



JSC Cloud OpenStack user training

2023-06-12 | Sebastian Achilles, Prateek Gautam, Björn Hagemeier | Juelich Supercomputing Centre

Overview

- Split training in two parts
 - Introduction
 - Core OpenStack services
 - Authentication
 - Virtual Machine service (VM) / Nova: instantiation, life-cycle, advanced actions
 - VM Images / Glance: roll your own, public, private, shared
 - Networking / Neutron: internal networks, routers, security groups, access to internal VMs, firewall
 - Storage / Cinder: suggested handling of payload data, snapshots, backups

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 - Networking / Neutron: internal networks, routers, security groups, access to internal VMs, firewall
 - Storage / Cinder: suggested handling of payload data, snapshots, backups
 - Advanced OpenStack services
 - Orchestration / Heat: how it helps us as Cloud administrators, further use cases
 - Orchestration / Kubernetes:
 - Load balancing (LBaaS) / Octavia
 - VPN as a service (VPNaaS) / Neutron

Agenda

Time	Topic	Who
09:00	Authentication, basic setup, environment	Björn
09:30	VM service, Nova	Sebastian
10:00	VM Exercise	
10:15	VM images	Björn
10:30	<i>Break</i>	
10:45	Networking	Björn
11:15	Networking exercise(s)	
11:30	Storage, Cinder	Prateek
11:50	Storage exercise	
12:00	<i>Lunch break</i>	
13:00	Heat	Björn
13:30	Heat Exercise	Björn
13:45	Kubernetes / LoadBalancers	Tim
14:30	Wrap-up and Discussion	all



Introduction

Cloud

A definition

*Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., **networks, servers, storage, applications, and services**) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.*

– NIST Cloud definition

Cloud

Characteristics, service models, deployment models

Characteristics

- on-demand self-service
- broad network access
- resource pooling
- rapid elasticity
- measured service

Service models

- Software as a service (SaaS)
- Platform as a service (PaaS)
- Infrastructure as a service (IaaS)

Deployment models

- private
- community
- public
- hybrid

Cloud

Infrastructure and software stacks

Infrastructures

- Amazon Web Services (AWS): IaaS, PaaS, approximately 200 services (SaaS), Function as a service (FaaS) with AWS Lambda
- Google Cloud Platform (GCP): IaaS, PaaS, FaaS
- Microsoft Azure: IaaS, PaaS, SaaS
- OVH
- IONOS
- T-Systems

Software

- OpenStack: IaaS, PaaS
- OpenNebula: IaaS
- Apache CloudStack: IaaS

Cloud

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- T-Systems

Software

- **OpenStack**: IaaS, PaaS
- OpenNebula: IaaS
- Apache CloudStack: IaaS



OpenStack

Overview – core services

Nova manages the lifecycle of virtual machines (VMs) that have

- a number of CPUs
- an amount of main memory
- storage: **system**, ephemeral, swap
- data storage: volumes
- network ports
- a template image containing an operating system

OpenStack

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} Nova

OpenStack

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} Nova
← Cinder

OpenStack

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OpenStack

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OpenStack

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- storage: **system**, ephemeral, swap
- data storage: volumes
- network ports
- a template image containing an operating system
- Keystone for service discovery and authentication

} Nova

← Cinder

← Neutron

← Glance

Tutorial environment

We will use both web UI and CLI to run examples

HDF JSC_LDAP dsi

Project / Network / Network Topology

Network Topology

Launch Instance

Topology Graph

Resize the canvas by scrolling up/down with your mouse/trackpad on the topology. Pan around the c behind the topology.

Toggle Labels Toggle Network Collapse Center Topology

2023-06-12

```
(openstack-venv-p3) [t.joern@zam035:~]$ os-dsl server show kolla-test-1
```

Field	Value
OS-DCF:diskConfig	AUTO
OS-EXT-RZ:availability_zone	HDFcloud
OS-EXT-SIS:power_state	Running
OS-EXT-SIS:task_state	None
OS-EXT-SIS:vm_state	active
OS-SRV-USG:launched_at	2021-10-08T08:28:57.000000
OS-SRV-USG:terminated_at	None
accessIPv4	
accessIPv6	
addresses	openstack-test=10.0.23.12; openstack-test-internal=10.0.25.12
config_drive	
created	2021-10-08T08:28:47Z
flavor	x18 (82c859c6-4e2d-433b-9a75-ff58d8fc1fde)
hostId	b1417b945619f2854ab497a742dc0c67e8f9eccb86327653d1b9380
id	e8af7b3e-ec04-481c-b81e-b4040cd9b0ac
image	CentOS 8 (bf79b3c3-975a-4ce1-aaaa-6b9fc700eb25)
key_name	devstack
name	kolla-test-1
progress	0
project_id	8b97289e6a2d4d14b2aae1c4060aad99
properties	
security_groups	names='deFault'
status	ACTIVE
updated	2021-10-08T11:46:33Z
user_id	1027fa268cbe223f45e14b167685bf72f3c4e68e3765fd99095d1e30972e1748
volumes_attached	

Tutorial environment

CLI setup

We'll use a Python virtual environment. Run the following in your shell:

```
$ python3 -m venv openstack
$ source openstack/bin/activate
$ pip install python-openstackclient
```

For authentication:

- Option 1: Download and source `openrc.sh`
- Option 2: Download `clouds.yaml`, put it in one of
 - current working directory as `clouds.yaml` or
 - `~/.config/openstack/clouds.yaml`

Tutorial environment

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Commandline Client

Introduction

- Help system accessible through `openstack help [command(s)]`
- The `--fit-width` or environment variable `CLIFF_FIT_WIDTH=1` helps improve readability by adjusting output width to terminal width
- List and pipe resources
- General resource operations: create, delete, list, show, set, unset, add, remove

```
$ openstack help
$ openstack help server list
$ openstack help server
server add fixed ip
server add floating ip
server add network
...
```

```
$ openstack server list --status
→ ACTIVE -f value -c ID | xargs
→ -n1 openstack server stop
```

Commandline Client

Introduction

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EXERCISE

```
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$ openstack help server list
$ openstack help server
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...
```

```
$ openstack server list --status
→ ACTIVE -f value -c ID | xargs
→ -n1 openstack server stop
```



Authentication and the JSC infrastructure

Enable HDFCloud in JuDoor

Exercise

- Go to your JuDoor profile page
- At the bottom, you'll find "connected services"
- "Make changes" → enable HDFCloud
- We need your username to add you to the training project

Connected Services

[trac](#) [jards](#) [rapla](#) [gitlab](#) [llview](#) [jupyter-jsc](#) [unicore](#) [HDFCloud](#) [techticket](#) [vcenter](#)

[↗ Make changes](#)

[← Back to hagemeyer2](#)

Manage Webservices

Services

- [my application](#) [✖](#)
- [Elixir](#)
- [map](#) [✖](#)
- [Team Project Build](#) [✖](#)
- [trac](#)
- [vcenter](#) [✖](#)
- [jards](#)
- [gitlab](#)
- [jupyter-jsc](#) [✖](#)
- [HDFCloud](#)

Submit

Authentication

JSC Account

- For login using JSC account, use "Keystone credentials" → "JuDoor"
- Enter username and password as in JuDoor
- Other option: Helmholtz AAI federated login

HELMHOLTZ
Data Federation | HDF

Log in

Authenticate using

Keystone Credentials

If you are not sure which authentication method to use, contact your administrator.

Domain

JuDoor

User Name

Password

Sign In

Download clouds.yaml

Exercise

- Visit the Horizon dashboard: <https://hdf-cloud.fz-juelich.de/>
- Download credential files from the web interface
- Go to "API Access"

The screenshot shows the HDF Horizon dashboard interface. On the left, a navigation menu is visible with the following items: Project, API Access (highlighted in blue), Compute, Volumes, Network, Orchestration, and Identity. On the right, a user profile dropdown menu is open for 'hagemeier2', showing options for Settings, Help, and OpenStack RC File (highlighted in yellow). Below this, a secondary dropdown menu is shown with the title 'Download OpenStack RC File' and two options: 'OpenStack clouds.yaml File' and 'OpenStack RC File'.

Keystone Functions

Basic Concepts

■ Identity

- Tenant/Project : abstraction to isolate users and resources (VMs, Volumes, etc)
- User : Person or service
- Role : set of rights and privileges allow user to perform operations in a tenant

■ Token

- Randomly generated string used in HTTP headers
- Authenticate and authorize interactions with the various OpenStack APIs

■ Policy

- Service based access policies for its resources
- simple rule based mechanism for expressing authorization
- eg. Policy for identity service can be configured in the `/etc/keystone/policy.json`

■ Catalog

- Provides an endpoint registry for various cloud services and used for discovering services' endpoints.

Exercise

Environment setup and authentication

- 1 Login at <https://hdf-cloud.fz-juelich.de/>
- 2 Find and download credential files
- 3 Setup a virtual environment and install the OpenStack cli

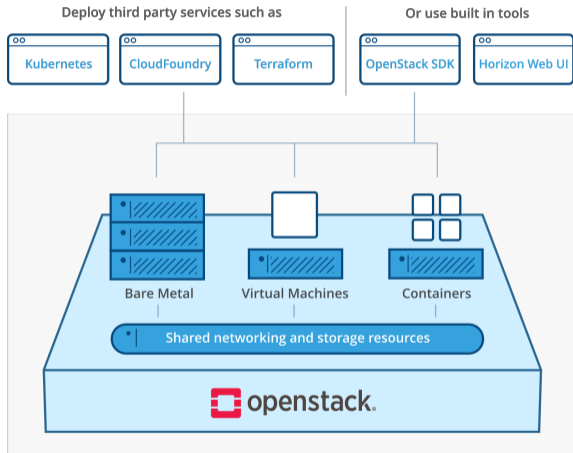


Compute (Nova)

Nova

Compute service

- Nova is the OpenStack compute service
- Offers virtual machines (VMs)
- Publicly available or custom images
- Multiple virtualization backends, we use KVM (x86)



Nova – server creation

Ingredients

- image
- flavor
- name
- network
- keypair
- user-data

Nova – image

- Use one of the provided images, which contain the `cloud-init` packages for ssh key and user injection:
 - CentOS 7
 - Debian 9/10/11
 - Rocky Linux 8
 - SystemRescue 8.05
 - Ubuntu 16.04/18.04/20.04/22.04
- Upload your own image.

Launch Instance

Instance source is the template used to create an instance. You can use an image, a snapshot of an instance (image snapshot), a volume or a volume snapshot (if enabled). You can also choose to use persistent storage by creating a new volume.

Select Boot Source: Image (dropdown) | Create New Volume: Yes No

Allocated: Displaying 0 items

Available (11): Select one

Name	Updated	Size	Type	Visibility	
> CentOS 7	10/5/21 11:40 AM	364.50 MB	CCOW2	Public	↕
> Debian Bullseye 11	10/5/21 11:40 AM	241.31 MB	CCOW2	Public	↕
> Debian Buster 10	10/5/21 11:40 AM	522.20 MB	CCOW2	Public	↕
> Debian Stretch 9	10/5/21 11:40 AM	559.59 MB	CCOW2	Public	↕
> RockyLinux 8	1/27/22 10:47 AM	1.40 GB	CCOW2	Public	↕
> SystemRescue 8.05	3/14/22 9:38 AM	753.00 MB	RAW	Public	↕
> SystemRescueCd 6.0.3	10/5/21 11:40 AM	841.00 MB	RAW	Public	↕
> Ubuntu Bionic 18.04 LTS	10/5/21 11:40 AM	340.94 MB	CCOW2	Public	↕
> Ubuntu Focal 20.04 LTS	10/5/21 11:40 AM	519.69 MB	CCOW2	Public	↕
> Ubuntu Jammy 22.04 Daily	3/18/22 3:42 PM	616.94 MB	CCOW2	Public	↕
> Ubuntu Xenial 16.04 LTS	10/5/21 11:40 AM	303.63 MB	CCOW2	Public	↕

Buttons: Cancel, < Back, Next >, Launch Instance

Nova – flavor

A flavor comprises

- number of VCPUs,
- amount of RAM,
- root disk size,
- ephemeral disk size,
- swap disk size, and
- RX/TX factor.

All parameters except VCPUs and RAM (and root disk size to some extent) are the same for all flavors in our deployment.

Launch Instance

Flavors manage the sizing for the compute, memory and storage capacity of the instance.

Allocated

Name	VCPUS	RAM	Total Disk	Root Disk	Ephemeral Disk	Public
Select an item from Available items below						

▼ Available ⓘ Select one

Click here for filters or full text search.

Name	VCPUS	RAM	Total Disk	Root Disk	Ephemeral Disk	Public
> t1.large-disk	1	512 MB	30 GB	30 GB	0 GB	Yes
> t1	1	512 MB	10 GB	10 GB	0 GB	Yes
> s1.large-disk	1	1 GB	30 GB	30 GB	0 GB	Yes
> i2	2	1 GB	10 GB	10 GB	0 GB	Yes
> s1	1	1 GB	10 GB	10 GB	0 GB	Yes
> i2.large-disk	2	1 GB	30 GB	30 GB	0 GB	Yes
> i4.large-disk	4	2 GB	30 GB	30 GB	0 GB	Yes
> s2.large-disk	2	2 GB	30 GB	30 GB	0 GB	Yes
> m1	1	2 GB	10 GB	10 GB	0 GB	Yes
> s2	2	2 GB	10 GB	10 GB	0 GB	Yes

Nova – flavor

		VCPUs					
		1	2	4	8	16	
RAM	0.5 GB	t1					
	1 GB	s1	t2				
	2 GB	m1	s2	t4			
	4 GB	l1	m2	s4	t8		
	8 GB	xl1	l2	m4	s8	t16	
	16 GB		xl2	l4	m8	s16	
	32 GB			xl4	l8	m16	
	64 GB				xl8	l16	
	128 GB					xl16	

Table: OpenStack flavors on the HDF-Cloud

Nova – flavor

Parameter	Value
root disk	10 GB / 30 GB ¹
ephemeral disk	0 GB
swap disk	0 MB
RX/TX factor	1

Table: Fixed parameters for defined flavors

¹for the #.large-disk flavors

Nova – Create VM

Steps when starting from a empty project:

- 1 Create a Security Group
- 2 Create a Network
- 3 Create a Router (not needed on HDF-Cloud, since each project will come with one router)
- 4 Create a Key Pair
- 5 Create one (or more) Instances

Nova – Create a Key Pair

Add Interface

- Project → Compute → Key Pairs
- Create Key Pair
- Define a name for the key and select SSH as key type

Create Key Pair ✕

Key Pair Name * ?

CloudTraining-key ✓

Key Type *

SSH Key ▾

✕ Cancel + Create Key Pair

Nova – Create an Instance

- Project → Compute → Instances
- Launch Instance
- Define a name for the instance

Launch Instance

Please provide the initial hostname for the instance, the availability zone where it will be deployed, and the instance count. Increase the Count to create multiple instances with the same settings.

Instance Name *

Description

Availability Zone

Count *

Total Instances (12 Max)
8%

0 Current Usage
1 Added
11 Remaining

Nova – Create an Instance

- Project → Compute → Instances
- Launch Instance
- Define a name for the instance

Launch Instance

Please provide the initial hostname for the instance, the availability zone where it will be deployed, and the instance count. Increase the Count to create multiple instances with the same settings.

Instance Name *

Description

Availability Zone

Count *

Total Instances (12 Max)
8%

0 Current Usage
1 Added
11 Remaining

Nova – Create an Instance

- In Source select an image for you instance

Launch Instance

Instance source is the template used to create an instance. You can use an image, a snapshot of an instance (image snapshot), a volume or a volume snapshot (if enabled). You can also choose to use persistent storage by creating a new volume.

Select Boot Source **Create New Volume**

Image

Allocated
Displaying 1 item

Name	Updated	Size	Type	Visibility
▶ Ubuntu Focal 20.04 LTS	10/5/21 11:40 AM	519.69 MB	QCOW2	Public <input type="button" value="↓"/>

Displaying 1 item

Available Select one

Displaying 10 items

Name	Updated	Size	Type	Visibility
▶ CentOS 7	10/5/21 11:40 AM	364.90 MB	QCOW2	Public <input type="button" value="↑"/>

Nova – Create an Instance

- Select a flavor for your instance

Launch Instance ✕

Flavors manage the sizing for the compute, memory and storage capacity of the instance. ?

Allocated

Name	VCPUS	RAM	Total Disk	Root Disk	Ephemeral Disk	Public	
> t1	1	512 MB	10 GB	10 GB	0 GB	Yes	↓

Available 43 Select one

Q Click here for filters or full text search. ✕

Name	VCPUS	RAM	Total Disk	Root Disk	Ephemeral Disk	Public	
> t1.large-disk	1	512 MB	30 GB	30 GB	0 GB	Yes	↑
> s1.large-disk	1	1 GB	30 GB	30 GB	0 GB	Yes	↑
> t2	2	1 GB	10 GB	10 GB	0 GB	Yes	↑
> s1	1	1 GB	10 GB	10 GB	0 GB	Yes	↑
> t2.large-disk	2	1 GB	30 GB	30 GB	0 GB	Yes	↑
> t4.large-disk	4	2 GB	30 GB	30 GB	0 GB	Yes	↑

Nova – Create an Instance

- Select a network, e.g. the one you have created

Launch Instance

Details

Source

Flavor

Networks

Network Ports

Security Groups

Key Pair

Configuration

Server Groups

Scheduler Hints

Metadata

Networks provide the communication channels for instances in the cloud.

▼ Allocated ¹ Select networks from those listed below.

	Network	Subnets Associated	Shared	Admin State	Status	
1	CloudTraining-network	CloudTraining-subnet	No	Up	Active	⌵

▼ Available ¹ Select at least one network

🔍 Click here for filters or full text search. ✕

Network	Subnets Associated	Shared	Admin State	Status
No available items				

✕ Cancel < Back Next > Launch Instance

Nova – Create an Instance

- Select a Security Group, e.g. `ssh_external`

Launch Instance

Select the security groups to launch the instance in.

▼ Allocated ²

Displaying 2 items

Name	Description
> default	Default security group
> ssh_external	

Displaying 2 items

▼ Available ¹ Select one or more

🔍 Click here for filters or full text search.

Displaying 0 items

Name	Description
No items to display.	

Displaying 0 items

Nova – Create an Instance

- Select a Key Pair

Launch Instance ✕ ?

A key pair allows you to SSH into your newly created instance. You may select an existing key pair, import a key pair, or generate a new key pair.

[+ Create Key Pair](#) [⬇ Import Key Pair](#)

Allocated

Displaying 1 item

Name	Type
▶ CloudTraining-key	ssh ⬇

Displaying 1 item

▼ Available 1 Select one

✕

Displaying 0 items

Name	Type
No items to display.	

Displaying 0 items

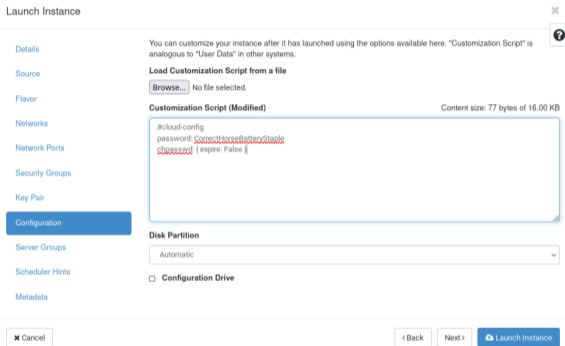
[✕ Cancel](#) [◀ Back](#) [Next >](#) [🔑 Launch Instance](#)

Nova – Create an Instance

- Adjust the customization Script
- For example you can set a password with cloud-config:

```
#cloud-config
password:
  ↪ CorrectHorseBatteryStaple
chpasswd: { expire: False
  ↪ }
```

- cloud-init reference:
<https://cloudinit.rtfid.io/>



The screenshot shows the 'Launch Instance' dialog in the OpenStack Nova interface, with the 'Configuration' tab selected. The left sidebar contains a list of configuration options: Details, Source, Flavor, Networks, Network Ports, Security Groups, Key Pair, Configuration (highlighted), Server Groups, Scheduler Hints, and Metadata. The main content area displays the 'Customization Script (Modified)' field, which contains the following text: `#cloud-config`, `password: CorrectHorseBatteryStaple`, and `chpasswd: { expire: False }`. Above this field, there is a 'Load Customization Script from a file' section with a 'Browse...' button and the text 'No file selected.' Below the script field, there is a 'Disk Partition' dropdown menu set to 'Automatic' and a checkbox for 'Configuration Drive' which is currently unchecked. At the bottom of the dialog, there are three buttons: 'Cancel', '< Back', and 'Next >', followed by a blue 'Launch Instance' button.

Nova – Create an Instance

Associate Floating IP

- Project → Compute → Instances
- For your instance → Actions → Associate Floating IP
- Click on + to allocate a floating IP
- Click on Associate

Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
CloudTrain-g-VM	Ubuntu Focal 20.04 LTS	10.0.2.153	t1	CloudTraining-key	Active	HPCloud	None	Running	0 minutes	Create Snapshot

Displaying 1 item

- Associate Floating IP
- Attach Interface
- Detach Instance
- Get Instance
- Attach Volume
- Detach Volume
- Update Metadata

Allocate Floating IP

Pool *
dmz-hdf-cloud

Description
CloudTraining-IP

Description:
Allocate a floating IP from a given floating IP pool.

Project Quotas
Floating IP 1 of 4 Used

Cancel Allocate IP

Manage Floating IP Associations

IP Address *
134.94.199.95

Select the IP address you wish to associate with the selected instance or port.

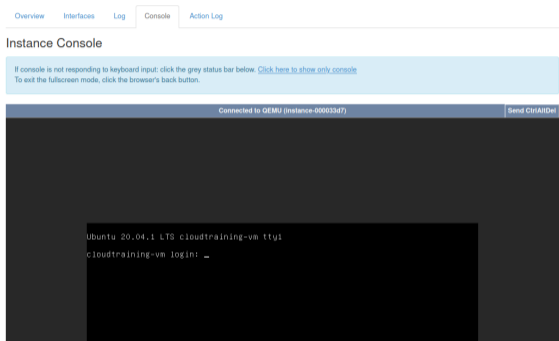
Port to be associated *
CloudTraining-VM. 10.0.2.153

Cancel Associate

Nova – Create an Instance

Accessing the Instance through the OpenStack dashboard

- Project → Compute → Instances
- Select instance → Console
- default user-names depends on your image
 - ubuntu
 - centos
 - rocky



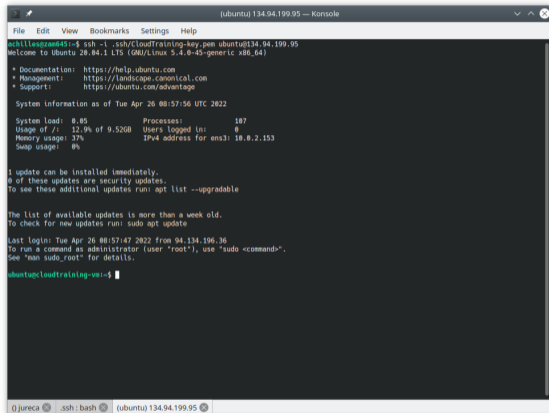
```
openstack console log show <server-name-or-id>  
openstack console url show <server-name-or-id>
```

Nova – Create an Instance

Accessing the Instance through SSH

- For ssh you need to use the key pair you have added during the instance creation and the default user name depending on the image you used

```
ssh -i  
→ .ssh/CloudTraining-key.pem  
→ ubuntu@134.94.199.95
```



```
(ubuntu) 134.94.199.95 — Konsole  
File Edit View Bookmarks Settings Help  
achilles@ach45:~$ ssh -i .ssh/CloudTraining-key.pem ubuntu@134.94.199.95  
Welcome to Ubuntu 20.04.1 LTS (GNU/Linux 5.4.0-45-generic x86_64)  
  
 * Documentation:  https://help.ubuntu.com  
 * Management:    https://landscape.canonical.com  
 * Support:       https://ubuntu.com/advantage  
  
System information as of Tue Apr 26 08:57:56 UTC 2022  
  
System load:  0.05          Processes:    107  
Usage of /:   12.9% of 9.52GB  Users logged in:  0  
Memory usage: 37%          IPv4 address for ens3: 10.8.2.153  
Swap usage:   0%  
  
1 update can be installed immediately.  
0 of these updates are security updates.  
To see these additional updates run: apt list --upgradable  
  
The list of available updates is more than a week old.  
To check for new updates run: sudo apt update  
  
Last login: Tue Apr 26 08:57:47 2022 from 94.134.196.36  
To run a command as administrator (user "root"), use "sudo <command>".  
See "man sudo_root" for details.  
  
ubuntu@cloudtraining-va:~$
```

Nova – Delete an Instance

Steps to delete an instance and optional also the network are:

- 1 Delete the instance
- 2 Release floating IP
- 3 (Delete Subnet)
- 4 (Delete Network)
- 5 (Delete Security Groups)
- 6 (Delete Key Pair)

Please note: there should be one router per project, therefor it is not necessary to remove the router.

Nova – Using the CLI

Activate the Python venv you created earlier, e.g.:

```
source openstack/bin/activate
```

Gather parameters to launch an instance:

```
openstack flavor list  
openstack image list  
openstack security group list  
openstack keypair list
```

Nova – Using the CLI

Configure access and security for instances

Either upload a public key or create a new key pair when specifying the filename for private key to save to:

```
openstack keypair create
  [--public-key <file> | --private-key <file>]
  [--type <type>] [--user <user>]
  [--user-domain <user-domain>]
  <name>
```

Create and manage security groups:

```
openstack security group list
openstack security group create [--description <description>] <name>
openstack security group delete <name>
```

Nova – Using the CLI

List security group rules:

```
openstack security group rule list
  [--all-projects]
  [--protocol <protocol>]
  [--ethertype <ethertype>]
  [--ingress | --egress]
  [--long]
  [<group>]
```

Nova – Using the CLI

Create and manage security group rules:

```
openstack security group rule create
  [--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>]]
  [--description <description>]
  <group>

openstack security group rule delete <rule>
```

Nova – Using the CLI

After you gather required parameters, run the following command to launch an instance. Specify the server name, flavor ID, and image ID:

```
openstack server create
  (--image <image> | --volume <volume>) --flavor <flavor>
  [--security-group <security-group>] [--key-name <key-name>]
  [--property <key=value>] [--file <dest-filename=source-filename>]
  [--user-data <user-data>] [--availability-zone <zone-name>]
  [--block-device-mapping <dev-name=mapping>]
  [--nic <net-id=net-uuid,v4-fixed-ip=ip-addr,v6-fixed-ip=ip-addr,
  ↪  port-id=port-uuid,auto,none>]
  [--network <network>] [--port <port>] [--hint <key=value>]
  [--config-drive <config-drive-volume>|True] [--min <count>]
  [--max <count>] [--wait]
  <server-name>
```

Nova – Using the CLI

After creating a server you can check the status with

```
openstack server list
  [--ip <ip-address-regex>]      [--ip6 <ip-address-regex>]
  [--name <name-regex>]  [--instance-name <server-name>]
  [--status <status>]  [--flavor <flavor>]
  [--image <image>]  [--host <hostname>]
  [--all-projects]  [--project <project>]
  [--user <user>]  [--long]  [-n]
  [--marker <server>]  [--limit <num-servers>]  [--deleted]
  [--changes-since <changes-since>]
```

Nova – Using the CLI

Create and assign a floating IP using the CLI:

```
openstack floating ip list
openstack floating ip create dmz-hdf-cloud
openstack server add floating ip <server> <ip-address>
openstack server list
```

Disassociate and delete floating IP addresses:

```
openstack server remove floating ip <server> <ip-address>
openstack floating ip delete <floating-ip>
```

Nova – Using the CLI

Manage instances

Resize instance:

```
openstack server resize [--flavor <flavor> | --confirm | --revert]
  [--wait]
  <server>
```

Suspend and resume an instance:

```
openstack server suspend <server>
openstack server resume <server>
```

Reboot:

```
openstack server reboot [--hard | --soft] [--wait] <server>
```


Nova – Using the CLI

Delete instance:

```
openstack server list
```

```
openstack server delete <server>
```



Compute (Nova) Exercise

Nova Exercise

For this exercise:

- Use the existing router, network and security group `ssh_external` in the shared project,
- Create your own key following this naming scheme: `CloudTraining_key_<lastname>`
- In case we have more participants than floating IPs, please use the console in the OpenStack dashboard to work on your instance, instead of assigning a floating IP,
- Please release the resources at the end of the exercise.

If you get stuck or run into problems please do not hesitate and reach out to one of the tutors and ask for help!

Nova Exercise

1) Launch an instance using the OpenStack dashboard:

- t1 flavor
- Ubuntu Focal 20.04 LTS image

Benchmark your VM with the following command in your shell:

```
$ sudo apt update
$ sudo apt install sysbench
$ sysbench cpu
↪ --cpu-max-prime=200000 run
```

Delete your instance afterwards.
Compare the events per second you are measuring.

2) Launch an instance using the OpenStack API:

- t2 flavor
- RockyLinux 8 image

Benchmark your VM with the following command in your shell:

```
$ sudo dnf -y install epel-release
$ sudo dnf -y update
$ sudo dnf install sysbench
$ sysbench cpu --threads=2
↪ --cpu-max-prime=200000 run
```

Delete your instance afterwards.



Images (Glance)

Images

- images are templates from which instance images (aka. VMs) can be created as a working copy
- frequently employ copy-on-write semantics to improve performance and save space
- Glance service provides discovery, registration and retrieval of VM images

Vanilla images

Official sources for common Linux distributions are:

- Ubuntu: <https://cloud-images.ubuntu.com/>
- CentOS: <https://cloud.centos.org/centos/7/images>
- Debian: <https://cdimage.debian.org/cdimage/openstack> and <https://cdimage.debian.org/images/cloud/>
- Rocky: <https://rockylinux.org/alternative-images>
- SystemRescueCD: <https://www.system-rescue.org/Download/>

We already provide these images as public images in HDF Cloud.

Using the image service

Dashboard

- you will find the images under Project → Compute → Images
- launch VM from image
- create
- search
- modify

HDF JSC_LDAP

Project / Compute / Images

Images

click here for filters or full text search. + Create Image Delete Images

Displaying 7 items

<input type="checkbox"/>	Name ^	Type	Status	Visibility	Protected	
<input type="checkbox"/>	> CentOS 7	Image	Active	Public	Yes	Launch
<input type="checkbox"/>	> Debian Bullseye 11	Image	Active	Public	No	Launch
<input type="checkbox"/>	> RockyLinux 8	Image	Active	Public	No	Launch
<input type="checkbox"/>	> SystemRescue 8.05	Image	Active	Public	No	Launch
<input type="checkbox"/>	> Ubuntu Bionic 18.04 LTS	Image	Active	Public	Yes	Launch
<input type="checkbox"/>	> Ubuntu Focal 20.04 LTS	Image	Active	Public	Yes	Launch
<input type="checkbox"/>	> Ubuntu Jammy 22.04 Daily	Image	Active	Public	No	Launch

Displaying 7 items

Visibility

public

- images visible to all projects, listed in default list
- can be booted by all projects
- can only be created by cloud administrators
- typical for vanilla distribution images as shown on previous slide

private (default)

- only visible, bootable within a single project

shared

- image can be shared with other projects explicitly (ACL)
- projects can "accept" or "reject" shared image
- accepted image in default list

community

- generally available, but not in default list
- also used for withdrawn or outdated images

Visibility

visibility	default image list	details	boot
public	all	all	all
private	project	project	project
shared	project, accepted member	project, member	project, member
community	accepted member	all	all

Details: https://wiki.openstack.org/wiki/Glance-v2-community-image-sharing#Accepting_a_.27Community.27_Image

Image formats

Disk and containers

Disk format

- raw
- vhd
- vhdx
- vmdk
- vdi
- iso
- ploop
- qcow2

- aki, ari, ami

Container format

- bare
- ovf
- aki, ari, ami
- ova
- docker
- compressed

Details: <https://docs.openstack.org/glance/yoga/user/formats.html>

Image formats

Disk and containers

Disk format

- raw
- vhd
- vhdx
- vmdk
- vdi
- iso
- ploop
- qcow2

- ~~aki, ari, ami~~

Container format

- bare
- ovf
- ~~aki, ari, ami~~
- ova
- docker
- compressed

Details: <https://docs.openstack.org/glance/yoga/user/formats.html>

Image metadata

- architecture='amd64',
- os_hash_algo='sha512',
- os_hash_value='07c56a879bb0d79522...',
- os_hidden='False',
- ...
- owner_specified.openstack.object='images/Debian 11 Bullseye',
- hw_disk_bus='virtio',
- hw_scsi_model='virtio-scsi'

Generally, useful image properties can be found in the OpenStack documentation: <https://docs.openstack.org/glance/latest/admin/useful-image-properties>

Image metadata

- architecture='amd64',
- os_hash_algo='sha512',
- os_hash_value='07c56a879bb0d79522...',
- os_hidden='False',
- ...
- owner_specified.openstack.object='images/Debian 11 Bullseye',
- hw_disk_bus='virtio',
- ~~hw_scsi_model='virtio-scsi'~~ ← not a good idea at JSC

Generally, useful image properties can be found in the OpenStack documentation: <https://docs.openstack.org/glance/latest/admin/useful-image-properties>

Image actions

list

```
$ openstack image list --public
```

```
...
```

```
$ openstack image list --community
```

```
...
```

```
$ openstack image list --property os_distro=ubuntu
```

```
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| ID                                     | Name                                     |
↳ | Status |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| f0d4e282-3a12-43ac-8e8b-b1663399e9fe | Ubuntu Bionic 18.04 LTS                |
↳ | active |
| 149a65b5-aeb8-499f-aaa6-ec966bd28dd6 | Ubuntu Focal 20.04 LTS                 |
↳ | active |
...
```

Image actions

create

```
$ wget https://download.cirros-cloud.net/0.5.2/cirros-0.5.2-
↳ x86_64-disk.img
$ openstack image create --private --file
↳ cirros-0.5.2-x86_64-disk.img --disk-format raw
↳ --container-format bare cirros-0.5.2-hagemeier2
$ openstack server create --flavor t1 --network internal --image
↳ cirros-0.5.2-bjoernh cirros-test-hagemeier2
$ openstack console log show cirros-test-hagemeier2
$ openstack console url show cirros-test-hagemeier2
```


Image actions

create

EXERCISE

```
$ wget https://download.cirros-cloud.net/0.5.2/cirros-0.5.2-  
→ x86_64-disk.img  
$ openstack image create --private --file  
→ cirros-0.5.2-x86_64-disk.img --disk-format raw  
→ --container-format bare cirros-0.5.2-hagemeier2  
$ openstack server create --flavor t1 --network internal --image  
→ cirros-0.5.2-bjoernh cirros-test-hagemeier2  
$ openstack console log show cirros-test-hagemeier2  
$ openstack console url show cirros-test-hagemeier2
```



Network (Neutron)

Networking

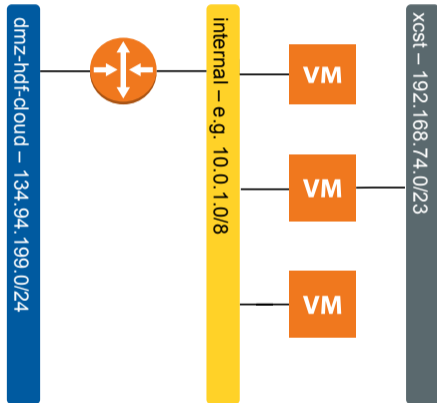
Specifics at JSC

- public network `dmz-hdf-cloud`
 - IPv4 addresses via **floating IPs**
 - subnet `134.94.199.0/24`
 - each virtual router consumes an address
- project network `internal`
 - user defined, local IPv4 addresses
 - subnets must not overlap with public subnets
- router provides NATing functionality through **masquerading** or **SNAT/DNAT**
 - think in terms of your network at home
- DATA storage network `xcst`
 - shared network controlled by Cloud administrators
 - direct connection to VM, will appear as additional network device
 - subnet `192.168.74.0/23`

Networking

Specifics at JSC

- **floating IPs** realized in router as DNAT/SNAT
- VMs without floating IPs not accessible from the outside and SNATed in outbound connections
- all new projects will be equipped with a **router** and **internal** network, such that you can immediately start working. JSC's **DNS servers** will be configured in the internal network



Network creation

Network

- Project → Network → Networks
- Set a name for the network, Admin status and Create subnet should both be "enabled".

Create Network ✕

Network

Subnet

Subnet Details

Network Name

Create a new network. In addition, a subnet associated with the network can be created in the following steps of this wizard.

Enable Admin State ⓘ

Create Subnet

Availability Zone Hints ⓘ

Cancel

◀ Back

Next ▶

```
$ openstack network create test-net  
$ openstack network delete test-net
```

Network creation

Subnet

- Set a name for the subnet
- The network address should be a private network range, such as **192.168.42.0/16** or **10.0.0.0/8**. This range is only available within your network and by the connected router (see next section)

Create Network

Network Subnet Subnet Details

Subnet Name

CloudTraining-subnet

Network Address ⓘ

10.0.0.0/8

IP Version

IPv4

Gateway IP ⓘ

Disable Gateway

Creates a subnet associated with the network. You need to enter a valid "Network Address" and "Gateway IP". If you did not enter the "Gateway IP", the first value of a network will be assigned by default. If you do not want gateway please check the "Disable Gateway" checkbox. Advanced configuration is available by clicking on the "Subnet Details" tab.

Cancel

« Back

Next »

```
$ openstack subnet create --network test-net --subnet-range  
↪ 10.0.0.0/8 --dns-nameserver 134.94.32.3 test-subnet
```

Network creation

Subnet Details

- In the subnet details, it is important to set the following three DNS servers:
 - 134.94.32.3
 - 134.94.32.4
 - 134.94.32.5
- Add nameservers

```
$ openstack subnet set
↪ --dns-nameserver
↪ 134.94.32.4
↪ --dns-nameserver
↪ 134.94.32.5
↪ test-subnet
$ openstack subnet unset
↪ --dns-nameserver
↪ 134.94.32.3
↪ test-subnet
```

Create Network

Network Subnet **Subnet Details**

Enable DHCP

Specify additional attributes for the subnet.

Allocation Pools

DNS Name Servers

134.94.32.3
134.94.32.4
134.94.32.5

Host Routes

Router creation

Basic settings

- Project → Network → Routers
- Define a Name for the router, Admin status "enabled", and an External network, which for the HDF cloud will be "dmz-hdf-cloud".

Create Router ✕

Router Name

Description:

Creates a router with specified parameters.

Enable Admin State ⓘ

External Network

Availability Zone Hints ⓘ

```
$ openstack router create --external-gateway dmz-hdf-cloud  
↪ test-router
```


Router creation

Connection to subnet

- In Project → Network → Routers, select the router
- Interfaces → Add interface
- Add an interface in your internal network.

Add Interface ✕

Subnet *

CloudTraining-network: 10.0.0.0/8 (CloudTrainin... ▾

IP Address (optional) ⓘ

Description:

You can connect a specified subnet to the router.

If you don't specify an IP address here, the gateway's IP address of the selected subnet will be used as the IP address of the newly created interface of the router. If the gateway's IP address is in use, you must use a different address which belongs to the selected subnet.

Cancel

Submit

```
$ openstack router add subnet test-router test-subnet
```

Ports

- links between networks and VMs (or other parts of the infrastructure) are created by ports
- typically created automatically in the general case
- additional ports can be created and added to VMs in two ways

```
$ openstack server add fixed ip <server> <network>
```

```
$ openstack port create --network <network> [<port-name>]
```

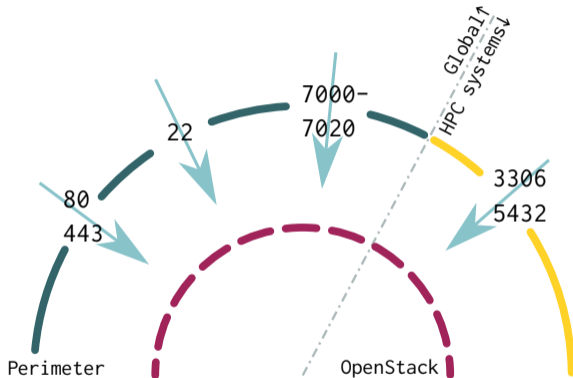
```
$ openstack server add port <server> <port-name-or-id>
```

- useful for specific scenarios like participation in multiple networks or for specific ports w/o port security

Networking

Security Groups and perimeter firewall

- Security Groups provide a way to define sets of firewall rules based on
 - source and target IPs
 - source security group (other VMs)
 - protocol and port
 - assigned to VMs
- they are assigned to compute instances
- perimeter firewall allows
 - HTTP, HTTPS
 - SSH
 - 7000 - 7020
 - MySQL and PostgreSQL from HPC systems



Security Groups

- Project → Network → Security groups
- Create a security group, e.g. `ssh_external`
- On Manage rules select a predefined rule, e.g. `SSH`
- Adjust CIDR: `0.0.0.0/0` for access from anywhere, or `134.94.0.0/16` from the FZJ network.

```
$ openstack security group create  
→ ssh_internal  
$ openstack security group rule  
→ create --remote-ip 134.94.0.0/16  
→ --dst-port 22 --protocol tcp  
→ ssh_internal
```

- Further information:
<https://docs.openstack.org/nova/latest/admin/security-groups.html>

Create Security Group

Name *

Description

Description:

Security groups are sets of IP filter rules that are applied to network interfaces of a VM. After the security group is created, you can add rules to the security group.

Create Security Group

Add Rule

Rule *

Description ⓘ

Remote * ⓘ

CIDR * ⓘ

Description:

Rules define which traffic is allowed to instances assigned to the security group. A security group rule consists of three main parts:

Rule: You can specify the desired rule template or use custom rules, the options are Custom TCP Rule, Custom UDP Rule, or Custom ICMP Rule.

Open Port/Port Range: For TCP and UDP rules you may choose to open either a single port or a range of ports. Selecting the "Port Range" option will provide you with space to provide both the starting and ending ports for the range. For ICMP rules you instead specify an ICMP type and code in the spaces provided.

Remote: You must specify the source of the traffic to be allowed via this rule. You may do so either in the form of an IP address block (CIDR) or via a source group (Security Group). Selecting a security group as the source will allow any other instance in that security group access to any other instance via this rule.

Networking

SSH forwarding using ProxyJump

- public IPs must be used sparingly
- whenever possible, use one publicly available VM as gateway into your internal network
- please do not attempt this forwarding magic yourself
- from the SSH man page
- can be concatenated (comma separated)

-J destination

Connect to the target host by first making a ssh connection

↪ to the jump

host described by destination and then establishing a TCP

↪ forwarding to

the ultimate destination from there. Multiple jump hops may

↪ be

specified separated by comma characters. ...



Cinder (volume)

Cinder - Introduction

- Block storage service for OpenStack.
- Provides software defined block storage via abstraction and automation on top of various backend storage devices (NFS at Juelich)
- Provisions and manages block devices known as Cinder volumes.
- Volumes lifecycle is independent of VMs.
- Volume types:
 - a group of volume policies: provision type, compression etc.
 - we are offering
 - DEFAULT
 - nfs-100
 - nfs
- Operations:
 - Create/Delete Volumes
 - Use volume with VM
 - Create/Delete Snapshot from Volumes
 - Create Volume from Snapshot
 - Extend Volume

Cinder - Dashboard

- You will find the volumes under Project → Volumes → volumes
- Create Volumes
- Search
- Delete Volumes
- Volume Actions (Edit Volume)

Project / Volumes / Volumes

API Access

Compute > Volumes

Filter

Displaying 4 items

Groups	Name	Description	Size	Status	Group	Type	Attached To	Availability Zone	Bootable	Encrypted	Actions
Group Snapshots	test-vo1	-	10GB	Available	-	__DEFAULT__		nova	No	No	<input type="button" value="Edit Volume"/>
Network	demo-2	-	5GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	<input type="button" value="Edit Volume"/>
Orchestration	demo-1	-	5GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	<input type="button" value="Edit Volume"/>
Data Processing	monasca	-	100GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	<input type="button" value="Edit Volume"/>

Admin > Identity >

Displaying 4 items

Encrypted: No

Actions:

- Extend Volume
- Manage Attachments
- Create Snapshot (Quota exceeded)
- Change Volume Type
- Upload to Image
- Update Metadata

Cinder - Volume Creation

- Volume creation fields:
 - Volume Name
 - Description : short description about volume
 - Volume source:
 - Empty source
 - Snapshot
 - Image
 - Volume
 - Type : volume type
 - Size : 1-max (project quota)
 - Availability Zone: Nova (default)
 - Groups

Create Volume ✕

Volume Name

Description

Volume Source
No source, empty volume ▾

Type
__DEFAULT__ ▾

Size (GiB) ^{*}
1 ▾

Availability Zone
nova ▾

Group [ⓘ]
No group ▾

Description:
Volumes are block devices that can be attached to instances.

Volume Type Description:
__DEFAULT__
No description available.

Volume Limits

Total Gibibytes 458,245 of 1,000,010 GiB Used

Number of Volumes 98 of 100 Used

Cinder - Attach volume to a VM

- Project → Compute → Instances → Choose VM (Action) → Attach Volume

- Select your volume to attach

The screenshot shows the OpenStack dashboard interface. The top navigation bar includes the HDF logo and the breadcrumb 'Project / Compute / Instances'. The left sidebar contains a navigation menu with 'Instances' selected. The main content area displays a table of instances. One instance named 'test' is visible, with columns for Instance Name, Image Name, IP Address, Flavor, Key Pair, Status, Availability Zone, Task, Power State, Age, and Actions. The 'Actions' dropdown menu is open, showing options like 'Detach Volume'. Below the table, the 'Attach Volume' dialog is displayed, featuring a 'Volume ID' dropdown menu with the text 'Select a volume', a 'Description' field with the text 'Attach Volume to Running Instance.', and 'Cancel' and 'Attach Volume' buttons.

Instance Name	Image Name	IP Address	Flavor	Key Pair	Status	Availability Zone	Task	Power State	Age	Actions
test	CentOS 7	10.0.0.31, 194.94.158.69	s1	devstack	Active	dfc1	None	Running	1 year, 4 months	Disassociate Floating IP, Attach Interface, Detach Interface, Edit Instance, Attach Volume, Detach Volume

Cinder - Mounting volume device in VM (1/2)

SSH/login to your VM

Check volume/block device is attached to the VM

```
ubuntu@ubuntu-exp:~$ lsblk
NAME        MAJ:MIN RM   SIZE RO TYPE MOUNTPOINT
vda         253:0    0    10G  0 disk
|-vda1     253:1    0    10G  0 part /
vdb         253:16   0     5G  0 disk
```

Create partition of the disk

```
sudo parted --script /dev/vdb mklabel gpt
sudo parted --script /dev/vdb mkpart primary 1 100%
sudo parted --script /dev/vdb set 1 lvm on
```

Cinder - Mounting volume device in VM (2/2)

Format the partition with preferred filesystem

```
sudo mkfs.ext4 /dev/vdb1
```

Mount the file system

```
sudo mkdir -p /mnt/vol-attach  
sudo echo "/dev/vdb1 /mnt/vol-attach ext4 defaults 0 0" | sudo tee -a  
→ /etc/fstab  
sudo mount -a
```

Verify

```
ubuntu@ubuntu-exp:~$ df -h  
Filesystem      Size  Used Avail Use% Mounted on  
...  
/dev/vdb1       5.0G  33M  5.0G   1% /mnt/vol-attach
```

Cinder - Creating Snapshots from Volume

- Select **Create Snapshot** action of the target volume.
- Provide a Snapshot name for the snapshot and click **Create Volume Snapshot**.

The screenshot shows the OpenStack Horizon interface for the 'HDF' project. The 'Volumes' page is active, displaying a table of four volumes. The 'Actions' menu for the first volume is open, showing the 'Create Snapshot' option. A modal dialog titled 'Create Volume Snapshot' is displayed, with the following fields and information:

- Snapshot Name:** test-egg[-snap]
- Description:** (empty text area)
- Description:** From here you can create a snapshot of a volume.
- Snapshot Limits:**
 - Total Gibbytes: 34 of 600 GiB Used
 - Number of Snapshots: 0 of 1 Used
- Buttons:** Cancel, Create Volume Snapshot

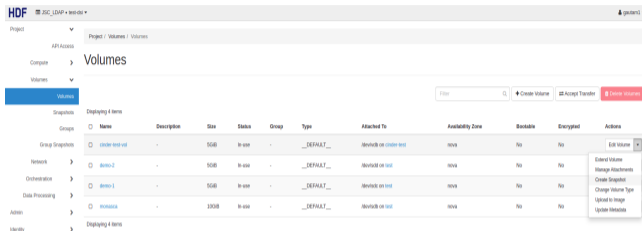
Cinder - Creating Volume from Snapshots

- You will find the snapshots under Project → Compute → Volumes → snapshots
- Select the **Create Volume** action of the target snapshot.
- Provide a volume name for the volume and click **Create Volume**.

The screenshot shows the OpenStack dashboard interface. On the left is a navigation menu with categories like Project, API Access, Compute, Volumes, Snapshots, Groups, Group Snapshots, Network, Orchestration, Data Processing, Admin, and Identity. The main content area is titled 'Volume Snapshots' and shows a table with one item: 'demo-01-snap' (5GB, Available). A 'Create Volume' button is visible next to it. Below the table is a 'Create Volume' form with the following fields: Volume Name (demo-01-snap), Description (empty), Use snapshot as a source (demo-01-snap (5 GiB)), Size (GiB) (5), and Group (No group). On the right side of the form, there are 'Description:' and 'Volume Limits' sections. The 'Volume Limits' section shows a progress bar for 'Total GiBbytes' (30 of 600 GiB Used) and 'Number of Volumes' (4 of 5 Used). At the bottom right of the form are 'Cancel' and 'Create Volume' buttons.

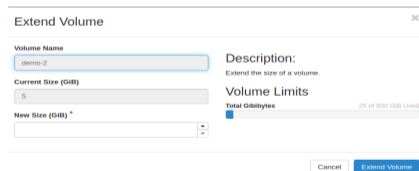
Cinder - Resize Volume

- Detach Volume from the VM
- From volume action drop down menu choose **Extend Volume**
- New Size = current Size + extra size



The screenshot shows the OpenStack Horizon interface for the 'Volumes' section. A table displays four volumes:

Name	Description	Size	Status	Group	Type	Attached To	Availability Zone	Bootable	Encrypted	Actions
cinder-test-vol	-	5GB	In-use	-	__DEFAULT__	Mounted on cinder-test	nova	No	No	Extend Volume
demo-2	-	5GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	Extend Volume Detach Volume Storage Attachments
demo-1	-	5GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	Create Snapshot Change Volume Type Upload to Image Update Metadata
demo-0	-	10GB	In-use	-	__DEFAULT__	Mounted on test	nova	No	No	



The 'Extend Volume' dialog box is shown with the following fields and options:

- Volume Name:** demo-2
- Description:** Extend the size of a volume.
- Current Size (GiB):** 5
- Volume Limits:** Total Gibibytes: 25 of 600 GiB Used
- New Size (GiB):** (Input field with a dropdown arrow)
- Buttons:** Cancel, Extend Volume

Cinder - Using the CLI

Create Volume

```
openstack volume create --size size <VOLUME NAME>  
openstack volume list  
openstack volume show <VOLUME>
```

Delete Volume

```
openstack volume delete <VOLUME>
```

Attach your volume to a server

```
openstack server add volume <VM> <VOLUME>
```


Cinder - Using the CLI

Create Snapshot from the volume

```
openstack volume snapshot create --volume <VOLUME> --description  
  ↪ <description> <SNAPSHOT NAME>  
openstack volume snapshot list  
openstack volume snapshot show <SNAPSHOT>
```

Delete Snapshot

```
openstack volume snapshot delete <SNAPSHOT>
```

Resize a volume

```
openstack server remove volume <VM> <VOLUME>  
openstack volume set <VOLUME> --size <SIZE>
```

Reference: <https://docs.openstack.org/python-openstackclient/victoria/cli/command-objects/volume.html>

Cinder Exercise

If you get stuck or run into problems please do not hesitate and reach out to one of the tutors and ask for help!

1. Create a Volume of size 2G
 - Find out volume-ID and list other metadata
2. Attach Volume to your Virtual Machine (VM)
 - Use previously created VM or create a new VM
3. Partition and mount attached volume and mount it at /mnt/
 - Create partition in the volume and format the partition with ext4 filesystem
 - Create new directory /mnt/vol-attach in the VM
 - Mount newly created filesystem at /mnt/vol-attach

Cinder Exercise

4. Install fio (flexible I/O tester) tool.

```
sudo apt install fio or sudo yum install fio
```

5. Fill 1G volume space and also perform I/O performance test

```
cd /mnt/vol-attach  
sudo fio --name=randomwrite --ioengine=libaio --iodepth=1  
↪ --rw=randwrite --bs=4k --direct=0 --size=1G --numjobs=1  
↪ --runtime=30 --group_reporting
```

6. Check usage of the filesystem

```
df -h
```