as shown in the output of **`openstack volume list`**

type Either `snap`, which means that the volume was created from a snapshot, or anything other than `snap` (a blank string is valid). In the preceding example, the volume was not created from a snapshot, so we leave this field blank in our following example.

size (GB) The size of the volume in gigabytes. It is safe to leave this blank and have the Compute Service infer the size.

delete-on-terminate A boolean to indicate whether the volume should be deleted when the instance is terminated. True can be specified as `True` or `1`. False can be specified as `False` or `0`.

The following command will boot a new instance and attach a volume at the same time. The volume of ID 13 will be attached as `/dev/vdc`. It is not a snapshot, does not specify a size, and will not be deleted when the instance is terminated:

```
$ openstack server create --image 4042220e-4f5e-4398-9054-39fbd75a5dd7 \
  --flavor 2 --key-name mykey --block-device-mapping vdc=13:::0 \
  boot-with-vol-test
```

If you have previously prepared block storage with a bootable file system image, it is even possible to boot from persistent block storage. The following command boots an image from the specified volume. It is similar to the previous command, but the image is omitted and the volume is now attached as `/dev/vda`:

```
$ openstck server create --flavor 2 --key-name mykey \
  --block-device-mapping vda=13:::0 boot-from-vol-test
```

Read more detailed instructions for launching an instance from a bootable volume in the OpenStack End User Guide.

To boot normally from an image and attach block storage, map to a device other than vda. You can find instructions for launching an instance and attaching a volume to the instance and for copying the image to the attached volume in the OpenStack End User Guide.

Taking Snapshots

The OpenStack snapshot mechanism allows you to create new images from running instances. This is very convenient for upgrading base images or for taking a published image and customizing it for local use. To snapshot a running instance to an image using the CLI, do this:

```
$ openstack image create IMAGE_NAME --volume VOLUME_NAME_OR_ID
```

The dashboard interface for snapshots can be confusing because the snapshots and images are displayed in the *Images* page. However, an instance snapshot *is* an image. The only difference between an image that you upload directly to the Image Service and an image that you create by snapshot is that an image created by snapshot has additional properties in the glance database. These properties are found in the `image_properties` table and include:

Name	Value
`image_type`	snapshot
`instance_uuid`	<uuid of instance that was snapshotted>
`base_image_ref`	<uuid of original image of instance that was snapshotted>
`image_location`	snapshot

Live Snapshots

Live snapshots is a feature that allows users to snapshot the running virtual machines without pausing them. These snapshots are simply disk-only snapshots. Snapshotting an instance can now be performed with no downtime (assuming QEMU 1.3+ and libvirt 1.0+ are used).

Note: If you use libvirt version `1.2.2`, you may experience intermittent problems with live snapshot creation.

To effectively disable the libvirt live snapshotting, until the problem is resolved, add the below setting to nova.conf.

```
[workarounds]
    disable_libvirt_livesnapshot = True
```

Ensuring Snapshots of Linux Guests Are Consistent

The following section is from Sébastien Han's OpenStack: Perform Consistent Snapshots blog entry.

A snapshot captures the state of the file system, but not the state of the memory. Therefore, to ensure your snapshot contains the data that you want, before your snapshot you need to ensure that:

- Running programs have written their contents to disk
- The file system does not have any "dirty" buffers: where programs have issued the command to write to disk, but the operating system has not yet done the write

To ensure that important services have written their contents to disk (such as databases), we recommend that you read the documentation for those applications to determine what commands to issue to have them sync their contents to disk. If you are unsure how to do this, the safest approach is to simply stop these running services normally.

To deal with the "dirty" buffer issue, we recommend using the sync command before snapshotting:

```
# sync
```

Running `sync` writes dirty buffers (buffered blocks that have been modified but not written yet to the disk block) to disk.

Just running `sync` is not enough to ensure that the file system is consistent. We recommend that you use the `fsfreeze` tool, which halts new access to the file system, and create a stable image on disk that is suitable for snapshotting. The `fsfreeze` tool supports several file systems, including ext3, ext4, and XFS. If your virtual machine instance is running on Ubuntu, install the util-linux package to get `fsfreeze`:

Note: In the very common case where the underlying snapshot is done via LVM, the filesystem freeze is automatically handled by LVM.

```
# apt-get install util-linux
```

If your operating system doesn't have a version of `fsfreeze` available, you can use `xfs_freeze` instead, which is available on Ubuntu in the xfsprogs package. Despite the "xfs" in the name, xfs_freeze also works on ext3 and ext4 if you are using a Linux kernel version 2.6.29 or greater, since it works at the virtual file system (VFS) level starting at 2.6.29. The xfs_freeze version supports the same command-line arguments as `fsfreeze`.

Consider the example where you want to take a snapshot of a persistent block storage volume, detected by the guest operating system as `/dev/vdb` and mounted on `/mnt`. The fsfreeze command accepts two arguments:

-f Freeze the system

-u Thaw (unfreeze) the system

To freeze the volume in preparation for snapshotting, you would do the following, as root, inside the instance:

```
# fsfreeze -f /mnt
```

You *must mount the file system* before you run the **fsfreeze** command.

When the **fsfreeze -f** command is issued, all ongoing transactions in the file system are allowed to complete, new write system calls are halted, and other calls that modify the file system are halted. Most importantly, all dirty data, metadata, and log information are written to disk.

Once the volume has been frozen, do not attempt to read from or write to the volume, as these operations hang. The operating system stops every I/O operation and any I/O attempts are delayed until the file system has been unfrozen.

Once you have issued the **fsfreeze** command, it is safe to perform the snapshot. For example, if the volume of your instance was named mon-volume and you wanted to snapshot it to an image named mon-snapshot, you could now run the following:

```
$ openstack image create mon-snapshot --volume mon-volume
```

When the snapshot is done, you can thaw the file system with the following command, as root, inside of the instance:

```
# fsfreeze -u /mnt
```

If you want to back up the root file system, you can't simply run the preceding command because it will freeze the prompt. Instead, run the following one-liner, as root, inside the instance:

```
# fsfreeze -f / && read x; fsfreeze -u /
```

After this command it is common practice to call **openstack image create** from your workstation, and once done press enter in your instance shell to unfreeze it. Obviously you could automate this, but at least it will let you properly synchronize.

Ensuring Snapshots of Windows Guests Are Consistent

Obtaining consistent snapshots of Windows VMs is conceptually similar to obtaining consistent snapshots of Linux VMs, although it requires additional utilities to coordinate with a Windows-only subsystem designed to facilitate consistent backups.

Windows XP and later releases include a Volume Shadow Copy Service (VSS) which provides a framework so that compliant applications can be consistently backed up on a live filesystem. To use this framework, a VSS requestor is run that signals to the VSS service that a consistent backup is needed. The VSS service notifies compliant applications (called VSS writers) to quiesce their data activity. The VSS service then tells the copy provider to create a snapshot. Once the snapshot has been made, the VSS service unfreezes VSS writers and normal I/O activity resumes.

QEMU provides a guest agent that can be run in guests running on KVM hypervisors. This guest agent, on Windows VMs, coordinates with the Windows VSS service to facilitate a workflow which ensures consistent snapshots. This feature requires at least QEMU 1.7. The relevant guest agent commands are:

guest-file-flush Write out "dirty" buffers to disk, similar to the Linux `sync` operation.

guest-fsfreeze Suspend I/O to the disks, similar to the Linux `fsfreeze -f` operation.

guest-fsfreeze-thaw Resume I/O to the disks, similar to the Linux `fsfreeze -u` operation.

To obtain snapshots of a Windows VM these commands can be scripted in sequence: flush the filesystems, freeze the filesystems, snapshot the filesystems, then unfreeze the filesystems. As with scripting similar workflows against Linux VMs, care must be used when writing such a script to ensure error handling is thorough and filesystems will not be left in a frozen state.

Instances in the Database

While instance information is stored in a number of database tables, the table you most likely need to look at in relation to user instances is the instances table.

The instances table carries most of the information related to both running and deleted instances. It has a bewildering array of fields; for an exhaustive list, look at the database. These are the most useful fields for operators looking to form queries:

- The `deleted` field is set to `1` if the instance has been deleted and `NULL` if it has not been deleted. This field is important for excluding deleted instances from your queries.
- The `uuid` field is the UUID of the instance and is used throughout other tables in the database as a foreign key. This ID is also reported in logs, the dashboard, and command-line tools to uniquely identify an instance.
- A collection of foreign keys are available to find relations to the instance. The most useful of these — `user_id` and `project_id` are the UUIDs of the user who launched the instance and the project it was launched in.
- The `host` field tells which compute node is hosting the instance.
- The `hostname` field holds the name of the instance when it is launched. The display-name is initially the same as hostname but can be reset using the nova rename command.

A number of time-related fields are useful for tracking when state changes happened on an instance:

- `created_at`
- `updated_at`
- `deleted_at`
- `scheduled_at`
- `launched_at`
- `terminated_at`

Good Luck!

This section was intended as a brief introduction to some of the most useful of many OpenStack commands. For an exhaustive list, please refer to the OpenStack Administrator Guide. We hope your users remain happy and recognize your hard work! (For more hard work, turn the page to the next chapter, where we discuss the system-facing operations: maintenance, failures and debugging.)

Maintenance, Failures, and Debugging

Cloud Controller and Storage Proxy Failures and Maintenance

The cloud controller and storage proxy are very similar to each other when it comes to expected and unexpected downtime. One of each server type typically runs in the cloud, which makes them very noticeable when they are not running.

For the cloud controller, the good news is if your cloud is using the FlatDHCP multi-host HA network mode, existing instances and volumes continue to operate while the cloud controller is offline. For the storage proxy, however, no storage traffic is possible until it is back up and running.

Planned Maintenance

One way to plan for cloud controller or storage proxy maintenance is to simply do it off-hours, such as at 1 a.m. or 2 a.m. This strategy affects fewer users. If your cloud controller or storage proxy is too important to have unavailable at any point in time, you must look into high-availability options.

Rebooting a Cloud Controller or Storage Proxy

All in all, just issue the **reboot** command. The operating system cleanly shuts down services and then automatically reboots. If you want to be very thorough, run your backup jobs just before you reboot.

After a cloud controller reboots, ensure that all required services were successfully started. The following commands use **ps** and **grep** to determine if nova, glance, and keystone are currently running:

```
# ps aux | grep nova-
# ps aux | grep glance-
# ps aux | grep keystone
# ps aux | grep cinder
```

Also check that all services are functioning. The following set of commands sources the `openrc` file, then runs some basic glance, nova, and openstack commands. If the commands work as expected, you can be confident that those services are in working condition:

```
# . openrc
# openstack image list
# openstack server list
# openstack project list
```

For the storage proxy, ensure that the *Object Storage service* has resumed:

```
# ps aux | grep swift
```

Also check that it is functioning:

```
# swift stat
```

Total Cloud Controller Failure

The cloud controller could completely fail if, for example, its motherboard goes bad. Users will immediately notice the loss of a cloud controller since it provides core functionality to your cloud environment. If your infrastructure monitoring does not alert you that your cloud controller has failed, your users definitely will. Unfortunately, this is a rough situation. The cloud controller is an integral part of your cloud. If you have only one controller, you will have many missing services if it goes down.

To avoid this situation, create a highly available cloud controller cluster. This is outside the scope of this document, but you can read more in the OpenStack High Availability Guide.

The next best approach is to use a configuration-management tool, such as Puppet, to automatically build a cloud controller. This should not take more than 15 minutes if you have a spare server available. After the controller rebuilds, restore any backups taken (see *Backup and Recovery*).

Also, in practice, the `nova-compute` services on the compute nodes do not always reconnect cleanly to rabbitmq hosted on the controller when it comes back up after a long reboot; a restart on the nova services on the compute nodes is required.

Compute Node Failures and Maintenance

Sometimes a compute node either crashes unexpectedly or requires a reboot for maintenance reasons.

Planned Maintenance

If you need to reboot a compute node due to planned maintenance, such as a software or hardware upgrade, perform the following steps:

1. Disable scheduling of new VMs to the node, optionally providing a reason comment:

```
# openstack compute service set --disable --disable-reason \
maintenance c01.example.com nova-compute
```

2. Verify that all hosted instances have been moved off the node:

   - If your cloud is using a shared storage:

     (a) Get a list of instances that need to be moved:

     ```
     # openstack server list --host c01.example.com --all-projects
     ```

     (b) Migrate all instances one by one:

     ```
     # openstack server migrate <uuid> --live c02.example.com
     ```

   - If your cloud is not using a shared storage, run:

     ```
     # openstack server migrate <uuid> --live --block-migration c02.example.com
     ```

3. Stop the `nova-compute` service:

```
# stop nova-compute
```

If you use a configuration-management system, such as Puppet, that ensures the `nova-compute` service is always running, you can temporarily move the `init` files:

```
# mkdir /root/tmp
# mv /etc/init/nova-compute.conf /root/tmp
# mv /etc/init.d/nova-compute /root/tmp
```

4. Shut down your compute node, perform the maintenance, and turn the node back on.

5. Start the `nova-compute` service:

```
# start nova-compute
```

You can re-enable the `nova-compute` service by undoing the commands:

```
# mv /root/tmp/nova-compute.conf /etc/init
# mv /root/tmp/nova-compute /etc/init.d/
```

6. Enable scheduling of VMs to the node:

```
# openstack compute service set --enable c01.example.com nova-compute
```

7. Optionally, migrate the instances back to their original compute node.

After a Compute Node Reboots

When you reboot a compute node, first verify that it booted successfully. This includes ensuring that the `nova-compute` service is running:

```
# ps aux | grep nova-compute
# status nova-compute
```

Also ensure that it has successfully connected to the AMQP server:

```
# grep AMQP /var/log/nova/nova-compute.log
2013-02-26 09:51:31 12427 INFO nova.openstack.common.rpc.common [-] Connected to AMQP
↪server on 199.116.232.36:5672
```

After the compute node is successfully running, you must deal with the instances that are hosted on that compute node because none of them are running. Depending on your SLA with your users or customers, you might have to start each instance and ensure that they start correctly.

Instances

You can create a list of instances that are hosted on the compute node by performing the following command:

```
# openstack server list --host c01.example.com --all-projects
```

After you have the list, you can use the **`openstack`** command to start each instance:

```
# openstack server reboot <server>
```

Note: Any time an instance shuts down unexpectedly, it might have problems on boot. For example, the instance might require an `fsck` on the root partition. If this happens, the user can use the dashboard VNC console to fix this.

If an instance does not boot, meaning `virsh list` never shows the instance as even attempting to boot, do the following on the compute node:

```
# tail -f /var/log/nova/nova-compute.log
```

Try executing the **`openstack server reboot`** command again. You should see an error message about why the instance was not able to boot.

In most cases, the error is the result of something in libvirt's XML file (`/etc/libvirt/qemu/instance-xxxxxxxx.xml`) that no longer exists. You can enforce re-creation of the XML file as well as rebooting the instance by running the following command:

```
# openstack server reboot --hard <server>
```

Inspecting and Recovering Data from Failed Instances

In some scenarios, instances are running but are inaccessible through SSH and do not respond to any command. The VNC console could be displaying a boot failure or kernel panic error messages. This could be an indication of file system corruption on the VM itself. If you need to recover files or inspect the content of the instance, qemu-nbd can be used to mount the disk.

> **Warning:** If you access or view the user's content and data, get approval first!

To access the instance's disk (`/var/lib/nova/instances/instance-xxxxxx/disk`), use the following steps:

1. Suspend the instance using the `virsh` command.
2. Connect the qemu-nbd device to the disk.
3. Mount the qemu-nbd device.
4. Unmount the device after inspecting.
5. Disconnect the qemu-nbd device.
6. Resume the instance.

If you do not follow last three steps, OpenStack Compute cannot manage the instance any longer. It fails to respond to any command issued by OpenStack Compute, and it is marked as shut down.

Once you mount the disk file, you should be able to access it and treat it as a collection of normal directories with files and a directory structure. However, we do not recommend that you edit or touch any files because this could change the *access control lists (ACLs)* that are used to determine which accounts can perform what operations on files and directories. Changing ACLs can make the instance unbootable if it is not already.

1. Suspend the instance using the **virsh** command, taking note of the internal ID:

```
# virsh list
Id Name                 State
----------------------------------
 1 instance-00000981    running
 2 instance-000009f5    running
30 instance-0000274a    running

# virsh suspend 30
Domain 30 suspended
```

2. Find the ID for each instance by listing the server IDs using the following command:

```
# openstack server list
+--------------------------------------+-------+---------+---------------------------
↪-+------------+
| ID                                   | Name  | Status  | Networks                  
↪ | Image Name |
+--------------------------------------+-------+---------+---------------------------
↪-+------------+
| 2da14c5c-de6d-407d-a7d2-2dd0862b9967 | try3  | ACTIVE  | finance-internal=10.10.0.4
↪ |            |
| 223f4860-722a-44a0-bac7-f73f58beec7b | try2  | ACTIVE  | finance-internal=10.10.0.
↪13 |            |
+--------------------------------------+-------+---------+---------------------------
↪-+------------+
```

3. Connect the qemu-nbd device to the disk:

```
# cd /var/lib/nova/instances/instance-0000274a
# ls -lh
total 33M
-rw-rw---- 1 libvirt-qemu kvm  6.3K Oct 15 11:31 console.log
-rw-r--r-- 1 libvirt-qemu kvm   33M Oct 15 22:06 disk
-rw-r--r-- 1 libvirt-qemu kvm  384K Oct 15 22:06 disk.local
-rw-rw-r-- 1 nova         nova 1.7K Oct 15 11:30 libvirt.xml
# qemu-nbd -c /dev/nbd0 `pwd`/disk
```

4. Mount the qemu-nbd device.

   The qemu-nbd device tries to export the instance disk's different partitions as separate devices. For example, if vda is the disk and vda1 is the root partition, qemu-nbd exports the device as `/dev/nbd0` and `/dev/nbd0p1`, respectively:

   ```
   # mount /dev/nbd0p1 /mnt/
   ```

   You can now access the contents of `/mnt`, which correspond to the first partition of the instance's disk.

   To examine the secondary or ephemeral disk, use an alternate mount point if you want both primary and secondary drives mounted at the same time:

   ```
   # umount /mnt
   # qemu-nbd -c /dev/nbd1 `pwd`/disk.local
   # mount /dev/nbd1 /mnt/
   # ls -lh /mnt/
   total 76K
   lrwxrwxrwx.  1 root root    7 Oct 15 00:44 bin -> usr/bin
   dr-xr-xr-x.  4 root root 4.0K Oct 15 01:07 boot
   drwxr-xr-x.  2 root root 4.0K Oct 15 00:42 dev
   drwxr-xr-x. 70 root root 4.0K Oct 15 11:31 etc
   drwxr-xr-x.  3 root root 4.0K Oct 15 01:07 home
   lrwxrwxrwx.  1 root root    7 Oct 15 00:44 lib -> usr/lib
   lrwxrwxrwx.  1 root root    9 Oct 15 00:44 lib64 -> usr/lib64
   drwx------.  2 root root  16K Oct 15 00:42 lost+found
   drwxr-xr-x.  2 root root 4.0K Feb  3  2012 media
   drwxr-xr-x.  2 root root 4.0K Feb  3  2012 mnt
   drwxr-xr-x.  2 root root 4.0K Feb  3  2012 opt
   drwxr-xr-x.  2 root root 4.0K Oct 15 00:42 proc
   dr-xr-x---.  3 root root 4.0K Oct 15 21:56 root
   drwxr-xr-x. 14 root root 4.0K Oct 15 01:07 run
   lrwxrwxrwx.  1 root root    8 Oct 15 00:44 sbin -> usr/sbin
   drwxr-xr-x.  2 root root 4.0K Feb  3  2012 srv
   drwxr-xr-x.  2 root root 4.0K Oct 15 00:42 sys
   drwxrwxrwt.  9 root root 4.0K Oct 15 16:29 tmp
   drwxr-xr-x. 13 root root 4.0K Oct 15 00:44 usr
   drwxr-xr-x. 17 root root 4.0K Oct 15 00:44 var
   ```

5. Once you have completed the inspection, unmount the mount point and release the qemu-nbd device:

   ```
   # umount /mnt
   # qemu-nbd -d /dev/nbd0
   /dev/nbd0 disconnected
   ```

6. Resume the instance using **virsh**:

```
# virsh list
Id Name                 State
----------------------------------
 1 instance-00000981    running
 2 instance-000009f5    running
30 instance-0000274a    paused

# virsh resume 30
Domain 30 resumed
```

Managing floating IP addresses between instances

In an elastic cloud environment using the `Public_AGILE` network, each instance has a publicly accessible IPv4 & IPv6 address. It does not support the concept of OpenStack floating IP addresses that can easily be attached, removed, and transferred between instances. However, there is a workaround using neutron ports which contain the IPv4 & IPv6 address.

Create a port that can be reused

1. Create a port on the `Public_AGILE` network:

```
$ openstack port create port1 --network Public_AGILE

Created a new port:
+-----------------------+------------------------------------------------------+
| Field                 | Value                                                |
+-----------------------+------------------------------------------------------+
| admin_state_up        | UP                                                   |
| allowed_address_pairs |                                                      |
| binding_host_id       | None                                                 |
| binding_profile       | None                                                 |
| binding_vif_details   | None                                                 |
| binding_vif_type      | None                                                 |
| binding_vnic_type     | normal                                               |
| created_at            | 2017-02-26T14:23:18Z                                 |
| description           |                                                      |
| device_id             |                                                      |
| device_owner          |                                                      |
| dns_assignment        | None                                                 |
| dns_name              | None                                                 |
| extra_dhcp_opts       |                                                      |
| fixed_ips             | ip_address='96.118.182.106',                         |
|                       | subnet_id='4279c70a-7218-4c7e-94e5-7bd4c045644e'     |
|                       | ip_address='2001:558:fc0b:100:f816:3eff:fefb:45fb',  |
|                       | subnet_id='11d8087b-6288-4129-95ff-42c3df0c1df0'     |
| id                    | 3871bf29-e963-4701-a7dd-8888dbaab375                 |
| ip_address            | None                                                 |
| mac_address           | fa:16:3e:e2:09:e0                                    |
| name                  | port1                                                |
| network_id            | f41bd921-3a59-49c4-aa95-c2e4496a4b56                 |
| option_name           | None                                                 |
| option_value          | None                                                 |
| port_security_enabled | True                                                 |
| project_id            | 52f0574689f14c8a99e7ca22c4eb572                      |
| qos_policy_id         | None                                                 |
| revision_number       | 6                                                    |
```

```
| security_groups       | 20d96891-0055-428a-8fa6-d5aed25f0dc6                |
| status                | DOWN                                                |
| subnet_id             | None                                                |
| updated_at            | 2017-02-26T14:23:19Z                                |
+-----------------------+-----------------------------------------------------+
```

2. If you know the fully qualified domain name (FQDN) that will be assigned to the IP address, assign the port with the same name:

```
$ openstack port create "example-fqdn-01.sys.example.com" --network Public_AGILE

Created a new port:
+-----------------------+-----------------------------------------------------+
| Field                 | Value                                               |
+-----------------------+-----------------------------------------------------+
| admin_state_up        | UP                                                  |
| allowed_address_pairs |                                                     |
| binding_host_id       | None                                                |
| binding_profile       | None                                                |
| binding_vif_details   | None                                                |
| binding_vif_type      | None                                                |
| binding_vnic_type     | normal                                              |
| created_at            | 2017-02-26T14:24:16Z                                |
| description           |                                                     |
| device_id             |                                                     |
| device_owner          |                                                     |
| dns_assignment        | None                                                |
| dns_name              | None                                                |
| extra_dhcp_opts       |                                                     |
| fixed_ips             | ip_address='96.118.182.107',                        |
|                       | subnet_id='4279c70a-7218-4c7e-94e5-7bd4c045644e'    |
|                       | ip_address='2001:558:fc0b:100:f816:3eff:fefb:65fc', |
|                       | subnet_id='11d8087b-6288-4129-95ff-42c3df0c1df0'    |
| id                    | 731c3b28-3753-4e63-bae3-b58a52d6ccca                |
| ip_address            | None                                                |
| mac_address           | fa:16:3e:fb:65:fc                                   |
| name                  | example-fqdn-01.sys.example.com                     |
| network_id            | f41bd921-3a59-49c4-aa95-c2e4496a4b56                |
| option_name           | None                                                |
| option_value          | None                                                |
| port_security_enabled | True                                                |
| project_id            | 52f0574689f14c8a99e7ca22c4eb5720                    |
| qos_policy_id         | None                                                |
| revision_number       | 6                                                   |
| security_groups       | 20d96891-0055-428a-8fa6-d5aed25f0dc6                |
| status                | DOWN                                                |
| subnet_id             | None                                                |
| updated_at            | 2017-02-26T14:24:17Z                                |
+-----------------------+-----------------------------------------------------+
```

3. Use the port when creating an instance:

```
$ openstack server create --flavor m1.medium --image ubuntu.qcow2 \
  --key-name team_key --nic port-id=PORT_ID \
  "example-fqdn-01.sys.example.com"
```

4. Verify the instance has the correct IP address:

```
+--------------------------------------+-------------------------------------------
↪------------+
| Field                                | Value                                     
↪            |
+--------------------------------------+-------------------------------------------
↪------------+
| OS-DCF:diskConfig                    | MANUAL                                    
↪            |
| OS-EXT-AZ:availability_zone          | nova                                      
↪            |
| OS-EXT-SRV-ATTR:host                 | os_compute-1                              
↪            |
| OS-EXT-SRV-ATTR:hypervisor_hostname  | os_compute.ece.example.com                
↪            |
| OS-EXT-SRV-ATTR:instance_name        | instance-00012b82                         
↪            |
| OS-EXT-STS:power_state               | Running                                   
↪            |
| OS-EXT-STS:task_state                | None                                      
↪            |
| OS-EXT-STS:vm_state                  | active                                    
↪            |
| OS-SRV-USG:launched_at               | 2016-11-30T08:55:27.000000                
↪            |
| OS-SRV-USG:terminated_at             | None                                      
↪            |
| accessIPv4                           |                                           
↪            |
| accessIPv6                           |                                           
↪            |
| addresses                            | public=172.24.4.236                       
↪            |
| config_drive                         |                                           
↪            |
| created                              | 2016-11-30T08:55:14Z                      
↪            |
| flavor                               | m1.medium (103)                           
↪            |
| hostId                               |
↪aca973d5b7981faaf8c713a0130713bbc1e64151be65c8dfb53039f7 |
| id                                   | f91bd761-6407-46a6-b5fd-11a8a46e4983      
↪            |
| image                                | Example Cloud Ubuntu 14.04 x86_64 v2.5
↪(fb49d7e1-273b-...|
| key_name                             | team_key                                  
↪            |
| name                                 | example-fqdn-01.sys.example.com           
↪            |
| os-extended-volumes:volumes_attached | []                                        
↪            |
| progress                             | 0                                         
↪            |
| project_id                           | 2daf82a578e9437cab396c888ff0ca57          
↪            |
| properties                           |                                           
↪            |
| security_groups                      | [{u'name': u'default'}]                   
↪            |
```

```
| status                              | ACTIVE                                    
↪            |
| updated                             | 2016-11-30T08:55:27Z                      
↪            |
| user_id                             | 8cbea24666ae49bbb8c1641f9b12d2d2          
↪            |
+-------------------------------------+-------------------------------------------
↪------------+
```

5. Check the port connection using the netcat utility:

```
$ nc -v -w 2 96.118.182.107 22
Ncat: Version 7.00 ( https://nmap.org/ncat )
Ncat: Connected to 96.118.182.107:22.
SSH-2.0-OpenSSH_6.6.1p1 Ubuntu-2ubuntu2.6
```

Detach a port from an instance

1. Find the port corresponding to the instance. For example:

```
$ openstack port list | grep -B1 96.118.182.107

| 731c3b28-3753-4e63-bae3-b58a52d6ccca | example-fqdn-01.sys.example.com |
↪fa:16:3e:fb:65:fc | ip_address='96.118.182.107', subnet_id='4279c70a-7218-4c7e-94e5-
↪7bd4c045644e' |
```

2. Run the **openstack port set** command to remove the port from the instance:

```
$ openstack port set 731c3b28-3753-4e63-bae3-b58a52d6ccca \
--device "" --device-owner "" --no-binding-profile
```

3. Delete the instance and create a new instance using the `--nic port-id` option.

Retrieve an IP address when an instance is deleted before detaching a port

The following procedure is a possible workaround to retrieve an IP address when an instance has been deleted with the port still attached:

1. Launch several neutron ports:

```
$ for i in {0..10}; do openstack port create --network Public_AGILE \
ip-recovery; done
```

2. Check the ports for the lost IP address and update the name:

```
$ openstack port set 731c3b28-3753-4e63-bae3-b58a52d6ccca \
--name "don't delete"
```

3. Delete the ports that are not needed:

```
$ for port in $(openstack port list | grep -i ip-recovery | \
awk '{print $2}'); do openstack port delete $port; done
```

4. If you still cannot find the lost IP address, repeat these steps again.

Volumes

If the affected instances also had attached volumes, first generate a list of instance and volume UUIDs:

```
mysql> select nova.instances.uuid as instance_uuid,
       cinder.volumes.id as volume_uuid, cinder.volumes.status,
       cinder.volumes.attach_status, cinder.volumes.mountpoint,
       cinder.volumes.display_name from cinder.volumes
       inner join nova.instances on cinder.volumes.instance_uuid=nova.instances.uuid
       where nova.instances.host = 'c01.example.com';
```

You should see a result similar to the following:

```
+--------------+------------+-------+--------------+-----------+--------------+
|instance_uuid |volume_uuid |status |attach_status |mountpoint | display_name |
+--------------+------------+-------+--------------+-----------+--------------+
|9b969a05      |1f0fbf36    |in-use |attached      |/dev/vdc   | test         |
+--------------+------------+-------+--------------+-----------+--------------+
1 row in set (0.00 sec)
```

Next, manually detach and reattach the volumes, where X is the proper mount point:

```
# openstack server remove volume <instance_uuid> <volume_uuid>
# openstack server add volume <instance_uuid> <volume_uuid> --device /dev/vdX
```

Be sure that the instance has successfully booted and is at a login screen before doing the above.

Total Compute Node Failure

Compute nodes can fail the same way a cloud controller can fail. A motherboard failure or some other type of hardware failure can cause an entire compute node to go offline. When this happens, all instances running on that compute node will not be available. Just like with a cloud controller failure, if your infrastructure monitoring does not detect a failed compute node, your users will notify you because of their lost instances.

If a compute node fails and won't be fixed for a few hours (or at all), you can relaunch all instances that are hosted on the failed node if you use shared storage for `/var/lib/nova/instances`.

To do this, generate a list of instance UUIDs that are hosted on the failed node by running the following query on the nova database:

```
mysql> select uuid from instances
       where host = 'c01.example.com' and deleted = 0;
```

Next, update the nova database to indicate that all instances that used to be hosted on c01.example.com are now hosted on c02.example.com:

```
mysql> update instances set host = 'c02.example.com'
       where host = 'c01.example.com' and deleted = 0;
```

If you're using the Networking service ML2 plug-in, update the Networking service database to indicate that all ports that used to be hosted on c01.example.com are now hosted on c02.example.com:

```
mysql> update ml2_port_bindings set host = 'c02.example.com'
       where host = 'c01.example.com';
mysql> update ml2_port_binding_levels set host = 'c02.example.com'
       where host = 'c01.example.com';
```

After that, use the **openstack** command to reboot all instances that were on c01.example.com while regenerating their XML files at the same time:

```
# openstack server reboot --hard <server>
```

Finally, reattach volumes using the same method described in the section *Volumes*.

/var/lib/nova/instances

It's worth mentioning this directory in the context of failed compute nodes. This directory contains the libvirt KVM file-based disk images for the instances that are hosted on that compute node. If you are not running your cloud in a shared storage environment, this directory is unique across all compute nodes.

`/var/lib/nova/instances` contains two types of directories.

The first is the `_base` directory. This contains all the cached base images from glance for each unique image that has been launched on that compute node. Files ending in `_20` (or a different number) are the ephemeral base images.

The other directories are titled `instance-xxxxxxxx`. These directories correspond to instances running on that compute node. The files inside are related to one of the files in the `_base` directory. They're essentially differential-based files containing only the changes made from the original `_base` directory.

All files and directories in `/var/lib/nova/instances` are uniquely named. The files in _base are uniquely titled for the glance image that they are based on, and the directory names `instance-xxxxxxxx` are uniquely titled for that particular instance. For example, if you copy all data from `/var/lib/nova/instances` on one compute node to another, you do not overwrite any files or cause any damage to images that have the same unique name, because they are essentially the same file.

Although this method is not documented or supported, you can use it when your compute node is permanently offline but you have instances locally stored on it.

Storage Node Failures and Maintenance

Because of the high redundancy of Object Storage, dealing with object storage node issues is a lot easier than dealing with compute node issues.

Rebooting a Storage Node

If a storage node requires a reboot, simply reboot it. Requests for data hosted on that node are redirected to other copies while the server is rebooting.

Shutting Down a Storage Node

If you need to shut down a storage node for an extended period of time (one or more days), consider removing the node from the storage ring. For example:

```
# swift-ring-builder account.builder remove <ip address of storage node>
# swift-ring-builder container.builder remove <ip address of storage node>
# swift-ring-builder object.builder remove <ip address of storage node>
```

```
# swift-ring-builder account.builder rebalance
# swift-ring-builder container.builder rebalance
# swift-ring-builder object.builder rebalance
```

Next, redistribute the ring files to the other nodes:

```
# for i in s01.example.com s02.example.com s03.example.com
> do
> scp *.ring.gz $i:/etc/swift
> done
```

These actions effectively take the storage node out of the storage cluster.

When the node is able to rejoin the cluster, just add it back to the ring. The exact syntax you use to add a node to your swift cluster with `swift-ring-builder` heavily depends on the original options used when you originally created your cluster. Please refer back to those commands.

Replacing a Swift Disk

If a hard drive fails in an Object Storage node, replacing it is relatively easy. This assumes that your Object Storage environment is configured correctly, where the data that is stored on the failed drive is also replicated to other drives in the Object Storage environment.

This example assumes that `/dev/sdb` has failed.

First, unmount the disk:

```
# umount /dev/sdb
```

Next, physically remove the disk from the server and replace it with a working disk.

Ensure that the operating system has recognized the new disk:

```
# dmesg | tail
```

You should see a message about `/dev/sdb`.

Because it is recommended to not use partitions on a swift disk, simply format the disk as a whole:

```
# mkfs.xfs /dev/sdb
```

Finally, mount the disk:

```
# mount -a
```

Swift should notice the new disk and that no data exists. It then begins replicating the data to the disk from the other existing replicas.

Handling a Complete Failure

A common way of dealing with the recovery from a full system failure, such as a power outage of a data center, is to assign each service a priority, and restore in order. *Table. Example service restoration priority list* shows an example.

Table 6: Table. Example service restoration priority list

Priority	Services
1	Internal network connectivity
2	Backing storage services
3	Public network connectivity for user virtual machines
4	`nova-compute`, cinder hosts
5	User virtual machines
10	Message queue and database services
15	Keystone services
20	`cinder-scheduler`
21	Image Catalog and Delivery services
22	`nova-scheduler` services
98	`cinder-api`
99	`nova-api` services
100	Dashboard node

Use this example priority list to ensure that user-affected services are restored as soon as possible, but not before a stable environment is in place. Of course, despite being listed as a single-line item, each step requires significant work. For example, just after starting the database, you should check its integrity, or, after starting the nova services, you should verify that the hypervisor matches the database and fix any mismatches.

Configuration Management

Maintaining an OpenStack cloud requires that you manage multiple physical servers, and this number might grow over time. Because managing nodes manually is error prone, we strongly recommend that you use a configuration-management tool. These tools automate the process of ensuring that all your nodes are configured properly and encourage you to maintain your configuration information (such as packages and configuration options) in a version-controlled repository.

Note: Several configuration-management tools are available, and this guide does not recommend a specific one. The most popular ones in the OpenStack community are:

- Puppet, with available OpenStack Puppet modules
- Ansible, with OpenStack Ansible
- Chef, with available OpenStack Chef recipes

Other newer configuration tools include Juju and Salt; and more mature configuration management tools include CFEngine and Bcfg2.

Working with Hardware

As for your initial deployment, you should ensure that all hardware is appropriately burned in before adding it to production. Run software that uses the hardware to its limits—maxing out RAM, CPU, disk, and network. Many options are available, and normally double as benchmark software, so you also get a good idea of the performance of your system.

Adding a Compute Node

If you find that you have reached or are reaching the capacity limit of your computing resources, you should plan to add additional compute nodes. Adding more nodes is quite easy. The process for adding compute nodes is the same as when the initial compute nodes were deployed to your cloud: use an automated deployment system to bootstrap the bare-metal server with the operating system and then have a configuration-management system install and configure OpenStack Compute. Once the Compute service has been installed and configured in the same way as the other compute nodes, it automatically attaches itself to the cloud. The cloud controller notices the new node(s) and begins scheduling instances to launch there.

If your OpenStack Block Storage nodes are separate from your compute nodes, the same procedure still applies because the same queuing and polling system is used in both services.

We recommend that you use the same hardware for new compute and block storage nodes. At the very least, ensure that the CPUs are similar in the compute nodes to not break live migration.

Adding an Object Storage Node

Adding a new object storage node is different from adding compute or block storage nodes. You still want to initially configure the server by using your automated deployment and configuration-management systems. After that is done, you need to add the local disks of the object storage node into the object storage ring. The exact command to do this is the same command that was used to add the initial disks to the ring. Simply rerun this command on the object storage proxy server for all disks on the new object storage node. Once this has been done, rebalance the ring and copy the resulting ring files to the other storage nodes.

Note: If your new object storage node has a different number of disks than the original nodes have, the command to add the new node is different from the original commands. These parameters vary from environment to environment.

Replacing Components

Failures of hardware are common in large-scale deployments such as an infrastructure cloud. Consider your processes and balance time saving against availability. For example, an Object Storage cluster can easily live with dead disks in it for some period of time if it has sufficient capacity. Or, if your compute installation is not full, you could consider live migrating instances off a host with a RAM failure until you have time to deal with the problem.

Databases

Almost all OpenStack components have an underlying database to store persistent information. Usually this database is MySQL. Normal MySQL administration is applicable to these databases. OpenStack does not configure the databases out of the ordinary. Basic administration includes performance tweaking, high availability, backup, recovery, and repairing. For more information, see a standard MySQL administration guide.

You can perform a couple of tricks with the database to either more quickly retrieve information or fix a data inconsistency error—for example, an instance was terminated, but the status was not updated in the database. These tricks are discussed throughout this book.

Database Connectivity

Review the component's configuration file to see how each OpenStack component accesses its corresponding database. Look for a `connection` option. The following command uses `grep` to display the SQL connection string for nova, glance, cinder, and keystone:

```
# grep -hE "connection ?=" \
  /etc/nova/nova.conf /etc/glance/glance-*.conf \
  /etc/cinder/cinder.conf /etc/keystone/keystone.conf \
  /etc/neutron/neutron.conf
connection = mysql+pymysql://nova:password@cloud.example.com/nova
connection = mysql+pymysql://glance:password@cloud.example.com/glance
connection = mysql+pymysql://glance:password@cloud.example.com/glance
connection = mysql+pymysql://cinder:password@cloud.example.com/cinder
connection = mysql+pymysql://keystone:password@cloud.example.com/keystone
connection = mysql+pymysql://neutron:password@cloud.example.com/neutron
```

The connection strings take this format:

```
mysql+pymysql:// <username> : <password> @ <hostname> / <database name>
```

Performance and Optimizing

As your cloud grows, MySQL is utilized more and more. If you suspect that MySQL might be becoming a bottleneck, you should start researching MySQL optimization. The MySQL manual has an entire section dedicated to this topic: Optimization Overview.

RabbitMQ troubleshooting

This section provides tips on resolving common RabbitMQ issues.

RabbitMQ service hangs

It is quite common for the RabbitMQ service to hang when it is restarted or stopped. Therefore, it is highly recommended that you manually restart RabbitMQ on each controller node.

Note: The RabbitMQ service name may vary depending on your operating system or vendor who supplies your RabbitMQ service.

1. Restart the RabbitMQ service on the first controller node. The **`service rabbitmq-server restart`** command may not work in certain situations, so it is best to use:

   ```
   # service rabbitmq-server stop
   # service rabbitmq-server start
   ```

2. If the service refuses to stop, then run the **`pkill`** command to stop the service, then restart the service:

   ```
   # pkill -KILL -u rabbitmq
   # service rabbitmq-server start
   ```

3. Verify RabbitMQ processes are running:

```
# ps -ef | grep rabbitmq
# rabbitmqctl list_queues
# rabbitmqctl list_queues 2>&1 | grep -i error
```

4. If there are errors, run the **`cluster_status`** command to make sure there are no partitions:

```
# rabbitmqctl cluster_status
```

   For more information, see RabbitMQ documentation.

5. Go back to the first step and try restarting the RabbitMQ service again. If you still have errors, remove the contents in the `/var/lib/rabbitmq/mnesia/` directory between stopping and starting the RabbitMQ service.

6. If there are no errors, restart the RabbitMQ service on the next controller node.

Since the Liberty release, OpenStack services will automatically recover from a RabbitMQ outage. You should only consider restarting OpenStack services after checking if RabbitMQ heartbeat functionality is enabled, and if OpenStack services are not picking up messages from RabbitMQ queues.

RabbitMQ alerts

If you receive alerts for RabbitMQ, take the following steps to troubleshoot and resolve the issue:

1. Determine which servers the RabbitMQ alarms are coming from.
2. Attempt to boot a nova instance in the affected environment.
3. If you cannot launch an instance, continue to troubleshoot the issue.
4. Log in to each of the controller nodes for the affected environment, and check the `/var/log/rabbitmq` log files for any reported issues.
5. Look for connection issues identified in the log files.
6. For each controller node in your environment, view the `/etc/init.d` directory to check it contains nova*, cinder*, neutron*, or glance*. Also check RabbitMQ message queues that are growing without being consumed which will indicate which OpenStack service is affected. Restart the affected OpenStack service.
7. For each compute node your environment, view the `/etc/init.d` directory and check if it contains nova*, cinder*, neutron*, or glance*, Also check RabbitMQ message queues that are growing without being consumed which will indicate which OpenStack services are affected. Restart the affected OpenStack services.
8. Open OpenStack Dashboard and launch an instance. If the instance launches, the issue is resolved.
9. If you cannot launch an instance, check the `/var/log/rabbitmq` log files for reported connection issues.
10. Restart the RabbitMQ service on all of the controller nodes:

```
# service rabbitmq-server stop
# service rabbitmq-server start
```

Note: This step applies if you have already restarted only the OpenStack components, and cannot connect to the RabbitMQ service.

11. Repeat steps 7-8.

Excessive database management memory consumption

Since the Liberty release, OpenStack with RabbitMQ 3.4.x or 3.6.x has an issue with the management database consuming the memory allocated to RabbitMQ. This is caused by statistics collection and processing. When a single node with RabbitMQ reaches its memory threshold, all exchange and queue processing is halted until the memory alarm recovers.

To address this issue:

1. Check memory consumption:

   ```
   # rabbitmqctl status
   ```

2. Edit the `/etc/rabbitmq/rabbitmq.config` configuration file, and change the `collect_statistics_interval` parameter between 30000-60000 milliseconds. Alternatively you can turn off statistics collection by setting `collect_statistics` parameter to "none".

File descriptor limits when scaling a cloud environment

A cloud environment that is scaled to a certain size will require the file descriptor limits to be adjusted.

Run the **`rabbitmqctl status`** to view the current file descriptor limits:

```
"{file_descriptors,
     [{total_limit,3996},
      {total_used,135},
      {sockets_limit,3594},
      {sockets_used,133}]},"
```

Adjust the appropriate limits in the `/etc/security/limits.conf` configuration file.

HDWMY

Here's a quick list of various to-do items for each hour, day, week, month, and year. Please note that these tasks are neither required nor definitive but helpful ideas:

Hourly

- Check your monitoring system for alerts and act on them.
- Check your ticket queue for new tickets.

Daily

- Check for instances in a failed or weird state and investigate why.
- Check for security patches and apply them as needed.

Weekly

- Check cloud usage:
  - User quotas
  - Disk space
  - Image usage
  - Large instances
  - Network usage (bandwidth and IP usage)
- Verify your alert mechanisms are still working.

Monthly

- Check usage and trends over the past month.
- Check for user accounts that should be removed.
- Check for operator accounts that should be removed.

Quarterly

- Review usage and trends over the past quarter.
- Prepare any quarterly reports on usage and statistics.
- Review and plan any necessary cloud additions.
- Review and plan any major OpenStack upgrades.

Semiannually

- Upgrade OpenStack.
- Clean up after an OpenStack upgrade (any unused or new services to be aware of?).

Determining Which Component Is Broken

OpenStack's collection of different components interact with each other strongly. For example, uploading an image requires interaction from `nova-api`, `glance-api`, `glance-registry`, keystone, and potentially `swift-proxy`. As a result, it is sometimes difficult to determine exactly where problems lie. Assisting in this is the purpose of this section.

Tailing Logs

The first place to look is the log file related to the command you are trying to run. For example, if `openstack server list` is failing, try tailing a nova log file and running the command again:

Terminal 1:

```
# tail -f /var/log/nova/nova-api.log
```

Terminal 2:

```
# openstack server list
```

Look for any errors or traces in the log file. For more information, see *Logging and Monitoring*.

If the error indicates that the problem is with another component, switch to tailing that component's log file. For example, if nova cannot access glance, look at the `glance-api` log:

Terminal 1:

```
# tail -f /var/log/glance/api.log
```

Terminal 2:

```
# openstack server list
```

Wash, rinse, and repeat until you find the core cause of the problem.

Running Daemons on the CLI

Unfortunately, sometimes the error is not apparent from the log files. In this case, switch tactics and use a different command; maybe run the service directly on the command line. For example, if the `glance-api` service refuses to start and stay running, try launching the daemon from the command line:

```
# sudo -u glance -H glance-api
```

This might print the error and cause of the problem.

Note: The `-H` flag is required when running the daemons with sudo because some daemons will write files relative to the user's home directory, and this write may fail if `-H` is left off.

Tip: Example of Complexity

One morning, a compute node failed to run any instances. The log files were a bit vague, claiming that a certain instance was unable to be started. This ended up being a red herring because the instance was simply the first instance in alphabetical order, so it was the first instance that `nova-compute` would touch.

Further troubleshooting showed that libvirt was not running at all. This made more sense. If libvirt wasn't running, then no instance could be virtualized through KVM. Upon trying to start libvirt, it would silently die immediately. The libvirt logs did not explain why.

Next, the `libvirtd` daemon was run on the command line. Finally a helpful error message: it could not connect to d-bus. As ridiculous as it sounds, libvirt, and thus `nova-compute`, relies on d-bus and somehow d-bus crashed. Simply starting d-bus set the entire chain back on track, and soon everything was back up and running.

What to do when things are running slowly

When you are getting slow responses from various services, it can be hard to know where to start looking. The first thing to check is the extent of the slowness: is it specific to a single service, or varied among different services? If your problem is isolated to a specific service, it can temporarily be fixed by restarting the service, but that is often only a fix for the symptom and not the actual problem.

This is a collection of ideas from experienced operators on common things to look at that may be the cause of slowness. It is not, however, designed to be an exhaustive list.

OpenStack Identity service

If OpenStack *Identity service* is responding slowly, it could be due to the token table getting large. This can be fixed by running the **`keystone-manage token_flush`** command.

Additionally, for Identity-related issues, try the tips in *SQL back end*.

OpenStack Image service

OpenStack *Image service* can be slowed down by things related to the Identity service, but the Image service itself can be slowed down if connectivity to the back-end storage in use is slow or otherwise problematic. For example, your back-end NFS server might have gone down.

OpenStack Block Storage service

OpenStack *Block Storage service* is similar to the Image service, so start by checking Identity-related services, and the back-end storage. Additionally, both the Block Storage and Image services rely on AMQP and SQL functionality, so consider these when debugging.

OpenStack Compute service

Services related to OpenStack Compute are normally fairly fast and rely on a couple of backend services: Identity for authentication and authorization), and AMQP for interoperability. Any slowness related to services is normally related to one of these. Also, as with all other services, SQL is used extensively.

OpenStack Networking service

Slowness in the OpenStack *Networking service* can be caused by services that it relies upon, but it can also be related to either physical or virtual networking. For example: network namespaces that do not exist or are not tied to interfaces correctly; DHCP daemons that have hung or are not running; a cable being physically disconnected; a switch not being configured correctly. When debugging Networking service problems, begin by verifying all physical networking functionality (switch configuration, physical cabling, etc.). After the physical networking is verified, check to be sure all of the Networking services are running (neutron-server, neutron-dhcp-agent, etc.), then check on AMQP and SQL back ends.

AMQP broker

Regardless of which AMQP broker you use, such as RabbitMQ, there are common issues which not only slow down operations, but can also cause real problems. Sometimes messages queued for services stay on the queues and are not consumed. This can be due to dead or stagnant services and can be commonly cleared up by either restarting the AMQP-related services or the OpenStack service in question.

SQL back end

Whether you use SQLite or an RDBMS (such as MySQL), SQL interoperability is essential to a functioning OpenStack environment. A large or fragmented SQLite file can cause slowness when using files as a back end. A locked or long-running query can cause delays for most RDBMS services. In this case, do not kill the query immediately, but look into it to see if it is a problem with something that is hung, or something that is just taking a long time to run and needs to finish on its own. The administration of an RDBMS is outside the scope of this document, but it should be noted that a properly functioning RDBMS is essential to most OpenStack services.

Uninstalling

While we'd always recommend using your automated deployment system to reinstall systems from scratch, sometimes you do need to remove OpenStack from a system the hard way. Here's how:

- Remove all packages.
- Remove remaining files.
- Remove databases.

These steps depend on your underlying distribution, but in general you should be looking for **`purge`** commands in your package manager, like **`aptitude purge ~c $package`**. Following this, you can look for orphaned files in the directories referenced throughout this guide. To uninstall the database properly, refer to the manual appropriate for the product in use.

Downtime, whether planned or unscheduled, is a certainty when running a cloud. This chapter aims to provide useful information for dealing proactively, or reactively, with these occurrences.

Network Troubleshooting

Network troubleshooting can be challenging. A network issue may cause problems at any point in the cloud. Using a logical troubleshooting procedure can help mitigate the issue and isolate where the network issue is. This chapter aims to give you the information you need to identify any issues for `nova-network` or OpenStack Networking (neutron) with Linux Bridge or Open vSwitch.

Using ip a to Check Interface States

On compute nodes and nodes running `nova-network`, use the following command to see information about interfaces, including information about IPs, VLANs, and whether your interfaces are up:

```
# ip a
```

If you are encountering any sort of networking difficulty, one good initial troubleshooting step is to make sure that your interfaces are up. For example:

```
$ ip a | grep state
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP
   qlen 1000
3: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast
   master br100 state UP qlen 1000
4: virbr0: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc noqueue state DOWN
5: br100: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UP
```

You can safely ignore the state of `virbr0`, which is a default bridge created by libvirt and not used by OpenStack.

Visualizing nova-network Traffic in the Cloud

If you are logged in to an instance and ping an external host, for example, Google, the ping packet takes the route shown in *Figure. Traffic route for ping packet*.

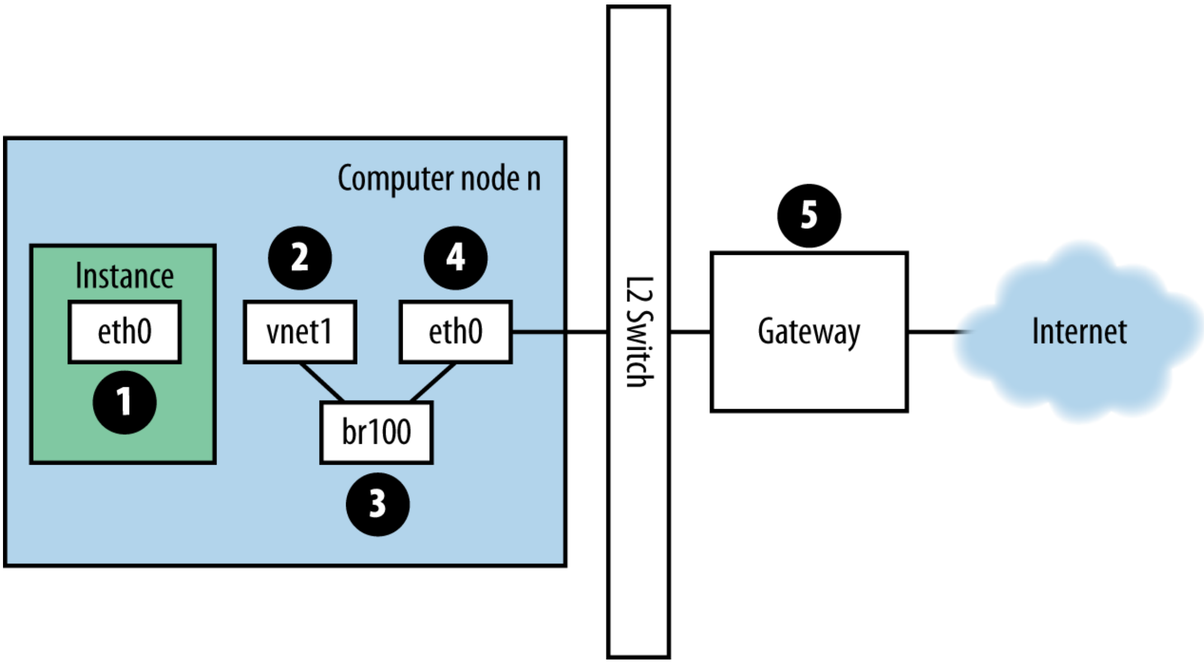


Fig. 2: Figure. Traffic route for ping packet

1. The instance generates a packet and places it on the virtual Network Interface Card (NIC) inside the instance, such as `eth0`.
2. The packet transfers to the virtual NIC of the compute host, such as, `vnet1`. You can find out what vnet NIC is being used by looking at the `/etc/libvirt/qemu/instance-xxxxxxxx.xml` file.
3. From the vnet NIC, the packet transfers to a bridge on the compute node, such as `br100`.

   If you run FlatDHCPManager, one bridge is on the compute node. If you run VlanManager, one bridge exists for each VLAN.

   To see which bridge the packet will use, run the command:

   ```
   $ brctl show
   ```

   Look for the vnet NIC. You can also reference `nova.conf` and look for the `flat_interface_bridge` option.

4. The packet transfers to the main NIC of the compute node. You can also see this NIC in the **brctl** output, or you can find it by referencing the `flat_interface` option in `nova.conf`.
5. After the packet is on this NIC, it transfers to the compute node's default gateway. The packet is now most likely out of your control at this point. The diagram depicts an external gateway. However, in the default configuration with multi-host, the compute host is the gateway.

Reverse the direction to see the path of a ping reply. From this path, you can see that a single packet travels across four different NICs. If a problem occurs with any of these NICs, a network issue occurs.

Visualizing OpenStack Networking Service Traffic in the Cloud

OpenStack Networking has many more degrees of freedom than `nova-network` does because of its pluggable back end. It can be configured with open source or vendor proprietary plug-ins that control software defined networking (SDN) hardware or plug-ins that use Linux native facilities on your hosts, such as Open vSwitch or Linux Bridge.

The networking chapter of the OpenStack Administrator Guide shows a variety of networking scenarios and their connection paths. The purpose of this section is to give you the tools to troubleshoot the various components involved however they are plumbed together in your environment.

For this example, we will use the Open vSwitch (OVS) back end. Other back-end plug-ins will have very different flow paths. OVS is the most popularly deployed network driver, according to the April 2016 OpenStack User Survey. We'll describe each step in turn, with *Figure. Neutron network paths* for reference.

1. The instance generates a packet and places it on the virtual NIC inside the instance, such as eth0.
2. The packet transfers to a Test Access Point (TAP) device on the compute host, such as tap690466bc-92. You can find out what TAP is being used by looking at the `/etc/libvirt/qemu/instance-xxxxxxxx.xml` file.

   The TAP device name is constructed using the first 11 characters of the port ID (10 hex digits plus an included '-'), so another means of finding the device name is to use the **neutron** command. This returns a pipe-delimited list, the first item of which is the port ID. For example, to get the port ID associated with IP address 10.0.0.10, do this:

   ```
   # openstack port list | grep 10.0.0.10 | cut -d \| -f 2
    ff387e54-9e54-442b-94a3-aa4481764f1d
   ```

   Taking the first 11 characters, we can construct a device name of tapff387e54-9e from this output.

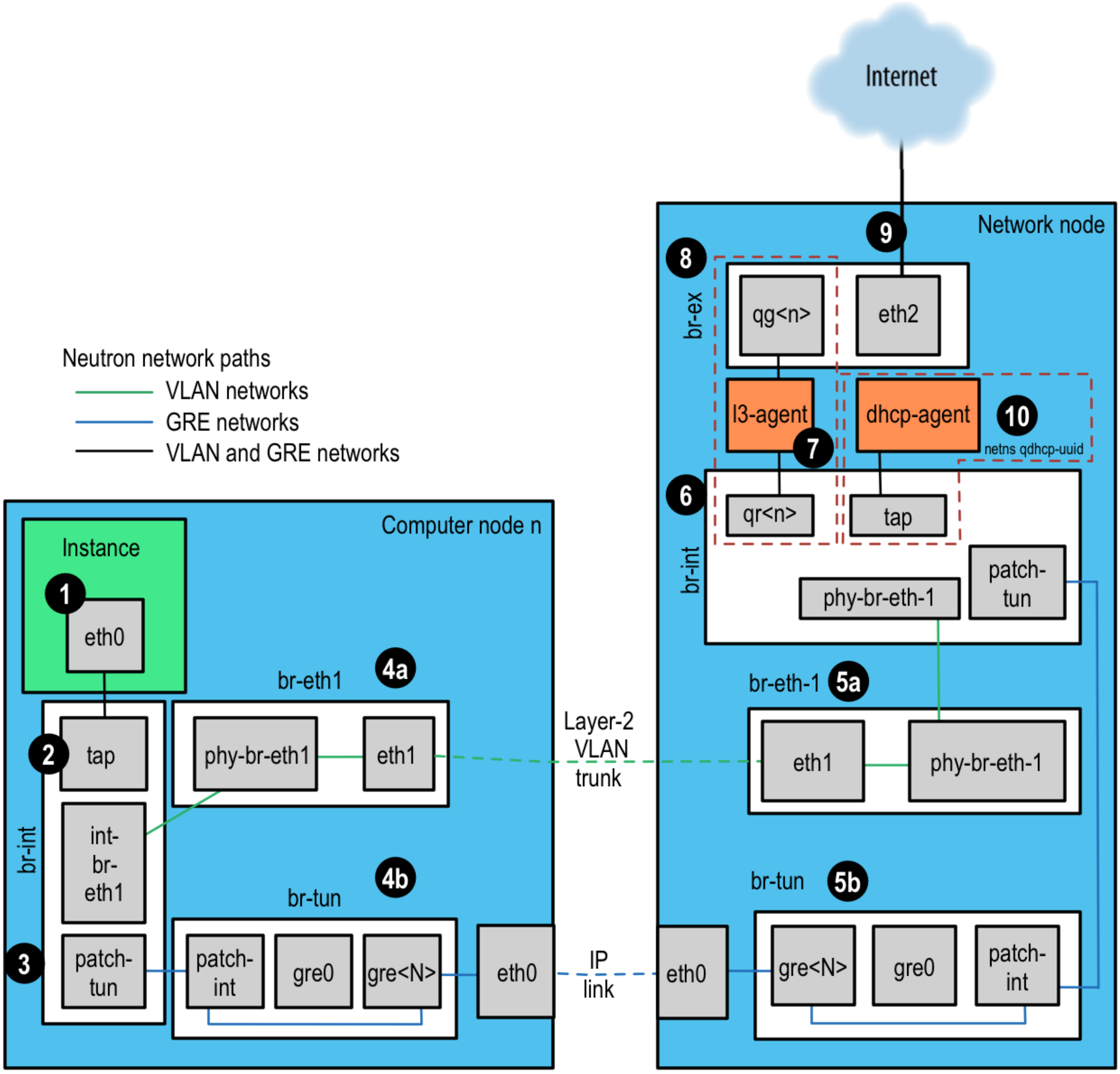


Fig. 3: Figure. Neutron network paths

3. The TAP device is connected to the integration bridge, `br-int`. This bridge connects all the instance TAP devices and any other bridges on the system. In this example, we have `int-br-eth1` and `patch-tun`. `int-br-eth1` is one half of a veth pair connecting to the bridge `br-eth1`, which handles VLAN networks trunked over the physical Ethernet device `eth1`. `patch-tun` is an Open vSwitch internal port that connects to the `br-tun` bridge for GRE networks.

   The TAP devices and veth devices are normal Linux network devices and may be inspected with the usual tools, such as **`ip`** and **`tcpdump`**. Open vSwitch internal devices, such as `patch-tun`, are only visible within the Open vSwitch environment. If you try to run **`tcpdump -i patch-tun`**, it will raise an error, saying that the device does not exist.

   It is possible to watch packets on internal interfaces, but it does take a little bit of networking gymnastics. First you need to create a dummy network device that normal Linux tools can see. Then you need to add it to the bridge containing the internal interface you want to snoop on. Finally, you need to tell Open vSwitch to mirror all traffic to or from the internal port onto this dummy port. After all this, you can then run **`tcpdump`** on the dummy interface and see the traffic on the internal port.

To capture packets from the patch-tun internal interface on integration bridge, br-int:

(a) Create and bring up a dummy interface, `snooper0`:

```
# ip link add name snooper0 type dummy
# ip link set dev snooper0 up
```

(b) Add device `snooper0` to bridge `br-int`:

```
# ovs-vsctl add-port br-int snooper0
```

(c) Create mirror of `patch-tun` to `snooper0` (returns UUID of mirror port):

```
# ovs-vsctl -- set Bridge br-int mirrors=@m  -- --id=@snooper0 \
  get Port snooper0  -- --id=@patch-tun get Port patch-tun \
  -- --id=@m create Mirror name=mymirror select-dst-port=@patch-tun \
  select-src-port=@patch-tun output-port=@snooper0 select_all=1
```

(d) Profit. You can now see traffic on `patch-tun` by running **tcpdump -i snooper0**.

(e) Clean up by clearing all mirrors on `br-int` and deleting the dummy interface:

```
# ovs-vsctl clear Bridge br-int mirrors
# ovs-vsctl del-port br-int snooper0
# ip link delete dev snooper0
```

On the integration bridge, networks are distinguished using internal VLANs regardless of how the networking service defines them. This allows instances on the same host to communicate directly without transiting the rest of the virtual, or physical, network. These internal VLAN IDs are based on the order they are created on the node and may vary between nodes. These IDs are in no way related to the segmentation IDs used in the network definition and on the physical wire.

VLAN tags are translated between the external tag defined in the network settings, and internal tags in several places. On the `br-int`, incoming packets from the `int-br-eth1` are translated from external tags to internal tags. Other translations also happen on the other bridges and will be discussed in those sections.

To discover which internal VLAN tag is in use for a given external VLAN by using the ovs-ofctl command

(a) Find the external VLAN tag of the network you're interested in. This is the `provider:segmentation_id` as returned by the networking service:

```
# neutron net-show --fields provider:segmentation_id <network name>
+---------------------------+--------------------------------------+
| Field                     | Value                                |
+---------------------------+--------------------------------------+
| provider:network_type     | vlan                                 |
| provider:segmentation_id  | 2113                                 |
+---------------------------+--------------------------------------+
```

(b) Grep for the `provider:segmentation_id`, 2113 in this case, in the output of **ovs-ofctl dump-flows br-int**:

```
# ovs-ofctl dump-flows br-int | grep vlan=2113
cookie=0x0, duration=173615.481s, table=0, n_packets=7676140,
n_bytes=444818637, idle_age=0, hard_age=65534, priority=3,
in_port=1,dl_vlan=2113 actions=mod_vlan_vid:7,NORMAL
```

```
```

Here you can see packets received on port ID 1 with the VLAN tag 2113 are modified to have the internal VLAN tag 7. Digging a little deeper, you can confirm that port 1 is in fact `int-br-eth1`:

```
# ovs-ofctl show br-int
OFPT_FEATURES_REPLY (xid=0x2): dpid:000022bc45e1914b
n_tables:254, n_buffers:256
capabilities: FLOW_STATS TABLE_STATS PORT_STATS QUEUE_STATS
ARP_MATCH_IP
actions: OUTPUT SET_VLAN_VID SET_VLAN_PCP STRIP_VLAN SET_DL_SRC
SET_DL_DST SET_NW_SRC SET_NW_DST SET_NW_TOS SET_TP_SRC
SET_TP_DST ENQUEUE
 1(int-br-eth1): addr:c2:72:74:7f:86:08
     config:     0
     state:      0
     current:    10GB-FD COPPER
     speed: 10000 Mbps now, 0 Mbps max
 2(patch-tun): addr:fa:24:73:75:ad:cd
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
 3(tap9be586e6-79): addr:fe:16:3e:e6:98:56
     config:     0
     state:      0
     current:    10MB-FD COPPER
     speed: 10 Mbps now, 0 Mbps max
 LOCAL(br-int): addr:22:bc:45:e1:91:4b
     config:     0
     state:      0
     speed: 0 Mbps now, 0 Mbps max
OFPT_GET_CONFIG_REPLY (xid=0x4): frags=normal miss_send_len=0
```

4. The next step depends on whether the virtual network is configured to use 802.1q VLAN tags or GRE:

   (a) VLAN-based networks exit the integration bridge via veth interface `int-br-eth1` and arrive on the bridge `br-eth1` on the other member of the veth pair `phy-br-eth1`. Packets on this interface arrive with internal VLAN tags and are translated to external tags in the reverse of the process described above:

   ```
   # ovs-ofctl dump-flows br-eth1 | grep 2113
   cookie=0x0, duration=184168.225s, table=0, n_packets=0, n_bytes=0,
   idle_age=65534, hard_age=65534, priority=4,in_port=1,dl_vlan=7
   actions=mod_vlan_vid:2113,NORMAL
   ```

   Packets, now tagged with the external VLAN tag, then exit onto the physical network via `eth1`. The Layer2 switch this interface is connected to must be configured to accept traffic with the VLAN ID used. The next hop for this packet must also be on the same layer-2 network.

   (b) GRE-based networks are passed with `patch-tun` to the tunnel bridge `br-tun` on interface `patch-int`. This bridge also contains one port for each GRE tunnel peer, so one for each compute node and network node in your network. The ports are named sequentially from `gre-1` onward.

   Matching `gre-<n>` interfaces to tunnel endpoints is possible by looking at the Open vSwitch state:

   ```
   # ovs-vsctl show | grep -A 3 -e Port\ \"gre-
           Port "gre-1"
               Interface "gre-1"
   ```

```
                type: gre
                options: {in_key=flow, local_ip="10.10.128.21",
                out_key=flow, remote_ip="10.10.128.16"}
```

In this case, `gre-1` is a tunnel from IP 10.10.128.21, which should match a local interface on this node, to IP 10.10.128.16 on the remote side.

These tunnels use the regular routing tables on the host to route the resulting GRE packet, so there is no requirement that GRE endpoints are all on the same layer-2 network, unlike VLAN encapsulation.

All interfaces on the `br-tun` are internal to Open vSwitch. To monitor traffic on them, you need to set up a mirror port as described above for `patch-tun` in the `br-int` bridge.

All translation of GRE tunnels to and from internal VLANs happens on this bridge.

To discover which internal VLAN tag is in use for a GRE tunnel by using the ovs-ofctl command

(a) Find the `provider:segmentation_id` of the network you're interested in. This is the same field used for the VLAN ID in VLAN-based networks:

```
# neutron net-show --fields provider:segmentation_id <network name>
+--------------------------+-------+
| Field                    | Value |
+--------------------------+-------+
| provider:network_type    | gre   |
| provider:segmentation_id | 3     |
+--------------------------+-------+
```

(b) Grep for 0x<`provider:segmentation_id`>, 0x3 in this case, in the output of `ovs-ofctl dump-flows br-tun`:

```
# ovs-ofctl dump-flows br-tun|grep 0x3
cookie=0x0, duration=380575.724s, table=2, n_packets=1800,
n_bytes=286104, priority=1,tun_id=0x3
actions=mod_vlan_vid:1,resubmit(,10)
 cookie=0x0, duration=715.529s, table=20, n_packets=5,
n_bytes=830, hard_timeout=300,priority=1,
vlan_tci=0x0001/0x0fff,dl_dst=fa:16:3e:a6:48:24
actions=load:0->NXM_OF_VLAN_TCI[],
load:0x3->NXM_NX_TUN_ID[],output:53
 cookie=0x0, duration=193729.242s, table=21, n_packets=58761,
n_bytes=2618498, dl_vlan=1 actions=strip_vlan,set_tunnel:0x3,
output:4,output:58,output:56,output:11,output:12,output:47,
output:13,output:48,output:49,output:44,output:43,output:45,
output:46,output:30,output:31,output:29,output:28,output:26,
output:27,output:24,output:25,output:32,output:19,output:21,
output:59,output:60,output:57,output:6,output:5,output:20,
output:18,output:17,output:16,output:15,output:14,output:7,
output:9,output:8,output:53,output:10,output:3,output:2,
output:38,output:37,output:39,output:40,output:34,output:23,
output:36,output:35,output:22,output:42,output:41,output:54,
output:52,output:51,output:50,output:55,output:33
```

Here, you see three flows related to this GRE tunnel. The first is the translation from inbound packets with this tunnel ID to internal VLAN ID 1. The second shows a unicast flow to output port 53 for packets destined for MAC address fa:16:3e:a6:48:24. The third shows the translation from the internal VLAN representation to the GRE tunnel ID flooded to all output ports. For further details of the flow descriptions, see the man page for `ovs-ofctl`. As in the previous VLAN example, numeric port IDs can be matched with their named representations by examining the output of `ovs-ofctl show br-tun`.

5. The packet is then received on the network node. Note that any traffic to the l3-agent or dhcp-agent will be visible only within their network namespace. Watching any interfaces outside those namespaces, even those that carry the network traffic, will only show broadcast packets like Address Resolution Protocols (ARPs), but unicast traffic to the router or DHCP address will not be seen. See *Dealing with Network Namespaces* for detail on how to run commands within these namespaces.

   Alternatively, it is possible to configure VLAN-based networks to use external routers rather than the l3-agent shown here, so long as the external router is on the same VLAN:

   (a) VLAN-based networks are received as tagged packets on a physical network interface, `eth1` in this example. Just as on the compute node, this interface is a member of the `br-eth1` bridge.

   (b) GRE-based networks will be passed to the tunnel bridge `br-tun`, which behaves just like the GRE interfaces on the compute node.

6. Next, the packets from either input go through the integration bridge, again just as on the compute node.

7. The packet then makes it to the l3-agent. This is actually another TAP device within the router's network namespace. Router namespaces are named in the form `qrouter-<router-uuid>`. Running **`ip a`** within the namespace will show the TAP device name, qr-e6256f7d-31 in this example:

```
# ip netns exec qrouter-e521f9d0-a1bd-4ff4-bc81-78a60dd88fe5 ip a | grep state
10: qr-e6256f7d-31: <BROADCAST,UP,LOWER_UP> mtu 1500 qdisc noqueue
    state UNKNOWN
11: qg-35916e1f-36: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500
    qdisc pfifo_fast state UNKNOWN qlen 500
28: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
```

8. The `qg-<n>` interface in the l3-agent router namespace sends the packet on to its next hop through device `eth2` on the external bridge `br-ex`. This bridge is constructed similarly to `br-eth1` and may be inspected in the same way.

9. This external bridge also includes a physical network interface, `eth2` in this example, which finally lands the packet on the external network destined for an external router or destination.

10. DHCP agents running on OpenStack networks run in namespaces similar to the l3-agents. DHCP namespaces are named `qdhcp-<uuid>` and have a TAP device on the integration bridge. Debugging of DHCP issues usually involves working inside this network namespace.

Finding a Failure in the Path

Use ping to quickly find where a failure exists in the network path. In an instance, first see whether you can ping an external host, such as google.com. If you can, then there shouldn't be a network problem at all.

If you can't, try pinging the IP address of the compute node where the instance is hosted. If you can ping this IP, then the problem is somewhere between the compute node and that compute node's gateway.

If you can't ping the IP address of the compute node, the problem is between the instance and the compute node. This includes the bridge connecting the compute node's main NIC with the vnet NIC of the instance.

One last test is to launch a second instance and see whether the two instances can ping each other. If they can, the issue might be related to the firewall on the compute node.

tcpdump

One great, although very in-depth, way of troubleshooting network issues is to use `tcpdump`. We recommended using `tcpdump` at several points along the network path to correlate where a problem might be. If you prefer working with a GUI, either live or by using a `tcpdump` capture, check out Wireshark.

For example, run the following command:

```
# tcpdump -i any -n -v 'icmp[icmptype] = icmp-echoreply or icmp[icmptype] = icmp-echo'
```

Run this on the command line of the following areas:

1. An external server outside of the cloud
2. A compute node
3. An instance running on that compute node

In this example, these locations have the following IP addresses:

```
Instance
    10.0.2.24
    203.0.113.30
Compute Node
    10.0.0.42
    203.0.113.34
External Server
    1.2.3.4
```

Next, open a new shell to the instance and then ping the external host where `tcpdump` is running. If the network path to the external server and back is fully functional, you see something like the following:

On the external server:

```
12:51:42.020227 IP (tos 0x0, ttl 61, id 0, offset 0, flags [DF],
proto ICMP (1), length 84)
    203.0.113.30 > 1.2.3.4: ICMP echo request, id 24895, seq 1, length 64
12:51:42.020255 IP (tos 0x0, ttl 64, id 8137, offset 0, flags [none],
proto ICMP (1), length 84)
    1.2.3.4 > 203.0.113.30: ICMP echo reply, id 24895, seq 1,
    length 64
```

On the compute node:

```
12:51:42.019519 IP (tos 0x0, ttl 64, id 0, offset 0, flags [DF],
proto ICMP (1), length 84)
    10.0.2.24 > 1.2.3.4: ICMP echo request, id 24895, seq 1, length 64
12:51:42.019519 IP (tos 0x0, ttl 64, id 0, offset 0, flags [DF],
proto ICMP (1), length 84)
    10.0.2.24 > 1.2.3.4: ICMP echo request, id 24895, seq 1, length 64
12:51:42.019545 IP (tos 0x0, ttl 63, id 0, offset 0, flags [DF],
proto ICMP (1), length 84)
    203.0.113.30 > 1.2.3.4: ICMP echo request, id 24895, seq 1, length 64
12:51:42.019780 IP (tos 0x0, ttl 62, id 8137, offset 0, flags [none],
proto ICMP (1), length 84)
    1.2.3.4 > 203.0.113.30: ICMP echo reply, id 24895, seq 1, length 64
12:51:42.019801 IP (tos 0x0, ttl 61, id 8137, offset 0, flags [none],
proto ICMP (1), length 84)
    1.2.3.4 > 10.0.2.24: ICMP echo reply, id 24895, seq 1, length 64
```

```
12:51:42.019807 IP (tos 0x0, ttl 61, id 8137, offset 0, flags [none],
proto ICMP (1), length 84)
    1.2.3.4 > 10.0.2.24: ICMP echo reply, id 24895, seq 1, length 64
```

On the instance:

```
12:51:42.020974 IP (tos 0x0, ttl 61, id 8137, offset 0, flags [none],
proto ICMP (1), length 84)
 1.2.3.4 > 10.0.2.24: ICMP echo reply, id 24895, seq 1, length 64
```

Here, the external server received the ping request and sent a ping reply. On the compute node, you can see that both the ping and ping reply successfully passed through. You might also see duplicate packets on the compute node, as seen above, because `tcpdump` captured the packet on both the bridge and outgoing interface.

iptables

Through `nova-network` or `neutron`, OpenStack Compute automatically manages iptables, including forwarding packets to and from instances on a compute node, forwarding floating IP traffic, and managing security group rules. In addition to managing the rules, comments (if supported) will be inserted in the rules to help indicate the purpose of the rule.

The following comments are added to the rule set as appropriate:

- Perform source NAT on outgoing traffic.
- Default drop rule for unmatched traffic.
- Direct traffic from the VM interface to the security group chain.
- Jump to the VM specific chain.
- Direct incoming traffic from VM to the security group chain.
- Allow traffic from defined IP/MAC pairs.
- Drop traffic without an IP/MAC allow rule.
- Allow DHCP client traffic.
- Prevent DHCP Spoofing by VM.
- Send unmatched traffic to the fallback chain.
- Drop packets that are not associated with a state.
- Direct packets associated with a known session to the RETURN chain.
- Allow IPv6 ICMP traffic to allow RA packets.

Run the following command to view the current iptables configuration:

```
# iptables-save
```

Note: If you modify the configuration, it reverts the next time you restart `nova-network` or `neutron-server`. You must use OpenStack to manage iptables.

Network Configuration in the Database for nova-network

With `nova-network`, the nova database table contains a few tables with networking information:

`fixed_ips` Contains each possible IP address for the subnet(s) added to Compute. This table is related to the `instances` table by way of the `fixed_ips.instance_uuid` column.

`floating_ips` Contains each floating IP address that was added to Compute. This table is related to the `fixed_ips` table by way of the `floating_ips.fixed_ip_id` column.

`instances` Not entirely network specific, but it contains information about the instance that is utilizing the `fixed_ip` and optional `floating_ip`.

From these tables, you can see that a floating IP is technically never directly related to an instance; it must always go through a fixed IP.

Manually Disassociating a Floating IP

Sometimes an instance is terminated but the floating IP was not correctly disassociated from that instance. Because the database is in an inconsistent state, the usual tools to disassociate the IP no longer work. To fix this, you must manually update the database.

First, find the UUID of the instance in question:

```
mysql> select uuid from instances where hostname = 'hostname';
```

Next, find the fixed IP entry for that UUID:

```
mysql> select * from fixed_ips where instance_uuid = '<uuid>';
```

You can now get the related floating IP entry:

```
mysql> select * from floating_ips where fixed_ip_id = '<fixed_ip_id>';
```

And finally, you can disassociate the floating IP:

```
mysql> update floating_ips set fixed_ip_id = NULL, host = NULL where
       fixed_ip_id = '<fixed_ip_id>';
```

You can optionally also deallocate the IP from the user's pool:

```
mysql> update floating_ips set project_id = NULL where
       fixed_ip_id = '<fixed_ip_id>';
```

Debugging DHCP Issues with nova-network

One common networking problem is that an instance boots successfully but is not reachable because it failed to obtain an IP address from dnsmasq, which is the DHCP server that is launched by the `nova-network` service.

The simplest way to identify that this is the problem with your instance is to look at the console output of your instance. If DHCP failed, you can retrieve the console log by doing:

```
$ openstack console log show <instance name or uuid>
```

If your instance failed to obtain an IP through DHCP, some messages should appear in the console. For example, for the Cirros image, you see output that looks like the following:

```
udhcpc (v1.17.2) started
Sending discover...
Sending discover...
Sending discover...
No lease, forking to background
starting DHCP forEthernet interface eth0 [ [1;32mOK[0;39m ]
cloud-setup: checking http://169.254.169.254/2009-04-04/meta-data/instance-id
wget: can't connect to remote host (169.254.169.254): Network is
unreachable
```

After you establish that the instance booted properly, the task is to figure out where the failure is.

A DHCP problem might be caused by a misbehaving dnsmasq process. First, debug by checking logs and then restart the dnsmasq processes only for that project (tenant). In VLAN mode, there is a dnsmasq process for each tenant. Once you have restarted targeted dnsmasq processes, the simplest way to rule out dnsmasq causes is to kill all of the dnsmasq processes on the machine and restart `nova-network`. As a last resort, do this as root:

```
# killall dnsmasq
# restart nova-network
```

Note: Use `openstack-nova-network` on RHEL/CentOS/Fedora but `nova-network` on Ubuntu/Debian.

Several minutes after `nova-network` is restarted, you should see new dnsmasq processes running:

```
# ps aux | grep dnsmasq
nobody 3735 0.0 0.0 27540 1044 ? S 15:40 0:00 /usr/sbin/dnsmasq --strict-order
    --bind-interfaces --conf-file=
    --domain=novalocal --pid-file=/var/lib/nova/networks/nova-br100.pid
    --listen-address=192.168.100.1 --except-interface=lo
    --dhcp-range=set:'novanetwork',192.168.100.2,static,120s
    --dhcp-lease-max=256
    --dhcp-hostsfile=/var/lib/nova/networks/nova-br100.conf
    --dhcp-script=/usr/bin/nova-dhcpbridge --leasefile-ro
root 3736 0.0 0.0 27512 444 ? S 15:40 0:00 /usr/sbin/dnsmasq --strict-order
     --bind-interfaces --conf-file=
     --domain=novalocal --pid-file=/var/lib/nova/networks/nova-br100.pid
     --listen-address=192.168.100.1 --except-interface=lo
     --dhcp-range=set:'novanetwork',192.168.100.2,static,120s
     --dhcp-lease-max=256
     --dhcp-hostsfile=/var/lib/nova/networks/nova-br100.conf
     --dhcp-script=/usr/bin/nova-dhcpbridge --leasefile-ro
```

If your instances are still not able to obtain IP addresses, the next thing to check is whether dnsmasq is seeing the DHCP requests from the instance. On the machine that is running the dnsmasq process, which is the compute host if running in multi-host mode, look at `/var/log/syslog` to see the dnsmasq output. If dnsmasq is seeing the request properly and handing out an IP, the output looks like this:

```
Feb 27 22:01:36 mynode dnsmasq-dhcp[2438]: DHCPDISCOVER(br100) fa:16:3e:56:0b:6f
Feb 27 22:01:36 mynode dnsmasq-dhcp[2438]: DHCPOFFER(br100) 192.168.100.3
                                           fa:16:3e:56:0b:6f
Feb 27 22:01:36 mynode dnsmasq-dhcp[2438]: DHCPREQUEST(br100) 192.168.100.3
```

```
                                           fa:16:3e:56:0b:6f
Feb 27 22:01:36 mynode dnsmasq-dhcp[2438]: DHCPACK(br100) 192.168.100.3
                                           fa:16:3e:56:0b:6f test
```

If you do not see the `DHCPDISCOVER`, a problem exists with the packet getting from the instance to the machine running dnsmasq. If you see all of the preceding output and your instances are still not able to obtain IP addresses, then the packet is able to get from the instance to the host running dnsmasq, but it is not able to make the return trip.

You might also see a message such as this:

```
Feb 27 22:01:36 mynode dnsmasq-dhcp[25435]: DHCPDISCOVER(br100)
            fa:16:3e:78:44:84 no address available
```

This may be a dnsmasq and/or `nova-network` related issue. (For the preceding example, the problem happened to be that dnsmasq did not have any more IP addresses to give away because there were no more fixed IPs available in the OpenStack Compute database.)

If there's a suspicious-looking dnsmasq log message, take a look at the command-line arguments to the dnsmasq processes to see if they look correct:

```
$ ps aux | grep dnsmasq
```

The output looks something like the following:

```
108 1695 0.0 0.0 25972 1000 ? S Feb26 0:00 /usr/sbin/dnsmasq
 -u libvirt-dnsmasq
 --strict-order --bind-interfaces
 --pid-file=/var/run/libvirt/network/default.pid --conf-file=
 --except-interface lo --listen-address 192.168.122.1
 --dhcp-range 192.168.122.2,192.168.122.254
 --dhcp-leasefile=/var/lib/libvirt/dnsmasq/default.leases
 --dhcp-lease-max=253 --dhcp-no-override
nobody 2438 0.0 0.0 27540 1096 ? S Feb26 0:00 /usr/sbin/dnsmasq
 --strict-order --bind-interfaces --conf-file=
 --domain=novalocal --pid-file=/var/lib/nova/networks/nova-br100.pid
 --listen-address=192.168.100.1
 --except-interface=lo
 --dhcp-range=set:'novanetwork',192.168.100.2,static,120s
 --dhcp-lease-max=256
 --dhcp-hostsfile=/var/lib/nova/networks/nova-br100.conf
 --dhcp-script=/usr/bin/nova-dhcpbridge --leasefile-ro
root 2439 0.0 0.0 27512 472 ? S Feb26 0:00 /usr/sbin/dnsmasq --strict-order
 --bind-interfaces --conf-file=
 --domain=novalocal --pid-file=/var/lib/nova/networks/nova-br100.pid
 --listen-address=192.168.100.1
 --except-interface=lo
 --dhcp-range=set:'novanetwork',192.168.100.2,static,120s
 --dhcp-lease-max=256
 --dhcp-hostsfile=/var/lib/nova/networks/nova-br100.conf
 --dhcp-script=/usr/bin/nova-dhcpbridge --leasefile-ro
```

The output shows three different dnsmasq processes. The dnsmasq process that has the DHCP subnet range of 192.168.122.0 belongs to libvirt and can be ignored. The other two dnsmasq processes belong to `nova-network`. The two processes are actually related—one is simply the parent process of the other. The arguments of the dnsmasq processes should correspond to the details you configured `nova-network` with.

If the problem does not seem to be related to dnsmasq itself, at this point use `tcpdump` on the interfaces to determine where the packets are getting lost.

DHCP traffic uses UDP. The client sends from port 68 to port 67 on the server. Try to boot a new instance and then systematically listen on the NICs until you identify the one that isn't seeing the traffic. To use `tcpdump` to listen to ports 67 and 68 on br100, you would do:

```
# tcpdump -i br100 -n port 67 or port 68
```

You should be doing sanity checks on the interfaces using command such as **`ip a`** and **`brctl show`** to ensure that the interfaces are actually up and configured the way that you think that they are.

Debugging DNS Issues

If you are able to use *SSH* to log into an instance, but it takes a very long time (on the order of a minute) to get a prompt, then you might have a DNS issue. The reason a DNS issue can cause this problem is that the SSH server does a reverse DNS lookup on the IP address that you are connecting from. If DNS lookup isn't working on your instances, then you must wait for the DNS reverse lookup timeout to occur for the SSH login process to complete.

When debugging DNS issues, start by making sure that the host where the dnsmasq process for that instance runs is able to correctly resolve. If the host cannot resolve, then the instances won't be able to either.

A quick way to check whether DNS is working is to resolve a hostname inside your instance by using the **`host`** command. If DNS is working, you should see:

```
$ host openstack.org
openstack.org has address 174.143.194.225
openstack.org mail is handled by 10 mx1.emailsrvr.com.
openstack.org mail is handled by 20 mx2.emailsrvr.com.
```

If you're running the Cirros image, it doesn't have the "host" program installed, in which case you can use ping to try to access a machine by hostname to see whether it resolves. If DNS is working, the first line of ping would be:

```
$ ping openstack.org
PING openstack.org (174.143.194.225): 56 data bytes
```

If the instance fails to resolve the hostname, you have a DNS problem. For example:

```
$ ping openstack.org
ping: bad address 'openstack.org'
```

In an OpenStack cloud, the dnsmasq process acts as the DNS server for the instances in addition to acting as the DHCP server. A misbehaving dnsmasq process may be the source of DNS-related issues inside the instance. As mentioned in the previous section, the simplest way to rule out a misbehaving dnsmasq process is to kill all the dnsmasq processes on the machine and restart `nova-network`. However, be aware that this command affects everyone running instances on this node, including tenants that have not seen the issue. As a last resort, as root:

```
# killall dnsmasq
# restart nova-network
```

After the dnsmasq processes start again, check whether DNS is working.

If restarting the dnsmasq process doesn't fix the issue, you might need to use `tcpdump` to look at the packets to trace where the failure is. The DNS server listens on UDP port 53. You should see the DNS request on the bridge (such as, br100) of your compute node. Let's say you start listening with `tcpdump` on the compute node:

```
# tcpdump -i br100 -n -v udp port 53
tcpdump: listening on br100, link-type EN10MB (Ethernet), capture size 65535 bytes
```

Then, if you use SSH to log into your instance and try `ping openstack.org`, you should see something like:

```
16:36:18.807518 IP (tos 0x0, ttl 64, id 56057, offset 0, flags [DF],
 proto UDP (17), length 59)
 192.168.100.4.54244 > 192.168.100.1.53: 2+ A? openstack.org. (31)
16:36:18.808285 IP (tos 0x0, ttl 64, id 0, offset 0, flags [DF],
 proto UDP (17), length 75)
 192.168.100.1.53 > 192.168.100.4.54244: 2 1/0/0 openstack.org. A
 174.143.194.225 (47)
```

Troubleshooting Open vSwitch

Open vSwitch, as used in the previous OpenStack Networking examples is a full-featured multilayer virtual switch licensed under the open source Apache 2.0 license. Full documentation can be found at the project's website. In practice, given the preceding configuration, the most common issues are being sure that the required bridges (`br-int`, `br-tun`, and `br-ex`) exist and have the proper ports connected to them.

The Open vSwitch driver should and usually does manage this automatically, but it is useful to know how to do this by hand with the **`ovs-vsctl`** command. This command has many more subcommands than we will use here; see the man page or use **`ovs-vsctl --help`** for the full listing.

To list the bridges on a system, use **`ovs-vsctl list-br`**. This example shows a compute node that has an internal bridge and a tunnel bridge. VLAN networks are trunked through the `eth1` network interface:

```
# ovs-vsctl list-br
br-int
br-tun
eth1-br
```

Working from the physical interface inwards, we can see the chain of ports and bridges. First, the bridge `eth1-br`, which contains the physical network interface `eth1` and the virtual interface `phy-eth1-br`:

```
# ovs-vsctl list-ports eth1-br
eth1
phy-eth1-br
```

Next, the internal bridge, `br-int`, contains `int-eth1-br`, which pairs with `phy-eth1-br` to connect to the physical network shown in the previous bridge, `patch-tun`, which is used to connect to the GRE tunnel bridge and the TAP devices that connect to the instances currently running on the system:

```
# ovs-vsctl list-ports br-int
int-eth1-br
patch-tun
tap2d782834-d1
tap690466bc-92
tap8a864970-2d
```

The tunnel bridge, `br-tun`, contains the `patch-int` interface and `gre-<N>` interfaces for each peer it connects to via GRE, one for each compute and network node in your cluster:

```
# ovs-vsctl list-ports br-tun
patch-int
gre-1
.
.
.
gre-<N>
```

If any of these links are missing or incorrect, it suggests a configuration error. Bridges can be added with `ovs-vsctl add-br`, and ports can be added to bridges with `ovs-vsctl add-port`. While running these by hand can be useful debugging, it is imperative that manual changes that you intend to keep be reflected back into your configuration files.

Dealing with Network Namespaces

Linux network namespaces are a kernel feature the networking service uses to support multiple isolated layer-2 networks with overlapping IP address ranges. The support may be disabled, but it is on by default. If it is enabled in your environment, your network nodes will run their dhcp-agents and l3-agents in isolated namespaces. Network interfaces and traffic on those interfaces will not be visible in the default namespace.

To see whether you are using namespaces, run **`ip netns`**:

```
# ip netns
qdhcp-e521f9d0-a1bd-4ff4-bc81-78a60dd88fe5
qdhcp-a4d00c60-f005-400e-a24c-1bf8b8308f98
qdhcp-fe178706-9942-4600-9224-b2ae7c61db71
qdhcp-0a1d0a27-cffa-4de3-92c5-9d3fd3f2e74d
qrouter-8a4ce760-ab55-4f2f-8ec5-a2e858ce0d39
```

L3-agent router namespaces are named `qrouter-<router_uuid>`, and dhcp-agent name spaces are named `qdhcp-<net_uuid>`. This output shows a network node with four networks running dhcp-agents, one of which is also running an l3-agent router. It's important to know which network you need to be working in. A list of existing networks and their UUIDs can be obtained by running `openstack network list` with administrative credentials.

Once you've determined which namespace you need to work in, you can use any of the debugging tools mention earlier by prefixing the command with `ip netns exec <namespace>`. For example, to see what network interfaces exist in the first qdhcp namespace returned above, do this:

```
# ip netns exec qdhcp-e521f9d0-a1bd-4ff4-bc81-78a60dd88fe5 ip a
10: tape6256f7d-31: <BROADCAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state UNKNOWN
    link/ether fa:16:3e:aa:f7:a1 brd ff:ff:ff:ff:ff:ff
    inet 10.0.1.100/24 brd 10.0.1.255 scope global tape6256f7d-31
    inet 169.254.169.254/16 brd 169.254.255.255 scope global tape6256f7d-31
    inet6 fe80::f816:3eff:feaa:f7a1/64 scope link
    valid_lft forever preferred_lft forever
28: lo: <LOOPBACK,UP,LOWER_UP> mtu 16436 qdisc noqueue state UNKNOWN
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
    inet6 ::1/128 scope host
    valid_lft forever preferred_lft forever
```

From this you see that the DHCP server on that network is using the `tape6256f7d-31` device and has an IP address of `10.0.1.100`. Seeing the address `169.254.169.254`, you can also see that the dhcp-agent is running a metadata-proxy service. Any of the commands mentioned previously in this chapter can be run in the same way. It is also possible to run a shell, such as `bash`, and have an interactive session within the namespace. In the latter case, exiting the shell returns you to the top-level default namespace.

Assign a lost IPv4 address back to a project

1. Using administrator credentials, confirm the lost IP address is still available:

```
# openstack server list --all-project | grep 'IP-ADDRESS'
```

2. Create a port:

```
$ openstack port create --network NETWORK_ID PORT_NAME
```

3. Update the new port with the IPv4 address:

```
# openstack subnet list
# neutron port-update PORT_NAME --request-format=json --fixed-ips \
type=dict list=true subnet_id=NETWORK_ID_IPv4_SUBNET_ID \
ip_address=IP_ADDRESS  subnet_id=NETWORK_ID_IPv6_SUBNET_ID
# openstack port show PORT-NAME
```

Tools for automated neutron diagnosis

easyOVS is a useful tool when it comes to operating your OpenvSwitch bridges and iptables on your OpenStack platform. It automatically associates the virtual ports with the VM MAC/IP, VLAN tag and namespace information, as well as the iptables rules for VMs.

Don is another convenient network analysis and diagnostic system that provides a completely automated service for verifying and diagnosing the networking functionality provided by OVS.

Additionally, you can refer to neutron debug for more options.

Logging and Monitoring

Logging

Where Are the Logs?

Most services use the convention of writing their log files to subdirectories of the `/var/log directory`, as listed in *Table OpenStack log locations*.

Table 7: Table OpenStack log locations

Node type	Service	Log location
Cloud controller	`nova-*`	`/var/log/nova`
Cloud controller	`glance-*`	`/var/log/glance`
Cloud controller	`cinder-*`	`/var/log/cinder`
Cloud controller	`keystone-*`	`/var/log/keystone`
Cloud controller	`neutron-*`	`/var/log/neutron`
Cloud controller	horizon	`/var/log/apache2/`
All nodes	misc (swift, dnsmasq)	`/var/log/syslog`
Compute nodes	libvirt	`/var/log/libvirt/libvirtd.log`
Compute nodes	Console (boot up messages) for VM instances:	`/var/lib/nova/instances/instance-<instance id>/console.log`
Block Storage nodes	cinder-volume	`/var/log/cinder/cinder-volume.log`

Reading the Logs

OpenStack services use the standard logging levels, at increasing severity: TRACE, DEBUG, INFO, AUDIT, WARNING, ERROR, and CRITICAL. That is, messages only appear in the logs if they are more "severe" than the particular log level, with DEBUG allowing all log statements through. For example, TRACE is logged only if the software has a stack trace, while INFO is logged for every message including those that are only for information.

To disable DEBUG-level logging, edit `/etc/nova/nova.conf` file as follows:

```
debug=false
```

Keystone is handled a little differently. To modify the logging level, edit the `/etc/keystone/logging.conf` file and look at the `logger_root` and `handler_file` sections.

Logging for horizon is configured in `/etc/openstack_dashboard/local_settings.py`. Because horizon is a Django web application, it follows the Django Logging framework conventions.

The first step in finding the source of an error is typically to search for a CRITICAL, or ERROR message in the log starting at the bottom of the log file.

Here is an example of a log message with the corresponding ERROR (Python traceback) immediately following:

```
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server [req-c0b38ace-2586-48ce-9336-
↪6233efa1f035 6c9808c2c5044e1388a83a74da9364d5 e07f5395c
2eb428cafc41679e7deeab1 - default default] Exception during message handling
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server Traceback (most recent call
↪last):
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/oslo_messaging/rpc/server.py", line 133, in _
↪process_incoming
```

```
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     res = self.dispatcher.
↪dispatch(message)
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/oslo_messaging/rpc/dispatcher.py", line 150, in
↪dispatch
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     return self._do_
↪dispatch(endpoint, method, ctxt, args)
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/oslo_messaging/rpc/dispatcher.py", line 121, in
↪_do_dispatch
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     result = func(ctxt, **new_
↪args)
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/cinder/volume/manager.py", line 4366, in create_
↪volume
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     allow_reschedule=allow_
↪reschedule, volume=volume)
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/cinder/volume/manager.py", line 634, in create_
↪volume
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     _run_flow()
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/cinder/volume/manager.py", line 626, in _run_
↪flow
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     flow_engine.run()
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/taskflow/engines/action_engine/engine.py", line
↪247, in run
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     for _state in self.run_
↪iter(timeout=timeout):
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/taskflow/engines/action_engine/engine.py", line
↪340, in run_iter
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     failure.Failure.reraise_
↪if_any(er_failures)
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/taskflow/types/failure.py", line 336, in
↪reraise_if_any
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server     failures[0].reraise()
2017-01-18 15:54:00.467 32552 ERROR oslo_messaging.rpc.server   File "/openstack/venvs/
↪cinder-14.0.0/lib/python2.7/site-packages/taskflow/types/failure.py", line 343, in reraise
```

In this example, `cinder-volumes` failed to start and has provided a stack trace, since its volume back end has been unable to set up the storage volume—probably because the LVM volume that is expected from the configuration does not exist.

Here is an example error log:

```
2013-02-25 20:26:33 6619 ERROR nova.openstack.common.rpc.common [-] AMQP server on
↪localhost:5672 is unreachable:
 [Errno 111] ECONNREFUSED. Trying again in 23 seconds.
```

In this error, a nova service has failed to connect to the RabbitMQ server because it got a connection refused error.

Tracing Instance Requests

When an instance fails to behave properly, you will often have to trace activity associated with that instance across the log files of various `nova-*` services and across both the cloud controller and compute nodes.

The typical way is to trace the UUID associated with an instance across the service logs.

Consider the following example:

```
$ openstack server list
+--------------------------------+--------+--------+--------------------------+------------+
| ID                             | Name   | Status | Networks                 | Image Name |
+--------------------------------+--------+--------+--------------------------+------------+
| fafed8-4a46-413b-b113-f1959ffe | cirros | ACTIVE | novanetwork=192.168.100.3| cirros     |
+--------------------------------------+--------+--------+--------------------+------------+
```

Here, the ID associated with the instance is `faf7ded8-4a46-413b-b113-f19590746ffe`. If you search for this string on the cloud controller in the `/var/log/nova-*.log` files, it appears in `nova-api.log` and `nova-scheduler.log`. If you search for this on the compute nodes in `/var/log/nova-*.log`, it appears in `nova-compute.log`. If no ERROR or CRITICAL messages appear, the most recent log entry that reports this may provide a hint about what has gone wrong.

Adding Custom Logging Statements

If there is not enough information in the existing logs, you may need to add your own custom logging statements to the `nova-*` services.

The source files are located in `/usr/lib/python2.7/dist-packages/nova`.

To add logging statements, the following line should be near the top of the file. For most files, these should already be there:

```
from nova.openstack.common import log as logging
LOG = logging.getLogger(__name__)
```

To add a DEBUG logging statement, you would do:

```
LOG.debug("This is a custom debugging statement")
```

You may notice that all the existing logging messages are preceded by an underscore and surrounded by parentheses, for example:

```
LOG.debug(_("Logging statement appears here"))
```

This formatting is used to support translation of logging messages into different languages using the gettext internationalization library. You don't need to do this for your own custom log messages. However, if you want to contribute the code back to the OpenStack project that includes logging statements, you must surround your log messages with underscores and parentheses.

RabbitMQ Web Management Interface or rabbitmqctl

Aside from connection failures, RabbitMQ log files are generally not useful for debugging OpenStack related issues. Instead, we recommend you use the RabbitMQ web management interface. Enable it on your cloud controller:

```
# /usr/lib/rabbitmq/bin/rabbitmq-plugins enable rabbitmq_management
```

```
# service rabbitmq-server restart
```

The RabbitMQ web management interface is accessible on your cloud controller at *http://localhost:55672*.

Note: Ubuntu 12.04 installs RabbitMQ version 2.7.1, which uses port 55672. RabbitMQ versions 3.0 and above use port 15672 instead. You can check which version of RabbitMQ you have running on your local Ubuntu machine by doing:

```
$ dpkg -s rabbitmq-server | grep "Version:"
Version: 2.7.1-0ubuntu4
```

An alternative to enabling the RabbitMQ web management interface is to use the `rabbitmqctl` commands. For example, **`rabbitmqctl list_queues| grep cinder`** displays any messages left in the queue. If there are messages, it's a possible sign that cinder services didn't connect properly to rabbitmq and might have to be restarted.

Items to monitor for RabbitMQ include the number of items in each of the queues and the processing time statistics for the server.

Centrally Managing Logs

Because your cloud is most likely composed of many servers, you must check logs on each of those servers to properly piece an event together. A better solution is to send the logs of all servers to a central location so that they can all be accessed from the same area.

The choice of central logging engine will be dependent on the operating system in use as well as any organizational requirements for logging tools.

Syslog choices

There are a large number of syslogs engines available, each have differing capabilities and configuration requirements.

rsyslog

A number of operating systems use rsyslog as the default logging service. Since it is natively able to send logs to a remote location, you do not have to install anything extra to enable this feature, just modify the configuration file. In doing this, consider running your logging over a management network or using an encrypted VPN to avoid interception.

rsyslog client configuration

To begin, configure all OpenStack components to log to the syslog log file in addition to their standard log file location. Also, configure each component to log to a different syslog facility. This makes it easier to split the logs into individual components on the central server:

`nova.conf`:

```
use_syslog=True
syslog_log_facility=LOG_LOCAL0
```

`glance-api.conf` and `glance-registry.conf`:

```
use_syslog=True
syslog_log_facility=LOG_LOCAL1
```

`cinder.conf`:

```
use_syslog=True
syslog_log_facility=LOG_LOCAL2
```

`keystone.conf`:

```
use_syslog=True
syslog_log_facility=LOG_LOCAL3
```

By default, Object Storage logs to syslog.

Next, create `/etc/rsyslog.d/client.conf` with the following line:

```
*.* @192.168.1.10
```

This instructs rsyslog to send all logs to the IP listed. In this example, the IP points to the cloud controller.

rsyslog server configuration

Designate a server as the central logging server. The best practice is to choose a server that is solely dedicated to this purpose. Create a file called `/etc/rsyslog.d/server.conf` with the following contents:

```
# Enable UDP
$ModLoad imudp
# Listen on 192.168.1.10 only
$UDPServerAddress 192.168.1.10
# Port 514
$UDPServerRun 514

# Create logging templates for nova
$template NovaFile,"/var/log/rsyslog/%HOSTNAME%/nova.log"
$template NovaAll,"/var/log/rsyslog/nova.log"

# Log everything else to syslog.log
$template DynFile,"/var/log/rsyslog/%HOSTNAME%/syslog.log"
*.* ?DynFile

# Log various openstack components to their own individual file
local0.* ?NovaFile
local0.* ?NovaAll
& ~
```

This example configuration handles the nova service only. It first configures rsyslog to act as a server that runs on port 514. Next, it creates a series of logging templates. Logging templates control where received logs are stored. Using the last example, a nova log from c01.example.com goes to the following locations:

- `/var/log/rsyslog/c01.example.com/nova.log`
- `/var/log/rsyslog/nova.log`

This is useful, as logs from c02.example.com go to:

- `/var/log/rsyslog/c02.example.com/nova.log`
- `/var/log/rsyslog/nova.log`

This configuration will result in a separate log file for each compute node as well as an aggregated log file that contains nova logs from all nodes.

Monitoring

There are two types of monitoring: watching for problems and watching usage trends. The former ensures that all services are up and running, creating a functional cloud. The latter involves monitoring resource usage over time in order to make informed decisions about potential bottlenecks and upgrades.

Process Monitoring

A basic type of alert monitoring is to simply check and see whether a required process is running. For example, ensure that the `nova-api` service is running on the cloud controller:

```
# ps aux | grep nova-api
nova 12786 0.0 0.0 37952 1312 ? Ss Feb11 0:00 su -s /bin/sh -c exec nova-api
--config-file=/etc/nova/nova.conf nova
nova 12787 0.0 0.1 135764 57400 ? S Feb11 0:01 /usr/bin/python
 /usr/bin/nova-api --config-file=/etc/nova/nova.conf
nova 12792 0.0 0.0 96052 22856 ? S Feb11 0:01 /usr/bin/python
/usr/bin/nova-api --config-file=/etc/nova/nova.conf
nova 12793 0.0 0.3 290688 115516 ? S Feb11 1:23 /usr/bin/python
/usr/bin/nova-api --config-file=/etc/nova/nova.conf
nova 12794 0.0 0.2 248636 77068 ? S Feb11 0:04 /usr/bin/python
/usr/bin/nova-api --config-file=/etc/nova/nova.conf
root 24121 0.0 0.0 11688 912 pts/5 S+ 13:07 0:00 grep nova-api
```

The OpenStack processes that should be monitored depend on the specific configuration of the environment, but can include:

Compute service (nova)

- nova-api
- nova-scheduler
- nova-conductor
- nova-novncproxy
- nova-compute

Block Storage service (cinder)

- cinder-volume
- cinder-api
- cinder-scheduler

Networking service (neutron)

- neutron-api
- neutron-server
- neutron-openvswitch-agent
- neutron-dhcp-agent
- neutron-l3-agent
- neutron-metadata-agent

Image service (glance)

- glance-api
- glance-registry

Identity service (keystone)

The keystone processes are run within Apache as WSGI applications.

Resource Alerting

Resource alerting provides notifications when one or more resources are critically low. While the monitoring thresholds should be tuned to your specific OpenStack environment, monitoring resource usage is not specific to OpenStack at all—any generic type of alert will work fine.

Some of the resources that you want to monitor include:

- Disk usage
- Server load
- Memory usage
- Network I/O
- Available vCPUs

Telemetry Service

The Telemetry service (*ceilometer*) collects metering and event data relating to OpenStack services. Data collected by the Telemetry service could be used for billing. Depending on deployment configuration, collected data may be accessible to users based on the deployment configuration. The Telemetry service provides a REST API documented at ceilometer V2 Web API. You can read more about the module in the OpenStack Administrator Guide or in the developer documentation.

OpenStack Specific Resources

Resources such as memory, disk, and CPU are generic resources that all servers (even non-OpenStack servers) have and are important to the overall health of the server. When dealing with OpenStack specifically, these resources are important for a second reason: ensuring that enough are available to launch instances. There are a few ways you can see OpenStack resource usage. The first is through the **nova** command:

```
# openstack usage list
```

This command displays a list of how many instances a tenant has running and some light usage statistics about the combined instances. This command is useful for a quick overview of your cloud, but it doesn't really get into a lot of details.

Next, the nova database contains three tables that store usage information.

The `nova.quotas` and `nova.quota_usages` tables store quota information. If a tenant's quota is different from the default quota settings, its quota is stored in the `nova.quotas` table. For example:

```
mysql> select project_id, resource, hard_limit from quotas;
+----------------------------------+-----------------------------+------------+
| project_id                       | resource                    | hard_limit |
+----------------------------------+-----------------------------+------------+
| 628df59f091142399e0689a2696f5baa | metadata_items              | 128        |
| 628df59f091142399e0689a2696f5baa | injected_file_content_bytes | 10240      |
| 628df59f091142399e0689a2696f5baa | injected_files              | 5          |
| 628df59f091142399e0689a2696f5baa | gigabytes                   | 1000       |
| 628df59f091142399e0689a2696f5baa | ram                         | 51200      |
| 628df59f091142399e0689a2696f5baa | floating_ips                | 10         |
| 628df59f091142399e0689a2696f5baa | instances                   | 10         |
| 628df59f091142399e0689a2696f5baa | volumes                     | 10         |
| 628df59f091142399e0689a2696f5baa | cores                       | 20         |
+----------------------------------+-----------------------------+------------+
```

The `nova.quota_usages` table keeps track of how many resources the tenant currently has in use:

```
mysql> select project_id, resource, in_use from quota_usages where project_id like '628%';
+----------------------------------+--------------+--------+
| project_id                       | resource     | in_use |
+----------------------------------+--------------+--------+
| 628df59f091142399e0689a2696f5baa | instances    | 1      |
| 628df59f091142399e0689a2696f5baa | ram          | 512    |
| 628df59f091142399e0689a2696f5baa | cores        | 1      |
| 628df59f091142399e0689a2696f5baa | floating_ips | 1      |
| 628df59f091142399e0689a2696f5baa | volumes      | 2      |
| 628df59f091142399e0689a2696f5baa | gigabytes    | 12     |
| 628df59f091142399e0689a2696f5baa | images       | 1      |
+----------------------------------+--------------+--------+
```

By comparing a tenant's hard limit with their current resource usage, you can see their usage percentage. For example, if this tenant is using 1 floating IP out of 10, then they are using 10 percent of their floating IP quota. Rather than doing the calculation manually, you can use SQL or the scripting language of your choice and create a formatted report:

```
+-----------------------------------+------------+-------------+---------------+
| some_tenant                                                                  |
+-----------------------------------+------------+-------------+---------------+
| Resource                          | Used       | Limit       |               |
+-----------------------------------+------------+-------------+---------------+
| cores                             | 1          | 20          |           5 % |
| floating_ips                      | 1          | 10          |          10 % |
| gigabytes                         | 12         | 1000        |           1 % |
| images                            | 1          | 4           |          25 % |
| injected_file_content_bytes       | 0          | 10240       |           0 % |
| injected_file_path_bytes          | 0          | 255         |           0 % |
```

```
| injected_files                   | 0          | 5          |             0 % |
| instances                        | 1          | 10         |            10 % |
| key_pairs                        | 0          | 100        |             0 % |
| metadata_items                   | 0          | 128        |             0 % |
| ram                              | 512        | 51200      |             1 % |
| reservation_expire               | 0          | 86400      |             0 % |
| security_group_rules             | 0          | 20         |             0 % |
| security_groups                  | 0          | 10         |             0 % |
| volumes                          | 2          | 10         |            20 % |
+----------------------------------+------------+------------+---------------+
```

The preceding information was generated by using a custom script that can be found on GitHub.

Note: This script is specific to a certain OpenStack installation and must be modified to fit your environment. However, the logic should easily be transferable.

Intelligent Alerting

Intelligent alerting can be thought of as a form of continuous integration for operations. For example, you can easily check to see whether the Image service is up and running by ensuring that the `glance-api` and `glance-registry` processes are running or by seeing whether `glance-api` is responding on port 9292.

But how can you tell whether images are being successfully uploaded to the Image service? Maybe the disk that Image service is storing the images on is full or the S3 back end is down. You could naturally check this by doing a quick image upload:

```
#!/bin/bash
#
# assumes that reasonable credentials have been stored at
# /root/auth


. /root/openrc
wget http://download.cirros-cloud.net/0.3.5/cirros-0.3.5-x86_64-disk.img
openstack image create --name='cirros image' --public \
--container-format=bare --disk-format=qcow2 \
--file cirros-0.3.5-x86_64-disk.img
```

By taking this script and rolling it into an alert for your monitoring system (such as Nagios), you now have an automated way of ensuring that image uploads to the Image Catalog are working.

Note: You must remove the image after each test. Even better, test whether you can successfully delete an image from the Image service.

Intelligent alerting takes considerably more time to plan and implement than the other alerts described in this chapter. A good outline to implement intelligent alerting is:

- Review common actions in your cloud.
- Create ways to automatically test these actions.
- Roll these tests into an alerting system.

Some other examples for Intelligent Alerting include:

- Can instances launch and be destroyed?
- Can users be created?
- Can objects be stored and deleted?
- Can volumes be created and destroyed?

Trending

Trending can give you great insight into how your cloud is performing day to day. You can learn, for example, if a busy day was simply a rare occurrence or if you should start adding new compute nodes.

Trending takes a slightly different approach than alerting. While alerting is interested in a binary result (whether a check succeeds or fails), trending records the current state of something at a certain point in time. Once enough points in time have been recorded, you can see how the value has changed over time.

All of the alert types mentioned earlier can also be used for trend reporting. Some other trend examples include:

- The number of instances on each compute node
- The types of flavors in use
- The number of volumes in use
- The number of Object Storage requests each hour
- The number of `nova-api` requests each hour
- The I/O statistics of your storage services

As an example, recording `nova-api` usage can allow you to track the need to scale your cloud controller. By keeping an eye on `nova-api` requests, you can determine whether you need to spawn more `nova-api` processes or go as far as introducing an entirely new server to run `nova-api`. To get an approximate count of the requests, look for standard INFO messages in `/var/log/nova/nova-api.log`:

```
# grep INFO /var/log/nova/nova-api.log | wc
```

You can obtain further statistics by looking for the number of successful requests:

```
# grep " 200 " /var/log/nova/nova-api.log | wc
```

By running this command periodically and keeping a record of the result, you can create a trending report over time that shows whether your `nova-api` usage is increasing, decreasing, or keeping steady.

A tool such as **collectd** can be used to store this information. While collectd is out of the scope of this book, a good starting point would be to use collectd to store the result as a COUNTER data type. More information can be found in collectd's documentation.

Monitoring Tools

Nagios

Nagios is an open source monitoring service. It is capable of executing arbitrary commands to check the status of server and network services, remotely executing arbitrary commands directly on servers, and allowing servers to push notifications back in the form of passive monitoring. Nagios has been around since 1999. Although newer monitoring services are available, Nagios is a tried-and-true systems administration staple.

You can create automated alerts for critical processes by using Nagios and NRPE. For example, to ensure that the `nova-compute` process is running on the compute nodes, create an alert on your Nagios server:

```
define service {
    host_name c01.example.com
    check_command check_nrpe_1arg!check_nova-compute
    use generic-service
    notification_period 24x7
    contact_groups sysadmins
    service_description nova-compute
}
```

On the Compute node, create the following NRPE configuration:

```
command[check_nova-compute]=/usr/lib/nagios/plugins/check_procs -c 1: -a nova-compute
```

Nagios checks that at least one `nova-compute` service is running at all times.

For resource alerting, for example, monitor disk capacity on a compute node with Nagios, add the following to your Nagios configuration:

```
define service {
    host_name c01.example.com
    check_command check_nrpe!check_all_disks!20% 10%
    use generic-service
    contact_groups sysadmins
    service_description Disk
}
```

On the compute node, add the following to your NRPE configuration:

```
command[check_all_disks]=/usr/lib/nagios/plugins/check_disk -w $ARG1$ -c $ARG2$ -e
```

Nagios alerts you with a *WARNING* when any disk on the compute node is 80 percent full and *CRITICAL* when 90 percent is full.

StackTach

StackTach is a tool that collects and reports the notifications sent by nova. Notifications are essentially the same as logs but can be much more detailed. Nearly all OpenStack components are capable of generating notifications when significant events occur. Notifications are messages placed on the OpenStack queue (generally RabbitMQ) for consumption by downstream systems. An overview of notifications can be found at System Usage Data.

To enable nova to send notifications, add the following to the `nova.conf` configuration file:

```
notification_topics=monitor
notification_driver=messagingv2
```

Once nova is sending notifications, install and configure StackTach. StackTach works for queue consumption and pipeline processing are configured to read these notifications from RabbitMQ servers and store them in a database. Users can inquire on instances, requests, and servers by using the browser interface or command-line tool, Stacky. Since StackTach is relatively new and constantly changing, installation instructions quickly become outdated. Refer to the StackTach Git repository for instructions as well as a demostration video. Additional details on the latest developments can be discovered at the official page

Logstash

Logstash is a high performance indexing and search engine for logs. Logs from Jenkins test runs are sent to logstash where they are indexed and stored. Logstash facilitates reviewing logs from multiple sources in a single test run, searching for errors or particular events within a test run, and searching for log event trends across test runs.

There are four major layers in Logstash setup which are:

- Log Pusher
- Log Indexer
- ElasticSearch
- Kibana

Each layer scales horizontally. As the number of logs grows you can add more log pushers, more Logstash indexers, and more ElasticSearch nodes.

Logpusher is a pair of Python scripts that first listens to Jenkins build events, then converts them into Gearman jobs. Gearman provides a generic application framework to farm out work to other machines or processes that are better suited to do the work. It allows you to do work in parallel, to load balance processing, and to call functions between languages. Later, Logpusher performs Gearman jobs to push log files into logstash. Logstash indexer reads these log events, filters them to remove unwanted lines, collapse multiple events together, and parses useful information before shipping them to ElasticSearch for storage and indexing. Kibana is a logstash oriented web client for ElasticSearch.

Summary

For stable operations, you want to detect failure promptly and determine causes efficiently. With a distributed system, it's even more important to track the right items to meet a service-level target. Learning where these logs are located in the file system or API gives you an advantage. This chapter also showed how to read, interpret, and manipulate information from OpenStack services so that you can monitor effectively.

As an OpenStack cloud is composed of so many different services, there are a large number of log files. This chapter aims to assist you in locating and working with them and describes other ways to track the status of your deployment.

Backup and Recovery

Standard backup best practices apply when creating your OpenStack backup policy. For example, how often to back up your data is closely related to how quickly you need to recover from data loss.

Note: If you cannot have any data loss at all, you should also focus on a highly available deployment. The OpenStack High Availability Guide offers suggestions for elimination of a single point of failure that could cause system downtime. While it is not a completely prescriptive document, it offers methods and techniques for avoiding downtime and data loss.

Other backup considerations include:

- How many backups to keep?
- Should backups be kept off-site?
- How often should backups be tested?

Just as important as a backup policy is a recovery policy (or at least recovery testing).

What to Back Up

While OpenStack is composed of many components and moving parts, backing up the critical data is quite simple.

This chapter describes only how to back up configuration files and databases that the various OpenStack components need to run. This chapter does not describe how to back up objects inside Object Storage or data contained inside Block Storage. Generally these areas are left for users to back up on their own.

Database Backups

The example OpenStack architecture designates the cloud controller as the MySQL server. This MySQL server hosts the databases for nova, glance, cinder, and keystone. With all of these databases in one place, it's very easy to create a database backup:

```
# mysqldump --opt --all-databases > openstack.sql
```

If you only want to backup a single database, you can instead run:

```
# mysqldump --opt nova > nova.sql
```

where `nova` is the database you want to back up.

You can easily automate this process by creating a cron job that runs the following script once per day:

```
#!/bin/bash
backup_dir="/var/lib/backups/mysql"
filename="${backup_dir}/mysql-`hostname`-`eval date +%Y%m%d`.sql.gz"
# Dump the entire MySQL database
/usr/bin/mysqldump --opt --all-databases | gzip > $filename
# Delete backups older than 7 days
find $backup_dir -ctime +7 -type f -delete
```

This script dumps the entire MySQL database and deletes any backups older than seven days.

File System Backups

This section discusses which files and directories should be backed up regularly, organized by service.

Compute

The `/etc/nova` directory on both the cloud controller and compute nodes should be regularly backed up.

`/var/log/nova` does not need to be backed up if you have all logs going to a central area. It is highly recommended to use a central logging server or back up the log directory.

`/var/lib/nova` is another important directory to back up. The exception to this is the `/var/lib/nova/instances` subdirectory on compute nodes. This subdirectory contains the KVM images of running instances. You would want to back up this directory only if you need to maintain backup copies of all instances. Under most circumstances, you do not need to do this, but this can vary from cloud to cloud and your service levels. Also be aware that making a backup of a live KVM instance can cause that instance to not boot properly if it is ever restored from a backup.

Image Catalog and Delivery

`/etc/glance` and `/var/log/glance` follow the same rules as their nova counterparts.

`/var/lib/glance` should also be backed up. Take special notice of `/var/lib/glance/images`. If you are using a file-based back end of glance, `/var/lib/glance/images` is where the images are stored and care should be taken.

There are two ways to ensure stability with this directory. The first is to make sure this directory is run on a RAID array. If a disk fails, the directory is available. The second way is to use a tool such as rsync to replicate the images to another server:

```
# rsync -az --progress /var/lib/glance/images backup-server:/var/lib/glance/images/
```

Identity

`/etc/keystone` and `/var/log/keystone` follow the same rules as other components.

`/var/lib/keystone`, although it should not contain any data being used, can also be backed up just in case.

Block Storage

`/etc/cinder` and `/var/log/cinder` follow the same rules as other components.

`/var/lib/cinder` should also be backed up.

Networking

`/etc/neutron` and `/var/log/neutron` follow the same rules as other components.

`/var/lib/neutron` should also be backed up.

Object Storage

`/etc/swift` is very important to have backed up. This directory contains the swift configuration files as well as the ring files and ring *builder files*, which if lost, render the data on your cluster inaccessible. A best practice is to copy the builder files to all storage nodes along with the ring files. Multiple backup copies are spread throughout your storage cluster.

Telemetry

Back up the `/etc/ceilometer` directory containing Telemetry configuration files.

Orchestration

Back up HOT template `yaml` files, and the `/etc/heat/` directory containing Orchestration configuration files.

Recovering Backups

Recovering backups is a fairly simple process. To begin, first ensure that the service you are recovering is not running. For example, to do a full recovery of nova on the cloud controller, first stop all nova services:

```
# stop nova-api
# stop nova-consoleauth
# stop nova-novncproxy
# stop nova-objectstore
# stop nova-scheduler
```

Now you can import a previously backed-up database:

```
# mysql nova < nova.sql
```

You can also restore backed-up nova directories:

```
# mv /etc/nova{,.orig}
# cp -a /path/to/backup/nova /etc/
```

Once the files are restored, start everything back up:

```
# start mysql
# for i in nova-api nova-consoleauth nova-novncproxy \
  nova-objectstore nova-scheduler
> do
> start $i
> done
```

Other services follow the same process, with their respective directories and databases.

Summary

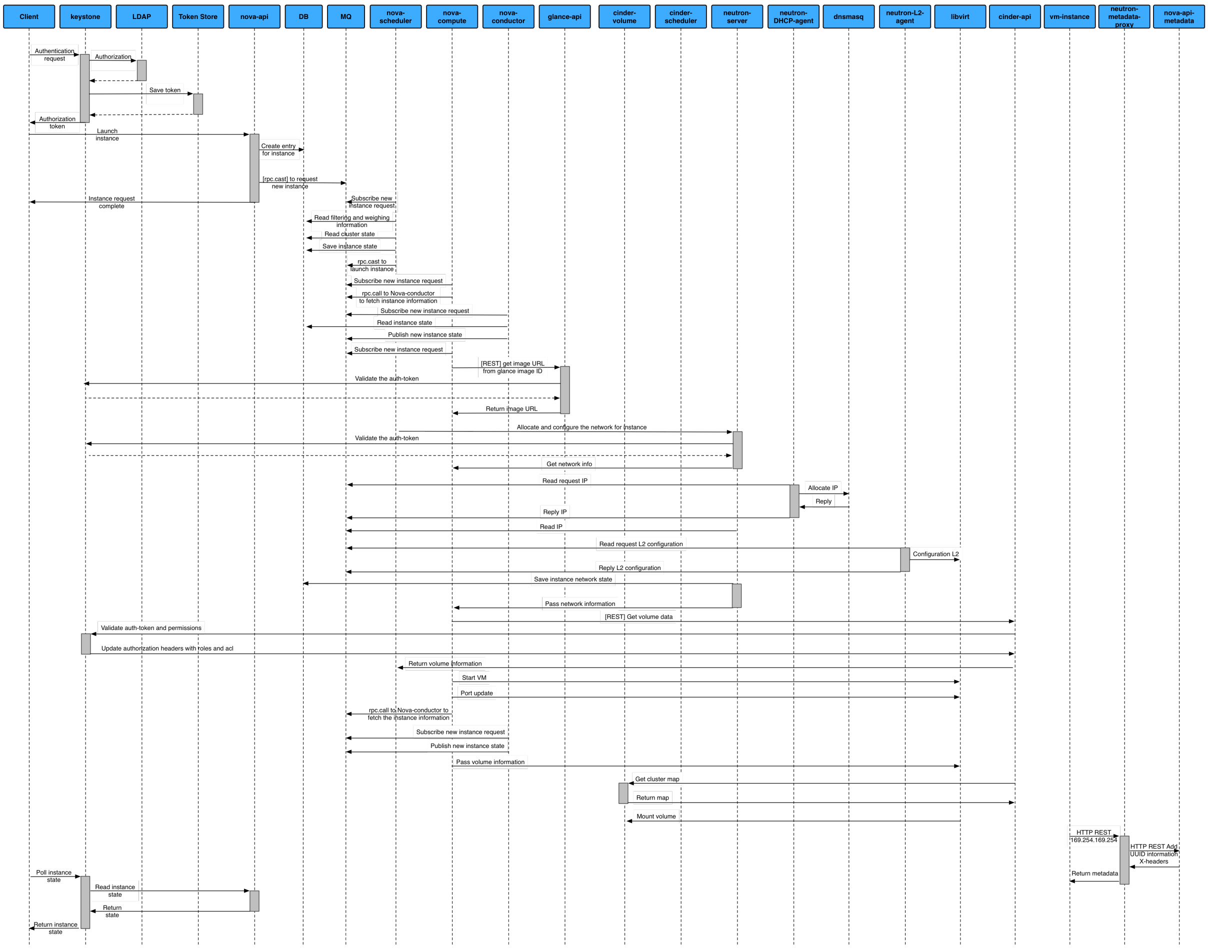
Backup and subsequent recovery is one of the first tasks system administrators learn. However, each system has different items that need attention. By taking care of your database, image service, and appropriate file system locations, you can be assured that you can handle any event requiring recovery.

Customization

Provision an instance

To help understand how OpenStack works, this section describes the end-to-end process and interaction of components when provisioning an instance on OpenStack.

Provision an instance



Create an OpenStack Development Environment

To create a development environment, you can use DevStack. DevStack is essentially a collection of shell scripts and configuration files that builds an OpenStack development environment for you. You use it to create such an environment for developing a new feature.

For more information on installing DevStack, see the DevStack website.

Customizing Object Storage (Swift) Middleware

OpenStack Object Storage, known as swift when reading the code, is based on the Python Paste framework. The best introduction to its architecture is A Do-It-Yourself Framework. Because of the swift project's use of this framework, you are able to add features to a project by placing some custom code in a project's pipeline without having to change any of the core code.

Imagine a scenario where you have public access to one of your containers, but what you really want is to restrict access to that to a set of IPs based on a whitelist. In this example, we'll create a piece of middleware for swift that allows access to a container from only a set of IP addresses, as determined by the container's metadata items. Only those IP addresses that you explicitly whitelist using the container's metadata will be able to access the container.

Warning: This example is for illustrative purposes only. It should not be used as a container IP whitelist solution without further development and extensive security testing.

When you join the screen session that `stack.sh` starts with `screen -r stack`, you see a screen for each service running, which can be a few or several, depending on how many services you configured DevStack to run.

The asterisk * indicates which screen window you are viewing. This example shows we are viewing the key (for keystone) screen window:

```
0$ shell  1$ key*  2$ horizon  3$ s-proxy  4$ s-object  5$ s-container  6$ s-account
```

The purpose of the screen windows are as follows:

`shell` A shell where you can get some work done

`key*` The keystone service

`horizon` The horizon dashboard web application

`s-{name}` The swift services

To create the middleware and plug it in through Paste configuration:

All of the code for OpenStack lives in `/opt/stack`. Go to the swift directory in the `shell` screen and edit your middleware module.

1. Change to the directory where Object Storage is installed:

   ```
   $ cd /opt/stack/swift
   ```

2. Create the `ip_whitelist.py` Python source code file:

   ```
   $ vim swift/common/middleware/ip_whitelist.py
   ```

3. Copy the code as shown below into `ip_whitelist.py`. The following code is a middleware example that restricts access to a container based on IP address as explained at the beginning of the section. Middleware passes the request on to another application. This example uses the swift "swob" library to wrap Web Server Gateway Interface (WSGI) requests and responses into objects for swift to interact with. When you're done, save and close the file.

   ```
   # vim: tabstop=4 shiftwidth=4 softtabstop=4
   # Copyright (c) 2014 OpenStack Foundation
   # All Rights Reserved.
   #
   #    Licensed under the Apache License, Version 2.0 (the "License"); you may
   #    not use this file except in compliance with the License. You may obtain
   #    a copy of the License at
   #
   #         http://www.apache.org/licenses/LICENSE-2.0
   #
   #    Unless required by applicable law or agreed to in writing, software
   #    distributed under the License is distributed on an "AS IS" BASIS, WITHOUT
   #    WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. See the
   #    License for the specific language governing permissions and limitations
   #    under the License.
   ```

```
import socket

from swift.common.utils import get_logger
from swift.proxy.controllers.base import get_container_info
from swift.common.swob import Request, Response

class IPWhitelistMiddleware(object):
    """
    IP Whitelist Middleware

    Middleware that allows access to a container from only a set of IP
    addresses as determined by the container's metadata items that start
    with the prefix 'allow'. E.G. allow-dev=192.168.0.20
    """

    def __init__(self, app, conf, logger=None):
        self.app = app

        if logger:
            self.logger = logger
        else:
            self.logger = get_logger(conf, log_route='ip_whitelist')

        self.deny_message = conf.get('deny_message', "IP Denied")
        self.local_ip = socket.gethostbyname(socket.gethostname())

    def __call__(self, env, start_response):
        """
        WSGI entry point.
        Wraps env in swob.Request object and passes it down.

        :param env: WSGI environment dictionary
        :param start_response: WSGI callable
        """
        req = Request(env)

        try:
            version, account, container, obj = req.split_path(1, 4, True)
        except ValueError:
            return self.app(env, start_response)

        container_info = get_container_info(
            req.environ, self.app, swift_source='IPWhitelistMiddleware')

        remote_ip = env['REMOTE_ADDR']
        self.logger.debug("Remote IP: %(remote_ip)s",
                          {'remote_ip': remote_ip})

        meta = container_info['meta']
        allow = {k:v for k,v in meta.iteritems() if k.startswith('allow')}
        allow_ips = set(allow.values())
        allow_ips.add(self.local_ip)
        self.logger.debug("Allow IPs: %(allow_ips)s",
                          {'allow_ips': allow_ips})

        if remote_ip in allow_ips:
            return self.app(env, start_response)
```

```
        else:
            self.logger.debug(
                "IP %(remote_ip)s denied access to Account=%(account)s "
                "Container=%(container)s. Not in %(allow_ips)s", locals())
            return Response(
                status=403,
                body=self.deny_message,
                request=req)(env, start_response)


def filter_factory(global_conf, **local_conf):
    """
    paste.deploy app factory for creating WSGI proxy apps.
    """
    conf = global_conf.copy()
    conf.update(local_conf)

    def ip_whitelist(app):
        return IPWhitelistMiddleware(app, conf)
    return ip_whitelist
```

There is a lot of useful information in `env` and `conf` that you can use to decide what to do with the request. To find out more about what properties are available, you can insert the following log statement into the `__init__` method:

```
self.logger.debug("conf = %(conf)s", locals())
```

and the following log statement into the `__call__` method:

```
self.logger.debug("env = %(env)s", locals())
```

4. To plug this middleware into the swift Paste pipeline, you edit one configuration file, `/etc/swift/proxy-server.conf`:

```
$ vim /etc/swift/proxy-server.conf
```

5. Find the `[filter:ratelimit]` section in `/etc/swift/proxy-server.conf`, and copy in the following configuration section after it:

```
[filter:ip_whitelist]
paste.filter_factory = swift.common.middleware.ip_whitelist:filter_factory
# You can override the default log routing for this filter here:
# set log_name = ratelimit
# set log_facility = LOG_LOCAL0
# set log_level = INFO
# set log_headers = False
# set log_address = /dev/log
deny_message = You shall not pass!
```

6. Find the `[pipeline:main]` section in `/etc/swift/proxy-server.conf`, and add `ip_whitelist` after ratelimit to the list like so. When you're done, save and close the file:

```
[pipeline:main]
pipeline = catch_errors gatekeeper healthcheck proxy-logging cache bulk tempurl
↪ratelimit ip_whitelist ...
```

7. Restart the `swift proxy` service to make swift use your middleware. Start by switching to the `swift-proxy` screen:
   (a) Press **Ctrl+A** followed by **3**.
   (b) Press **Ctrl+C** to kill the service.
   (c) Press **Up Arrow** to bring up the last command.
   (d) Press Enter to run it.
8. Test your middleware with the `swift` CLI. Start by switching to the shell screen and finish by switching back to the `swift-proxy` screen to check the log output:
   (a) Press **Ctrl+A** followed by **0**.
   (b) Make sure you're in the `devstack` directory:
   ```
   $ cd /root/devstack
   ```
   (c) Source openrc to set up your environment variables for the CLI:
   ```
   $ . openrc
   ```
   (d) Create a container called `middleware-test`:
   ```
   $ swift post middleware-test
   ```
   (e) Press **Ctrl+A** followed by **3** to check the log output.
9. Among the log statements you'll see the lines:
```
proxy-server Remote IP: my.instance.ip.address (txn: ...)
proxy-server Allow IPs: set(['my.instance.ip.address']) (txn: ...)
```
   These two statements are produced by our middleware and show that the request was sent from our DevStack instance and was allowed.
10. Test the middleware from outside DevStack on a remote machine that has access to your DevStack instance:
   (a) Install the `keystone` and `swift` clients on your local machine:
   ```
   # pip install python-keystoneclient python-swiftclient
   ```
   (b) Attempt to list the objects in the `middleware-test` container:
   ```
   $ swift --os-auth-url=http://my.instance.ip.address:5000/v2.0/ \
     --os-region-name=RegionOne --os-username=demo:demo \
     --os-password=devstack list middleware-test
   Container GET failed: http://my.instance.ip.address:8080/v1/AUTH_.../
       middleware-test?format=json 403 Forbidden   You shall not pass!
   ```
11. Press **Ctrl+A** followed by **3** to check the log output. Look at the swift log statements again, and among the log statements, you'll see the lines:
```
proxy-server Authorizing from an overriding middleware (i.e: tempurl) (txn: ...)
proxy-server ... IPWhitelistMiddleware
proxy-server Remote IP: my.local.ip.address (txn: ...)
```

```
proxy-server Allow IPs: set(['my.instance.ip.address']) (txn: ...)
proxy-server IP my.local.ip.address denied access to Account=AUTH_... \
   Container=None. Not in set(['my.instance.ip.address']) (txn: ...)
```

Here we can see that the request was denied because the remote IP address wasn't in the set of allowed IPs.

12. Back in your DevStack instance on the shell screen, add some metadata to your container to allow the request from the remote machine:

    (a) Press **Ctrl+A** followed by **0**.

    (b) Add metadata to the container to allow the IP:

    ```
    $ swift post --meta allow-dev:my.local.ip.address middleware-test
    ```

    (c) Now try the command from Step 10 again and it succeeds. There are no objects in the container, so there is nothing to list; however, there is also no error to report.

    > **Warning:** Functional testing like this is not a replacement for proper unit and integration testing, but it serves to get you started.

You can follow a similar pattern in other projects that use the Python Paste framework. Simply create a middleware module and plug it in through configuration. The middleware runs in sequence as part of that project's pipeline and can call out to other services as necessary. No project core code is touched. Look for a `pipeline` value in the project's `conf` or `ini` configuration files in `/etc/<project>` to identify projects that use Paste.

When your middleware is done, we encourage you to open source it and let the community know on the OpenStack mailing list. Perhaps others need the same functionality. They can use your code, provide feedback, and possibly contribute. If enough support exists for it, perhaps you can propose that it be added to the official swift middleware.

Customizing the OpenStack Compute (nova) Scheduler

Many OpenStack projects allow for customization of specific features using a driver architecture. You can write a driver that conforms to a particular interface and plug it in through configuration. For example, you can easily plug in a new scheduler for Compute. The existing schedulers for Compute are feature full and well documented at Scheduling. However, depending on your user's use cases, the existing schedulers might not meet your requirements. You might need to create a new scheduler.

To create a scheduler, you must inherit from the class `nova.scheduler.driver.Scheduler`. Of the five methods that you can override, you *must* override the two methods marked with an asterisk (*) below:

- `update_service_capabilities`
- `hosts_up`
- `group_hosts`
- * `schedule_run_instance`
- * `select_destinations`

To demonstrate customizing OpenStack, we'll create an example of a Compute scheduler that randomly places an instance on a subset of hosts, depending on the originating IP address of the request and the prefix of the hostname. Such an example could be useful when you have a group of users on a subnet and you want all of their instances to start within some subset of your hosts.

> **Warning:** This example is for illustrative purposes only. It should not be used as a scheduler for Compute without further development and testing.

When you join the screen session that `stack.sh` starts with `screen -r stack`, you are greeted with many screen windows:

```
0$ shell*  1$ key  2$ horizon  ...  9$ n-api  ...  14$ n-sch ...
```

shell A shell where you can get some work done

key The keystone service

horizon The horizon dashboard web application

n-{name} The nova services

n-sch The nova scheduler service

To create the scheduler and plug it in through configuration

1. The code for OpenStack lives in `/opt/stack`, so go to the `nova` directory and edit your scheduler module. Change to the directory where `nova` is installed:

```
$ cd /opt/stack/nova
```

2. Create the `ip_scheduler.py` Python source code file:

```
$ vim nova/scheduler/ip_scheduler.py
```

3. The code shown below is a driver that will schedule servers to hosts based on IP address as explained at the beginning of the section. Copy the code into `ip_scheduler.py`. When you are done, save and close the file.

```
# vim: tabstop=4 shiftwidth=4 softtabstop=4
# Copyright (c) 2014 OpenStack Foundation
# All Rights Reserved.
#
#    Licensed under the Apache License, Version 2.0 (the "License"); you may
#    not use this file except in compliance with the License. You may obtain
#    a copy of the License at
#
#         http://www.apache.org/licenses/LICENSE-2.0
#
#    Unless required by applicable law or agreed to in writing, software
#    distributed under the License is distributed on an "AS IS" BASIS, WITHOUT
#    WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. See the
#    License for the specific language governing permissions and limitations
#    under the License.

"""
IP Scheduler implementation
"""
```

```
import random

from oslo_config import cfg

from nova.compute import rpcapi as compute_rpcapi
from nova import exception
from nova.openstack.common import log as logging
from nova.openstack.common.gettextutils import _
from nova.scheduler import driver

CONF = cfg.CONF
CONF.import_opt('compute_topic', 'nova.compute.rpcapi')
LOG = logging.getLogger(__name__)

class IPScheduler(driver.Scheduler):
    """
    Implements Scheduler as a random node selector based on
    IP address and hostname prefix.
    """

    def __init__(self, *args, **kwargs):
        super(IPScheduler, self).__init__(*args, **kwargs)
        self.compute_rpcapi = compute_rpcapi.ComputeAPI()

    def _filter_hosts(self, request_spec, hosts, filter_properties,
        hostname_prefix):
        """Filter a list of hosts based on hostname prefix."""

        hosts = [host for host in hosts if host.startswith(hostname_prefix)]
        return hosts

    def _schedule(self, context, topic, request_spec, filter_properties):
        """Picks a host that is up at random."""

        elevated = context.elevated()
        hosts = self.hosts_up(elevated, topic)
        if not hosts:
            msg = _("Is the appropriate service running?")
            raise exception.NoValidHost(reason=msg)

        remote_ip = context.remote_address

        if remote_ip.startswith('10.1'):
            hostname_prefix = 'doc'
        elif remote_ip.startswith('10.2'):
            hostname_prefix = 'ops'
        else:
            hostname_prefix = 'dev'

        hosts = self._filter_hosts(request_spec, hosts, filter_properties,
            hostname_prefix)
        if not hosts:
            msg = _("Could not find another compute")
            raise exception.NoValidHost(reason=msg)

        host = random.choice(hosts)
        LOG.debug("Request from %(remote_ip)s scheduled to %(host)s" % locals())
```

```
        return host

    def select_destinations(self, context, request_spec, filter_properties):
        """Selects random destinations."""
        num_instances = request_spec['num_instances']
        # NOTE(timello): Returns a list of dicts with 'host', 'nodename' and
        # 'limits' as keys for compatibility with filter_scheduler.
        dests = []
        for i in range(num_instances):
            host = self._schedule(context, CONF.compute_topic,
                    request_spec, filter_properties)
            host_state = dict(host=host, nodename=None, limits=None)
            dests.append(host_state)

        if len(dests) < num_instances:
            raise exception.NoValidHost(reason='')
        return dests

    def schedule_run_instance(self, context, request_spec,
                              admin_password, injected_files,
                              requested_networks, is_first_time,
                              filter_properties, legacy_bdm_in_spec):
        """Create and run an instance or instances."""
        instance_uuids = request_spec.get('instance_uuids')
        for num, instance_uuid in enumerate(instance_uuids):
            request_spec['instance_properties']['launch_index'] = num
            try:
                host = self._schedule(context, CONF.compute_topic,
                                      request_spec, filter_properties)
                updated_instance = driver.instance_update_db(context,
                        instance_uuid)
                self.compute_rpcapi.run_instance(context,
                        instance=updated_instance, host=host,
                        requested_networks=requested_networks,
                        injected_files=injected_files,
                        admin_password=admin_password,
                        is_first_time=is_first_time,
                        request_spec=request_spec,
                        filter_properties=filter_properties,
                        legacy_bdm_in_spec=legacy_bdm_in_spec)
            except Exception as ex:
                # NOTE(vish): we don't reraise the exception here to make sure
                #             that all instances in the request get set to
                #             error properly
                driver.handle_schedule_error(context, ex, instance_uuid,
                                             request_spec)
```

There is a lot of useful information in `context`, `request_spec`, and `filter_properties` that you can use to decide where to schedule the instance. To find out more about what properties are available, you can insert the following log statements into the `schedule_run_instance` method of the scheduler above:

```
LOG.debug("context = %(context)s" % {'context': context.__dict__})
LOG.debug("request_spec = %(request_spec)s" % locals())
LOG.debug("filter_properties = %(filter_properties)s" % locals())
```

4. To plug this scheduler into nova, edit one configuration file, `/etc/nova/nova.conf`:

```
$ vim /etc/nova/nova.conf
```

5. Find the `scheduler_driver` config and change it like so:

```
scheduler_driver=nova.scheduler.ip_scheduler.IPScheduler
```

6. Restart the nova scheduler service to make nova use your scheduler. Start by switching to the `n-sch` screen:

   (a) Press **Ctrl+A** followed by **9**.

   (b) Press **Ctrl+A** followed by **N** until you reach the `n-sch` screen.

   (c) Press **Ctrl+C** to kill the service.

   (d) Press **Up Arrow** to bring up the last command.

   (e) Press **Enter** to run it.

7. Test your scheduler with the nova CLI. Start by switching to the `shell` screen and finish by switching back to the `n-sch` screen to check the log output:

   (a) Press **Ctrl+A** followed by **0**.

   (b) Make sure you are in the `devstack` directory:

   ```
   $ cd /root/devstack
   ```

   (c) Source `openrc` to set up your environment variables for the CLI:

   ```
   $ . openrc
   ```

   (d) Put the image ID for the only installed image into an environment variable:

   ```
   $ IMAGE_ID=`openstack image list | egrep cirros | egrep -v "kernel|ramdisk" | awk
   ↪'{print $2}'`
   ```

   (e) Boot a test server:

   ```
   $ openstack server create --flavor 1 --image $IMAGE_ID scheduler-test
   ```

8. Switch back to the `n-sch` screen. Among the log statements, you'll see the line:

```
2014-01-23 19:57:47.262 DEBUG nova.scheduler.ip_scheduler
[req-... demo demo] Request from xx.xx.xx.xx scheduled to devstack-havana
_schedule /opt/stack/nova/nova/scheduler/ip_scheduler.py:76
```

> **Warning:** Functional testing like this is not a replacement for proper unit and integration testing, but it serves to get you started.

A similar pattern can be followed in other projects that use the driver architecture. Simply create a module and class that conform to the driver interface and plug it in through configuration. Your code runs when that feature is used and can call out to other services as necessary. No project core code is touched. Look for a "driver" value in the project's `.conf` configuration files in `/etc/<project>` to identify projects that use a driver architecture.

When your scheduler is done, we encourage you to open source it and let the community know on the OpenStack mailing list. Perhaps others need the same functionality. They can use your code, provide feedback, and possibly contribute. If enough support exists for it, perhaps you can propose that it be added to the official Compute schedulers.

Customizing the Dashboard (Horizon)

The dashboard is based on the Python Django web application framework. To know how to build your Dashboard, see Building a Dashboard using Horizon.

Conclusion

When operating an OpenStack cloud, you may discover that your users can be quite demanding. If OpenStack doesn't do what your users need, it may be up to you to fulfill those requirements. This chapter provided you with some options for customization and gave you the tools you need to get started.

OpenStack might not do everything you need it to do out of the box. To add a new feature, you can follow different paths.

To take the first path, you can modify the OpenStack code directly. Learn how to contribute, follow the Developer's Guide, make your changes, and contribute them back to the upstream OpenStack project. This path is recommended if the feature you need requires deep integration with an existing project. The community is always open to contributions and welcomes new functionality that follows the feature-development guidelines. This path still requires you to use DevStack for testing your feature additions, so this chapter walks you through the DevStack environment.

For the second path, you can write new features and plug them in using changes to a configuration file. If the project where your feature would need to reside uses the Python Paste framework, you can create middleware for it and plug it in through configuration. There may also be specific ways of customizing a project, such as creating a new scheduler driver for Compute or a custom tab for the dashboard.

This chapter focuses on the second path for customizing OpenStack by providing two examples for writing new features. The first example shows how to modify Object Storage service (swift) middleware to add a new feature, and the second example provides a new scheduler feature for Compute service (nova). To customize OpenStack this way you need a development environment. The best way to get an environment up and running quickly is to run DevStack within your cloud.

Advanced Configuration

OpenStack is intended to work well across a variety of installation flavors, from very small private clouds to large public clouds. To achieve this, the developers add configuration options to their code that allow the behavior of the various components to be tweaked depending on your needs. Unfortunately, it is not possible to cover all possible deployments with the default configuration values.

At the time of writing, OpenStack has more than 3,000 configuration options. You can see them documented at the OpenStack Configuration Reference. This chapter cannot hope to document all of these, but we do try to introduce the important concepts so that you know where to go digging for more information.

Differences Between Various Drivers

Many OpenStack projects implement a driver layer, and each of these drivers will implement its own configuration options. For example, in OpenStack Compute (nova), there are various hypervisor drivers implemented—libvirt, xenserver, hyper-v, and vmware, for example. Not all of these hypervisor drivers have the same features, and each has different tuning requirements.

Note: The currently implemented hypervisors are listed on the OpenStack Configuration Reference. You can see a matrix of the various features in OpenStack Compute (nova) hypervisor drivers at the Hypervisor support matrix page.

The point we are trying to make here is that just because an option exists doesn't mean that option is relevant to your driver choices. Normally, the documentation notes which drivers the configuration applies to.

Implementing Periodic Tasks

Another common concept across various OpenStack projects is that of periodic tasks. Periodic tasks are much like cron jobs on traditional Unix systems, but they are run inside an OpenStack process. For example, when OpenStack Compute (nova) needs to work out what images it can remove from its local cache, it runs a periodic task to do this.

Periodic tasks are important to understand because of limitations in the threading model that OpenStack uses. OpenStack uses cooperative threading in Python, which means that if something long and complicated is running, it will block other tasks inside that process from running unless it voluntarily yields execution to another cooperative thread.

A tangible example of this is the `nova-compute` process. In order to manage the image cache with libvirt, `nova-compute` has a periodic process that scans the contents of the image cache. Part of this scan is calculating a checksum for each of the images and making sure that checksum matches what `nova-compute` expects it to be. However, images can be very large, and these checksums can take a long time to generate. At one point, before it was reported as a bug and fixed, `nova-compute` would block on this task and stop responding to RPC requests. This was visible to users as failure of operations such as spawning or deleting instances.

The take away from this is if you observe an OpenStack process that appears to "stop" for a while and then continue to process normally, you should check that periodic tasks aren't the problem. One way to do this is to disable the periodic tasks by setting their interval to zero. Additionally, you can configure how often these periodic tasks run—in some cases, it might make sense to run them at a different frequency from the default.

The frequency is defined separately for each periodic task. Therefore, to disable every periodic task in OpenStack Compute (nova), you would need to set a number of configuration options to zero. The current list of configuration options you would need to set to zero are:

- `bandwidth_poll_interval`
- `sync_power_state_interval`
- `heal_instance_info_cache_interval`
- `host_state_interval`
- `image_cache_manager_interval`
- `reclaim_instance_interval`
- `volume_usage_poll_interval`

- shelved_poll_interval
- shelved_offload_time
- instance_delete_interval

To set a configuration option to zero, include a line such as `image_cache_manager_interval=0` in your `nova.conf` file.

This list will change between releases, so please refer to your configuration guide for up-to-date information.

Specific Configuration Topics

This section covers specific examples of configuration options you might consider tuning. It is by no means an exhaustive list.

Security Configuration for Compute, Networking, and Storage

The OpenStack Security Guide provides a deep dive into securing an OpenStack cloud, including SSL/TLS, key management, PKI and certificate management, data transport and privacy concerns, and compliance.

High Availability

The OpenStack High Availability Guide offers suggestions for elimination of a single point of failure that could cause system downtime. While it is not a completely prescriptive document, it offers methods and techniques for avoiding downtime and data loss.

Enabling IPv6 Support

You can follow the progress being made on IPV6 support by watching the neutron IPv6 Subteam at work.

By modifying your configuration setup, you can set up IPv6 when using `nova-network` for networking, and a tested setup is documented for FlatDHCP and a multi-host configuration. The key is to make `nova-network` think a `radvd` command ran successfully. The entire configuration is detailed in a Cybera blog post, "An IPv6 enabled cloud".

Geographical Considerations for Object Storage

Support for global clustering of object storage servers is available for all supported releases. You would implement these global clusters to ensure replication across geographic areas in case of a natural disaster and also to ensure that users can write or access their objects more quickly based on the closest data center. You configure a default region with one zone for each cluster, but be sure your network (WAN) can handle the additional request and response load between zones as you add more zones and build a ring that handles more zones. Refer to Geographically Distributed Clusters in the documentation for additional information.

Upgrades

With the exception of Object Storage, upgrading from one version of OpenStack to another can take a great deal of effort. This chapter provides some guidance on the operational aspects that you should consider for performing an upgrade for an OpenStack environment.

Pre-upgrade considerations

Upgrade planning

- Thoroughly review the release notes to learn about new, updated, and deprecated features. Find incompatibilities between versions.
- Consider the impact of an upgrade to users. The upgrade process interrupts management of your environment including the dashboard. If you properly prepare for the upgrade, existing instances, networking, and storage should continue to operate. However, instances might experience intermittent network interruptions.
- Consider the approach to upgrading your environment. You can perform an upgrade with operational instances, but this is a dangerous approach. You might consider using live migration to temporarily relocate instances to other compute nodes while performing upgrades. However, you must ensure database consistency throughout the process; otherwise your environment might become unstable. Also, don't forget to provide sufficient notice to your users, including giving them plenty of time to perform their own backups.
- Consider adopting structure and options from the service configuration files and merging them with existing configuration files. The OpenStack Configuration Reference contains new, updated, and deprecated options for most services.
- Like all major system upgrades, your upgrade could fail for one or more reasons. You can prepare for this situation by having the ability to roll back your environment to the previous release, including databases, configuration files, and packages. We provide an example process for rolling back your environment in *Rolling back a failed upgrade*.
- Develop an upgrade procedure and assess it thoroughly by using a test environment similar to your production environment.

Pre-upgrade testing environment

The most important step is the pre-upgrade testing. If you are upgrading immediately after release of a new version, undiscovered bugs might hinder your progress. Some deployers prefer to wait until the first point release is announced. However, if you have a significant deployment, you might follow the development and testing of the release to ensure that bugs for your use cases are fixed.

Each OpenStack cloud is different even if you have a near-identical architecture as described in this guide. As a result, you must still test upgrades between versions in your environment using an approximate clone of your environment.

However, that is not to say that it needs to be the same size or use identical hardware as the production environment. It is important to consider the hardware and scale of the cloud that you are upgrading. The following tips can help you minimise the cost:

Use your own cloud The simplest place to start testing the next version of OpenStack is by setting up a new environment inside your own cloud. This might seem odd, especially the double virtualization used in running compute nodes. But it is a sure way to very quickly test your configuration.

Use a public cloud Consider using a public cloud to test the scalability limits of your cloud controller configuration. Most public clouds bill by the hour, which means it can be inexpensive to perform even a test with many nodes.

Make another storage endpoint on the same system If you use an external storage plug-in or shared file system with your cloud, you can test whether it works by creating a second share or endpoint. This allows you to test the system before entrusting the new version on to your storage.

Watch the network Even at smaller-scale testing, look for excess network packets to determine whether something is going horribly wrong in inter-component communication.

To set up the test environment, you can use one of several methods:

- Do a full manual install by using the Installation Tutorials and Guides for your platform. Review the final configuration files and installed packages.
- Create a clone of your automated configuration infrastructure with changed package repository URLs.

  Alter the configuration until it works.

Either approach is valid. Use the approach that matches your experience.

An upgrade pre-testing system is excellent for getting the configuration to work. However, it is important to note that the historical use of the system and differences in user interaction can affect the success of upgrades.

If possible, we highly recommend that you dump your production database tables and test the upgrade in your development environment using this data. Several MySQL bugs have been uncovered during database migrations because of slight table differences between a fresh installation and tables that migrated from one version to another. This will have impact on large real datasets, which you do not want to encounter during a production outage.

Artificial scale testing can go only so far. After your cloud is upgraded, you must pay careful attention to the performance aspects of your cloud.

Upgrade Levels

Upgrade levels are a feature added to OpenStack Compute since the Grizzly release to provide version locking on the RPC (Message Queue) communications between the various Compute services.

This functionality is an important piece of the puzzle when it comes to live upgrades and is conceptually similar to the existing API versioning that allows OpenStack services of different versions to communicate without issue.

Without upgrade levels, an X+1 version Compute service can receive and understand X version RPC messages, but it can only send out X+1 version RPC messages. For example, if a nova-conductor process has been upgraded to X+1 version, then the conductor service will be able to understand messages from X version nova-compute processes, but those compute services will not be able to understand messages sent by the conductor service.

During an upgrade, operators can add configuration options to `nova.conf` which lock the version of RPC messages and allow live upgrading of the services without interruption caused by version mismatch. The configuration options allow the specification of RPC version numbers if desired, but release name alias are also supported. For example:

```
[upgrade_levels]
compute=X+1
conductor=X+1
scheduler=X+1
```

will keep the RPC version locked across the specified services to the RPC version used in X+1. As all instances of a particular service are upgraded to the newer version, the corresponding line can be removed from `nova.conf`.

Using this functionality, ideally one would lock the RPC version to the OpenStack version being upgraded from on nova-compute nodes, to ensure that, for example X+1 version nova-compute processes will continue to work with X version nova-conductor processes while the upgrade completes. Once the upgrade of nova-compute processes is complete, the operator can move onto upgrading nova-conductor and remove the version locking for nova-compute in `nova.conf`.

Upgrade process

This section describes the process to upgrade a basic OpenStack deployment based on the basic two-node architecture in the Installation Tutorials and Guides. All nodes must run a supported distribution of Linux with a recent kernel and the current release packages.

Service specific upgrade instructions

Refer to the following upgrade notes for information on upgrading specific OpenStack services:

- Networking service (neutron) upgrades
- Compute service (nova) upgrades
- Identity service (keystone) upgrades
- Block Storage service (cinder) upgrades
- Image service (glance) zero downtime database upgrades
- Image service (glance) rolling upgrades
- Bare Metal service (ironic) upgrades
- Object Storage service (swift) upgrades
- Telemetry service (ceilometer) upgrades

Prerequisites

- Perform some cleaning of the environment prior to starting the upgrade process to ensure a consistent state. For example, instances not fully purged from the system after deletion might cause indeterminate behavior.
- For environments using the OpenStack Networking service (neutron), verify the release version of the database. For example:

```
# su -s /bin/sh -c "neutron-db-manage --config-file /etc/neutron/neutron.conf \
  --config-file /etc/neutron/plugins/ml2/ml2_conf.ini current" neutron
```

Perform a backup

1. Save the configuration files on all nodes. For example:

```
# for i in keystone glance nova neutron openstack-dashboard cinder heat ceilometer; \
  do mkdir $i-RELEASE_NAME; \
  done
# for i in keystone glance nova neutron openstack-dashboard cinder heat ceilometer; \
  do cp -r /etc/$i/* $i-RELEASE_NAME/; \
  done
```

Note: You can modify this example script on each node to handle different services.

2. Make a full database backup of your production data. Since the Kilo release, database downgrades are not supported, and restoring from backup is the only method available to retrieve a previous database version.

```
# mysqldump -u root -p --opt --add-drop-database --all-databases > RELEASE_NAME-db-
↪backup.sql
```

Note: Consider updating your SQL server configuration as described in the Installation Tutorials and Guides.

Manage repositories

On all nodes:

1. Remove the repository for the previous release packages.
2. Add the repository for the new release packages.
3. Update the repository database.

Upgrade packages on each node

Depending on your specific configuration, upgrading all packages might restart or break services supplemental to your OpenStack environment. For example, if you use the TGT iSCSI framework for Block Storage volumes and the upgrade includes new packages for it, the package manager might restart the TGT iSCSI services and impact connectivity to volumes.

If the package manager prompts you to update configuration files, reject the changes. The package manager appends a suffix to newer versions of configuration files. Consider reviewing and adopting content from these files.

Note: You may need to explicitly install the `ipset` package if your distribution does not install it as a dependency.

Update services

To update a service on each node, you generally modify one or more configuration files, stop the service, synchronize the database schema, and start the service. Some services require different steps. We recommend verifying operation of each service before proceeding to the next service.

The order you should upgrade services, and any changes from the general upgrade process is described below:

Controller node

1. Identity service - Clear any expired tokens before synchronizing the database.
2. Image service
3. Compute service, including networking components.
4. Networking service
5. Block Storage service
6. Dashboard - In typical environments, updating Dashboard only requires restarting the Apache HTTP service.
7. Orchestration service
8. Telemetry service - In typical environments, updating the Telemetry service only requires restarting the service.
9. Compute service - Edit the configuration file and restart the service.
10. Networking service - Edit the configuration file and restart the service.

Storage nodes

- Block Storage service - Updating the Block Storage service only requires restarting the service.

Compute nodes

- Networking service - Edit the configuration file and restart the service.

Final steps

On all distributions, you must perform some final tasks to complete the upgrade process.

1. Decrease DHCP timeouts by modifying the `/etc/nova/nova.conf` file on the compute nodes back to the original value for your environment.
2. Update all `.ini` files to match passwords and pipelines as required for the OpenStack release in your environment.
3. After migration, users see different results from **`openstack image list`** and **`glance image-list`**. To ensure users see the same images in the list commands, edit the `/etc/glance/policy.json` file and `/etc/nova/policy.json` file to contain `"context_is_admin": "role:admin"`, which limits access to private images for projects.
4. Verify proper operation of your environment. Then, notify your users that their cloud is operating normally again.

Rolling back a failed upgrade

This section provides guidance for rolling back to a previous release of OpenStack. All distributions follow a similar procedure.

Warning: Rolling back your environment should be the final course of action since you are likely to lose any data added since the backup.

A common scenario is to take down production management services in preparation for an upgrade, completed part of the upgrade process, and discovered one or more problems not encountered during testing. As a consequence, you must roll back your environment to the original "known good" state. You also made sure that you did not make any state changes after attempting the upgrade process; no new instances, networks, storage volumes, and so on. Any of these new resources will be in a frozen state after the databases are restored from backup.

Within this scope, you must complete these steps to successfully roll back your environment:

1. Roll back configuration files.
2. Restore databases from backup.
3. Roll back packages.

You should verify that you have the requisite backups to restore. Rolling back upgrades is a tricky process because distributions tend to put much more effort into testing upgrades than downgrades. Broken downgrades take significantly more effort to troubleshoot and, resolve than broken upgrades. Only you can weigh the risks of trying to push a failed upgrade forward versus rolling it back. Generally, consider rolling back as the very last option.

The following steps described for Ubuntu have worked on at least one production environment, but they might not work for all environments.

To perform a rollback

1. Stop all OpenStack services.
2. Copy contents of configuration backup directories that you created during the upgrade process back to `/etc/<service>` directory.
3. Restore databases from the `RELEASE_NAME-db-backup.sql` backup file that you created with the **mysqldump** command during the upgrade process:

```
# mysql -u root -p < RELEASE_NAME-db-backup.sql
```

4. Downgrade OpenStack packages.

   Warning: Downgrading packages is by far the most complicated step; it is highly dependent on the distribution and the overall administration of the system.

   (a) Determine which OpenStack packages are installed on your system. Use the **dpkg --get-selections** command. Filter for OpenStack packages, filter again to omit packages explicitly marked in the `deinstall` state, and save the final output to a file. For example, the following command covers a controller node with keystone, glance, nova, neutron, and cinder:

```
# dpkg --get-selections | grep -e keystone -e glance -e nova -e neutron \
-e cinder | grep -v deinstall | tee openstack-selections
cinder-api                                      install
cinder-common                                   install
cinder-scheduler                                install
cinder-volume                                   install
```

```
glance                                                install
glance-api                                            install
glance-common                                         install
glance-registry                                       install
neutron-common                                        install
neutron-dhcp-agent                                    install
neutron-l3-agent                                      install
neutron-lbaas-agent                                   install
neutron-metadata-agent                                install
neutron-plugin-openvswitch                            install
neutron-plugin-openvswitch-agent                      install
neutron-server                                        install
nova-api                                              install
nova-common                                           install
nova-conductor                                        install
nova-consoleauth                                      install
nova-novncproxy                                       install
nova-objectstore                                      install
nova-scheduler                                        install
python-cinder                                         install
python-cinderclient                                   install
python-glance                                         install
python-glanceclient                                   install
python-keystone                                       install
python-keystoneclient                                 install
python-neutron                                        install
python-neutronclient                                  install
python-nova                                           install
python-novaclient                                     install
```

Note: Depending on the type of server, the contents and order of your package list might vary from this example.

(b) You can determine the package versions available for reversion by using the `apt-cache policy` command. For example:

```
# apt-cache policy nova-common

nova-common:
Installed: 2:14.0.1-0ubuntu1~cloud0
Candidate: 2:14.0.1-0ubuntu1~cloud0
Version table:
*** 2:14.0.1-0ubuntu1~cloud0 500
      500 http://ubuntu-cloud.archive.canonical.com/ubuntu xenial-updates/newton/
↪main amd64 Packages
      100 /var/lib/dpkg/status
    2:13.1.2-0ubuntu2 500
      500 http://archive.ubuntu.com/ubuntu xenial-updates/main amd64 Packages
    2:13.0.0-0ubuntu2 500
      500 http://archive.ubuntu.com/ubuntu xenial/main amd64 Packages
```

Note: If you removed the release repositories, you must first reinstall them and run the **`apt-get`**

update command.

The command output lists the currently installed version of the package, newest candidate version, and all versions along with the repository that contains each version. Look for the appropriate release version— `2:14.0.1-0ubuntu1~cloud0` in this case. The process of manually picking through this list of packages is rather tedious and prone to errors. You should consider using a script to help with this process. For example:

```
# for i in `cut -f 1 openstack-selections | sed 's/neutron/;'`;
  do echo -n $i ;apt-cache policy $i | grep -B 1 RELEASE_NAME |
  grep -v Packages | awk '{print "="$1}';done | tr '\n' ' ' |
  tee openstack-RELEASE_NAME-versions
cinder-api=2:9.0.0-0ubuntu1~cloud0
cinder-common=2:9.0.0-0ubuntu1~cloud0
cinder-scheduler=2:9.0.0-0ubuntu1~cloud0
cinder-volume=2:9.0.0-0ubuntu1~cloud0
glance=2:13.0.0-0ubuntu1~cloud0
glance-api=2:13.0.0-0ubuntu1~cloud0 500
glance-common=2:13.0.0-0ubuntu1~cloud0 500
glance-registry=2:13.0.0-0ubuntu1~cloud0 500
neutron-common=2:9.0.0-0ubuntu1~cloud0
neutron-dhcp-agent=2:9.0.0-0ubuntu1~cloud0
neutron-l3-agent=2:9.0.0-0ubuntu1~cloud0
neutron-lbaas-agent=2:9.0.0-0ubuntu1~cloud0
neutron-metadata-agent=2:9.0.0-0ubuntu1~cloud0
neutron-server=2:9.0.0-0ubuntu1~cloud0
nova-api=2:14.0.1-0ubuntu1~cloud0
nova-common=2:14.0.1-0ubuntu1~cloud0
nova-conductor=2:14.0.1-0ubuntu1~cloud0
nova-consoleauth=2:14.0.1-0ubuntu1~cloud0
nova-novncproxy=2:14.0.1-0ubuntu1~cloud0
nova-objectstore=2:14.0.1-0ubuntu1~cloud0
nova-scheduler=2:14.0.1-0ubuntu1~cloud0
python-cinder=2:9.0.0-0ubuntu1~cloud0
python-cinderclient=1:1.9.0-0ubuntu1~cloud0
python-glance=2:13.0.0-0ubuntu1~cloud0
python-glanceclient=1:2.5.0-0ubuntu1~cloud0
python-neutron=2:9.0.0-0ubuntu1~cloud0
python-neutronclient=1:6.0.0-0ubuntu1~cloud0
python-nova=2:14.0.1-0ubuntu1~cloud0
python-novaclient=2:6.0.0-0ubuntu1~cloud0
python-openstackclient=3.2.0-0ubuntu2~cloud0
```

(c) Use the **apt-get install** command to install specific versions of each package by specifying `<package-name>=<version>`. The script in the previous step conveniently created a list of `package=version` pairs for you:

```
# apt-get install `cat openstack-RELEASE_NAME-versions`
```

This step completes the rollback procedure. You should remove the upgrade release repository and run **apt-get update** to prevent accidental upgrades until you solve whatever issue caused you to roll back your environment.

Appendix

Use Cases

This appendix contains a small selection of use cases from the community, with more technical detail than usual. Further examples can be found on the OpenStack website.

NeCTAR

Who uses it: researchers from the Australian publicly funded research sector. Use is across a wide variety of disciplines, with the purpose of instances ranging from running simple web servers to using hundreds of cores for high-throughput computing.

Deployment

Using OpenStack Compute cells, the NeCTAR Research Cloud spans eight sites with approximately 4,000 cores per site.

Each site runs a different configuration, as a resource cells in an OpenStack Compute cells setup. Some sites span multiple data centers, some use off compute node storage with a shared file system, and some use on compute node storage with a non-shared file system. Each site deploys the Image service with an Object Storage back end. A central Identity, dashboard, and Compute API service are used. A login to the dashboard triggers a SAML login with Shibboleth, which creates an account in the Identity service with an SQL back end. An Object Storage Global Cluster is used across several sites.

Compute nodes have 24 to 48 cores, with at least 4 GB of RAM per core and approximately 40 GB of ephemeral storage per core.

All sites are based on Ubuntu 14.04, with KVM as the hypervisor. The OpenStack version in use is typically the current stable version, with 5 to 10 percent back-ported code from trunk and modifications.

Resources

- OpenStack.org case study
- NeCTAR-RC GitHub
- NeCTAR website

MIT CSAIL

Who uses it: researchers from the MIT Computer Science and Artificial Intelligence Lab.

Deployment

The CSAIL cloud is currently 64 physical nodes with a total of 768 physical cores and 3,456 GB of RAM. Persistent data storage is largely outside the cloud on NFS, with cloud resources focused on compute resources. There are more than 130 users in more than 40 projects, typically running 2,000–2,500 vCPUs in 300 to 400 instances.

We initially deployed on Ubuntu 12.04 with the Essex release of OpenStack using FlatDHCP multi-host networking.

The software stack is still Ubuntu 12.04 LTS, but now with OpenStack Havana from the Ubuntu Cloud Archive. KVM is the hypervisor, deployed using FAI and Puppet for configuration management. The FAI and Puppet combination is used lab-wide, not only for OpenStack. There is a single cloud controller node, which also acts as network controller, with the remainder of the server hardware dedicated to compute nodes.

Host aggregates and instance-type extra specs are used to provide two different resource allocation ratios. The default resource allocation ratios we use are 4:1 CPU and 1.5:1 RAM. Compute-intensive workloads use instance types that require non-oversubscribed hosts where `cpu_ratio` and `ram_ratio` are both set to 1.0. Since we have hyper-threading enabled on our compute nodes, this provides one vCPU per CPU thread, or two vCPUs per physical core.

With our upgrade to Grizzly in August 2013, we moved to OpenStack Networking, neutron (quantum at the time). Compute nodes have two-gigabit network interfaces and a separate management card for IPMI management. One network interface is used for node-to-node communications. The other is used as a trunk port for OpenStack managed VLANs. The controller node uses two bonded 10g network interfaces for its public IP communications. Big pipes are used here because images are served over this port, and it is also used to connect to iSCSI storage, back-ending the image storage and database. The controller node also has a gigabit interface that is used in trunk mode for OpenStack managed VLAN traffic. This port handles traffic to the dhcp-agent and metadata-proxy.

We approximate the older `nova-network` multi-host HA setup by using "provider VLAN networks" that connect instances directly to existing publicly addressable networks and use existing physical routers as their default gateway. This means that if our network controller goes down, running instances still have their network available, and no single Linux host becomes a traffic bottleneck. We are able to do this because we have a sufficient supply of IPv4 addresses to cover all of our instances and thus don't need NAT and don't use floating IP addresses. We provide a single generic public network to all projects and additional existing VLANs on a project-by-project basis as needed. Individual projects are also allowed to create their own private GRE based networks.

Resources

- CSAIL homepage

DAIR

Who uses it: DAIR is an integrated virtual environment that leverages the CANARIE network to develop and test new information communication technology (ICT) and other digital technologies. It combines such digital infrastructure as advanced networking and cloud computing and storage to create an environment for developing and testing innovative ICT applications, protocols, and services; performing at-scale experimentation for deployment; and facilitating a faster time to market.

Deployment

DAIR is hosted at two different data centers across Canada: one in Alberta and the other in Quebec. It consists of a cloud controller at each location, although, one is designated the "master" controller that is in charge of central authentication and quotas. This is done through custom scripts and light modifications to OpenStack. DAIR is currently running Havana.

For Object Storage, each region has a swift environment.

A NetApp appliance is used in each region for both block storage and instance storage. There are future plans to move the instances off the NetApp appliance and onto a distributed file system such as *Ceph* or GlusterFS.

VlanManager is used extensively for network management. All servers have two bonded 10GbE NICs that are connected to two redundant switches. DAIR is set up to use single-node networking where the cloud controller is the gateway for all instances on all compute nodes. Internal OpenStack traffic (for example, storage traffic) does not go through the cloud controller.

Resources

- DAIR homepage

CERN

Who uses it: researchers at CERN (European Organization for Nuclear Research) conducting high-energy physics research.

Deployment

The environment is largely based on Scientific Linux 6, which is Red Hat compatible. We use KVM as our primary hypervisor, although tests are ongoing with Hyper-V on Windows Server 2008.

We use the Puppet Labs OpenStack modules to configure Compute, Image service, Identity, and dashboard. Puppet is used widely for instance configuration, and Foreman is used as a GUI for reporting and instance provisioning.

Users and groups are managed through Active Directory and imported into the Identity service using LDAP. CLIs are available for nova and Euca2ools to do this.

There are three clouds currently running at CERN, totaling about 4,700 compute nodes, with approximately 120,000 cores. The CERN IT cloud aims to expand to 300,000 cores by 2015.

Resources

- OpenStack in Production: A tale of 3 OpenStack Clouds
- Review of CERN Data Centre Infrastructure
- CERN Cloud Infrastructure User Guide

Tales From the Cryp^H^H^H^H Cloud

Herein lies a selection of tales from OpenStack cloud operators. Read, and learn from their wisdom.

Double VLAN

I was on-site in Kelowna, British Columbia, Canada setting up a new OpenStack cloud. The deployment was fully automated: Cobbler deployed the OS on the bare metal, bootstrapped it, and Puppet took over from there. I had run the deployment scenario so many times in practice and took for granted that everything was working.

On my last day in Kelowna, I was in a conference call from my hotel. In the background, I was fooling around on the new cloud. I launched an instance and logged in. Everything looked fine. Out of boredom, I ran **`ps aux`** and all of the sudden the instance locked up.

Thinking it was just a one-off issue, I terminated the instance and launched a new one. By then, the conference call ended and I was off to the data center.

At the data center, I was finishing up some tasks and remembered the lock-up. I logged into the new instance and ran **`ps aux`** again. It worked. Phew. I decided to run it one more time. It locked up.

After reproducing the problem several times, I came to the unfortunate conclusion that this cloud did indeed have a problem. Even worse, my time was up in Kelowna and I had to return back to Calgary.

Where do you even begin troubleshooting something like this? An instance that just randomly locks up when a command is issued. Is it the image? Nope—it happens on all images. Is it the compute node? Nope—all nodes. Is the instance locked up? No! New SSH connections work just fine!

We reached out for help. A networking engineer suggested it was an MTU issue. Great! MTU! Something to go on! What's MTU and why would it cause a problem?

MTU is maximum transmission unit. It specifies the maximum number of bytes that the interface accepts for each packet. If two interfaces have two different MTUs, bytes might get chopped off and weird things happen—such as random session lockups.

Note: Not all packets have a size of 1500. Running the **`ls`** command over SSH might only create a single packets less than 1500 bytes. However, running a command with heavy output, such as **`ps aux`** requires several packets of 1500 bytes.

OK, so where is the MTU issue coming from? Why haven't we seen this in any other deployment? What's new in this situation? Well, new data center, new uplink, new switches, new model of switches, new servers, first time using this model of servers… so, basically everything was new. Wonderful. We toyed around with raising the MTU at various areas: the switches, the NICs on the compute nodes, the virtual NICs in the instances, we even had the data center raise the MTU for our uplink interface. Some changes worked, some didn't. This line of troubleshooting didn't feel right, though. We shouldn't have to be changing the MTU in these areas.

As a last resort, our network admin (Alvaro) and myself sat down with four terminal windows, a pencil, and a piece of paper. In one window, we ran ping. In the second window, we ran `tcpdump` on the cloud controller. In the third, `tcpdump` on the compute node. And the forth had `tcpdump` on the instance. For background, this cloud was a multi-node, non-multi-host setup.

One cloud controller acted as a gateway to all compute nodes. VlanManager was used for the network config. This means that the cloud controller and all compute nodes had a different VLAN for each OpenStack project. We used the `-s` option of `ping` to change the packet size. We watched as sometimes packets would fully return, sometimes they'd only make it out and never back in, and sometimes the packets would stop at a random point. We changed `tcpdump` to start displaying the hex dump of the packet. We pinged between every combination of outside, controller, compute, and instance.

Finally, Alvaro noticed something. When a packet from the outside hits the cloud controller, it should not be configured with a VLAN. We verified this as true. When the packet went from the cloud controller to the compute node, it should only have a VLAN if it was destined for an instance. This was still true. When the ping reply was sent from the instance, it should be in a VLAN. True. When it came back to the cloud controller and on its way out to the Internet, it should no longer have a VLAN. False. Uh oh. It looked as though the VLAN part of the packet was not being removed.

That made no sense.

While bouncing this idea around in our heads, I was randomly typing commands on the compute node:

```
$ ip a
…
10: vlan100@vlan20: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue master br100
↪state UP
…
```

"Hey Alvaro, can you run a VLAN on top of a VLAN?"

"If you did, you'd add an extra 4 bytes to the packet…"

Then it all made sense…

```
$ grep vlan_interface /etc/nova/nova.conf
vlan_interface=vlan20
```

In `nova.conf`, `vlan_interface` specifies what interface OpenStack should attach all VLANs to. The correct setting should have been:

```
vlan_interface=bond0
```

As this would be the server's bonded NIC.

vlan20 is the VLAN that the data center gave us for outgoing Internet access. It's a correct VLAN and is also attached to bond0.

By mistake, I configured OpenStack to attach all tenant VLANs to vlan20 instead of bond0 thereby stacking one VLAN on top of another. This added an extra 4 bytes to each packet and caused a packet of 1504 bytes to be sent out which would cause problems when it arrived at an interface that only accepted 1500.

As soon as this setting was fixed, everything worked.

"The Issue"

At the end of August 2012, a post-secondary school in Alberta, Canada migrated its infrastructure to an OpenStack cloud. As luck would have it, within the first day or two of it running, one of their servers just disappeared from the network. Blip. Gone.

After restarting the instance, everything was back up and running. We reviewed the logs and saw that at some point, network communication stopped and then everything went idle. We chalked this up to a random occurrence.

A few nights later, it happened again.

We reviewed both sets of logs. The one thing that stood out the most was DHCP. At the time, OpenStack, by default, set DHCP leases for one minute (it's now two minutes). This means that every instance contacts the cloud controller (DHCP server) to renew its fixed IP. For some reason, this instance could not renew its IP. We correlated the instance's logs with the logs on the cloud controller and put together a conversation:

1. Instance tries to renew IP.

2. Cloud controller receives the renewal request and sends a response.
3. Instance "ignores" the response and re-sends the renewal request.
4. Cloud controller receives the second request and sends a new response.
5. Instance begins sending a renewal request to `255.255.255.255` since it hasn't heard back from the cloud controller.
6. The cloud controller receives the `255.255.255.255` request and sends a third response.
7. The instance finally gives up.

With this information in hand, we were sure that the problem had to do with DHCP. We thought that for some reason, the instance wasn't getting a new IP address and with no IP, it shut itself off from the network.

A quick Google search turned up this: DHCP lease errors in VLAN mode which further supported our DHCP theory.

An initial idea was to just increase the lease time. If the instance only renewed once every week, the chances of this problem happening would be tremendously smaller than every minute. This didn't solve the problem, though. It was just covering the problem up.

We decided to have `tcpdump` run on this instance and see if we could catch it in action again. Sure enough, we did.

The `tcpdump` looked very, very weird. In short, it looked as though network communication stopped before the instance tried to renew its IP. Since there is so much DHCP chatter from a one minute lease, it's very hard to confirm it, but even with only milliseconds difference between packets, if one packet arrives first, it arrived first, and if that packet reported network issues, then it had to have happened before DHCP.

Additionally, this instance in question was responsible for a very, very large backup job each night. While "The Issue" (as we were now calling it) didn't happen exactly when the backup happened, it was close enough (a few hours) that we couldn't ignore it.

Further days go by and we catch The Issue in action more and more. We find that dhclient is not running after The Issue happens. Now we're back to thinking it's a DHCP issue. Running `/etc/init.d/networking` restart brings everything back up and running.

Ever have one of those days where all of the sudden you get the Google results you were looking for? Well, that's what happened here. I was looking for information on dhclient and why it dies when it can't renew its lease and all of the sudden I found a bunch of OpenStack and dnsmasq discussions that were identical to the problem we were seeing!

Problem with Heavy Network IO and Dnsmasq.

instances losing IP address while running, due to No DHCPOFFER.

Seriously, Google.

This bug report was the key to everything: KVM images lose connectivity with bridged network.

It was funny to read the report. It was full of people who had some strange network problem but didn't quite explain it in the same way.

So it was a qemu/kvm bug.

At the same time of finding the bug report, a co-worker was able to successfully reproduce The Issue! How? He used `iperf` to spew a ton of bandwidth at an instance. Within 30 minutes, the instance just disappeared from the network.

Armed with a patched qemu and a way to reproduce, we set out to see if we've finally solved The Issue. After 48 hours straight of hammering the instance with bandwidth, we were confident. The rest is history. You can search the bug report for "joe" to find my comments and actual tests.

Disappearing Images

At the end of 2012, Cybera (a nonprofit with a mandate to oversee the development of cyberinfrastructure in Alberta, Canada) deployed an updated OpenStack cloud for their DAIR project. A few days into production, a compute node locks up. Upon rebooting the node, I checked to see what instances were hosted on that node so I could boot them on behalf of the customer. Luckily, only one instance.

The **nova reboot** command wasn't working, so I used **virsh**, but it immediately came back with an error saying it was unable to find the backing disk. In this case, the backing disk is the Glance image that is copied to `/var/lib/nova/instances/_base` when the image is used for the first time. Why couldn't it find it? I checked the directory and sure enough it was gone.

I reviewed the `nova` database and saw the instance's entry in the `nova.instances` table. The image that the instance was using matched what virsh was reporting, so no inconsistency there.

I checked Glance and noticed that this image was a snapshot that the user created. At least that was good news—this user would have been the only user affected.

Finally, I checked StackTach and reviewed the user's events. They had created and deleted several snapshots—most likely experimenting. Although the timestamps didn't match up, my conclusion was that they launched their instance and then deleted the snapshot and it was somehow removed from `/var/lib/nova/instances/_base`. None of that made sense, but it was the best I could come up with.

It turns out the reason that this compute node locked up was a hardware issue. We removed it from the DAIR cloud and called Dell to have it serviced. Dell arrived and began working. Somehow or another (or a fat finger), a different compute node was bumped and rebooted. Great.

When this node fully booted, I ran through the same scenario of seeing what instances were running so I could turn them back on. There were a total of four. Three booted and one gave an error. It was the same error as before: unable to find the backing disk. Seriously, what?

Again, it turns out that the image was a snapshot. The three other instances that successfully started were standard cloud images. Was it a problem with snapshots? That didn't make sense.

A note about DAIR's architecture: `/var/lib/nova/instances` is a shared NFS mount. This means that all compute nodes have access to it, which includes the `_base` directory. Another centralized area is `/var/log/rsyslog` on the cloud controller. This directory collects all OpenStack logs from all compute nodes. I wondered if there were any entries for the file that **virsh** is reporting:

```
dair-ua-c03/nova.log:Dec 19 12:10:59 dair-ua-c03
2012-12-19 12:10:59 INFO nova.virt.libvirt.imagecache
[-] Removing base file:
/var/lib/nova/instances/_base/7b4783508212f5d242cbf9ff56fb8d33b4ce6166_10
```

Ah-hah! So OpenStack was deleting it. But why?

A feature was introduced in Essex to periodically check and see if there were any `_base` files not in use. If there were, OpenStack Compute would delete them. This idea sounds innocent enough and has some good qualities to it. But how did this feature end up turned on? It was disabled by default in Essex. As it should be. It was decided to be turned on in Folsom. I cannot emphasize enough that:

Actions which delete things should not be enabled by default.

Disk space is cheap these days. Data recovery is not.

Secondly, DAIR's shared /var/lib/nova/instances directory contributed to the problem. Since all compute nodes have access to this directory, all compute nodes periodically review the _base directory. If there is only one instance using an image, and the node that the instance is on is down for a few minutes, it won't be able to mark the image as still in use. Therefore, the image seems like it's not in use and is deleted. When the compute node comes back online, the instance hosted on that node is unable to start.

The Valentine's Day Compute Node Massacre

Although the title of this story is much more dramatic than the actual event, I don't think, or hope, that I'll have the opportunity to use "Valentine's Day Massacre" again in a title.

This past Valentine's Day, I received an alert that a compute node was no longer available in the cloud—meaning,

```
$ openstack compute service list
```

showed this particular node in a down state.

I logged into the cloud controller and was able to both ping and SSH into the problematic compute node which seemed very odd. Usually if I receive this type of alert, the compute node has totally locked up and would be inaccessible.

After a few minutes of troubleshooting, I saw the following details:

- A user recently tried launching a CentOS instance on that node
- This user was the only user on the node (new node)
- The load shot up to 8 right before I received the alert
- The bonded 10gb network device (bond0) was in a DOWN state
- The 1gb NIC was still alive and active

I looked at the status of both NICs in the bonded pair and saw that neither was able to communicate with the switch port. Seeing as how each NIC in the bond is connected to a separate switch, I thought that the chance of a switch port dying on each switch at the same time was quite improbable. I concluded that the 10gb dual port NIC had died and needed replaced. I created a ticket for the hardware support department at the data center where the node was hosted. I felt lucky that this was a new node and no one else was hosted on it yet.

An hour later I received the same alert, but for another compute node. Crap. OK, now there's definitely a problem going on. Just like the original node, I was able to log in by SSH. The bond0 NIC was DOWN but the 1gb NIC was active.

And the best part: the same user had just tried creating a CentOS instance. What?

I was totally confused at this point, so I texted our network admin to see if he was available to help. He logged in to both switches and immediately saw the problem: the switches detected spanning tree packets coming from the two compute nodes and immediately shut the ports down to prevent spanning tree loops:

```
Feb 15 01:40:18 SW-1 Stp: %SPANTREE-4-BLOCK_BPDUGUARD: Received BPDU packet on Port-
↪Channel35 with BPDU guard enabled. Disabling interface. (source mac fa:16:3e:24:e7:22)
Feb 15 01:40:18 SW-1 Ebra: %ETH-4-ERRDISABLE: bpduguard error detected on Port-Channel35.
Feb 15 01:40:18 SW-1 Mlag: %MLAG-4-INTF_INACTIVE_LOCAL: Local interface Port-Channel35 is
↪link down. MLAG 35 is inactive.
Feb 15 01:40:18 SW-1 Ebra: %LINEPROTO-5-UPDOWN: Line protocol on Interface Port-Channel35
↪(Server35), changed state to down
```

```
Feb 15 01:40:19 SW-1 Stp: %SPANTREE-6-INTERFACE_DEL: Interface Port-Channel35 has been
↪removed from instance MST0
Feb 15 01:40:19 SW-1 Ebra: %LINEPROTO-5-UPDOWN: Line protocol on Interface Ethernet35
↪(Server35), changed state to down
```

He re-enabled the switch ports and the two compute nodes immediately came back to life.

Unfortunately, this story has an open ending... we're still looking into why the CentOS image was sending out spanning tree packets. Further, we're researching a proper way on how to mitigate this from happening. It's a bigger issue than one might think. While it's extremely important for switches to prevent spanning tree loops, it's very problematic to have an entire compute node be cut from the network when this happens. If a compute node is hosting 100 instances and one of them sends a spanning tree packet, that instance has effectively DDOS'd the other 99 instances.

This is an ongoing and hot topic in networking circles —especially with the raise of virtualization and virtual switches.

Down the Rabbit Hole

Users being able to retrieve console logs from running instances is a boon for support—many times they can figure out what's going on inside their instance and fix what's going on without bothering you. Unfortunately, sometimes overzealous logging of failures can cause problems of its own.

A report came in: VMs were launching slowly, or not at all. Cue the standard checks—nothing on the Nagios, but there was a spike in network towards the current master of our RabbitMQ cluster. Investigation started, but soon the other parts of the queue cluster were leaking memory like a sieve. Then the alert came in—the master Rabbit server went down and connections failed over to the slave.

At that time, our control services were hosted by another team and we didn't have much debugging information to determine what was going on with the master, and we could not reboot it. That team noted that it failed without alert, but managed to reboot it. After an hour, the cluster had returned to its normal state and we went home for the day.

Continuing the diagnosis the next morning was kick started by another identical failure. We quickly got the message queue running again, and tried to work out why Rabbit was suffering from so much network traffic. Enabling debug logging on nova-api quickly brought understanding. A `tail -f /var/log/nova/nova-api.log` was scrolling by faster than we'd ever seen before. CTRL+C on that and we could plainly see the contents of a system log spewing failures over and over again - a system log from one of our users' instances.

After finding the instance ID we headed over to `/var/lib/nova/instances` to find the `console.log`:

```
adm@cc12:/var/lib/nova/instances/instance-00000e05# wc -l console.log
92890453 console.log
adm@cc12:/var/lib/nova/instances/instance-00000e05# ls -sh console.log
5.5G console.log
```

Sure enough, the user had been periodically refreshing the console log page on the dashboard and the 5G file was traversing the Rabbit cluster to get to the dashboard.

We called them and asked them to stop for a while, and they were happy to abandon the horribly broken VM. After that, we started monitoring the size of console logs.

To this day, the issue doesn't have a permanent resolution, but we look forward to the discussion at the next summit.

Havana Haunted by the Dead

Felix Lee of Academia Sinica Grid Computing Centre in Taiwan contributed this story.

I just upgraded OpenStack from Grizzly to Havana 2013.2-2 using the RDO repository and everything was running pretty well—except the EC2 API.

I noticed that the API would suffer from a heavy load and respond slowly to particular EC2 requests such as `RunInstances`.

Output from `/var/log/nova/nova-api.log` on *Havana*:

```
2014-01-10 09:11:45.072 129745 INFO nova.ec2.wsgi.server
[req-84d16d16-3808-426b-b7af-3b90a11b83b0
0c6e7dba03c24c6a9bce299747499e8a 7052bd6714e7460caeb16242e68124f9]
117.103.103.29 "GET
/services/Cloud?AWSAccessKeyId=[something]&Action=RunInstances&ClientToken=[something]&
↪ImageId=ami-00000001&InstanceInitiatedShutdownBehavior=terminate...
HTTP/1.1" status: 200 len: 1109 time: 138.5970151
```

This request took over two minutes to process, but executed quickly on another co-existing Grizzly deployment using the same hardware and system configuration.

Output from `/var/log/nova/nova-api.log` on *Grizzly*:

```
2014-01-08 11:15:15.704 INFO nova.ec2.wsgi.server
[req-ccac9790-3357-4aa8-84bd-cdaab1aa394e
ebbd729575cb404081a45c9ada0849b7 8175953c209044358ab5e0ec19d52c37]
117.103.103.29 "GET
/services/Cloud?AWSAccessKeyId=[something]&Action=RunInstances&ClientToken=[something]&
↪ImageId=ami-00000007&InstanceInitiatedShutdownBehavior=terminate...
HTTP/1.1" status: 200 len: 931 time: 3.9426181
```

While monitoring system resources, I noticed a significant increase in memory consumption while the EC2 API processed this request. I thought it wasn't handling memory properly—possibly not releasing memory. If the API received several of these requests, memory consumption quickly grew until the system ran out of RAM and began using swap. Each node has 48 GB of RAM and the "nova-api" process would consume all of it within minutes. Once this happened, the entire system would become unusably slow until I restarted the nova-api service.

So, I found myself wondering what changed in the EC2 API on Havana that might cause this to happen. Was it a bug or a normal behavior that I now need to work around?

After digging into the nova (OpenStack Compute) code, I noticed two areas in `api/ec2/cloud.py` potentially impacting my system:

```
instances = self.compute_api.get_all(context,
                                     search_opts=search_opts,
                                     sort_dir='asc')

sys_metas = self.compute_api.get_all_system_metadata(
    context, search_filts=[{'key': ['EC2_client_token']},
                          {'value': [client_token]}])
```

Since my database contained many records—over 1 million metadata records and over 300,000 instance records in "deleted" or "errored" states—each search took a long time. I decided to clean up the database by first archiving a copy for backup and then performing some deletions using the MySQL client. For example, I ran the following SQL command to remove rows of instances deleted for over a year:

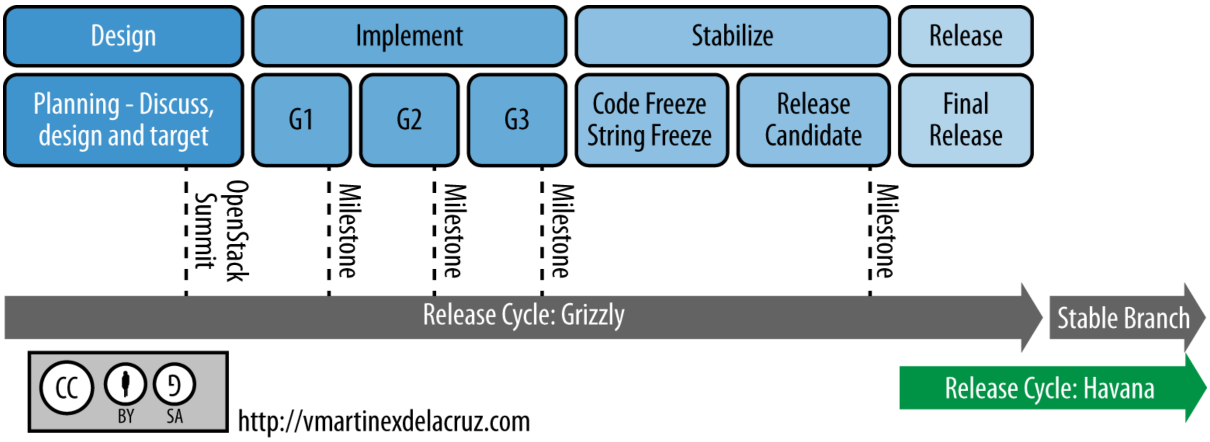
```
mysql> delete from nova.instances where deleted=1 and terminated_at < (NOW() - INTERVAL 1
↪YEAR);
```

Performance increased greatly after deleting the old records and my new deployment continues to behave well.

Working with Roadmaps

The good news: OpenStack has unprecedented transparency when it comes to providing information about what's coming up. The bad news: each release moves very quickly. The purpose of this appendix is to highlight some of the useful pages to track, and take an educated guess at what is coming up in the next release and perhaps further afield.

OpenStack follows a six month release cycle, typically releasing in April/May and October/November each year. At the start of each cycle, the community gathers in a single location for a design summit. At the summit, the features for the coming releases are discussed, prioritized, and planned. The below figure shows an example release cycle, with dates showing milestone releases, code freeze, and string freeze dates, along with an example of when the summit occurs. Milestones are interim releases within the cycle that are available as packages for download and testing. Code freeze is putting a stop to adding new features to the release. String freeze is putting a stop to changing any strings within the source code.



Information Available to You

There are several good sources of information available that you can use to track your OpenStack development desires.

Release notes are maintained on the OpenStack wiki, and also shown here:

Series	Status	Releases	Date
Liberty	Under Development	2015.2	Oct, 2015
Kilo	Current stable release, security-supported	2015.1	Apr 30, 2015
Juno	Security-supported	2014.2	Oct 16, 2014
Icehouse	End-of-life	2014.1	Apr 17, 2014
		2014.1.1	Jun 9, 2014
		2014.1.2	Aug 8, 2014
		2014.1.3	Oct 2, 2014
Havana	End-of-life	2013.2	Apr 4, 2013
		2013.2.1	Dec 16, 2013

Continued on next page

Table 8 – continued from previous page

Series	Status	Releases	Date
		2013.2.2	Feb 13, 2014
		2013.2.3	Apr 3, 2014
		2013.2.4	Sep 22, 2014
		2013.2.1	Dec 16, 2013
Grizzly	End-of-life	2013.1	Apr 4, 2013
		2013.1.1	May 9, 2013
		2013.1.2	Jun 6, 2013
		2013.1.3	Aug 8, 2013
		2013.1.4	Oct 17, 2013
		2013.1.5	Mar 20, 2015
Folsom	End-of-life	2012.2	Sep 27, 2012
		2012.2.1	Nov 29, 2012
		2012.2.2	Dec 13, 2012
		2012.2.3	Jan 31, 2013
		2012.2.4	Apr 11, 2013
Essex	End-of-life	2012.1	Apr 5, 2012
		2012.1.1	Jun 22, 2012
		2012.1.2	Aug 10, 2012
		2012.1.3	Oct 12, 2012
Diablo	Deprecated	2011.3	Sep 22, 2011
		2011.3.1	Jan 19, 2012
Cactus	Deprecated	2011.2	Apr 15, 2011
Bexar	Deprecated	2011.1	Feb 3, 2011
Austin	Deprecated	2010.1	Oct 21, 2010

Here are some other resources:

- A breakdown of current features under development, with their target milestone
- A list of all features, including those not yet under development
- Rough-draft design discussions ("etherpads") from the last design summit
- List of individual code changes under review

Influencing the Roadmap

OpenStack truly welcomes your ideas (and contributions) and highly values feedback from real-world users of the software. By learning a little about the process that drives feature development, you can participate and perhaps get the additions you desire.

Feature requests typically start their life in Etherpad, a collaborative editing tool, which is used to take coordinating notes at a design summit session specific to the feature. This then leads to the creation of a blueprint on the Launchpad site for the particular project, which is used to describe the feature more formally. Blueprints are then approved by project team members, and development can begin.

Therefore, the fastest way to get your feature request up for consideration is to create an Etherpad with your ideas and propose a session to the design summit. If the design summit has already passed, you may also create a blueprint directly. Read this blog post about how to work with blueprints the perspective of Victoria Martínez, a developer intern.

The roadmap for the next release as it is developed can be seen at Releases.

To determine the potential features going in to future releases, or to look at features implemented previously, take a look at the existing blueprints such as OpenStack Compute (nova) Blueprints, OpenStack Identity (keystone) Blueprints, and release notes.

Aside from the direct-to-blueprint pathway, there is another very well-regarded mechanism to influence the development roadmap: the user survey. Found at OpenStack User Survey, it allows you to provide details of your deployments and needs, anonymously by default. Each cycle, the user committee analyzes the results and produces a report, including providing specific information to the technical committee and project team leads.

Aspects to Watch

You want to keep an eye on the areas improving within OpenStack. The best way to "watch" roadmaps for each project is to look at the blueprints that are being approved for work on milestone releases. You can also learn from PTL webinars that follow the OpenStack summits twice a year.

Driver Quality Improvements

A major quality push has occurred across drivers and plug-ins in Block Storage, Compute, and Networking. Particularly, developers of Compute and Networking drivers that require proprietary or hardware products are now required to provide an automated external testing system for use during the development process.

Easier Upgrades

One of the most requested features since OpenStack began (for components other than Object Storage, which tends to "just work"): easier upgrades. In all recent releases internal messaging communication is versioned, meaning services can theoretically drop back to backward-compatible behavior. This allows you to run later versions of some components, while keeping older versions of others.

In addition, database migrations are now tested with the Turbo Hipster tool. This tool tests database migration performance on copies of real-world user databases.

These changes have facilitated the first proper OpenStack upgrade guide, found in *Upgrades*, and will continue to improve in the next release.

Deprecation of Nova Network

With the introduction of the full software-defined networking stack provided by OpenStack Networking (neutron) in the Folsom release, development effort on the initial networking code that remains part of the Compute component has gradually lessened. While many still use `nova-network` in production, there has been a long-term plan to remove the code in favor of the more flexible and full-featured OpenStack Networking.

An attempt was made to deprecate `nova-network` during the Havana release, which was aborted due to the lack of equivalent functionality (such as the FlatDHCP multi-host high-availability mode mentioned in this guide), lack of a migration path between versions, insufficient testing, and simplicity when used for the more straightforward use cases `nova-network` traditionally supported. Though significant effort has been made to address these concerns, `nova-network` was not be deprecated in the Juno release. In addition, to a limited degree, patches to `nova-network` have again begin to be accepted, such as adding a per-network settings feature and SR-IOV support in Juno.

This leaves you with an important point of decision when designing your cloud. OpenStack Networking is robust enough to use with a small number of limitations (performance issues in some scenarios, only basic high availability of layer 3 systems) and provides many more features than `nova-network`. However, if you do not have the more complex use cases that can benefit from fuller software-defined networking capabilities, or are uncomfortable with the new concepts introduced, `nova-network` may continue to be a viable option for the next 12 months.

Similarly, if you have an existing cloud and are looking to upgrade from `nova-network` to OpenStack Networking, you should have the option to delay the upgrade for this period of time. However, each release of OpenStack brings significant new innovation, and regardless of your use of networking methodology, it is likely best to begin planning for an upgrade within a reasonable timeframe of each release.

As mentioned, there's currently no way to cleanly migrate from `nova-network` to neutron. We recommend that you keep a migration in mind and what that process might involve for when a proper migration path is released.

Distributed Virtual Router

One of the long-time complaints surrounding OpenStack Networking was the lack of high availability for the layer 3 components. The Juno release introduced Distributed Virtual Router (DVR), which aims to solve this problem.

Early indications are that it does do this well for a base set of scenarios, such as using the ML2 plug-in with Open vSwitch, one flat external network and VXLAN tenant networks. However, it does appear that there are problems with the use of VLANs, IPv6, Floating IPs, high north-south traffic scenarios and large numbers of compute nodes. It is expected these will improve significantly with the next release, but bug reports on specific issues are highly desirable.

Replacement of Open vSwitch Plug-in with Modular Layer 2

The Modular Layer 2 plug-in is a framework allowing OpenStack Networking to simultaneously utilize the variety of layer-2 networking technologies found in complex real-world data centers. It currently works with the existing Open vSwitch, Linux Bridge, and Hyper-V L2 agents and is intended to replace and deprecate the monolithic plug-ins associated with those L2 agents.

New API Versions

The third version of the Compute API was broadly discussed and worked on during the Havana and Icehouse release cycles. Current discussions indicate that the V2 API will remain for many releases, and the next iteration of the API will be denoted v2.1 and have similar properties to the existing v2.0, rather than an entirely new v3 API. This is a great time to evaluate all API and provide comments while the next generation APIs are being defined. A new working group was formed specifically to improve OpenStack APIs and create design guidelines, which you are welcome to join.

OpenStack on OpenStack (TripleO)

This project continues to improve and you may consider using it for greenfield deployments, though according to the latest user survey results it remains to see widespread uptake.

Data processing service for OpenStack (sahara)

A much-requested answer to big data problems, a dedicated team has been making solid progress on a Hadoop-as-a-Service project.

Bare metal Deployment (ironic)

The bare-metal deployment has been widely lauded, and development continues. The Juno release brought the OpenStack Bare metal drive into the Compute project, and it was aimed to deprecate the existing bare-metal driver in Kilo. If you are a current user of the bare metal driver, a particular blueprint to follow is Deprecate the bare metal driver

Database as a Service (trove)

The OpenStack community has had a database-as-a-service tool in development for some time, and we saw the first integrated release of it in Icehouse. From its release it was able to deploy database servers out of the box in a highly available way, initially supporting only MySQL. Juno introduced support for Mongo (including clustering), PostgreSQL and Couchbase, in addition to replication functionality for MySQL. In Kilo, more advanced clustering capability was delivered, in addition to better integration with other OpenStack components such as Networking.

Message Service (zaqar)

A service to provide queues of messages and notifications was released.

DNS service (designate)

A long requested service, to provide the ability to manipulate DNS entries associated with OpenStack resources has gathered a following. The designate project was also released.

Scheduler Improvements

Both Compute and Block Storage rely on schedulers to determine where to place virtual machines or volumes. In Havana, the Compute scheduler underwent significant improvement, while in Icehouse it was the scheduler in Block Storage that received a boost. Further down the track, an effort started this cycle that aims to create a holistic scheduler covering both will come to fruition. Some of the work that was done in Kilo can be found under the Gantt project.

Block Storage Improvements

Block Storage is considered a stable project, with wide uptake and a long track record of quality drivers. The team has discussed many areas of work at the summits, including better error reporting, automated discovery, and thin provisioning features.

Toward a Python SDK

Though many successfully use the various python-*client code as an effective SDK for interacting with OpenStack, consistency between the projects and documentation availability waxes and wanes. To combat this, an effort to improve the experience has started. Cross-project development efforts in OpenStack have a checkered history, such as the unified client project having several false starts. However, the early signs for the SDK project are promising, and we expect to see results during the Juno cycle.

Resources

OpenStack

- OpenStack Installation Tutorial for openSUSE and SUSE Linux Enterprise Server
- OpenStack Installation Tutorial for Red Hat Enterprise Linux and CentOS
- OpenStack Installation Tutorial for Ubuntu Server
- OpenStack Administrator Guide
- OpenStack Cloud Computing Cookbook (Packt Publishing)

Cloud (General)

- The NIST Definition of Cloud Computing

Python

- Dive Into Python (Apress)

Networking

- TCP/IP Illustrated, Volume 1: The Protocols, 2/E (Pearson)
- The TCP/IP Guide (No Starch Press)
- A tcpdump Tutorial and Primer

Systems Administration

- UNIX and Linux Systems Administration Handbook (Prentice Hall)

Virtualization

- The Book of Xen (No Starch Press)

Configuration Management

- Puppet Labs Documentation
- Pro Puppet (Apress)

Community support

The following resources are available to help you run and use OpenStack. The OpenStack community constantly improves and adds to the main features of OpenStack, but if you have any questions, do not hesitate to ask. Use the following resources to get OpenStack support and troubleshoot your installations.

Documentation

For the available OpenStack documentation, see docs.openstack.org.

To provide feedback on documentation, join and use the openstack-docs@lists.openstack.org mailing list at OpenStack Documentation Mailing List, join our IRC channel `#openstack-doc` on the freenode IRC network, or report a bug.

The following books explain how to install an OpenStack cloud and its associated components:

- Installation Tutorial for openSUSE Leap 42.2 and SUSE Linux Enterprise Server 12 SP2
- Installation Tutorial for Red Hat Enterprise Linux 7 and CentOS 7
- Installation Tutorial for Ubuntu 16.04 (LTS)

The following books explain how to configure and run an OpenStack cloud:

- Architecture Design Guide
- Administrator Guide
- Configuration Reference
- Operations Guide
- Networking Guide
- High Availability Guide
- Security Guide
- Virtual Machine Image Guide

The following books explain how to use the OpenStack Dashboard and command-line clients:

- End User Guide
- Command-Line Interface Reference

The following documentation provides reference and guidance information for the OpenStack APIs:

- API Guide

The following guide provides how to contribute to OpenStack documentation:

- Documentation Contributor Guide

ask.openstack.org

During the set up or testing of OpenStack, you might have questions about how a specific task is completed or be in a situation where a feature does not work correctly. Use the ask.openstack.org site to ask questions and get answers. When you visit the Ask OpenStack site, scan the recently asked questions to see whether your question has already been answered. If not, ask a new question. Be sure to give a clear, concise summary in the title and provide as much detail as possible in the description. Paste in your command output or stack traces, links to screen shots, and any other information which might be useful.

OpenStack mailing lists

A great way to get answers and insights is to post your question or problematic scenario to the OpenStack mailing list. You can learn from and help others who might have similar issues. To subscribe or view the archives, go to the general OpenStack mailing list. If you are interested in the other mailing lists for specific projects or development, refer to Mailing Lists.

The OpenStack wiki

The OpenStack wiki contains a broad range of topics but some of the information can be difficult to find or is a few pages deep. Fortunately, the wiki search feature enables you to search by title or content. If you search for specific information, such as about networking or OpenStack Compute, you can find a large amount of relevant material. More is being added all the time, so be sure to check back often. You can find the search box in the upper-right corner of any OpenStack wiki page.

The Launchpad Bugs area

The OpenStack community values your set up and testing efforts and wants your feedback. To log a bug, you must sign up for a Launchpad account. You can view existing bugs and report bugs in the Launchpad Bugs area. Use the search feature to determine whether the bug has already been reported or already been fixed. If it still seems like your bug is unreported, fill out a bug report.

Some tips:

- Give a clear, concise summary.
- Provide as much detail as possible in the description. Paste in your command output or stack traces, links to screen shots, and any other information which might be useful.
- Be sure to include the software and package versions that you are using, especially if you are using a development branch, such as, `"Kilo release" vs git commit bc79c3ecc55929bac585d04a03475b72e06a3208`.
- Any deployment-specific information is helpful, such as whether you are using Ubuntu 14.04 or are performing a multi-node installation.

The following Launchpad Bugs areas are available:

- Bugs: OpenStack Block Storage (cinder)
- Bugs: OpenStack Compute (nova)
- Bugs: OpenStack Dashboard (horizon)
- Bugs: OpenStack Identity (keystone)

- Bugs: OpenStack Image service (glance)
- Bugs: OpenStack Networking (neutron)
- Bugs: OpenStack Object Storage (swift)
- Bugs: Application catalog (murano)
- Bugs: Bare metal service (ironic)
- Bugs: Clustering service (senlin)
- Bugs: Container Infrastructure Management service (magnum)
- Bugs: Data processing service (sahara)
- Bugs: Database service (trove)
- Bugs: Deployment service (fuel)
- Bugs: DNS service (designate)
- Bugs: Key Manager Service (barbican)
- Bugs: Monitoring (monasca)
- Bugs: Orchestration (heat)
- Bugs: Rating (cloudkitty)
- Bugs: Shared file systems (manila)
- Bugs: Telemetry (ceilometer)
- Bugs: Telemetry v3 (gnocchi)
- Bugs: Workflow service (mistral)
- Bugs: Messaging service (zaqar)
- Bugs: OpenStack API Documentation (developer.openstack.org)
- Bugs: OpenStack Documentation (docs.openstack.org)

The OpenStack IRC channel

The OpenStack community lives in the #openstack IRC channel on the Freenode network. You can hang out, ask questions, or get immediate feedback for urgent and pressing issues. To install an IRC client or use a browser-based client, go to https://webchat.freenode.net/. You can also use Colloquy (Mac OS X), mIRC (Windows), or XChat (Linux). When you are in the IRC channel and want to share code or command output, the generally accepted method is to use a Paste Bin. The OpenStack project has one at Paste. Just paste your longer amounts of text or logs in the web form and you get a URL that you can paste into the channel. The OpenStack IRC channel is `#openstack` on `irc.freenode.net`. You can find a list of all OpenStack IRC channels on the IRC page on the wiki.

Documentation feedback

To provide feedback on documentation, join and use the openstack-docs@lists.openstack.org mailing list at OpenStack Documentation Mailing List, or report a bug.

OpenStack distribution packages

The following Linux distributions provide community-supported packages for OpenStack:

- **Debian:** https://wiki.debian.org/OpenStack
- **CentOS, Fedora, and Red Hat Enterprise Linux:** https://www.rdoproject.org/
- **openSUSE and SUSE Linux Enterprise Server:** https://en.opensuse.org/Portal:OpenStack
- **Ubuntu:** https://wiki.ubuntu.com/ServerTeam/CloudArchive

Glossary

This glossary offers a list of terms and definitions to define a vocabulary for OpenStack-related concepts.

To add to OpenStack glossary, clone the openstack/openstack-manuals repository and update the source file `doc/common/glossary.rst` through the OpenStack contribution process.

0-9

6to4 A mechanism that allows IPv6 packets to be transmitted over an IPv4 network, providing a strategy for migrating to IPv6.

A

absolute limit Impassable limits for guest VMs. Settings include total RAM size, maximum number of vCPUs, and maximum disk size.

access control list (ACL) A list of permissions attached to an object. An ACL specifies which users or system processes have access to objects. It also defines which operations can be performed on specified objects. Each entry in a typical ACL specifies a subject and an operation. For instance, the ACL entry `(Alice, delete)` for a file gives Alice permission to delete the file.

access key Alternative term for an Amazon EC2 access key. See EC2 access key.

account The Object Storage context of an account. Do not confuse with a user account from an authentication service, such as Active Directory, /etc/passwd, OpenLDAP, OpenStack Identity, and so on.

account auditor Checks for missing replicas and incorrect or corrupted objects in a specified Object Storage account by running queries against the back-end SQLite database.

account database A SQLite database that contains Object Storage accounts and related metadata and that the accounts server accesses.

account reaper An Object Storage worker that scans for and deletes account databases and that the account server has marked for deletion.

account server Lists containers in Object Storage and stores container information in the account database.

account service An Object Storage component that provides account services such as list, create, modify, and audit. Do not confuse with OpenStack Identity service, OpenLDAP, or similar user-account services.

accounting The Compute service provides accounting information through the event notification and system usage data facilities.

Active Directory Authentication and identity service by Microsoft, based on LDAP. Supported in OpenStack.

active/active configuration In a high-availability setup with an active/active configuration, several systems share the load together and if one fails, the load is distributed to the remaining systems.

active/passive configuration In a high-availability setup with an active/passive configuration, systems are set up to bring additional resources online to replace those that have failed.

address pool A group of fixed and/or floating IP addresses that are assigned to a project and can be used by or assigned to the VM instances in a project.

Address Resolution Protocol (ARP) The protocol by which layer-3 IP addresses are resolved into layer-2 link local addresses.

admin API A subset of API calls that are accessible to authorized administrators and are generally not accessible to end users or the public Internet. They can exist as a separate service (keystone) or can be a subset of another API (nova).

admin server In the context of the Identity service, the worker process that provides access to the admin API.

administrator The person responsible for installing, configuring, and managing an OpenStack cloud.

Advanced Message Queuing Protocol (AMQP) The open standard messaging protocol used by OpenStack components for intra-service communications, provided by RabbitMQ, Qpid, or ZeroMQ.

Advanced RISC Machine (ARM) Lower power consumption CPU often found in mobile and embedded devices. Supported by OpenStack.

alert The Compute service can send alerts through its notification system, which includes a facility to create custom notification drivers. Alerts can be sent to and displayed on the dashboard.

allocate The process of taking a floating IP address from the address pool so it can be associated with a fixed IP on a guest VM instance.

Amazon Kernel Image (AKI) Both a VM container format and disk format. Supported by Image service.

Amazon Machine Image (AMI) Both a VM container format and disk format. Supported by Image service.

Amazon Ramdisk Image (ARI) Both a VM container format and disk format. Supported by Image service.

Anvil A project that ports the shell script-based project named DevStack to Python.

aodh Part of the OpenStack *Telemetry service*; provides alarming functionality.

Apache The Apache Software Foundation supports the Apache community of open-source software projects. These projects provide software products for the public good.

Apache License 2.0 All OpenStack core projects are provided under the terms of the Apache License 2.0 license.

Apache Web Server The most common web server software currently used on the Internet.

API endpoint The daemon, worker, or service that a client communicates with to access an API. API endpoints can provide any number of services, such as authentication, sales data, performance meters, Compute VM commands, census data, and so on.

API extension Custom modules that extend some OpenStack core APIs.

API extension plug-in Alternative term for a Networking plug-in or Networking API extension.

API key Alternative term for an API token.

API server Any node running a daemon or worker that provides an API endpoint.

API token Passed to API requests and used by OpenStack to verify that the client is authorized to run the requested operation.

API version In OpenStack, the API version for a project is part of the URL. For example, `example.com/nova/v1/foobar`.

applet A Java program that can be embedded into a web page.

Application Catalog service (murano) The project that provides an application catalog service so that users can compose and deploy composite environments on an application abstraction level while managing the application lifecycle.

Application Programming Interface (API) A collection of specifications used to access a service, application, or program. Includes service calls, required parameters for each call, and the expected return values.

application server A piece of software that makes available another piece of software over a network.

Application Service Provider (ASP) Companies that rent specialized applications that help businesses and organizations provide additional services with lower cost.

arptables Tool used for maintaining Address Resolution Protocol packet filter rules in the Linux kernel firewall modules. Used along with iptables, ebtables, and ip6tables in Compute to provide firewall services for VMs.

associate The process associating a Compute floating IP address with a fixed IP address.

Asynchronous JavaScript and XML (AJAX) A group of interrelated web development techniques used on the client-side to create asynchronous web applications. Used extensively in horizon.

ATA over Ethernet (AoE) A disk storage protocol tunneled within Ethernet.

attach The process of connecting a VIF or vNIC to a L2 network in Networking. In the context of Compute, this process connects a storage volume to an instance.

attachment (network) Association of an interface ID to a logical port. Plugs an interface into a port.

auditing Provided in Compute through the system usage data facility.

auditor A worker process that verifies the integrity of Object Storage objects, containers, and accounts. Auditors is the collective term for the Object Storage account auditor, container auditor, and object auditor.

Austin The code name for the initial release of OpenStack. The first design summit took place in Austin, Texas, US.

auth node Alternative term for an Object Storage authorization node.

authentication The process that confirms that the user, process, or client is really who they say they are through private key, secret token, password, fingerprint, or similar method.

authentication token A string of text provided to the client after authentication. Must be provided by the user or process in subsequent requests to the API endpoint.

AuthN The Identity service component that provides authentication services.

authorization The act of verifying that a user, process, or client is authorized to perform an action.

authorization node An Object Storage node that provides authorization services.

AuthZ The Identity component that provides high-level authorization services.

Auto ACK Configuration setting within RabbitMQ that enables or disables message acknowledgment. Enabled by default.

auto declare A Compute RabbitMQ setting that determines whether a message exchange is automatically created when the program starts.

availability zone An Amazon EC2 concept of an isolated area that is used for fault tolerance. Do not confuse with an OpenStack Compute zone or cell.

AWS CloudFormation template AWS CloudFormation allows Amazon Web Services (AWS) users to create and manage a collection of related resources. The Orchestration service supports a CloudFormation-compatible format (CFN).

B

back end Interactions and processes that are obfuscated from the user, such as Compute volume mount, data transmission to an iSCSI target by a daemon, or Object Storage object integrity checks.

back-end catalog The storage method used by the Identity service catalog service to store and retrieve information about API endpoints that are available to the client. Examples include an SQL database, LDAP database, or KVS back end.

back-end store The persistent data store used to save and retrieve information for a service, such as lists of Object Storage objects, current state of guest VMs, lists of user names, and so on. Also, the method that the Image service uses to get and store VM images. Options include Object Storage, locally mounted file system, RADOS block devices, VMware datastore, and HTTP.

Backup, Restore, and Disaster Recovery service (freezer) The project that provides integrated tooling for backing up, restoring, and recovering file systems, instances, or database backups.

bandwidth The amount of available data used by communication resources, such as the Internet. Represents the amount of data that is used to download things or the amount of data available to download.

barbican Code name of the *Key Manager service*.

bare An Image service container format that indicates that no container exists for the VM image.

Bare Metal service (ironic) The OpenStack service that provides a service and associated libraries capable of managing and provisioning physical machines in a security-aware and fault-tolerant manner.

base image An OpenStack-provided image.

Bell-LaPadula model A security model that focuses on data confidentiality and controlled access to classified information. This model divides the entities into subjects and objects. The clearance of a subject is compared to the classification of the object to determine if the subject is authorized for the specific access mode. The clearance or classification scheme is expressed in terms of a lattice.

Benchmark service (rally) OpenStack project that provides a framework for performance analysis and benchmarking of individual OpenStack components as well as full production OpenStack cloud deployments.

Bexar A grouped release of projects related to OpenStack that came out in February of 2011. It included only Compute (nova) and Object Storage (swift). Bexar is the code name for the second release of OpenStack. The design summit took place in San Antonio, Texas, US, which is the county seat for Bexar county.

binary Information that consists solely of ones and zeroes, which is the language of computers.

bit A bit is a single digit number that is in base of 2 (either a zero or one). Bandwidth usage is measured in bits per second.

bits per second (BPS) The universal measurement of how quickly data is transferred from place to place.

block device A device that moves data in the form of blocks. These device nodes interface the devices, such as hard disks, CD-ROM drives, flash drives, and other addressable regions of memory.

block migration A method of VM live migration used by KVM to evacuate instances from one host to another with very little downtime during a user-initiated switchover. Does not require shared storage. Supported by Compute.

Block Storage API An API on a separate endpoint for attaching, detaching, and creating block storage for compute VMs.

Block Storage service (cinder) The OpenStack service that implement services and libraries to provide on-demand, self-service access to Block Storage resources via abstraction and automation on top of other block storage devices.

BMC (Baseboard Management Controller) The intelligence in the IPMI architecture, which is a specialized micro-controller that is embedded on the motherboard of a computer and acts as a server. Manages the interface between system management software and platform hardware.

bootable disk image A type of VM image that exists as a single, bootable file.

Bootstrap Protocol (BOOTP) A network protocol used by a network client to obtain an IP address from a configuration server. Provided in Compute through the dnsmasq daemon when using either the FlatDHCP manager or VLAN manager network manager.

Border Gateway Protocol (BGP) The Border Gateway Protocol is a dynamic routing protocol that connects autonomous systems. Considered the backbone of the Internet, this protocol connects disparate networks to form a larger network.

browser Any client software that enables a computer or device to access the Internet.

builder file Contains configuration information that Object Storage uses to reconfigure a ring or to re-create it from scratch after a serious failure.

bursting The practice of utilizing a secondary environment to elastically build instances on-demand when the primary environment is resource constrained.

button class A group of related button types within horizon. Buttons to start, stop, and suspend VMs are in one class. Buttons to associate and disassociate floating IP addresses are in another class, and so on.

byte Set of bits that make up a single character; there are usually 8 bits to a byte.

C

cache pruner A program that keeps the Image service VM image cache at or below its configured maximum size.

Cactus An OpenStack grouped release of projects that came out in the spring of 2011. It included Compute (nova), Object Storage (swift), and the Image service (glance). Cactus is a city in Texas, US and is the code name for the third release of OpenStack. When OpenStack releases went from three to six months long, the code name of the release changed to match a geography nearest the previous summit.

CALL One of the RPC primitives used by the OpenStack message queue software. Sends a message and waits for a response.

capability Defines resources for a cell, including CPU, storage, and networking. Can apply to the specific services within a cell or a whole cell.

capacity cache A Compute back-end database table that contains the current workload, amount of free RAM, and number of VMs running on each host. Used to determine on which host a VM starts.

capacity updater A notification driver that monitors VM instances and updates the capacity cache as needed.

CAST One of the RPC primitives used by the OpenStack message queue software. Sends a message and does not wait for a response.

catalog A list of API endpoints that are available to a user after authentication with the Identity service.

catalog service An Identity service that lists API endpoints that are available to a user after authentication with the Identity service.

ceilometer Part of the OpenStack *Telemetry service*; gathers and stores metrics from other OpenStack services.

cell Provides logical partitioning of Compute resources in a child and parent relationship. Requests are passed from parent cells to child cells if the parent cannot provide the requested resource.

cell forwarding A Compute option that enables parent cells to pass resource requests to child cells if the parent cannot provide the requested resource.

cell manager The Compute component that contains a list of the current capabilities of each host within the cell and routes requests as appropriate.

CentOS A Linux distribution that is compatible with OpenStack.

Ceph Massively scalable distributed storage system that consists of an object store, block store, and POSIX-compatible distributed file system. Compatible with OpenStack.

CephFS The POSIX-compliant file system provided by Ceph.

certificate authority (CA) In cryptography, an entity that issues digital certificates. The digital certificate certifies the ownership of a public key by the named subject of the certificate. This enables others (relying parties) to rely upon signatures or assertions made by the private key that corresponds to the certified public key. In this model of trust relationships, a CA is a trusted third party for both the subject (owner) of the certificate and the party relying upon the certificate. CAs are characteristic of many public key infrastructure (PKI) schemes. In OpenStack, a simple certificate authority is provided by Compute for cloudpipe VPNs and VM image decryption.

Challenge-Handshake Authentication Protocol (CHAP) An iSCSI authentication method supported by Compute.

chance scheduler A scheduling method used by Compute that randomly chooses an available host from the pool.

changes since A Compute API parameter that downloads changes to the requested item since your last request, instead of downloading a new, fresh set of data and comparing it against the old data.

Chef An operating system configuration management tool supporting OpenStack deployments.

child cell If a requested resource such as CPU time, disk storage, or memory is not available in the parent cell, the request is forwarded to its associated child cells. If the child cell can fulfill the request, it does. Otherwise, it attempts to pass the request to any of its children.

cinder Codename for *Block Storage service*.

CirrOS A minimal Linux distribution designed for use as a test image on clouds such as OpenStack.

Cisco neutron plug-in A Networking plug-in for Cisco devices and technologies, including UCS and Nexus.

cloud architect A person who plans, designs, and oversees the creation of clouds.

Cloud Auditing Data Federation (CADF) Cloud Auditing Data Federation (CADF) is a specification for audit event data. CADF is supported by OpenStack Identity.

cloud computing A model that enables access to a shared pool of configurable computing resources, such as networks, servers, storage, applications, and services, that can be rapidly provisioned and released with minimal management effort or service provider interaction.

cloud controller Collection of Compute components that represent the global state of the cloud; talks to services, such as Identity authentication, Object Storage, and node/storage workers through a queue.

cloud controller node A node that runs network, volume, API, scheduler, and image services. Each service may be broken out into separate nodes for scalability or availability.

Cloud Data Management Interface (CDMI) SINA standard that defines a RESTful API for managing objects in the cloud, currently unsupported in OpenStack.

Cloud Infrastructure Management Interface (CIMI) An in-progress specification for cloud management. Currently unsupported in OpenStack.

cloud-init A package commonly installed in VM images that performs initialization of an instance after boot using information that it retrieves from the metadata service, such as the SSH public key and user data.

cloudadmin One of the default roles in the Compute RBAC system. Grants complete system access.

Cloudbase-Init A Windows project providing guest initialization features, similar to cloud-init.

cloudpipe A compute service that creates VPNs on a per-project basis.

cloudpipe image A pre-made VM image that serves as a cloudpipe server. Essentially, OpenVPN running on Linux.

Clustering service (senlin) The project that implements clustering services and libraries for the management of groups of homogeneous objects exposed by other OpenStack services.

command filter Lists allowed commands within the Compute rootwrap facility.

Common Internet File System (CIFS) A file sharing protocol. It is a public or open variation of the original Server Message Block (SMB) protocol developed and used by Microsoft. Like the SMB protocol, CIFS runs at a higher level and uses the TCP/IP protocol.

Common Libraries (oslo) The project that produces a set of python libraries containing code shared by OpenStack projects. The APIs provided by these libraries should be high quality, stable, consistent, documented and generally applicable.

community project A project that is not officially endorsed by the OpenStack Foundation. If the project is successful enough, it might be elevated to an incubated project and then to a core project, or it might be merged with the main code trunk.

compression Reducing the size of files by special encoding, the file can be decompressed again to its original content. OpenStack supports compression at the Linux file system level but does not support compression for things such as Object Storage objects or Image service VM images.

Compute API (Nova API) The nova-api daemon provides access to nova services. Can communicate with other APIs, such as the Amazon EC2 API.

compute controller The Compute component that chooses suitable hosts on which to start VM instances.

compute host Physical host dedicated to running compute nodes.

compute node A node that runs the nova-compute daemon that manages VM instances that provide a wide range of services, such as web applications and analytics.

Compute service (nova) The OpenStack core project that implements services and associated libraries to provide massively-scalable, on-demand, self-service access to compute resources, including bare metal, virtual machines, and containers.

compute worker The Compute component that runs on each compute node and manages the VM instance lifecycle, including run, reboot, terminate, attach/detach volumes, and so on. Provided by the nova-compute daemon.

concatenated object A set of segment objects that Object Storage combines and sends to the client.

conductor In Compute, conductor is the process that proxies database requests from the compute process. Using conductor improves security because compute nodes do not need direct access to the database.

congress Code name for the *Governance service*.

consistency window The amount of time it takes for a new Object Storage object to become accessible to all clients.

console log Contains the output from a Linux VM console in Compute.

container Organizes and stores objects in Object Storage. Similar to the concept of a Linux directory but cannot be nested. Alternative term for an Image service container format.

container auditor Checks for missing replicas or incorrect objects in specified Object Storage containers through queries to the SQLite back-end database.

container database A SQLite database that stores Object Storage containers and container metadata. The container server accesses this database.

container format A wrapper used by the Image service that contains a VM image and its associated metadata, such as machine state, OS disk size, and so on.

Container Infrastructure Management service (magnum) The project which provides a set of services for provisioning, scaling, and managing container orchestration engines.

container server An Object Storage server that manages containers.

container service The Object Storage component that provides container services, such as create, delete, list, and so on.

content delivery network (CDN) A content delivery network is a specialized network that is used to distribute content to clients, typically located close to the client for increased performance.

controller node Alternative term for a cloud controller node.

core API Depending on context, the core API is either the OpenStack API or the main API of a specific core project, such as Compute, Networking, Image service, and so on.

core service An official OpenStack service defined as core by DefCore Committee. Currently, consists of Block Storage service (cinder), Compute service (nova), Identity service (keystone), Image service (glance), Networking service (neutron), and Object Storage service (swift).

cost Under the Compute distributed scheduler, this is calculated by looking at the capabilities of each host relative to the flavor of the VM instance being requested.

credentials Data that is only known to or accessible by a user and used to verify that the user is who he says he is. Credentials are presented to the server during authentication. Examples include a password, secret key, digital certificate, and fingerprint.

CRL A Certificate Revocation List (CRL) in a PKI model is a list of certificates that have been revoked. End entities presenting these certificates should not be trusted.

Cross-Origin Resource Sharing (CORS) A mechanism that allows many resources (for example, fonts, JavaScript) on a web page to be requested from another domain outside the domain from which the resource originated. In particular, JavaScript's AJAX calls can use the XMLHttpRequest mechanism.

Crowbar An open source community project by SUSE that aims to provide all necessary services to quickly deploy and manage clouds.

current workload An element of the Compute capacity cache that is calculated based on the number of build, snapshot, migrate, and resize operations currently in progress on a given host.

customer Alternative term for project.

customization module A user-created Python module that is loaded by horizon to change the look and feel of the dashboard.

D

daemon A process that runs in the background and waits for requests. May or may not listen on a TCP or UDP port. Do not confuse with a worker.

Dashboard (horizon) OpenStack project which provides an extensible, unified, web-based user interface for all OpenStack services.

data encryption Both Image service and Compute support encrypted virtual machine (VM) images (but not instances). In-transit data encryption is supported in OpenStack using technologies such as HTTPS, SSL, TLS, and SSH. Object Storage does not support object encryption at the application level but may support storage that uses disk encryption.

Data loss prevention (DLP) software Software programs used to protect sensitive information and prevent it from leaking outside a network boundary through the detection and denying of the data transportation.

Data Processing service (sahara) OpenStack project that provides a scalable data-processing stack and associated management interfaces.

data store A database engine supported by the Database service.

database ID A unique ID given to each replica of an Object Storage database.

database replicator An Object Storage component that copies changes in the account, container, and object databases to other nodes.

Database service (trove) An integrated project that provides scalable and reliable Cloud Database-as-a-Service functionality for both relational and non-relational database engines.

deallocate The process of removing the association between a floating IP address and a fixed IP address. Once this association is removed, the floating IP returns to the address pool.

Debian A Linux distribution that is compatible with OpenStack.

deduplication The process of finding duplicate data at the disk block, file, and/or object level to minimize storage use—currently unsupported within OpenStack.

default panel The default panel that is displayed when a user accesses the dashboard.

default project New users are assigned to this project if no project is specified when a user is created.

default token An Identity service token that is not associated with a specific project and is exchanged for a scoped token.

delayed delete An option within Image service so that an image is deleted after a predefined number of seconds instead of immediately.

delivery mode Setting for the Compute RabbitMQ message delivery mode; can be set to either transient or persistent.

denial of service (DoS) Denial of service (DoS) is a short form for denial-of-service attack. This is a malicious attempt to prevent legitimate users from using a service.

deprecated auth An option within Compute that enables administrators to create and manage users through the `nova-manage` command as opposed to using the Identity service.

designate Code name for the *DNS service*.

Desktop-as-a-Service A platform that provides a suite of desktop environments that users access to receive a desktop experience from any location. This may provide general use, development, or even homogeneous testing environments.

developer One of the default roles in the Compute RBAC system and the default role assigned to a new user.

device ID Maps Object Storage partitions to physical storage devices.

device weight Distributes partitions proportionately across Object Storage devices based on the storage capacity of each device.

DevStack Community project that uses shell scripts to quickly build complete OpenStack development environments.

DHCP agent OpenStack Networking agent that provides DHCP services for virtual networks.

Diablo A grouped release of projects related to OpenStack that came out in the fall of 2011, the fourth release of OpenStack. It included Compute (nova 2011.3), Object Storage (swift 1.4.3), and the Image service (glance). Diablo is the code name for the fourth release of OpenStack. The design summit took place in the Bay Area near Santa Clara, California, US and Diablo is a nearby city.

direct consumer An element of the Compute RabbitMQ that comes to life when a RPC call is executed. It connects to a direct exchange through a unique exclusive queue, sends the message, and terminates.

direct exchange A routing table that is created within the Compute RabbitMQ during RPC calls; one is created for each RPC call that is invoked.

direct publisher Element of RabbitMQ that provides a response to an incoming MQ message.

disassociate The process of removing the association between a floating IP address and fixed IP and thus returning the floating IP address to the address pool.

Discretionary Access Control (DAC) Governs the ability of subjects to access objects, while enabling users to make policy decisions and assign security attributes. The traditional UNIX system of users, groups, and read-write-execute permissions is an example of DAC.

disk encryption The ability to encrypt data at the file system, disk partition, or whole-disk level. Supported within Compute VMs.

disk format The underlying format that a disk image for a VM is stored as within the Image service back-end store. For example, AMI, ISO, QCOW2, VMDK, and so on.

dispersion In Object Storage, tools to test and ensure dispersion of objects and containers to ensure fault tolerance.

distributed virtual router (DVR) Mechanism for highly available multi-host routing when using OpenStack Networking (neutron).

Django A web framework used extensively in horizon.

DNS record A record that specifies information about a particular domain and belongs to the domain.

DNS service (designate) OpenStack project that provides scalable, on demand, self service access to authoritative DNS services, in a technology-agnostic manner.

dnsmasq Daemon that provides DNS, DHCP, BOOTP, and TFTP services for virtual networks.

domain An Identity API v3 entity. Represents a collection of projects, groups and users that defines administrative boundaries for managing OpenStack Identity entities. On the Internet, separates a website from other sites. Often, the domain name has two or more parts that are separated by dots. For example, yahoo.com, usa.gov, harvard.edu, or mail.yahoo.com. Also, a domain is an entity or container of all DNS-related information containing one or more records.

Domain Name System (DNS) A system by which Internet domain name-to-address and address-to-name resolutions are determined. DNS helps navigate the Internet by translating the IP address into an address that is easier to remember. For example, translating 111.111.111.1 into www.yahoo.com. All domains and their components, such as mail servers, utilize DNS to resolve to the appropriate locations. DNS servers are usually set up in a master-slave relationship such that failure of the master invokes the slave. DNS servers might also be clustered or replicated such that changes made to one DNS server are automatically propagated to other active servers. In Compute, the support that enables associating DNS entries with floating IP addresses, nodes, or cells so that hostnames are consistent across reboots.

download The transfer of data, usually in the form of files, from one computer to another.

durable exchange The Compute RabbitMQ message exchange that remains active when the server restarts.

durable queue A Compute RabbitMQ message queue that remains active when the server restarts.

Dynamic Host Configuration Protocol (DHCP) A network protocol that configures devices that are connected to a network so that they can communicate on that network by using the Internet Protocol (IP). The protocol is implemented in a client-server model where DHCP clients request configuration data, such as an IP address, a default route, and one or more DNS server addresses from a DHCP server. A method to automatically configure networking for a host at boot time. Provided by both Networking and Compute.

Dynamic HyperText Markup Language (DHTML) Pages that use HTML, JavaScript, and Cascading Style Sheets to enable users to interact with a web page or show simple animation.

E

east-west traffic Network traffic between servers in the same cloud or data center. See also north-south traffic.

EBS boot volume An Amazon EBS storage volume that contains a bootable VM image, currently unsupported in OpenStack.

ebtables Filtering tool for a Linux bridging firewall, enabling filtering of network traffic passing through a Linux bridge. Used in Compute along with arptables, iptables, and ip6tables to ensure isolation of network communications.

EC2 The Amazon commercial compute product, similar to Compute.

EC2 access key Used along with an EC2 secret key to access the Compute EC2 API.

EC2 API OpenStack supports accessing the Amazon EC2 API through Compute.

EC2 Compatibility API A Compute component that enables OpenStack to communicate with Amazon EC2.

EC2 secret key Used along with an EC2 access key when communicating with the Compute EC2 API; used to digitally sign each request.

Elastic Block Storage (EBS) The Amazon commercial block storage product.

encapsulation The practice of placing one packet type within another for the purposes of abstracting or securing data. Examples include GRE, MPLS, or IPsec.

encryption OpenStack supports encryption technologies such as HTTPS, SSH, SSL, TLS, digital certificates, and data encryption.

endpoint See API endpoint.

endpoint registry Alternative term for an Identity service catalog.

endpoint template A list of URL and port number endpoints that indicate where a service, such as Object Storage, Compute, Identity, and so on, can be accessed.

entity Any piece of hardware or software that wants to connect to the network services provided by Networking, the network connectivity service. An entity can make use of Networking by implementing a VIF.

ephemeral image A VM image that does not save changes made to its volumes and reverts them to their original state after the instance is terminated.

ephemeral volume Volume that does not save the changes made to it and reverts to its original state when the current user relinquishes control.

Essex A grouped release of projects related to OpenStack that came out in April 2012, the fifth release of OpenStack. It included Compute (nova 2012.1), Object Storage (swift 1.4.8), Image (glance), Identity (keystone), and Dashboard (horizon). Essex is the code name for the fifth release of OpenStack. The design summit took place in Boston, Massachusetts, US and Essex is a nearby city.

ESXi An OpenStack-supported hypervisor.

ETag MD5 hash of an object within Object Storage, used to ensure data integrity.

euca2ools A collection of command-line tools for administering VMs; most are compatible with OpenStack.

Eucalyptus Kernel Image (EKI) Used along with an ERI to create an EMI.

Eucalyptus Machine Image (EMI) VM image container format supported by Image service.

Eucalyptus Ramdisk Image (ERI) Used along with an EKI to create an EMI.

evacuate The process of migrating one or all virtual machine (VM) instances from one host to another, compatible with both shared storage live migration and block migration.

exchange Alternative term for a RabbitMQ message exchange.

exchange type A routing algorithm in the Compute RabbitMQ.

exclusive queue Connected to by a direct consumer in RabbitMQ—Compute, the message can be consumed only by the current connection.

extended attributes (xattr) File system option that enables storage of additional information beyond owner, group, permissions, modification time, and so on. The underlying Object Storage file system must support extended attributes.

extension Alternative term for an API extension or plug-in. In the context of Identity service, this is a call that is specific to the implementation, such as adding support for OpenID.

external network A network segment typically used for instance Internet access.

extra specs Specifies additional requirements when Compute determines where to start a new instance. Examples include a minimum amount of network bandwidth or a GPU.

F

FakeLDAP An easy method to create a local LDAP directory for testing Identity and Compute. Requires Redis.

fan-out exchange Within RabbitMQ and Compute, it is the messaging interface that is used by the scheduler service to receive capability messages from the compute, volume, and network nodes.

federated identity A method to establish trusts between identity providers and the OpenStack cloud.

Fedora A Linux distribution compatible with OpenStack.

Fibre Channel Storage protocol similar in concept to TCP/IP; encapsulates SCSI commands and data.

Fibre Channel over Ethernet (FCoE) The fibre channel protocol tunneled within Ethernet.

fill-first scheduler The Compute scheduling method that attempts to fill a host with VMs rather than starting new VMs on a variety of hosts.

filter The step in the Compute scheduling process when hosts that cannot run VMs are eliminated and not chosen.

firewall Used to restrict communications between hosts and/or nodes, implemented in Compute using iptables, arptables, ip6tables, and ebtables.

FireWall-as-a-Service (FWaaS) A Networking extension that provides perimeter firewall functionality.

fixed IP address An IP address that is associated with the same instance each time that instance boots, is generally not accessible to end users or the public Internet, and is used for management of the instance.

Flat Manager The Compute component that gives IP addresses to authorized nodes and assumes DHCP, DNS, and routing configuration and services are provided by something else.

flat mode injection A Compute networking method where the OS network configuration information is injected into the VM image before the instance starts.

flat network Virtual network type that uses neither VLANs nor tunnels to segregate project traffic. Each flat network typically requires a separate underlying physical interface defined by bridge mappings. However, a flat network can contain multiple subnets.

FlatDHCP Manager The Compute component that provides dnsmasq (DHCP, DNS, BOOTP, TFTP) and radvd (routing) services.

flavor Alternative term for a VM instance type.

flavor ID UUID for each Compute or Image service VM flavor or instance type.

floating IP address An IP address that a project can associate with a VM so that the instance has the same public IP address each time that it boots. You create a pool of floating IP addresses and assign them to instances as they are launched to maintain a consistent IP address for maintaining DNS assignment.

Folsom A grouped release of projects related to OpenStack that came out in the fall of 2012, the sixth release of OpenStack. It includes Compute (nova), Object Storage (swift), Identity (keystone), Networking (neutron), Image service (glance), and Volumes or Block Storage (cinder). Folsom is the code name for the sixth release of OpenStack. The design summit took place in San Francisco, California, US and Folsom is a nearby city.

FormPost Object Storage middleware that uploads (posts) an image through a form on a web page.

freezer Code name for the *Backup, Restore, and Disaster Recovery service*.

front end The point where a user interacts with a service; can be an API endpoint, the dashboard, or a command-line tool.

G

gateway An IP address, typically assigned to a router, that passes network traffic between different networks.

generic receive offload (GRO) Feature of certain network interface drivers that combines many smaller received packets into a large packet before delivery to the kernel IP stack.

generic routing encapsulation (GRE) Protocol that encapsulates a wide variety of network layer protocols inside virtual point-to-point links.

glance Codename for the *Image service*.

glance API server Alternative name for the *Image API*.

glance registry Alternative term for the Image service *image registry*.

global endpoint template The Identity service endpoint template that contains services available to all projects.

GlusterFS A file system designed to aggregate NAS hosts, compatible with OpenStack.

gnocchi Part of the OpenStack *Telemetry service*; provides an indexer and time-series database.

golden image A method of operating system installation where a finalized disk image is created and then used by all nodes without modification.

Governance service (congress) The project that provides Governance-as-a-Service across any collection of cloud services in order to monitor, enforce, and audit policy over dynamic infrastructure.

Graphic Interchange Format (GIF) A type of image file that is commonly used for animated images on web pages.

Graphics Processing Unit (GPU) Choosing a host based on the existence of a GPU is currently unsupported in OpenStack.

Green Threads The cooperative threading model used by Python; reduces race conditions and only context switches when specific library calls are made. Each OpenStack service is its own thread.

Grizzly The code name for the seventh release of OpenStack. The design summit took place in San Diego, California, US and Grizzly is an element of the state flag of California.

Group An Identity v3 API entity. Represents a collection of users that is owned by a specific domain.

guest OS An operating system instance running under the control of a hypervisor.

H

Hadoop Apache Hadoop is an open source software framework that supports data-intensive distributed applications.

Hadoop Distributed File System (HDFS) A distributed, highly fault-tolerant file system designed to run on low-cost commodity hardware.

handover An object state in Object Storage where a new replica of the object is automatically created due to a drive failure.

HAProxy Provides a load balancer for TCP and HTTP-based applications that spreads requests across multiple servers.

hard reboot A type of reboot where a physical or virtual power button is pressed as opposed to a graceful, proper shutdown of the operating system.

Havana The code name for the eighth release of OpenStack. The design summit took place in Portland, Oregon, US and Havana is an unincorporated community in Oregon.

health monitor Determines whether back-end members of a VIP pool can process a request. A pool can have several health monitors associated with it. When a pool has several monitors associated with it, all monitors check each member of the pool. All monitors must declare a member to be healthy for it to stay active.

heat Codename for the *Orchestration service*.

Heat Orchestration Template (HOT) Heat input in the format native to OpenStack.

high availability (HA) A high availability system design approach and associated service implementation ensures that a prearranged level of operational performance will be met during a contractual measurement period. High availability systems seek to minimize system downtime and data loss.

horizon Codename for the *Dashboard*.

horizon plug-in A plug-in for the OpenStack Dashboard (horizon).

host A physical computer, not a VM instance (node).

host aggregate A method to further subdivide availability zones into hypervisor pools, a collection of common hosts.

Host Bus Adapter (HBA) Device plugged into a PCI slot, such as a fibre channel or network card.

hybrid cloud A hybrid cloud is a composition of two or more clouds (private, community or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models. Hybrid cloud can also mean the ability to connect colocation, managed and/or dedicated services with cloud resources.

Hyper-V One of the hypervisors supported by OpenStack.

hyperlink Any kind of text that contains a link to some other site, commonly found in documents where clicking on a word or words opens up a different website.

Hypertext Transfer Protocol (HTTP) An application protocol for distributed, collaborative, hypermedia information systems. It is the foundation of data communication for the World Wide Web. Hypertext is structured text that uses logical links (hyperlinks) between nodes containing text. HTTP is the protocol to exchange or transfer hypertext.

Hypertext Transfer Protocol Secure (HTTPS) An encrypted communications protocol for secure communication over a computer network, with especially wide deployment on the Internet. Technically, it is not a protocol in and of itself; rather, it is the result of simply layering the Hypertext Transfer Protocol (HTTP) on top of the TLS or SSL protocol, thus adding the security capabilities of TLS or SSL to standard HTTP communications. Most OpenStack API endpoints and many inter-component communications support HTTPS communication.

hypervisor Software that arbitrates and controls VM access to the actual underlying hardware.

hypervisor pool A collection of hypervisors grouped together through host aggregates.

I

Icehouse The code name for the ninth release of OpenStack. The design summit took place in Hong Kong and Ice House is a street in that city.

ID number Unique numeric ID associated with each user in Identity, conceptually similar to a Linux or LDAP UID.

Identity API Alternative term for the Identity service API.

Identity back end The source used by Identity service to retrieve user information; an OpenLDAP server, for example.

identity provider A directory service, which allows users to login with a user name and password. It is a typical source of authentication tokens.

Identity service (keystone) The project that facilitates API client authentication, service discovery, distributed multi-project authorization, and auditing. It provides a central directory of users mapped to the OpenStack services they can access. It also registers endpoints for OpenStack services and acts as a common authentication system.

Identity service API The API used to access the OpenStack Identity service provided through keystone.

IETF Internet Engineering Task Force (IETF) is an open standards organization that develops Internet standards, particularly the standards pertaining to TCP/IP.

image A collection of files for a specific operating system (OS) that you use to create or rebuild a server. OpenStack provides pre-built images. You can also create custom images, or snapshots, from servers that you have launched. Custom images can be used for data backups or as "gold" images for additional servers.

Image API The Image service API endpoint for management of VM images. Processes client requests for VMs, updates Image service metadata on the registry server, and communicates with the store adapter to upload VM images from the back-end store.

image cache Used by Image service to obtain images on the local host rather than re-downloading them from the image server each time one is requested.

image ID Combination of a URI and UUID used to access Image service VM images through the image API.

image membership A list of projects that can access a given VM image within Image service.

image owner The project who owns an Image service virtual machine image.

image registry A list of VM images that are available through Image service.

Image service (glance) The OpenStack service that provide services and associated libraries to store, browse, share, distribute and manage bootable disk images, other data closely associated with initializing compute resources, and metadata definitions.

image status The current status of a VM image in Image service, not to be confused with the status of a running instance.

image store The back-end store used by Image service to store VM images, options include Object Storage, locally mounted file system, RADOS block devices, VMware datastore, or HTTP.

image UUID UUID used by Image service to uniquely identify each VM image.

incubated project A community project may be elevated to this status and is then promoted to a core project.

Infrastructure Optimization service (watcher) OpenStack project that aims to provide a flexible and scalable resource optimization service for multi-project OpenStack-based clouds.

Infrastructure-as-a-Service (IaaS) IaaS is a provisioning model in which an organization outsources physical components of a data center, such as storage, hardware, servers, and networking components. A service provider owns the equipment and is responsible for housing, operating and maintaining it. The client typically pays on a per-use basis. IaaS is a model for providing cloud services.

ingress filtering The process of filtering incoming network traffic. Supported by Compute.

INI format The OpenStack configuration files use an INI format to describe options and their values. It consists of sections and key value pairs.

injection The process of putting a file into a virtual machine image before the instance is started.

Input/Output Operations Per Second (IOPS) IOPS are a common performance measurement used to benchmark computer storage devices like hard disk drives, solid state drives, and storage area networks.

instance A running VM, or a VM in a known state such as suspended, that can be used like a hardware server.

instance ID Alternative term for instance UUID.

instance state The current state of a guest VM image.

instance tunnels network A network segment used for instance traffic tunnels between compute nodes and the network node.

instance type Describes the parameters of the various virtual machine images that are available to users; includes parameters such as CPU, storage, and memory. Alternative term for flavor.

instance type ID Alternative term for a flavor ID.

instance UUID Unique ID assigned to each guest VM instance.

Intelligent Platform Management Interface (IPMI) IPMI is a standardized computer system interface used by system administrators for out-of-band management of computer systems and monitoring of their operation. In layman's terms, it is a way to manage a computer using a direct network connection, whether it is turned on or not; connecting to the hardware rather than an operating system or login shell.

interface A physical or virtual device that provides connectivity to another device or medium.

interface ID Unique ID for a Networking VIF or vNIC in the form of a UUID.

Internet Control Message Protocol (ICMP) A network protocol used by network devices for control messages. For example, `ping` uses ICMP to test connectivity.

Internet protocol (IP) Principal communications protocol in the internet protocol suite for relaying datagrams across network boundaries.

Internet Service Provider (ISP) Any business that provides Internet access to individuals or businesses.

Internet Small Computer System Interface (iSCSI) Storage protocol that encapsulates SCSI frames for transport over IP networks. Supported by Compute, Object Storage, and Image service.

IP address Number that is unique to every computer system on the Internet. Two versions of the Internet Protocol (IP) are in use for addresses: IPv4 and IPv6.

IP Address Management (IPAM) The process of automating IP address allocation, deallocation, and management. Currently provided by Compute, melange, and Networking.

ip6tables Tool used to set up, maintain, and inspect the tables of IPv6 packet filter rules in the Linux kernel. In OpenStack Compute, ip6tables is used along with arptables, ebtables, and iptables to create firewalls for both nodes and VMs.

ipset Extension to iptables that allows creation of firewall rules that match entire "sets" of IP addresses simultaneously. These sets reside in indexed data structures to increase efficiency, particularly on systems with a large quantity of rules.

iptables Used along with arptables and ebtables, iptables create firewalls in Compute. iptables are the tables provided by the Linux kernel firewall (implemented as different Netfilter modules) and the chains and rules it stores. Different kernel modules and programs are currently used for different protocols: iptables applies to IPv4, ip6tables to IPv6, arptables to ARP, and ebtables to Ethernet frames. Requires root privilege to manipulate.

ironic Codename for the *Bare Metal service*.

iSCSI Qualified Name (IQN) IQN is the format most commonly used for iSCSI names, which uniquely identify nodes in an iSCSI network. All IQNs follow the pattern iqn.yyyy-mm.domain:identifier, where 'yyyy-mm' is the year and month in which the domain was registered, 'domain' is the reversed domain name of the issuing organization, and 'identifier' is an optional string which makes each IQN under the same domain unique. For example, 'iqn.2015-10.org.openstack.408ae959bce1'.

ISO9660 One of the VM image disk formats supported by Image service.

itsec A default role in the Compute RBAC system that can quarantine an instance in any project.

J

Java A programming language that is used to create systems that involve more than one computer by way of a network.

JavaScript A scripting language that is used to build web pages.

JavaScript Object Notation (JSON) One of the supported response formats in OpenStack.

jumbo frame Feature in modern Ethernet networks that supports frames up to approximately 9000 bytes.

Juno The code name for the tenth release of OpenStack. The design summit took place in Atlanta, Georgia, US and Juno is an unincorporated community in Georgia.

K

Kerberos A network authentication protocol which works on the basis of tickets. Kerberos allows nodes communication over a non-secure network, and allows nodes to prove their identity to one another in a secure manner.

kernel-based VM (KVM) An OpenStack-supported hypervisor. KVM is a full virtualization solution for Linux on x86 hardware containing virtualization extensions (Intel VT or AMD-V), ARM, IBM Power, and IBM zSeries. It consists of a loadable kernel module, that provides the core virtualization infrastructure and a processor specific module.

Key Manager service (barbican) The project that produces a secret storage and generation system capable of providing key management for services wishing to enable encryption features.

keystone Codename of the *Identity service*.

Kickstart A tool to automate system configuration and installation on Red Hat, Fedora, and CentOS-based Linux distributions.

Kilo The code name for the eleventh release of OpenStack. The design summit took place in Paris, France. Due to delays in the name selection, the release was known only as K. Because `k` is the unit symbol for kilo and the kilogram reference artifact is stored near Paris in the Pavillon de Breteuil in Sèvres, the community chose Kilo as the release name.

L

large object An object within Object Storage that is larger than 5 GB.

Launchpad The collaboration site for OpenStack.

Layer-2 (L2) agent OpenStack Networking agent that provides layer-2 connectivity for virtual networks.

Layer-2 network Term used in the OSI network architecture for the data link layer. The data link layer is responsible for media access control, flow control and detecting and possibly correcting errors that may occur in the physical layer.

Layer-3 (L3) agent OpenStack Networking agent that provides layer-3 (routing) services for virtual networks.

Layer-3 network Term used in the OSI network architecture for the network layer. The network layer is responsible for packet forwarding including routing from one node to another.

Liberty The code name for the twelfth release of OpenStack. The design summit took place in Vancouver, Canada and Liberty is the name of a village in the Canadian province of Saskatchewan.

libvirt Virtualization API library used by OpenStack to interact with many of its supported hypervisors.

Lightweight Directory Access Protocol (LDAP) An application protocol for accessing and maintaining distributed directory information services over an IP network.

Linux Unix-like computer operating system assembled under the model of free and open-source software development and distribution.

Linux bridge Software that enables multiple VMs to share a single physical NIC within Compute.

Linux Bridge neutron plug-in Enables a Linux bridge to understand a Networking port, interface attachment, and other abstractions.

Linux containers (LXC) An OpenStack-supported hypervisor.

live migration The ability within Compute to move running virtual machine instances from one host to another with only a small service interruption during switchover.

load balancer A load balancer is a logical device that belongs to a cloud account. It is used to distribute workloads between multiple back-end systems or services, based on the criteria defined as part of its configuration.

load balancing The process of spreading client requests between two or more nodes to improve performance and availability.

Load-Balancer-as-a-Service (LBaaS) Enables Networking to distribute incoming requests evenly between designated instances.

Load-balancing service (octavia) The project that aims to provide scalable, on demand, self service access to load-balancer services, in technology-agnostic manner.

Logical Volume Manager (LVM) Provides a method of allocating space on mass-storage devices that is more flexible than conventional partitioning schemes.

M

magnum Code name for the *Containers Infrastructure Management service*.

management API Alternative term for an admin API.

management network A network segment used for administration, not accessible to the public Internet.

manager Logical groupings of related code, such as the Block Storage volume manager or network manager.

manifest Used to track segments of a large object within Object Storage.

manifest object A special Object Storage object that contains the manifest for a large object.

manila Codename for OpenStack *Shared File Systems service*.

manila-share Responsible for managing Shared File System Service devices, specifically the back-end devices.

maximum transmission unit (MTU) Maximum frame or packet size for a particular network medium. Typically 1500 bytes for Ethernet networks.

mechanism driver A driver for the Modular Layer 2 (ML2) neutron plug-in that provides layer-2 connectivity for virtual instances. A single OpenStack installation can use multiple mechanism drivers.

melange Project name for OpenStack Network Information Service. To be merged with Networking.

membership The association between an Image service VM image and a project. Enables images to be shared with specified projects.

membership list A list of projects that can access a given VM image within Image service.

memcached A distributed memory object caching system that is used by Object Storage for caching.

memory overcommit The ability to start new VM instances based on the actual memory usage of a host, as opposed to basing the decision on the amount of RAM each running instance thinks it has available. Also known as RAM overcommit.

message broker The software package used to provide AMQP messaging capabilities within Compute. Default package is RabbitMQ.

message bus The main virtual communication line used by all AMQP messages for inter-cloud communications within Compute.

message queue Passes requests from clients to the appropriate workers and returns the output to the client after the job completes.

Message service (zaqar) The project that provides a messaging service that affords a variety of distributed application patterns in an efficient, scalable and highly available manner, and to create and maintain associated Python libraries and documentation.

Meta-Data Server (MDS) Stores CephFS metadata.

Metadata agent OpenStack Networking agent that provides metadata services for instances.

migration The process of moving a VM instance from one host to another.

mistral Code name for *Workflow service*.

Mitaka The code name for the thirteenth release of OpenStack. The design summit took place in Tokyo, Japan. Mitaka is a city in Tokyo.

Modular Layer 2 (ML2) neutron plug-in Can concurrently use multiple layer-2 networking technologies, such as 802.1Q and VXLAN, in Networking.

monasca Codename for OpenStack *Monitoring*.

Monitor (LBaaS) LBaaS feature that provides availability monitoring using the `ping` command, TCP, and HTTP/HTTPS GET.

Monitor (Mon) A Ceph component that communicates with external clients, checks data state and consistency, and performs quorum functions.

Monitoring (monasca) The OpenStack service that provides a multi-project, highly scalable, performant, fault-tolerant monitoring-as-a-service solution for metrics, complex event processing and logging. To build an extensible platform for advanced monitoring services that can be used by both operators and projects to gain operational insight and visibility, ensuring availability and stability.

multi-factor authentication Authentication method that uses two or more credentials, such as a password and a private key. Currently not supported in Identity.

multi-host High-availability mode for legacy (nova) networking. Each compute node handles NAT and DHCP and acts as a gateway for all of the VMs on it. A networking failure on one compute node doesn't affect VMs on other compute nodes.

multinic Facility in Compute that allows each virtual machine instance to have more than one VIF connected to it.

murano Codename for the *Application Catalog service*.

N

Nebula Released as open source by NASA in 2010 and is the basis for Compute.

netadmin One of the default roles in the Compute RBAC system. Enables the user to allocate publicly accessible IP addresses to instances and change firewall rules.

NetApp volume driver Enables Compute to communicate with NetApp storage devices through the NetApp OnCommand Provisioning Manager.

network A virtual network that provides connectivity between entities. For example, a collection of virtual ports that share network connectivity. In Networking terminology, a network is always a layer-2 network.

Network Address Translation (NAT) Process of modifying IP address information while in transit. Supported by Compute and Networking.

network controller A Compute daemon that orchestrates the network configuration of nodes, including IP addresses, VLANs, and bridging. Also manages routing for both public and private networks.

Network File System (NFS) A method for making file systems available over the network. Supported by OpenStack.

network ID Unique ID assigned to each network segment within Networking. Same as network UUID.

network manager The Compute component that manages various network components, such as firewall rules, IP address allocation, and so on.

network namespace Linux kernel feature that provides independent virtual networking instances on a single host with separate routing tables and interfaces. Similar to virtual routing and forwarding (VRF) services on physical network equipment.

network node Any compute node that runs the network worker daemon.

network segment Represents a virtual, isolated OSI layer-2 subnet in Networking.

Network Service Header (NSH) Provides a mechanism for metadata exchange along the instantiated service path.

Network Time Protocol (NTP) Method of keeping a clock for a host or node correct via communication with a trusted, accurate time source.

network UUID Unique ID for a Networking network segment.

network worker The `nova-network` worker daemon; provides services such as giving an IP address to a booting nova instance.

Networking API (Neutron API) API used to access OpenStack Networking. Provides an extensible architecture to enable custom plug-in creation.

Networking service (neutron) The OpenStack project which implements services and associated libraries to provide on-demand, scalable, and technology-agnostic network abstraction.

neutron Codename for OpenStack *Networking service*.

neutron API An alternative name for *Networking API*.

neutron manager Enables Compute and Networking integration, which enables Networking to perform network management for guest VMs.

neutron plug-in Interface within Networking that enables organizations to create custom plug-ins for advanced features, such as QoS, ACLs, or IDS.

Newton The code name for the fourteenth release of OpenStack. The design summit took place in Austin, Texas, US. The release is named after "Newton House" which is located at 1013 E. Ninth St., Austin, TX. which is listed on the National Register of Historic Places.

Nexenta volume driver Provides support for NexentaStor devices in Compute.

NFV Orchestration Service (tacker) OpenStack service that aims to implement Network Function Virtualization (NFV) orchestration services and libraries for end-to-end life-cycle management of network services and Virtual Network Functions (VNFs).

Nginx An HTTP and reverse proxy server, a mail proxy server, and a generic TCP/UDP proxy server.

No ACK Disables server-side message acknowledgment in the Compute RabbitMQ. Increases performance but decreases reliability.

node A VM instance that runs on a host.

non-durable exchange Message exchange that is cleared when the service restarts. Its data is not written to persistent storage.

non-durable queue Message queue that is cleared when the service restarts. Its data is not written to persistent storage.

non-persistent volume Alternative term for an ephemeral volume.

north-south traffic Network traffic between a user or client (north) and a server (south), or traffic into the cloud (south) and out of the cloud (north). See also east-west traffic.

nova Codename for OpenStack *Compute service*.

Nova API Alternative term for the *Compute API*.

nova-network A Compute component that manages IP address allocation, firewalls, and other network-related tasks. This is the legacy networking option and an alternative to Networking.

O

object A BLOB of data held by Object Storage; can be in any format.

object auditor Opens all objects for an object server and verifies the MD5 hash, size, and metadata for each object.

object expiration A configurable option within Object Storage to automatically delete objects after a specified amount of time has passed or a certain date is reached.

object hash Unique ID for an Object Storage object.

object path hash Used by Object Storage to determine the location of an object in the ring. Maps objects to partitions.

object replicator An Object Storage component that copies an object to remote partitions for fault tolerance.

object server An Object Storage component that is responsible for managing objects.

Object Storage API API used to access OpenStack *Object Storage*.

Object Storage Device (OSD) The Ceph storage daemon.

Object Storage service (swift) The OpenStack core project that provides eventually consistent and redundant storage and retrieval of fixed digital content.

object versioning Allows a user to set a flag on an *Object Storage* container so that all objects within the container are versioned.

Ocata The code name for the fifteenth release of OpenStack. The design summit will take place in Barcelona, Spain. Ocata is a beach north of Barcelona.

Octavia Code name for the *Load-balancing service*.

Oldie Term for an *Object Storage* process that runs for a long time. Can indicate a hung process.

Open Cloud Computing Interface (OCCI) A standardized interface for managing compute, data, and network resources, currently unsupported in OpenStack.

Open Virtualization Format (OVF) Standard for packaging VM images. Supported in OpenStack.

Open vSwitch Open vSwitch is a production quality, multilayer virtual switch licensed under the open source Apache 2.0 license. It is designed to enable massive network automation through programmatic extension, while still supporting standard management interfaces and protocols (for example NetFlow, sFlow, SPAN, RSPAN, CLI, LACP, 802.1ag).

Open vSwitch (OVS) agent Provides an interface to the underlying Open vSwitch service for the Networking plug-in.

Open vSwitch neutron plug-in Provides support for Open vSwitch in Networking.

OpenLDAP An open source LDAP server. Supported by both Compute and Identity.

OpenStack OpenStack is a cloud operating system that controls large pools of compute, storage, and networking resources throughout a data center, all managed through a dashboard that gives administrators control while empowering their users to provision resources through a web interface. OpenStack is an open source project licensed under the Apache License 2.0.

OpenStack code name Each OpenStack release has a code name. Code names ascend in alphabetical order: Austin, Bexar, Cactus, Diablo, Essex, Folsom, Grizzly, Havana, Icehouse, Juno, Kilo, Liberty, Mitaka, Newton, Ocata, Pike, Queens, and Rocky. Code names are cities or counties near where the corresponding OpenStack design summit took place. An exception, called the Waldon exception, is granted to elements of the state flag that sound especially cool. Code names are chosen by popular vote.

openSUSE A Linux distribution that is compatible with OpenStack.

operator The person responsible for planning and maintaining an OpenStack installation.

optional service An official OpenStack service defined as optional by DefCore Committee. Currently, consists of Dashboard (horizon), Telemetry service (Telemetry), Orchestration service (heat), Database service (trove), Bare Metal service (ironic), and so on.

Orchestration service (heat) The OpenStack service which orchestrates composite cloud applications using a declarative template format through an OpenStack-native REST API.

orphan In the context of Object Storage, this is a process that is not terminated after an upgrade, restart, or reload of the service.

Oslo Codename for the *Common Libraries project*.

P

panko Part of the OpenStack *Telemetry service*; provides event storage.

parent cell If a requested resource, such as CPU time, disk storage, or memory, is not available in the parent cell, the request is forwarded to associated child cells.

partition A unit of storage within Object Storage used to store objects. It exists on top of devices and is replicated for fault tolerance.

partition index Contains the locations of all Object Storage partitions within the ring.

partition shift value Used by Object Storage to determine which partition data should reside on.

path MTU discovery (PMTUD) Mechanism in IP networks to detect end-to-end MTU and adjust packet size accordingly.

pause A VM state where no changes occur (no changes in memory, network communications stop, etc); the VM is frozen but not shut down.

PCI passthrough Gives guest VMs exclusive access to a PCI device. Currently supported in OpenStack Havana and later releases.

persistent message A message that is stored both in memory and on disk. The message is not lost after a failure or restart.

persistent volume Changes to these types of disk volumes are saved.

personality file A file used to customize a Compute instance. It can be used to inject SSH keys or a specific network configuration.

Pike The code name for the sixteenth release of OpenStack. The design summit will take place in Boston, Massachusetts, US. The release is named after the Massachusetts Turnpike, abbreviated commonly as the Mass Pike, which is the easternmost stretch of Interstate 90.

Platform-as-a-Service (PaaS) Provides to the consumer an operating system and, often, a language runtime and libraries (collectively, the "platform") upon which they can run their own application code, without providing any control over the underlying infrastructure. Examples of Platform-as-a-Service providers include Cloud Foundry and OpenShift.

plug-in Software component providing the actual implementation for Networking APIs, or for Compute APIs, depending on the context.

policy service Component of Identity that provides a rule-management interface and a rule-based authorization engine.

policy-based routing (PBR) Provides a mechanism to implement packet forwarding and routing according to the policies defined by the network administrator.

pool A logical set of devices, such as web servers, that you group together to receive and process traffic. The load balancing function chooses which member of the pool handles the new requests or connections received on the VIP address. Each VIP has one pool.

pool member An application that runs on the back-end server in a load-balancing system.

port A virtual network port within Networking; VIFs / vNICs are connected to a port.

port UUID Unique ID for a Networking port.

preseed A tool to automate system configuration and installation on Debian-based Linux distributions.

private image An Image service VM image that is only available to specified projects.

private IP address An IP address used for management and administration, not available to the public Internet.

private network The Network Controller provides virtual networks to enable compute servers to interact with each other and with the public network. All machines must have a public and private network interface. A private network interface can be a flat or VLAN network interface. A flat network interface is controlled by the flat_interface with flat managers. A VLAN network interface is controlled by the `vlan_interface` option with VLAN managers.

project Projects represent the base unit of "ownership" in OpenStack, in that all resources in OpenStack should be owned by a specific project. In OpenStack Identity, a project must be owned by a specific domain.

project ID Unique ID assigned to each project by the Identity service.

project VPN Alternative term for a cloudpipe.

promiscuous mode Causes the network interface to pass all traffic it receives to the host rather than passing only the frames addressed to it.

protected property Generally, extra properties on an Image service image to which only cloud administrators have access. Limits which user roles can perform CRUD operations on that property. The cloud administrator can configure any image property as protected.

provider An administrator who has access to all hosts and instances.

proxy node A node that provides the Object Storage proxy service.

proxy server Users of Object Storage interact with the service through the proxy server, which in turn looks up the location of the requested data within the ring and returns the results to the user.

public API An API endpoint used for both service-to-service communication and end-user interactions.

public image An Image service VM image that is available to all projects.

public IP address An IP address that is accessible to end-users.

public key authentication Authentication method that uses keys rather than passwords.

public network The Network Controller provides virtual networks to enable compute servers to interact with each other and with the public network. All machines must have a public and private network interface. The public network interface is controlled by the `public_interface` option.

Puppet An operating system configuration-management tool supported by OpenStack.

Python Programming language used extensively in OpenStack.

Q

QEMU Copy On Write 2 (QCOW2) One of the VM image disk formats supported by Image service.

Qpid Message queue software supported by OpenStack; an alternative to RabbitMQ.

Quality of Service (QoS) The ability to guarantee certain network or storage requirements to satisfy a Service Level Agreement (SLA) between an application provider and end users. Typically includes performance requirements like networking bandwidth, latency, jitter correction, and reliability as well as storage performance in Input/Output Operations Per Second (IOPS), throttling agreements, and performance expectations at peak load.

quarantine If Object Storage finds objects, containers, or accounts that are corrupt, they are placed in this state, are not replicated, cannot be read by clients, and a correct copy is re-replicated.

Queens The code name for the seventeenth release of OpenStack. The design summit will take place in Sydney, Australia. The release is named after the Queens Pound river in the South Coast region of New South Wales.

Quick EMUlator (QEMU) QEMU is a generic and open source machine emulator and virtualizer. One of the hypervisors supported by OpenStack, generally used for development purposes.

quota In Compute and Block Storage, the ability to set resource limits on a per-project basis.

R

RabbitMQ The default message queue software used by OpenStack.

Rackspace Cloud Files Released as open source by Rackspace in 2010; the basis for Object Storage.

RADOS Block Device (RBD) Ceph component that enables a Linux block device to be striped over multiple distributed data stores.

radvd The router advertisement daemon, used by the Compute VLAN manager and FlatDHCP manager to provide routing services for VM instances.

rally Codename for the *Benchmark service*.

RAM filter The Compute setting that enables or disables RAM overcommitment.

RAM overcommit The ability to start new VM instances based on the actual memory usage of a host, as opposed to basing the decision on the amount of RAM each running instance thinks it has available. Also known as memory overcommit.

rate limit Configurable option within Object Storage to limit database writes on a per-account and/or per-container basis.

raw One of the VM image disk formats supported by Image service; an unstructured disk image.

rebalance The process of distributing Object Storage partitions across all drives in the ring; used during initial ring creation and after ring reconfiguration.

reboot Either a soft or hard reboot of a server. With a soft reboot, the operating system is signaled to restart, which enables a graceful shutdown of all processes. A hard reboot is the equivalent of power cycling the server. The virtualization platform should ensure that the reboot action has completed successfully, even in cases in which the underlying domain/VM is paused or halted/stopped.

rebuild Removes all data on the server and replaces it with the specified image. Server ID and IP addresses remain the same.

Recon An Object Storage component that collects meters.

record Belongs to a particular domain and is used to specify information about the domain. There are several types of DNS records. Each record type contains particular information used to describe the purpose of that record. Examples include mail exchange (MX) records, which specify the mail server for a particular domain; and name server (NS) records, which specify the authoritative name servers for a domain.

record ID A number within a database that is incremented each time a change is made. Used by Object Storage when replicating.

Red Hat Enterprise Linux (RHEL) A Linux distribution that is compatible with OpenStack.

reference architecture A recommended architecture for an OpenStack cloud.

region A discrete OpenStack environment with dedicated API endpoints that typically shares only the Identity (keystone) with other regions.

registry Alternative term for the Image service registry.

registry server An Image service that provides VM image metadata information to clients.

Reliable, Autonomic Distributed Object Store (RADOS)

A collection of components that provides object storage within Ceph. Similar to OpenStack Object Storage.

Remote Procedure Call (RPC) The method used by the Compute RabbitMQ for intra-service communications.

replica Provides data redundancy and fault tolerance by creating copies of Object Storage objects, accounts, and containers so that they are not lost when the underlying storage fails.

replica count The number of replicas of the data in an Object Storage ring.

replication The process of copying data to a separate physical device for fault tolerance and performance.

replicator The Object Storage back-end process that creates and manages object replicas.

request ID Unique ID assigned to each request sent to Compute.

rescue image A special type of VM image that is booted when an instance is placed into rescue mode. Allows an administrator to mount the file systems for an instance to correct the problem.

resize Converts an existing server to a different flavor, which scales the server up or down. The original server is saved to enable rollback if a problem occurs. All resizes must be tested and explicitly confirmed, at which time the original server is removed.

RESTful A kind of web service API that uses REST, or Representational State Transfer. REST is the style of architecture for hypermedia systems that is used for the World Wide Web.

ring An entity that maps Object Storage data to partitions. A separate ring exists for each service, such as account, object, and container.

ring builder Builds and manages rings within Object Storage, assigns partitions to devices, and pushes the configuration to other storage nodes.

Rocky The code name for the eightteenth release of OpenStack. The design summit will take place in Vancouver, Kanada. The release is named after the Rocky Mountains.

role A personality that a user assumes to perform a specific set of operations. A role includes a set of rights and privileges. A user assuming that role inherits those rights and privileges.

Role Based Access Control (RBAC) Provides a predefined list of actions that the user can perform, such as start or stop VMs, reset passwords, and so on. Supported in both Identity and Compute and can be configured using the dashboard.

role ID Alphanumeric ID assigned to each Identity service role.

Root Cause Analysis (RCA) service (Vitrage) OpenStack project that aims to organize, analyze and visualize OpenStack alarms and events, yield insights regarding the root cause of problems and deduce their existence before they are directly detected.

rootwrap A feature of Compute that allows the unprivileged "nova" user to run a specified list of commands as the Linux root user.

round-robin scheduler Type of Compute scheduler that evenly distributes instances among available hosts.

router A physical or virtual network device that passes network traffic between different networks.

routing key The Compute direct exchanges, fanout exchanges, and topic exchanges use this key to determine how to process a message; processing varies depending on exchange type.

RPC driver Modular system that allows the underlying message queue software of Compute to be changed. For example, from RabbitMQ to ZeroMQ or Qpid.

rsync Used by Object Storage to push object replicas.

RXTX cap Absolute limit on the amount of network traffic a Compute VM instance can send and receive.

RXTX quota Soft limit on the amount of network traffic a Compute VM instance can send and receive.

S

sahara Codename for the *Data Processing service*.

SAML assertion Contains information about a user as provided by the identity provider. It is an indication that a user has been authenticated.

scheduler manager A Compute component that determines where VM instances should start. Uses modular design to support a variety of scheduler types.

scoped token An Identity service API access token that is associated with a specific project.

scrubber Checks for and deletes unused VMs; the component of Image service that implements delayed delete.

secret key String of text known only by the user; used along with an access key to make requests to the Compute API.

secure boot Process whereby the system firmware validates the authenticity of the code involved in the boot process.

secure shell (SSH) Open source tool used to access remote hosts through an encrypted communications channel, SSH key injection is supported by Compute.

security group A set of network traffic filtering rules that are applied to a Compute instance.

segmented object An Object Storage large object that has been broken up into pieces. The re-assembled object is called a concatenated object.

self-service For IaaS, ability for a regular (non-privileged) account to manage a virtual infrastructure component such as networks without involving an administrator.

SELinux Linux kernel security module that provides the mechanism for supporting access control policies.

senlin Code name for the *Clustering service*.

server Computer that provides explicit services to the client software running on that system, often managing a variety of computer operations. A server is a VM instance in the Compute system. Flavor and image are requisite elements when creating a server.

server image Alternative term for a VM image.

server UUID Unique ID assigned to each guest VM instance.

service An OpenStack service, such as Compute, Object Storage, or Image service. Provides one or more endpoints through which users can access resources and perform operations.

service catalog Alternative term for the Identity service catalog.

Service Function Chain (SFC) For a given service, SFC is the abstracted view of the required service functions and the order in which they are to be applied.

service ID Unique ID assigned to each service that is available in the Identity service catalog.

Service Level Agreement (SLA) Contractual obligations that ensure the availability of a service.

service project Special project that contains all services that are listed in the catalog.

service provider A system that provides services to other system entities. In case of federated identity, OpenStack Identity is the service provider.

service registration An Identity service feature that enables services, such as Compute, to automatically register with the catalog.

service token An administrator-defined token used by Compute to communicate securely with the Identity service.

session back end The method of storage used by horizon to track client sessions, such as local memory, cookies, a database, or memcached.

session persistence A feature of the load-balancing service. It attempts to force subsequent connections to a service to be redirected to the same node as long as it is online.

session storage A horizon component that stores and tracks client session information. Implemented through the Django sessions framework.

share A remote, mountable file system in the context of the *Shared File Systems service*. You can mount a share to, and access a share from, several hosts by several users at a time.

share network An entity in the context of the *Shared File Systems service* that encapsulates interaction with the Networking service. If the driver you selected runs in the mode requiring such kind of interaction, you need to specify the share network to create a share.

Shared File Systems API A Shared File Systems service that provides a stable RESTful API. The service authenticates and routes requests throughout the Shared File Systems service. There is python-manilaclient to interact with the API.

Shared File Systems service (manila) The service that provides a set of services for management of shared file systems in a multi-project cloud environment, similar to how OpenStack provides block-based storage management through the OpenStack *Block Storage service* project. With the Shared File Systems service, you can create a remote file system and mount the file system on your instances. You can also read and write data from your instances to and from your file system.

shared IP address An IP address that can be assigned to a VM instance within the shared IP group. Public IP addresses can be shared across multiple servers for use in various high-availability scenarios. When an IP address is shared to another server, the cloud network restrictions are modified to enable each server to listen to and respond on that IP address. You can optionally specify that the target server network configuration be modified. Shared IP addresses can be used with many standard heartbeat facilities, such as keepalive, that monitor for failure and manage IP failover.

shared IP group A collection of servers that can share IPs with other members of the group. Any server in a group can share one or more public IPs with any other server in the group. With the exception of the first server in a shared IP group, servers must be launched into shared IP groups. A server may be a member of only one shared IP group.

shared storage Block storage that is simultaneously accessible by multiple clients, for example, NFS.

Sheepdog Distributed block storage system for QEMU, supported by OpenStack.

Simple Cloud Identity Management (SCIM) Specification for managing identity in the cloud, currently unsupported by OpenStack.

Simple Protocol for Independent Computing Environments (SPICE) SPICE provides remote desktop access to guest virtual machines. It is an alternative to VNC. SPICE is supported by OpenStack.

Single-root I/O Virtualization (SR-IOV) A specification that, when implemented by a physical PCIe device, enables it to appear as multiple separate PCIe devices. This enables multiple virtualized guests to share direct access to the physical device, offering improved performance over an equivalent virtual device. Currently supported in OpenStack Havana and later releases.

SmokeStack Runs automated tests against the core OpenStack API; written in Rails.

snapshot A point-in-time copy of an OpenStack storage volume or image. Use storage volume snapshots to back up volumes. Use image snapshots to back up data, or as "gold" images for additional servers.

soft reboot A controlled reboot where a VM instance is properly restarted through operating system commands.

Software Development Lifecycle Automation service (solum) OpenStack project that aims to make cloud services easier to consume and integrate with application development process by automating the source-to-image process, and simplifying app-centric deployment.

Software-defined networking (SDN) Provides an approach for network administrators to manage computer network services through abstraction of lower-level functionality.

SolidFire Volume Driver The Block Storage driver for the SolidFire iSCSI storage appliance.

solum Code name for the *Software Development Lifecycle Automation service*.

spread-first scheduler The Compute VM scheduling algorithm that attempts to start a new VM on the host with the least amount of load.

SQLAlchemy An open source SQL toolkit for Python, used in OpenStack.

SQLite A lightweight SQL database, used as the default persistent storage method in many OpenStack services.

stack A set of OpenStack resources created and managed by the Orchestration service according to a given template (either an AWS CloudFormation template or a Heat Orchestration Template (HOT)).

StackTach Community project that captures Compute AMQP communications; useful for debugging.

static IP address Alternative term for a fixed IP address.

StaticWeb WSGI middleware component of Object Storage that serves container data as a static web page.

storage back end The method that a service uses for persistent storage, such as iSCSI, NFS, or local disk.

storage manager A XenAPI component that provides a pluggable interface to support a wide variety of persistent storage back ends.

storage manager back end A persistent storage method supported by XenAPI, such as iSCSI or NFS.

storage node An Object Storage node that provides container services, account services, and object services; controls the account databases, container databases, and object storage.

storage services Collective name for the Object Storage object services, container services, and account services.

strategy Specifies the authentication source used by Image service or Identity. In the Database service, it refers to the extensions implemented for a data store.

subdomain A domain within a parent domain. Subdomains cannot be registered. Subdomains enable you to delegate domains. Subdomains can themselves have subdomains, so third-level, fourth-level, fifth-level, and deeper levels of nesting are possible.

subnet Logical subdivision of an IP network.

SUSE Linux Enterprise Server (SLES) A Linux distribution that is compatible with OpenStack.

suspend The VM instance is paused and its state is saved to disk of the host.

swap Disk-based virtual memory used by operating systems to provide more memory than is actually available on the system.

swauth An authentication and authorization service for Object Storage, implemented through WSGI middleware; uses Object Storage itself as the persistent backing store.

swift Codename for OpenStack *Object Storage service*.

swift All in One (SAIO) Creates a full Object Storage development environment within a single VM.

swift middleware Collective term for Object Storage components that provide additional functionality.

swift proxy server Acts as the gatekeeper to Object Storage and is responsible for authenticating the user.

swift storage node A node that runs Object Storage account, container, and object services.

sync point Point in time since the last container and accounts database sync among nodes within Object Storage.

sysadmin One of the default roles in the Compute RBAC system. Enables a user to add other users to a project, interact with VM images that are associated with the project, and start and stop VM instances.

system usage A Compute component that, along with the notification system, collects meters and usage information. This information can be used for billing.

T

tacker Code name for the *NFV Orchestration service*

Telemetry service (telemetry) The OpenStack project which collects measurements of the utilization of the physical and virtual resources comprising deployed clouds, persists this data for subsequent retrieval and analysis, and triggers actions when defined criteria are met.

TempAuth An authentication facility within Object Storage that enables Object Storage itself to perform authentication and authorization. Frequently used in testing and development.

Tempest Automated software test suite designed to run against the trunk of the OpenStack core project.

TempURL An Object Storage middleware component that enables creation of URLs for temporary object access.

tenant A group of users; used to isolate access to Compute resources. An alternative term for a project.

Tenant API An API that is accessible to projects.

tenant endpoint An Identity service API endpoint that is associated with one or more projects.

tenant ID An alternative term for *project ID*.

token An alpha-numeric string of text used to access OpenStack APIs and resources.

token services An Identity service component that manages and validates tokens after a user or project has been authenticated.

tombstone Used to mark Object Storage objects that have been deleted; ensures that the object is not updated on another node after it has been deleted.

topic publisher A process that is created when a RPC call is executed; used to push the message to the topic exchange.

Torpedo Community project used to run automated tests against the OpenStack API.

transaction ID Unique ID assigned to each Object Storage request; used for debugging and tracing.

transient Alternative term for non-durable.

transient exchange Alternative term for a non-durable exchange.

transient message A message that is stored in memory and is lost after the server is restarted.

transient queue Alternative term for a non-durable queue.

TripleO OpenStack-on-OpenStack program. The code name for the OpenStack Deployment program.

trove Codename for OpenStack *Database service*.

trusted platform module (TPM) Specialized microprocessor for incorporating cryptographic keys into devices for authenticating and securing a hardware platform.

U

Ubuntu A Debian-based Linux distribution.

unscoped token Alternative term for an Identity service default token.

updater Collective term for a group of Object Storage components that processes queued and failed updates for containers and objects.

user In OpenStack Identity, entities represent individual API consumers and are owned by a specific domain. In OpenStack Compute, a user can be associated with roles, projects, or both.

user data A blob of data that the user can specify when they launch an instance. The instance can access this data through the metadata service or config drive. Commonly used to pass a shell script that the instance runs on boot.

User Mode Linux (UML) An OpenStack-supported hypervisor.

V

VIF UUID Unique ID assigned to each Networking VIF.

Virtual Central Processing Unit (vCPU) Subdivides physical CPUs. Instances can then use those divisions.

Virtual Disk Image (VDI) One of the VM image disk formats supported by Image service.

Virtual Extensible LAN (VXLAN) A network virtualization technology that attempts to reduce the scalability problems associated with large cloud computing deployments. It uses a VLAN-like encapsulation technique to encapsulate Ethernet frames within UDP packets.

Virtual Hard Disk (VHD) One of the VM image disk formats supported by Image service.

virtual IP address (VIP) An Internet Protocol (IP) address configured on the load balancer for use by clients connecting to a service that is load balanced. Incoming connections are distributed to back-end nodes based on the configuration of the load balancer.

virtual machine (VM) An operating system instance that runs on top of a hypervisor. Multiple VMs can run at the same time on the same physical host.

virtual network An L2 network segment within Networking.

Virtual Network Computing (VNC) Open source GUI and CLI tools used for remote console access to VMs. Supported by Compute.

Virtual Network InterFace (VIF) An interface that is plugged into a port in a Networking network. Typically a virtual network interface belonging to a VM.

virtual networking A generic term for virtualization of network functions such as switching, routing, load balancing, and security using a combination of VMs and overlays on physical network infrastructure.

virtual port Attachment point where a virtual interface connects to a virtual network.

virtual private network (VPN) Provided by Compute in the form of cloudpipes, specialized instances that are used to create VPNs on a per-project basis.

virtual server Alternative term for a VM or guest.

virtual switch (vSwitch) Software that runs on a host or node and provides the features and functions of a hardware-based network switch.

virtual VLAN Alternative term for a virtual network.

VirtualBox An OpenStack-supported hypervisor.

Vitrage Code name for the *Root Cause Analysis service*.

VLAN manager A Compute component that provides dnsmasq and radvd and sets up forwarding to and from cloudpipe instances.

VLAN network The Network Controller provides virtual networks to enable compute servers to interact with each other and with the public network. All machines must have a public and private network interface. A VLAN network is a private network interface, which is controlled by the `vlan_interface` option with VLAN managers.

VM disk (VMDK) One of the VM image disk formats supported by Image service.

VM image Alternative term for an image.

VM Remote Control (VMRC) Method to access VM instance consoles using a web browser. Supported by Compute.

VMware API Supports interaction with VMware products in Compute.

VMware NSX Neutron plug-in Provides support for VMware NSX in Neutron.

VNC proxy A Compute component that provides users access to the consoles of their VM instances through VNC or VMRC.

volume Disk-based data storage generally represented as an iSCSI target with a file system that supports extended attributes; can be persistent or ephemeral.

Volume API Alternative name for the Block Storage API.

volume controller A Block Storage component that oversees and coordinates storage volume actions.

volume driver Alternative term for a volume plug-in.

volume ID Unique ID applied to each storage volume under the Block Storage control.

volume manager A Block Storage component that creates, attaches, and detaches persistent storage volumes.

volume node A Block Storage node that runs the cinder-volume daemon.

volume plug-in Provides support for new and specialized types of back-end storage for the Block Storage volume manager.

volume worker A cinder component that interacts with back-end storage to manage the creation and deletion of volumes and the creation of compute volumes, provided by the cinder-volume daemon.

vSphere An OpenStack-supported hypervisor.

W

Watcher Code name for the *Infrastructure Optimization service*.

weight Used by Object Storage devices to determine which storage devices are suitable for the job. Devices are weighted by size.

weighted cost The sum of each cost used when deciding where to start a new VM instance in Compute.

weighting A Compute process that determines the suitability of the VM instances for a job for a particular host. For example, not enough RAM on the host, too many CPUs on the host, and so on.

worker A daemon that listens to a queue and carries out tasks in response to messages. For example, the cinder-volume worker manages volume creation and deletion on storage arrays.

Workflow service (mistral) The OpenStack service that provides a simple YAML-based language to write workflows (tasks and transition rules) and a service that allows to upload them, modify, run them at scale and in a highly available manner, manage and monitor workflow execution state and state of individual tasks.

X

X.509 X.509 is the most widely used standard for defining digital certificates. It is a data structure that contains the subject (entity) identifiable information such as its name along with its public key. The certificate can contain a few other attributes as well depending upon the version. The most recent and standard version of X.509 is v3.

Xen Xen is a hypervisor using a microkernel design, providing services that allow multiple computer operating systems to execute on the same computer hardware concurrently.

Xen API The Xen administrative API, which is supported by Compute.

Xen Cloud Platform (XCP) An OpenStack-supported hypervisor.

Xen Storage Manager Volume Driver A Block Storage volume plug-in that enables communication with the Xen Storage Manager API.

XenServer An OpenStack-supported hypervisor.

XFS High-performance 64-bit file system created by Silicon Graphics. Excels in parallel I/O operations and data consistency.

Z

zaqar Codename for the *Message service*.

ZeroMQ Message queue software supported by OpenStack. An alternative to RabbitMQ. Also spelled 0MQ.

Zuul Tool used in OpenStack development to ensure correctly ordered testing of changes in parallel.

INDEX

Symbols

A

B

C

D

E

F

G

H

I

J

K

P

Q

R

S

T